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CHARACTERISTICS OF FISH PLANT WASTES IN NOVA SCOTIA AND THEIR EFFECTS ON COASTAL BAYS

V: NEARSHORE EFFECTS

Environmental Impact and Assessment
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Characteristics of fish plant wastes in Nova Scotia and their effects on coastal bays. V : nearshore effects.

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CHARACTERISTICS OF FISH PLANT WASTES IN NOVA SCOTIA AND THEIR EFFECTS ON COASTAL BAYS

V: NEARSHORE EFFECTS

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FOREWORD

This report is the last of a five part series entitled "Characteristics of Fish Plant Wastes in Nova Scotia and Their Effects on Coastal Bays". Other reports in the series are:

Vol. I	Summary and General Conclusions EPS-8-AR-75-2
Vol. II	Waste Water Characterization EPS-8-AR-75-3
Vol. III	Toxicity Studies EPS-8-AR-75-4
Vol. IV	Bacteriological Characteristics EPS-8-AR-75-5

Volume V, "Nearshore Effects", is a technical report on the results of an investigation of the receiving waters for groundfish plant wastes. Readers interested in the recommendations arising out of this study should consult Volume I.

The report was written under very trying circumstances. Owing to the transfer of the principal investigator, completion of this portion of the project was contracted to Waterside Consultants on the Coastal Environment after the data collection had terminated. Before beginning to write, the consultants had to establish what had been done and become familiar with the data. Their task was to synthesize the results of an experimental design not of their own choosing into a pertinent set of conclusions. The comprehensiveness of this volume is a tribute to their success.

ABSTRACT

In order to determine the environmental effects of effluents from groundfish processing plants, the nearshore environment around two large Nova Scotia operations was studied during the summer of 1974. The characteristics of these effluents are reported elsewhere in this report series.

Louisbourg is a well flushed harbour, but the harbour water was occasionally heavily enriched with nutrients. Planktonic chlorophyll concentrations were high, and the distribution of rooted algae reflected disturbed conditions. Benthic diversity was not only lower overall, but was more variable within the immediate area of effluent discharge.

The inner harbour at Lockeport is nearly enclosed, and the levels of nutrients were at times very high, but the outer harbour also receives a heavy domestic sewage load. Information about the distribution of plants and animals proved to be too limited for a trend related to pollution to be detected statistically.

Chemical inhomogeneities in the water at Lockeport support the concept of Perkins that spatial complexity leads to the formation of cells of water whose composition is not adequately represented by large scale averages.

Groundfish processing wastes released into the environment do not result in abiotic zones, but do enrich the sediment and overlying water. This leads to a shift in the distribution of rooted macrophytes and to a benthic community of lower and more variable diversity.

RÉSUMÉ

Afin de déterminer les influences des effluents des usines de traitement de poisson de fond sur l'environnement, on a étudié les eaux côtières près de deux usines en Nouvelle-Ecosse durant l'été 1974. Les caractéristiques furent décrites dans les autres rapports de cette série.

Le havre de Louisbourg est bien débourbé mais les eaux du havre sont occasionnellement fortement enrichies de nutrients. Les concentrations de chlorophyll planktonique étaient élevées et la distribution d'algue attachée reflétait des conditions agitées. La diversité de la faune du fond n'était pas seulement basse mais elle était aussi plus variable dans la zone immediate de l'embouchure de l'effluent.

L'arrière-port de Lockeport est presque totalement enclos et le niveau des nutrients était parfois très élevés. L'avant-port cependant, reçoit un gros chargement d'eaux d'égouts. Les données sur la distribution de la flore et de la faune n'étaient pas assez complète pour un rendement statistique sur l'influence de la pollution.

Le fait que la composition chimique des eaux de Lockeport n'est pas homogène supporte le concept de Perkins. Ce concept indique que la complexité spatiale cause la formation de cellule d'eau qui ne reflète pas la moyenne totale du havre.

Les déchets des usines de traitement de poisson du fond qui sont déchargés envers l'environnement ne cause pas de zone ou l'on ne trouve pas de biota. Cependant ces déchets enrichient les sédiments et l'eau cotière. Ceci mène à un déplacement dans la distribution des macrophytes attachés et à une communauté du fond plus basse et plus variée.

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SYMBOLS USED IN TEXT

BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
NH3	Ammonia-nitrogen
NO3	Nitrate-nitrogen
NSP	National Sea Products Ltd.
OG	Oil & grease
SS	Suspended solids
TIP	Total inorganic phosphate-phosphorus
TOP	Total organic phoshate-phosphorus

1 INTRODUCTION

In the past several years increasing attention has been paid to the characteristics of effluents from fish-processing plants[1-3]. Similarly there has been much study of improved wastewater handling[4,5]. But between analysis and prescription of treatment systems should come an understanding of how various levels of pollutant affect the receiving waters and natural communities. This understanding does not appear to be available regarding the impact of fish plants. In the few studies that have been completed, there is little evidence of environmental damage to marine systems[6,7]. Yet estuaries and coastal inlets are remarkably diverse in dynamic properties and it is these poorly understood processes that define ability to assimilate wastes . Nakatani et al.[7] caution against too wide an application of their results from a study of salmon cannery wastes and effects, citing the uniqueness of coastal ecosystems as the limitation.

Assessment of impact is never easy; generalising is even less so. The environmental effects of fish-processing wastes were studied in this project at two inlets of widely different hydrodynamic regimes - Louisbourg and Lockeport Harbours in Nova Scotia. The aim was to make the generalisation of results potentially feasible.

2.1 THE INLETS OF THE STUDY

Location of Louisbourg and Lockeport Harbours is shown in Fig. 1. Louisbourg Harbour can be divided operationally into two basins separated by the deepest waters (20-22 m.) near the mouth of the inlet. These are known as the Northeast and Southwest Arms. The latter, adjacent to the famous Fortress of Louisbourg is somewhat steeper along the bottom than the Northeast Arm. The only significant fresh water input comes from at the head of the Southwest Arm. The Northeast Arm is the site of the present day town of Louisbourg, a community of about 1500 people. It is also the site of the National Sea Products fish and meal plants as well as the much smaller Hopkins' fish-plant. Gerratt Brookenters the Northeast Arm immediately to the south of National Sea Products. Another stream flows in at the head of the Arm. No information on flow rates is available.

The area of the study at Lockeport is not a distinct water body itself in terms of natural origin. It is instead a cove of Lockeport Harbour's west side that has been modified with breakwaters and wharves so that an artificial embayment has been formed. This embayment - referred to throughout the report as the inner harbour - is the site of the town of Lockeport and of two active fish-plants, National Sea Products and Swim Brothers. A third processing plant operated within the inner harbour until its destruction by fire in 1973.

No major inflow of fresh water comes into the inner harbour. The town of Lockeport is nearly an island; on the opposite side to the inner harbour is another fairly restricted embayment known as Back Harbour.

Mean tidal range at Louisbourg is 3.8 ft (≃ 1.16 m.) with spring tide range of 5.6 ft (≃ 1.70 m.). At Lockeport these values are respectively 5.5 and 8.0 ft (1.67, 2.43 m.). Tides at both are diurnal.

As mentioned above, Louisbourg has a population of approximately 1500. Domestic wastes are released untreated to the harbour at three outflows, one about 500 ft. north of NSP with the others farther towards the head of the Northeast Arm[8]. Føyn[9] has cited 240 l/day as a typical per capita wastewater output. Using this and his data on concentration of various components of such effluent,rough estimates can be derived for waste loads entering the harbour at Louisbourg (other than those from the fish-plants). These are given in Table 1 , with comparison with the loads from the NSP and Hopkins' operations. Values for the latter are estimates derived from Tables 1-4 and 15-19 of Volume 2.

Lockeport has approximately the same human population as Louisbourg. However, most of its domestic wastes discharge into Back Harbour with only a few private sewers draining to the inner harbour[10]. Domestic sewage at Lockeport receives no treatment and represents a possible interference with the control area rather than

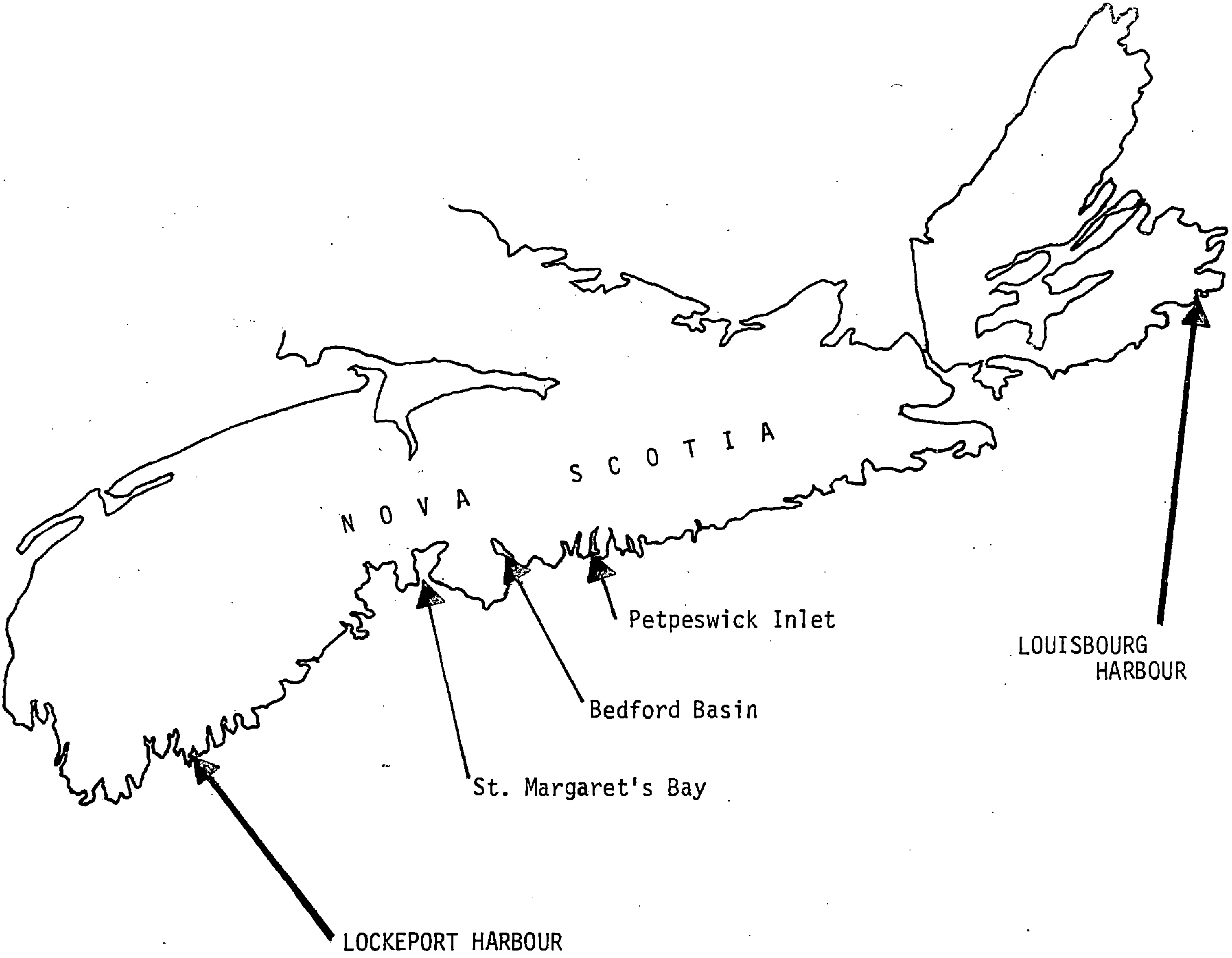


FIG. 1 Location of the study inlets and other Nova Scotian inlets mentioned in this chapter

the inner harbour.

Table 1 suggests that at Louisbourg, domestic sewage is far more important than fish-plant wastes as a nitrogen source. For other water quality properties except for organic phosphate the fish-plants' effluent runs around 10 to 20 times estimates for domestic additions. This probably means that the fish-plants have the major controlling effect on concentrations in the water column,but their activity may have strong seasonal variation. If so information would be needed on annual composite loadings to describe the relative importance of domestic effluent.

TABLE 1 Estimated daily contribution (lbs/day) for various components of effluent from Louisbourg fish-plants and town.

	Town*	NSP	Hopkins	NSP+ Hopkins	Ratio of Town: Plants
BOD	85	1348	44	1392	.06
COD	112	2029	69	2098	.06
SS	58	608	15	625	.09
TIP	4.9	74	2.7	76.7	.06
TOP	2.5	9	.2	9.2	.27
Total N§	10.9	.3	.01	.31	35.
Grease	15.1	357	no estimate	357	.04

§ Fish-plant estimates are based on combined NO_3+NO_2. NH_3 was not assessed for entire operation(i.e fish plant + meal plant).

* Calculated from Føyn[9]. See text.

2.2 Location of the Stations

2.2.1 Benthic Stations

Ten benchmarks were established in the "fish-plant" and control areas in each inlet of the study. These consisted of concrete blocks with floats and were placed at a mean tide depth of about 4-5 m. For the purposes of benthic sampling, one station was established at each benchmark and two more were set up along a transect away from and perpendicular to the shore. These were the sublittoral stations. As well,in the littoral zone adjacent to the benchmarks, two intertidal stations were selected, one in the lower intertidal zone and one near the upper limit of tidal extension. Thus, surrounding all the benchmarks there were to be 5 benthic stations, 2 littoral and 3 sublittoral. It was intended that the sublittoral would be at 6 and 9 fathoms (11 and 16.5 m. respectively) depth in addition to the station at the benchmark. Neither inlet proved to be sufficiently deep for establishing both depths for every benchmark. The depths over the inlets for benthic stations are, therefore, variable.

Benthic stations are labelled as follows: the first two characters signify the inlet (LB for Louisbourg, LP for Lockeport); the following letter - F or C - denotes whether the station was in the "fish-plant" or the control area; the next character, a number, corresponds to the benchmark number ; the final number signifies the position of the station on the transect from the highest littoral station (1) through to the deepest sublittoral station (5). To summarize by way of example, LBC43 would be in the Louisbourg control area, third from the highest intertidal; that is, the benthic station right next to benchmark # 4. Note then that all stations ending in the numbers,1 or 2,are intertidal.

All of the sublittoral stations at Louisbourg are depicted in Fig.2 . The intertidal stations are omitted but are positioned adjacent and inshore to sublittoral stations of the same benchmark number. Approximate location of the National Sea Products' and Hopgood's processing plant outflows are shown on this map.

Sublittoral stations are shown for Lockeport in Fig.3 Unlike at Louisbourg, however, no intertidal stations were established in the "fish-plant" area; most of the intertidal zone actually consisted of piers and waterfront on which a fauna comparable to the control area intertidal communities would not be anticipated, pollution or not.

2.2.2 Water Quality Stations

Labelling of water quality stations at the two harbours follows a similar approach to that used for benthic stations. In the "fish-plant"area of Louisbourg, the prefix LBF is followed by numbers 1-10. The first five (LBF1-LBF5) were located at the benchmarks 1-5, mentioned in the above section. In addition there were five other water quality stations in the "fish-plant" area. Similarly, in the control area there were stations LBC1-LBC5 at the

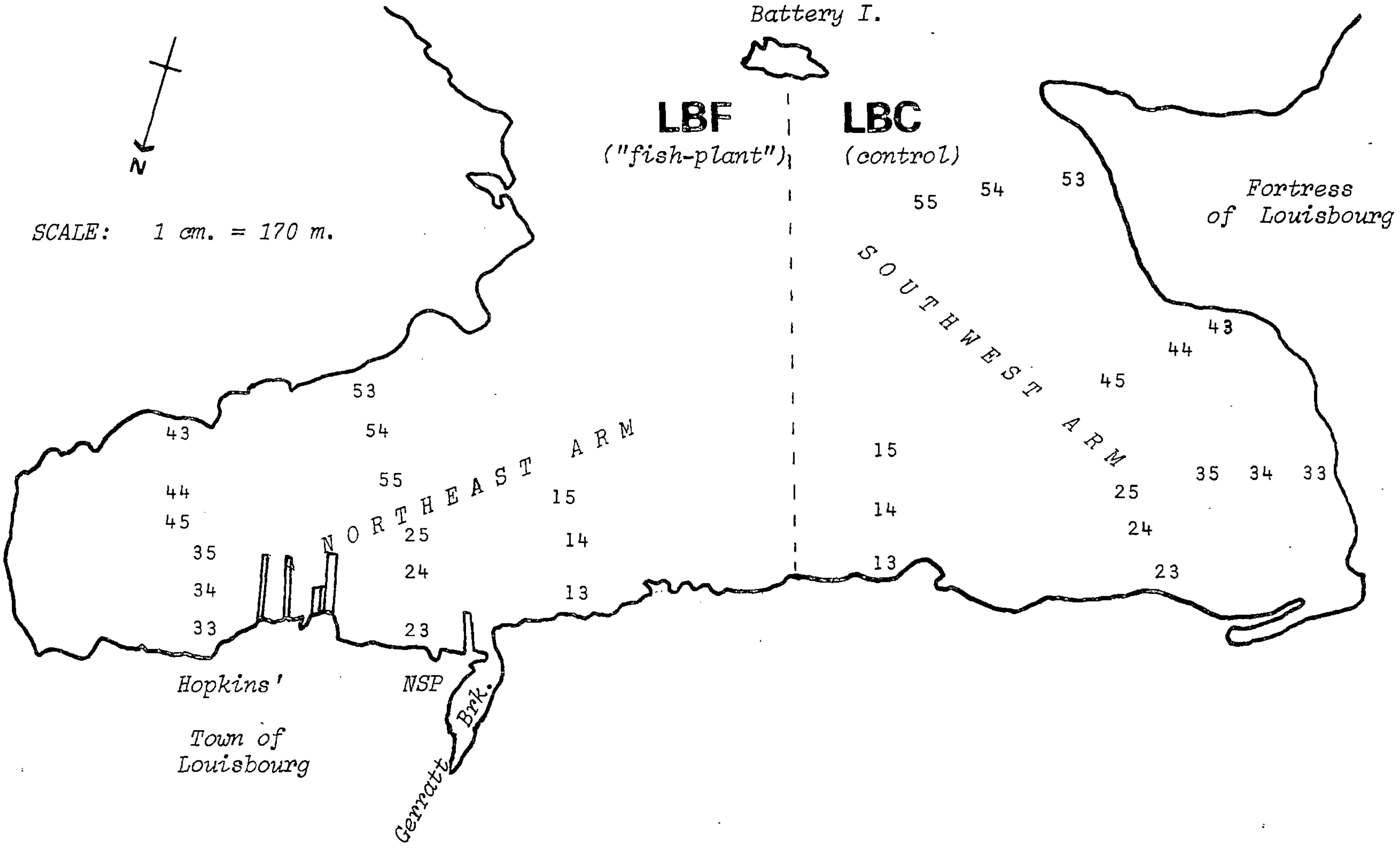
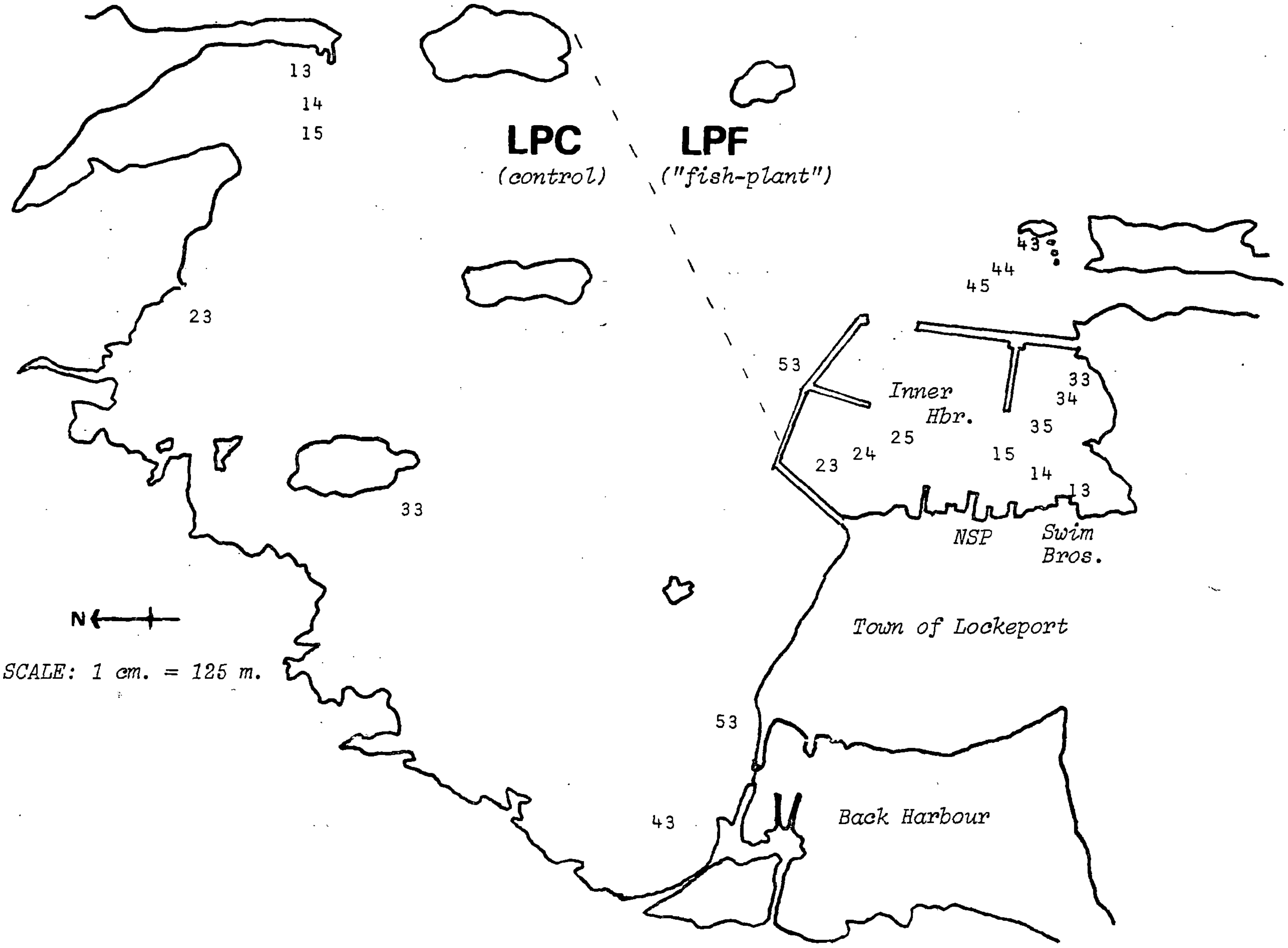


FIG. 2 Location of subtidal benthic stations and of places named in text (Louisbourg)

FIG. 3 Location of subtidal benthic stations and of places named in text (Lockeport)



benchmarks for faunal sampling. Five more stations were established additionally, labelled LBC6 to LBC10. Thus there were 20 stations for water quality in all at Louisbourg (For location see Fig. 4.). There were also 20 stations for water quality at Lockeport. For the "fish-plant" area, LPF1 to LPF5 are located adjacent to the benchmarks 1 to 5 used in marking benthic stations. However, there is not such a correspondence between control area benthic and water quality stations (See Fig. 5).

FIG 4 Location of Louisbourg Water Quality Stations.

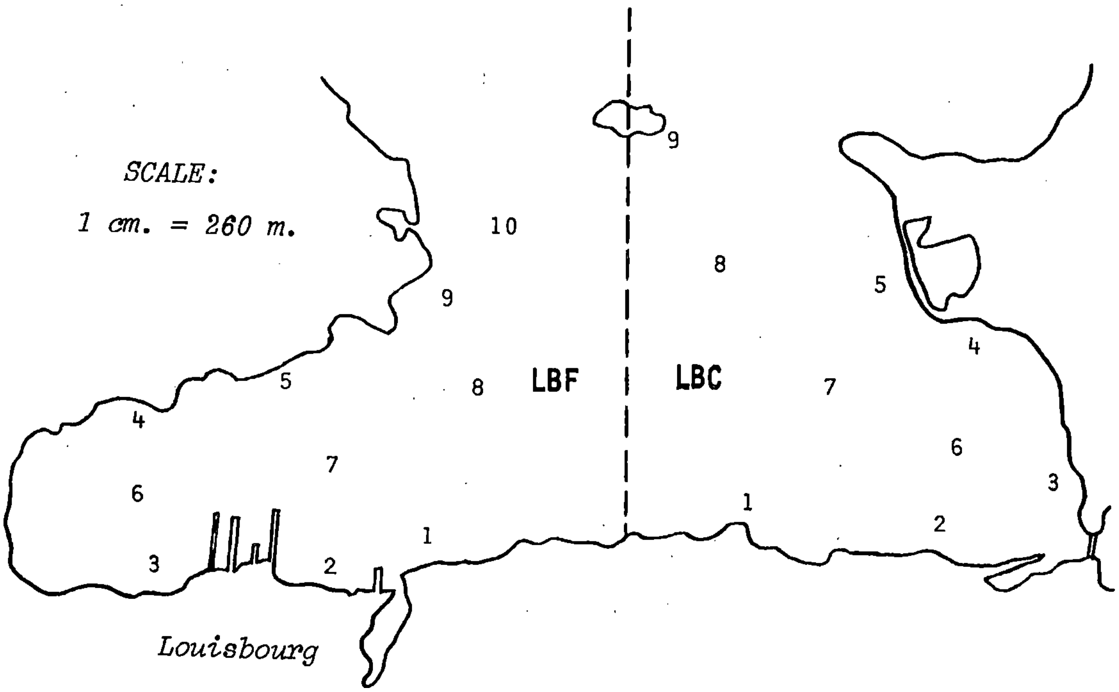
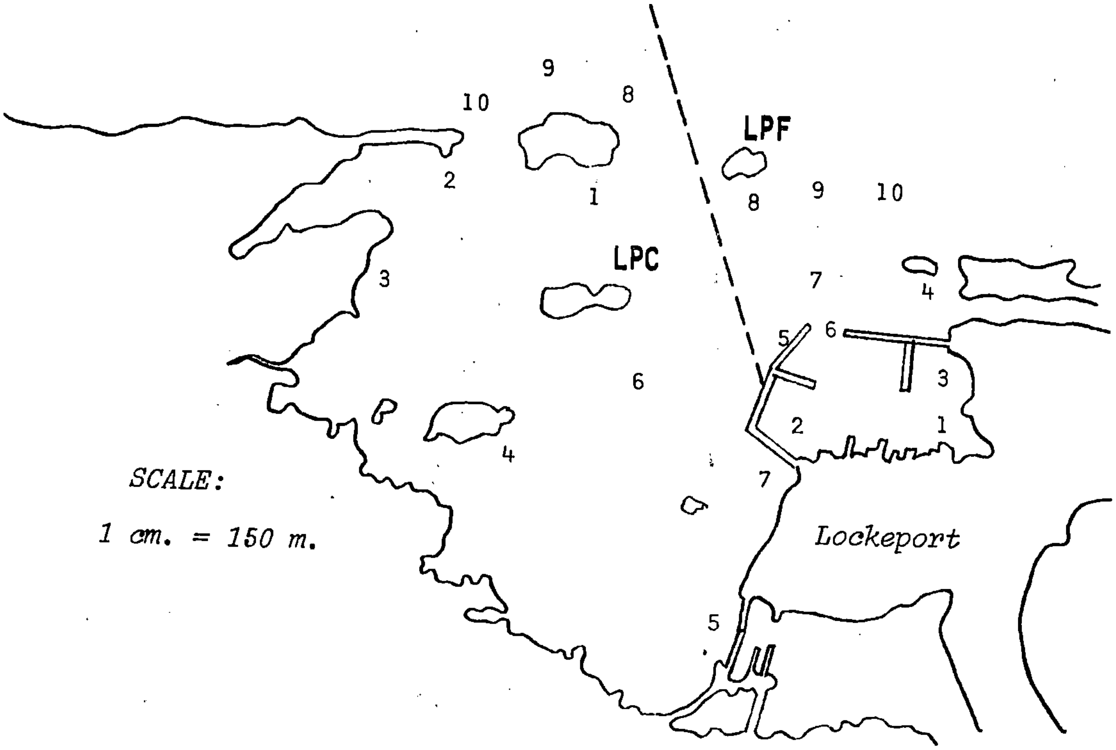


FIG 5 Location of Lockeport Water Quality Stations.



II. WHEN IS A COASTAL INLET POLLUTED ?

A grossly polluted estuary or inlet is not hard to recognize. The growing demand for coastal zone management is based on not letting the environment become utterly deteriorated before something is done about it. This creates the need for indicators of pollution to be identified and for standards to be set that are more stringent than previously. The major problem is determining at what level of particular indices one is willing to say that an estuary is polluted and action required. For example, how much organic matter should be in the water column or - and this is much more difficult - how diverse ought a benthic community to be ? It is easier and at present more practical to design (and control) criteria for the end of the effluent pipe. Governments everywhere are caught in this difficulty, for what is acceptable as an effluent load on one inlet may not be on another. Ecologists have no easier a time than administrators in advising polluters on how much to clean up so that quality coastal waters are assured. In setting guidelines, environmentalist positions are taken that would essentially eliminate human activity or even presence in the coastal zone[11]!

The performance of a guideline must be assessed ultimately by determining how prescribed levels of effluent have affected different kinds of coastal systems. As a framework for examining the implications of various environmental quality indicators, we can generalize pollution effects into several broad categories:

(a) *Direct toxicity (biocidal effects)* - caused by the release of substances not usually encountered in the coastal environment and which lead in the field and in laboratory tests to organism death (e.g. most pesticides, various heavy metals). We may wish to include in this category the effects of substances that are normally present in very small quantities without causing harm but which can be poisonous at high concentrations (e.g.ammonium ion)

(b) *Deoxygenation* - caused by the release of excess oxidizable substances that are either decomposed or chemically oxidized (e.g. large proportion of organic matter released falls into this category).

(c) *Physical interference* - physical changes associated with suspended solids released; including reduction of light penetration, "smothering" of benthos with mats of residue, alteration of bottom-type and hence suitability of substrate for larval settling, burrowing etc.

(d) *Fertilization* - caused by the release of nutrients with direct consequence of excessive growth of some forms of primary producers.

(e) *Insidious alterations* - existence of this category is mostly due to failure in the explanation of various kinds of change in marine ecosystems. In this is included the integrative effects of chronic low-level exposures; alteration of food-chain relationships, competitive equilibria etc. Odum[12] has discussed and defined this category vis-a-vis estuaries.

Any typology will be guilty of isolating that which should be considered as a whole; obviously, fertilization can lead secondarily to most of the other kinds of observed effects. The same could be said for the other categories. In Table 2 a cross-listing is made of properties and indices examined at Louisbourg and Lockeport, against the above categories of impact. The purpose is to show the *principal* effects which we can learn something about from particular properties. The table is strictly qualitative; excellent reviews exist on the meaning of many of these parameters[13-16] and important, if as yet controversial, efforts have been made to set quantitative limits in receiving waters.[17,18]

TABLE 2 Parameters of the study of receiving waters and their relationship general categories of effect on aquatic environment: E = excellent indicator of effect (i.e. closely related); x = related to effect. N.B. almost all properties are ultimately interrelated.

	EFFECT				
PARAMETER	Direct toxicity	Deoxygenation	Physical interference	Fertilization	Insidious alterations
Water quality					
BOD		E			
COD		x	x	x	
Suspended Solids			E		
Inorganic PO4-P				x	
Organic PO4-P				x	
NO4-N				x	
NH3-N	x			x	
Oil & Grease		x	x		
Chlorophyll-a				E	
Particulate C,N			x		
Dissolved O_2		E		x	
Benthic Environment					
Sediment C,N				x	
Algal indicators				E	x
Faunal indicators					E
Specific diversity richness, etc.				x	E

The problem of interpreting environmental data, deciding on acceptable levels, and prescribing effluent limits is great enough. To this are added further special problems related to some unique characteristics of estuaries. For one, coastal aquatic ecosystems are extraordinarily productive in terms of carbon fixation[19], not to mention less well understood productive pathways associated with nitrogen and sulphur cycles[20]. Release by the natural primary producers of heavy annual loads of dissolved and particulate organic matter is not easily separated in measurements of culturally derived organic loads. In a few words, it is difficult to establish baselines in coastal waters.

Perhaps even more distracting is the high spatial and temporal heterogeneity of coastal ecosystems. Surveillance and analysis is, for example, much more of a problem in coastal inlets than in rivers. In the latter,uni-directional flow leads, under reasonably constant rates of effluent addition, to conditions approaching a steady state; hence the classic diagrams of various water quality gradients in streams[21]. In coastal waters, independant action of waves, wind-generated and tidal currents, and fresh water inflow, preclude any such an approach to a steady state.

Both spatial and temporal heterogeneity have been studied in Nova Scotian waters with attention to their impact on measurement of water characteristics. According to Platt et al.[22],

> " ...heterogeneity in plankton distribution can give rise to coefficients of variation up to 70% in single observations of chlorophyll concentration, for which the analytical technique has a precision of better than 10%".

The impact of temporal heterogeneity has been examined in other studies of the same bays with the conclusion that even conservative properties like salinity may change drastically over periods of less than a week[23]. This has led to examination of variability through time of chlorophyll-a concentration over periods as short as 1 day with evidence again of significant short-term variability[24].

Scientists are beginning to consider explicitly the implications of such results for monitoring and management and to devise models that assist in overcoming limitations imposed by intrinsic high variability of coastal systems[25]. But this is far from reality.

The upshot of this is that even an extensive survey of coastal water quality with small and well-replicated sampling intervals, is subjected to errors that cannot be adequately estimated. At Louisbourg and Lockeport, water quality data was collected on 4-5 occasions over one summer. Benthic data for the most part comes from single samples. While the limitations of the data are dealt with in the analysis and discussion throughout the following sections, an attempt has been made to consider the implications of various patterns as if heterogeneity was less than the precision of measurements. The reader, however, ought to be constantly aware of this working assumption.

