Biological and Oceanographic Observations in the Neroutsos Inlet Area with Emphasis on the Effect of Sulfite Pulp Mill Waste on Pacific Salmon. 1973-1977

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BIOLOGICAL AND OCEANOGRAPHIC OBSERVATIONS IN THE NEROUTSOS INLET AREA WITH EMPHASIS ON THE EFFECT OF SULFITE PULP MILL WASTE ON PACIFIC SALMON. 1973-1977

by

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Davis, J.C., I.G. Shand, G. Christie, and G. Kosakoski. 1978. Biological and oceanographic observations in the Neroutsos Inlet area with emphasis on the effect of sulfite pulp mill waste on Pacific Salmon. 1973-1977. Fish. Mar. Serv. MS Rep. 1447: 88 p.

Results of investigative programs concerning the impact of sulfite pulp mill waste on the water quality and acute and chronic effects of effluent on Pacific salmon in Neroutsos Inlet are described. *In situ* bioassays conducted with caged coho (*Oncorhynchus kisutch*) yearlings and juveniles, and sockeye (*O. nerka*) underyearlings in July and November 1973 showed both acute mortality and sublethal effects in caged fish located seaward of the mill. Acute mortality was observed up to 4.6 km seaward of the mill while sublethal effects observed included elevated hematocrit and increased blood clotting times. Hematocrit levels were signficantly higher 10 km seaward of the mill in the July study in comparison to those of fish located at a control station in Quatsino Narrows 21 km from the outfall.

During August of 1975 a major shutdown of the pulp mill occurred resulting in cessation of effluent discharge to the inlet and improvement of water quality. Residual oxygen bioassays using underyearling chum salmon (*Oncorhynchus keta*) and water samples collected from 5 stations and 2 depths were conducted 16-19 days after mill shutdown. No significant differences were observed between residual oxygen levels in fish exposed to inlet water compared to control water held aboard a laboratory vessel. Hydrographic observations conducted at 9 stations in the vicinity of the mill over a 10 day period commencing 16 days after shutdown confirmed a major improvement of dissolved oxygen conditions in the inlet in comparison to past studies. These data are considered useful baseline information for waste treatment considerations in the area.

Beach seine surveys were conducted during June 1976 and March 1977 to document the presence, abundance, habitat utilization and possible migratory pathways of chum fry and coho smolts in the vicinity of Port Alice. Seine surveys indicated utilization of the Cayuse Creek estuary and the area west of Ketchen Island by both species and suggested that chum fry were more prevalent on the west shore of the head of Neroutsos Inlet than the east shore over a distance of 5.5 km seaward from the head of the inlet. Suitable seine sites and recommendations for an expanded survey program for a further study are included.

Keywords: Pacific salmon, pulp mill effluent, acute toxicity, sublethal effects, hydrographic observations, distribution, abundance, habitat utilization.

RÉSUMÉ

Davis, J.C., I.G. Shand, G. Christie, and G. Kosakoski. 1978. Biological and oceanographic observations in the Neroutsos Inlet area with emphasis on the effect of sulfite pulp mill waste on Pacific Salmon. 1973-1977. Fish. Mar. Serv. MS Rep. 1447: 88 p.

Nous avons étudié l'incidence des effluents de fabriques de pâtes au bisulfite sur la qualité de l'eau, et leurs effets aigus et chroniques sur le saumon du Pacifique dans l'inlet Neroutsos. Des essais biologiques sur le terrain effectués en juillet et en novembre avec des saumons coho (Oncorhynchus kisutch) jeunes d'un an et juvéniles et des saumons rouges (O. nerka) de moins d'un an gardés dans des cages ont mis en évidence une mortalité élevée jusqu'à 4,6 km au large de la fabrique et des effets sublétaux comprenant un hématocrite élevé et une augmentation du temps de coagulation du sang. L'étude de juillet a démontré un hématrocrite significativement plus élevé à 10 km au large de la fabrique, comparativement à celui des poissons gardés dans une station témoin, dans la baie Quatsino, à 21 km de l'exutoire.

En août 1975, un arrêt prolongé de la fabrique a entraîné l'interruption du rejet d'effluents dans l'inlet et une amélioration de la qualité de l'eau. De 16 à 19 jours après la fermeture de la fabrique, on a dosé l'oxygène résiduel à l'aide de saumons kéta (O. keta) de moins d'un an et on a recueilli des échantillons d'eau à cinq emplacements et à deux profondeurs. On n'a observé aucune différence significative entre les concentrations d'oxygène résiduel des poissons exposés aux eaux de l'inlet et les témoins gardés à bord d'un laboratoire flottant. Des observations hydrologiques, effectuées sur 9 stations voisines de la fabrique pendant une période de 10 jours débutant 16 jours après la fermeture on mis en évidence une amélioration majeure des conditions d'oxygène dissous dans l'inlet, comparativement aux résultats d'études antérieures. Ces données constituent des renseignements de base utiles, en ce qui concerne les problèmes de traitement des effluents dans cette région.

Des prélèvements à la seine ont été effectués sur les plages, en juin 1976 et en mars 1977, afin d'obtenir des données sur la présence, les effectifs, l'utilisation de l'habitat et les routes migratoires possibles des alevins du saumon kéta et des saumoneaux du saumon coho, dans la région de Port-Alice. Ces relevés ont démontré l'utilisation de l'estuaire du ruisseau Cayuse et de la région située à l'ouest de l'île Ketchen par les deux espèces et portent à croire que les alevins du saumon kéta sont plus communs sur la rive ouest que sur la rive est de l'inlet Neroutsos et ce, sur une distance de 5,5 km à partir de la tête de l'inlet. Nous situons les emplacements propices pour le seinage et nous formulons des recommendations en vue d'un programme élargi de prélèvements.

Mots-clés: Saumon du Pacifique, effluents de fabriques de pâtes, toxicité aiguë, effets sublétaux, observations hydrographiques, répartition abondance, utilisation de l'habitat.

Part I - *In situ* Bioassays - Coho and Sockeye Salmon

Introduction

In situ bioassays conducted with cages of young saltwater-acclimated salmon were utilized in July 25 - 26 and November 7 - 8, 1973 to study the effect of sulphite discharge on salmonid survival and physiological state in the Neroutsos Inlet/Quatsino Narrows area. It was envisioned that these tests would provide a crude estimate of the extent of the mill's potential impact on salmonids near the shores of the inlet system. In addition, it was hoped that use of physiological tests might indicate the presence or absence of sublethal effects.

Methods

Tests were conducted in net cages suspended at a depth of 3 m below anchored floats. Details of the enclosures are shown in Figure 1. Six bioassay station sites were employed at the locations shown in Figure 2.

The test procedure consisted of anchoring the test cages in the appropriate location, adding a group of saltwater-acclimated fish to each cage, sampling the fish after approximately 24 or 42 hours exposure at each location, recording mortality statistics and sampling blood for physiological testing. To sample and observe the mortality it was necessary to pull the cage to the surface and conduct sampling as rapidly as possible (5 - 10 minutes total elasped time).

Physiological measurements made on bioassay fish following exposure in the cages consisted of hematocrit and blood clotting time determinations. A fish was removed from the cage, killed with a quick blow to the head, blotted dry on paper towel and the tail was severed. Clotting time was determined

Figure 1. *In situ* bioassay cage used for acute mortality studies and for sublethal effect experiments described in Part I. The cage was weighted to cause it to sink to the desired depth below an attached float and held in position via an anchor line to the bottom.

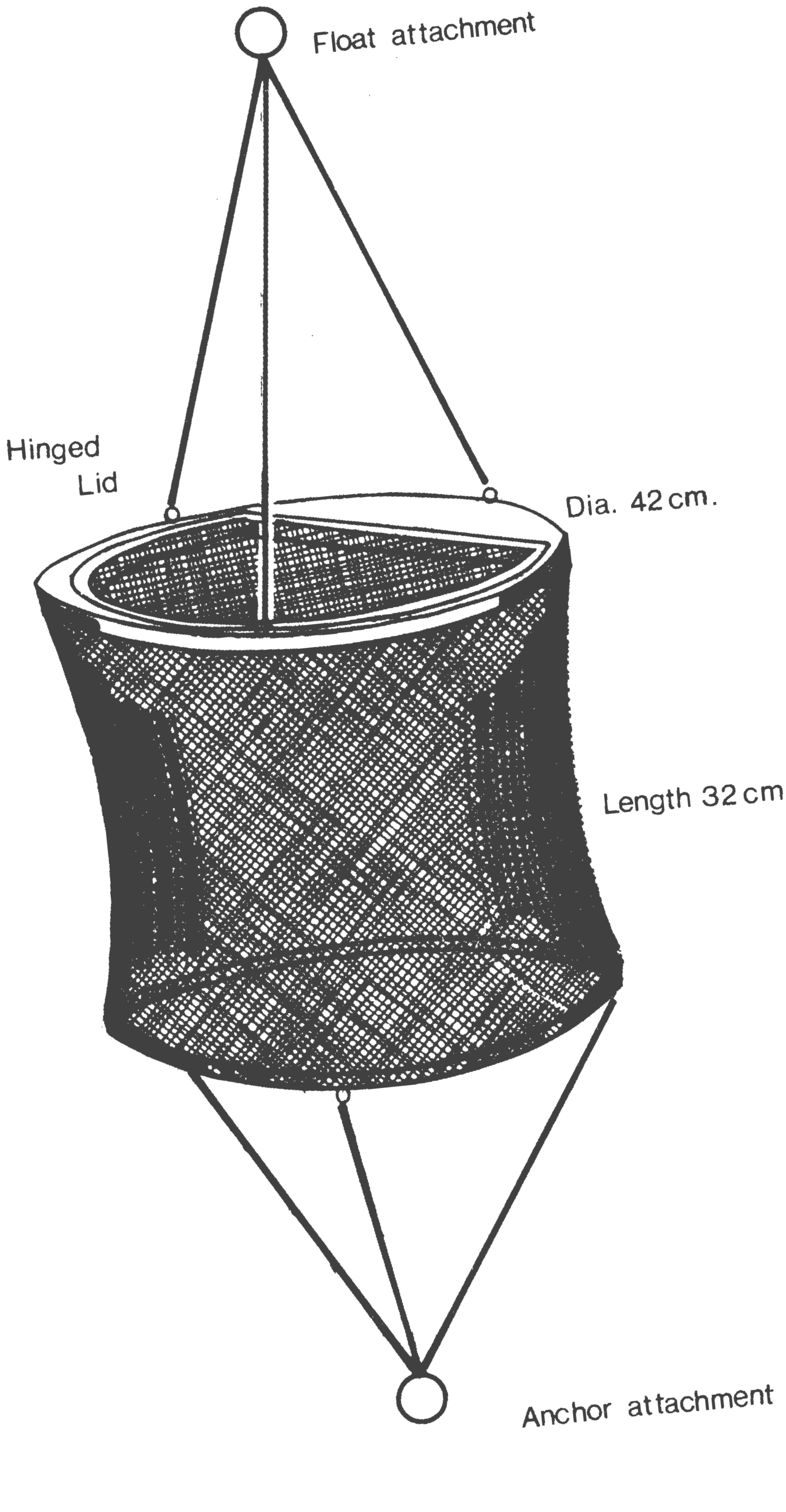
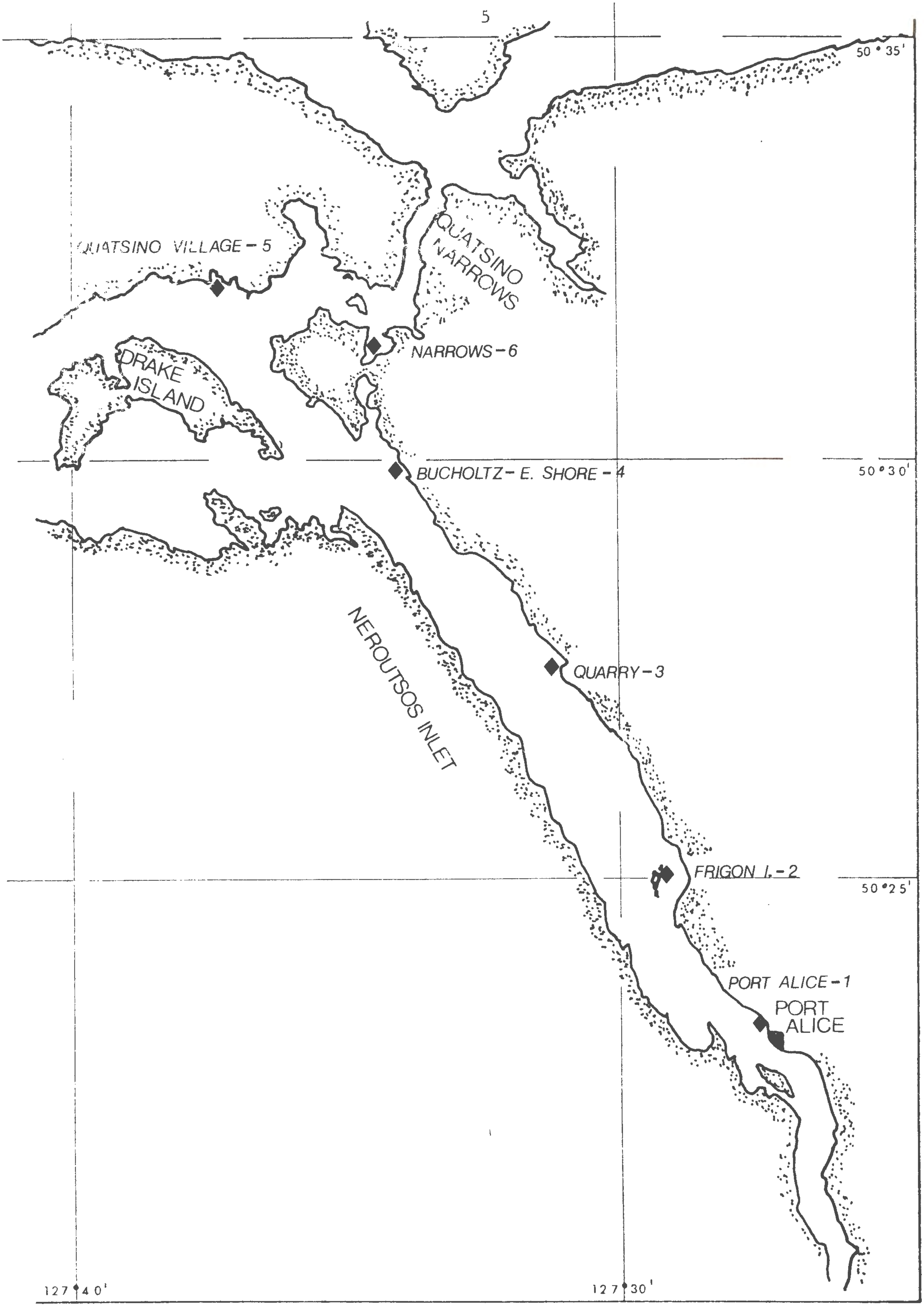

Float attachment
Hinged
Lid
Dia. 42 cm.
Length 32 cm.
Anchor attachment

Figure 2. *In situ* bioassay stations utilized during the 1973 survey. Stations are designated both by number and verbal description and actual locations are given in Tables 1-3.


50°35'
QUATSINO VILLAGE - 5
QUATSINO NARROWS
NARROWS - 6
DRAKE ISLAND
BUCHOLTZ - E. SHORE - 4
50°30'
NEROUTSOS INLET
QUARRY - 3
FRIGON I. - 2
50°25'
PORT ALICE - 1
PORT ALICE
127°40'
127°30'

by immediately collecting a blood sample in a scored unheparinized 20 μl capillary tube and sequentially breaking off short segments of the tube until a fibrous clot was observed when the broken portions of tubing separated. Clotting time was recorded as the period, in seconds, between severing of the tail and clot formation. Hematocrit, or packed red blood cell volume, expressed as a percentage of blood sample volume, was determined by collecting a blood sample in a heparinized microhematocrit tube immediately after the clotting time sample was taken. Tubes were sealed with a commercial microhematocrit sealing compound and were transported back to the ship-board laboratory for centrifugation and hematocrit determination.

Fish used in both studies were transported to the area aboard ship in 200 l fibreglass,baffled fish tanks with flowing seawater drawn from the ship's deep hull intake. Prior to transportation, stocks were gradually acclimated to full strength seawater (Salinity = 27-28^{0}/oo, T = 8-10°C) at the Pacific Environment Institute using an acclimation period of at least four weeks. For the July 1973 studies, a stock of yearling coho salmon, *Oncorhynchus kisutch*, 8-10 cm, was used. The November 1973 survey utilized underyearling sockeye salmon, *Oncorhynchus nerka*, 6.5 - 8.9 cm.

As additional information on the possible effect of transportation and salinity acclimation on hematocrit and clotting time, a stock of underyearling sockeye was held at the Pacific Environment Institute and tested following the cruise. One half of the stock was held in salt water and the other half in freshwater. These fish were then sampled for hematocrit and clotting time upon completion of the cruise.

During the July study oxygen levels (Unmodified Winkler Method), salinity (salinometer) and pH (Radiometer pH meter) were measured at each cage location at the start of the bioassay. For the November study, oxygen, pH and salinity levels were determined at the start of the bioassay as well as at the 24 or 42 hour observation periods. In addition, samples were collected and frozen for ammonia analysis (Orion specific ion electrode technique) upon completion of the trip.

Results

A) July 25-26, 1973 Survey - coho yearlings

Table 1 summarizes the findings of the July survey at the six bioassay sites. Oxygen levels at 3 m depth at the start of the bioassay were highest at Quatsino Narrows, approximately 19.8 km from the mill and declined at stations progressively nearer the mill. Similarly, pH decreased as the mill was neared, presumably due to freshwater influx into Neroutsos Inlet. Salinity was fairly uniform along the series, except at the mill itself which is located near the discharge of Cayeghle and Cayuse Creeks and is resultantly less saline.

After 24 hours exposure to 3 m water, all the fish in the cage at the mill dock and all but one individual at the Frigon Island station were dead. As a result, no information on clotting time or hematocrit was obtained at those two stations.

No mortality was observed after 24 hours at the other four stations, nor did there appear to be any trend in blood clotting times between the stations. Hematocrit values however, appeared to increase in stations progressively closer to the outfall. A student's T - test (0.01% level of significance) established that the mean hematocrit was significantly higher at the Quarry site compared to the Quatsino Narrows site.

B) November 7-8, 1973 Survey - sockeye underyearlings, coho juveniles

Oxygen levels at 3 m at the start, 24 - 26 and 41 - 43 hours following

Table 1: Coho yearlings - July 23-26, 1973 — After 24-26 hours exposure

Station	Position	mgO_2/l start	pH start	S^o/oo start	% Mortality		Clotting Time Sec.	Hct vol.%
Quatsino Narrows	50°31.35'N 127°34.50'W	9.21	7.95	30.2	0	$\bar{x}$	64.1	35.8
						SE	4.98	2.47
						n	10	10
Quatsino Village	50°32.0 'N 127°37.37'W	4.78	7.50	29.6	0	$\bar{x}$	64.6	38.8
						SE	8.96	1.32
						n	10	8
Bucholtz E. shore	50°29.82'N 127°33.95'W	4.20	7.42	30.0	0	$\bar{x}$	54.18	45.0
						SE	6.21	2.10
						n	11	11
Quarry Site	50°27.59'N 127°31.34'W	3.52	7.39	30.2	0	$\bar{x}$	68.3	52.0
						SE	10.09	2.20
						n	9	9
Frigon Islands	50°25.04'N 127°29.36'W	2.45	7.01	30.4	90		-	-
Port Alice Wharf	50°23.23'N 127°27.38'W	2.36	7.08	27.9	100		-	-

Table 2. November 7-8, 1973 Physical and Chemical Bioassay Conditions at 3m

Period	Quatsino Narrows	Quatsino Village	Bucholtz-E.shore	Quarry Site	Frigon Islands	Port Alice Wharf
			Oxygen - mgO_2/l			
Start of Bioassay	5.75	3.98	3.46	4.38	4.00	4.17
After 24-26 hours	6.02	5.33	4.75	5.48	4.21	2.11
After 41-43 hours	5.79	6.24	4.87	4.68	3.57	0.52
			Temperature - °C			
Start of Bioassay	9.0	9.0	8.7	9.0	8.8	9.3
After 24-26 hours	8.8	9.1	8.8	9.1	8.7	9.0
After 41-43 hours	8.0	8.8	8.8	9.0	8.0	8.5
			Salinity - $^{o}/oo$			
Start of Bioassay	29.75	29.62	29.37	29.84	30.03	30.58
After 24-26 hours	29.57	30.38	30.11	30.35	30.17	30.20
After 41-43 hours	29.98	30.64	30.31	30.46	29.77	29.25
			pH			
Start of Bioassay	7.53	7.33	7.26	7.38	7.28	7.38
After 24-26 hours	7.70	7.65	7.52	7.48	7.38	7.17
After 41-43 hours	7.62	7.74	7.61	7.57	7.13	6.90
			Ammonia - mg/l			
Start of Bioassay	0.08	0.13	0.10	0.10	0.12	0.11
After 24-26 hours	0.08	0.07	0.10	0.13	0.12	0.18
After 41-43 hours	0.08	0.08	0.12	0.09	0.46	0.58

Table 3. Underyearling Sockeye - November 7-8, 1973 Bioassay Results

Station	Position	Elapsed Time	Mortality %	Clotting Time (sec.)	HcT (vol.%)	Elapsed Time	Mortality %	HcT (vol.%)
Quatsino Narrows	50°31.35'N 127°34.50'W	24 h, 10 min.	0	$\bar{x}$ 102	47.6	41 h, 25 min.	0	$\bar{x}$ 39.8
				SE 6.20	3.25			SE 1.24
				n 8	5			n 8
Quatsino Village	50°32.0 'N 127°37.37'W	24 h, 39 min.	0	$\bar{x}$ 100.5	38.4	41 h, 20 min.	0	$\bar{x}$ 46.2
				SE 10.29	0.88			SE 0.85
				n 10	10			n 10
Bucholtz- E. Shore	50°29.82'N 127°33.95'W	26 h, 28 min.	0	$\bar{x}$ 127.2	40.3	42 h, 53 min.	0	$\bar{x}$ 43.9
				SE 14.8	1.38			SE 1.89
				n 9	9			n 10
Quarry Site	50°27.59'N 127°31.34'W	25 h.	0	$\bar{x}$ 90.3	37.9	42 h, 28 min.	0	$\bar{x}$ 44.8
				SE 7.90	0.43			SE 1.60
				n 10	11			n 10
Frigon Islands	50°25.04'N 127°29.36'W	26 h, 45 min.	0	$\bar{x}$ 132.0	35.0	42 h, 10 min.	0	$\bar{x}$ 44.4
				SE 13.6	0.82			SE 1.09
				n 8	9			n 10
Port Alice Wharf	50°23.23'N 127°27.38'W	25 h, 40 min.	10	$\bar{x}$ 131.7	43.0	42 h, 45 min.	100	$\bar{x}$ -
				9.49	1.03			SE -
				9	10			n -

placement of fish in the cages are summarized in Table 2. Similarly, temperature, salinity, pH and ammonia levels are documented. Oxygen levels were lower closer to the mill, particularly at the 41 - 43 hour observation which was also associated with high ammonia levels in comparison to stations more distant from the mill. Trends in salinity and pH resembled those observed in the July survey while water temperatures were fairly similar across the station series.

Results of *in situ* bioassay studies with sockeye underyearlings at the six stations are summarized in Table 3. In this study, mortality was only observed at the Port Alice wharf station adjacent to the mill and appeared coincident with lowered oxygen and elevated ammonia levels in comparison to the other stations (Table 2). Blood clotting times varied considerably between individual fish at any one station and were significantly higher (t -test, $p = 0.025$) at the Port Alice wharf station in comparison to the Quatsino Narrows station. Hematocrits however, showed little trend among the stations except that the 41 - 43 hour values were usually higher that at 24 - 27 hours.

Sockeye underyearlings of the same size and stock as those used in the November study held at the laboratory and tested within two weeks of the end of the *in situ* bioassay gave the following results:

Table 4

Saltwater Acclimated

	length (mm)	clotting time (sec.)	Hct (vol%)
$\bar{x}$	77.5	43.0	42.3
SE	3.68	8.45	1.66
n	10	10	10

Freshwater Acclimated

	length (mm)	clotting time (sec.)	Hct (vol%)
$\bar{x}$	73.6	41.1	33.2
SE	2.11	7.49	1.71
n	10	10	10

Clotting times of both acclimation groups were similar and were much more rapid than any of the times observed during the *in situ* test. Hematocrit values of the saltwater acclimated group were significantly higher (t - test, p = .01) than the freshwater group.

Discussion

Mortality was observed in bioassay cages close to the Port Alice mill in both the July and November studies. In the July study 90% mortality occurred after twenty-four hours at the Frigon Island station, 4.7 km from the outfall, whereas no mortality was observed during the November study at that site. These results are probably at least partly related to differences in oxygen availability in the inlet water between the two studies as oxygen levels at the Frigon Island site appeared lower in July in comparison to November (Tables 1, 2). Of course, other factors such as toxicity of the effluent may also have contributed to these mortality figures.

Ammonia levels showed a trend towards higher values closer to the mill, particularly at the 41 - 43 hour observation period in the November study. Obviously some variation existed in the pattern of ammonia distribution in the inlet which was probably related to the effect of wind, currents and tide on effluent dispersal.

Ammonia gas is soluble in water as ammonium hydroxide which dissociates readily as follows:

$$NH_4 + H_2O \rightleftharpoons HN_4^+ + OH^-$$

The unionized form of ammonia constitutes the toxic component to fish. The equilibrium of the reaction is pH dependent and toxicity increases with increased pH. At 20°C and a pH of 7.0 there is very little un-ionized ammonia present while at a pH of 8 there is roughly 4% un-ionized ammonia present in a solution of ammonium hydroxide (Water Quality Criteria 1972). Thus, at the pH range found here (Table 2) it is doubtful that much un-ionized ammonia was present. The presence of small amounts of un-ionized ammonia however, could contribute to toxicity as ammonia has been shown to increase in toxicity to fish at low oxygen levels (Downing and Merkens 1955; Lloyd 1961; Merkens and Downing 1957; Wuhrmann 1952). Brockway (1950) reported impairment of oxygen-carrying capacity of trout blood at elevated ammonia nitrogen levels, suggesting a mechanism for sensitivity to ammonia in the presence of reduced oxygen.

The two hematogical parameters studied, hematocrit and blood clotting times, appeared to show some evidence of sublethal effects between the fish at different station sites. The increase in hematocrit observed at the Quarry site in comparison to Quatsino Narrows in July could have been related to dissolved oxygen levels in the water. Holeton (1964) observed increased hematocrit in rainbow trout, *Salmo gairdneri*, exposed to severe hypoxia. This increase however, appeared related to elevated blood CO_2 levels during hypoxia rather than increased blood cell counts. Ferguson and Black (1941) demonstrated that red blood cells of trout swell considerably *in vitro* in the presence of CO_2.

Sockeye tested in November failed to show any significant trend in hematocrit among the station locations. In fact, the highest mean hematocrit value observed was that for the Quatsino Narrows station most distant from the mill. Perhaps oxygen depletion levels in the water, which were not generally as severe in November as in July, account in part for the difference in response observed. Species differences could also be involved.

Blood clotting times of underyearling sockeye increased significantly after approximately twenty-four hours at the Port Alice station in comparison to the Quatsino Narrows site. Increased blood clotting times may result from a physiological stress response in fish. Stress influences the pituitary-interrenal axis in salmonids leading to a decrease in circulating lymphocytes in the bloodstream (McLeay 1973). Thrombocytes, a cell type involved in the clotting process (Gardner and Yevich 1969), decrease in abundance lengthening the clotting time. Iwama et al.(1976) observed increased clotting time in coho salmon exposed to a toxicant, dehydroabietic acid, isolated from kraft mill effluent. Gardner and Yevitch (1970) described nuclear changes in thrombocytes of *Fundulus* exposed to cadmium while McLeay(1975) documented decreased white blood cell thrombocyte counts in coho salmon exposed to kraft waste and zinc. To our knowledge, no worker has observed elevated clotting times due to changes in white cell counts in salmon exposed to sulfite mill effluent. The presence of a generalized stress response to the effluent however, does seem highly likely.

In contrast to the November clotting time results with sockeye, coho salmon tested in July showed no trends in clotting time relative to distance from the outfall. The reason for the difference between the two studies is not understood. In all cases there was considerable variability in the data, hence trends could have been masked by variability at the small sample size. Also possible, is species difference in stress response relative to clotting time. McLeay (1975) concluded that the pituitary-interrenal axis in coho juveniles was activated by cold temperature acclimation and smoltification. Presumably the smoltification process occurred correctly during saltwater acclimation of the coho. Timing of the pituitary-interrenal activation and the strength and nature of the generalized stress response in underyearling sockeye is not known to us at this time.

As a criticism of technique, it was obvious that clotting times of sockeye examined in fresh and salt water in the lab following the November study

(Table 4) were quite different from those observed at all stations during the study (Table 3). This suggests that considerable stress may have been present in all the cages as an interfering factor in the study. Stress of transport, handling, confinement in the test cages and of sampling were likely present. Indeed, McLeay (1975) observed stress responses in coho due to crowding or handling that lasted several days. Such findings cast doubt on the usefulness of conducting hematological tests of this type where fish must be transported and handled for sampling. Indeed, Gardner and Yevich (1970) urged caution in the use of a restricted number of hematogical tests to study stress in fish. They suggested a complete spectrum of diagnostic tests was required for meaningful results.

In situ bioassays in general have inherent weaknesses. Fish are confined in cages at a selected depth and have no opportunity to exhibit normal behavior. Their behavioral threshold may be quite different from that which causes sublethal physiological effects or produces mortality. Furthermore, it is often difficult to monitor conditions at the cage site adequately. Thus when one finds a group of dead fish, the question arises as to the cause of death - i.e.- prolonged exposure to marginal conditions or some event which occurred during the test. Such uncertainty calls for use of automated monitoring devices or, at least, frequent monitoring of water quality. Indeed, the observations used in our study were somewhat inadequate as they occurred only at the beginning or coincident with sampling at the cage site.

In situ bioassays can be useful however. They do show, in a crude way, that a problem does or does not exist in an area that may have survival implications for fish stocks. Also, sublethal effects can be observed which occur at toxicant levels below those causing acute mortality, thus yielding increased sensitivity in monitoring an area of effluent impact. More work is required in devising sensitive *in situ* techniques that overcome some of the limitations of the experiments described herein.

Part II- Residual Oxygen Bioassays - Chum Underyearlings, August 1975

Introduction

Carter (1962) proposed a simple residual oxygen bioassay which tested the oxygen extraction ability of fish in the presence and absence of toxicant. The test consists of sealing fish, either as individuals or in groups, in small jars of test solution and determining the residual oxygen in solution at the time of death of the fish. When toxicants are present, oxygen extraction is apparently impaired and the residual O_2 level is elevated. Ballard and Oliff (1969) evaluated the procedure in comparison to 24 and 48 hour acute toxicity tests, and concluded it was a rapid and accurate method for monitoring purposes. Vigers and Maynard (1977) compared the procedure with standard 96 hour bioassay techniques and found no significant difference using rainbow trout and sodium pentachlorophenate. Their studies showed comparability of the test results with standard 96 hour tests using chloralkali plant waste and three kraft pulp mill bleach plant wastes. McLeay (1976) showed the procedure is capable of estimating toxic concentrations equivalent to the 96 hour LC50 for kraft bleach plant waste, chloralkali waste, whole bleached kraft mill waste, dehydroabietic acid, zinc, phenol and lindane. In the case of zinc and lindane, sensitivity appeared present at 0.5 and 0.6 ($p = .05$) of the 96 hr LC50 respectively and there was evidence that the procedure showed sensitivity at sublethal bleached kraft mill effluent concentrations.

Several problems are evident in conducting on-site toxicity tests with fish to assess the impact of toxic discharges on receiving waters. These include lack of adequate control over *in situ* bioassay cages, lack of knowledge of varying chemical and physical conditions at the cage site during the test, difficulties in observing test organisms without causing stress and large use of man hours and support equipment. The objective of this study was to evaluate the residual oxygen technique as a method for water quality monitoring in the vicinity of a sulfite pulp mill. Due to the simplicity and rapidity of the procedure (2 - 3 hours) and small sample volume required (2 l), it was felt that a residual O_2 test receiving water survey could be conducted aboard a floating laboratory vessel, L. PACIFICA, using samples collected by bottle casts on a daily basis.

Methods

Prior to the barge trip, preliminary tests were conducted at the Pacific Environment Institute using the residual oxygen technique and a stock of salt-water acclimated chum salmon underyearlings (*Oncorhynchus keta*) ranging in weight from 3.5 - 5.95 g (7.62 - 8.63 cm fork length). The residual oxygen level resulting from those studies, expressed as oxygen partial pressure, PO_2, was 25.74 mm Hg (S.D. = 5.956, S.E. = 2.251) based on an average of 8 grand means with 3 replicates/mean = 24 fish tested. Laboratory studies were conducted with fully O_2 saturated salt water (PO_2 = 154 - 158) at the start of the test and a constant temperature of 11.0°C.

Chum underyearlings held aboard L. PACIFICA were kept in 3 fibreglass 200 l tanks supplied with recirculated, temperature-controlled, filtered seawater. This seawater was put aboard the barge from the Pacific Environment Institute seawater system prior to departure and had an initial salinity of approx. 28^{o}/oo. Observations of water temperatures and salinity in the recirculation system during the trip are summarized in Appendix 1. This water was maintained at 13.0 °C ± 0.13 excepting a power failure of 72 hours duration, when the temperature rose to 15.2°C in the system. Water was kept clean in the recirculation system via a large single Jacuzzi-type sand-filled swimming pool filter on the return side of the system. No evidence of turbidity or fouling of the water was observed during the 16 days the system operated.

Residual oxygen bioassays were conducted on L. PACIFICA using individual chum underyearlings in 300 ml B.O.D. bottles held in a temperature control bath flushed with recirculation water. Fish were not fed 24 hours prior to testing. The procedure consisted of filling each bottle with test solution, removing a water sample via a bubble-free 1 ml syringe and #18 G Spinal needle, inserting the fish via a widemouthed funnel, sealing the bottle with a ground glass stopper to exclude air, and observing the bottle until death occurred. At the time of death (cessation of ventilatory movement) the bottle was opened and a second water sample was taken for determination of residual oxygen level. At death, fish weight (blotted dry) and fork length was determined. Oxygen levels were determined using a Radiometer pH M 71 acid-base analyser and oxygen electrode system calibrated frequently with air and sodium sulfite zero solution. For each water sample examined, 6 replicates (6 bottles, each with 1 fish) were tested.

Solutions tested included barge recirculation water and water from 2 and 20 m collected via a 5 l Van Dorn bottle cast at stations A - F (Part III, Fig. 3) over a four day period. Samples were collected from M.V. CHIMAERA, anaerobically placed in sealed 300 ml B.O.D. bottles, and immediately transported to the barge for residual oxygen analysis. On the barge the samples were kept sealed and equilibrated in the temperature control bath for 1 hour before testing. All samples were collected during ebb tides as described in Part III.

Results

Residual oxygen levels for chum underyearlings (5 tests, 3 replicates/ test = 15 fish) tested in barge recirculation water showed a mean residual PO_2 of 39.29 ± 1.99 at 13.0 °C. This level was significantly higher (p.05, one-tailed t test) than the residual O_2 (25.74 ± 2.25) recorded in the laboratory prior to the cruise.

Results of residual O_2 tests on water samples collected from stations A - F at 2 depths are given in Table 5. Grand means for each depth and

Table 5. Residual oxygen bioassay results with chum salmon underyearlings at Port Alice, B.C., 1975.

Station	Depth-m		PO_2 start	PO_2 residual	T°C	Wt. g	Leng. cm	Elapsed Time-min.	Date Waters Sampled
A	2.0*	$\bar{x}$	149.5	46.3	13.4	4.810	7.358	80.33	2/8/75
		S.D.	1.323	5.38		1.926	2.983	30.144	
		S.E.	.592	2.196		0.786	1.218	12.31	
		N	5	6		6	6	6	
	20.0*		53.33	32.467	13.4	4.478	8.38	38.83	2/8/75
			6.401	3.28		2.075	1.098	5.565	
			2.613	1.339		0.847	0.448	2.272	
			6	6		6	6	6	
B	2.0*		160.75	44.84	13.4	5.82	8.867	54.0	1/8/75
			1.037	5.916		1.804	0.852	13.54	
			.423	.447		0.736	0.348	5.53	
			6	5		6	6	6	
	20.0*		55.83	41.25	13.4	5.57	8.65	33.67	1/8/75
			2.735	5.10		1.593	0.706	9.026	
			1.117	2.082		0.65	0.288	3.684	
			6	6		6	6	6	

C	2.0*	169.66	37.75	13.7	4.388	8.80	99.33	31/7/75
		3.983	9.606		2.455	1.311	35.03	
		1.626	3.922		1.002	0.535	14.301	
		6	6		6	6	6	
	20.0*	51.32	40.2	13.5	6.336	9.00	29.2	31/7/75
		3.23	7.686		1.359	.570	5.02	
		1.44	2.236		0.608	.255	2.245	
		5	5		5	5	5	
D	2.0*	140.67	41.25	13.5	4.28	7.93	66.66	2/8/75
		13.692	4.287		1.90	1.166	21.27	
		5.590	1.750		0.776	0.476	8.683	
		6	6		6	6	6	
	20.0*	48.25	34.75	13.5	5.25	8.47	32.5	
		5.645	5.90		1.23	0.766	4.85	
		2.525	2.639		0.55	0.323	2.169	
		6	6		6	6	6	
E	2.0*	134.88	47.167	15	4.69	8.30	42.33	3/8/75
		0.4915	11.30		1.25	.586	9.29	
		0.22	5.059		.560	.262	4.155	
		6	6		6	6	6	

E (not aerated)	20.0*	33.70 3.27 1.63 5	28.0 4.72 2.111 6	15	6.88 1.046 0.468 6	9.43 0.403 0.180 6	14.83 2.48 1.109 6	3/8/75
(aerated+)	20.0	152.41 5.23 2.339 6	43.833 10.318 4.614 6	14.9	6.57 1.101 .492 6	9.15 .362 .162 6	48.17 11.72 5.242 6	3/8/75
F	2.0	130.1 1.917 0.985 5	44.30 8.703 3.892 6	—	7.14 0.943 0.422 6	9.33 .388 .174 6	43.83 6.24 2.791 6	3/8/75
(aerated)	20.0	154.58 7.724 4.460 4	50.34 6.10 3.05 5	—	5.20 2.40 1.20 5	8.45 1.20 0.60 5	61.0 20.11 10.055 5	3/8/75

* = included in analysis of variance

\+ = low O_2 brought up to full satn. prior to test station were compared via a randomized complete-block design analysis of variance (Steel & Torrie, 1960). This analysis demonstrated no significant difference between depths or among stations at the 0.05 level. T tests conducted on the grand mean residual oxygen level from barge recirculation water and those for all 2 m or 20 m water showed no significant difference between recirculation water and either depth at the 0.05 level (two-tailed tests).