4 MOVEMENT OF THE WATERS AND THE EFFLUENT

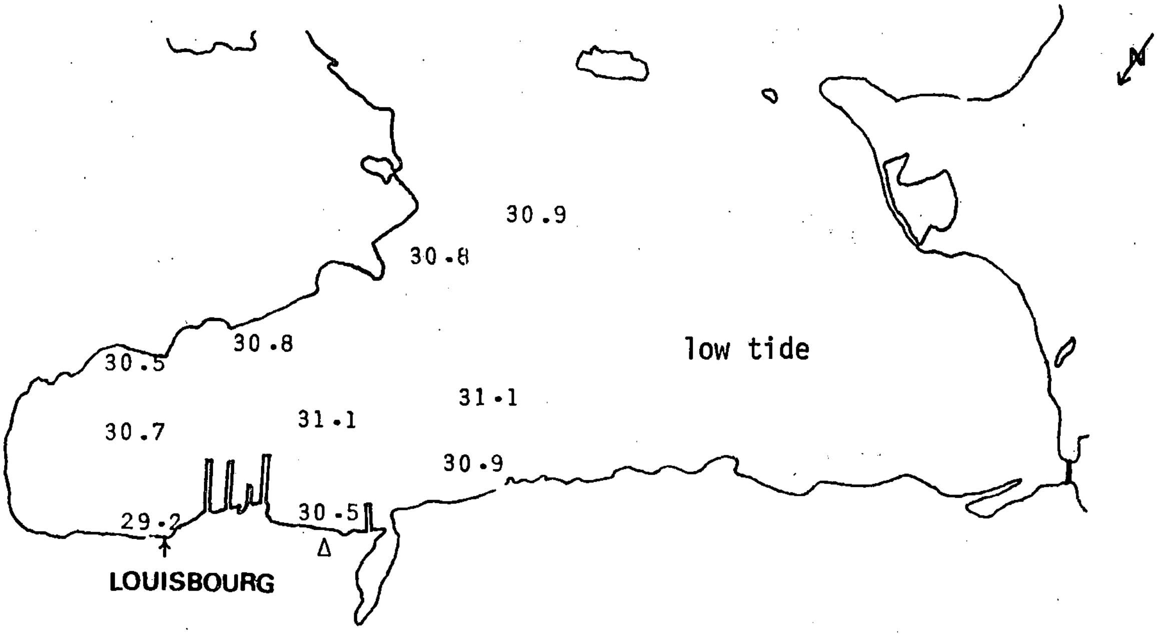
The patterns of marine circulation, including estuarine circulation, are usually determined by examination of salinity, temperature, and dissolved oxygen distributions[26]. In an inshore impact study there are, of course, *a priori* reasons for treating the last of these as a quality indicator rather than a tracer of water masses. Dye and drogue studies can be used additionally, in particular when there is interest in following dispersion patterns from a point source such as an effluent outflow . Extensive work must be carried out for any of these approaches if prediction of the fate of pollutants is to be attempted. In this study, measurement of temperature and salinity and drogue and dye studies were limited and results are used here only as preliminary indicators of circulation patterns.

Louisbourg

Salinity in parts per thousand at 3 m. on sampling dates in June and August are shown in Figs 6a,b . Temperature at the same depth and occasion is given in Figs 7a,b .

The salinities at the station closest to National Sea Products always fall within the range of values obtained farther out in the harbour. While the meal plant utilizes salt water, much larger quantities of fresh water flow from the combined effluents of the filleting and unloading operations (see Volume 2 in this Series). The lack of a noticeable decrease in salinity close to National Sea Products suggests that mixing in that vicinity is fairly vigourous. On the contrary near the Hopkins' plant closer to the head of the

FIG.6 (a) Salinity °/∞ at 3 m., Jun 11



Approximate location of National Sea Products ....Δ
" " Hopkins ....↑

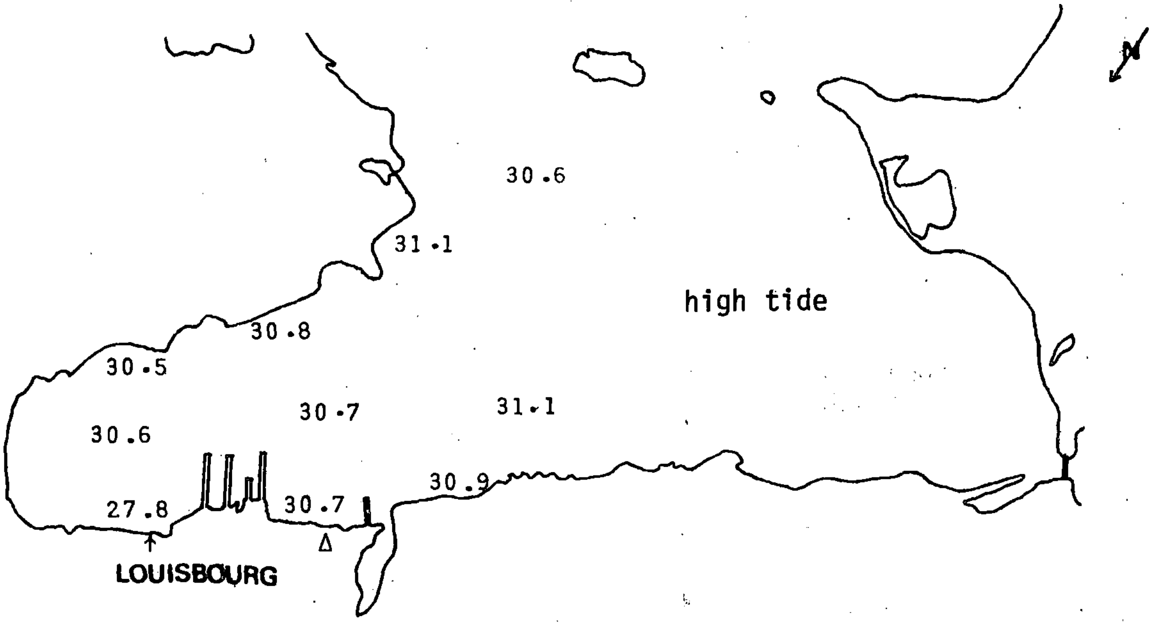


FIG.6(b) Salinity ‰ at 3 m., Aug 7

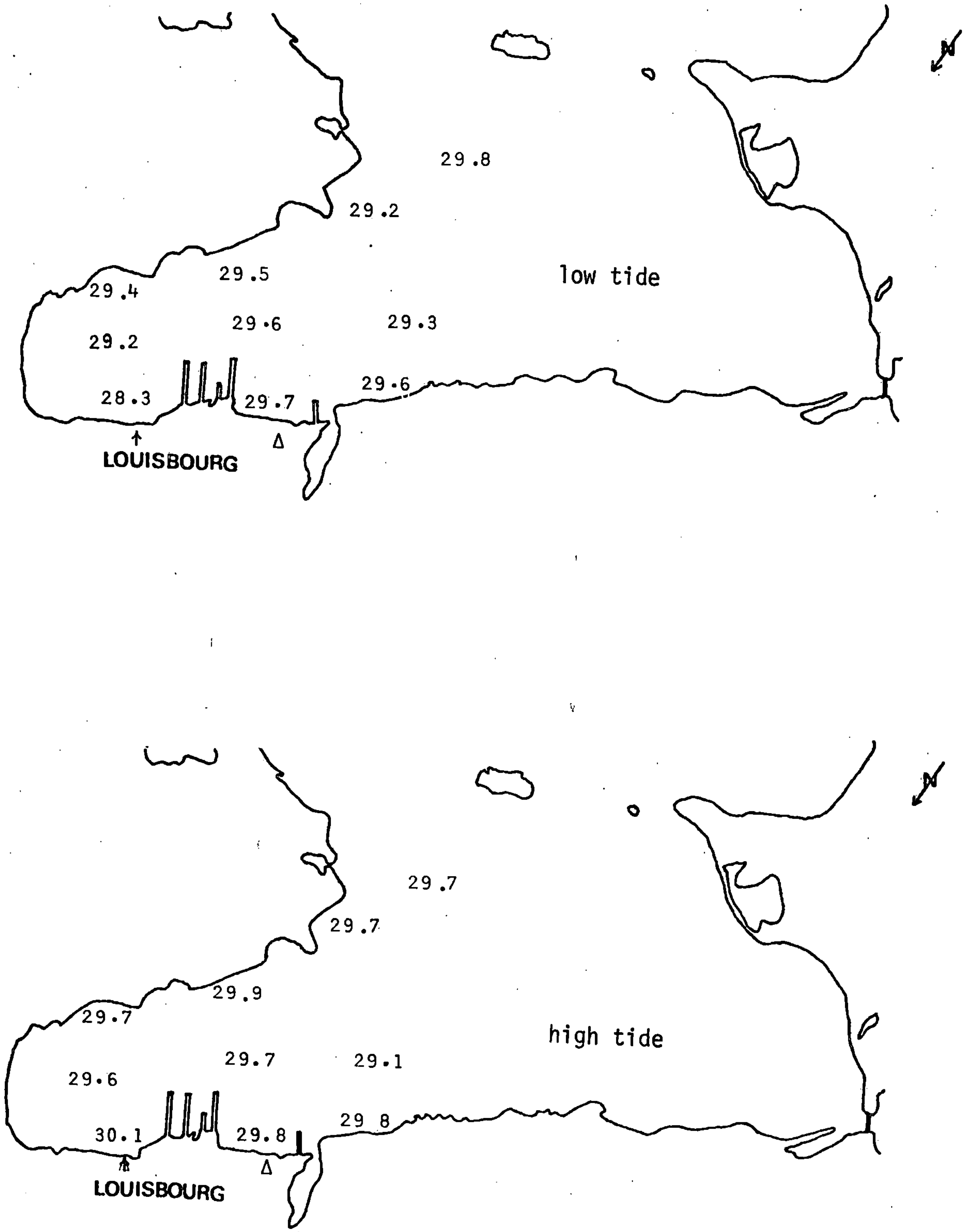


FIG.7(a) Temperature (°C) at 3 m., Jun 11

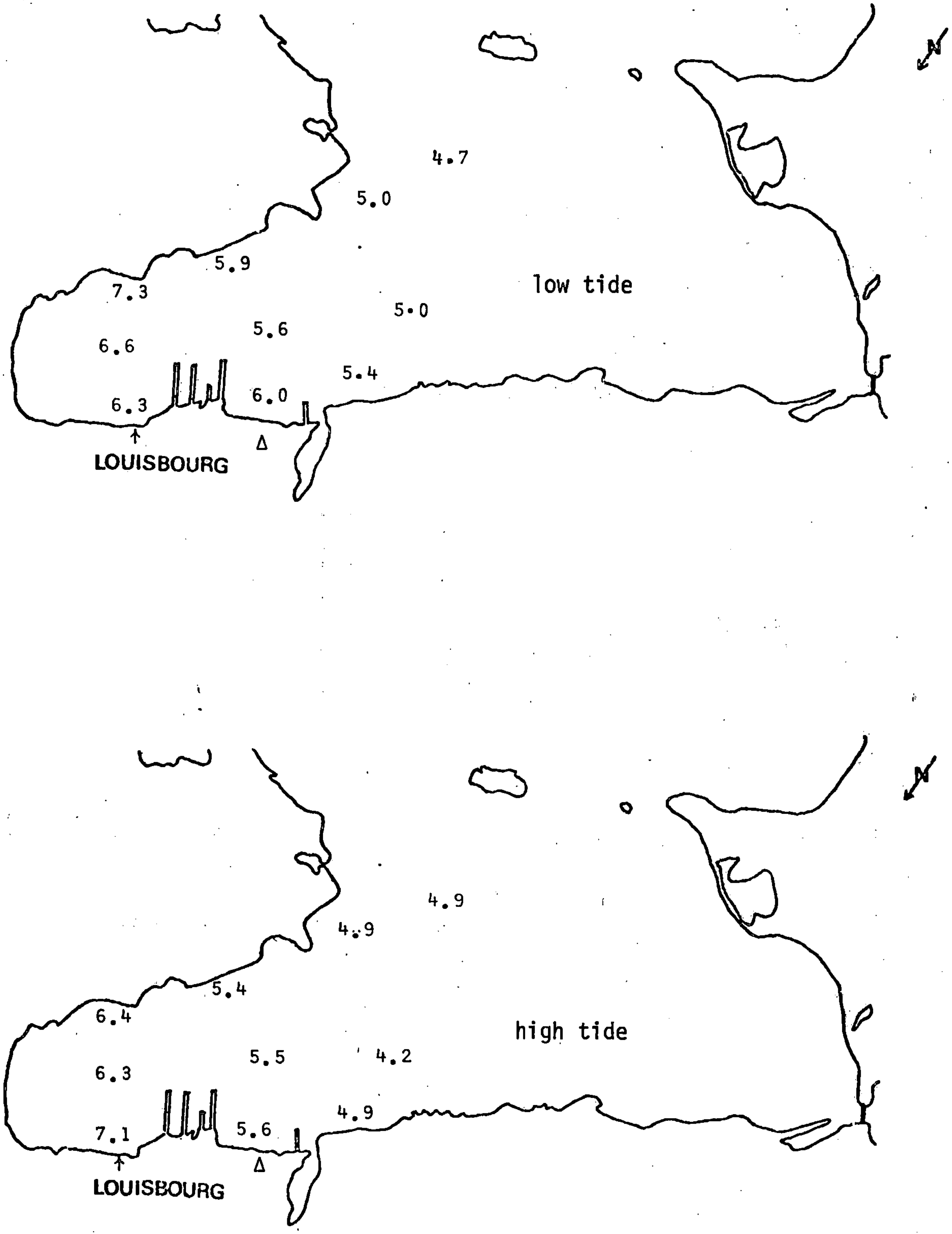
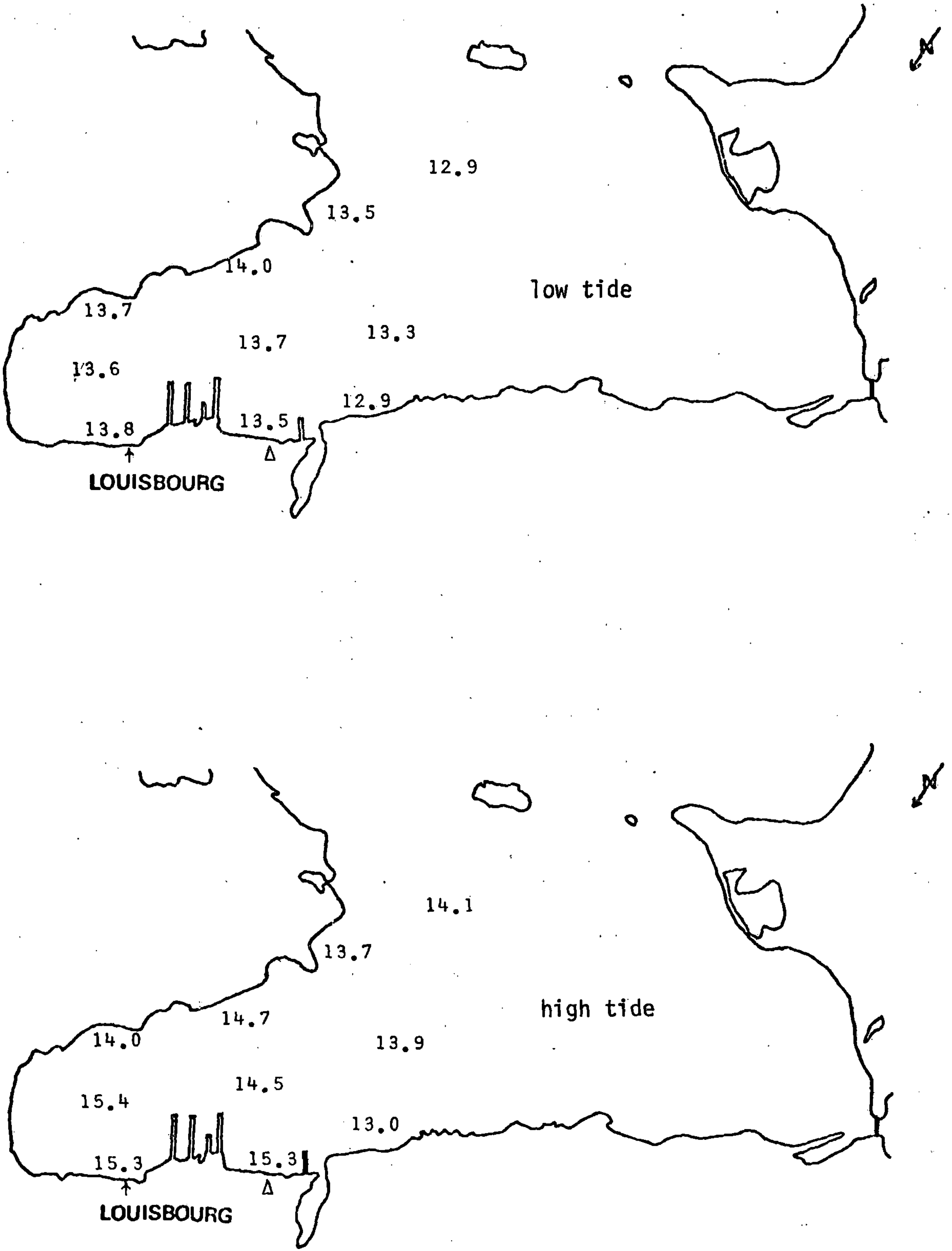


FIG 7(b) Temperature (°C) at 3 m., Aug 7

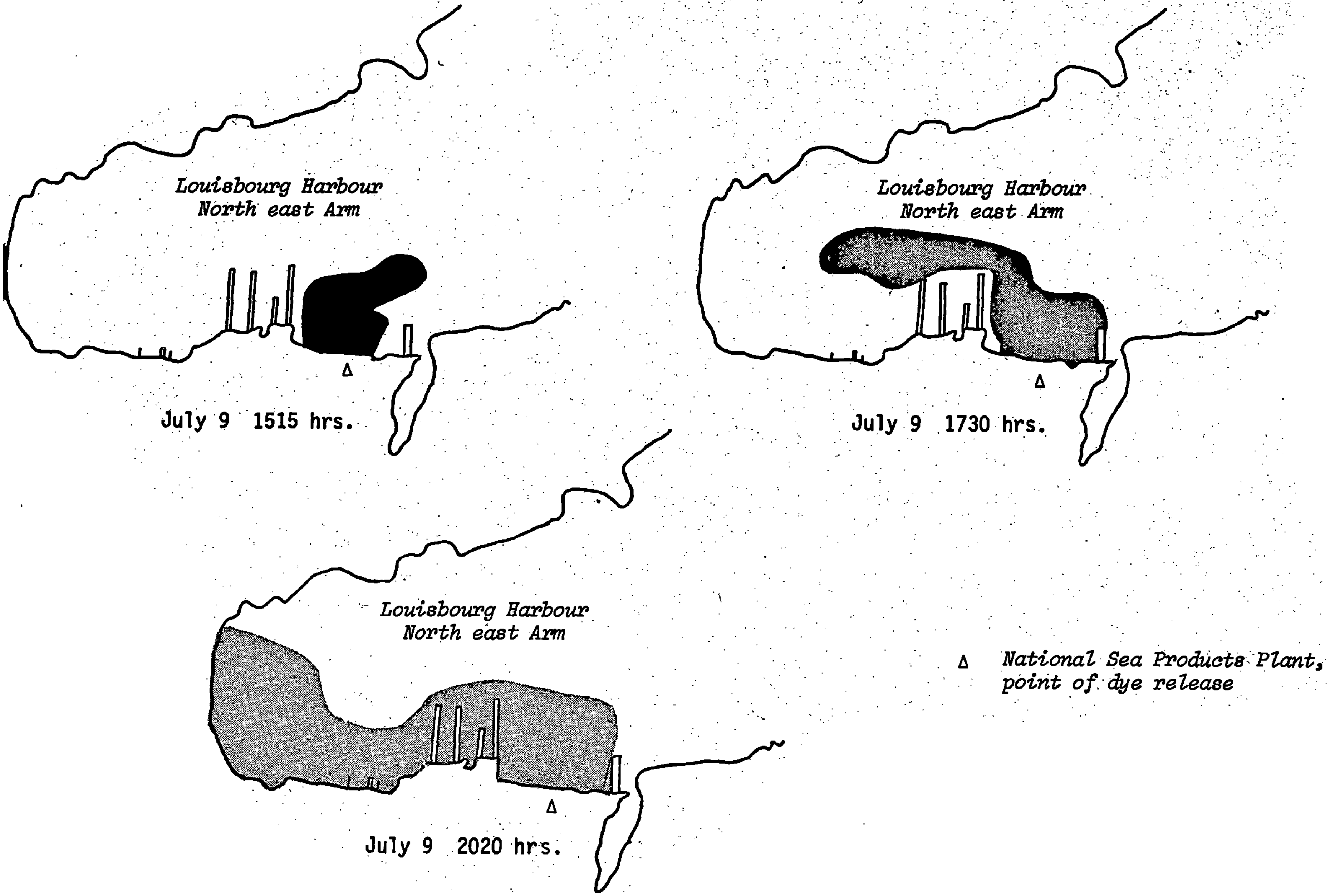


of the Northeast Arm, salinity values were 1 to 3 parts per thousand lower than elsewhere in the harbour, except at the August 7 high tide. On the latter occasion a maximum obtained near Hopkin's and no explanation is offered here. Following the reasoning above, lower salinities suggest that mixing is not vigorous adjacent to the Hopkins' plant. This operation is, in terms of effluent volume, less than 5 % the size of National Sea Products. It is probable that other sources of fresh water and a more restricted circulation join to account for the stronger impact on salinity. The next closest station to Hopkins' shows none of these salinity minima so that mixing appears to have occurred by the time one reaches a point approximately 250 m. from the closer station.

Temperature was consistently higher at the six innermost stations in the Northeast Arm of Louisbourg Harbour. Some limited data not presented here was available on near-bottom temperature at all stations but it did not indicate a thermal stratification in the water column. Higher temperatures may result from the warming effect of inner intertidal areas exposed to warmer air at low water.

Dyes released in an effluent give some indication of the fate of dissolved constituents in the marine environment[27]. On July 9, 1974, at 1230 hrs rhodamine-B was released with effluent from the National Sea Products fish-plant. The visual field of the dye was reported subsequently at 1515, 1730 and 2020 hrs (see Fig.8) Several observations were also made the next day.

FIG. 8 Movement of Rhodamine-B dye, released in NSP (Louisbourg) effluent, 1230, July 9/74



July 9 1515 hrs.

July 9 1730 hrs.

July 9 2020 hrs.

Δ *National Sea Products Plant, point of dye release*

Release of the dye was at high water; thus the first movement and observations reflect circulation on the ebb tide. The dye field was seen to move out past water quality station LBF2 by 1515 hrs. Two hours later dye had reached LBF7 and LBF6 (see Section I-b and Fig. 2). Low water occurred at approximately 1840 hrs and a final observation for the day was made on the rising tide at 2020 hrs. By this time the visual dye field had reached the uppermost part of the Northeast Arm. For the morning on the following day, the field remained conspicuous within this arm and it was not until mid-afternoon that water stations LBF5 and LBF8 fell within the visibly coloured area.

Drogues were placed within the harbour several times on July 10. At 0730 hrs(rising tide) drogues were released approximately at LBF8; at 1030 these arrived at National Sea Products waterfront. Drogues released near high tide about 100 m. southwest of station LBF5, crossed the harbour and were recovered two hours later by LBF1. Finally, drogues freed at station LBF6 at 1445 (ebb tide) were almost immediately washed up on shores at the head of the Northeast Arm.

Experimental errors in assessing current patterns have been considered in the literature both for dye tracer studies[28] and drogues[29]. We are somewhat less concerned with these limitations here since it is the fate of pollutants released at a determined point rather than overall current patterns that are being followed. A more serious difficulty is that observations were taken on only one occasion. Krauel[30], studying the Margaree and Cheticamp estuaries, found quite distinctly different patterns under changing meteorological conditions. Very limited data here means that only correspondingly limited use can be made of the dye and drogue results. In section 5 later in this report, these results have assisted in the assigning of a "rank-ordered distance" from the outflow for correlative studies of water quality. It should be mentioned that divers working on other parts of this project agreed that water movement in the area adjacent to the National Sea Products plant was generally in the direction of the upper parts of the Northeast Arm.

Lockeport

Salinity at the Lockeport "Fish-plant" water stations (3 m.) is shown for two dates in Fig. 9a,b . Temperature readings taken at the same time are given in Fig.10a,b.

Salinity at stations LP1 and LP2 (respectively, the closest to Swim Bros. and National Sea Products) were at no sampling time significantly lower than elsewhere in the area. Swim Bros. uses mainly saltwater for in-plant operations whereas NSP consumes in the order of 150,000 gpd fresh water (see Table 13, Volume 2 of this report). Using the same interpretation as above in the Louisbourg account, one must conclude that mixing is fairly vigorous in the waters adjacent to NSP; otherwise a localized salinity minimum would be encountered. For the Aug 21 sampling, additional information was available on sub-surface salinities at Lockeport. This did not suggest stratification. Had there been stratification it would have been easier to explain the lack of impact that effluent from NSP has on the salinities observed at a depth of 3 metres. We have no alternative to the conclusion that

FIG. 9(a) Salinity °/oo at 3 m., Jul 3

Approx. location, National Sea Products...Δ
" " Swim Bros. ....T

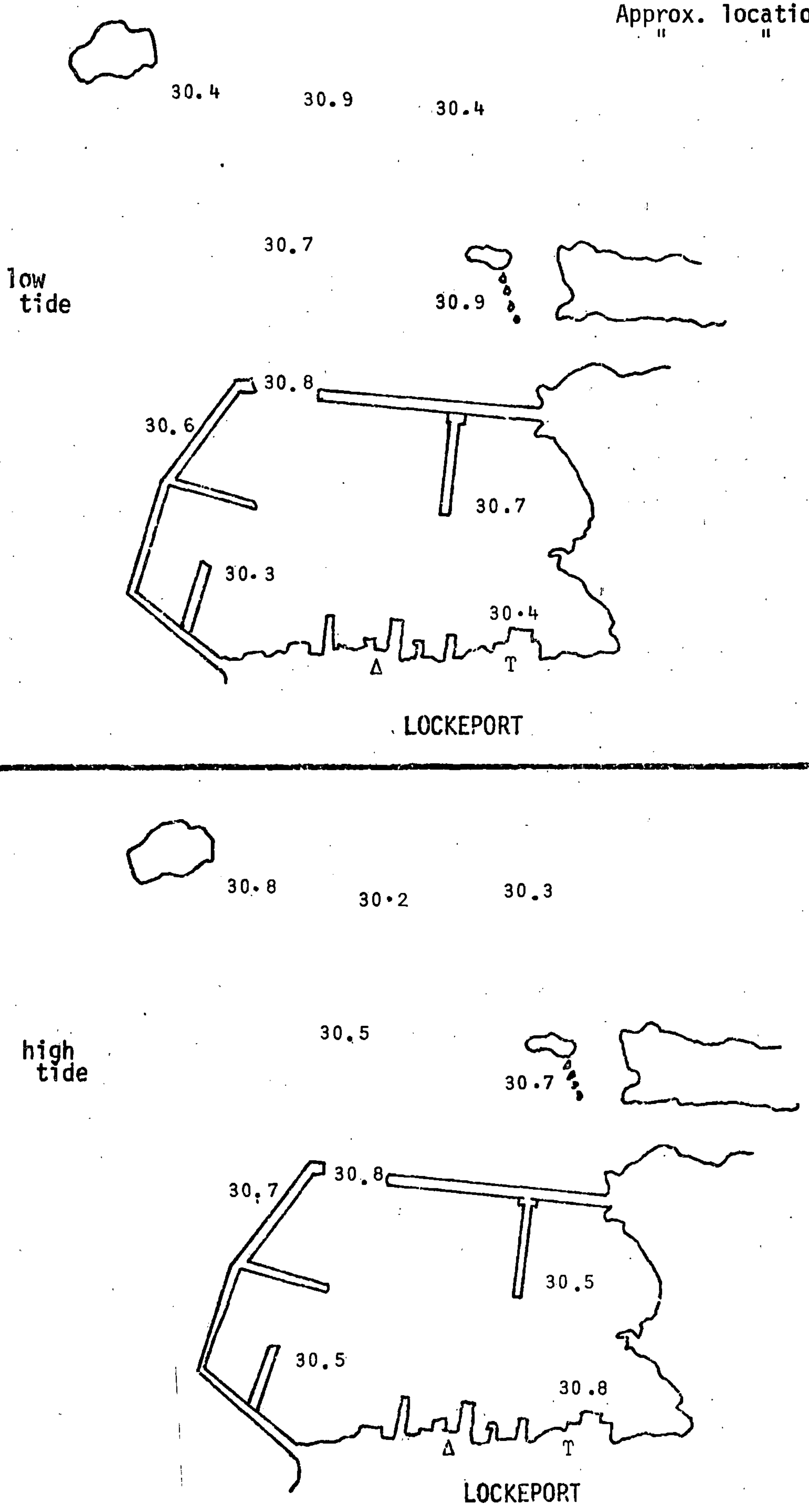


FIG. 9(b) Salinity ‰ at 3 m., Aug 21

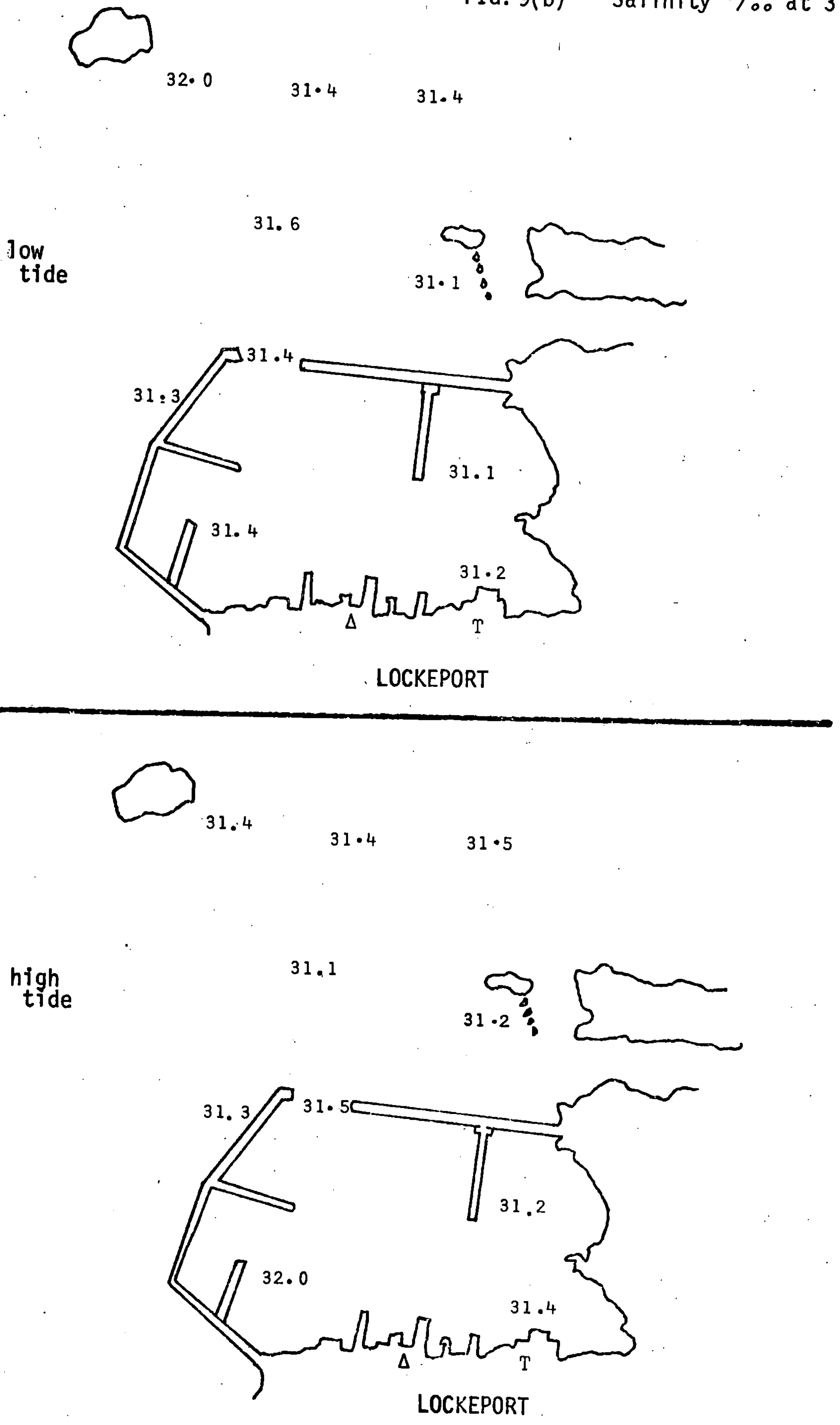


FIG.10(a)Temperature (°C) at 3 m., Jul 3

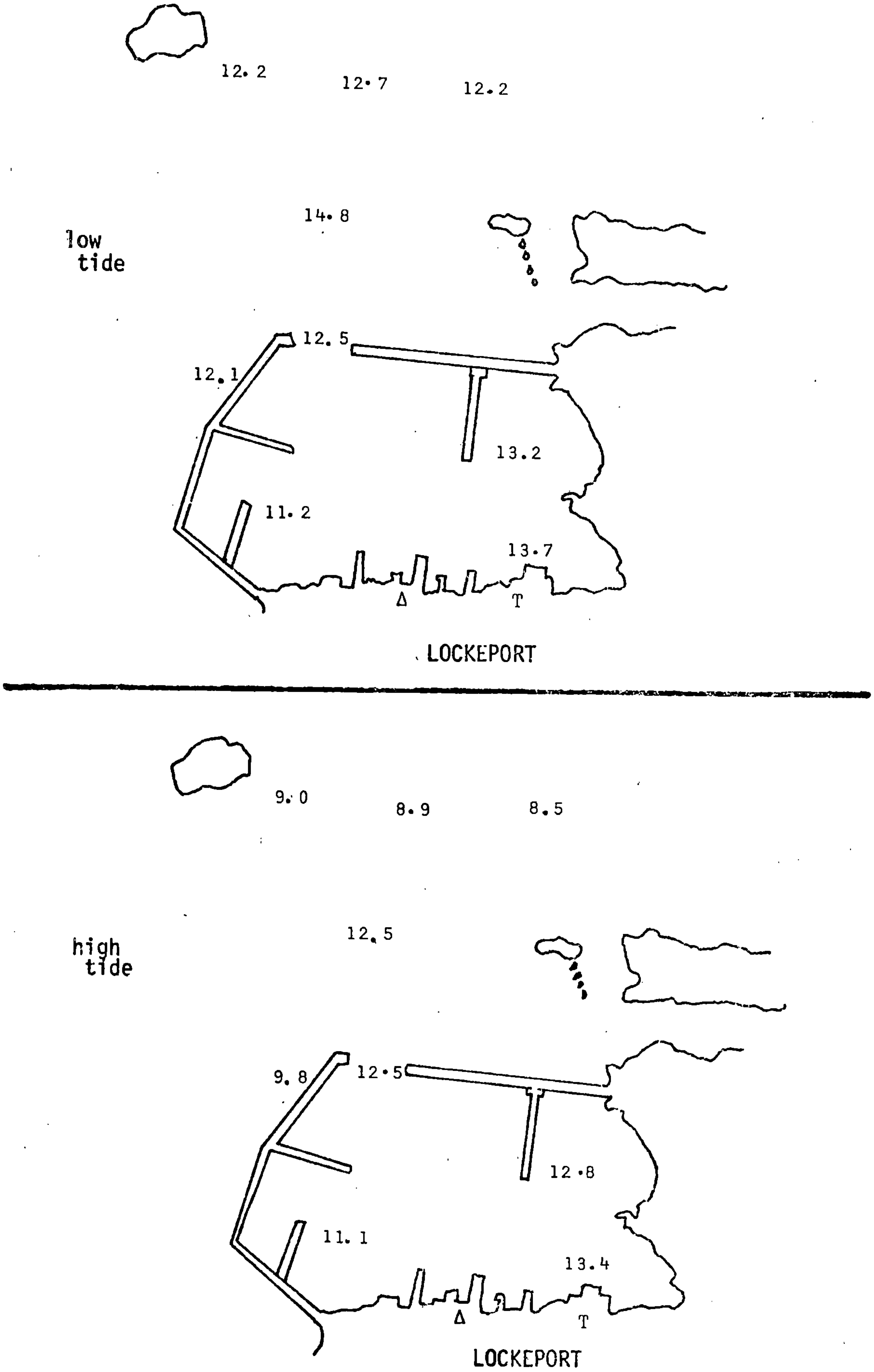
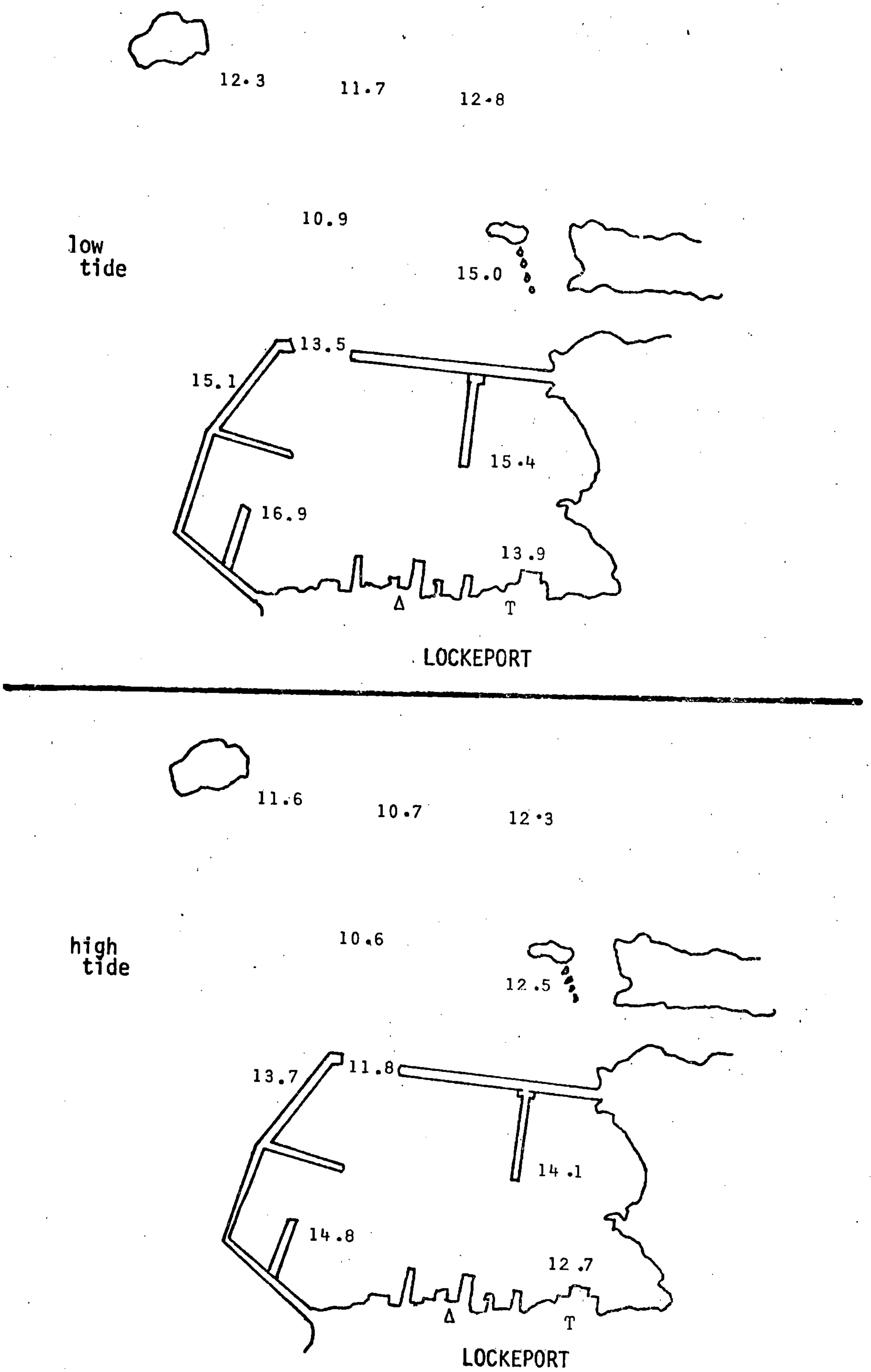


FIG.10(b) Temperature (°C) at 3 m., Aug 21



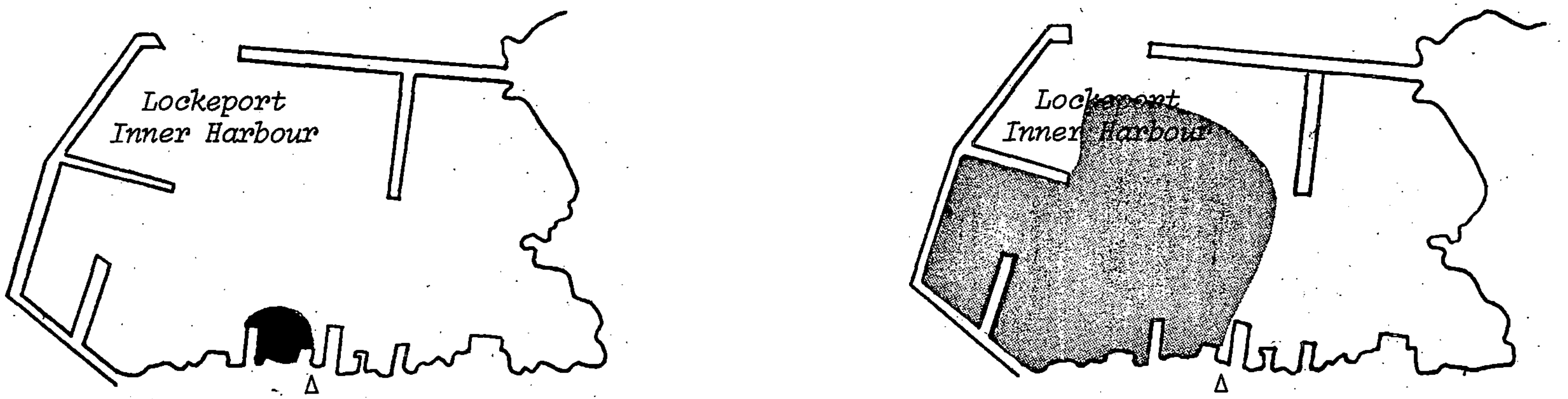
on the basis of limited salinity data the inner harbour is well-mixed. As will be seen below, a less vigorous circulation is indicated by dye studies.

Temperature tended to be higher within the harbour's inner section. The pattern was not, however, consistent over the four sampling times; for example, on the high tide, July 3, station LBF2 is several degrees colder than the other inner harbour stations. But on the same tide in August, temperature is the highest at LBF2. The variation in temperature over short distances is quite large on several occasions: at 3 m. depth on the high tide in July station LBF6 at the mouth of the inner harbour is 2.7 ° warmer than LBF5 around the corner of the breakwater. On August 21,LBF7 is more than 4 degrees colder at low tide than LBF5 - they are 300 m. apart with no intervening shoals or structures.

It appears that there are considerable inhomogeneities in the harbour at Lockeport vis-a-vis temperature. Reconciling this with the salinity observations is not possible in the scope of this study. Perkins[31] found sub-surface patches of warm water in the estuary of the River Blackwater. These "cells of water" were traceable to creeks, littoral areas receiving high insolation, and possibly heated effluent of a power plant. His hypothesis was that high sediment loads in these patches conferred unique specific gravity values and hence stability. Other workers[32] have reported the persistence of narrow plumes from combined domestic and fish-processing wastes at distances of up to 70 km from the outflow. Clearly, the fine structure of water masses may be very different from averaged data. This has immediate significance in pollution studies. Perkins believes that the "existence (of discrete cells of isothermal water) is consistent with the early view that the River Blackwater is not entirely well mixed."[33] Thermal heterogeneity at Lockeport Harbour may have similar implications.

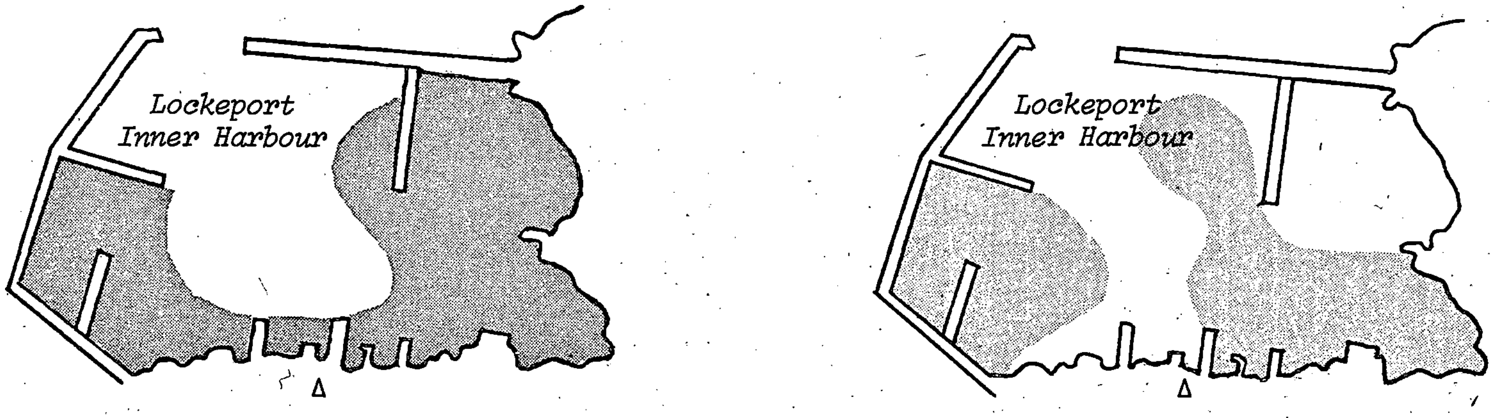
Rhodamine-B dye tracing studies were undertaken at Lockeport on July 23. Dye was added to the effluent from National Sea Products and visual observations of the dye field were made subsequently as summarized in Fig.11 . Release was made at full high tide. In the first 1¼ hours the field diffused over an area of only 100 by 50 m. As the tide ebbed the field moved north and towards the mouth of the inner harbour. Station LPF2 was the first water quality station reached by the dye; this is used as with the Louisbourg dye study to support rank-order correlation analysis in section 5 below. A final observation of the day was made at 2000hrs approximately 7½ hours after release and 1 ½ hours into the new flood tide. The visual dye field had essentially disappeared from the centre of the inner harbour and had formed a U-shaped ring following the waterfront around from the jetty on the north breakwater to the government wharf directly across the harbour from Swim Bros. By the next day the dye field had broken into two patches, one cradled in the angle of the north breakwater, the other extending towards the harbour mouth from the waterfront of the two fish plants. No visible quantity of dye had escaped through the mouth of the harbour.

The same reservation regarding the limited basis for interpreting dye studies applies here as at Louisbourg. Drogues



July 23 1345 hrs.

July 23 1700 hrs.



July 23 2000 hrs.

July 24 1030 hrs.

FIG. 11 Movement of Rhodamine-B Dye, released in NSP (Lockeport) effluent, 1230, July 23/74 released on the same day as the dye repeated the early path of movement suggested by the dispersion of the dye field - towards the north breakwater from a release point near NSP. The indication of good mixing from relatively homogeneous salinity values at 3 m. is at odds both with the observations on thermal patchiness and with the dye studies. The latter, especially in the final formations of the dye field, hints at the cellular structure that Perkins suggested as a characteristic of poor mixing. It is easily imagined that the numerous breakwaters and finger piers dividing the inner harbour into subareas could lead to entrapment of water masses and ultimately to the formation of Perkins' cells. Entrapment could lead to failure of pollutants to disperse as well as to sedimentation of suspended matter.

The complexity of water movement in coastal areas is added to by the construction of structures such as wharves, groins, breakwaters etc. At Lockeport, temperature and dye studies support the idea that circulation may be weak; salinity patterns do not.

5 QUALITY CHARACTERISTICS OF THE RECEIVING WATERS

5.1 Introduction

Some of the problems in using coastal water quality data for pollution assessment were covered in Section II. The importance of variability over short time and space intervals cannot be overemphasized. It is an ever-present constraint on the generalization of the results of even extensive surveys. Regrettably, in the field part of the work at Louisbourg and Lockeport, time did not permit sampling to be carried out over both the control and "fish-plant" areas on the same day. As mentioned elsewhere in this report, variability in the water column of inlets is significant over time intervals shorter than one 24 hr. period. Therefore, where possible, comparisons made here are limited to those among the "fish-plant" area stations near to and more distant from the effluent release point. For the assessment of results of particulate carbon and nitrogen and chlorophyll data, the restricted numbers of stations made it necessary to compare samples obtained on different occasions.

Several approaches have been used in the interpretation of water quality information. Graphical, correlational, and anova analyses, as well as comparisons with other published data, have been made for the following parameters: chemical oxygen demand (COD)[†], suspended solids (SS), total phosphorous as inorganic phosphate (TIP), total phosphorous as organic phosphate (TOP), nitrate-nitrogen (NO3),

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[†] This and the other abbreviations following in parentheses are used freely in subsequent text, figures and tables.

ammonia-nitrogen (NH3), and oils and grease (OG). Results and discussion of these parameters are in section 5.2.

Preliminary examination of the particulate carbon and nitrogen data was sufficient to determine that their levels did notindicate pollution in either harbour. This is considered in section 5.3, together with comparison with particulate loads in other Nova Scotian bays.

Information on chlorophyll concentrations at Louisbourg was studied using analysis of variance with stations, depths, and sampling dates as "main effects". Again, comparisons were made with other data from the region. Data from Lockeport was very limited; fortunately, however, on one occasion both the control and "fish-plant" areas were sampled for chlorophyll analyses. Simple comparisons within the Lockeport area and also with other bays of this coast were made. The chlorophyll results and assessment make up section 5.4.

5.2 COD, SS, Phosphate, Nitrate, Ammonium, and Oil& Grease

Before detailed consideration of the above parameters, mention should be made of several other properties that were studied in the course of the project. Dissolved oxygen patterns are discussed in section 6 on the benthic environment - the habitat usually most affected by oxygen deficit.

Biochemical oxygen demand (BOD) was assessed at Louisbourg but reached measurable levels in only three samples; one from LBF3 near Hopkins' plant (2.3 mg/L at high tide, June 12) and in duplicate samples at LBF5 (2.1 and 1.7 mg/L at low tide on June 11) across the harbour from the fish-plants. Even these few measurable readings are safely below the limits suggested by some authors [34]. As will be seen in section 6, these data for oxygen demand concur with observed values for dissolved oxygen. No BOD observations were available from Lockeport Harbour.

Phenol concentration was assessed on several occasions to see if release might be occurring in any activities associated with the processing plants. No measurable quantities were encountered at either inlet.

Approaches used in the assessment of water quality parameters were uniform. To avoid repetition the rationale and statistical procedures will be described here before considering individual properties. The initial step was to look at patterns of each parameter as related to distance from the outflows.

Distance from the outflow is difficult to define in a meaningful way under the complex hydrographical regimes of tidal inlets. Graphs of the various properties were made, therefore, using only the data from stations which could be ordered regarding distance in a fairly clearcut sequence. For example, at Lockeport station LPF2 is quite obviously closer to the fish-plants than LPF6, however "distance" is defined. Graphs prepared using reasonable if still subjective distance-rankings are useful in gaining an initial view of patterns in the water quality variables.

Along with the problem of assigning a meaningful value to distance from the outflow, there was the problem for many of the parameters that data points were often recorded as less than a certain threshold level of detectability. For ordinary parametric statistical analysis such data must either be omitted or given arbitrary values. Either way, the analysis may be affected in a manner that cannot be detected. In short, the problems with variables in this study were such that a non-parametric approach to analysis of relationships was warranted. Rankings were made of the 10 water quality stations at both harbours using a combination of the information from dye-tracer studies (section 4) and linear distance. Subsequently these rankings were used in calculation of Kendall's τ (tau) correlation coefficient. This non-parametric coefficient is preferable to Spearman's r_S coefficient in data that contain numerous ties[35], a condition that existed for most of the parameters studied.

Finally, a one-way analysis of variance was performed using stations as "main effects". This permitted a priori tests of various group means; of particular interest was the hypothesis that the group of water quality stations closest to the fish-plants would have significantly higher readings of COD, SS etc. than groups of more distant stations.

All statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS) as described by Nie et al.[36]

The above approaches seek an answer to the question of whether there is significant pollution with the assumption that distant water quality stations are essentially unaffected. A check on this assumption and on the seriousness of levels of various water quality indicators is available in data from other Nova Scotian inlets where pollution is either low or well-assessed. Fortunately, considerable effort has been made at St.Margaret's Bay and Petpeswick Inlet on the study of some of the same parameters used here. Comparison is made with these inlets as well as with Bedford Basin where eutrophication is known to have occurred.

TABLE 3 Relationships between distance(rank) from effluent source and water quality properties at Louisbourg, as indicated by Kendall's τ correlation coefficient (number of paired observations,N, and significance level,α , presented below values of τ)

VARIABLE		CORRELATION WITH							
		Rank Distance	COD	SS	TIP	TOP	NO3	O & G	NH3
COD	τ	-.08	-	.05	-.07	.04	.08	.14	.54*
	N	31		30	28	28	28	18	9
	α	.357		.357	.296	.398	.286	.211	.023
SS	τ	-.31**		-	.10	.16	.11	.11	.05
	N	39			36	36	36	25	10
	α	.003			.193	.445	.169	.221	.427
TIP	τ	-.04			-	-.41***	.54***	.25*	.14
	N	47				47	47	26	20
	α	.364				.001	.001	.036	.20
TOP	τ	-.09				-	-.23**	-.10	-.12
	N	47					47	26	20
	α	.176					.012	.23	.230
NO3	τ	-.15					-	.15	-.22
	N	47						26	20
	α	.062						.143	.085
O & G	τ	.01						-	-.25
	N	26							10
	α	.463							.159
NH3	τ	-.09							-
	N	20							
	α	.270							

	error prob.	
*	.05	.01
**	.01	.001
***	.001	

TABLE 4 Relationships between distance(rank) from the effluent source and water quality properties at Lockeport, as indicated by Kendall's correlation coefficient (symbols and other information as in Table 3)

VARIABLE		CORRELATION WITH							
		Rank Distance	COD	SS	TIP	TOP	NO3	O & G	NH3
COD	τ	-.04	-	.37***	.05	-.16	.15	-.19	-.27
	N	43		42	42	43	43	18	17
	α	.345		.001	.307	.064	.072	.125	.064
SS	τ	-.03		-	.03	-.39***	.12	-.22	-.41**
	N	47			47	47	47	18	20
	α	.386			.374	.001	.117	.097	.006
TIP	τ	-.40***			-	-.18	.57	.24	-.11
	N	48				48	48	18	20
	α	.001				.030	.001	.083	.245
TOP	τ	-.13				-	-.15	.13	.40**
	N	48					48	18	20
	α	.104					.063	.212	.008
NO3	τ	-.37***					-	.26	-.31
	N	48						18	20
	α	.001							
O & G	τ	-.55***						-	.54*
	N	18							10
	α	.001							.015
NH3	τ	-.22							-
	N	20							
	α	.085							

TABLE 5 Results of the analysis of variance and *a priori* testing of contrasts between means of station (and groups of stations) water quality variables.

For Louisbourg

List of individual stations or groups of stations involved in contrasts

CONTRAST 1 = Group mean(LBF2, LBF3, LBF6, LBF7) versus Group mean (LBF8, LBF9, LBF10)

CONTRAST 2 = Mean (LBF2) versus Group mean (LBF8, LBF9, LBF10)

CONTRAST 3 = Mean (LBF2) versus Mean (LBF8)

CONTRAST 4 = Mean (LBF2) versus Mean (LBF9)

CONTRAST 5 = Mean (LBF2) versus Mean (LBF10)

(a) COD :

ANOVA:

	df	MS	F	*p*[*]
Between Stations	9	48060.5	.412	.914
Within Stations	21	116540.7		

CONTRASTS:

	1	2	3	4	5
t-value	.14	-.27	1.89	1.70	1.37
t-prob.[Φ]	.90	.81	.20	.23	.40

(b) SS :

ANOVA:

	df	MS	F	*p*
Between Stations	9	9395.1	1.441	.217
Within Stations	29	21001.9		

CONTRASTS:

	1	2	3	4	5
t-value	.32	1.39	2.74	2.36	2.68
t-prob.	.053	.26	.07	.11	.08

---

[*] *p* is the probability that there is no real difference between the variance between stations and within stations. Note that the error variance ("within stations") includes the effect of different sampling times so that what is being tested is a difference between stations that persists.

[Φ] the probability that observed difference between means is due to chance.

...*continued*

TABLE 5 *continued*

(c) TIP :

ANOVA:

	df	MS	F	*p*
Between Stations	9	7265.7	1.01	.453
Within Stations	37	7227.9		

CONTRASTS:	1	2	3	4	5
t-value	1.76	1.29	1.62	1.76	1.65
t-prob.	.12	.27	.18	.15	.17

(d) TOP :

ANOVA:

	df	MS	F	*p*
Between Stations	9	9051.6	.50	.869
Within Stations	37	18272.7		

CONTRASTS:	1	2	3	4	5
t-value	.75	.48	3.76	3.05	3.45
t-prob.	.46	.64	≃.01	≃.01	≃.01

(e) NO3 :

ANOVA:

	df	MS	F	*p*
Between Stations	9	7847.2	1.16	.349
Within Stations	37	6773.6		

CONTRASTS:	1	2	3	4	5
t-value	.19	1.04	1.78	1.84	1.78
t-prob.	.85	.34	.15	.11	.15

(f) OG :

ANOVA:

	df	MS	F	*p*
Between Stations	9	4412.5	1.06	.439
Within Stations	16	4160.9		

CONTRASTS:	1	2	3	4	5
t- value	3.16	5.27	-	13.5	-
t- prob.	>.05	.12	-	.05	-

(g) NH3 :

ANOVA:

	df	MS	F	*p*
Between Stations	9	83775.4	.95	.526
Within Stations	10	88231.5		

CONTRASTS	1	2	3	4	5
t-value	1.01	.87	4.52	2.76	4.16
t-prob.	.50	.48	.14	.22	.15

TABLE 6 Results of the analysis of variance and *a priori* testing of contrasts between means of station (and groups of stations)water quality variables

For Lockeport

List of contrasts

CONTRAST 1 = Group mean (LPF1,LPF2,LPF3,LPF6) versus group mean of (LPF4,LPF5,LPF7,LPF8,LPF9,LPF10)

CONTRAST 2 = Group mean (LPF1,LPF2,LPF3) versus group mean (LPF4, LPF5,LPF7,LPF8,LPF9,LPF10)

CONTRAST 3 = Mean (LPF2) versus group mean (LPF4,LPF5,LPF7,LPF8, LPF9,LPF10)

CONTRAST 4 = Mean (LPF2) versus mean (LPF8)

CONTRAST 5 = Mean (LPF2) versus mean (LPF9)

CONTRAST 6 = Mean (LPF2) versus mean (LPF10)

(a) COD :

ANOVA	df	MS	F	*p*
Between stations	9	1278.4	1.04	.432
Among stations	33	1232.4		

CONTRASTS

	1	2	3	4	5	6
t-value	.49	.61	-1.74	6.63	3.63	3.80
t-prob.	.63	.55	.11	.001	.02	.03

(b) SS :

ANOVA	df	MS	F	*p*
Between stations	9	2241.8	.44	.905
Among stations	37	5117.2		

CONTRASTS

	1	2	3	4	5	6
t- value	.64	.95	.99	2.34	2.37	2.36
t- prob.	.53	.35	.33	.047	.045	.046

(c) TIP :

ANOVA	df	MS	F	*p*
Between stations	9	5719.4	4.34	.001
Among stations	38	1318.5		

CONTRASTS

	1	2	3	4	5	6
t- value	4.91	5.31	3.71	6.93	6.96	7.71
t- prob.	< .001	<.001	.002	<.001	<.001	<.001

TABLE 6 - *continued*

(d) TOP : ANOVA

	df	MS	F	*p*
Between stations	9	3402.1	.36	.949
Among stations	38	9585.1		

CONTRASTS

	1	2	3	4	5	6
t -value	.97	.73	.66	4.93	3.28	4.68
t -prob.	.34	.47	.52	.002	.03	.031

(e) OG : ANOVA

	df	MS	F	*p*
Between stations	9	1712.4	.60	.767
Among stations	8	2840.6		

CONTRASTS

	1	2	3	4	5	6
t- value	4.66	4.84	3.38	3.75	3.75	3.75
t- prob.	.010	.008	.08	.06	.06	.06

(f) NO3 : ANOVA

	df	MS	F	*p*
Between stations	9	76.09	1.83	.095
Among stations	38	41.62		

CONTRASTS

	1	2	3	4	5	6
t- value	2.74	2.86	1.34	7.55	7.55	7.55
t- prob.	.015	.011	.23	.001	.001	.001

(g) NH3 : ANOVA

	df	MS	F	*p*
Between stations	9	12073.	.65	.735
Among stations	10	18541.		

CONTRASTS

	1	2	3	4	5	6
t- value	-.17	.05	.39	1.23	1.24	1.23
t- prob.	.88	.96	.74	.43	.43	.43

COD: Louisbourg

From Fig. 12 there is some suggestion of higher COD at stations closer to the fish-plants. However, this trend was not verified when distance-rankings for all stations were used in correlation analysis (Table 3). Nor was there any indication of a consistent difference between groups of stations from near and far from the fish-plants, as tested after analysis of variance (Table 5).

The most impressive characteristic of the COD measurements was the variability. COD, between the June and the August samplings, varied by close to two orders of magnitude at all "fish-plant" area stations. In fact, some of the June COD values in the receiving waters were not very much below the concentrations measured in the actual effluent (see Table 15, Volume 2). August values were much lower (see Appendix I for all data).

COD is not a property that marine ecologists studying natural ecosystems often look at. No information on a baseline exists therefore. For the purpose of general comparison, data from the Louisbourg control area on COD, can be averaged and compared to COD values (Table 7). In June, the "fish-plant" and control area averages are significantly different. However for August data this is no longer true. Note also that the standard errors for the fish-plant COD's are much higher than in the control area, indicating more variability both in space and time.

FIG. 12 Chemical oxygen demand (COD) versus station (stations portrayed at approximate relative distance from NSP plant outflow) at <u>Louisbourg</u>

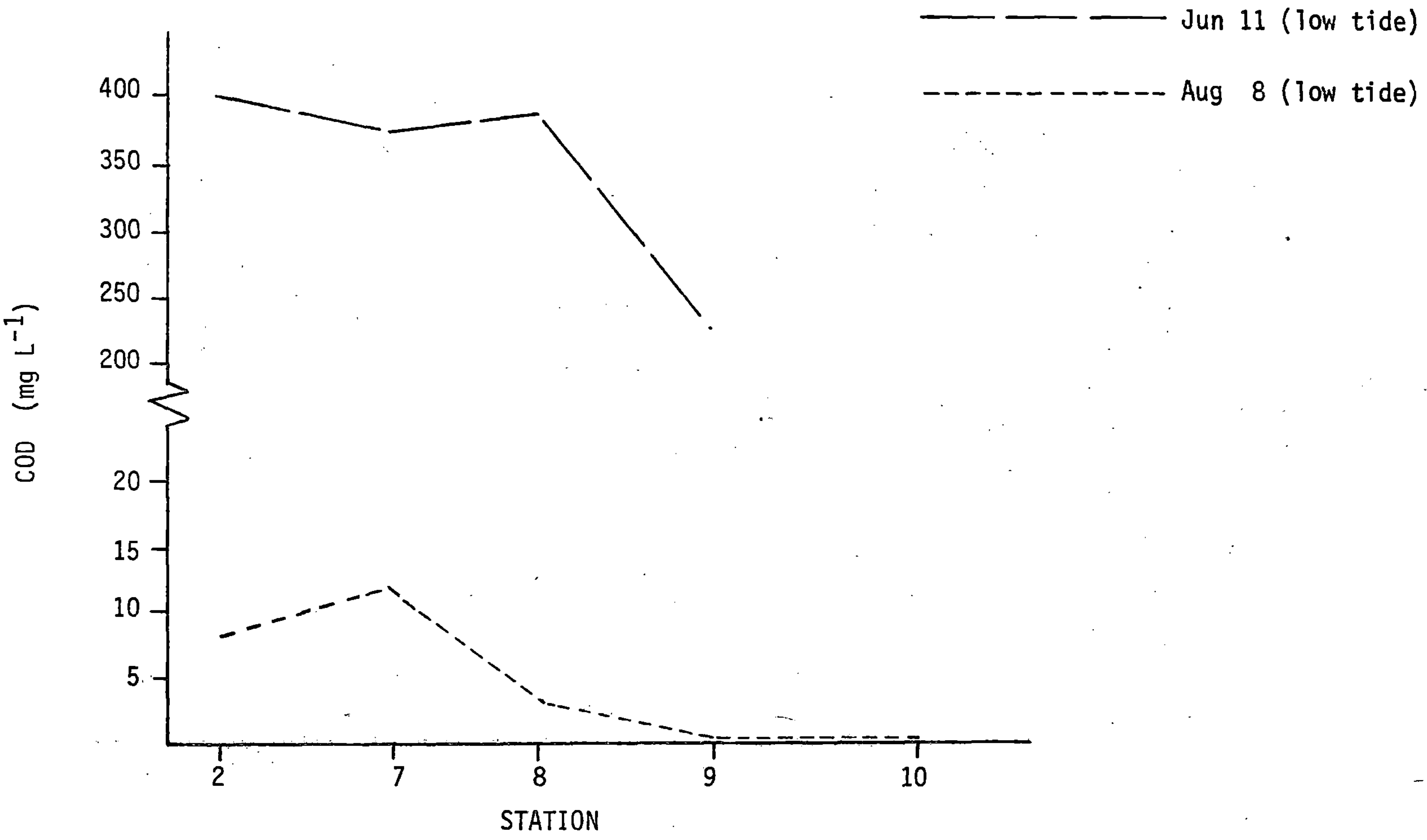


TABLE 7 Average COD (mg/L) and 95 % confidence limits for Louisbourg "fish-plant" and control areas in June and in August

	Jun	Aug
"fish-plant	459.8 ± 128.96	33.5 ± 48.95
control	73.1 ± 15.57	55.4 ± 6.20

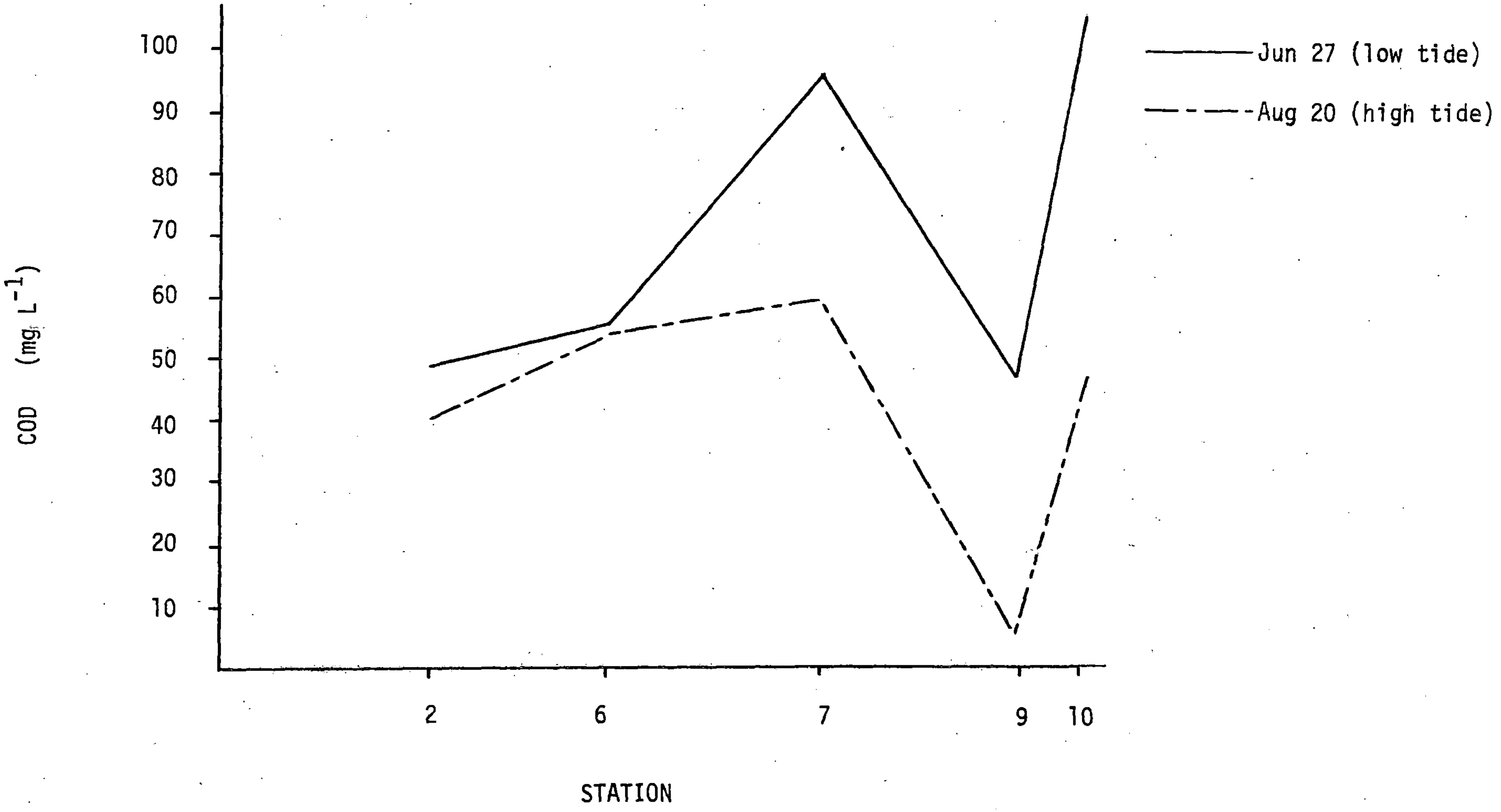
Information was available on seasonal variation in the activity of the fish-plants.[37] Combined values of lbs per day COD from the NSP fish and meal plants, are actually higher in August than June (see Table 15, Vol. 2). As with receiving water concentrations, those of the effluent are highly variable.