Discussion

On the basis of the residual oxygen bioassay, no significant differences were observed in oxygen extraction ability of chum underyearlings exposed to barge recirculation water or water from 5 stations and 2 depths in the vicinity of the Port Alice pulp mill. These tests were conducted 16 - 19 days after the mill ceased operation and presumably after considerable improvement in degree of pollution caused by the pulp mill discharge. Assuming the effluent was largely absent from the inlet (see part III) this data can be considered useful baseline data for future studies when the mill is operating and impact of sulfite waste can be assessed. It is planned to repeat this study at a future date with an operating mill condition.

A significant difference in residual oxygen level was observed when results of studies conducted at P.E.I. prior to the trip were compared with those done on the barge with recirculation water. The latter water yielded higher residual O_2 levels. Several explanations are possible for these results. Lab. tests were conducted 16 - 22 days prior to the barge study on slightly smaller and younger fish. Possibly, oxygen extraction ability changes with age. Also, barge fish were transported by air and held aboard under conditions possibly more stressful (vibration, noise, handling, etc.)

than lab stock conditions. Such conditions might elevate residual O_2 levels. More probable however, is a temperature effect. Tests on the barge were done at 13°C; those in the laboratory at 11°C. Elevated temperature increases metabolic rate of salmonids, particularly in the presence of activity such as evidenced during the residual O_2 bioassay. Furthermore, warmer water holds less O_2 than cool water suggesting a limiting situation may be reached more rapidly in warm water than in cold (Davis, 1975). Probably, temperature effects in combination with some of the above factors produced the difference between residual O_2's in barge and laboratory water. Obviously, these factors require more study in evaluating the residual O_2 technique. Temperature, in particular, should be rigidly controlled, (Gordon & McLeay, 1977).

Table 5 summarizes oxygen tensions in water samples at the time bioassay samples were sealed. Oxygen tensions in 2 m water samples from all stations were close to full saturation in all cases while 20 m samples were approximately 30% saturated. Analysis of variance demonstrated no difference between residual oxygen levels at the two depths suggesting that results are independent of starting O_2 level over a fairly wide range of PO_2's. Table 5 however, includes data for stations E and F where the 20 m water was very low in O_2. Aeration of these samples resulted in elevated residual O_2 levels suggesting that initially low levels can influence test results. Just why a fish can depress the oxygen level to a lower level when exposed to very low initial oxygen conditions is not understood. Possibly it is a time-to-death phenomenon in low O_2 conditions where greater extraction results from some finite resistance time prior to death. If initial oxygen levels are higher, the time course of the experiment will be longer, resistance to low oxygen will be protracted over a longer period, possibly resulting in fatigue and collapse at a higher residual O_2 tension.

Aeration of solutions prior to the test elevates residual O_2 levels but may drive off volatiles in samples such as pulp mill waste (Davis & Mason, 1973). The relationship between residual O_2 and oxygen level in the sample at the start of the test may thus influence results and this factor requires more investigation. This problem is a potential complicating factor for receiving water tests with high B.O.D. wastes containing volatiles.

Part III - Oceanographic Survey in the vicinity of the Port Alice Pulp Mill following shutdown (1/8/75 - 10/8/75)

Introduction

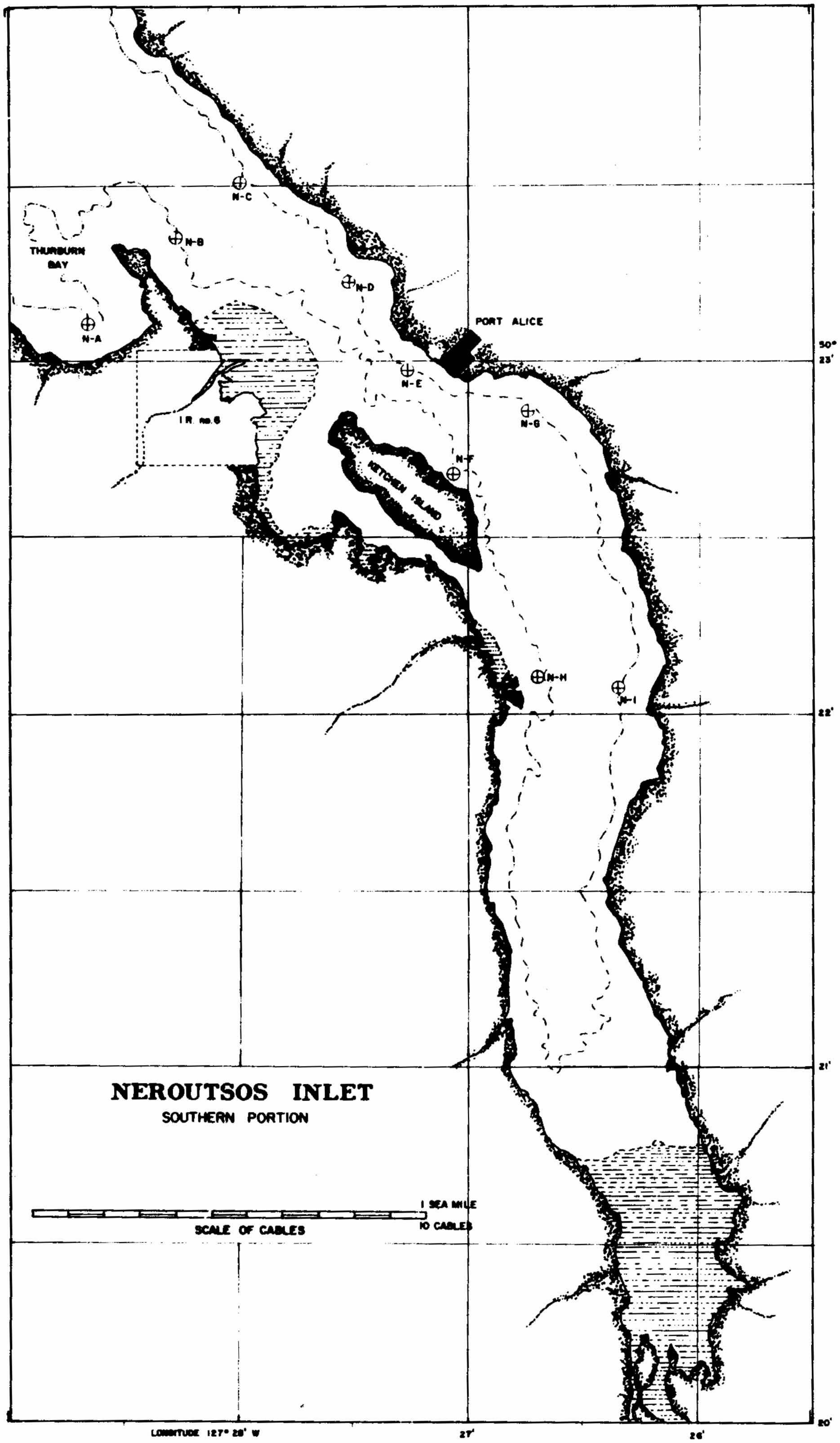
The sulfite mill at Port Alice was closed during the period July 16 - October 10, 1975 due to a labour dispute. During the period August 1 - 10, 1975 an oceanographic survey was carried out in the vicinity of the mill to study physical and chemical characteristics in the water, document the effect of cessation of mill discharge on water quality and study variation in physical and chemical characteristics over several days at various sites. Nine stations were studied over the ten day period (Figure 3).

Station Procedure and Methods of Observation

Sampling was carried out from the 32' research vessel CHIMAERA IV utilizing a hydraulic winch and standard Nansen Bottle cast techniques. The research barge L. PACIFICA, anchored at Station N-A (Fig. 3) served as a base station and laboratory for sample analysis. Station position was fixed by radar and positions reported are those occupied by the vessel when sampling occurred (dropping of the messenger).

Water samples were taken at depths ranging from the surface (bottle just immersed prior to tripping) to a depth of 40 m (depending on the maximal depth at the station). Station procedure consisted of positioning the vessel, lowering the Nansen bottle series, determining water temperature at depth from pairs of reversing thermometers mounted on the bottles, taking a Secchi disc reading and collecting water samples for salinity and dissolved oxygen determination.

Figure 3. Water quality monitoring stations studied during the August 1975 survey of Neroutsos Inlet following the closure of the pulp mill. Stations are designated "N" followed by the letter A-I. Actual location for each bottle cast is given in the following tables.


NEROUTSOS INLET
SOUTHERN PORTION
THURBURN BAY
PORT ALICE
KETCHEN ISLAND
I R no.6
N-A
N-B
N-C
N-D
N-E
N-F
N-G
N-H
N-I
1 SEA MILE
10 CABLES
SCALE OF CABLES
50°
23'
22'
21'
20'
LONGITUDE 127° 28' W
27'
26'

Presentation of Results

Results of the survey are summarized in the following pages using this format:

a) Heading of Tables

Station: Prefixed "N" for Neroutsos and followed by the alphabetical station designation 'A' to 'I'.

Position: Given as latitude and longitude in degrees and minutes as determined by a radar fix at the time the messenger was dropped to trip the Nansen bottles.

Time Messenger: Time of day the messenger was dropped, given as Pacific Standard Time.

Date: Given as day,month and year

Depth: Depth of water under CHIMAERA IV's keel, in fathoms, as determined by the vessel's echo sounder.

Secchi: Secchi disc reading as determined by an observation from the vessel's deck - i.e. - depth at which a white disc, 30 cm in diameter, just disappears from sight, expressed in meters together with the color of the water over the disc at depth of 1.0 meter (abbreviations: Lt = light, Br = brown, Gr = green).

Tide: The state of the tide is indicated in a plot of tidal height versus standard time, yielding a tide curve. The state of the tide at the time of the bottle cast is illustrated by the arrow on the tide curve. Tidal heights and times are based upon the Canadian Tide and Current Tables, 1975, using Secondary Port corrections for Port Alice on Tofino tides.

b) Body of Tables

Depth (m): Depth of water in meters at which a given Nansen bottle was tripped by a messenger dropped from above. The top of the upper (zero depth) bottle was 2 - 3 cm below the surface prior to tripping and other bottles were positioned using a meter block and remote readout dial.

T (°C): Temperature was determined by reversing thermometers attached in pairs to each Nansen bottle and corrected according to standard practice (U.S. Navy Hydrographic Office, 1955). Results are reported to the nearest 0.01° Celsius.

S (^{o}/oo): Total salt content of water expressed in parts per thousand (^{o}/oo). Salinity values given to the nearest 0.01^{o}/oo are considered accurate to that level and were determined on a precision salinometer.

$\sigma\tau$: A conveniently abbreviated value of density (ρ) of a seawater sample of temperature, T, and salinity, S: $\sigma\tau = (\rho \quad S, T - 1) \times 10^3$.

Oxygen (mg/l, mg a/l, % Satu.): Dissolved oxygen content of water samples processed according to the standard modified Winkler method (Strickland and Parsons 1965) expressed as: mg a/l - milligram - atoms O_2/liter water

mg/l - milligrams O_2/liter water

% sat. - % saturation of oxygen at *in situ* salinity and temperature according to:

$$\% \text{ Satu.} = \frac{\text{observed dissolved oxygen conc.}}{\text{saturation dissolved oxygen conc.}}$$

The saturation concentration was determined by nomographs or from formulae relating salinity, temperature and saturation (Truesdale and Gameson 1957).

Results are summarized in the following tables:

Station: N-B

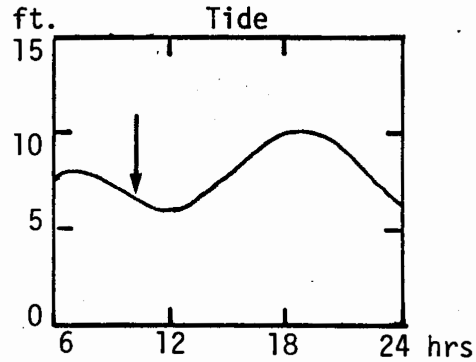
Position: 50°23.37'N
127°28.28'W

Time Messenger: 10:20

Date: 1/VIII/75

Depth: 20 fath.

Secchi: -



Depth (M)	Salinity ($^o/oo$)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	mg/l	% Satu.
0	29.70	21.79	15.62	.601	9.62	119.2
2	30.59	22.60	15.10	.530	8.48	104.6
4	30.71	22.87	14.27	.487	7.79	94.5
10	31.57	-	-	.219	3.50	-
20	31.90	24.81	8.38	.112	1.79	19.2
35	32.61	25.50	7.52	.138	2.21	23.3

Station: N-C

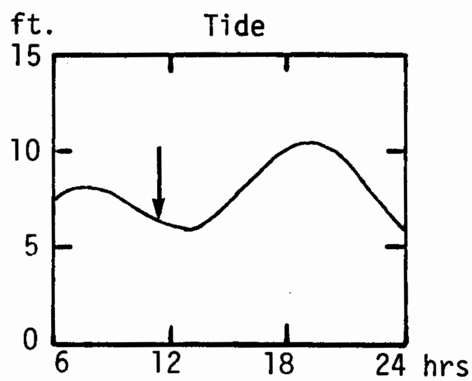
Position: 50°23.55'N
127°28.0'W

Time Messenger: 11:07

Date: 1/VIII/75

Depth: 25 fath.

Secchi: -



Depth (M)	Salinity ($^o/oo$)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	mg/l	% Satu.
0	29.45	21.72	15.10	.604	9.66	118.3
2	30.71	22.78	14.67	.539	8.62	105.5
4	31.03	23.13	13.88	.482	6.78	81.8
10	31.61	24.49	9.18	.202	3.23	35.2
20	31.99	24.93	8.26	-	-	-
40	32.68	25.50	7.40	.171	2.74	28.9

Station: N-D

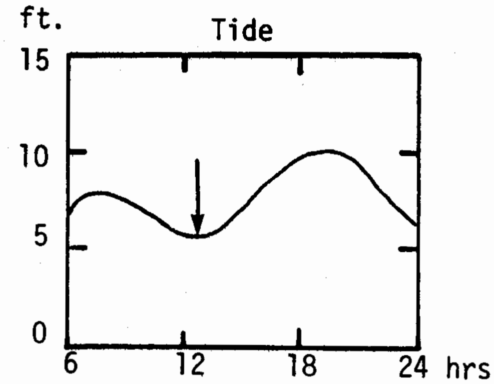
Position: 50°23.23'N
127°27.5'W

Time Messenger: 12:50

Date: 1/VIII/75

Depth: 25 fath.

Secchi: -



Depth (M)	Salinity (°/oo)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	28.77	20.98	16.1	.647	10.75	133.7
2	30.65	22.76	14.67	.479	7.66	93.7
4	30.96	23.31	13.03	.401	6.41	75.9
10	31.61	24.53	8.89	.171	2.74	29.7
20	31.97	24.79	8.88	.088	1.41	15.3
40	32.63	25.52	7.57	.107	1.71	18.1

Station: N-A

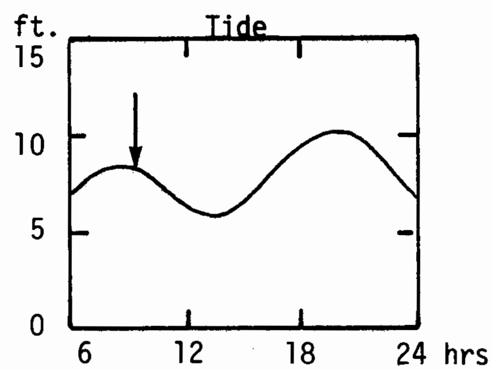
Position: 50°23.12'N
127°28.62'W

Time Messenger: 09:20

Date: 2/VIII/75

Depth: 20 fath.

Secchi: -



Depth (M)	Salinity (°/oo)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	30.21	22.32	14.99	.537	8.59	105.5
2	30.65	22.73	14.73	.503	8.05	98.6
4	30.78	22.86	14.60	.473	7.57	92.5
10	31.63	24.35	10.09	.254	4.06	45.0
20	31.84	24.76	8.53	.190	3.04	32.7
35	32.72	25.59	7.44	.226	3.62	38.2

Station: N-H

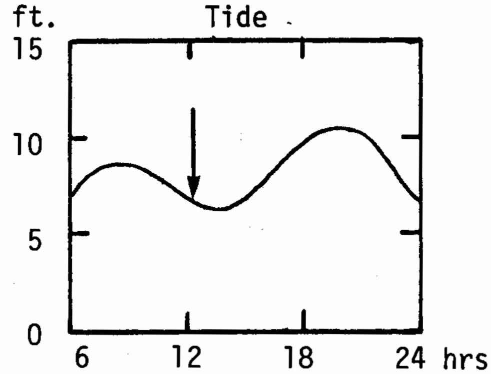
Position: 50°22.08'N
127°26.66'W

Time Messenger: 12:07

Date: 2/VIII/75

Depth: 21 fath.

Secchi: 3.7, Br.



Depth (M)	Salinity (°/oo)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	29.55	21.71	15.53	.535	8.25	102.0
2	30.12	22.30	14.75	.525	8.40	102.6
4	31.01	23.42	12.66	.364	5.82	68.4
10	31.55	24.47	9.09	.179	2.86	31.1
20	31.99	25.02	7.50	.066	1.05	11.0
35	32.61	25.50	7.51	.038	0.61	6.4

Station: N-I

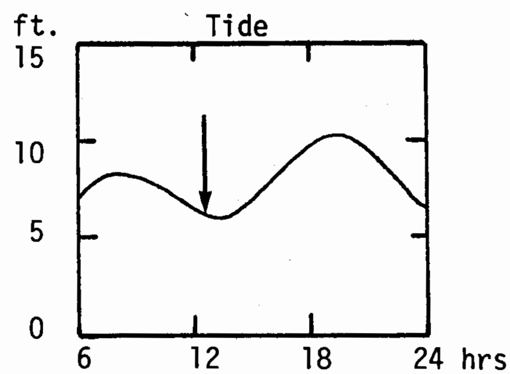
Position: 50° 22.05'N
127° 26.33'W

Time Messenger: 12:35

Date: 2/VIII/75

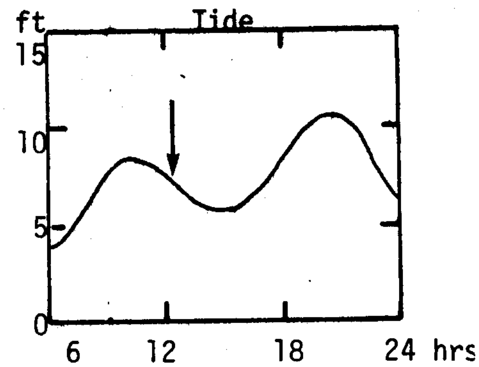
Depth: 20 fath.