COD is a measure of refractory organic matter in waters, from natural as well as human sources. In near-coastal waters an increase is expected in high-molecular weight dissolved organics and in particulate matter to which is adsorbed organic molecules.[38, 39] Decomposition of such compounds or complexes proceeds extremely slowly; thus they contribute to COD. The values of COD in the control area (and in the "fish-plant" area in August) may represent a reasonable estimate of background COD. Assuming this, the high levels such as obtained in June in the "fish-plant" area do not persist and must either be transported from the inlet or deposited on the bottom. The fact that such peaks may be short-lived can be no comfort to those who design coastal monitoring programmes.

COD: Lockeport

No relationship is evident from Fig.13 between distance from the effluent source and COD. There is some correspondence between COD levels at each station on the two different occasions.

FIG. 13 Chemical oxygen demand (COD) versus station (stations portrayed at approximate relative distance from NSP plant outflow) at Lockeport.



The results of the correlation analysis support the impression from Fig.13,as no significant relationships were detected. As can be seen from the table of contrasts (Table 6) the only significant differences over all sampling occasions were between LPF2, near the fish-plants, and each of LPF8, LPF9, and LPF10. It is apparent from both the graph and the data (see Appendix I) that LPF8 and LPF10 are, in fact, higher in COD than the stations within the inner harbour.

Recalling the Louisbourg data, COD levels comparable to the high values there in June are never encountered at Lockeport Harbour. Averages were calculated from the Lockeport control area and are compared(Table 8) to those for the "fish-plant" area. Differences are not significant, if anything, the COD's in the control tend to be somewhat higher.

TABLE 8 Average COD (mg/L) and 95 % confidence limits for <u>Lockeport</u> "fish-plant" and control areas in late June/early July and August

	late Jun/early Jul	Aug
"fish-plant"	63.3 ± 21.18	27.7 ± 7.42
control	84.7 ± 30.23	35.7 ± 5.46

All of the COD values at Lockeport are reasonably close to those from the control area at Louisbourg, data which, we suggested,might represent a background level. There seems little evidence, therefore, that COD values indicate poor condition of waters receiving fish-plant wastes at Lockeport Harbour.

SS: Louisbourg

Suspended solids seem to be higher towards the effluent source in Fig. 14. Correlation analysis supports this impression; a negative and significant value of τ is obtained for distance versus suspended solids concentration (Table 3). Both the scatter of the graph and the fairly low coefficient seem to indicate that the relationship is not very strong. But given the fact that the data is from several occasions and tidal levels, it is important that any relationship emerged.

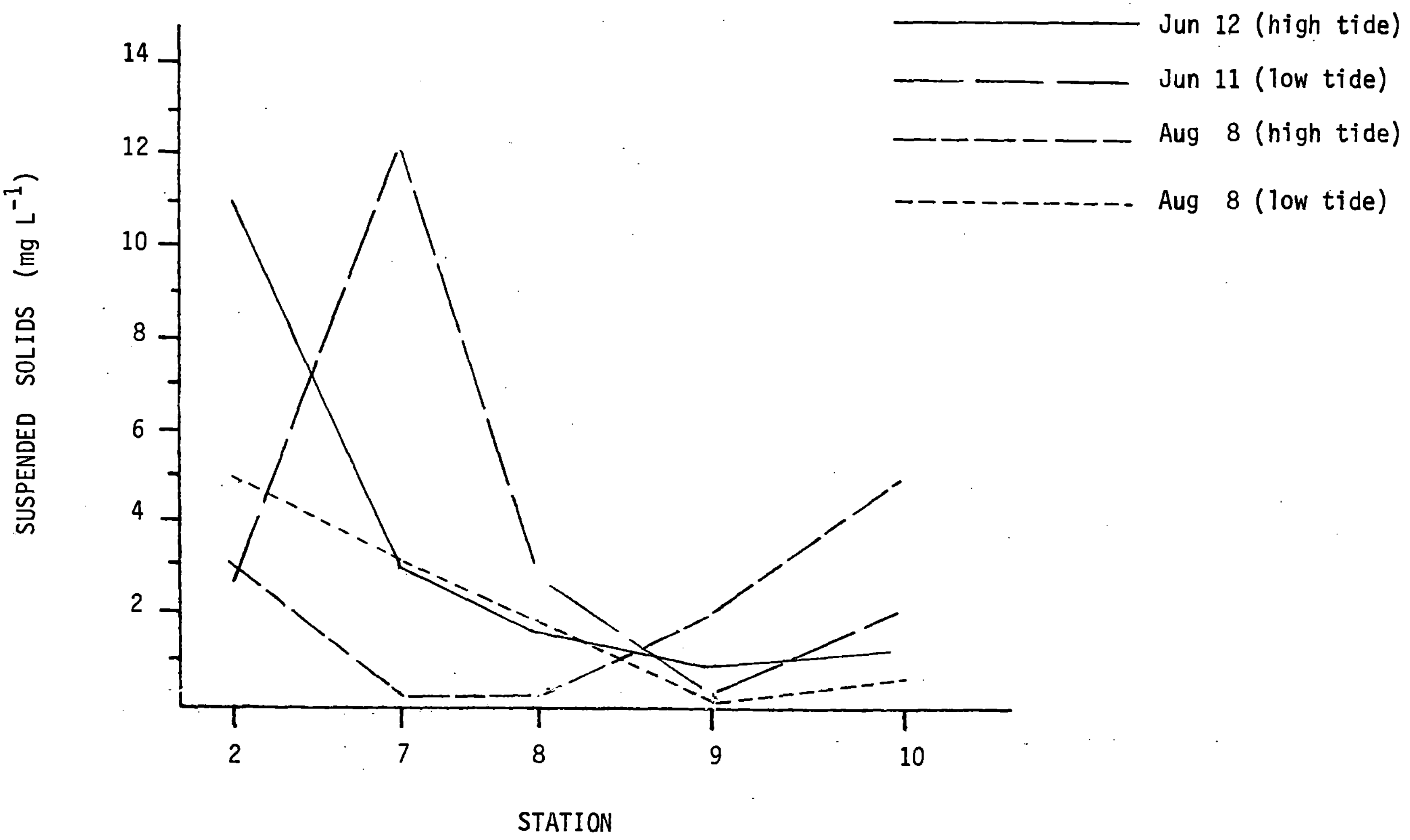
None of the contrasts tested following analysis of variance (Table 5) were significant at the .05 level. However, the contrast of the group mean from the four stations nearest to the fish-plants (LBF2,LBF3,LBF6,LBF7) with the group mean of the most distant stations (LBF8-10) approached this significance level. Variation at each station between sampling times appears from Appendix I to be very high and this creates a "within-group" variance estimate that is correspondingly high. Under this circumstance finding significance in the contrasts is difficult.

In Table 9 mean SS values at the four stations nearest to the fish-plant are compared to the overall mean for those from control area stations. There is no significant difference.

TABLE 9 Mean SS (mg/L) for four "fish-plant" stations and overall for the control area, for all sampling occasions(95% confidence limits for control)

LBF2	LBF3	LBF6	LBF7	Control
4.7	2.3	1.9	5.1	4.0 ± 1.94

FIG. 14 Suspended solids versus station (stations portrayed at approximate relative distance from NSP plant outflow) at Louisbourg



Comparison of suspended solid loads between Louisbourg and other coastal inlets is difficult for several reasons. Some studies intentionally exclude samples that are significantly organic so that suspended sediment can approximate mineral sediment load . More important, background levels of SS (i.e. natural load) must vary tremendously depending on the size, cover, and soil types of adjacent watersheds. Thus according to Perkins , "Water quality requirements for specifying the permissible limits for settleable solids and floating materials cannot be expressed quantitatively at present".[41] Again, the problem is generalizing for ecosystems among which individuality is high. However, seen beside the following comment, Louisbourg SS values are not probably in a range overly harmful to aquatic life: "There does seem reason to suggest that concentrations of suspended solids of 50 to 60 ppm (=mg/l) should not affect growth in fishes to any significant degree".[42]

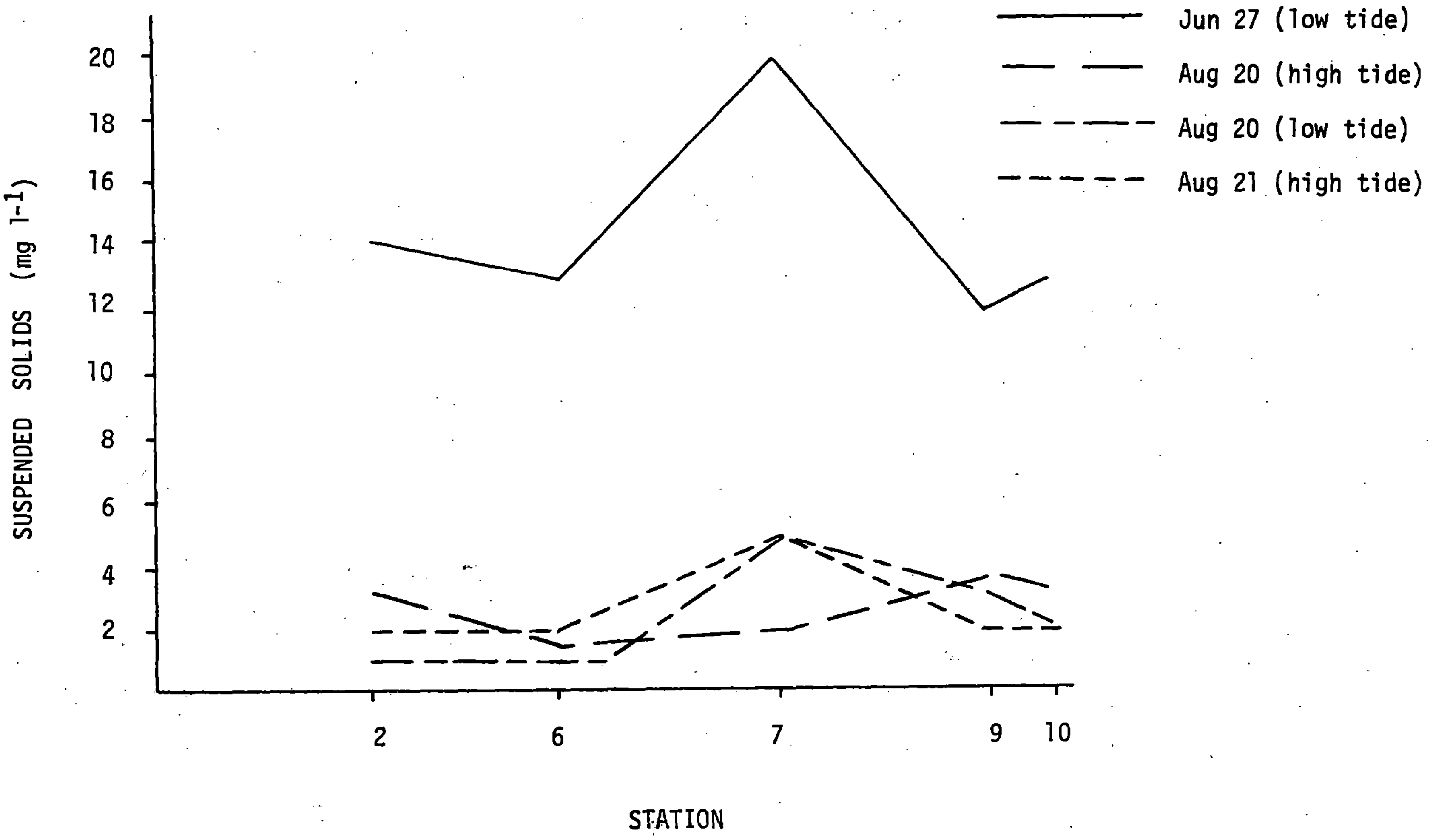
SS: Lockeport

At Lockeport, suspended solid concentrations were generally below 5 mg/l (Fig. 15). On the June 27 low tide, it can be seen that much higher concentrations were encountered. As discussed below, similar high values were obtained in other June samples.

The correlation coefficient for distance against SS at Lockeport was not significantly different from zero (Table 4)

The analysis of variance contrasts (Table 6) suggest, however, that LPF2 was significantly higher over the summer in SS than any of the following: LPF8, LPF9, LPF10. This is certainly not apparent in Fig.15. The divergence results from the effect on

FIG. 15 Suspended solids versus station (stations portrayed at approximate relative distance from NSP outflow) at Lockeport.



LPF2's mean of very high SS readings on June 26 and 27 (Appendix I), dates on which no samples were processed from LPF8-10. The significance of the contrast of overall station means is in doubt therefore, since SS from stations LPF8-10 might well have been high also on the June dates. Data is available for control area stations from early July (1 week after the "fish-plant" area SS values were obtained). This data does suggest that suspended solids were higher throughout Lockeport Harbour during the early part of the summer (Table 10)

TABLE 10 SS values for L F2, control area, and in the effluent of the fish-plants at Lockeport during the early and late summer, 1974.(95 % conf.limits for control)

	Late Jun/ Early July	August
LPF2 (mg/L)	17.1	2.0
Control overall mean (mg/L)	13.4 ± 1.47	2.2 ± .80
Combined Effluent Totals (lbs/day)	137.1	637.2

The mean in June of 3 observations at LPF2 is slightly higher than the overall control mean obtained from samples one week later. No difference exists between the August means.

Fortunately, estimates of the pollutional load from both fish-plants were made on the same dates as the receiving water sampling at LPF2.[43] These are included in Table 10; if anything, the relationship between SS released and SS observed near the plants is a negative one. It is also worth noting that, while June/early July concentrations throughout Lockeport are somewhat higher than those at Louisbourg, they are still considerably below the 50-60 ppm limit implied by Wilber.[44]

In summary, suspended solids near the fish-plant are remarkable neither in relative or absolute quantities and, on limited observation, do not seem to be related to amounts released in the fish-plant effluent.

TIP & TOP: Louisbourg

Phosphorus* both as inorganic and as organic phosphate, showed a very high spatial variability at most sampling times (Fig.16) No single station was consistently high or low relative to others; for example, total inorganic phosphate (TIP) at station LBF2 was far higher than all other stations indicated on the graph on the June 11 low tide. Temporal variability was similarly extreme; LBF8 was the lowest in TIP on the low tide of August 8, but the highest at the following high water.

For TIP, rank correlation and analysis of variance with contrast testing (Tables 3 & 5 respectively) confirmed the impression of variability obtained from graphical analysis. No significant relationship with distance or difference between station means were detected.

Total organic phosphate-P (TOP) likewise showed no significant correlation with ranked distance from the effluent source (Table 3). Contrast testing subsequent to analysis of variance did, however, indicate that the mean TOP concentration at LBF2 was significantly different from means for stations LBF8-10. As can be seen from Table 5 , these means may have been consistently different but are not dramatically so.

Tables 11 & 12 for TIP and TOP respectively, show comparison of values at LBF2 to overall means for the control area for June and August sampling. Inorganic phosphorus is significantly higher on both occasions near the fish-plants.

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* Throughout the following discussion reference to concentrations are all to phosphate-phosphorus.

FIG. 16 Total inorganic phosphate-P vs. station (stations portrayed at approximate relative distance from NSP plant outflow) at Louisbourg

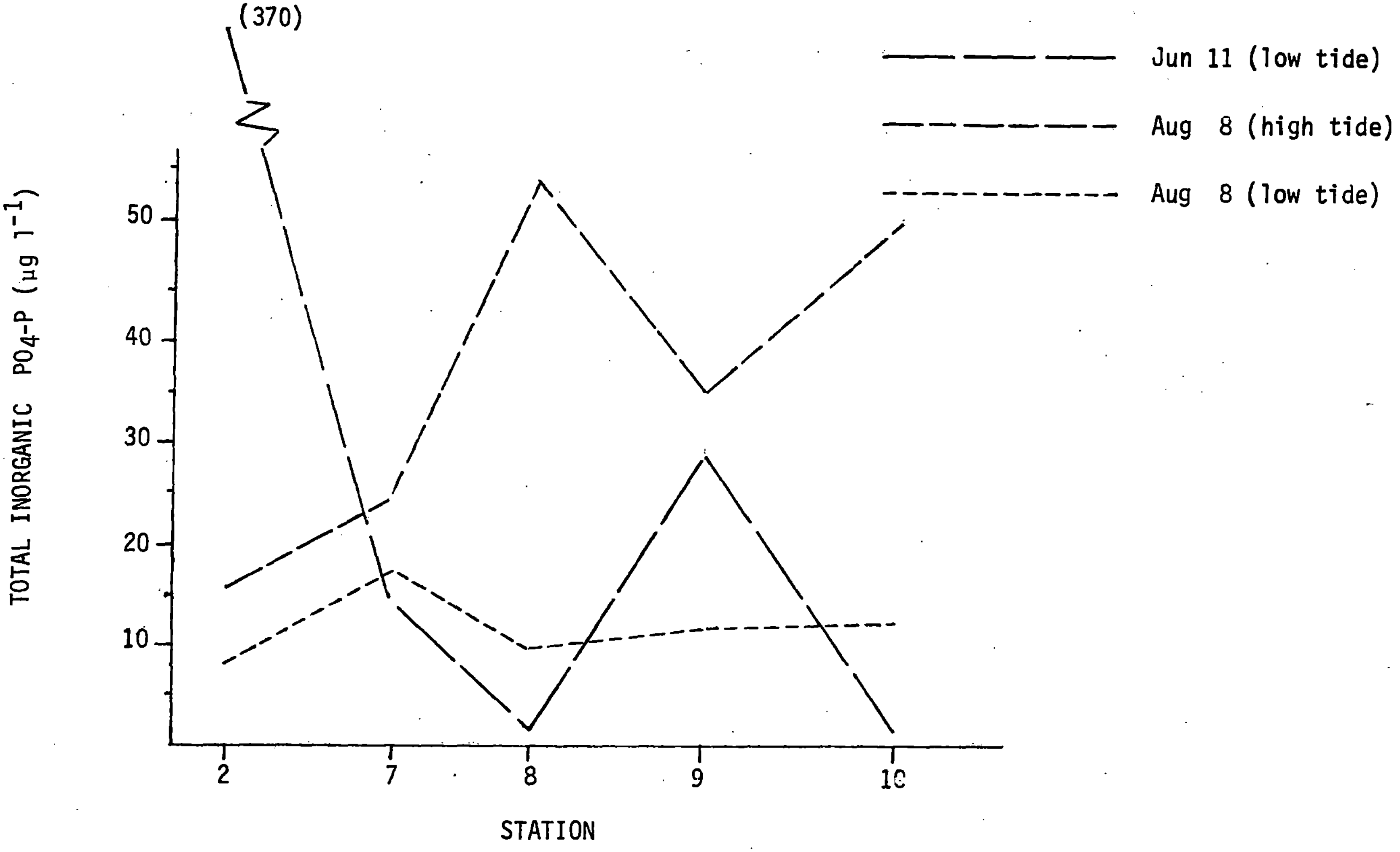


FIG. 17 Total organic phosphate-P versus station (stations portrayed at approximate relative distance from NSP plant outflow) at Louisbourg

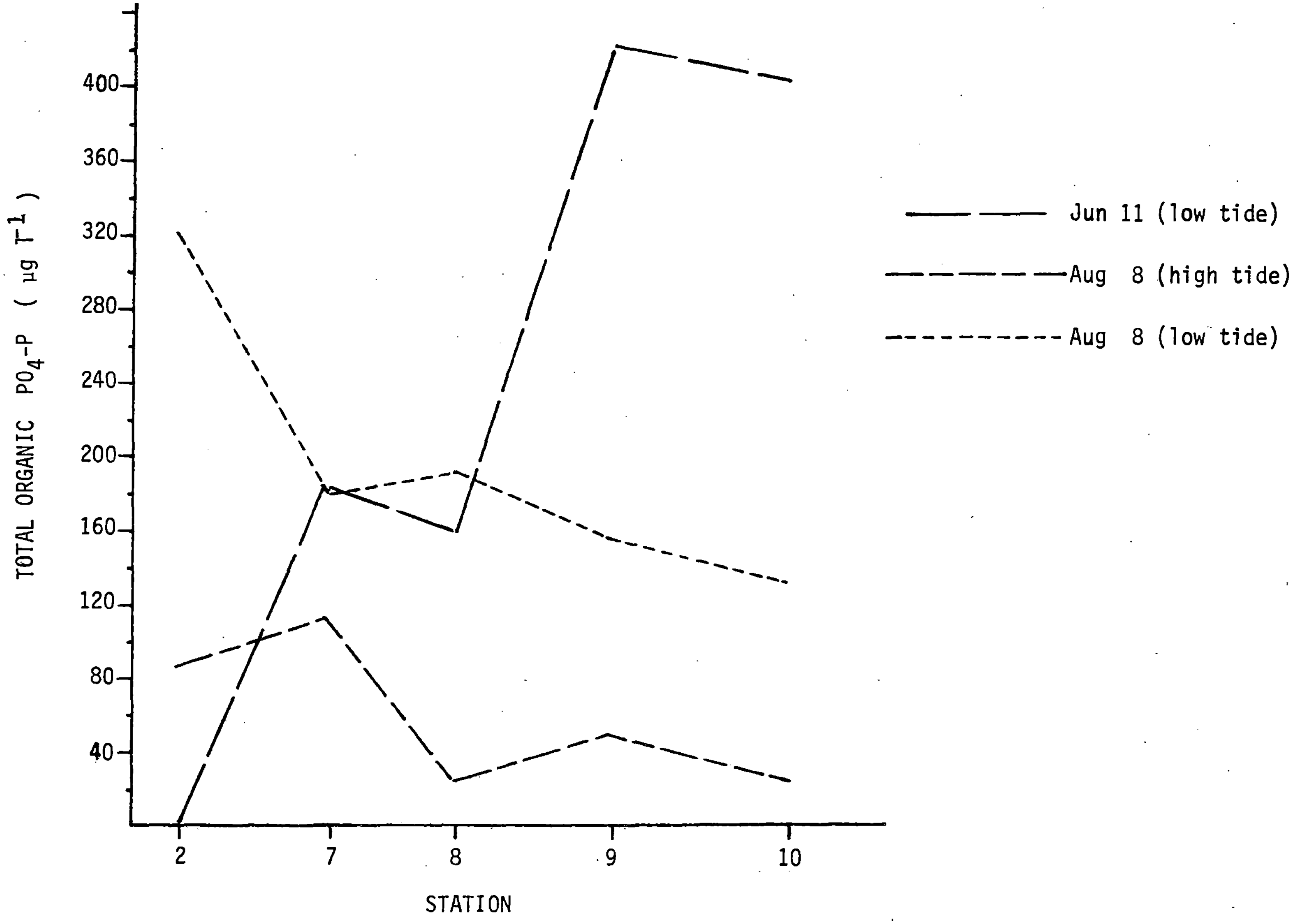


TABLE 11 TIP for June and August dates at station LBF2, for the overall mean of control area stations and in the effluent of the National Sea Products fish and meal operations (95 % confidence limits for control)

	Jun	Aug
LBF2 (μg/l)	126.6	74.0
Control mean (μg/l)	8.5 ± 3.96	28.4 ± 10.58
NSP load (lbs/day)	61.2	79.5

The pattern for total organic phosphorus is quite different, however. In June average TOP is significantly higher in the control area than at LBF2. For the August sampling, values of TOP at LBF2 fall marginally above the upper confidence limit on the mean for the control.

TABLE 12 TOP for June and August dates at LBF2, for the overall control mean and in the effluent from meal plant of NSP (95 % confidence limits for control)

	Jun	Aug
LBF2 (μg/l)	187.5	178.0
Control mean (μg/l)	320.4 ± 51.35	136.5 ± 34.08
NSP load (lbs/day)	1.75	19.10

Information on the pollutional load was available for TIP from the NSP fish and meal plants and for TOP from the meal plant, for dates close to the water sampling occasions (Table 15 Vol.2). This is included in Tables 11 & 12. No simple relationship between amounts of either TIP or TOP released and quantities in the water is seen.

An attempt to disentangle in detail the dynamics of the relationships between these patterns of phosphorus constituents is not at all possible with the data available. As Ketchum and Corwin[45] established, the relationship between quantities of inorganic versus organic phosphorus in coastal waters cannot be expected to be straightforward; they are linked by the natural metabolic processes of photosynthesis and decomposition and in shallow areas to metabolic activities of the sediments. To oversimplify, one might expect to encounter an inorganic phosphate maximum near an effluent and an organic phosphate maximum at some greater distance "downstream" as incorporation into living cells occurs. In inlets such as Louisbourg, there is no "downstream" so that prediction of where various maxima will occur is complex and, without a detailed knowledge of hydrodynamics of the inlet, impossible. Nonetheless, there is at least some suggestion that inorganic phosphate peaks near the effluent source while TOP reaches its maximum elsewhere.

Data is available from other Nova Scotian inlets and this is useful for obtaining a general idea of the importance of observed inorganic phosphate at Louisbourg. Most of this information is expressed as μg-atoms per litre and has been converted to μg/l in Table 13, for the sake of comparison. This table also includes information from Lockeport to be discussed below.

TABLE 13 Comparison of TIP[§] values obtained at Louisbourg and Lockeport with other published data from Nova Scotian inlets.(Where given, confidence limits are for 95%)

STATION/ INLET	Jun or Jul (μg/L)	August (μg/L)
Bedford Basin[†]	3.1 - 12.7	1.2 - 4.7
Petpeswick Inlet[ξ]	9.3 - 17.1	33.2 - 36.6
St.Margaret's Bay[¶]	4.7 - 15.5	3.1 - 10.3
Louisbourg		
LBF2	126.6	74.0
"Fish-plant" $\bar{x}$	45.6 ± 43.33	28.3 ± 13.70
Control $\bar{x}$	8.5 ± 3.96	28.4 ± 10.58
Lockeport		
LPF2	89.3	85.6
"Fish-plant" $\bar{x}$	76.6 ± 27.86	47.1 ± 13.48
Control $\bar{x}$	10.8 ± 5.1	70.1 ± 28.10

[§] All data from top 1-metre

[†] Range of values for June and for August, 1967 (Krauel[46])

[ξ] Range of values for June and for August, 1971 (Platt & Irwin[47])

[¶] Range of values for June and for August, 1969 (Platt & Irwin[48])

Data for making this kind of comparison for total organic phosphate is not so readily available. The sources used in Table 13 frequently report dissolved organic phosphate and/or total particulate phosphate, but not total organic. Since organic phosphate may make up an important proportion of the particulate fraction depending on adsorption and metal complex formation[49], no suitable conversion factor can be devised. It is rather unfortunate that so little information can be found on levels of TOP in natural and polluted waters. Chu[50] established the importance of dissolved organic phosphate as a phosphorus source for some phytoplankton. Moreover, organic phosphate removal is far less efficient than inorganic phosphate removal in treatment systems.[51] Thus, as wastewater treatment is prescribed the importance of understanding this parameter increases.

At Louisbourg, station LBF2 has significantly higher TIP concentration than any of the samples from other studies of Nova Scotian inlets. In fact, many of the values from the fish-plant area as a whole fall outside the range observed from the published data. This is especially true in June. In August, both of the overall means ("fish-plant" and control) seem to be in the range approximately of Petpeswick Inlet. The latter is a naturally highly productive inlet bordered by marsh- and eel-grass beds[52]. Petpeswick Inlet is by no means in a pristine condition; the village of Musquodoboit Harbour is at the head of the inlet, near which is an anaerobic basin of questionable origin. Probably its condition is closer to the natural "end of the spectrum" than Bedford Basin. Interestingly, the latter is a known example of eutrophication yet has generally as low or lower TIP in its surface waters than Petpeswick or St. Margaret's Bay. Deeper waters of Bedford Basin are far richer, however, than the other bays, yielding an integrated TIP (i.e. value under 1 m^2 to the bottom) that is indicative of eutrophication. Comparison of surface nutrient values is of limited value, helping only to detect fairly serious conditions of pollution. Ketchum[53] does offer an upper limit to inorganic phosphate of 52.7 µg/l for summer readings: "These limits may be accepted as danger signals in evaluating the eutrophication of an estuary". At Louisbourg, LBF2 is beyond this limit and at least in June the overall mean for the "fish-plant" area (i.e. the Northeast Arm) approaches Ketchum's "danger signals".

TIP & TOP: Lockeport

With regard to total inorganic phosphate, there is a clear decline with the distance from the outflow among those stations on the graph in Fig. 18 . The Kendall correlation coefficient is very significant and negative, indicating that this decline is evident when all stations are included in the analysis (Table 4). Furthermore, all of the contrasts tested in the analysis of variance were significant. In words, the group mean for the 3 or 4 closest stations to the outflow was much greater than for the group mean of LPF8-10. As well, station LPF2 proves to be significantly higher than any of the individual stations outside the inner harbour.

There is no clearcut relationship beteen distance from the outflow and total organic phosphate apparent from the graph of Lockeport data (Fig. 19) nor a significant relationship indicated by correlation analysis. Station LPF2 does have significantly higher concentration of TOP than does any of LBF8-10 (Table 6).

FIG. 18 Total inorganic phosphate-P vs. station (stations portrayed at approximate relative distance from NSP outflow) at Lockeport.

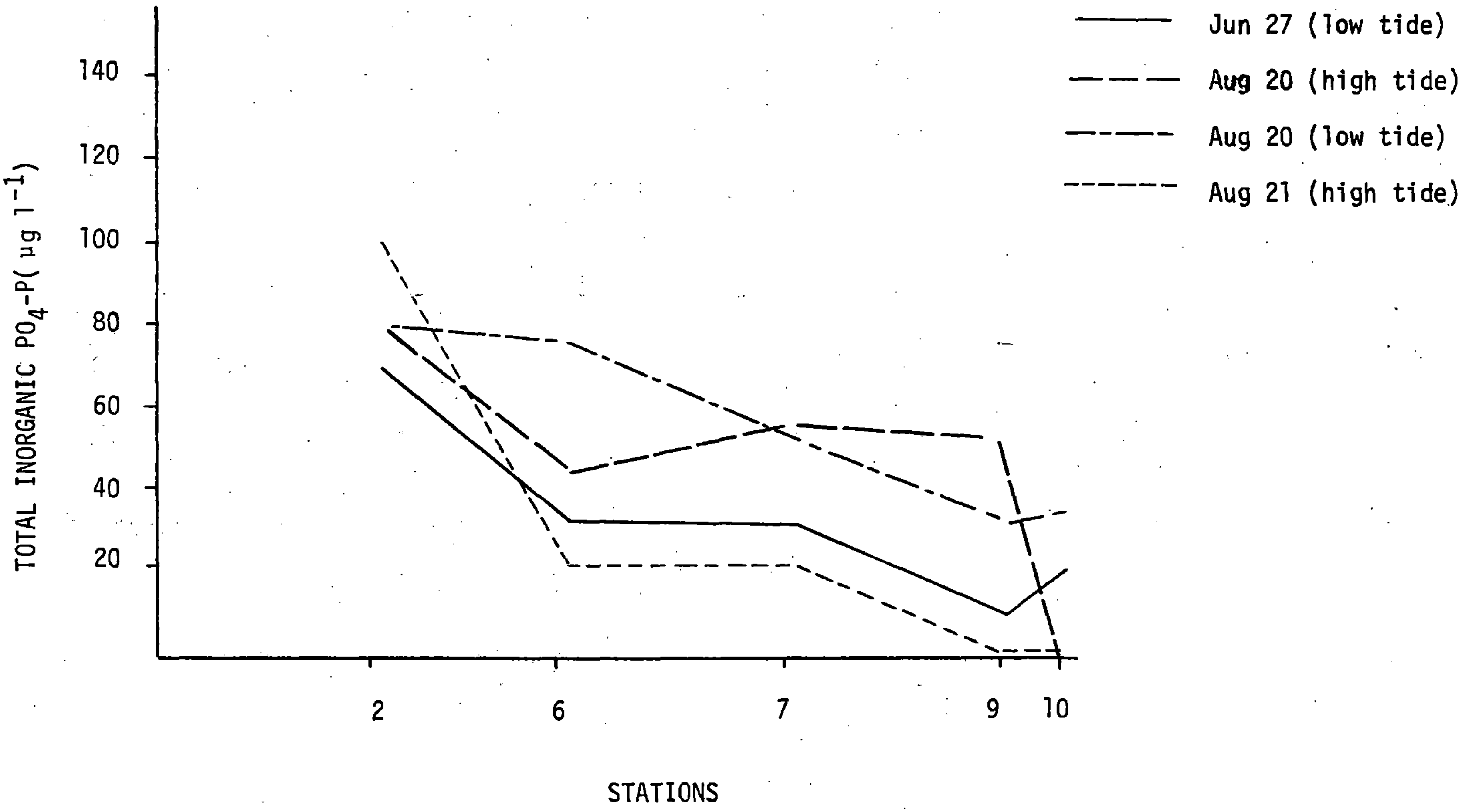
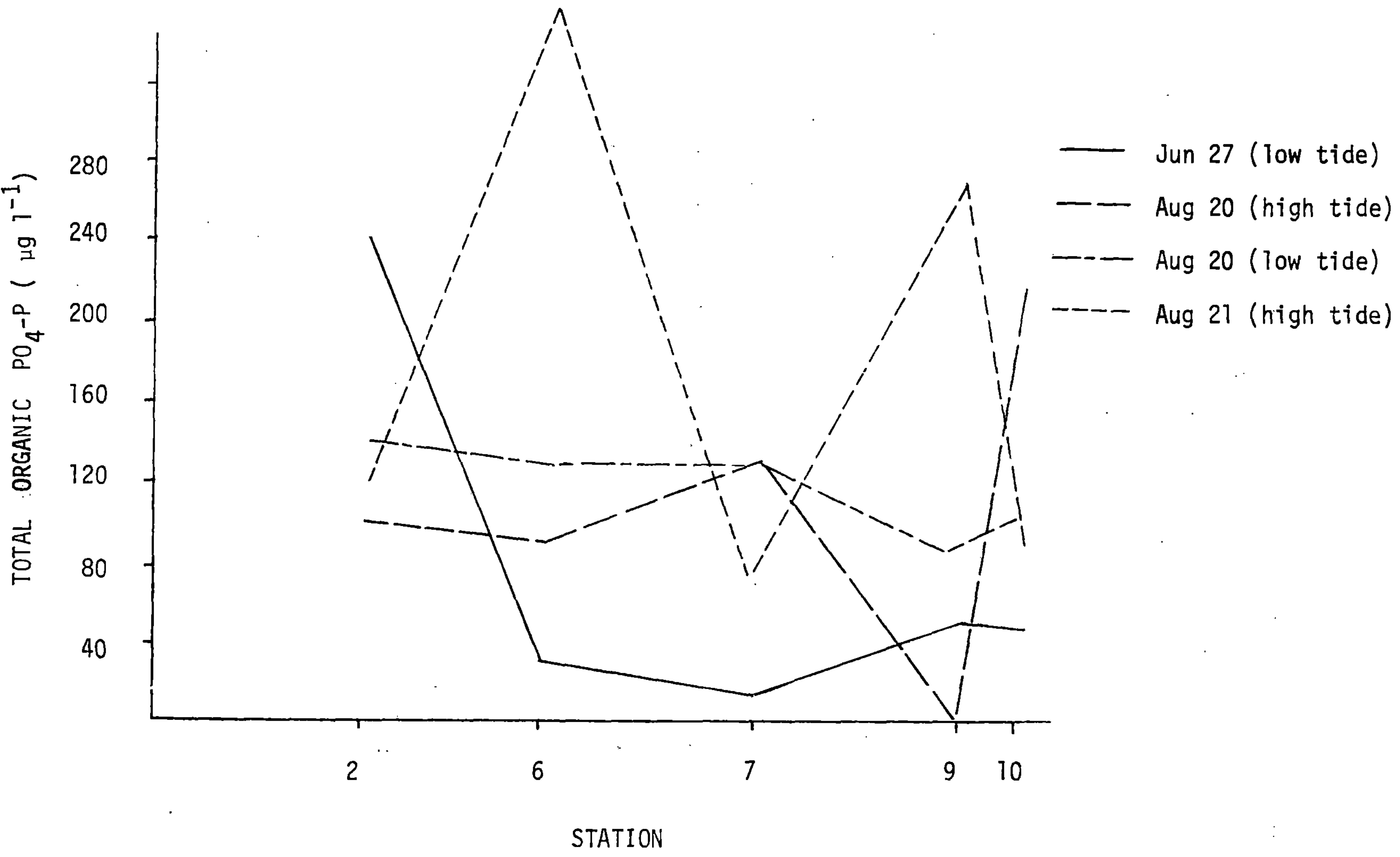


FIG. 19 Total organic phosphate-P versus stations (stations portrayed at approximate relative distance from NSP plant outflow) at Lockeport.



TIP does not change appreciably over the summer at LPF2 although some decline occurs in the average value for the "fish-plant" area as a whole. The greatest change occurring between the sampling dates is the sevenfold increase in the mean value of the control area (Table 14). By August, many of the control area stations have TIP concentrations higher than the 52.7 μg/l mentioned above as Ketchum's limit of estuarine eutrophy.[55] Several hypotheses could be offered for this in light of the coincident decline of TOP (Table 14). There is no chance of supporting or rejecting such speculation with existing data. A number of other indices in this study suggest that the control area at Lockeport ought not to be considered a baseline against which the inner harbour's characteristics can be compared (see Section 6.1).

TABLE 14 TIP & TOP at various locations at Lockeport and in the effluent from the fish-plants

		Jul	Aug
TIP	LPF2 (μg/L)	89.3	85.6
	"Fish-plant" $\bar{x}$ (μg/L)	76.6 ± 27.86	47.1 ± 13.48
	Control $\bar{x}$ (μg/L)	10.8 ± 5.1	70.1 ± 28.10
	Effluent load (lbs/day)	65.0 §	172.8
TOP	LPF2 (μg/L)	112.0	118.0
	"Fish-plant" $\bar{x}$ (μg/L)	43.2 ± 30.39	142.3 ± 30.99
	Control $\bar{x}$ (μg/L)	94.3 ± 38.29	33.1 ± 13.69
	Effluent Load (lbs/day)	27.5 §	no estimate

§ Estimates made in late June; see Tables 19 & 21, Chapter

There can be no question that TIP is very high in the "fish-plant" area and particularly at LPF2 near the outflow of the processing plants. Other relationships are more complex. The main source of the problem of interpreting this data may be that no simultaneous effort was directed to the study of the phosphorus compounds of the underlying sediments. Little doubt exists that the store of phosphorous in the bottom sediments is orders of magnitude greater than that in the water column on an areal basis.[56] The relationship between exchange of phosphorus at the mud-water interface and metabolic processes within and outside the bottom are only beginning to be understood, notably with the help of mathematical models[57]. Interpretation of static observations in pollution surveys will continue to be frought with inconsistencies and mystery until the dynamic view becomes clearer.

NO3-N: Louisbourg

The method used for nitrate-nitrogen analysis could not detect concentrations less than 5.0 μg/l. Of all samples at Louisbourg ("fish-plant" and control), only eleven were above this level. Graphs were not prepared for NO3; neither correlation analysis or contrasts subsequent to anova computation suggested a consistent difference between stations. This may well be due to the problems of analysing data with large numbers of ties[58].

The eleven observations above 5.0 μg/l are presented in Table 15, along with data on the range of NO3 concentration at Lockeport and at other Nova Scotian Inlets.

TABLE 15 NO3 at Louisbourg and Lockeport, 1974, and from published data at other Nova Scotian Inlets. All values are as μg/L. Sources of information as in Table 13.

		Jun	Aug
Louisbourg	LBF2 (Jun 11)	294	
	LBF3 "	215	
	LBF4 "	175	
	LBF9 "	381	
	LBF3 (Aug 7)		7
	LBF4 "		10
	LBF7 "		15
	LBF2 (Aug 8)		250
	LBF6 "		15
	LBC5 (Aug 14)		70
	LBC1 (Aug 15)		10
Lockeport	LPF2	< 5 - 15	< 5 - 10
	"Fish-plant"	< 5 - 30	< 5 - 12
	Control	all < 5	all < 5
Bedford Basin		2.4 - 19.1	1.1 - 5.7
Petpeswick Inlet		all < 1	< 1 - 10.6
St.Margaret's Bay		1.5 - 7.8	1.3 - 5.6

For six samples, NO3-N levels in the harbour of Louisbourg were well outside the range encountered even in an inlet known to be receiving metropolitan wastes (Bedford Basin). One of these observations was made in the control area and could perhaps be unrelated to fish-plant activities. Given that for all other "fish-plant" stations on June 11 and August 8, NO3 was either under 5 μg/l or within the range observed for Petpeswick and St. Margaret's Bay, the most startling pattern is the extreme variability. The general decline of more than an order of magnitude from June to August roughly parallels the disappearance of nitrate during the summer, reported by Carpenter et al.[59] in polluted areas of the Chesapeake Bay. Those authors attribute the decline to biodeposition. As with phosphate, interpretation is a question of whether or not one treats NO3 levels as reflections of input quantities or as the outcome of dynamic balance of metabolic and physical processes. The fact that NO3 persists neither in time (all values were less than 5 μg/l on the following day after the high June 11 values - see Appendix I) or in space (in particular, note the single high NO3 reading at LBF2 on August 8) implies that the simpler interpretation may be satisfactory. NO3 may reach locally extreme levels on some occasions as effluent is released; tides and diffusion cause a fairly rapid dilution.

NO3-N: Lockeport

Most of the stations used in other sections for graphical display had NO3 below 5 μg/l; thus there was not much to be gained from such a representation for NO3. The correlation coefficient between distance and NO3 was significant and negative indicating an overall decline of the nutrient away from the fish - plants. This pattern was also evident from the contrasts (Table 6) made subsequent to analysis of variance. The group mean from the inner harbour was significantly higher than from the"fish-plant" stations outside. LPF2 was, on the basis of individual comparisons, significantly higher than these stations as well.

As can be seen in Table 15, absolute levels of NO3 do not approach the very high concentrations encountered at Louisbourg. Instead, they are approximately in the range reported from other Nova Scotian Inlets. From the concentrations alone, therefore, NO3 levels do not indicate eutrophication of Lockeport Harbour. However, the same conclusion might also be reached from the values from Bedford Basin. Thus, once again, the interpretation of non-continuous nutrient data from surface waters can give only a partial view of the effects of enrichment.

Ammonia-N : Louisbourg

Ammonia-nitrogen* was measured on only two occasions at Louisbourg: in the "fish-plant" area on June 11 and August 8 and in the control area on June 20 and August 15. NH3 values for the usual "fish-plant" stations are graphed in Fig.20 for June 11 but not for the August sampling when almost no difference occurred between stations (range $<$ 20 - 30 µg/l). With only one repeated sampling, significant relationships are expected to be difficult to demonstrate. Neither the correlation with distance nor any of the contrasts tested proved to be significant (Tables 3 & 5, respectively).

Of more interest is the comparison of NH3 concentrations near the fish-plants to (a) the control area and (b) values from other Nova Scotian waters. Comparison of ranges of values obtained for June and August sampling is made in Table 16 .

On the two sampling dates, station LBF2 had ammonia-N concentrations considerably higher than those of the top 1-m. of the three Nova Scotian inlets studied by Platt and Irwin. Even in Bedford Basin (Platt and Irwin's station 3) at a station close to several effluent outflows the highest surface ammonia-N value was 139.6 g/l, about 25 % less than the LBF2 concentration. Moreover, there was no apparent reduction of NH3 by August as apparently occurred in Bedford Basin and Petpeswick. NH3 for the whole "fish-plant" area at Louisbourg exhibited a wide range with station LBF2

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* For convenience the terms NH3, NH3-N, and ammonia-N are used synonymously in the discussion.

FIG 20 NH3-N versus station (stations portrayed at approximate relative distance from NSP plant outflow) at Louisbourg

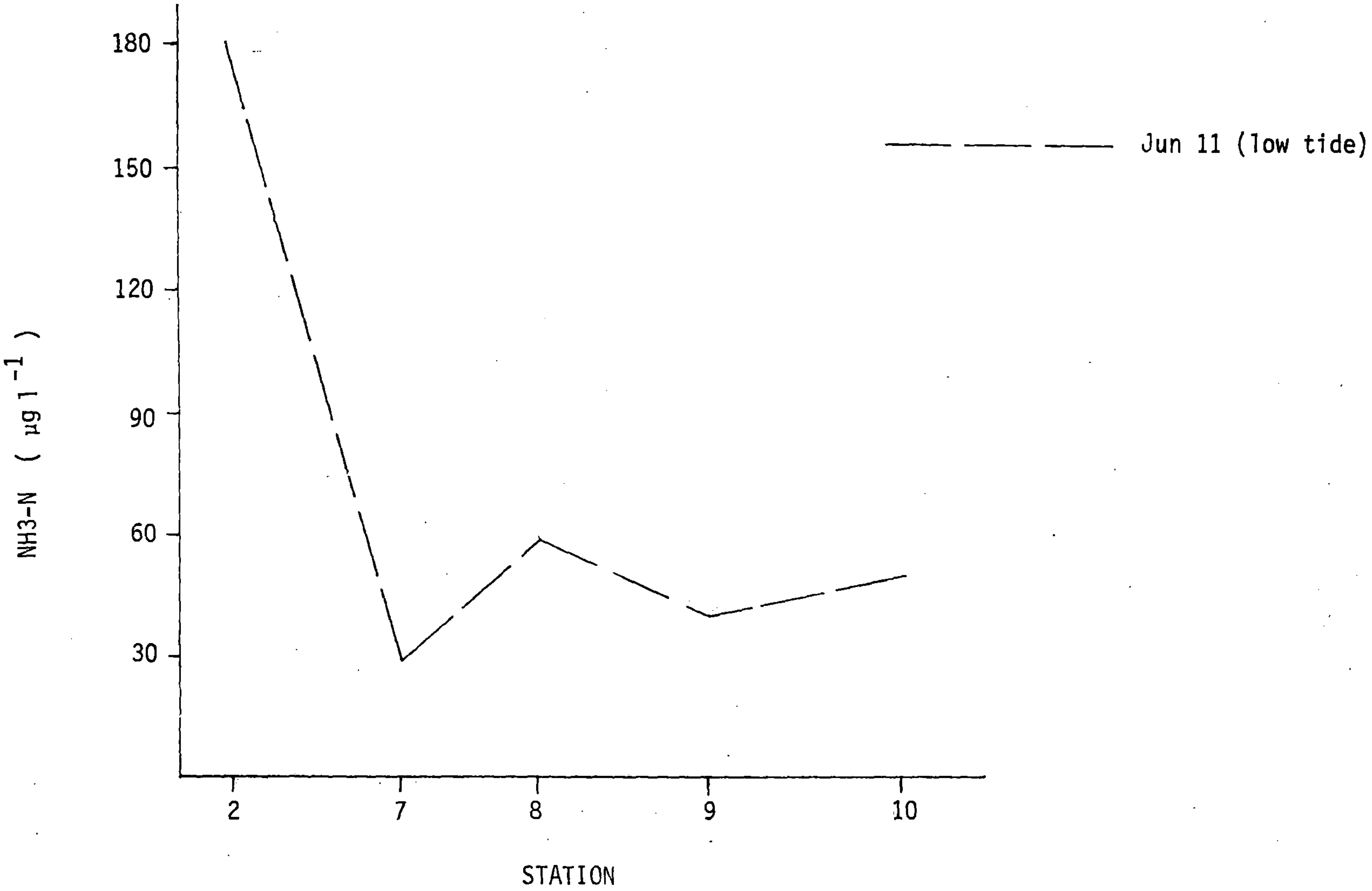

TABLE 16 NH3 range of concentration for early and late summer at Louisbourg, Lockeport, and other Nova Scotian inlets

		Jun /Jul (μg/l)	Aug (μg/l)
Louisbourg	LPF2	180	200
	"Fish-plant"	30 - 180	20 - 1600*
	Control	20 - 110	20 - 60
Lockeport	LPF2	180	2700
	"Fish-plant"	20 - 1290	20 - 4300
	Control	60 - 890	17 - 140
Bedford Basin †		6.7 - 139.6	0.7 - 9.0 (127.7)§
Petpeswick Inlet ξ		4.2 - 18.5 (378.0)§	7.7 - 12.5 (123.8)§
St. Margaret's Bay ¶		1.3 - 6.4 (22.7)§	no values

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§ Highest NH3 values encountered in inlet's deepest waters at each sampling time

† Values from all stations, 1969, Platt & Irwin[60]

ξ Values from station 1, 1971, Platt & Irwin[61]

¶ Values from station A, 1967, Platt & Irwin[62]

* A value of 133 mg/l (133000 μg/l) was recorded for station LBF3 on Aug 8; it is probably a contaminated sample.

reaching the maximum value (consult Appendix I for exact data). In August a concentration of 1600 g/l (1.6 mg/l) was recorded for station LBF1 near the mouth of Gerratt Brook a value more than ten times as high as recorded in the *bottom waters* of either Bedford Basin or Petpeswick in August. Additionally, as recorded in a footnote in Table 16 , the remarkable value of 133 mg/l of NH3 was encountered in a sample from LBF3 near the Hopkin's plant. This would not make a bad household cleaner - but is probably due to contamination of the sample.

The control area had much lower maximum NH3 concentrations but was still higher in these by far than Petpeswick Inlet and St. Margaret's Bay.

Handling of samples for and the actual measurement of ammonia-N is one of the more troublesome analyses facing the water chemist. This methodological difficulty led for many years to the exclusion of ammonia-N analysis from studies of nitrogen cycling.[63] In the experience of the author and colleagues, collections of NH3 data have a high proportion of what statisticians euphemistically call "outliers". Yet in the Louisbourg data there appears to be strong evidence of fairly high NH3 with or without "outliers". Vaccaro[64] has found NH3 to be the dominant - in fact the only measurable - form of inorganic nitrogen in coastal surface waters in the mid to late summer. Certainly at Louisbourg, especially in August, this is true.

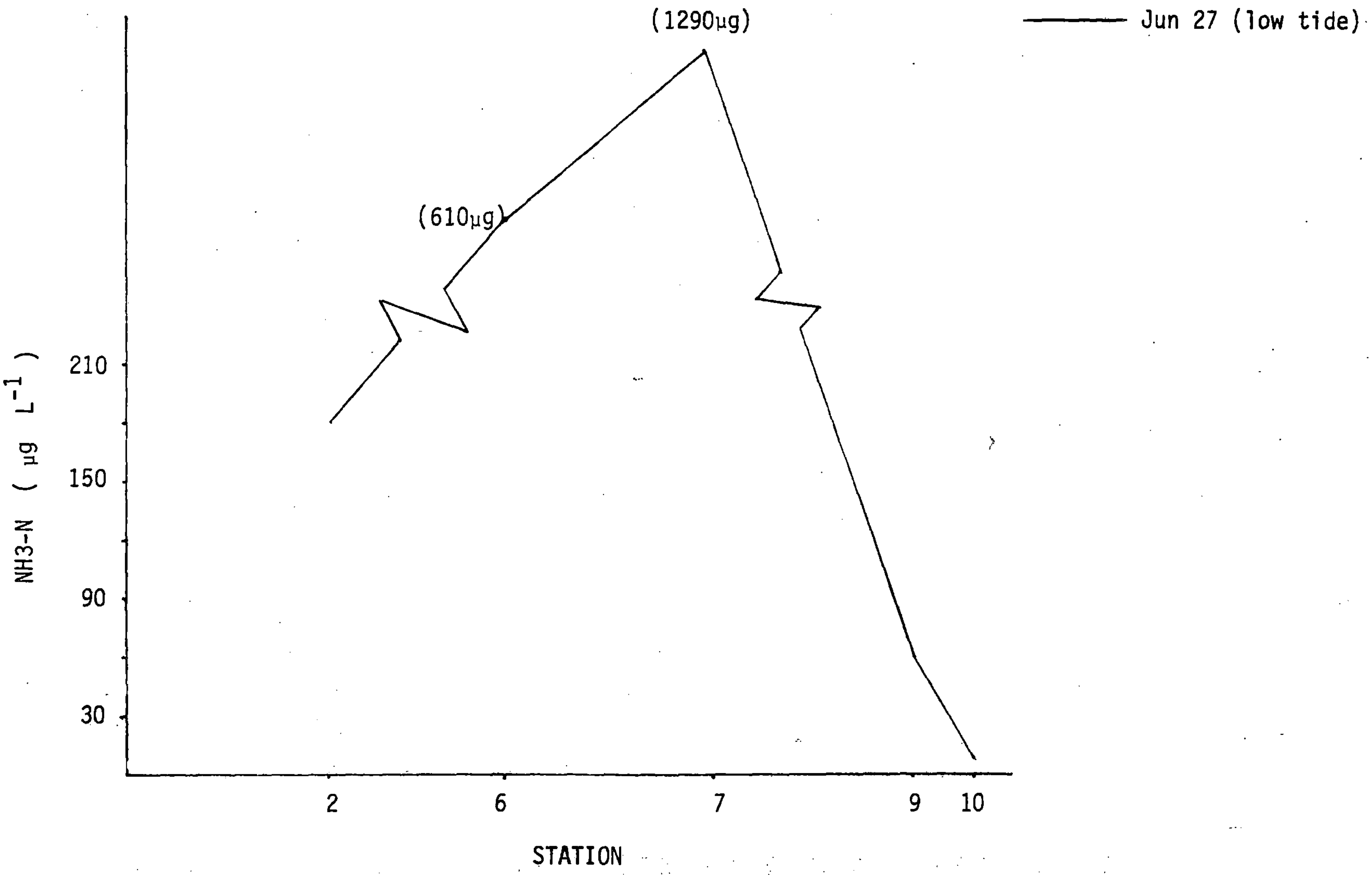
Fish-processing wastes are known to have a relatively high protein content[65]. Unfortunately information was not obtained on total nitrogen or organic nitrogen content of the effluent from the National Sea Products plant. In other studies that have been made of fish-processing waste concentrations, organic nitrogen has generally been found to be an order of magnitude higher than ammonia-nitrogen.[66] Probably this is the major ultimate source of the high concentrations of NH3 in Louisbourg Harbour. NH3 is released in the decomposition of nitrogenous organics especially those which have accumulated on the bottom. Ammonification proceeds under anaerobic conditions but usually ammonia-N so released is oxidized creating what can be a significant O_2 demand[67]. Thus, where well aerated waters overlie anoxic sediments, the reduced gases released from the sediment do not generally appear in significant quantities in the water[68]. As we will see in section 6, oxygen was at near saturation values when measurements were obtained at Louisbourg. Unless one invokes the idea that ammonia-N concentrations are due to excretion of organisms in the water column (and this would involve very high rates given the high NH3 values) then there is little possibility of reconciling oxygen data with the liklihood that the major NH3 source is ammonification of fish waste.

Aside from experimental error in one or the other measurement, the only tenuous conclusion on the oxygen and NH3 data is that the latter does not persist for very long, only under conditions that favour occasional reduction of dissolved oxygen.

Ammonia-N : Lockeport

As at Louisbourg, sampling for NH3-N was on two occasions only. Complete data is in Appendix I. Scatter of NH3 values on both days was great; only the June 27 data is graphed using the usual transect stations and it was clear from this that no pattern of

FIG. 21 NH3-N versus station (stations portrayed at approximate relative distance from NSP plant outflow) at Lockeport



NH3 concentration decrease with distance was emerging. No significant correlation was detected in the nonparametric analysis (Table 4). Again as at Louisbourg, no significant difference emerged between group means for the inner harbour and outer harbour "fish-plant" stations (see Table 6).

If spatial patterns were inconclusive for ammonia-N, there was, on the other hand, a clear and alarming absolute concentration in Lockeport Harbour at both sampling times (June 27, August 21). On each occasion NH3 values greater than 1000 μg/l (1 mg/l) were encountered. On June 27, 1.29 mg/l was recorded at LPF7 (outside the inner harbour) with a fairly high value at LPF6 also. The rest of the NH3 concentrations were considerably less. This is suggestive of the "cells of water" discussed in section 4 . On August 21 yet higher ammonia-N values were obtained; several stations both inside and outside of the inner harbour exceeded 2 mg/l with a value of 4.3 mg/l at LPF5 on the outside of the north breakwater.

Obviously the NH3 concentrations at Lockeport are well beyond any encountered at other Nova Scotian inlets for which published information exists (see Table 16). In fact, the August values are generally higher, for example, than those encountered on the Potomac estuary, a water body usually described as being "hypereutrophic".[69] In fresh water, concentrations such as those encountered at Lockeport have had proven sublethal effects on fish.[70] While there is small danger of this at the well-buffered ambient pH of seawater, the Lockeport NH3 concentrations do indicate an extremely large nitrogen pool in the water column. It is noted that smaller , although still high, concentrations were encountered in the control area on separate sampling occasions. As mentioned in section 3, Back Harbour (see Fig.2, p. 9) receives most of the domestic wastes; elsewhere in this report there has been evidence leading to the conclusion that the control area is far from clean, with the implication that domestic wastes may be affecting these stations. The higher values obtained in the"fish-plant" area do suggest that despite the high nitrogen load expected in domestic sewage, the overall effect of the fish processing plants is greater. At Louisbourg, because of the close proximity of sewer outfalls to fish-plants, comparative contributions cannot be assessed directly. It may be possible, however, to extrapolate from the conclusions on Lockeport and to assert that the processing plants at Louisbourg are the major nitrogen source, This is contrary to what we were able to conclude from the conversions of effluent characteristics information (see p.5).

Oil & Grease: Louisbourg

Quantities of oil and grease were assessed at Louisbourg on June 11 and 12 but not later in the summer. Many of the values for oil and grease were reported as being less than 5 ppm. As mentioned in the section on nitrate, this creates problems both for graphical and statistical procedures.† The reader is referred to Appendix I for detailed information on the oil and grease concentrations in Louisbourg Harbour.

On examination the pattern that emerges is that oil and grease is detected only in the upper part of the Northeast Arm, in quantities exceeding 7 ppm. On two of the three sampling occasions, peak values were at LBF3, adjacent to the Hopkins' plant. On the other occasion, the highest concentration was across the harbour at LBF5.

Oil and grease may occur in waters due to natural decomposition of aquatic organisms[71] but the quantities so produced are unlikely to be detectable with the method used in this work. Unfortunately, oil and grease concentration is another property that is not part of routine oceanographic sampling. The only comparison that can be made is with data from the control. Oil and grease was measured in the control area on successive tides on June 19. At high tide values between 17.1 and 11.6 ppm were encountered. On the following low tide, reduced but still measurable quantities were found.

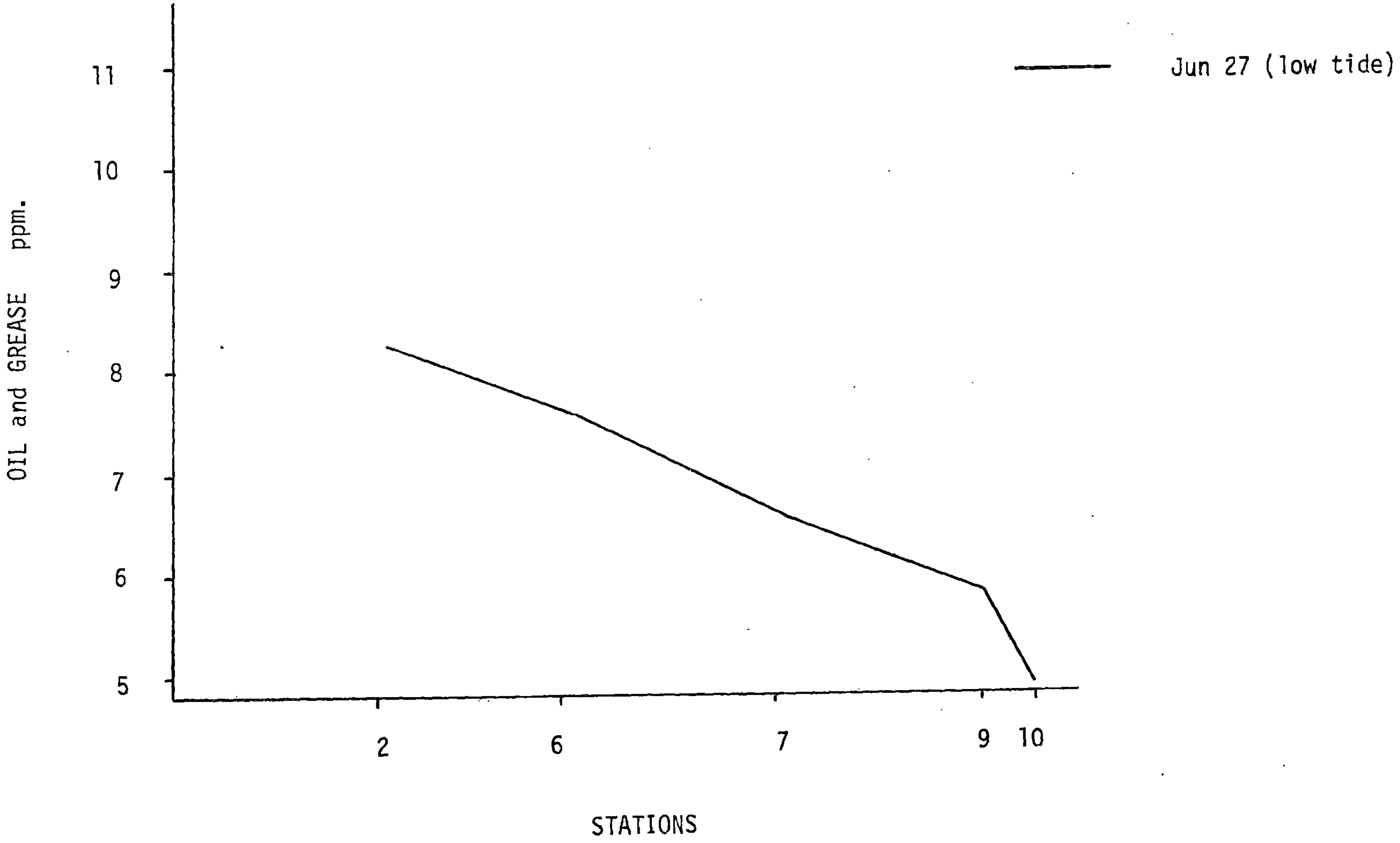
† In Table 5, it is evident that insufficient degrees of freedom are available since high *t*-values are attained but significance is, at best, borderline.

Naturally it would be interesting to have had data for June 19 from the "fish-plant" area. Without it and on the basis of a single comparison, the only possible conclusion is that when significant quantities of oil and grease are released they can be distributed either in patches or quite widely across all of Louisbourg Harbour. High-molecular weight hydrocarbons are capable of existing in water either as thin surface slicks or as emulsions.[72] Patchy distributions suggest the former while homogeneous ones, the latter. When slicks occur ordinary volumetric approaches to sampling and expression of data are inadequate.

Oil & Grease: Lockeport

As at Louisbourg, oil and grease was assessed at Lockeport during one two-day period in the earlier part of the summer. On June 26, samples were taken at the three water quality stations within the inner harbour and at LPF4 in shallow water outside. Values at the latter station fell within the range of the inner harbour on the low tide and were slightly lower on the following high tide (Appendix I). On June 27 at high tide, oil and grease was measured at all stations in the "fish-plant" area. Results from several stations appear in Figure 21. This data strongly suggests a gradient effect decreasing with distance from the effluent source. On the basis of this and the more limited data from the previous occasions, a fairly strong correlation with distance emerges (Table 4). As would be expected, contrasts of the inner and outer harbour also prove to be significant (Table 6).

FIG. 22 Oil and grease versus station (stations portrayed at approximate relative distance from NSP plant) at Lockeport.



Since so few data are involved, there is little justification in concluding too much from this apparent pattern. In terms of absolute quantities, oil and grease concentrations are not as high as in the patches in the "fish-plant" area at Louisbourg or throughout the control area there on June 19. Following the logic used above regarding patchy versus even distributions of oil and grease, it appears that such substances found at Lockeport are present as emulsions rather than slicks. This would account for the gradient effect; slicks by definition are likely to result in localized patches of even concentration distributed unevenly in the aquatic environment.

Again as at Louisbourg, sampling undertaken on a separate date in the control area yielded oil and grease concentrations greater than in the "fish-plant" area. Data obtained from samples taken over two tides on July 3 ranged from less than 5 ppm to 76 ppm at LPC1. Most values were between 10 and 30 ppm. At both harbours the question remains open: is oil and grease from the fish-plant widely distributed or are there other important and unrecognized sources? Domestic sewage emptied into Back Harbour at Lockeport is at least a possibility; at Louisbourg where sewage is released in the "fish-plant" area even this unsatisfactory answer is not tenable.

5.3 Particulate Carbon and Nitrogen in the Water Column

Louisbourg

As mentioned above, comparison is difficult between the control and fish-plant areas because they were sampled for particulate carbon(C) and nitrogen(N) on different occasions. Discussion here is restricted to observations made by "eyeballing" the data. Data is presented in Table 18 .

In July, particulate C and N at the fish-plant area stations (LBF6, LBF7, LBF8)are 2 to 3 times higher than values obtained at the control stations the following week. Yet in August an apparently significant minimum obtains at station LBF7, the nearest of the stations to National Sea Products' plant. In August, station LBF6 near the Hopkins' plant is within the range of values obtained subsequently in the control area. At LBF8, on the other hand, in August, the highest value obtained during the summer was encountered. Significantly, the C/N ratio is much higher than those obtained near the fish-plants at either sampling time. This suggests contamination of this sample either experimentally or by organic material from sources other than the fish-plants.

Comparison of these values for particulates with figures from other Nova Scotian inlets will be considered below, following the summary on Lockeport harbour.

Lockeport

On July 25, samples were obtained both within and outside of the inner harbour where effects of the fish-plants are presumably highest. At that time, somewhat higher particulate C values occurred within the harbour (in the case of station LBF1 the difference does not appear to be significant). Both stations in the control area are close to the shore (see Figure 5). It would appear then that higher values within the harbour may well be related to proximity to the fish plants. This is assuming that no effluent source of comparable magnitude to the fish plants occurs within the harbour area.

In late August, sampling within and outside the harbour was carried out on different occasions. The tendency for higher particulate C values within the harbour seems to be somewhat weaker than in the previous month. Particulate C at LPF2, some 500 m. from the National Sea Products' plant is essentially equal to the value at LPC9, more than 800 m. from the mouth of the harbour. Although the C/N ratio at the former is higher (10.8 versus 8.6) it would be tenuous to say that this signifies a difference in origin. Again, the station nearest National Sea Products has a particulate C only slightly higher than LPC9.

The values of particulate C are within the range of results that have been obtained at other inlets along the same coast of Nova Scotia. At Petpeswick Inlet values from 200 to 360 μg/l are most common (W. Sutcliffe, pers. comm.) while at St. Margaret's Bay, total particulate C can run to 600 μg/l and higher (Sutcliffe [73]). These bays are relatively undisturbed by major industries or by urban concentrations. However, high productivity does occur in these areas among the phytoplankton and macrophyte communities[74]. This production has the consequence that natural particulates may be added copiously

TABLE 17 Particulate Carbon, Nitrogen, and C/N ratios in the water column at Louisbourg (μg/L)

	July 9			Aug 7		
Stn.	C	N	C/N	C	N	C/N
LBF6	601.2	71.9	8.4	256.2	43.6	5.9
LBF7	426.9	49.6	8.6	135.2	17.3	7.8
LBF8	220.9	28.9	7.7	982.4	39.7	24.7
	July 17			Aug 14		
LBC6	124.4	13.5	9.2	225.6	29.5	7.7
LBC7	154.5	20.7	7.5	281.1	36.4	7.7
LBC8	117.1	12.7	9.2	230.1	33.9	6.8

TABLE 18 Particulate Carbon, Nitrogen, and C/N ratios in the water column at Lockeport (μg/L)

	July 25			Aug 22		
Stn.	C	N	C/N	C	N	C/N
LPF1	154.6	21.6	7.2	230.1	30.9	7.4
LPF2	363.6	37.1	9.8	208.6	19.3	10.8
LPF3	209.5	29.7	8.1	384.7	35.4	10.9
LPC3	139.9	22.2	6.3	Aug 28		
LPC5	95.9	8.6	11.2	140.8	29.5	9.4
LPC6				153.8	26.8	7.6
LPC9				208.0	35.7	8.6

to the systems.

At Louisbourg and Lockeport the contribution of natural flora to the particulate load is unknown. It can only be said that even with the fish plants nearby, particulate levels are still within the range observed at Nova Scotian inlets lacking such industry.