Secchi: 2.3, Br.



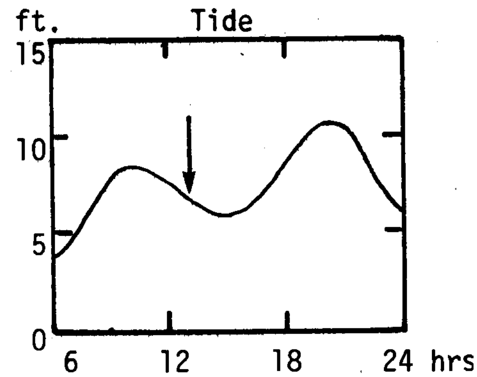
Depth (M)	Salinity (°/oo)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	29.51	21.72	15.38	.450	7.20	88.7
2	30.37	22.46	14.89	.440	7.04	86.3
4	30.88	23.27	12.87	.329	5.26	62.0
10	31.72	24.63	8.80	.152	2.43	26.3
20	32.34	-	-	.023	0.37	-
35	32.63	25.53	7.49	.014	0.22	2.3

Station: N-E
Position: 50° 22.98'N
127° 27.28'W
Time Messenger: 12:40
Date: 3/VIII/75
Depth: 20 fath.
Secchi: 3.9 m, Br.



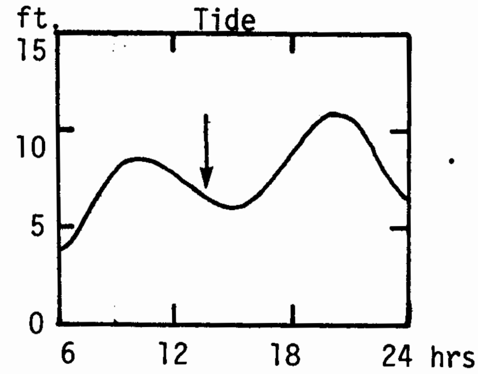
Depth (M)	Salinity (°/oo)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	29.76	22.01	14.89	.488	7.81	95.4
2	30.44	22.67	14.21	.438	7.01	84.8
4	31.34	24.00	10.78	.253	4.05	45.8
10	31.63	24.58	8.74	.115	1.84	19.9
20	31.97	24.92	8.18	.073	1.17	12.5
35	32.67	25.56	7.46	.117	1.87	19.7

Station: N-F
Position: 50° 22.68'N
127° 27.05'W
Time Messenger: 13:03
Date: 3/VIII/75
Depth: 20 fath.
Secchi: 4.0 m, Br



Depth (M)	Salinity (°/oo)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	30.27	22.38	14.93	.521	8.34	102.3
2	30.44	22.79	13.65	.424	6.78	81.1
4	30.86	23.25	12.94	.447	7.15	84.4
10	31.61	24.56	8.78	.147	2.35	25.3
20	32.05	25.00	8.02	.1070	1.12	11.9
35	32.67	25.56	7.46	.136	2.17	22.8

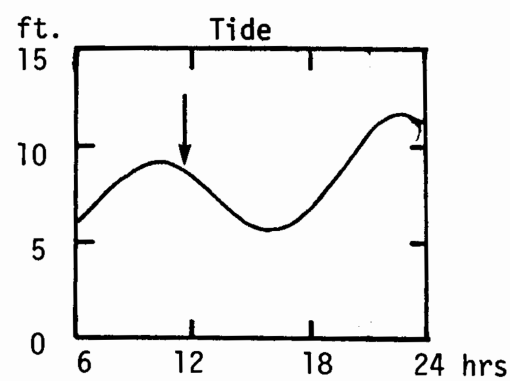
Station: N-G
Position: 50°22.88'N
127°26.76'W
Time Messenger: 13:28
Date: 3/VIII/75
Depth: 18 fath.
Secchi: 3.5 m, Br



Depth (M)	Salinity (^{o}/oo)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	30.17	22.33	14.77	.470	7.52	122.1
2	30.35	22.59	14.26	.428	6.84	82.7
4	30.48	22.78	13.74	.398	6.24	74.7
10	31.61	24.56	8.72	.135	2.16	23.3
20	32.20	25.12	7.87	.042	0.67	7.1
30	-*	-	7.49	-	-	-

* data missing

Station: N-H
Position: 50°22.08'N
127°26.66'W
Time Messenger: 11:35
Date: 4/VIII/75
Depth: 20 fath.
Secchi: 5.5 m, Br



Depth (M)	Salinity (^{o}/oo)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	25.24	19.51	9.24	.276	4.41	46.2
2	31.68	24.60	8.89	.159	2.54	27.5
4	31.76	24.66	8.73	.156	2.50	27.0
10	31.97	24.90	8.31	.114	1.82	19.5
20	32.38	25.40	6.91	.023	0.37	3.8
35	32.72	25.59	7.47	.115	1.84	19.4

Station: N-I

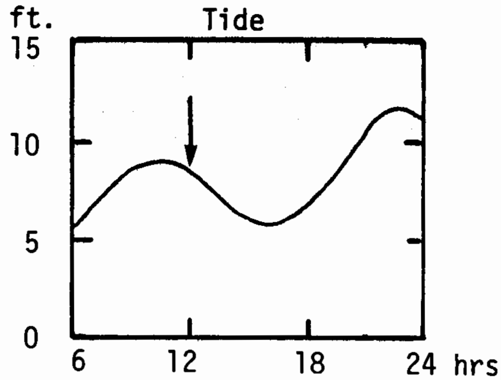
Position: 50°22.05'N
127°26.33'W

Time Messenger: 12:00

Date: 4/VIII/75

Depth: 20 fath.

Secchi: 8.0 m, Lt Br (clear below surface)



Depth (M)	Salinity (°/oo)	Density (σ_τ)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	23.47	17.73	11.88	.410	6.56	72.1
2	31.53	24.36	9.60	.181	2.89	31.8
4	31.63	24.58	8.67	.133	2.13	23.0
10	31.88	24.81	8.37	.106	1.69	18.1
20	32.40	25.30	7.73	.015	0.24	2.5
35	32.72	25.58	7.46	.135	2.16	22.7

Station: N-F

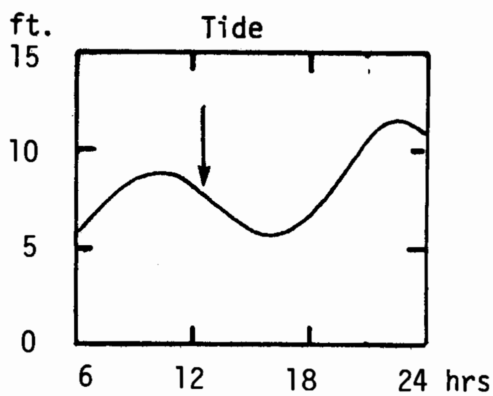
Position: 50°22.68'N
127°27.05'W

Time Messenger: 12:33

Date: 4/VIII/75

Depth: 20 fath.

Secchi: 7.0 m, Lt Br



Depth (M)	Salinity (°/oo)	Density (σ_τ)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	26.17	19.79	12.00	.383	6.13	68.7
2	31.76	24.65	8.87	.156	2.56	27.8
4	31.80	24.69	8.75	.171	2.74	29.6
10	31.88	24.76	8.62	.193	3.14	33.9
20	32.13	25.05	8.09	.092	1.47	15.7
35	32.70	25.58	7.50	.097	1.55	16.4

Station: N-G

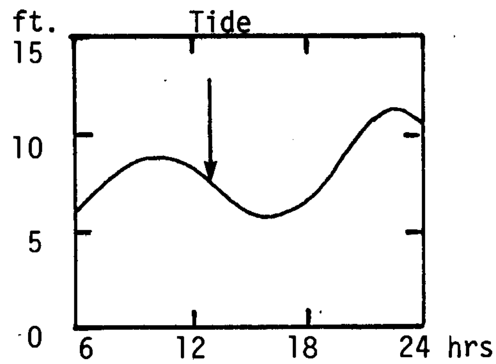
Position: 50°22.88'N
127°26.76'W

Time Messenger: 12:58

Date: 4/VIII/75

Depth: 18 fath.

Secchi: 4.0, Br



Depth (M)	Salinity (^{0}/oo)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	21.45	16.18	11.78	.433	6.93	75.0
2	31.30	24.02	10.47	.182	2.91	32.6
4	31.68	24.56	8.94	.156	2.56	27.7
10	31.76	24.67	8.73	.138	2.21	23.8
20	32.26	25.16	7.92	.042	0.67	7.1
35	32.70	25.57	7.48	.084	1.34	14.1

Station: N-A

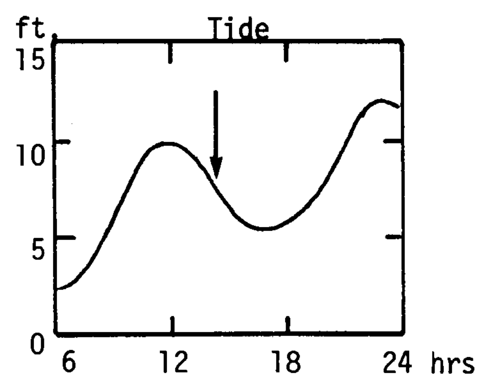
Position: 50°23.12'N
127°28.62'W

Time Messenger: 14:17

Date: 5/VIII/75

Depth: 17 fath.

Secchi: 6.2, Lt.Br.



Depth (M)	Salinity (^{0}/oo)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	31.42	23.99	11.19	.371	5.93	67.6
2	31.45	24.03	11.02	.384	6.14	69.7
4	31.47	24.08	10.97	.380	6.08	69.0
10	31.53	24.18	10.71	.378	6.05	68.3
20	31.61	24.34	10.00	.304	4.86	54.0
27	31.90	24.74	8.90	.230	3.68	39.9

Station: N-C

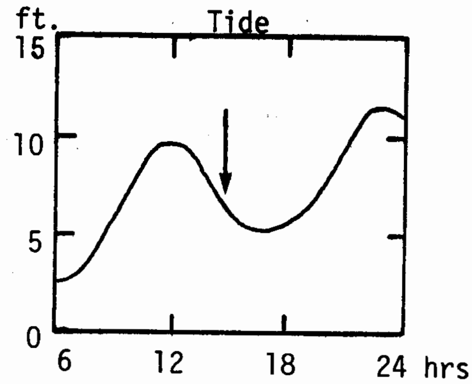
Position: 50°23.55'N
127°28.0' W

Time Messenger: 14:50

Date: 5/VIII/75

Depth: 20 fath.

Secchi: 4.2 m, Lt. Br.



Depth (M)	Salinity ($^{0}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	mg/l	% Satu.
0	27.07	20.59	11.48	.411	6.58	73.3
2	-	-	10.94	-	-	-
4	31.42	24.13	10.52	.346	5.54	62.2
10	31.63	24.32	10.20	.322	5.15	57.5
20	31.78	24.46	10.03	.322	5.15	57.3
35	32.03	24.95	8.36	.129	2.06	22.1

Station: N-D

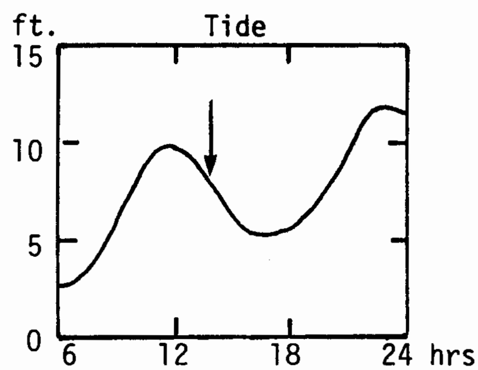
Position: 50°23.23'N
127°27.5' W

Time Messenger: 13:50

Date: 6/VIII/75

Depth: 20 fath.

Secchi: 3.3, Br.



Depth (M)	Salinity ($^{0}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	mg/l	% Satu.
0	30.16	23.13	11.47	.404	6.46	73.5
2	31.17	23.82	11.09	.369	5.90	67.0
4	31.53	24.11	11.09	.392	6.27	71.4
10	31.68	24.32	10.38	.345	5.52	61.9
20	31.72	24.46	9.85	.281	4.49	49.8
35	32.18	25.08	8.12	.090	1.44	15.3

Station: N-E

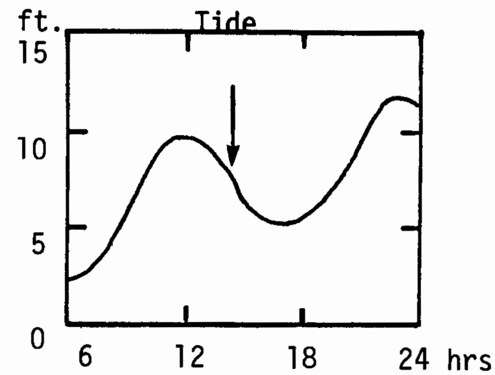
Position: 50°22.98'N
127°27.28'W

Time Messenger: 14:20

Date: 6/VIII/75

Depth: 20 fath.

Secchi: 4.7 m, Lt. Br.



Depth (M)	Salinity (°/oo)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	29.77	22.68	11.47	.411	6.58	74.7
2	30.90	23.60	11.19	.401	6.42	72.9
4	31.22	23.86	11.05	.359	5.74	65.1
10	31.51	24.20	10.50	.341	5.46	61.3
20	31.72	24.49	9.63	.258	4.13	45.5
35	-*	-	8.16	-	-	-

*hit bottom

Station: N-F

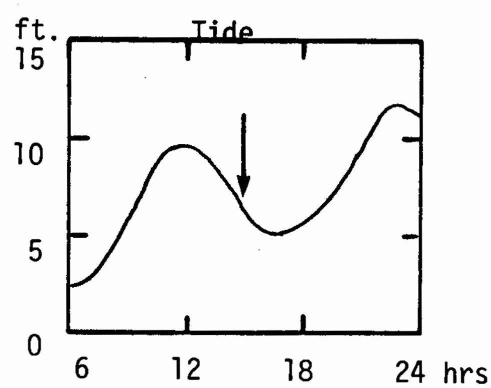
Position: 50°22.68'N
127°27.05'W

Time Messenger: 14:48

Date: 6/VIII/75

Depth: 20 fath.

Secchi: 5.0 m, Gr.



Depth (M)	Salinity (°/oo)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	29.72	22.67	11.38	.419	6.70	75.8
2	31.07	23.72	11.17	.410	7.46	
4	31.32	23.93	11.06	.410	6.56	74.5
10	31.63	24.26	10.60	.384	5.44	61.3
20	31.70	24.47	9.66	.262	4.19	46.2
35	32.34	25.22	7.95	.060	0.96	10.2

Station: N-B

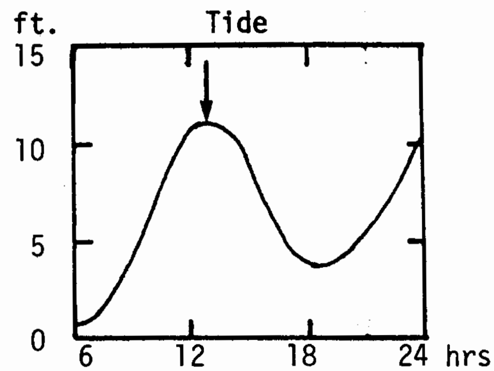
Position: 50°23.37'N
127°28.28'W

Time Messenger: 12:38

Date: 7/VIII/75

Depth: 20 fath.

Secchi: 4.0 m, Gr.



Depth (M)	Salinity (‰)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	27.62	21.08	10.98	.438	7.01	77.6
2	31.67	24.27	10.67	.378	6.05	68.3
4	31.68	24.28	10.65	.369	5.90	66.6
10	31.76	24.42	10.26	.341	5.46	61.1
20	31.86	24.65	9.31	.249	3.98	43.6
35	31.93	24.77	8.83	.202	3.23	35.0

Station: N-I

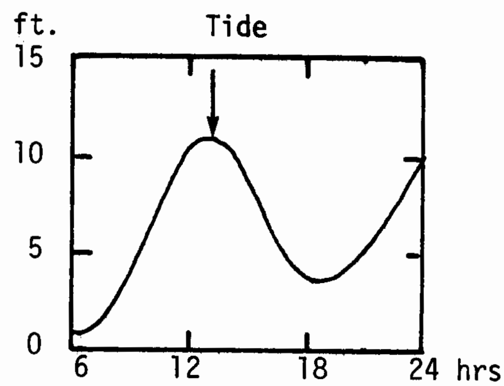
Position: 50°22.05'N
127°26.33'W

Time Messenger: 13:03

Date: 7/VIII/75

Depth: 20 fath.

Secchi: 6.0 m, Gr.



Depth (M)	Salinity (‰)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	26.79	20.50	11.08	.431	6.89	76.0
2	31.53	24.18	10.63	.355	5.68	64.0
4	31.47	24.18	10.34	.318	5.10	57.0
10	31.61	24.37	9.87	.290	4.64	51.4
20	31.74	24.67	8.66	.158	2.52	27.1
35	32.26	25.18	7.84	.032	0.51	5.4

Station: N-H

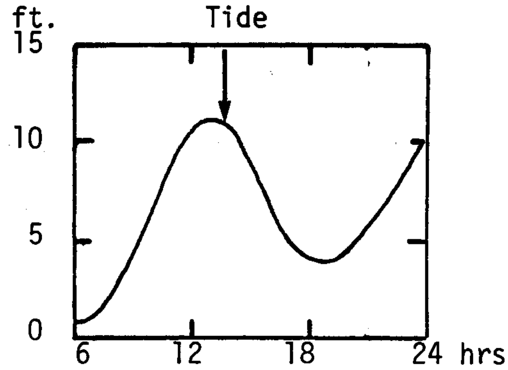
Position: 50°22.08'N 127°26.66'W

Time Messenger: 13:35

Date: 7/VIII/75

Depth: 20 fath.

Secchi: 6.0 m, Gr.



Depth (M)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	20.74	15.73	10.97	.516	8.25	87.3
2	31.28	23.96	10.78	.352	5.63	63.5
4	31.57	24.26	10.35	.322	5.15	57.7
10	31.68	24.42	9.85	.276	4.41	48.9
20	31.84	24.67	9.04	.220	3.52	38.3
35	32.20	25.11	8.00	.032	0.51	5.4

Station: N-G

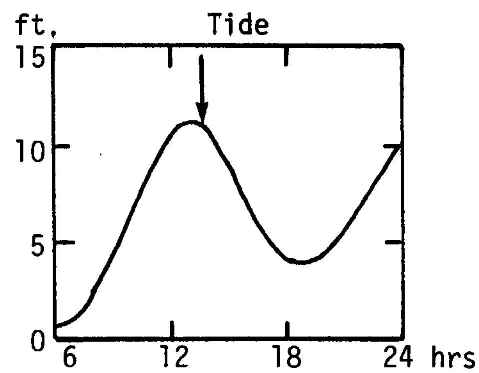
Position: 50°22.88'N 127°26.76'W

Time Messenger: 13:46

Date: 7/VIII/75

Depth: 23 fath.