5.4 Chlorophyll

Louisbourg

Data for chlorophyll concentration at Louisbourg Harbour is presented in Table 19 . As can be seen, chlorophyll was measured on different occasions in the "fish-plant: and control areas. In the case of water quality parameters discussed in section 5.2 , sufficient stations had been established within the former area that the effect of proximity of the processing plants could be studied using data collected on the same occasion; thus in that section, control area information was used only for very broad comparisons along with published data. With chlorophyll there is no choice but to use between-area comparisons since only three stations were represented by chlorophyll data in each area.*

A three-way analysis of variance was performed to examine the separate and interacting effects of station, depth and month of sampling. The latter, of course, is a somewhat dubious "main effect" but assessing its contribution to the overall variance can give some indication of temporal variability. The second-order interaction was assumed to be zero and used as the error variance in F-ratio computation. Results are presented in Table 20.

Of the main effects and the interactions analysed, two contributed significantly to the variance: station and month.

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* At this point the reader might wish to re-read the last paragraphs of section 3 and some of the papers referred to there.

TABLE 19 Concentration of chlorophyll-a at different stations at Louisbourg (1 and 3 m. depths), summer 1974 (μg/L)*

month	*depth (m)*	*station*					
		LBF6	LBF7	LBF8	LBC6	LBC7	LBC8
Jun	1	1.99	.80	.30	.75	.67	.76
	3	.24	.40	1.18	.45	.61	.73
Jul	1	7.34	4.86	1.73	.82	.96	.68
	3	2.74	2.46	1.51	.52	.51	.62
Aug	1	2.55	.58	.54	.92	.64	.94
	3	2.50	.79	.50	.89	.85	.86

* Most values are the mean of two replicate analyses. It is realized that in pooling the information a potentially valuable estimate of error variance was lost. However, 5 of the above values are based on only one measurement; thus use of error between replicates woul have required calculation of "dummy" values for missing values, a procedure that is complicated in three-way anova classifications.

TABLE 20 Results of three-way analysis of variance on chlorophyll data from Table 19.

Main Effects	df	SS	MS	F
Station(S)	5	23.998	4.800	7.84***
Depth (D)	1	2.467	2.467	4.03^{ns}
Month (M)	2	11.464	5.732	9.37**
Interactions				
S x D	5	3.991	.798	1.30^{ns}
S x M	10	17.118	1.712	2.80^{ns}
D x M	2	3.118	1.559	2.54^{ns}
S x D x M (error variance)	10	6.120	.612	

The significant contribution of month-to-month variability to overall variance does establish that time is an important factor. The exact dates of sampling in the "fish-plant" area were June 12, July 9, and August 7 with control area sampling 7 or 8 days later for each month. We have an estimate of variation over a period of months but not for weeks. From the data, LBF6 (the station farthest up the Northwest Arm) certainly appears to be consistently higher in chlorophyll than all the others. On the other hand, LBF7 and LBF8 are notably higher than control-area stations really only on the July samples. The failure to obtain a significant interaction between station and month is probably due to the continuance of high chlorophyll readings at LBF6 into August.

If we accept, with reservations implied above, that the "fish-plant" area stations were higher in chlorophyll than the controls, then it is of interest to compare these values to published data from inlets nearby. This is done in Table 21.

Seen as a whole, this data seems to contain two orders of chlorophyll ranges: one contains those values that at maximum are only approximately 1 μg/l - St. Margaret's Bay and the Louisbourg control. At Petpeswick Inlet, Bedford Basin, and the Louisbourg "fish-plant" area, maximum chlorophyll runs between two to more than seven times as high without exception. The station for which the range was reported at Petpeswick is in the upper part of the inlet which receives some sewage and is bordered by marsh grass beds of high productivity[75]. Bedford Basin receives (or, at least, did receive at the time of sampling)

TABLE 21 Range of chlorophyll concentration (μg/l) in Louisbourg and Lockeport Harbours, and in several other Nova Scotian inlets

		Jun	Jul	Aug
Louisbourg	"Fish-plant"	.30 - 1.99	1.51 - 7.34	.50 - 2.55
	Control	.45 - .75	.51 - .96	.64 - .94
Lockeport	"Fish-plant"	.37 - 1.69	1.01 - 1.74	.48 - 1.02
	Control*	.64 - .83	.73 - .90	.79 - .90
Bedford Basin[†]		1.32 - 2.83	.50 - 2.70	2.09 - 5.67
Petpeswick Inlet[ξ]		1.03 - 4.25	3.44 - 4.05	5.46 - 6.27
St. Margaret's Bay[¶]		.23 - .39	.44 - .67	.21 - .98

* See footnote to Table 22 .

† values from 1969, Platt & Irwin[76]

ξ values from 1971, Platt & Irwin[77]

¶ values from 1969, Platt & Irwin[78]

some of the effluent from the city of Halifax and most from the towns of Bedford and Sackville.[79] There may be some significance, then, that chlorophyll concentration in Louisbourg's Northeast Arm ("fish-plant"area) resembles values from two eutrophic basins while the Southwest Arm data is much more like values from St.Margaret's Bay, a less affected inlet. Attempts have been made to define critical chlorophyll values beyond which a coastal system may be considered polluted: Jaworski et al.[80] set as the desired limit a concentration of 25 μg/l chlorophyll in prescribing nutrient management for the Potomac estuary. Yentsch[81] used the relationship of phosphate and chlorophyll as a measure of eutrophication. This appears to be a desirable approach since nutrients and chlorophyll levels are likely to have relationships observable more through time than space. Taking the most eutrophic station at Louisbourg for which coincident readings of chlorophyll and phosphate are available (LBF6), values can be plotted on Yentsch's chlorophyll versus phosphate axes. When this is done, either for June or August data, LBF6 is well below points for polluted estuaries. It should be pointed out, however, that Yentsch's polluted estuary data is for very grossly polluted waters. On the basis of chlorophyll concentration (and TIP)the Northeast Arm is not grossly polluted but the higher values in the "fish-plant" area suggest that the system has been enriched considerably.

Lockeport

Chlorophyll concentration at Lockeport was measured in the top 1 m. only. Data is presented for 3 "fish-plant" and 5 control stations (again, sampled 1 week apart) in Table 22.

TABLE 22 Concentration of Chlorophyll-a in the waters of Lockeport Harbour, summer 1974 (μg/L). All data from 1 m.

month	*station* LPF1	LPF2	LPF3	LPC2	LPC4	LPC6	LPC7	LPC9
Jun*	1.64	-	.37	.45	.83	-	.66	-
	1.43	-	1.69	.62	.04	-	.69	-
Jul	1.30	1.74	1.01	.76	.73	-	-	-
	1.47	1.13	1.64	.69	.90	-	-	-
Aug	.59	.52	.83	-	-	.79	-	.90
	1.45	.48	1.02	-	-	.90	-	.79

* For Lockeport control, this sampling was actually done on Jul 3, but following approach used in comparisons in Louisbourg, is treated as comparable to previous week's "fish-plant" data.

Replicate analysis results are included in this table. The results are not readily analysed using the anova approach since different control stations were used at various sampling times. It is reasonably clear that the three stations in the inner harbour (LPF1 LPF2, LPF3) were higher in chlorophyll in June and July. There does not appear to be a significant difference in August. Data from Lockeport Harbour are presented in Table 21 , in which comparison is made with other inlets of Nova Scotia. The chlorophyll content of waters from the "fish-plant" area is intermediate to the two distinct ranges of chlorophyll mentioned in the section on Louisbourg. In the control area, summer chlorophyll values are quite similar to St.Margaret's Bay and Louisbourg control data.

It has often been observed that amounts of organic matter added by the algal growth resulting from fertilization can be far higher than direct organic additions[82]. In assessing eutrophication, a useful although ill-defined measure is the *ultimate oxygen demand* (UOD). Properly assessed such a measure would integrate information on standing stock of all forms of important nutrient and standing stock of phytoplankton (as measured probably by chlorophyll) so that a prediction of ultimate organic loading could be derived. This approach is implicit in the classic paper of Redfield [83] and more explicit attempts at derivation of UOD have recently been attempted[84]. Recalling the nutrient data on Louisbourg and Lockeport (see Tables 13, 15, & 16), the latter was generally somewhat more enriched. Yet Louisbourg has, in the "fish-plant" area, higher chlorophyll. It is quite probable that these differences represent merely different stages of a cycle involving uptake of nutrients, phytoplankton growth, nutrient reduction, and mineralization.

As at Louisbourg, the absolute quantity of chlorophyll combined with TIP levels, in the"fish-plant" area is suggestive of detectable enrichment rather than gross pollution.

6 THE BENTHIC ENVIRONMENT

The problem that dominated our discussion of water quality indicators - short time interval variability - is much less of a hindrance in benthic data interpretation. This is, in fact, the standard rationale for looking at the bottom and interpreting such analyses with greater confidence than water column information.

In this section several approaches are taken to the analysis of the benthic environment. Section 6.1 consists of discussion of results on the chemistry of the bottom - organic carbon content, nitrogen, and dissolved oxygen in the waters immediately above the sediments. The remainder of this part of the report is about the benthic biota of Louisbourg and Lockeport. Some of the rationale and constraints of the indicator-organism approach are summarised by way of introduction (6.2). In section 6.3, information on the algal composition of samples is presented and the more extensive data (and interpretation) on macrofauna is in 6.3 Finally, section 6.4 involves the analysis of community-level properties that bear on the question of the degree of pollution in the harbours.

6.1 Chemistry of the Benthic Environment

This subsection is further divided into a major part on sedimentary organic matter and a smaller part on dissolved oxygen in the waters immediately above the bottom.

Sedimentary organic matter: Louisbourg

Percentage by weight of organic carbon (C) and nitrogen (N) was obtained for twelve "fish-plant" and three control area stations. The latter were represented by single samples with the remainder based on duplicates. From this information C/N ratios were derived and, as well, the product of %C and %N was obtained. The latter parameter is one proposed by Ballinger and McKee[85] specifically for the determination of degree of pollution from sedimentary organic matter data. The product is called the Organic Sediment Index (OSI) and is considered in more detail below. Values for the fundamental and derived sediment properties are presented in Table 23.

Originally,plans were to subject this data to similar treatment to that used in section on specific diversity etc.; that is, non-parametric comparison of groups using the Mann-Whitney test. By itself, inspection of the data was sufficient to yield a clearly discernible trend. Three ranges of sedimentary properties are observed: the control area stations have organic carbon and nitrogen concentrations between 1/4 and 1/5 of those occurring in the "fish-plant" area - with a major exception. The LBF1 benthic stations are consistently lower than even the control area stations in both C and N. This is probably the best evidence of the uniqueness of these stations but we have noted in several other parts of this study that LBF13-15 do not resemble other "fish-plant"

TABLE 23 Organic carbon, nitrogen, C/N ratio and organic sediment index (OSI) for superficial sediments of Louisbourg Harbour

STATION	DATE	Org.C. %	N	C/N	OSI*
LBC43	Jul 16	.208	.029	7.2	.006
LBC44	Jul 16	.160	.024	6.7	.004
LBC45	Jul 16	.106	.017	6.2	.002
LBF13	Jul 16	.067	.015	4.5	.001
	Aug 6	.068	.012	5.7	.001
LBF14	Jul 16	.062	.012	5.2	.001
	Aug 6	.087	.014	6.2	.001
LBF15	Jul 16	.073	.014	5.2	.001
	Aug 6	.085	.014	6.1	.001
LBF33	Jul 16	1.01	.093	10.9	.094
	Aug 6	1.90	.141	13.5	.268
LBF34	Jul 16	1.12	.090	12.4	.101
	Aug 6	1.16	.103	11.3	.119
LBF35	Jul 16	1.17	.108	10.8	.126
	Aug 6	1.48	.125	11.8	.185
LBF43	Jul 16	5.18	.438	11.8	2.27
	Aug 6	4.23	.376	11.3	1.59
LBF44	Jul 16	4.82	.382	12.6	1.84
	Aug 6	3.64	.329	11.1	1.20
LBF45	Jul 16	5.77	.464	12.4	2.67
	Aug 6	2.51	.218	11.5	.547
LBF53	Jul 16	1.34	.112	12.0	.150
	Aug 6	3.24	.249	13.0	.807
LBF54	Jul 16	1.92	.158	12.2	.303
	Aug 6	1.97	.173	11.4	.341
LBF55	Jul 16	1.94	.163	11.9	.316
	Aug 6	2.34	.190	12.3	.445

* The Organic Sediment Index (OSI) is the product of the percentage organic carbon and percentage nitrogen. Its use has been suggested by Ballinger & McKee (1971). See text for further discussion.

area stations (Sect. 6.3 & 6.5). Gerratt Brook separates LBF1 from the "fish-plant" area and quite possibly the fresh water flow creates a barrier to the movement of detrital materials. As well, the circulation of the Northeast Arm appears to be from the vicinity of NSP away from the LBF1 stations (Sect. III).

In addition to the higher C and N, "fish-plant" stations have consistently higher C/N ratios and, as would be expected, higher OSI. Ballinger and McKee used the OSI on estuarine as well as on fresh water systems and were able to detect expected changes with increasing distance from a variety of pollution sources. In a situation such as this where C and N are positively related, OSI seems to do little more than dramatize already obvious differences. Conversely it could be argued that where C and N are not closely correlated, the C/N ratio provides more information (beyond what is learned from the basic C and N data) than does OSI, for it contrasts rather than confounds the properties. A further problem is that in shallow marine sediments naturally abundant organic matter is common.[86] The author has studied organic carbon and nitrogen in sediments of an unpolluted cove of Petpeswick Bay; from Dale[87] (Table 1) OSI values could be derived over a short distance, of both greater than 20 and less than 1. Yet the implications of Ballinger and McKee's Table 2 is that an OSI of over 5 represents fairly advanced pollution while under 1 is natural. Hicks[88] has applied these limits in analysis of the impact of Newfoundland fish processing plants and found that all sediments in stations closest to the plants reached OSI values over 5. Fortunately he had controls for which a baseline OSI could be established. Caution must be used to utilize the OSI only in such a relative way and not as an absolute criterion; its powers appear to be that of suggestion rather than indication.

Establishment of a baseline - that is, how much organic matter is expected in coastal sediments - would naturally be very desirable. As mentioned above high variations in the organic content of unpolluted sediments has been reported elsewhere by the author in another inlet of this coast. In that study and in most others on relationship of organic matter to environments of deposition, a strong correlation with the grain size of the deposits' mineral fraction has been reported[89,90]. One expects that this close relationship might be disturbed by the addition of highly organic effluent to parts of a system with normal low concentrations of organic matter. We do not have information on mineral particle size distribution for either Louisbourg area and so our conclusions must be qualified ones: *if on the whole the hydrographic regimes of the "fish-plant" and control areas can be assumed to be very similar (with the consequence that ranges of mineral particle size would also be similar) then effluent from the fish-plants, with some additional domestic waste contribution, has had a significant impact on the organic content of the bottom deposits.*

C/N ratio is usually considered to be a somewhat qualitative assessment parameter for the organic matter[91]. Its use in studies of bottom deposits was for a long time based on the idea that the origin of sediment organic matter could be traced from the ratio. C/N ratios of various classes of organisms vary greatly[92]. However, it is now well established that changes occur in C/N during the initial and subsequent stages of decomposition.[93] On calculations made with published data of COD and nitrogen in fish processing wastes, a range of approximately 4.0 to 9.5 has been found for the ratio.[94] Yet this is below all values encountered in the "fish-plant" area excepting the LBF1 stations.

Very commonly, C/N ratio is found to increase with higher overall organic content in sediments[95]. This is also the case at Louisbourg. The basis of this relationship is unlikely to be simple. Waksman[96] long ago suggested that it occurred because of limitations placed on decomposer bacteria in varying concentrations of organics. Another possibility is that sediments of an area may contain a high and fairly constant proportion of ammonium ion fixed in the lattice structure of the mineral fraction.[97] Thus as organic matter increases (presuming this material is of constant C/N ratio) the proportional contribution of this fixed ammonium decreases and C/N rises. Either interpretation renders the use of C/N ratio rather limited in the assessment of the effect of pollution on bottom deposits.

Sedimentary organic matter: Lockeport

Three control and thirteen "fish-plant" area benthic stations are represented with values for C and N (as well as for the derived indices) in Table 24 . Again, as at Louisbourg it was possible to recognize three reasonably distinct sets of values for organic carbon and the other properties. However, at

TABLE 24 Organic carbon, nitrogen, C/N ratio and organic sediment index (OSI) for superficial sediments of Lockeport Harbour

STATION	DATE	Org. C. %	N %	C/N	OSI
LPC13	Jul 23	4.90	.597	8.2	2.93
LPC14	Jul 23	4.97	.617	8.1	3.07
LPC15	Jul 23	4.73	.572	8.3	2.71
LPF13	Jul 23	5.01	.574	8.7	2.88
	Aug 20	4.22	.357	11.8	1.51
LPF14	Jul 23	4.77	.548	8.7	2.61
	Aug 20	5.11	.544	9.4	2.78
LPF15	Jul 23	6.45	.688	9.4	4.44
	Aug 20	3.19	.277	11.5	.88
LPF23	Jul 23	4.88	.511	9.6	2.49
	Aug 20	-	-	-	-
LPF24	Jul 23	4.76	.447	10.6	2.13
	Aug 20	4.97	.573	8.7	2.85
LPF25	Jul 23	4.69	.424	11.1	1.99
	Aug 20	4.57	.527	8.7	2.41
LPF33	Jul 23	.76	.094	8.1	.07
	Aug 20	1.15	.139	8.3	.16
LPF34	Jul 23	.69	.080	8.7	.06
	Aug 20	.52	.063	8.3	.03
LPF35	Jul 23	1.03	.118	8.7	.12
	Aug 20	1.71	.191	9.0	.33
LPF43	Jul 23	.22	.029	7.4	<.01
	Aug 20	.31	.035	8.8	.01
LPF44	Jul 23	.16	.020	7.8	<.01
	Aug 20	.29	.032	9.1	.01
LPF45	Jul 23	.18	.024	7.4	<.01
	Aug 20	.20	.025	7.9	<.01

Lockeport, the control area organic content was well within the range of the richest sediments of the "fish-plant" area. The LPF1 and LPF2 series of stations and the control stations were generally from 4.5 to 5.0 % weight organic carbon. Stations near benchmark 3 (the LPF3 stations) within the inner harbour were only ¼ as high in organic carbon and the LPF4 series were still lower - the maximum there was 0.31 %. As at Louisbourg, both the nitrogen content and the OSI followed the pattern of organic carbon closely. However, C/N ratio does not increase with organic carbon in as pronounced a manner as at Louisbourg. Although the organic carbon content was as high in the control as the higher "fish-plant" values for C, C/N ratio seemed to be slightly lower. For reasons given in the section on Louisbourg, it is difficult to interpret why such a difference occurs.

Tentative explanations can be offered for the distinct values obtained at the LPF3 and LBF4 benthic stations. The latter are outside the inner harbour where considerable entrainment of suspended solids may occur. The LBF4 stations are also well removed from the control area in which, as has been pointed out often in this study, there must certainly be alternative sources of high organic contribution. With regard to the LBF3 stations, it was considered likely that circulation of wastes tended to be in the opposite direction from benchmark 3 in the analysis of water movement (Section III). Again as at Louisbourg it would have been helpful to have had analyses of the mineral grain size distribution so that some idea could be gained of the local environments of deposition.

Although we have suspicions that the control area is enriched we have no strong evidence of the source. This leaves us in no position to say definitively that Lockeport's inner harbour is high in organic carbon because of the NSP and Swim Bros. plants. While approximately 5 % organic carbon is a fairly enriched sediment, the author found as high and even greater concentrations in sheltered parts of an unpolluted cove along the same coast as Lockeport.[98]

Dissolved oxygen: Louisbourg and Lockeport

As a result of their relative isolation from the more vigorous surface water movement and the oxygen of the atmosphere, bottom waters generally contain the lowest concentrations of oxygen in the water column. Our interest here is, therefore, restricted to dissolved oxygen near the bottom and for this reason we have included this section with properties of the benthic environment where the consequences of low oxygen are most strongly felt. Bottom waters may, in fact, become anoxic in areas where organic matter accumulates, causing radical changes in the composition and density of benthic organisms . The phenomenon of anoxic basins has been reported twice on the Nova Scotian coast; at Bedford Basin,[99] which receives domestic wastes from much of metropolitan Halifax, and at Petpeswick Inlet[100] where sewage from a small village and, more important, detritus from highly productive marshes is added.

Dissolved oxygen values for benthic stations at Louisbourg are presented in Table 25 with the same information for Lockeport in Table 26 . The data is expressed as percent saturation, calculated from the oxygen concentration, salinity, and temperature data using the tables of Green and Carritt[101].

DO was between 69 and 139 % saturation at Louisbourg Harbour with most values saturated or supersaturated. Furthermore, no difference is apparent in the concentrations in the "fish-plant" and control areas. At Lockeport, the lowest % saturation is 61 %. Again many of the values are above saturation for the ambient salinity and temperature. Lowest values at Lockeport were in late June, at the

TABLE 25 Percent saturation by oxygen of above bottom waters of some benthic stations at Louisbourg.
HT=high tide, LT=low tide.

STATION	Jun 11 HT	Jun 11 LT	Jun 12 HT	Jul 8 LT	Aug 8 HT	Aug 15 LT
LBF13	110	120	97	110	100	128
LBF14	110	120	97	110	100	128
LBF15	94	105	88	123	116	102
LBF23	98	106	95	114	97	137
LBF24	98	106	95	114	97	137
LBF25	92	103	94	91	95	88
LBF33	112	109	105	118	100	130
LBF34	113	107	94	105	110	98
LBF43	100	105	94	116	101	126
LBF44	100	105	94	116	101	126
LBF45	113	107	94	105	110	98
LBF53	106	105	91	112	102	131
LBF54	106	105	91	112	102	131

STATION	Jun 19 HT	Jun 19 LT
LBC13	99	99
LBC15	105	93
LBC23	97	98
LBC25	97	102
LBC33	69	96
LBC34	97	102
LBC43	101	97
LBC45	105	93
LBC53	108	99
LBC54	108	95

TABLE 26 Percent saturation by oxygen of above bottom waters of some benthic stations at <u>Lockeport</u>.
HT=high tide, LT=low tide.

STATION	Jun 26 HT	Jun 26 LT	Jun 27 LT	Jul 3 HT	Jul 3 LT	Aug 21 LT	Aug 21 HT	Aug 22 HT
LPF13	87.5	69	82	107	116	130	91	151
LPF25		79	64	133	138	162	133	134
LPF33		75	61	123	121	148	103	143
LPF53			65	110	121	166	107	124

STATION	Aug 28 LT	Aug 28 HT	Aug 29 HT
LPC11	99	101	100
LPC21	82	93	104
LPC31	91	82	110
LPC43	95	109	107
LPC53	84	97	108

same time that maximum suspended solids loads were encountered (Section IV). However, DO was still well above any limiting levels for benthic life.

The high dissolved oxygen levels at Louisbourg are in agreement with the fact that BOD was consistently below detection. There is, however, still the problem of rationalising the DO data in view of occasionally high NH3, suspended solids, COD etc. Even outside the anoxic area of Petpeswick Inlet, the maximum % saturation that Hoos encountered in 1970-71 (summer)[102] at similar depths was 60%. It is surprising, especially in the sheltered inner harbour at Lockeport, that despite the presence of large fish-plants with effluent quantities far greater than a small village would release (cf. Table 1, p.5 above), minimum DO coincides with the maximum at Petpeswick's bottom waters. Supersaturated bottom waters are not common - the possibility that these measurements contained experimental errors of some importance must be entertained.

6.2 Rationale for the Use of the "Indicator-Species" Approach

Most benthic organisms have sedentary and long lives relative to the existence of pelagic species. Their distribution reflects their tolerance of the many kinds of environmental stress occurring over the year - salinity fluctuations, occasional oxygen depletions, periods of food scarcity. Benthic organisms monitor the environment with a persistence and sensitivity well beyond the budgets and capability of any pollution agency.! Many workers have argued for the use of benthos as the primary component of surveys, surveillance and monitoring.[103,104]

The concept of an indicator organism has, in fact, gained tremendous acceptance in a few cases - *E. coli* abundance has if anything been depended on to excess in following sewage pollution. In fresh waters, *Sphaerotilus natans*, a fungus, and the tubificid oligochaetes are well-accepted and consensus is growing on the significance of a polychaete, *Capitella capitata*,[105] in pollution studies on marine systems. The list of potential indicator species expands particularly as studies accumulate that combine field presence/absence data with controlled laboratory experiments.

It must be realized, however, that indicator species like all organisms are responding to a mulitiplicity of factors other than ones associated with pollution. Geographical barriers may exist so that the absence of a widely known indicator tells little. For example, *Capitella capitata* has been cited as an indicator in Italy, Finland, and California yet is rarely encountered along the coast of eastern North America, pollution or not. Its absence from both of the inlets in this study does not necessarily mean that all is well. The opposite also holds: presence of a "notorious" indicator is not tantamount to proof of significant pollution. Cotton[106] showed this more than 60 years ago in a study of the relationship of *Ulva*, the sea lettuce, to sewage pollution.

These problems can be alleviated somewhat by (a) undertaking a study of several years duration; and (b) selecting controls that are likely to have no geographical barriers between them and the area of interest. The second of these strategies ought to be fairly easy to achieve since most bottom-dwellers have life history stages that are planktonic and, at least on this coast, mass water exchange between shelf waters and inlets is common[117].

At both Louisbourg and Lockeport the harbours were operationally divided into "fish-plant" and control areas with the assumption that the areas were pretty well alike in all respects except exposure to pollution from the fish-plants. As we have seen in the section on water quality and will have more evidence here, this assumption may not be thoroughly valid.

6.3 Patterns in Algal Distribution

Introduction

Seaweeds have been used as pollution indicators for more than half a century. The abundance of *Ulva* was seen as positively related to sewage pollution by several contributors to the Royal Commission on Sewage Disposal (U.K.) in 1911. However, the general problems faced in the use of indicator species are even more problematic with seaweeds, for algae are able to survive under extreme stress, reacting in their physiology rather than by mortality. Burrows[109] has emphasized the need to look at individual rather than merely community level responses. In an analysis of pollution effects on three British estuaries Edwards[110] was unable to distinguish areas affected by domestic or industrial wastes from those relatively free of pollution, on the basis of algal species composition. Yet other workers have found clearer trends in relation to pollution: North[111] has observed an overall decline in numbers of algal species near sewage outfalls while European researchers have reported disappearance of many brown algae (Phaeophyceae) especially fucoids near sources of organic pollution.[112]

The data from Louisbourg and Lockeport on algae was mainly in presence/absence form. An attempt was made to record wet weights (see Appendix II) but for many species, particularly coralline rhodophytes, this was not appropriate. Thus the analysis is only of presence/absence information from which numbers of species encountered can be used to compare "fish-plant" and control areas.

Louisbourg:

The occurrence of species and classes of algae at Louisbourg is recorded in Table 27. It will be noted that a separate column lists the species composition of the "fish-plant" area exclusive of stations LBF11 -15. In several other places in this report the distinctiveness of this sub-area has been mentioned with the implication that it may be closer in properties to the control area. During the preliminary examination of the algal information, it was similarly noted that LBF11-15 included several species that occurred nowhere else in the "fish-plant" area. There is interest, then, in seeing what the algal composition looks like with and without these species.

From Table 27 it appears that exclusion of the LBF1 benthic stations only clarifies differences that occur between "fish-plant" and control stations. Numbers of brown and red algae are very much reduced in the former. There are too few green algae to distinguish a trend; in light of the early work on *Ulva* and more recent data indicating the significance to pollution studies of *Enteromorpha*;[113] it is unfortunate that biomass information was not available. Referring, however, to above reference to fucoids, it is probably significant that only two of five species (*Ascophyllum + Fucus spp.)* occurred in the "fish-plant" area. As well, Grenager[114] has suggested that two other brown algae that occur in our control but not near the fish-plants, *Chorda filium* and *Chordaria flagelliformis*, are especially intolerant of pollution. The "fish-plant" area also lacks two common species of kelp, *Laminaria intermedia* and *L. longicruris* that are recorded as present in the control area. Kelp sensitivity

TABLE 27 Occurrence of macroscopic attached alage at Louisbourg

Chlorophyceae	CONTROL AREA	"FISH-PLANT" AREA	"FISH-PLANT" (- LBF1 stns)*
Cladophora expansa	-	X	-
Enteromorpha sp.	X	X	X
Entocladia viridis	X	-	-
Ulva lactuca	X	X	X
Phaeophyceae			
Ascophyllum nodosum	X	-	-
Chorda filium	X	-	-
Chordaria flagelliformis	X	-	-
Desmarestia aculeata	X	X	X
Dictyosiphon foeniculaceus	X	-	-
Dictyosiphon sp.	X	X	-
Fucus evanescens	X	X	-
Fucus sp.	X	X	X
Fucus spiralis	X	-	-
Fucus vesiculosus	X	X	X
Laminaria intermedia	X	-	-
Laminaria longicruris	X	X	-
Laminaria sp.	X	X	X
Petalonia sp.	X	X	X
Pylaiella sp.	X	X	-
Saccorhiza dermatodea	X	-	-
Rhodophyceae			
Antithamnion sp.	X	-	-
Bangia sp.	X	-	-
Chondrus crispus	X	X	X
Corallina officinalis	X	X	X
Gigartina stellata	X	X	-
Lithothamnion sp.	X	-	-
Phycodrys rubens	X	X	X
Polyides caprinus	-	X	X
Polysiphonia lanosa	X	X	X
Porphyra umbilicalis	X	-	-
Rhodophyllis sp.	X	-	-
Rhodymenia palmata	X	-	-
Spermothamnion turneri	X	-	-

SUMMARY

No. species -	Chlorophyceae	3	3	2
	Phaeophyceae	16	9	5
	Rhodophyceae	12	6	5
	Algae Total	31	18	12

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* "Fish-plant" area total excluding algae ocurring only at LBF11 - LBF15.

to organic pollution has been thoroughly studied and documented at the community-level[115] and at the individual level[116]. However, another laminarian, unidentified to species, did occur quite close to the effluent outflow of National Sea Products.

Overall, there does seem to be a substantial decline in total number of species. In summary, there is evidence from the information on seaweeds to suggest that the community has become less diverse in response to different conditions in the "fish-plant" compared to the control area at Louisbourg.

Lockeport

As there were fewer stations at Lockeport than at Louisbourg (10 as compared to 45), a much smaller number of species were recorded for the whole harbour. These are listed in Table 28 , with a summary of abundance of different classes. Interestingly, the fucoids were absent from the "fish-plant" area, following the pattern at Louisbourg. But there is simply not enough information to draw even a tentative conclusion on the effects of the fish-plant effluent on algal species diversity.

TABLE 28 Occurrence of macroscopic attached algae at Lockeport

	CONTROL AREA	"FISH-PLANT" AREA
Chlorophyceae		
Enteromorpha sp.	x	x
Ulva lactuca	-	x
Phaeophyceae		
Ascophyllum nodosum	x	-
Desmarestia aculeata	-	x
Fucus sp.	x	-
Fucus vesiculosus	x	-
Petalonia sp.	-	x
Rhodophyceae		
Corallina officinalis	-	x
Gymnogongrus norvegicus	-	x
Polysiphonia lanosa	x	-
Rhodymenia palmata	-	x
SUMMARY		
No. species - Chlorophyceae	1	2
Phaeophyceae	3	2
Rhodophyceae	1	3
Algae Total	5	7

6.4 Distribution of Benthic Faunal Indicator Species*

Introduction

Several species were chosen for distribution studies on the basis of reports in the literature that they were indicators of organic pollution, usually sewage pollution. O'Sullivan's[117] classification of response was adopted. *Sensitive* species are those most likely to disappear from polluted areas, *tolerant* species those relatively unaffected by pollution and likely to flourish with reduced competition, and *transgressive* species those that move into a polluted area where they had not previously been found. In the Louisbourg and Lockeport studies, we might expect to find the sensitive species in the control areas only, the tolerant species in both areas but more abundant near the fishplants, and the transgressive species in the fishplant areas only.

Table 29 lists the indicator species found in the studies, the type of response to pollution, the literature source on which the selection was based, and a brief discussion of the distributions in both harbours. Distribution of these species is indicated in Figs 23 & 24 for Louisbourg and Lockeport respectively. Approximate density is represented, each dot being 5 or 10 organisms as indicated. Where the species is very abundant, stations may appear to overlap.

There were no transgressive species reported at either Louisbourg or Lockeport. Transgressive species most commonly reported in the literature on marine pollution include the capitellid polychaetes (e.g. *Capitella capitata*), harpticoid copepods, and molluscs like

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* Complete lists of the occurrence of all faunal spp. at Louisbourg and Lockeport are presented in Appendix II.

TABLE 29 Classification of indicator organisms with published source and occurrence at Louisbourg and Lockeport. (In parentheses under species name is location map figure no. for Louisbourg (Fig.23) and Lockeport(Fig.24)

SPECIES	CLASSIFICATION	SOURCE	DISTRIBUTION
Balanus spp. (23-a,24-a)	tolerant	Persoone & DePauw[118] Smyth[119]	*Louisbourg*- not abundant; equally distributed in fishplant and control areas. *Lockeport*- occurs only once in the fishplant area.
Clitellio arenarius (23-b,24-b)	tolerant	Wass[120] Tulkki[121] Smyth	*Louisbourg*- abundant near effluent outflows in fishplant area. *Lockeport*-more abundant in the control area.
Corophium insidiosum (23-c,24-c)	tolerant	Reish & Winter[122] Persoone & DePauw	*Louisbourg*- abundant; in control area only. *Lockeport*- occurs only in the fishplant area. Not very abundant.
Crangon sp. (24-d)	tolerant	Tulkki	*Louisbourg*- does not occur. *Lockeport*- found in the control area; does not appear in fishplant area.
Harmothoe imbricata (23-d,24-e)	tolerant	O'Sullivan[123]	*Louisbourg*- common; equally abundant in both the areas. *Lockeport* - occurs in the fishplant area only.
Idotea spp. (23-e,24-f)	tolerant	Tulkki O'Sullivan	*Louisbourg*- a common species, equally distributed in both control and fishplant areas. *Lockeport* - occurs in fishplant area, and in control area near Back Harbour.
Jassa falcata (23-f)	tolerant	Barnard[124]	*Louisbourg*- abundant at station LBC1 in the control area. *Lockeport* - not reported.
Littorina littorea (23-g,24-g)	tolerant	Smyth	*Louisbourg*- ubiquitous; equally abundant in control and fishplant areas. *Lockeport* - about equally abundant in fishplant and control areas; not present at some LPF stations.