Secchi: 7.0 m, Gr.



Depth (M)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	15.25	11.46	11.38	.548	8.64	89.2
2	31.17	23.77	11.05	.457	7.31	98.1
4	31.59	24.22	10.67	.355	5.68	64.1
10	31.65	24.34	10.17	.304	5.29	59.6
20	31.74	24.57	9.23	.217	3.47	37.9
35	32.24	25.13	7.94	.075	1.20	12.8

Station: N-F

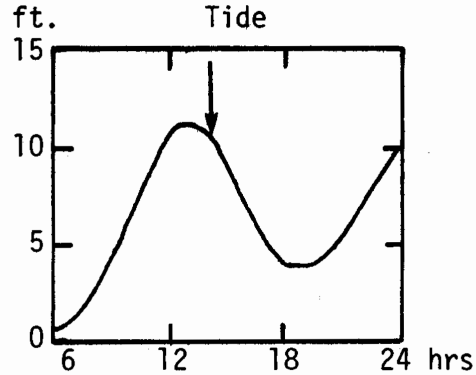
Position: 50°22.68'N
127°27.05'W

Time Messenger: 14:09

Date: 7/VIII/75

Depth: 20 fath.

Secchi: 6 m, Gr.



Depth (M)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	24.80	18.82	11.41	.466	7,46	81,8
2	31.26	23.92	10.86	.355	5.68	64.2
4	31.61	24.27	10.43	.321	5,14	57.7
10	31.72	24.40	10.15	.313	5.01	55.9
20	31.84	24.63	9.33	.249	3.98	43.6
35	32.36	25.24	7.89	.061	0.97	10.3

Station: N-E

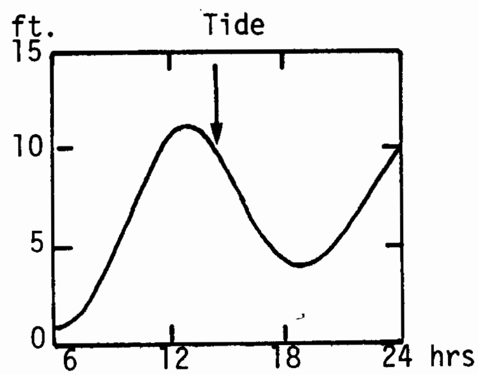
Position: 50°22.98'N
127°27.28'W

Time Messenger: 14:40

Date: 7/VIII/75

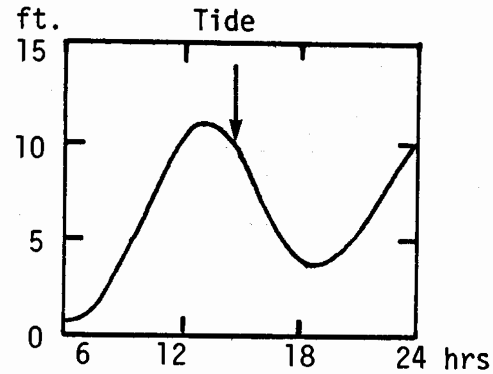
Depth: 20 fath.

Secchi: 4.0 m, Lt. Br.



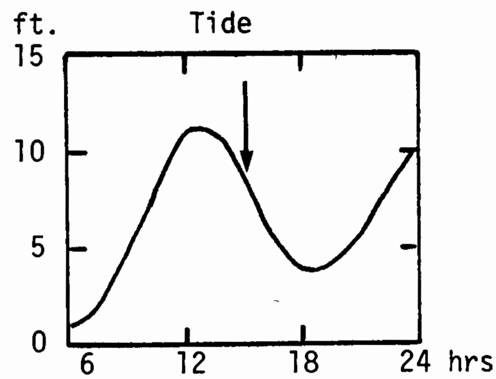
Depth (M)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	17.05	12.90	11.23	.535	8.56	89.0
2	31.55	24.20	10.63	.347	5.52	62.2
4	31.61	24.28	10.32	.310	4.96	55.5
10	31.68	24.37	10.14	.253	4.05	45.2
20	31.80	24.61	9.21	.212	3.39	37.0

Station: N-D
Position: 50°23.23'N
127°27.5' W
Time Messenger: 14:54
Date: 7/VIII/75
Depth: 20 fath.
Secchi: 4.0 m, Lt. Gr.



Depth (M)	Salinity ($^{o}/oo$)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	23.59	17.89	11.24	.459	7.34	79.6
2	31.43	24.09	10.86	.350	5.60	63.4
4	31.60	24.27	10.46	.332	5.31	59.6
10	31.70	24.40	10.04	.296	4.74	52.8
20	31.86	24.69	9.13	.239	3.82	41.7
35	31.99	24.90	8.42	.148	2.37	25.5

Station: N-C
Position: 50°23.55'N
127°28.0' W
Time Messenger: 15:12
Date: 7/VIII/75
Depth: 20 fath.
Secchi: 4.0 m, Lt. Br.



Depth (M)	Salinity ($^{o}/oo$)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	21.05	15.97	11.55	.488	7.81	83.9
2	31.44	24.10	10.79	.355	5.68	64.2
4	31.63	24.30	10.39	.329	4.80	53.8
10	31.80	24.46	10.31	.350	5.60	62.7
20	31.84	-	-	.288	4.13	-
35	31.94	-	-	.179	2.86	-

Station: N-A

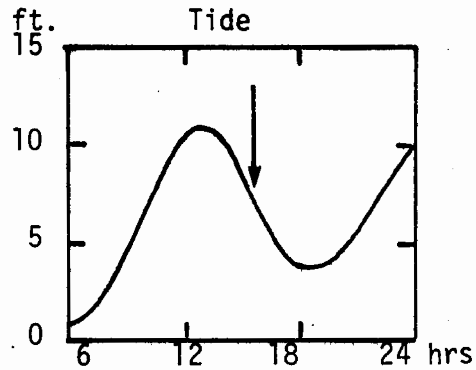
Position: 50°23.12'N
127°28.62'W

Time Messenger: 15:34

Date: 7/VIII/75

Depth: 18 fath.

Secchi: 8.0 m, Gr.



Depth (M)	Salinity (^{o}/oo)	Density (σ_{τ})	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	31.76	24.30	10.88	.376	6.02	68.3
2	31.74	24.35	10.55	.374	5.98	67.3
4	31.78	24.40	10.46	.373	5.97	67.1
10	31.84	24.55	9.80	.332	5.31	58.8
20	31.90	24.62	9.54	.302	4.86	53.5
27	31.92	24.70	9.35	.270	4.32	47.4

Station: N-B

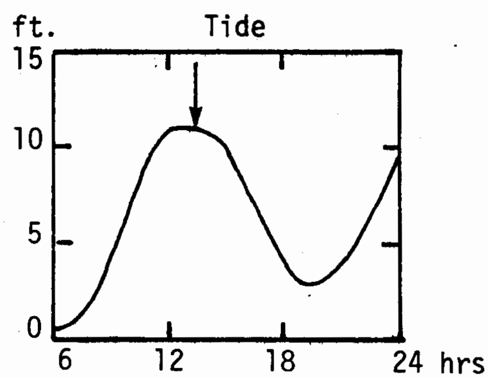
Position: 50°23.37'N
127°28.28'W

Time Messenger: 13:38

Date: 8/VIII/75

Depth: 20 fath.

Secchi: 4.0 m, Gr.



Depth (M)	Salinity (^{o}/oo)	Density (σ_{τ})	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	-	-	11.82	.387	6.19	-
2	-	-	11.03	.424	6.78	-
4	-	-	10.95	.402	6.42	-
10	-	-	10.64	.370	5.93	-
20	31.86	24.52	9.99	.322	5.16	57.4
35	31.92	24.76	8.93	.200	3.20	34.7

Station: N-I

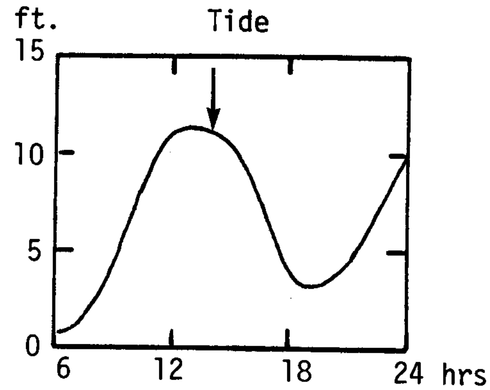
Position: 50°22.05'N
127°26.33'W

Time Messenger: 14:01

Date: 8/VIII/75

Depth: 20 fath.

Secchi: 6.0 m, Gr.



Depth (m)	Salinity (^{o}/oo)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	24.20	18.31	11.67	.493	7.89	86.7
2	31.36	23.98	10.97	.382	6.12	69.4
4	31.47	24.10	10.83	.369	5.90	66.7
10	31.61	24.29	10.35	.321	5.13	57.5
20	31.67	24.45	9.64	.255	4.08	45.0
35	31.82	24.75	8.49	.124	1.99	21.4

Station: N-H

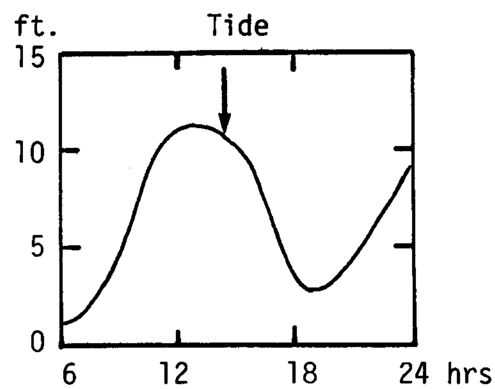
Position: 50°22.08'N
127°26.66'W

Time Messenger: 14:21

Date: 8/VIII/75

Depth: 20 fath.

Secchi: 5.0 m, Gr.



Depth (m)	Salinity (^{o}/oo)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	29.02	22.10	11.43	.461	7.38	83.3
2	31.30	23.92	11.07	.410	6.56	74.6
4	31.59	24.28	10.20	.359	5.75	64.2
10	31.67	24.27	10.68	.373	5.97	67.4
20	31.68	24.42	9.88	.295	4.72	52.4
35	31.84	24.72	8.73	.158	2.53	27.3

Station: N-G

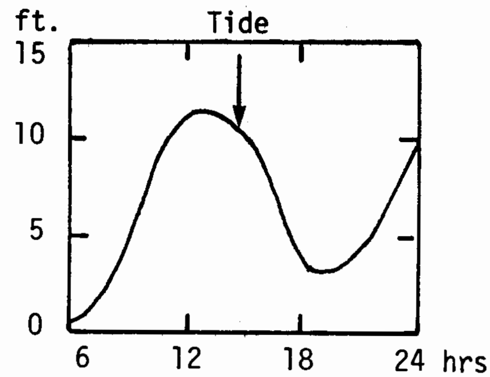
Position: 50°22.88'N
127°26.76'N

Time Messenger: 14:52

Date: 8/VIII/75

Depth: 20 fath.

Secchi: 4.0 m, Lt. Br.



Depth (m)	Salinity (°/oo)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	17.11	13.37	7.87	.564	9.03	86.9
2	31.05	23.73	11.05	.359	5.75	65.2
4	31.36	24.05	10.65	.336	5.38	60.6
10	31.68	24.33	10.38	.324	5.19	58.2
20	31.78	24.46	10.00	.309	4.94	54.9
40	32.38	25.26	7.81	.028	0.45	4.7

Station: N-F

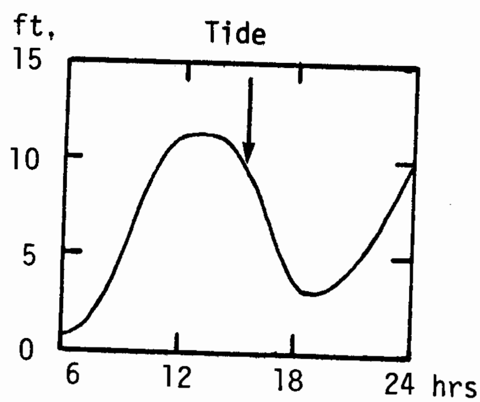
Position: 50°22.68'N
127°27.05'W

Time Messenger: 15:12

Date: 8/VIII/75

Depth: 20 fath.

Secchi: 5.0 m, Gr.



Depth (m)	Salinity (°/oo)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	28.09	21.32	11.69	.461	7.38	83.2
2	31.07	23.74	11.08	.424	6.78	76.9
4	31.55	24.15	10.94	.405	6.49	73.7
10	31.72	24.33	10.57	.364	5.83	65.7
20	31.76	24.43	10.14	.325	5.21	58.1
35	31.92	24.79	8.66	.156	2.50	26.9

Station: N-E

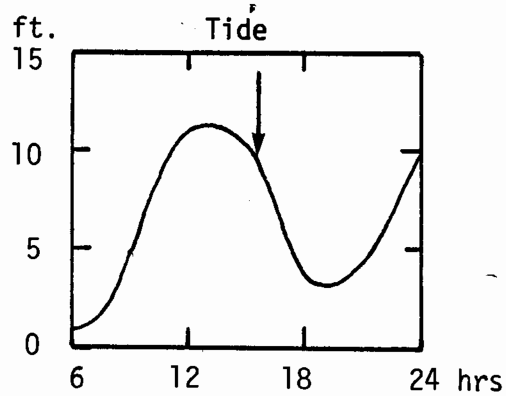
Position: 50°22.98'N
127°27.28'W

Time Messenger: 15:31

Date: 8/VIII/75

Depth: 20 fath.

Secchi: -



Depth (m)	Salinity ($^{0}/oo$)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	mg/l	% Satu
0	24.67	18.65	11.71	.488	7.82	86.3
2	31.13	23.80	10.97	.322	5.16	58.5
4	31.51	24.16	10.77	.332	5.31	60.0
10	31.68	24.31	10.46	.336	5.38	60.4
20	31.74	24.43	10.03	.295	4.72	52.5
35	31.88	24.78	8.53	.125	2.00	21.5

Station: N-D

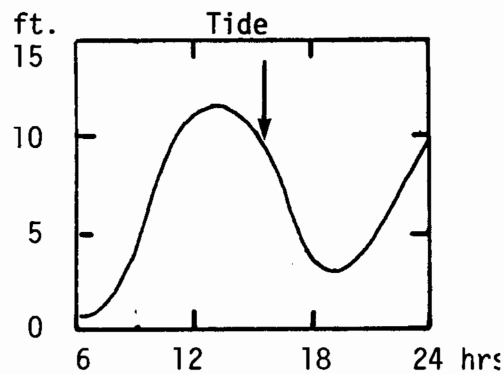
Position: 50°23.23'N
127°27.5'W

Time Messenger: 15:49

Date: 8/VIII/75

Depth: 20 fath.

Secchi: 5.0 m, Gr.



Depth (m)	Salinity ($^{0}/oo$)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	mg/l	% Satu.
0	27.15	20.60	11.70	.470	7.52	80.8
2	31.26	23.90	10.98	.410	6.56	72.4
4	31.55	24.17	10.87	.396	6.34	71.7
10	31.70	24.31	10.64	.373	5.97	67.4
20	31.78	24.48	9.90	.295	4.72	52.4
35	31.97	24.84	8.61	.110	1.77	19.0

Station: N-C

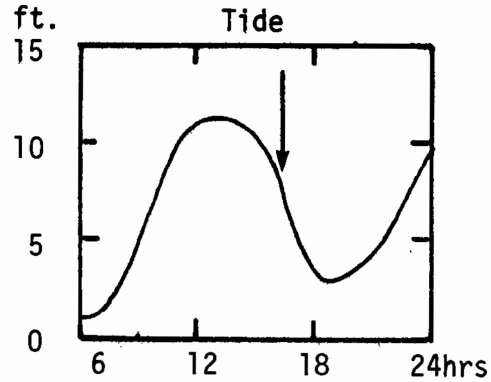
Position: 50°23.55'N
127°28.0'W

Time Messenger: 16:14

Date: 8/VIII/75

Depth: 20 fath.

Secchi: 5 m, Gr



Depth (m)	Salinity (‰)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	24.24	18.28	11.90	.499	7.99	88.3
2	31.45	24.05	11.07	.415	6.64	75.5
4	31.57	24.18	10.86	.388	6.21	70.4
10	31.67	24.27	10.71	.378	6.05	68.4
20	31.80	24.47	10.04	.313	5.01	55.8
35	31.86	26.50	9.34	.242	3.88	42.5

Station: N-A

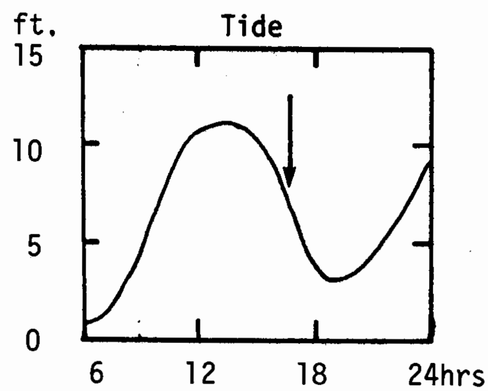
Position: 50°23.12'N
127°28.62'W

Time Messenger: 16:44

Date: 8/VIII/75

Depth: 20 fath.

Secchi: 7.0 m, Gr.



Depth (m)	Salinity (‰)	Density (σT)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	31.13	23.75	11.30	.428	6.86	78.3
2	31.42	24.01	11.04	.419	6.71	76.3
4	-	-	11.05	.405	6.49	-
10	31.57	24.16	10.96	.405	6.49	73.7
20	31.76	24.36	10.57	.378	6.05	68.0
27	31.86	24.52	10.02	.332	5.31	59.1

Station: N-B

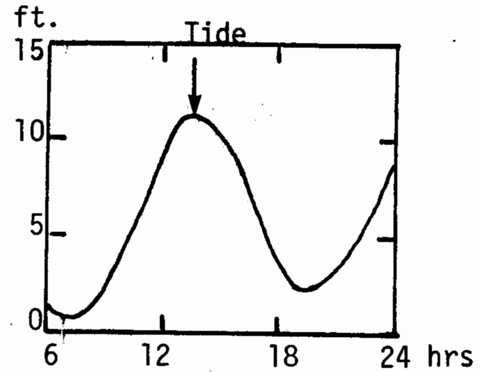
Position: 50°23.37'N
127°28.28'W

Time Messenger: 13:51

Date: 9/VIII/75

Depth: 20 fath.

Secchi: -



Depth (m)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	-	-	12.04	.505	8.09	-
2	31.55	24.13	11.09	.409	6.54	74.5
4	31.65	24.22	10.94	.398	6.37	72.3
10	31.67	24.25	10.81	.377	6.04	68.4
20	31.78	24.44	10.27	.333	5.32	59.5
35	31.93	24.86	8.32	.179	2.86	30.6

Station: N-I

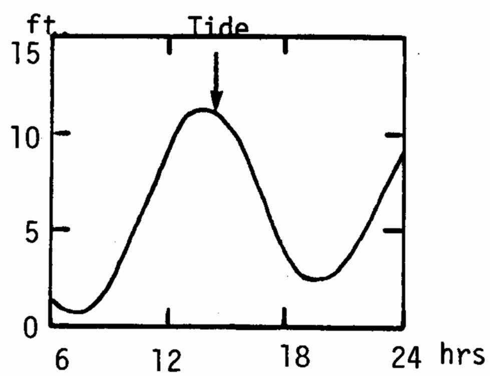
Position: 50°22.05'N
127°26.33'W

Time Messenger: 14:17

Date: 9/VIII/75

Depth: 20 fath.

Secchi: 8.0, Gr.



Depth (m)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	-	-	11.55	.404	6.47	-
2	31.34	23.93	11.22	.393	6.30	71.3
4	31.51	24.13	10.93	.370	5.93	67.0
10	31.57	24.23	10.51	.313	5.01	56.3
20	31.65	24.42	9.70	.246	3.93	43.4
35	31.86	24.79	8.42	.104	1.67	17.9

Station: N-H

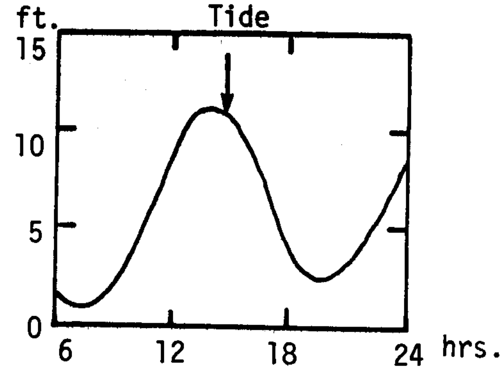
Position: 50°22.08'N
127°26.66'W

Time Messenger: 14:40

Date: 9/VIII/75

Depth: 20 fath.

Secchi: 7.5 m, Gr.



Depth (m)	Salinity ($^{0}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	31.73	23.73	11.48	.422	6.76	77.7
2	31.38	24.00	10.93	.396	6.34	71.8
4	31.57	24.17	10.89	.369	5.91	67.0
10	31.63	24.24	10.75	.358	5.73	64.8
20	31.70	24.44	9.88	.277	4.40	48.8
35	31.92	24.82	8.49	.122	1.96	21.0

Station: N-G

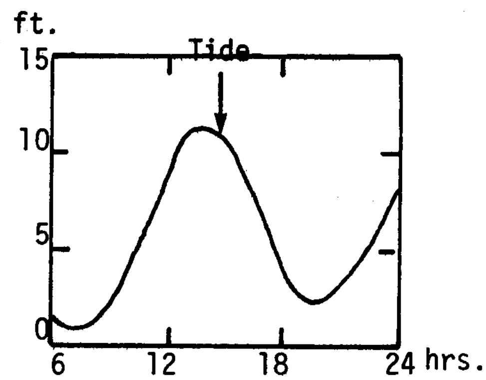
Position: 50°22.88'N
127°26.76'W

Time Messenger: 14:53

Date: 9/VIII/75

Depth: 26 fath.

Secchi: 5.0, Gr.



Depth (m)	Salinity ($^{0}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	29.59	22.52	11.58	.384	6.10	69.3
2	30.54	23.27	11.55	.419	6.70	76.5
4	31.42	24.00	11.13	.398	6.37	72.5
10	31.63	24.24	10.77	.367	5.87	66.4
20	31.72	24.38	10.34	.318	5.09	57.0
40	32.45	25.34	7.71	.019	0.31	3.2

Station: N-F

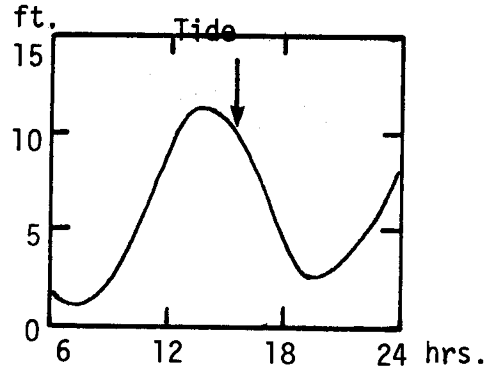
Position: 50°22.68'N
127°27.05'W

Time Messenger: 15:18

Date: 9/VIII/75

Depth: 20 fath.

Secchi: 5.5 m, Gr.



Depth (m)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	31.07	23.69	11.41	.420	6.73	76.9
2	31.19	23.31	11.27	.402	6.44	73.5
4	31.55	24.15	10.96	.384	6.15	69.8
10	31.65	24.24	10.76	.367	5.87	66.4
20	31.74	24.40	10.27	.314	5.02	56.2
35	31.84	24.72	8.76	.154	2.47	26.7

Station: N-E

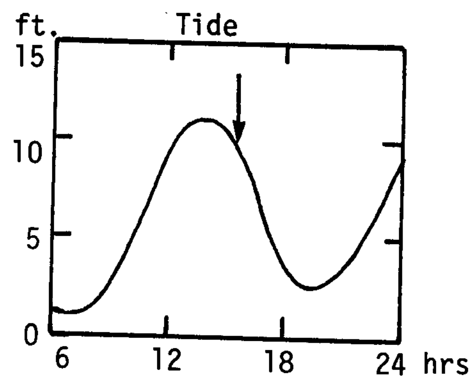
Position: 50°22.98'N
127°27.28'W

Time Messenger: 15:40

Date: 9/VIII/75

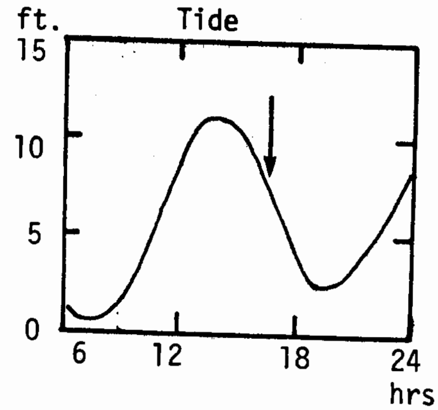
Depth: 20 fath.

Secchi: 7.2 m, Gr.



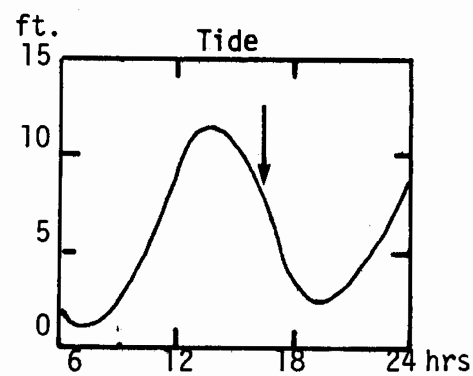
Depth (m)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	26.77	20.31	11.68	.455	7.29	81.5
2	31.32	23.94	11.06	.390	6.24	70.9
4	31.57	24.17	10.87	.373	5.97	67.7
10	31.67	24.28	10.64	.336	5.38	60.7
20	31.86	24.47	10.32	.314	5.02	56.3
35	31.72	24.58	9.11	.188	3.00	32.6

Station: N-D
Position: 50'23.23'N
127°27.5 'W
Time Messenger: 16:05
Date: 9/VIII/75
Depth: 20 fath.
Secchi: 4.3 m, Gr.



Depth (m)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	30.84	23.51	11.39	.407	6.51	74.3
2	31.53	24.13	10.96	.359	5.75	65.3
4	31.57	24.17	10.87	.359	5.75	65.1
10	31.69	24.30	10.63	.342	5.47	61.7
20	31.72	24.38	10.27	.313	5.01	56.0
35	31.88	24.73	8.84	.156	2.50	27.1

Station: N-C
Position: 50°23.55'N
127°28. 0'W
Time Messenger: 16:25
Date: 9/VIII/75
Depth: 20 fath.
Secchi: 5.5 m, Gr.



Depth (m)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	30.42	23.13	11.73	.425	6.80	77.9
2	31.13	23.75	11.33	.402	6.44	73.5
4	31.47	24.08	11.00	.397	6.36	72.2
10	31.70	24.28	10.73	.376	6.01	67.9
20	31.76	24.42	10.15	.309	4.95	55.2
35	31.86	24.69	9.02	.188	3.00	32.6

Station: N-A

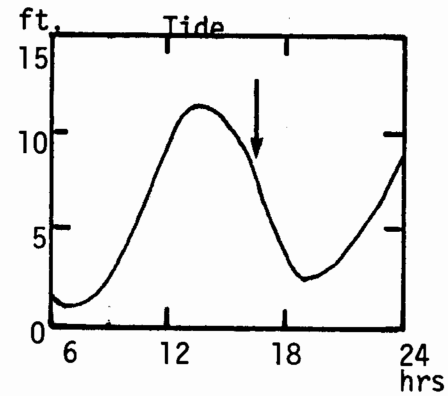
Position: 50°23.12'N
127°28.62'W

Time Messenger: 1650

Date: 9/VIII/75

Depth: 18 fath.

Secchi: 9.0, Gr.



Depth (m)	Salinity ($^{0}/oo$)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	31.65	24.18	11.11	.386	6.18	70.4
2	31.65	24.21	10.97	.390	6.24	70.9
4	31.67	24.23	10.87	.380	6.08	68.9
10	31.70	24.28	10.78	.371	5.94	67.2
20	31.84	24.48	10.18	.340	5.44	60.8
27	31.88	24.58	9.86	.304	4.87	54.0

Station: N-B

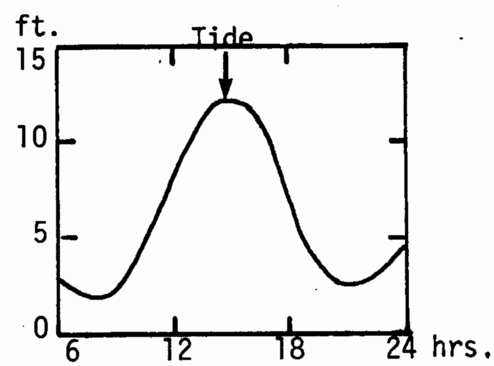
Position: 50°23.37'N
127°23.28'W

Time Messenger: 14:47

Date: 10/VIII/75

Depth: 20 fath.

Secchi: 8.5 m, Gr.



Depth (m)	Salinity ($^{0}/oo$)	Density (σ_T)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	30.88	23.44	11.98	.474	7.59	87.7
2	30.96	23.65	11.16	.301	4.81	54.6
4	31.36	23.94	11.18	.393	6.30	71.8
10	31.69	24.27	10.76	.384	6.15	69.6
20	31.78	24.40	10.44	.355	5.68	63.8
35	31.86	24.65	9.27	.228	3.65	39.9

Station: N-I

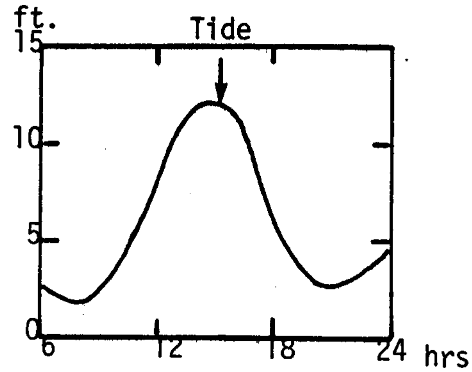
Position: 50°22.05'N
127°26.33'W

Time Messenger: 15:10

Date: 10/VIII/75

Depth: 20 fath.

Secchi: 11.5 m, Gr.



Depth (m)	Salinity ($^0/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	28.26	21.32	12.49	.465	7.44	85.5
2	31.05	23.46	12.60	.425	6.80	79.8
4	31.53	24.12	11.02	.371	5.94	67.5
10	31.61	24.27	10.45	.314	5.02	56.3
20	31.67	24.47	9.54	.230	3.68	40.5

Station: N-H

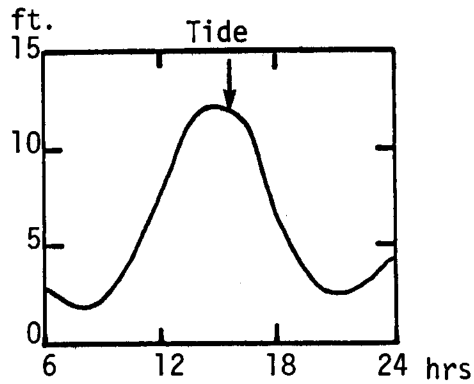
Position: 50°22.08'N
127°26.66'W

Time Messenger: 15:35

Date: 10/VIII/75

Depth: 20 fath.

Secchi: 7.0 m, Gr.



Depth (m)	Salinity ($^0/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	28.07	21.19	12.30	.487	7.80	89.1
2	-	-	11.63	.438	7.01	
4	31.40	24.00	11.09	.386	6.18	70.3
10	31.65	24.12	11.57	.328	5.25	60.5
20	31.72	24.41	10.13	.296	4.74	52.9
35	31.84	24.67	9.03	.180	2.89	31.5

Station: N-G

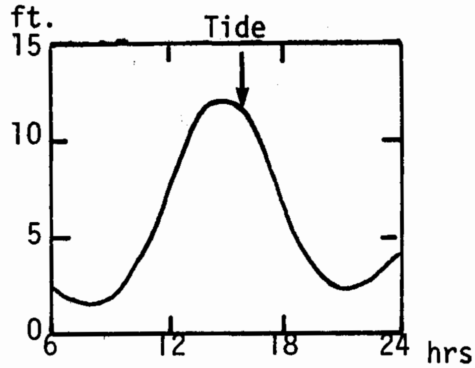
Position: 50°22.88'N
127°26.76'W

Time Messenger: 15:58

Date: 10/VIII/75

Depth: 20 fath.

Secchi: 9.2, Gr.



Depth (m)	Salinity ($^{o}/oo$)	Density (σ_τ)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	29.97	22.72	12.09	.425	6.80	78.4
2	-	-	11.13	.376	6.03	-
4	31.55	24.16	10.86	.368	5.90	66.9
10	31.65	24.26	10.70	.335	5.37	60.7
20	31.76	24.46	10.01	.286	4.38	50.9
40	32.03	24.95	8.31	.080	1.36	14.6

Station: N-F

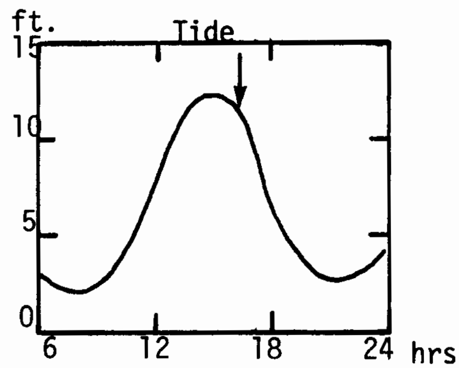
Position: 50°22.68'N
127°27.05'W

Time Messenger: 16:18

Date: 10/VIII/75

Depth: 20 fath.

Secchi: 9.8 m, Gr.



Depth (m)	Salinity ($^{o}/oo$)	Density (σ_τ)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	31.01	23.54	11.98	.470	7.52	87.1
2	31.11	23.70	11.58	.449	7.19	82.5
4	31.47	24.08	10.97	.368	5.90	66.9
10	31.67	24.27	10.69	.349	5.58	63.0
20	31.74	24.46	10.04	.290	4.85	28.1
35	31.88	24.75	8.81	.162	2.60	28.2

Station: N-E

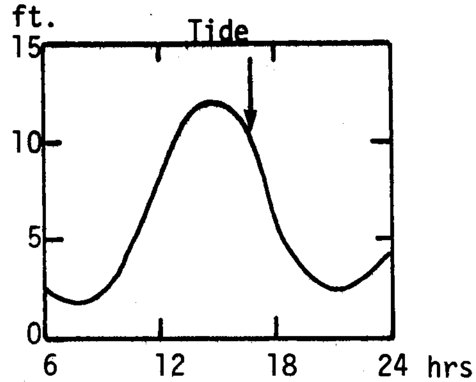
Position: 50°22.98'N
127°27.28'W

Time Messenger: 16:44

Date: 10/VIII/75

Depth: 20 fath.

Secchi: 9.0, Gr.



Depth (m)	Salinity (^{0}/oo)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu
0	29.30	22.08	12.77	.470	7.52	87.6
2	31.11	23.66	11.76	.452	7.23	83.3
4	31.47	24.07	11.02	.296	4.74	53.8
10	31.65	24.27	10.62	.340	5.44	61.4
20	31.74	24.41	10.25	.317	5.08	57.8
35	31.90	24.75	8.85	.161	2.57	27.8

Station: N-D

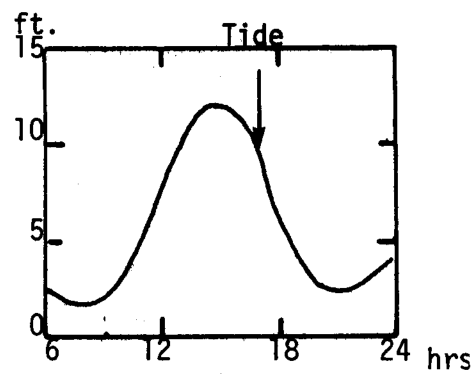
Position: 50°23.23'N
127°27.5 'W

Time Messenger: 17:05

Date: 10/VIII/75

Depth: 20 fath.

Secchi: 8.5 m, Gr.



Depth (m)	Salinity (^{0}/oo)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	Oxygen mg/l	Oxygen % Satu.
0	30.67	23.20	12.46	.503	8.05	93.9
2	31.00	23.53	11.96	.483	7.73	89.5
4	31.34	23.94	11.17	.425	6.80	77.5
10	31.61	24.31	11.77	.358	5.73	66.3
20	31.76	24.39	10.40	.346	5.54	62.2
35	31.84	24.58	9.62	.340	5.44	60.0
				.262	4.19	

Station: N-C

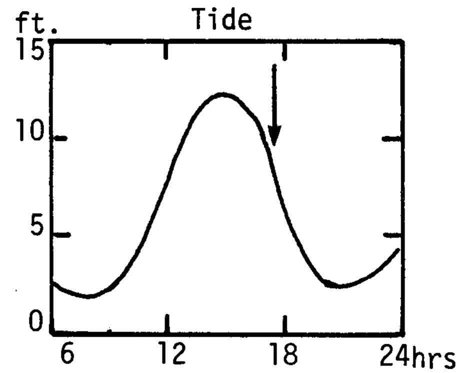
Position: 50°23.55'N
127°28.0 'W

Time Messenger: 17:30

Date: 10/VIII/75

Depth: 20 fath.

Secchi: 6.0 m, Gr.