TABLE 29 continued

ORGANISM	CLASSIFICATION	SOURCE	DISTRIBUTION
Monoculodes sp. (23-h)	tolerant	Pearce[125]	*Louisbourg*- one occurence, in the control area only. *Lockeport* - does not occur.
Mya arenaria (23-i)	tolerant	Fraser[126] Hynes[127] Tulkki Hoos[128]	*Louisbourg*- infrequent; occurs equally in both the areas. *Lockeport* - does not occur.
Mytilus edulis (23-j,24-h)	tolerant	Nair[129] Persoone & DePauw Hoos	*Louisbourg*- common; more abundant in the control area. *Lockeport* - only abundant at one fishplant station.
nematodes (23-k,24-n)	tolerant	Persoone & DePauw O'Sullivan	*Louisbourg*- abundant at outflow of fishplant effluents. *Lockeport* - not abundant; occur about equally in the two areas.
Nephtys sp. (23-l)	tolerant	Tulkki Hoos	*Louisbourg*- one occurrence, in fishplant area. *Lockeport* - does not occur.
Nereis sp. (23-m)	tolerant	Reish & Winter Dean & Haskins[130] Tulkki	*Louisbourg*- occurs only in the control area, and is not abundant there. *Lockeport* - not reported.
Phyllodoce maculata (23-o, 24-m)	tolerant	Smyth	*Louisbourg*- present in both areas about equally. *Lockeport* - one occurence, in fish plant area.
Spio setosa (24-o)	tolerant	Wass	*Louisbourg*- does not occur. *Lockeport* - one occurence, in the fish plant area.

TABLE 29 continued

ORGANISM	CLASSIFICATION	SOURCE	DISTRIBUTION
ascidians (23-n,24-i)	sensitive	O'Sullivan	*Louisbourg*- not abundant; occurs in both areas. *Lockeport* -occurs in fishplant area, and in control near Back Harbour.
Cancer irroratus (23-q)	sensitive	Pearce	*Louisbourg*- found in control area only. *Lockeport* - does not occur.
Lepidonotus squamatus (23-p)	sensitive	Bagge[131]	*Louisbourg*-occurs about equally in both areas. *Lockeport* - only one occurrence, in the fishplant area.
Littorina obtusata (23-s,23-j)	sensitive	Smyth	*Louisbourg*- very common; occurs about equally in both areas. *Lockeport* - slightly more abundant in the fishplant area.
Ophiura sp. (23-r)	sensitive	Beyer[132] Tulkki	*Louisbourg*- in control area only, not abundant. *Lockeport* - does not occur.
sponges (24-k)	sensitive	O'Sullivan	*Louisbourg*- do not occur. *Lockeport* - occurs immediately outside fish plant area; not in control.
Thais lapillus (23-t,24-l)	sensitive	Smyth	*Louisbourg*- slightly more abundant in the control. *Lockeport* - occurs only in the control area.

Nucula spp.[133] Neither the capitellids or *Nucula* are mentioned as common species in a report on another eutrophic basin of the region (Bedford Basin).[134] Quite possibly the harpacticoid copepods would not have been included with sampling methods used here (diver hand collection of surface organisms). The conclusion cannot be reached, then, that absence of these organisms from the benthos necessarily establishes a low level of pollution.

A generalisation can be made regarding the occurrence of tolerant and sensitive indicator-species at both Louisbourg and Lockeport: *there is essentially no difference in the proportional abundance of pollution-tolerant (or pollution-sensitive) animals between the "fish-plant" and control areas*. At Louisbourg only one tolerant form, *Clitellio arenarius*, showed any apparent 'preference' for the "fish-plant" area. Only two of the sensitive indicator species - *Cancer irroratus* and *Ophiura spp.* were excluded from the area while four species reported to be sensitive did occur. Three of the latter occurred at the stations nearest the fish-plant (LBF2 series).

At Lockeport, with more limited sampling and, hence, numbers of species, the pattern is less clear. While more of the tolerant species occurred in the inner harbour than elsewhere, it is also true that simply more species occurred there in total (this became more apparent in the community analysis, 6.5). Occurrence of the sensitive species was so sparse that one hardly can identify their proportional abundance between the areas. If sponges and *Littorina obtusata* can really be accepted as being pollution-sensitive[135], then their occurrence in the inner harbour at Lockeport must mean that conditions cannot be of gross pollution.

Thus, while the "non-occurrence" of one of O'Sullivan's transgressive species is not a particularly strong piece of evidence, presence of an organism reported to be intolerant of pollution is a more positive indication that pollution is not advanced. From this point-of-view, neither harbour of the study seems to be in a serious state of degradation, according to the most sensitive monitors of the marine environment.

FIG. 23. Distribution of selected indicator organisms at Louisbourg at "fish-plant" and control area stations. (density per 2 m^2 quadrat)

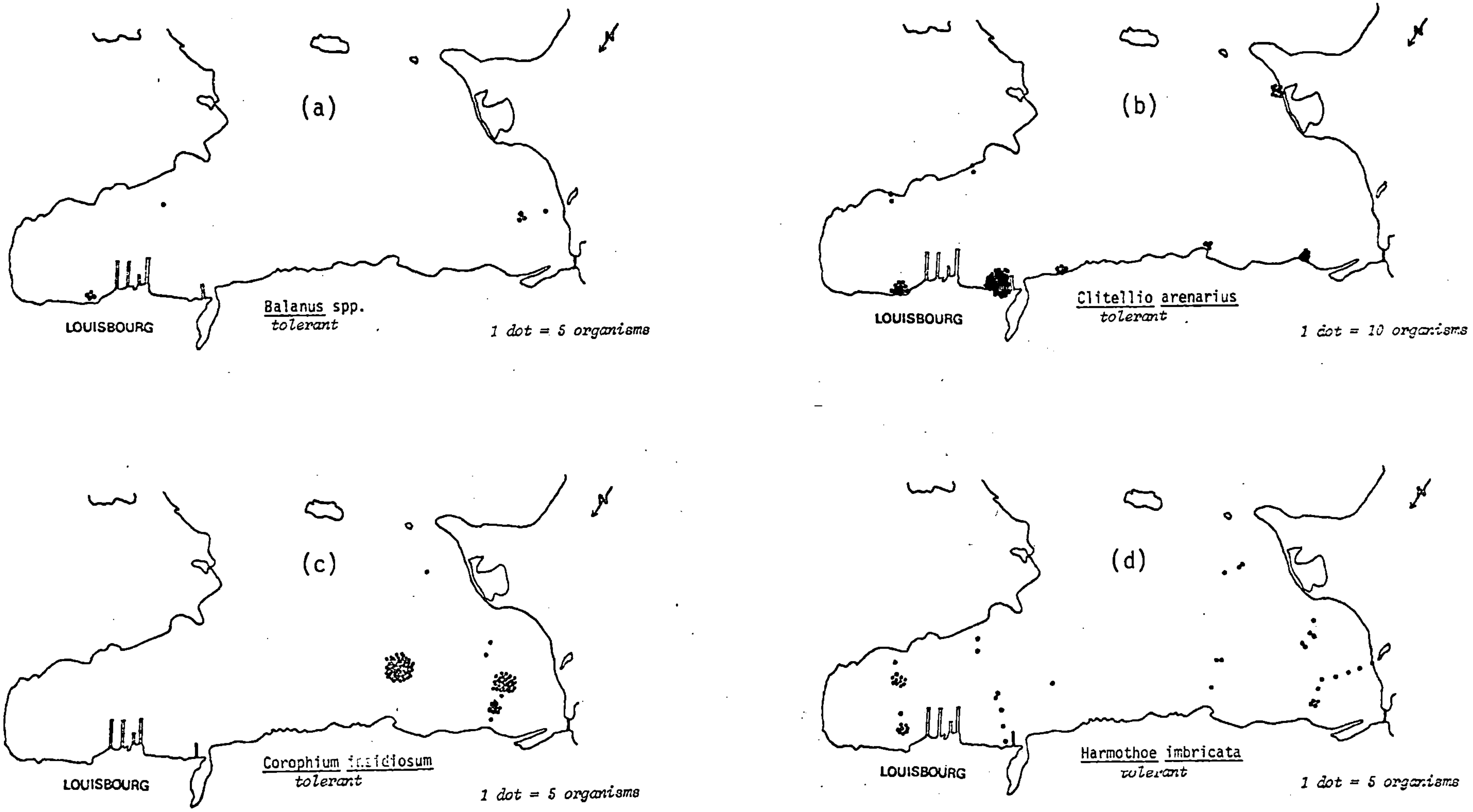


FIG. 23 continued (p.2 of 5)

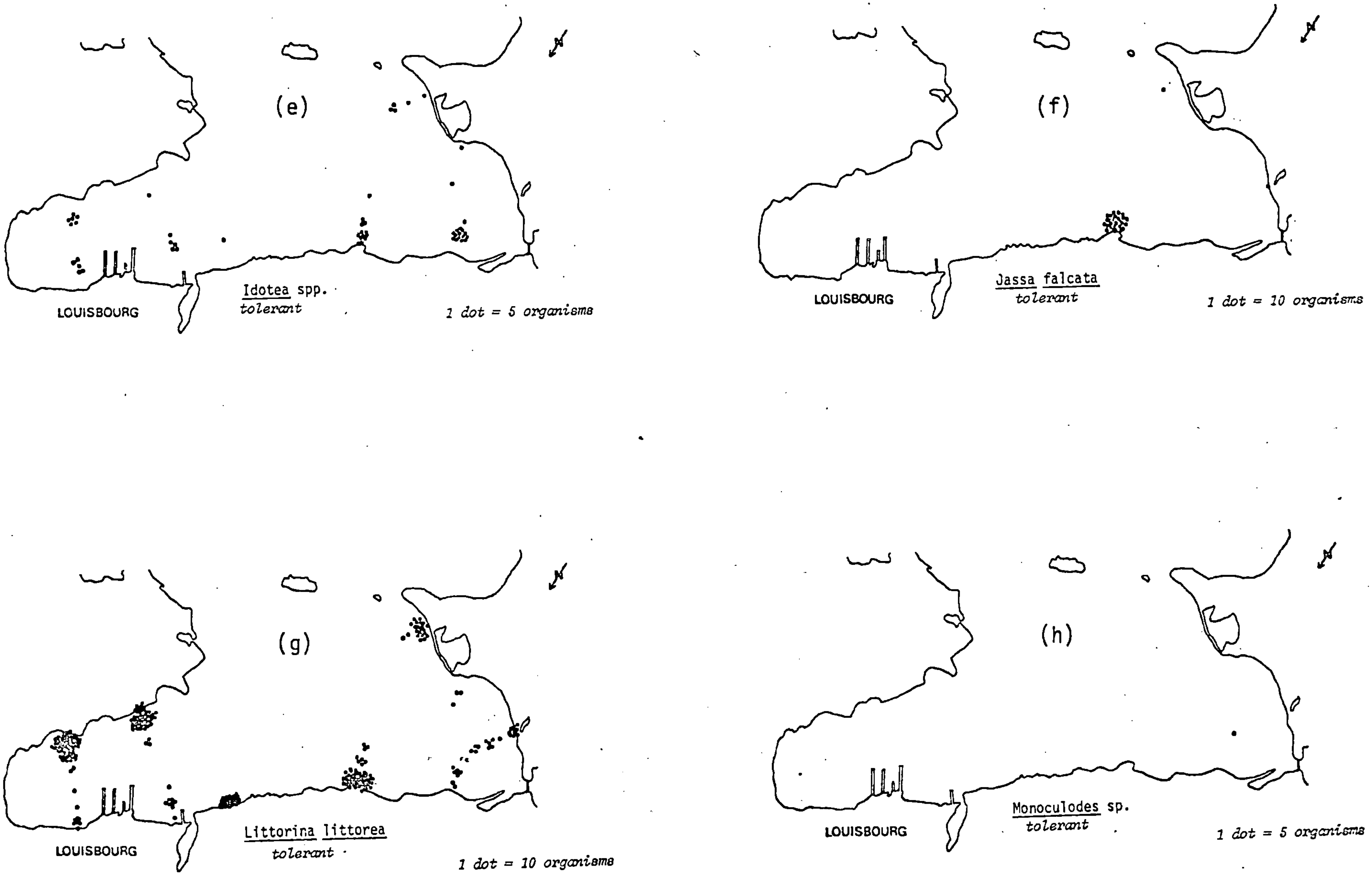
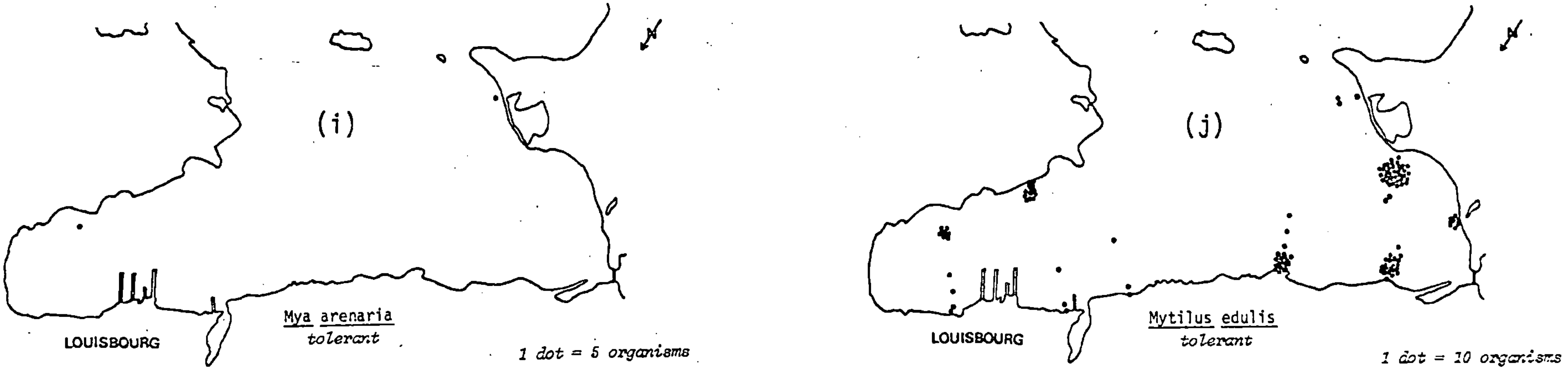


FIG. 23 continued (p.3 of 5)

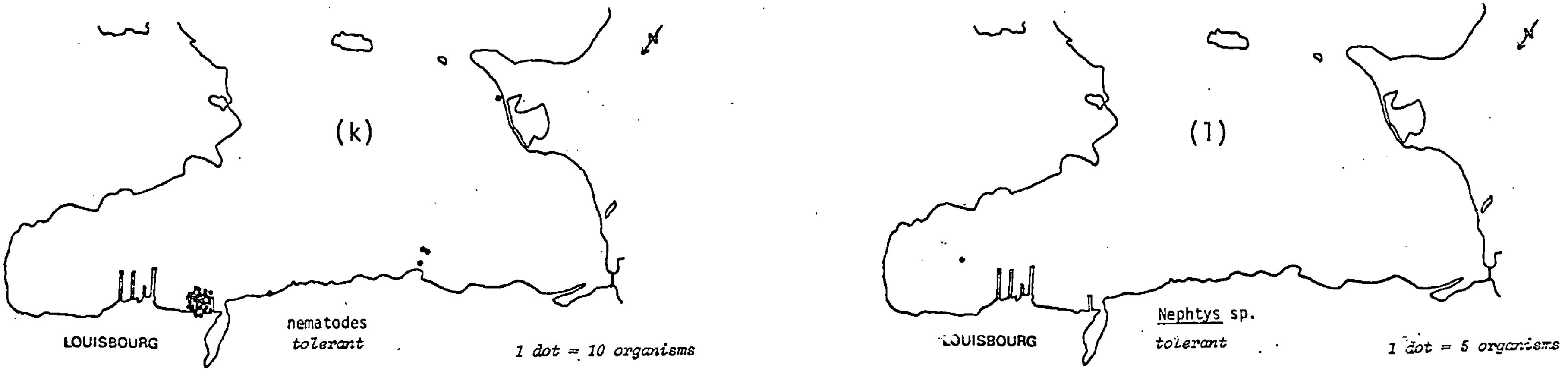


Mya arenaria
tolerant

1 dot = 5 organisms

Mytilus edulis
tolerant

1 dot = 10 organisms



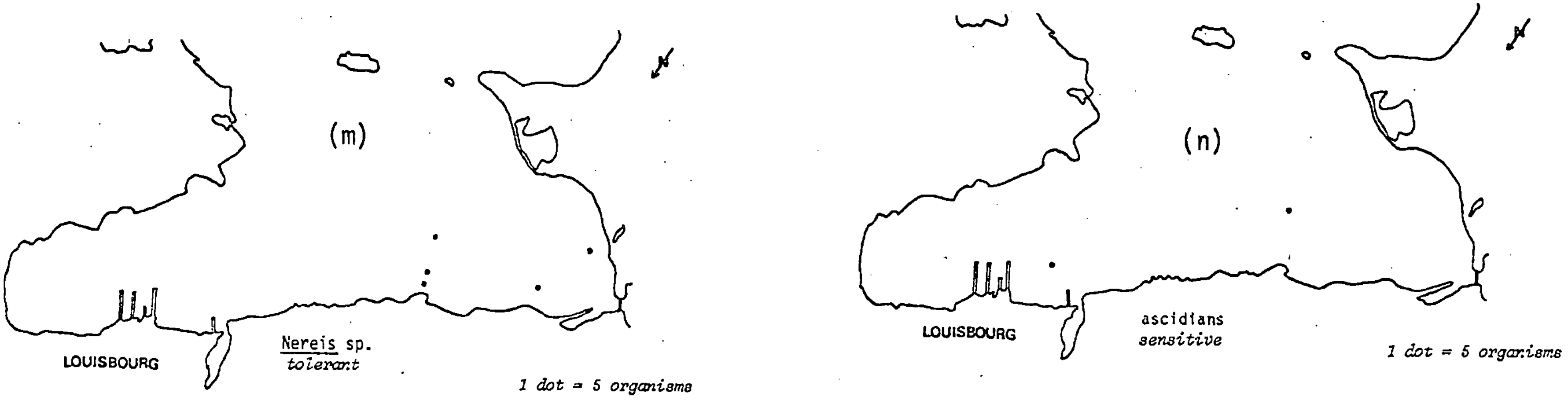
nematodes
tolerant

1 dot = 10 organisms

Nephtys sp.
tolerant

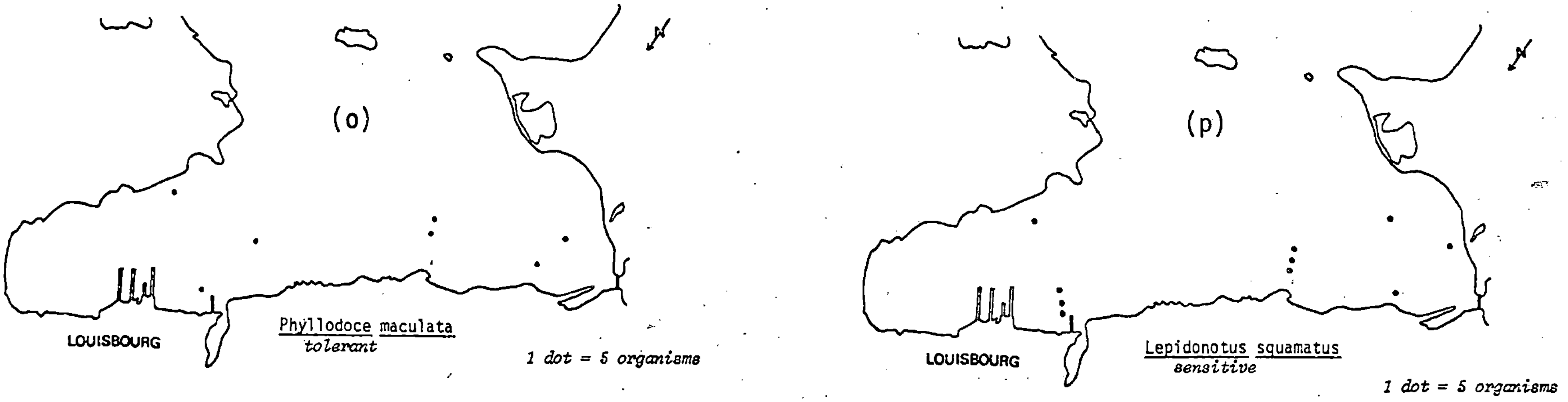
1 dot = 5 organisms

FIG. 23 continued (p.4 of 5)



(m) Nereis sp. *tolerant*

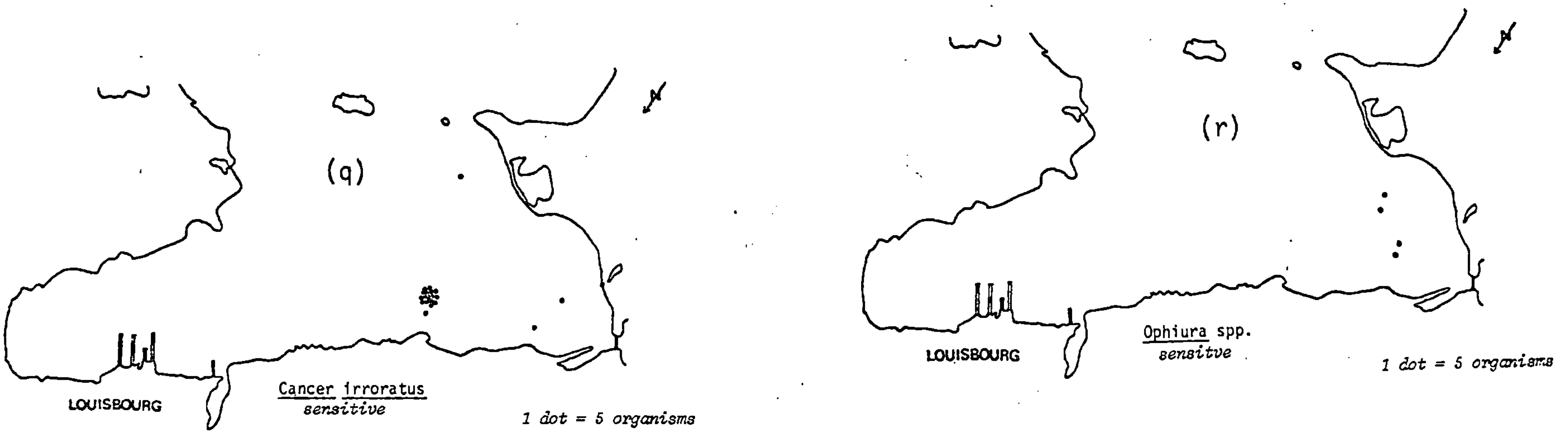
(n) ascidians *sensitive*



(o) Phyllodoce maculata *tolerant*

(p) Lepidonotus squamatus *sensitive*

FIG. 23 continued (p.5 of 5)



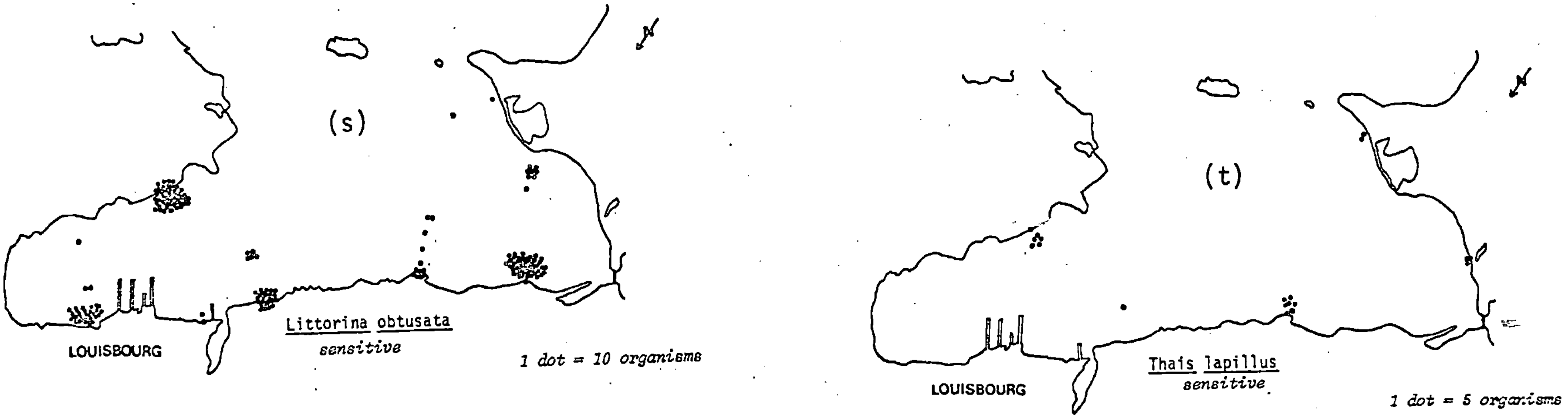
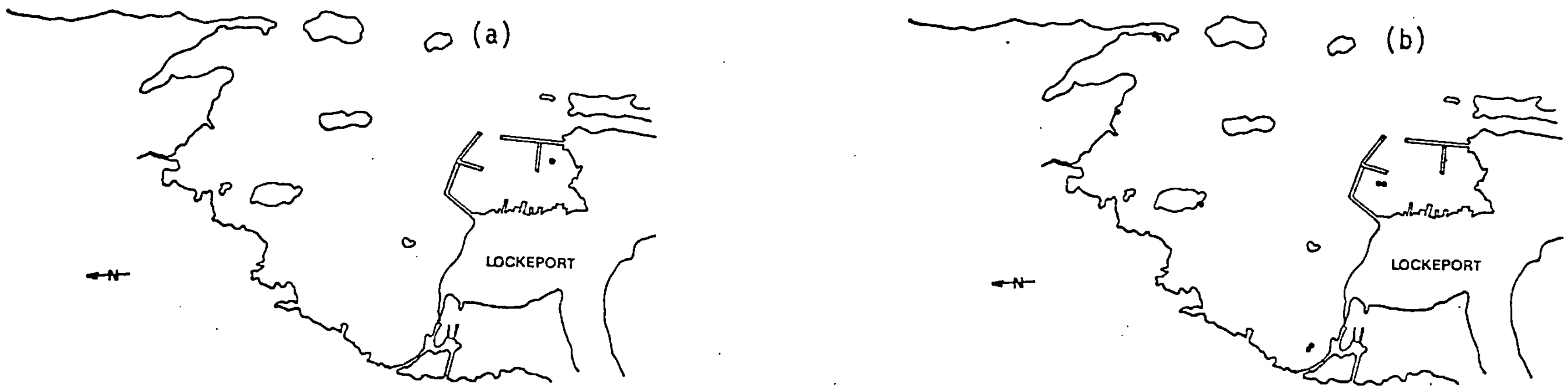
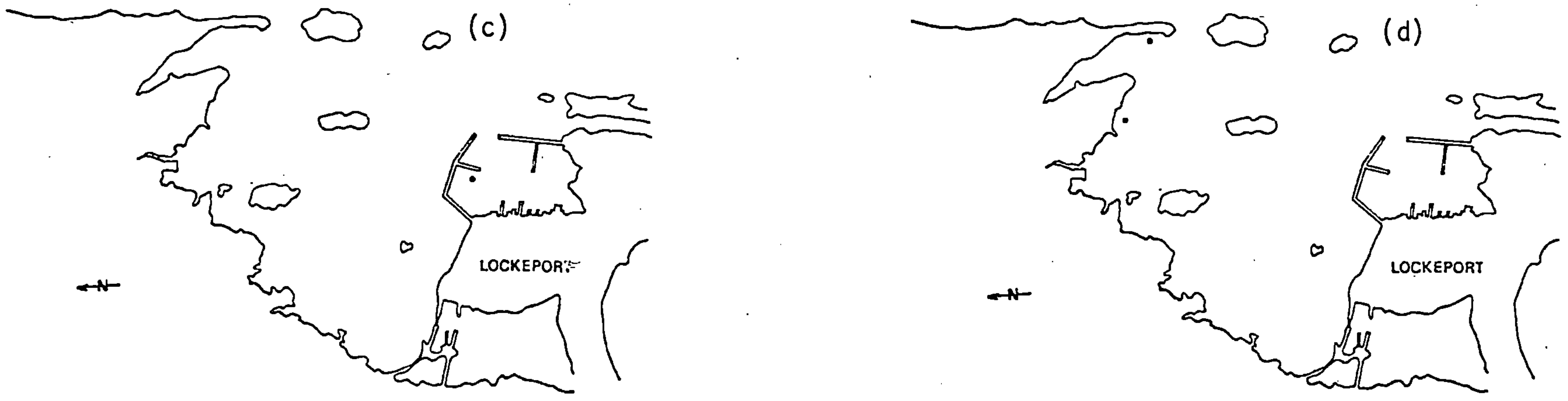


FIG. 24 Distribution of selected indicator organisms at Lockeport at "fish-plant" and control area stations (density per 2 m^2 quadrat)



Balanus spp.
tolerant *1 dot = 5 organisms*

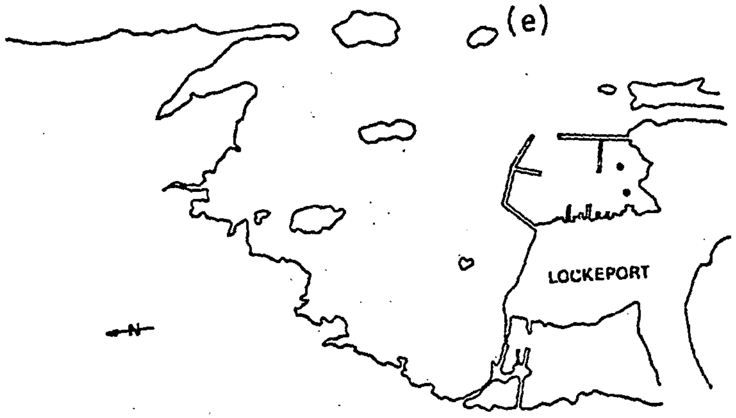
Clitellio arenarius
tolerant *1 dot = 5 organisms*



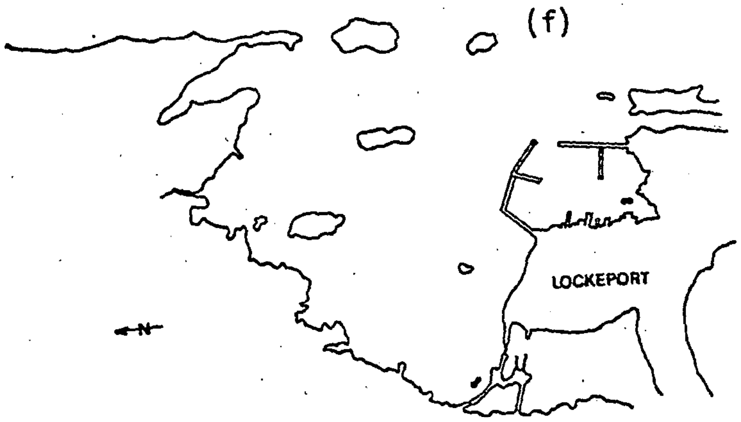
Corophium insidiosum
tolerant *1 dot = 5 organisms*

Crangon sp.
tolerant *1 dot = 5 organisms*

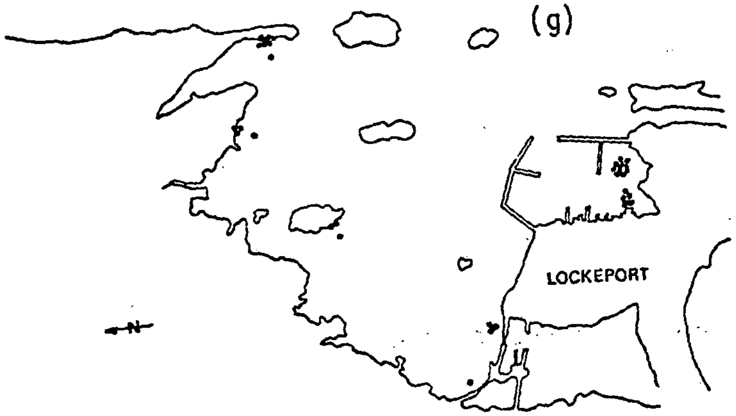
FIG.24 continued (p.2 of 4)



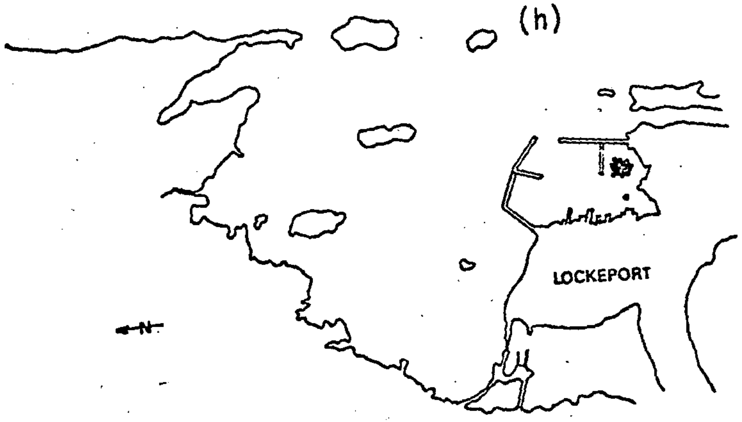
Harmothoe imbricata
tolerant
1 dot = 5 organisms