Depth (m)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	mg/l	% Satu
0	30.94	23.40	12.49	.474	7.59	88.8
2	31.07	23.63	11.76	.461	7.37	84.9
4	31.07	23.65	11.65	.447	7.16	82.3
10	31.63	24.22	10.83	.358	5.73	64.9
20	31.72	24.31	10.65	.362]	5.80	65.5
35	31.86	24.65	9.29	.223	3.58	39.2

Station: N-A

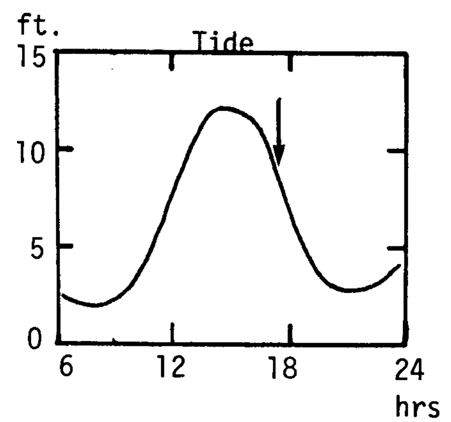
Position: 50°23.21'N
127°28.62'W

Time Messenger: 17:45

Date: 10/VIII/75

Depth: 20 fath.

Secchi: 8.5 m, Gr.



Depth (m)	Salinity ($^{o}/oo$)	Density ($\sigma\tau$)	Temp (°C)	Oxygen mg a/l	mg/l	% Satu.
0	30.60	23.18	12.28	.474	7.59	88.2
2	30.63	23.26	11.95	.461	7.37	85.0
4	30.71	23.32	11.95	.447	7.16	82.7
10	31.40	23.95	11.29	.358	5.73	65.5
20	31.59	24.16	11.04	.362	5.80	66.0
35	31.76	24.37	10.55	.223	3.58	40.3

Discussion

Oxygen levels at stations A - I were generally high in surface waters during the series. This is in contrast to severely depressed surface O_2 levels usually present with an operative mill, particularly during the late summer and fall seasons (Waldichuk 1958; Waldichuk et al. 1968; Davis et al. 1977). Oxygen levels at deeper depths, 20-40 m, were usually quite low at most stations, probably as a result of residual effluent BOD, BOD of accumulated deposits near the bottom, natural phenomena, or a combination of these factors.

Secchi depth, an index of water transparency, was much greater than that usually observed with an operative mill (Davis et al. 1977). Secchi depth increased markedly at stations N - H, I & F on August 4 and the colour of the water later in the series tended to be green, suggesting some phytoplankton (green algae) may have been present.

Elevated surface oxygen values, considerable water clarity and possible algal bloom activity suggest that cessation of effluent discharge and a period of recovery prior to the test series (16 - 25 days) had benefitted water quality in the area. These data form a useful record for comparison with conditions when the mill is operative.

Part IV - Preliminary Surveys - Occurrence of Juvenile Salmonids in the Vicinity of Port Alice

Introduction

Utilization of the shoreline areas adjacent to the Port Alice pulpmill by juvenile salmonids has been little studied. Young salmon typically can be found close to shore in coastal B.C. inlets during their first spring and summer where they actively school and feed during their early sea life. In Neroutsos Inlet both coho (*Oncorhynchus kisutch*) and chum salmon juveniles (*Oncorhynchus keta*) may be found.

The majority of the fish in Neroutsos inlet come from the Cayeghle Creek system and its tributaries (Utlah and Colonial Creeks) located at the head of the inlet. Other creeks near the mill (Cayuse, Teeta, Nequitpaulin) appear to contribute small runs of chum and coho to the system. In addition, small runs of steelhead (*Salmo gairdneri*) have been reported in Cayeghle, Colonial, Teeta and Cayuse Creeks (from observation records of local fisheries officers).

It is important to know the migratory pathways, feeding habits and areas utilized by young salmonids in Neroutsos Inlet relative to strategies of effluent treatment and outfall location siting for the pulp mill. In anticipation of a detailed study of this type in the future, the present preliminary surveys were carried out. Specifically, we wished to determine:

1)-whether beach seining techniques could be used to collect juvenile salmonids in the vicinity of the mill.

2)-what beach seine sites would be useful for future regular sampling.

3)-if young fish were utilizing the area to the west of Ketchen Island which was a proposed site for a secondary waste treatment pond.

4)-if any observable migratory pathways could be defined.

Methods

Seine Survey 1 - June 9, 1976 (Ketchen Island Area)

This survey was conducted from 0700 - 1000 hrs. P.S.T. coincident with a rising tide which was about half way through the flood at the start of operations.

Three seine hauls were conducted with a 20 x 1.5 m fine-mesh beach seine set approximately 80 m offshore and hauled onto the beach. The objective of this survey was to detect the presence of salmon fry and smolts in the area west of Ketchen Island and the Cayuse Creek estuary. The three seine haul sites are illustrated in Figure 4 designated 1, 2 & 3.

Counts of fish captured in each haul were made and samples of representative species were collected, preserved and transported to the laboratory for taxonomic confirmation. Five coho smolts collected at seine site 2 were preserved in 10% formalin and transported to the laboratory for stomach content analysis.

Seine Survey 2 - March 23, 24, 1977 Port Alice Area, East and West Sides of Inlet

A more detailed beach seine survey was conducted during the juvenile salmon migration in March of 1977. In this survey two teams of workers simultaneously sampled the east and west shore of Neroutsos Inlet from the Cayeghle Creek estuary seaward at suitable sites over a distance of approximately 8 km. This survey was repeated on two consecutive days (0815 - 1240 hrs. March 23, 0615 - 0830 March 24, 1977) coincident with low water conditions. Stations occupied on each day are shown in Figures 5 and 6 with seine stations on the east shore designated "A" and those on the west shore "B". Unfortunately, two seine nets of equivalent size were not available hence the group doing "A" stations utilized a fine mesh seine with dimensions of

Figure 4. Beach seine sites sampled in the Cayuse Creek estuary site opposite the pulp mill June 9, 1976. Sites are designated 1 - 3 in order of sampling.

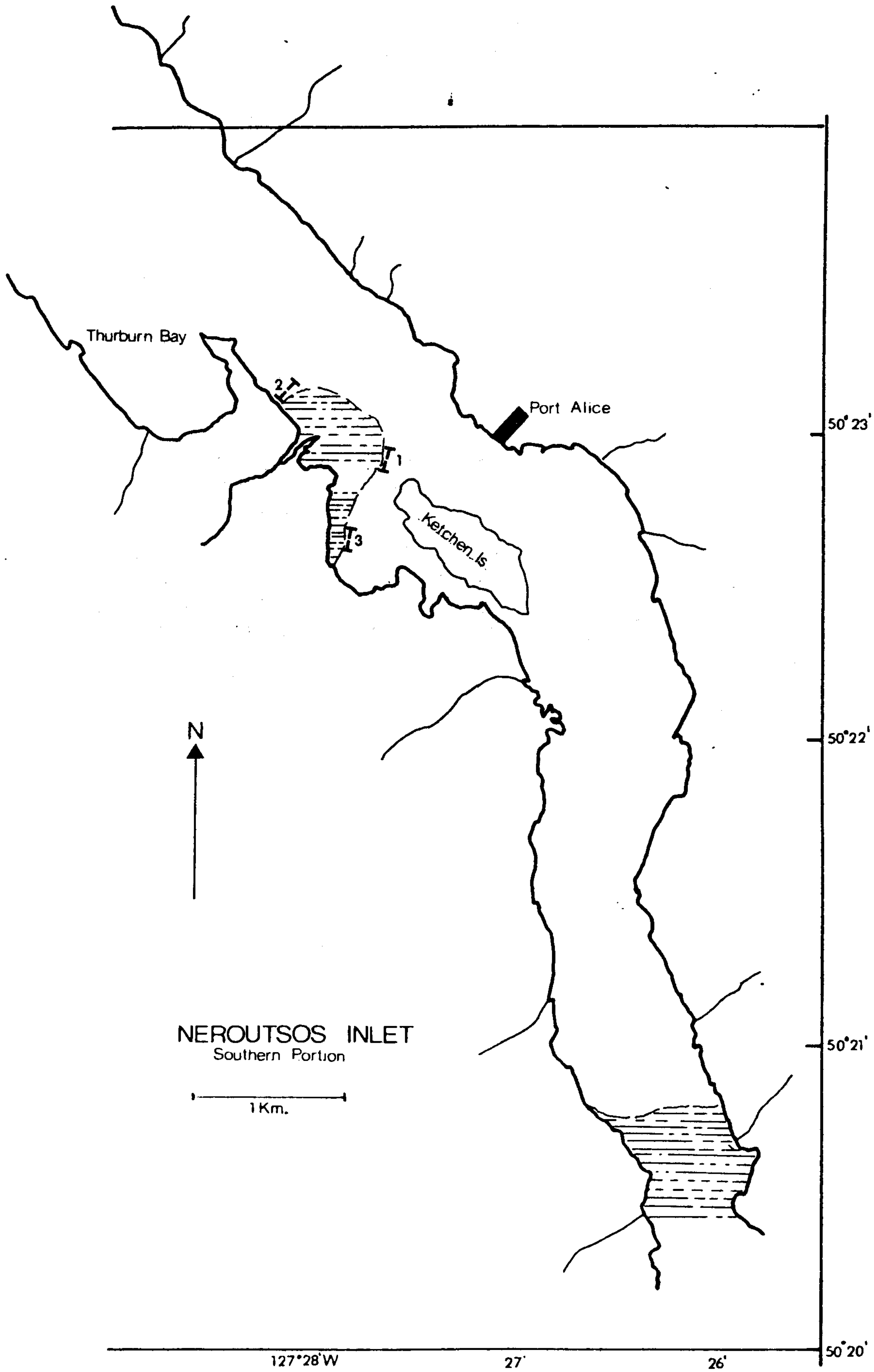

Thurburn Bay
Port Alice
Ketchen Is
2
1
3
N
NEROUTSOS INLET
Southern Portion
1 Km.
50°23'
50°22'
50°21'
50°20'
127°28'W
27'
26'

Figure 5. Beach seine sites sampled March 23, 1977 by two seine parties simultaneously sampling the east and west shores of Neroutsos Inlet and working seaward from the Inlet's head. East shore stations are designated A-1 to A9 while west shore stations are designated B-1 to B-9. The number following the station designation is the catch of salmonids at each site. Thus B-1/4 designates a catch of 4 fish at station B-1. Actual station positions and descriptions are given on page 71.

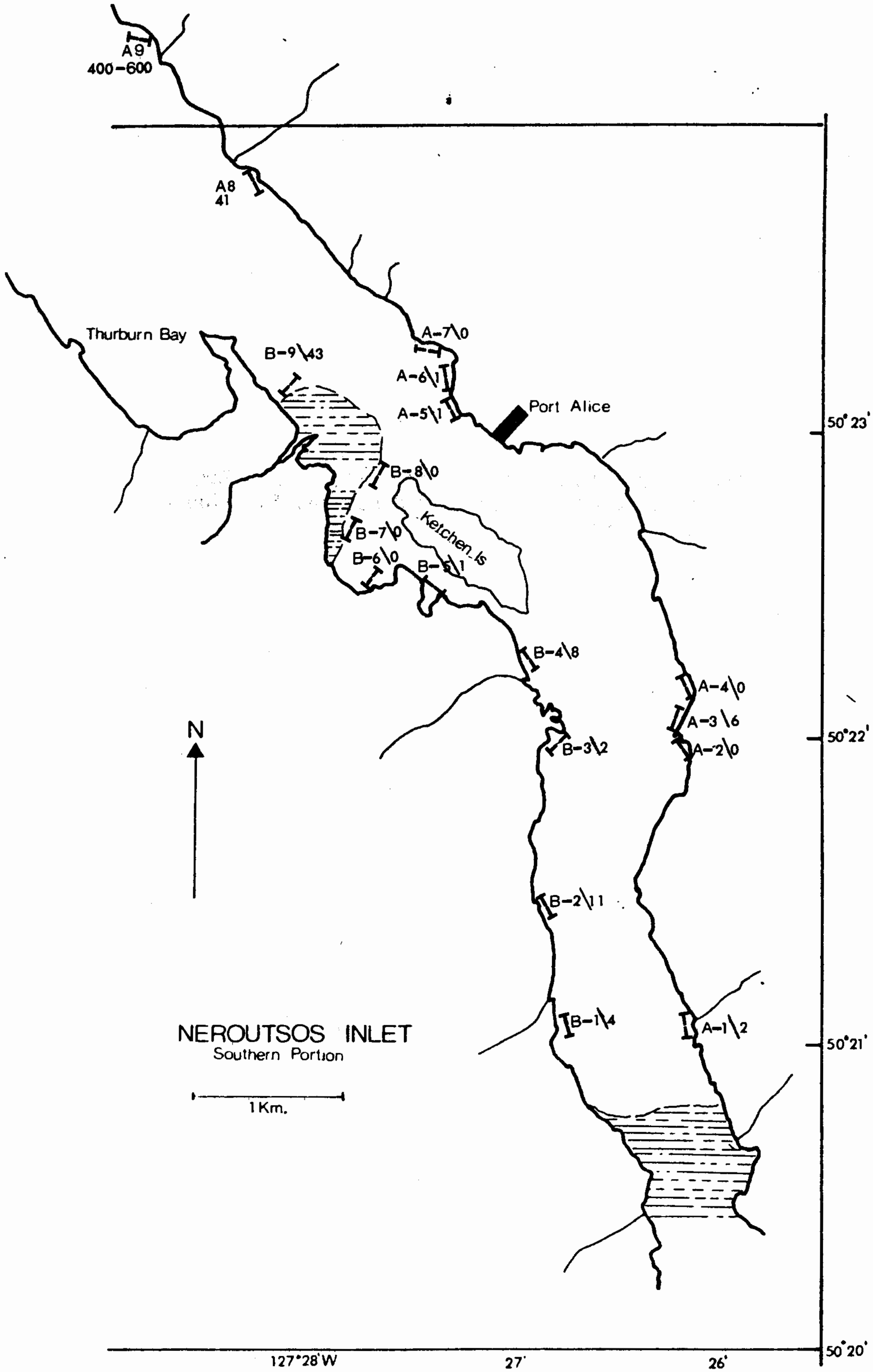
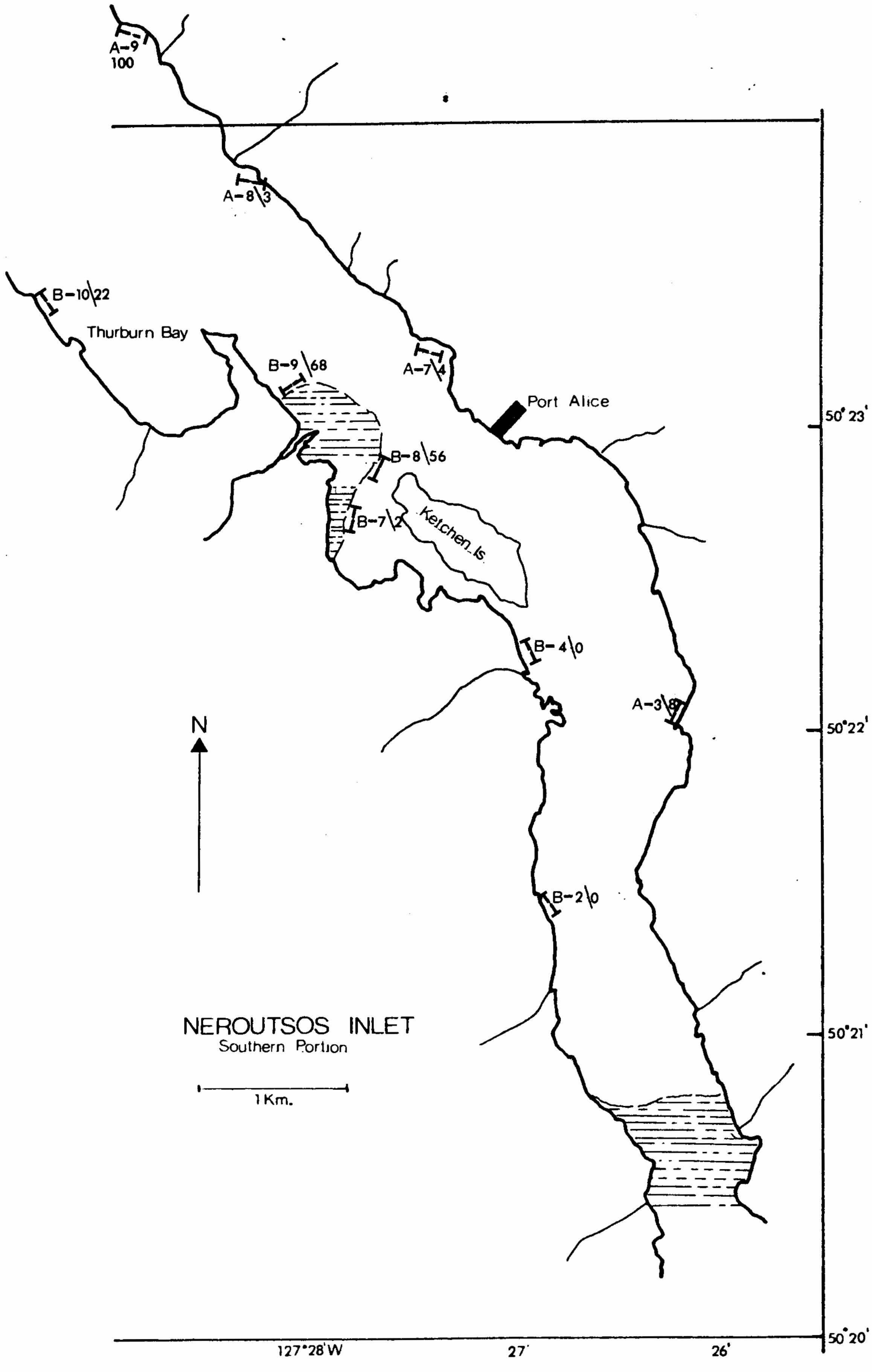

A9
400-600
A8
41
Thurburn Bay
B-9\43
A-7\0
A-6\1
A-5\1
Port Alice
B-8\0
Ketchen Is
B-7\0
B-6\0
B-5\1
B-4\8
A-4\0
A-3\6
A-2\0
B-3\2
N
B-2\11
B-1\4
A-1\2
NEROUTSOS INLET
Southern Portion
1 Km.
50°23'
50°22'
50°21'
50°20'
127°28'W
27'
26'

Figure 6. Beach seine sites sampled March 24, 1977. Format of the figure is identical to that described for Figure 5 (proceeding page).


A-9
100
A-8\3
B-10\22
Thurburn Bay
B-9 \68
A-7\4
Port Alice
B-8\56
B-7\2
Ketchen Is.
B-4\0
A-3\8
N
B-2\0
NEROUTSOS INLET
Southern Portion
1 Km.
50°23'
50°22'
50°21'
50°20'
127°28'W
27'
26'

30.5 x 1.5 m while those doing "B" stations used a 20 x 1.5 m seine. Thus the results between seines would not be strictly comparable and this survey is considered only useful in indicating the presence or absence of salmonids in specific areas without accurate quantitative implications.

Coincident with seining activity, determinations of temperature, conductivity, salinity, pH, oxidation reduction potential, dissolved oxygen and ammonia concentration were made at a number of seine locations by a third work party in an inflatable boat. At each site, water samples were taken for dissolved oxygen and salinity determination at 0, 0.5, 1.0 and 2.0 m with a Van Dorn bottle. Temperature, conductivity, and pH were determined at the same depths utilizing a Hydrolab Model 6D-12-1 *in situ* analyser calibrated with known standards in the boat. Samples for ammonia analysis (Orion specific ion electrode) were also collected from 0.0, 0.5 and 2.0 m depths. These samples were all taken directly offshore from the seine sites in 2 - 5.0 m of water.

Unfortunately, the party conducting water quality measurements had difficulty keeping up with both seine crews, hence some disparity developed between time of seine haul at a given location and timing of the water quality determinations as each day progressed. Also, it proved physically impossible to monitor every seine site. Furthermore, an accident occurred to the vessel C.S.S. VECTOR during the homeward journey following the study and a number of preserved samples were lost due to collision breakage.

Results

A) Seine Survey 1 - June 9, 1976 (Ketchen Island Area)

Fish found in the beach seine hauls at the various sites were as follows:

Station 1 - Cayuse Creek estuary opposite N. tip Ketchen Island

Species	Size Range (cm)	Number in Catch
Oncorhynchus keta	3-4	20
Leptocottus armatus	4-10	>25
Gasterosteus aculeatus	4-5	<25

Station 2 - North margin, Cayuse Creek Estuary

Species	size Range (cm)	Number in Catch
Oncorhynchus kisutch	6-10	61
Cymatogaster aggregata	6-8	10
Leptocottus armatus	4-10	>50
Gasterosteus aculeatus	4-5	20

Station 3 - Channel to west of Ketchen Island

Species	size Range (cm)	Number in Catch
Oncorhynchus keta	3-4	6
Leptocottus armatus	3-10	>25
Gasterosteus aculeatus	4-5	50 (approx.)

In each of the above hauls a variety of invertebrates was also present. Particularly evident were amphipods, *Anisogammarus* sp., especially at Station 1.

Stomach contents were examined from coho smolts seined at Station 2 by pooling the stomach contents of a sample of 5 fish and examining the aggregate sample in the laboratory. The stomachs of these fish were full of invertebrates and the fish appeared in good nutritional condition. Stomach contents, in terms of ranked abundance from most abundant to least were:

1. *Anisogammarus pugettensis*
2. *Anisogammarus confervicolus*
3. *Hyale pugettensis*
4. *Corophium spinicorne*
5. Chirononid larvae; ants

Thus the dominant food organisms found in the stomachs were amphipods with a few terrestrial organisms included.

B) Seine Survey 2 - March 23, 24, 1977 Port Alice Area, East and West Sides of Inlet

Seine sites occupied March 23 and 24 are indicated in Figures 5 and 6 along with the catches of chum fry at each site (see Figure caption). Times of seine hauls and water quality determinations along with water quality data are summarized in Tables 6 - 9. During this survey the only salmonids collected at all stations were chum fry (*Oncorhynchus keta*) and many of these fish were only just "buttoned up" indicating recent emergence from freshwater.

Water quality data indicated considerable salinity stratification with brackish conditions near the surface, particularly in the vicinity of Cayeghle Creek while at 2.0 m salinities were generally in the order of 26 - 28^{o}/oo. Dissolved oxygen levels were generally high at the surface and ranged from 4.65 - 7.76 mg/l at 2.0 m depth over the station series. Ammonia levels were typically low except at stations A7, B6, B7 & B8 where elevated levels were noted.

Discussion

Seine survey 1 conducted in June 1976 indicated that both chum salmon fry and coho smolts frequented the area to the northwest of Ketchen Island and that considerable numbers of coho smolts could be found on the north margin of Cayuse Creek estuary. Stomach content analysis of the coho smolts revealed that the fish were actively feeding and that the diet was mainly comprised of amphipods - particularly *Anisogammarus pugettensis*. In addition, both fry and smolts looked in good nutritional condition suggesting that food supply was sufficient to produce adequate fish condition in the area during the survey.

Table 6: Fish Catch Data and Water Quality Parameters - March 23, 1977 - Survey - East Shore Stations

Station	# Chum fry caught	Time fish catch (Time Water Quality) P.S.T.	Depth (m)	T (°C)	Salinity Hydrolab (⁰/oo)	Salinity Salinometer (⁰/oo)	pH	Oxygen (mg/l)	Ammonia (mg/l)
A1	2	0830-0840	0	5.0	1.6	-	7.2	14.04	0.01
		(0830-0845)	0.5	5.0	2.1	3.79	7.1	12.96	<0.01
			1.0	7.5	20.5	-	7.0	6.45	-
			2.0	8.1	28.4	26.72	7.2	5.94	0.03
A2	0	0900	-	-	-	-	-	-	-
A3	6	0915-0930	0	5.0	3.0	-	7.2	12.73	<0.01
		(0940-0950)	0.5	6.0	6.5	9.85	7.15	10.61	0.01
			1.0	7.4	25.5	-	7.2	8.65	-
			2.0	8.0	27.7	27.85	7.25	6.22	0.03
A4	0	0945	0	5.5	7.2	-	7.4	12.01	< .01
		(1040)	0.5	5.7	9.5	10.87	7.0	9.69	-
			1.0	7.5	24.0	-	7.2	6.83	-
			2.0	8.25	27.7	27.26	7.3	5.56	0.04
A5	1	1000-1015	-	-	-	-	-	-	-
A6	1	1045-1055	-	-	-	-	-	-	-
A7	0	1100-1110	0	7.2	16.4	15.18	6.3	4.97	2.9
		(1210)	0.5	7.5	23.2	22.80	6.8	4.34	1.4
			1.0	8.2	27.4	-	7.0	5.22	-
			2.0	8.5	28.8	28.62	7.4	6.41	0.02
A8	41	1130-1140	-	-	-	-	-	-	-
A9	400-600 (estimate)	1150-1200	-	-	-	-	-	-	-

Table 7 : Fish Catch Data and Water Quality Parameters - March 23, 1977 - Survey - West Shore Stations

Station	# Chum fry caught	Time fish catch (Time Water Quality) P.S.T.	Depth (m)	T (°C)	Salinity Hydrolab (°/oo)	Salinity Salinometer (°/oo)	pH	Oxygen (mg/l)	Ammonia (mg/l)
B1	4	0815	0	5.6	4.6	3.18	7.15	13.47	<0.01
		(0815)	0.5	5.5	7.1	3.53	7.25	12.63	<0.01
			1.0	5.5	9.0	-	7.28	7.30	-
			2.0	8.2	28.4	26.65	7.30	6.79	0.04
B2	11	0850	0	5.0	2.6	-	7.1	13.66	<0.01
		(0855)	0.5	5.3	6.2	8.00	7.2	10.36	0.12
			1.0	6.5	11.7	-	7.1	6.01	-
			2.0	8.2	28.4	28.52	7.3	6.03	0.03
B3	2	0910	0	6.2	8.0	5.13	7.1	11.10	0.02
		(0920)	0.5	7.0	18.6	17.11	7.1	8.04	0.03
			1.0	8.0	25.5	-	7.2	6.13	-
			2.0	8.5	28.4	28.37	7.3	7.11	0.03
B4	8	0940	0	5.0	5.1	4.25	7.4	12.10	0.02
		(1100)	0.5	5.5	10.6	13.37	7.4	9.88	0.03
			1.0	7.2	19.2	-	7.35	6.92	-
			2.0	8.0	28.8	28.13	7.4	7.23	0.03
B5	1	1005	0	5.5	6.1	6.08	7.3	12.14	0.02
		(1120)	0.5	5.7	8.0	9.99	7.3	10.47	0.03
			1.0	7.0	17.9	-	7.2	6.96	-
			2.0	8.0	27.3	28.17	7.35	5.75	0.03

Table 7: (cont'd)

Station	# Chum fry caught	Time fish catch (time water quality) P.S.T.	Depth (m)	T (°C)	Salinity Hydrolab (°/oo)	Salinity Salinometer (°/oo)	pH	Oxygen (mg/l)	Ammonia (mg/l)
B6	0	1034	0	5.5	6.9	6.79	7.4	11.84	0.02
		(1135)	0.5	5.7	9.2	14.59	7.4	8.23	0.08
			1.0	7.0	17.9	-	6.9	4.95	-
			2.0	8.2	28.4	27.71	7.2	4.97	0.05
B7		1055	0	5.2	5.5	-	7.4	12.01	0.02
		(1145)	0.5	5.0	5.5	20.49	7.4	6.64	0.08
			1.0	7.9	25.7	-	7.1	4.93	-
			2.0	8.0	28.8	27.53	7.3	4.89	0.05
B8	0	1110	0	5.7	6.9	6.95	7.4	12.14	0.02
		(1225)	0.5	5.5	7.0	21.98	7.3	5.75	1.30
			1.0	7.3	25.7	-	6.6	5.29	1.80
			2.0	-	-	28.49	-	-	-
B9		1130-1142	0	8.5	28.8	-	7.7	8.14	0.02
		(1240)	0.5	8.5	20.0	-	7.65	7.70	0.02
			1.0	8.5	29.0	-	7.65	8.08	-
			2.0	8.5	29.0	-	7.65	7.68	0.02

Table 8 : Fish Catch Data and Water Quality Parameters - March 24, 1977 - Survey - East Shore Stations

Station	# Chum fry caught	Time fish catch (Time Water Quality) P.S.T.	Depth (m)	T (°C)	Salinity Hydrolab (°/oo)	Salinity Salinometer (°/oo)	pH	Oxygen (mg/l)	Ammonia (mg/l)
A3	8	0615-0625 (0640)	0	6.0	6.8	9.97	7.2	-	-
			0.5	7.2	20.5	21.03	7.5	-	-
			1.0	7.6	27.0	22.75	7.4	-	-
			2.0	8.5	29.0	26.42	7.4	-	-
A7	4	0630 (0725)	0	7.6	7.3	15.69	6.9	-	-
			0.5	7.7	18.0	24.82	5.9	-	-
			1.0	8.2	26.4	21.78	6.6	-	-
			2.0	8.5	28.4	28.73	7.3	-	-
A8	3	0650 (0810)	0	7.0	7.8	9.91	6.4	-	-
			0.5	7.0	15.0	15.38	6.1	-	-
			1.0	7.2	15.8	26.94	6.0	5.92	-
			2.0	8.5	28.4	28.11	7.6	6.83	-
A9	100 (estimate)	0710-0715 (0820)	0	7.5	19.2	4.66	6.5	11.94	-
			0.5	8.0	21.3	27.06	7.0	6.66	-
			1.0	8.5	28.4	27.75	7.6	6.98	-
			2.0	8.5	28.4	28.79	7.6	7.76	-

Table 9: Fish Catch Data and Water Quality Parameters - March 24, 1977 - Survey - West Shore Stations

Station	# Chum fry caught	Time fish catch (Time Water Quality) P.S.T.	Depth (m)	T (°C)	Salinity Hydrolab (°/oo)	Salinity Salinometer (°/oo)	pH	Oxygen (mg/l)	Ammonia (mg/l)
B2	0	0630 (0625)	0	6.0	6.8	9.69	7.5	-	-
			0.5	7.0	17.8	24.46	7.5	-	-
			1.0	8.2	25.5	22.33	7.4	-	-
			2.0	8.5	29.0	27.24	7.5	-	-
B4	0	0700 (0655)	0	7.0	7.1	16.11	7.3	-	-
			0.5	7.5	19.9	17.52	7.2	-	-
			1.0	8.5	28.4	27.54	7.4	-	-
			2.0	8.5	28.4	23.60	7.4	-	-
B8	56	0715 (0710)	0	6.7	7.0	7.44	7.2	-	-
			0.5	8.0	24.0	17.23	7.0	-	-
			1.0	-	-	28.60	-	-	-
			2.0	-	-	28.71	-	-	-
B9	68	0740 (0750)	0	8.5	28.4	27.30	7.6	-	-
			0.5	8.5	29.0	28.69	7.6	-	-
			1.0	8.5	28.4	28.83	7.6	-	-
			2.0	8.5	29.0	28.92	7.6	-	-
B10	22	0800 (0835)	0	8.0	25.5	25.19	7.7	8.57	-
			0.5	8.2	27.7	27.56	7.7	7.72	-
			1.0	8.3	28.4	28.64	7.7	7.66	-
			2.0	8.5	28.4	28.79	7.7	7.00	-
B7	2	0800	-	-	-	-	-	-	-

Figures 6 - 9, summarizing the March 1977 survey, indicate that relatively few chum fry were observed on the inlet's east shore for a distance of approximately 5.5 km seaward from Cayeghle Creek estuary. A grand total of 22 chum fry were collected at Stations A1 - A7 over the two days while Stations B1 - B9, spanning roughly the same distance on the west shore, yielded a total of 195 fish in the same period. These data may indicate a trend towards utilization of the west shore of upper Neroutsos Inlet by chum fry.

As in the 1976 survey, the Cayuse Creek area appeared to be utilized in 1977 by chum fry with a total catch of 167 fish recorded in the Cayuse Creek estuary. It is not clear whether these fish were Cayuse Creek stock or if they had resulted from stock emerging from other areas such as Cayeghle Creek and its tributaries.

Significant catches of chum fry were recorded approximately 2-3 km seaward of the mill on the inlet's east shore on March 23 and 24, 1977 (Stations A8, A9) while 22 individuals were collected at Station B10 on the west shore March 24. The source of these fish was not known and only a rough estimate of 400 - 600 individuals at Station A9 on March 23 was made so as to allow release of the school without significant damage due to counting stress.

Most fish collected in the March 1977 survey were apparently only recent migrants to salt water as most showed signs of very recent completion of yolk sac reabsorption. This fact suggests that the 1977 survey was conducted early in the chum run or that the fish may have been migrating fairly rapidly in a seaward direction if indeed the fish came from Cayeghle Creek stock.

It is interesting that fish caught at most of the stations averaged 0.4 - 0.5 grams in weight while those caught at stations A9 and B9 were larger (wt. = 0.6 - 0.75 g). These differences could be related to stock size differentials if several populations from various creeks were sampled or age differences with the larger fish groups having spent more time in sea water.

Water quality parameters during the 1977 survey appear to be acceptable for fish survival at most of the seine sites. Dissolved oxygen values, particularly in the upper meter were generally high. On March 23 Stations A7, B6, B7 and B8 had ammonia levels generally higher than elsewhere, as well as the lowest dissolved oxygen levels. No fish were collected at those sites on that date suggesting a possible influence of water quality characteristics on distribution.

From the 1976 and 1977 surveys, which are obviously of a very preliminary nature, some tentative conclusions may be drawn. Namely:

- there would appear to be more fish on the west shore of the head of Neroutsos Inlet and a paucity of fish close to the pulp mill on the east shore.
- Cayuse Creek estuary appears to be utilized by both chum fry and coho smolts and the latter appear to be feeding actively in the area upon amphipods and other organisms.
- suitable seining sites for standard beach seine hauls are present on both shores of the inlet for a distance of at least 8 km seaward from the Inlet's head.

Recommendations for Future Studies

In order to better understand the habitat utilization and migration patterns of young salmonids in the Port Alice area relative to strategies of effluent treatment and disposal, it is necessary to carry out a detailed study in the area during the spring seaward migration period. Ideally, this study should span several years to include variations in runs, climatic and seasonal effects, as well as natural variations in physical and chemical characteristics of the inlet waters in relation to effluent discharge.

The following seine sites have been identified as workable at low to mid tidal height levels with a 20-30 m long, fine mesh beach seine:

A Stations - East Shore Neroutsos Inlet

Station Designation	Position	Comments
A1	50°21.06'N; 127°26.13'W	- steep shore, frequent snags
A3	50°22.03'N; 127°26.23'W	
A4	50°22.16'N; 127°26.15'W	- snags and debris
A5	50°23.1 'N; 127°27.37'W	- construction debris present
A6	50°23.19'N; 127°27.35'W	
A7	50°23.29'N; 127°27.45'W	
A8	50°23.85'N; 127°28.30'W	
A9	50°24.30'N; 127°28.76'W	- steep shore - net can be difficult to recover properly.

B Stations - West Shore Neroutsos Inlet

Station Designation	Position	Comments
B1	50°21.1 'N; 127°26.79'W	- best worked at low water
B2	50°21.46'N; 127°26.88'W	- fairly steep shore
B3	50°22.20'N; 127°26.80'W	- good small bay for seining
B4	50°22.30'N; 127°27.0 'W	- good, some booming debris
B5	50°22.48'N; 127°27.46'W	- poor muddy site
B6	50°22.53'N; 127°27.70'W	- best worked at low water
B7	50°22.72'N; 127°27.86'W	- best worked at low water
B8	50°22.85'N; 127°27.71'W	- excellent seining site, shallow
B9	50°23.12'N; 127°28.12'W	- excellent seining site, shallow
B10	50°23.52'N; 127°29.50'W	- cobble - rocky shore, snags

The above sites are by no means all the possible seining sites in the area but could form the basis for future survey projects in this region.

In order to conduct a proper survey, the following information would be needed:

- observations on the timing of the runs from the major salmon producing streams in the area from the start of the run to its cessation.
- some numerical analysis of the size of the various runs.
- marking and recapture of emergent fry so that their migratory and feeding behavior during early sea life could be related to collection sites and rate of movement along the shores of Neroutsos Inlet.
- stomach content analysis of feeding fish at different sites to determine habitat utilization patterns and food sources.
- the relationship of water physical and chemical characteristics and effluent dispersal patterns to fish distribution and abundance.

The above studies might be designed with several periods of intensive survey activity covering the duration of the runs until most of the fish move seaward into Quatsino Sound. Such a study might therefore occur from March until at least late May - early June and possibly throughout the summer if it is determined that young fish remain in the Neroutsos Inlet area until September.

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Appendix I

Table 1. Temperature of L. PACIFICA recirculation water taken in laboratory tanks during Neroutsos Inlet cruise, 1975.

Date	Time - PST-hrs.	T°C		Comment
29/7/75	13:30	13.3		- system operating well
30/7/75	10:00	12.5		
30/7/75	15:52	13.2		
31/7/75	09:23	12.6		
31/7/75	23:00	12.2		
1/8/75	14:30	13.3		
2/8/75	14:00	13.4		
2/8/75	18:00	13.3		- power failure - cooling stopped
3/8/75	14:50	15.0	*	- no cooling
4/8/75	11:00	15.2	*	- no cooling
5/8/75	18:00	11.3	*	- power restored & cooling started
6/8/75	10:40	13.2		- system operating well
7/8/75	18:40	12.9		
8/8/75	14:38	13.4		
8/8/75	17:20	13.5		
	$\bar{x}$	13.067		
	S.D.	0.419		
	S.E.	0.126		
	n	12		(excluding asterisks)

Table 2. Salinity of recirculation water aboard L. PACIFICA at Port Alice, Summer, 1975.

Date	Time - P.S.T.	Salinity - $^{o}/oo$ *
3/8/75	14:30	29.565
5/8/75	22:45	29.205
6/8/75	10:20	29.375
6/8/75	18:30	29.508
7/8/75	08:00	29.680
7/8/75	20:15	30.441
8/8/75	21:25	30.518

* Guildline Autosal Salinometer
standardized with Copenhagen sea water