Idotea spp.
tolerant.
1 dot = 5 organisms

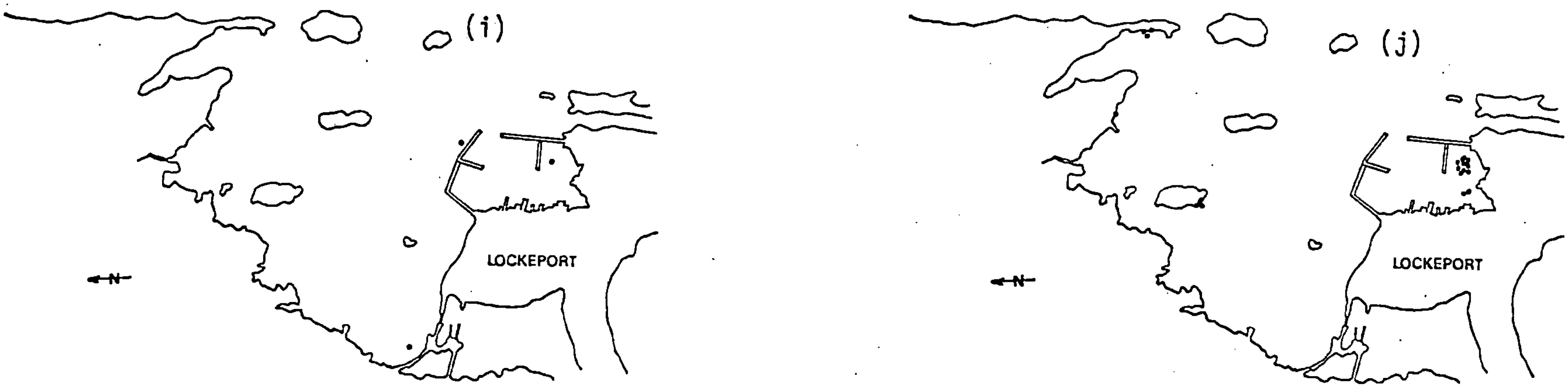


Littorina littorea
tolerant
1 dot = 10 organisms



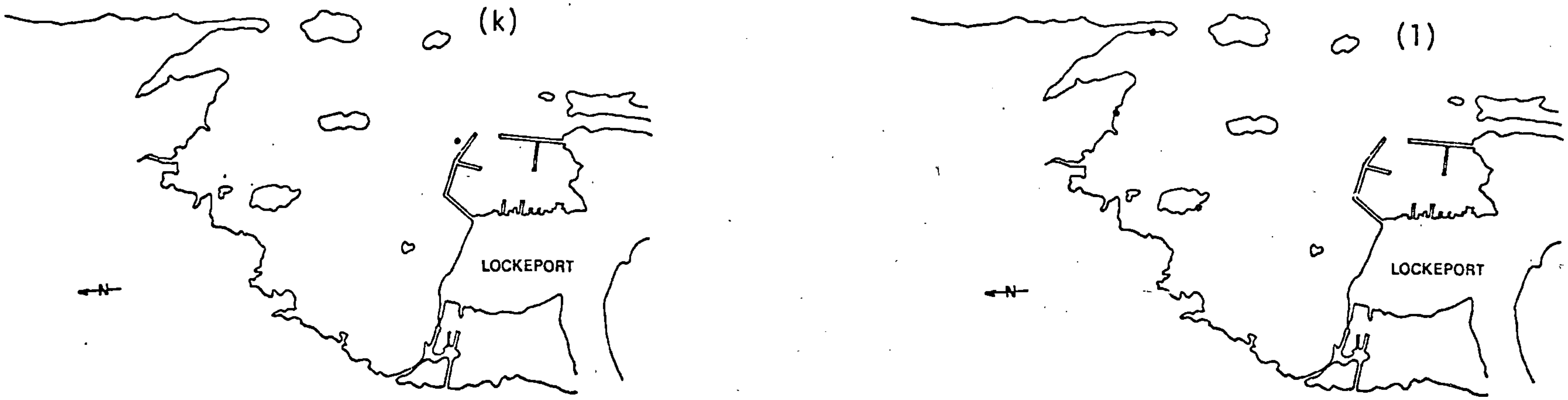
Mytilus edulis
tolerant
1 dot = 5 organisms

FIG. 24 continued (p.3 of 4)



ascidians
sensitive
1 dot = 5 organisms

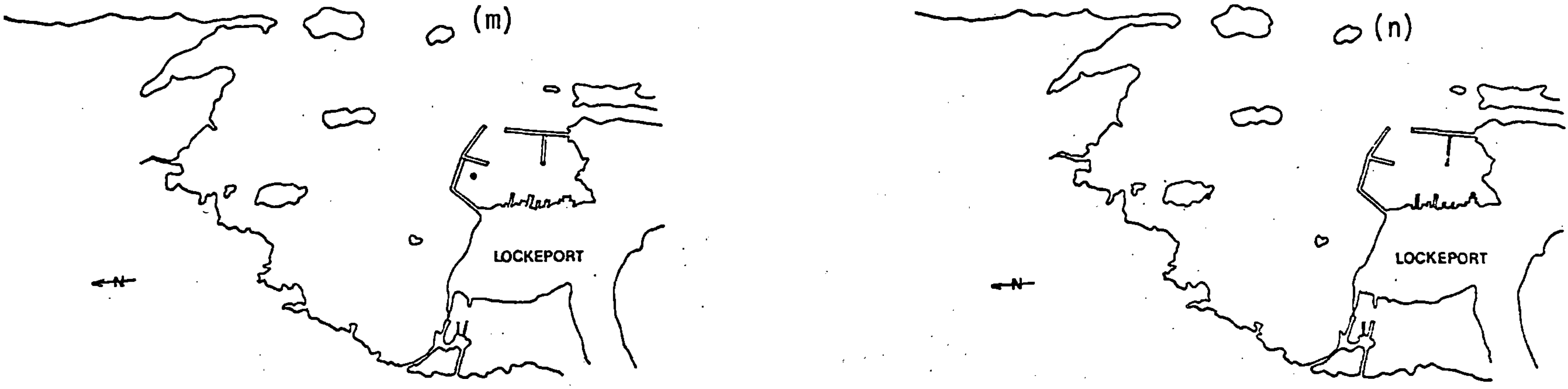
Littorina obtusata
sensitive
1 dot = 10 organisms



sponges
sensitive
1 dot = 5 organisms

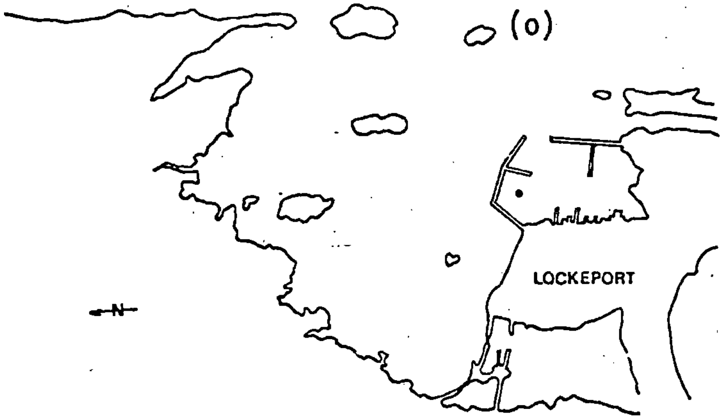
Thais lapillus
sensitive
1 dot = 5 organisms

FIG. 24 continued (p.4 of 4)



Phyllodoce maculata
tolerant *1 dot = 5 organisms*

nematodes
tolerant *1 dot = 5 organisms*



Spio setosa
tolerant *1 dot = 5 organisms*

6.5 Ecosystem Attributes in Relation to Pollution

While there are strong arguments for examining physiological and individual responses to the stress of pollution[136] there is, as well, a need to look at entire ecological systems. Margalef[137] and Odum[138] have presented separate arguments on the existence of ecosystem-level attributes that reflect and respond to the physical stress of the environment. They have also outlined expected changes in such attributes in the course of succession or ecosystem development. In a sense, this provides a charting of the normal course of ecological communities through time; departure from this course can at the very least be seen as abnormal and, from the viewpoint of the environmental manager, wrong.

Species diversity and related measures are expected to increase in a maturing ecosystem. Stress retards this maturation. Thus indices of diversity have become probably the most popular community-level attribute for assessment of man-induced stress on natural systems. Such indices have been applied in the analysis of pollution effects on biota of streams[139], lakes[140], and in the marine environment.[141]

In this analysis three kinds of diversity measurement have been used in comparing "fish-plant" and control areas at Louisbourg and Lockeport. The first is the popular index based on information theory and first proposed by Margalef[142]. It is given by

$$H = - \Sigma P_i \log P_i$$

in which H is the diversity index and P_i is the proportional abundance of the i th taxon.

The rationale for applying this measure of signal uncertainty to ecological diversity has been adequately discussed by Margalef and by Pielou[143].

A second measure used here is that of species richness, given by:

$$R = \frac{S - 1}{\log N}$$

in which R is richness, S is the number of species observed and N is the total number of individual organisms in the collection. This is also a measure devised by Margalef[144]. It is based on a definition that "richness" is highest when every individual is of a distinct species. As can be deduced from the formula, this measure is closely related to the simple first-approximation of diversity - number of species - when samples are not too different in density.

A measure of the evenness of the community was also used in analysis of benthic communities here. Evenness is given by

$$E = \frac{H}{\log S}$$

with E, the evenness index (Pielou[145]), H, the diversity index and S, the number of species. Log S is the theoretical maximum evenness attained when all species are equal in abundance.

As Odum[146] has lucidly discussed, the information diversity index can be thought of as composed of richness and evenness components. Margalef[147] has described the separate meaning of these components in their application to pollution studies: reduction in richness reflects increasing stress in a very direct way - the environment simply becomes an intolerably "hard" place in which to live. On the other hand, reduction of evenness comes about through the "...play of accelerations and decelerations in the dynamics of populations".[148] Of course these two components are not independant of each other. This is apparent from the equations and is seen in real terms when the removal of certain species (due to physical stress) reduces competition with hardier organisms which then "accelerate".

Such measurements of diversity essentially "ignore" qualitative information on the biological composition of communities. This is, in our view, a serious drawback when only diversity is measured. But when qualitative information is also available (as in other parts of Section 6) this insensitivity to what species are present can be a real advantage. The indicator-species approach is completely dependent on how much is known about particular species. Undoubtedly,excellent potential indicator-species exist of which we are as yet unaware but their response to pollution is already gauged and integrated in an overall measure of diversity. Species diversity indices and related measures are, therefore, quite robust. It is essential, however, that uniform methods of sampling be used if comparisons are to be made on diversity. For this reason, no attempt is made in the following specific analyses to compare diversity outside of this study.

Only nonparametric tests have been used to compare diversity measures in "fish-plant" and control areas. In some studies, sufficient information has been available to discern whether or not ordinary assumptions of t-tests and anovas are met.[149] Here, diversity was calculated on the basis of single samples so that these assumptions cannot be tested. Measures based on fractional or composite expressions of fundamental properties are always to be treated cautiously. Here, Mann-Whitney *U*-tests were used in lieu of analysis of variance. Procedures were as described by Sokal and Rohlf.[150]

Louisbourg

The following parameters are presented in Table 30 : total numbers of individuals, total numbers of species, richness index, evenness index, and information diversity index. Data used to compile these composite parameters is in Appendix II .

The reader will recall that all stations whose labels end in '1' or '2' are from intertidal zones while the rest are subtidal. There is consensus in the literature that the intertidal biota are generally less diverse than neighbouring subtidal communities.[152,153] Comparison of the "fish-plant" and control areas consist, therefore, of Mann-Whitney *U*-tests separately for the intertidal and subtidal communities. Results of these tests are shown in Table 31 .

In the intertidal area, numbers of species encountered is significantly higher (at .05 level) in the control than in the "fish-plant" area. The richness and diversity indices are accepted as higher in the control area with a probability of error between .05 and .10. Depression of diversity and richness in the "fish-plant" area is pronounced, however, in the subtidal zone. As well, the evenness of the distribution of individuals among species is significantly less.

TABLE 30 Numbers of individuals (N) and species (S), richness (R), evenness (E), and diversity (H) of benthic fauna at Louisbourg

Station	N	S	R	E	H
LBC11	598	18	2.66	.66	1.90
12	687	20	2.91	.76	2.27
13	126	20	3.93	.73	2.20
14	308	19	3.14	.69	2.04
15	523	26	3.99	.63	2.07
21	76	4	.69	.22	.31
22	786	11	1.50	.63	1.52
23	500	31	4.10	.69	2.36
24	308	20	2.65	.63	1.89
25	201	11	1.89	.76	1.82
31	348	9	1.37	.71	1.52
33	96	15	3.07	.68	1.86
34	101	9	1.73	.75	1.64
35	61	9	1.95	.86	1.89
42	1844	13	1.60	.71	1.82
43	88	12	2.46	.63	1.57
44	627	24	3.57	.59	1.86
45	1517	19	2.46	.56	1.64
51	82	3	.45	.56	.62
52	371	14	2.20	.64	1.68
53	312	21	3.48	.88	2.67
54	233	15	2.57	.89	2.41
55	5	2	.62	1.46	1.01
LBF11	369	8	1.18	.64	1.33
12	855	8	1.04	.79	1.63
13	53	4	.76	.39	.54
14	36	16	4.19	1.03	2.84
15	85	12	2.48	.66	1.64
21	43	4	.60	.18	.25
22	586	8	1.10	.42	.87
23	94	5	.88	.42	.68
24	111	17	3.40	.75	2.12
25	314	12	1.91	.57	1.42
31	88	3	.45	.23	.25
32	687	8	1.07	.77	1.61
33	192	20	3.61	.71	2.11
34	2115	17	2.09	.12	.34
41	55	4	.75	.78	1.08
42	757	4	.45	.70	.98
43	953	16	2.19	.64	1.76
44	124	12	2.28	.65	1.61
51	1174	8	.99	.47	.98
52	988	9	1.16	.71	1.56
53	353	17	2.73	.62	1.76
54	42	4	.80	.51	.71

TABLE 31 Mann-Whitney tests of differences in properties of the benthic environment between the "fish-plant" and control areas at Louisbourg (symbols as in Table 30)

INTERTIDAL (10 "fish-plant stations versus 8 control stations)

	N	S	R	E	H
U -statistic	$41^{1}{}_{2}$	$61^{1}{}_{4}$	58	42	58

Critical values: $U_{.10}(10,8) = 56$, $U_{.05}(10,8) = 60$, $U_{.01}(10,8) = 67$

SUBTIDAL (12 "fish-plant stations versus 14 control stations

	N	S	R	E	H
U -statistic	105	$117^{3}{}_{4}$	122	119	$124^{2}{}_{3}$

Critical values: $U_{.10}(12,14) = 110$, $U_{.05}(12,14) = 117$, $U_{.01}(12,14) = 124$

Within the"fish-plant" area there is considerable variation in diversity and in the other indices.[†] This may be even more significant in the interpretation of the effects of the effluent than the demonstrated differences between the control and "fish-plant" areas. Johnson believes that,

> "The continual occurrence of small-scale disturbances would ... account for part of the spatial and temporal variation of diversity within benthic marine communities in relatively homogeneous environments".[151]

It follows that a high within-area variability may reflect the relative frequency of "small-scale disturbances". From Fig. 25 it is quite clear that variability of specific diversity is much less in the control area - among the subtidal stations no value below 1.00 is obtained. In the "fish-plant" area adjacent stations (e.g. LBF23 and LBF24) have much larger ranges than for the whole control area.

This interpretation of within-area variability in diversity would be consistent with the extremes mentioned in various parts of the discussion on water quality. One could also suggest tentatively the possibility that oxygen deficits might occur sporadically. This *occasional* perturbation (or other kinds of occasional perturbation) could cause limited mortality and highly localized reduction of diversity without being detected in a discrete sampling programme. Patches of low diversity might then slowly recover with recolonization from less affected patches. The integrated effect, however, of occasional disturbances would be the existence of low and higher diversity patches at any given time. Since fish-processing plants are dependant on the

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[†] See Fig 25

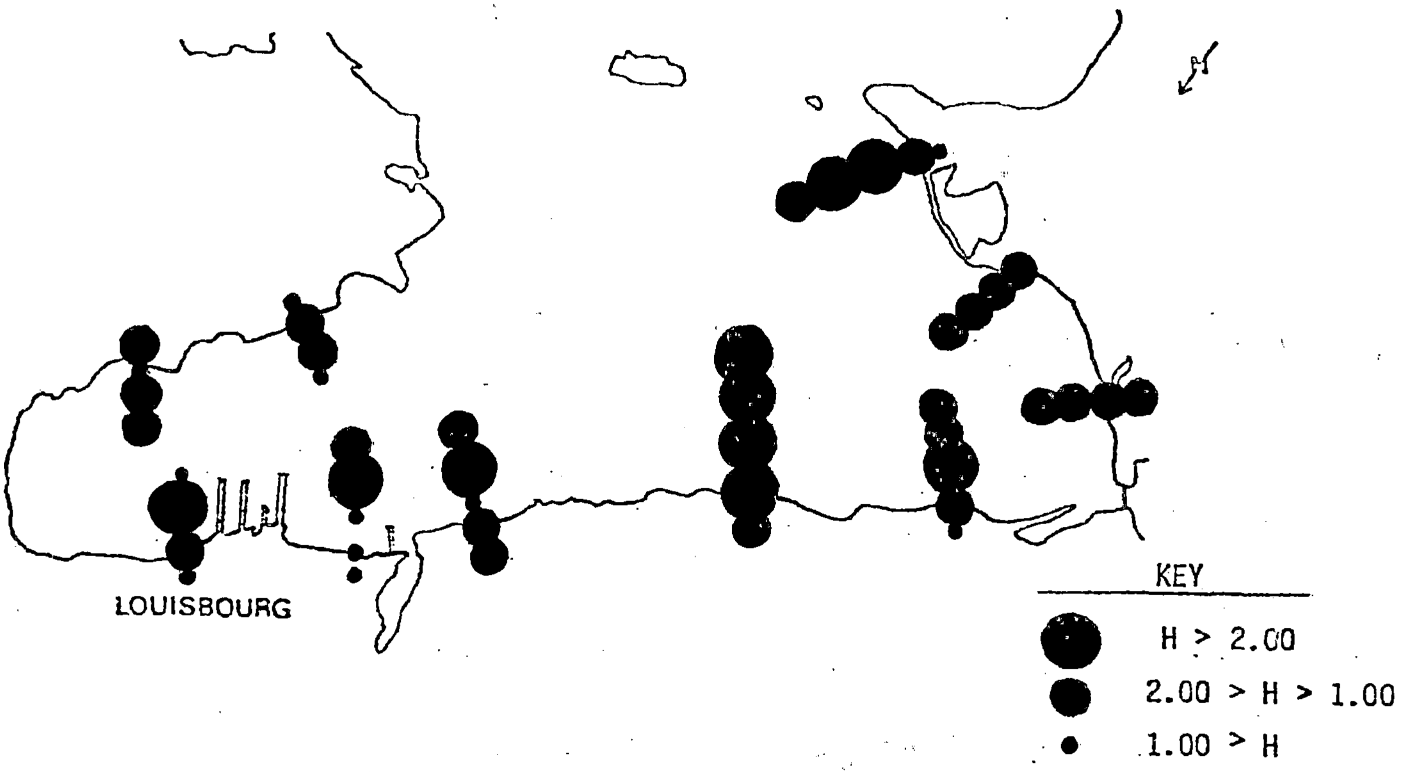
FIG 25 Specific diversity (H) at Louisbourg Harbour*

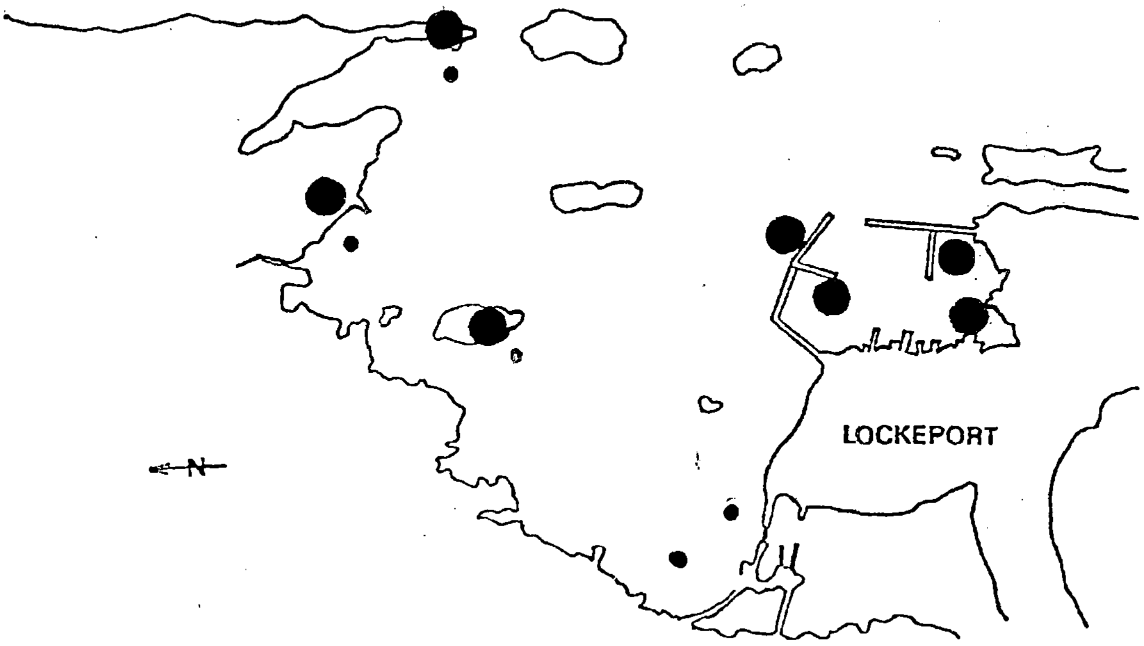
FIG 26 Specific diversity at Lockeport Harbour*

KEY: AS ABOVE

* Locations only approximate; intertidal station position on shore is exaggerated.

vagaries of fishing success on the shelf it might be expected that production - and release of effluent - would be quite variable through time, certainly in comparison to release of domestic wastes. If this is true for the plants at Louisbourg then it may partially explain and be reflected in the variation of diversity within the Northeast Arm of the harbour.

Lockeport

Characteristics of the benthic communities of the "fish-plant" and control areas as Lockeport are shown in Table 32 . The small number of stations involved required no sophisticated statistical analysis for discerning patterns. If anything, the patterns of diversity and the other indices were reversed from what was encountered at Louisbourg. The four "fish-plant" stations were all higher than any of the subtidal control stations in both richness (excepting LPC43) and in diversity (all stations). Clearly, numbers of individuals and of species are also higher in the "fish-plant" area. The number of samples involved is so small that one is tempted to avoid reaching any conclusion; nonetheless, it is concluded that the "fish-plant" area at Lockeport does not show either low or highly variable diversities as encountered at Louisbourg.† In short, diversity measurements do not indicate heavy pollution.

As elsewhere in this analysis, one must also conclude that something is amiss in the so-called control area if, despite its obviously better circulation and the absence of major waste sources, it shows quality characteristics below those attained in the inner harbour.

† See Fig. 26

TABLE 32 Numbers of individuals, species, richness, evenness, and diversity of benthic fauna at Lockeport (Symbols as in Table 30)

Station	N	S	R	E	H
LPC11	124	6	1.04	.88	1.58
LPC13	12	3	.80	.66	.72
LPC21	47	8	1.32	.73	1.51
LPC23	10	3	.87	.58	.64
LPC31	78	12	2.52	.71	1.77
LPC33	6	1	0	0	0
LPC43	29	10	2.67	.25	.57
LPC53	27	2	.30	.23	.16
LPF13	400	11	1.67	.57	1.40
LPF25	164	9	1.57	.54	1.18
LPF33	390	13	2.01	.68	1.75
LPC53	54	10	2.26	.80	1.84

Relationships of sediment chemistry to diversity etc.

Both the chemical and community characteristics of the benthic environment proved to be significantly different in the "fish-plant" and control areas at Louisbourg Harbour. At Lockeport, diversity and other measures of "maturity" were actually somewhat higher in the "fish-plant" area. Storrs et al.[154] discovered that for stations with diversity lower than expected (from data on chlorosity and grain-size), diversity was correlated negatively with an "index of putrescibility". The latter is, in essence, a COD for the sediments and is tightly correlated with organic carbon and nitrogen content. It was of interest, therefore, to examine the relationship between diversity at Louisbourg and Lockeport and C and N content of deposits from the same station.

Correlation and regression analyses were performed on species diversity (H) versus all of the chemical parameters - basic and derived - describing sedimentary organic matter. No significant relationships emerged. In fact the largest Pearson r value obtained was less than .10; the analysis was repeated using non-parametric methods with still no significant results. The problem is quite obviously that only 3 control stations were represented by sediment chemical properties. Thus, we were by and large looking at the relationship *within* the "fish-plant" area. This would still have been valuable had sediment and biological samples been gathered at exactly the same time. This was not the case and it is probable that sediments collected on a separate occasion were not truly representative of the "patch" of diversity from the the station of the same number.

It would be very desirable to obtain some simultaneously taken samples of the biota, organic matter, and mineral fraction of the benthic environment of these harbours. Relationships are known to be important in natural systems[155-156] and a departure from expected biological distributions would be strongly indicative of an important perturbation.

VI SUMMARY AND CONCLUSIONS

Two Nova Scotian inlets receiving effluent from fish-processing plants were surveyed in June-August, 1974. Louisbourg Harbour receives wastes from National Sea Products (NSP) and a smaller fish-plant, Hopkins, as well as domestic wastes from the Town of Louisbourg (est.pop. 1500). Rough calculations suggest quantities of effluent released by the town are considerably less than by the two fish-plants (Section I) At Lockeport - also a town of approximately 1500 - fish-plant wastes enter the inner harbour (Fig.2) while domestic wastes are mostly released to the area known as Back Harbour (Fig.2). Benthic and water quality stations were established at both harbours in areas operationally referred to as the "fish-plant" and control areas.

Eleven water quality properties and several characteristics of the benthic biota were assessed in both harbours (Table 2). This provided information on expected consequences of organic pollution. Heterogeneity of coastal inlets is a constraint on generalising the results. For the most part, however, data has been treated as representative of conditions at the two harbours.

Failure to observe a decline in salinity near the NSP plant, despite significant use in that plant of fresh water, indicates fairly good mixing at Louisbourg. Dye studies there suggest that the common direction of water motion is towards the head of the harbour away from the NSP plant. At Lockeport, a larger proportion of water use is from seawater in the two plants - NSP and Swim Bros. However fresh water is released in quantities in the order of hundreds of thousands gpd without noticeable effect on adjacent salinities. This suggests reasonable mixing; however, dye studies and spatial heterogeneity in temperature indicate that "cells of water" may

may occur at Lockeport and that flushing of such cells may be fairly slow. In summary, at Louisbourg circulation is vigorous with the possibility that larger suspended matter could be deposited at the head of the harbour; at Lockeport, heterogeneity in water properties and variable strength of circulation seems to be indicated (Section III)

Water quality data from stations near the fish-plants at both harbours have been compared (a) to other stations in the "fish-plant" area, (b) to control area stations, and (c) to characteristics of waters in other Nova Scotian inlets.

BOD and phenols were with very few exceptions below detection limits at both harbours.

LOUISBOURG - COD showed some tendency to be higher in the "fish-plant" than the control area. The most impressive trend was extreme variability in the former area. Between June and August, COD changed by an order of magnitude; this was not simply related to the quantities of effluent released at these times. SS (suspended solids) decreased with distance from the outflow within the "fish-plant" area but was not significantly different overall between this and the control area. Moreover, absolute values were generally low (below 20 mg/1). TIP did not show a gradient decline with increasing distance from the outflow. Overall, "fish-plant" values were higher than control. TIP in the "fish-plant" area and particularly near the plants was far higher than concentrations at comparable depths in other N.S. inlets, both eutrophic and oligotrophic. TOP was actually somewhat higher in the control area than in the "fish-plant" area. Concentrations were in the same general range as those for TIP. Little information is available on expected TOP in natural waters; TIP at Louisbourg *was often higher than what has been called "danger" levels* in the literature (see ref.53). Some values of NO3 were very high compared to data from other N.S. inlets, especially in late June. Yet variability was high both spatially and temporally as many stations fell below limits of detection throughout the summer. Excessive concentrations and extreme variability was even more pronounced for NH3 concentrations. NH3 values were obtained which were far higher than those found, for example, in the bottom waters of Bedford Basin. Again these did not persist between sampling times or through the "fish-plant" area as a whole. OG (oil & grease) was measured only in June and at that time was not simply related to distance from the outflow. The highest OG readings were, in fact, in the control area.

Particulate C and N at Louisbourg was assessed at only three stations in each area. One fairly high value was recorded at a station in the "fish-plant" area but, for the most part, values were at least as low as data recorded in St. Margaret's Bay, a reasonably unpolluted inlet of this coast.

Analysis of variance indicated that standing crop of phytoplankton (as assessed with chlorophyll-a data) was higher in the "fish-plant" area. In its concentration of chlorophyll, the "fish-plant" area most closely resembled some other eutrophic N.S. inlets while the control area concentrations are more like those of St. Margaret's Bay. This implies that the "fish-plant" area is indeed enriched.

LOCKEPORT - COD values at Lockeport never reached the levels observed at Louisbourg. If anything, the inner harbour had lower COD than stations outside and more distant from the fish-plants. Throughout Lockeport

SS was under 5mg/l except on one occasion when values 3 to 4 times this high were generally recorded throughout control and "fish-plant" areas. Even at this time concentrations were much less than levels considered dangerous to aquatic life. Stations nearest the fish-plants did have the highest TIP concentrations, in June. However, in August the control area had TIP concentrations quite similar to those occurring in the inner harbour. Most of these values were near or above the "danger" level referred to above. TOP did not appear to be simply related to distance from the outflow. In June, concentrations were similar in the "fish-plant" and control areas while in August the latter was considerably less. This apparent decline may well be related to the observed increase in TIP (i.e. some of the organically-bound PO4-P appears to have been mineralised) No NO3 levels were recorded that were suggestive of heavy nutrient addition but there were NH3 concentrations much beyond the range encountered elsewhere in Nova Scotian inlets. In fact, NH3 attained levels in the "fish-plant" area as high or higher than the range of values in the Potomac River below Washington, D.C. Maxima at Lockeport exceeded those at Louisbourg. The control area was lower in NH3 but still high by comparison with other inlets of this coast. The fact that highest values at Lockeport were in the area of fish-plant waste addition rather than domestic addition indicates that the former is an important source of nitrogen. This conclusion may be applied to the Louisbourg situation where examination of receiving waters cannot distinguish domestic from processing plant wastes. Oil and grease concentrations within the "fish-plant" area were highest near the plants but yet higher concentrations were observed in samples from the control area.

Particulate C and N were higher in the inner harbour than outside in June but this difference was not very apparent during August. As at Louisbourg, the range of concentrations observed are not remarkable in comparison to data from systems believed to be relatively free of serious organic pollution.

Data on chlorophyll at Lockeport was quite limited. It did appear that higher values occurred within the inner harbour than in the control area.

Chemical characteristics of the sediments, DO in the bottom waters and biological composition was assessed to see how the benthic environment had responded to wastes from the plants.

LOUISBOURG - Sedimentary organic C and N, C/N ratio and organic sediment index (OSI) were much higher in the "fish-plant" area - with the exception of very low values recorded at the LBF1 series of benthic stations. If the strength of water circulation and grain-size of the sediment mineral fraction can be considered to be similar in the control and "fish-plant" areas, then these properties indicate that significant enrichment has occurred under the influence of the processing plants. DO (dissolved oxygen) in the bottom waters was never limiting and, in fact, often supersaturated. It is hard to reconcile this with the NH3 results and, again, there is a suggestion of high variability in conditions at Louisbourg.

Algal composition - both total numbers and relative abundance of species known to be pollution-sensitive - suggested that the "fish-plant" area at Louisbourg was disturbed. No such trends were suggested in the information on distribution of faunal indicator-organisms.

Diversity and richness of the intertidal communities were somewhat lower in the "fish-plant" than in the control area and this trend was more apparent with the same community properties (and evenness) for the subtidal benthos. Moreover, the variation of diversity within the "fish-plant" area was considerably higher than variations within the control. This may reflect and integrate the impact through time of small-scale and short-term perturbations.

While it is obvious in general that chemical properties of the sediment organic matter and species diversity are negatively related, this trend could not be confirmed through regression and correlation analysis.

LOCKEPORT - Organic C and N were higher at the stations nearest to the fish-plants than at other "fish-plant " area stations within and outside the inner harbour. Yet control area stations had organic content equivalent to the highest stations in the "fish-plant" area. This confirms what has been indicated several times in this study: the control area of Lockeport must be subject to heavy organic loads alternative to the wastes from the fish-plants. As at Louisbourg, no low DO readings were obtained in the bottom waters. Again this is surprising and the possibility that a consistent measurement error (e.g. malfunctioning of the O_2- meter) occurred, cannot be disregarded. Otherwise extremely high NH3 values are difficult to explain.

Both algal distributions and faunal indicator-organism information were based on too limited information for pollution-related trends to be discerned. Strictly speaking, the same is true for the diversity and related measures; however, it did appear that the "fish-plant" area communities were, if anything, more diverse and less variable in diversity than the control area benthos.

MAIN CONCLUSIONS

(1) Louisbourg is reasonably well flushed yet occasional high concentrations are recorded for nutrients. This and high chlorophyll concentrations near the fish-plants indicate enrichment. The distribution of algae reflects disturbed conditions. Diversity is not only lower overall but more variable within the immediate area of the fish-plants. This is probably the result of periodic disturbances - a hypothesis that is in accordance with the expected day-to-day and seasonal variation in production of fish processing-plants.

(2) Lockeport's inner harbour is in better shape than might be expected from its highly enclosed state. There are very high nutrient concentrations at times, especially of NH3. Although the sediments are obviously highly enriched, this enrichment does not appear to have resulted in an impoverished benthic community. There is some possibility that spatial complexity of the inner harbour may lead to the formation of small distinct water masses of a chemical composition not adequately represented by large-scale averages.

(3) Fish-plant wastes released into the marine environment do not result in abiotic zones. The effect is clear in a more organic sediment and, generalizing from the more complete Louisbourg information, a benthic community of a lower and more variable diversity.

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$$\mathrm{TOC} = \mathrm{COD} \div 2.67$$

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APPENDICES

p.A1-A2 -Appendix I: Water quality data for Louisbourg and Lockeport, summer, 1974.

Property	Unit	Missing data	Minimum detectable
COD	mg/L	Blank	not given
SS	mg/L×10	Blank	not given
TIP	µg/L	0	5
TOP	µg/L	0	5
NO3	µg/L	0	5
OG	ppm	0	5
NH3	µg/L	0	17

Thus all data for nutrients TIP,TOP,NO3 that is listed as 5 was either 5µg/L or less; as 0 means that no value was obtained.

p.A3-A19- Appendix II: Raw data on numbers of faunal individuals or wet weight algae per 2 m^2 quadrat, at Louisbourg and Lockeport.

Most faunal species names follow Gosner, K.G.(1971, Guide to identification of marine and estuarine invertebrates.Wiley-Interscience) while algae are named as in Taylor, W.R.(1957. Marine algae of the northeastern coast of North America, U.Mich.Press 2nd edition.)

LBF 1	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	1356.			23.	
SS	19.	10.	41.	20.	0.
TOP	5.	5.	5.	7.	30.
TIP	280.	85.	371.	313.	67.
NO3	5.	5.	5.	5.	5.
OG	5.	5.	5.	0.	0.
NH3	34.	0.	0.	0.	160.

LBF 2	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	400.			8.	
SS	23.	3.	112.	50.	0.
TOP	379.	5.	5.	8.	140.
TIP	5.	238.	531.	322.	34.
NO3	294.	5.	5.	5.	250.
OG	5.	5.	5.	0.	0.
NH3	180.	0.	0.	0.	20.

LBF 3	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	464.	154.	455.	228.	
SS	24.	1.	22.	40.	0.
TOP	345.	5.	21.	24.	54.
TIP	5.	395.	145.	236.	136.
NO3	215.	5.	5.	7.	5.
OG	20.	5.	25.	0.	0.
NH3	130.	0.	1.	0.	1330.00.

LBF 4	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	824.	114.	456.	11.	
SS	20.	0.	114.	30.	0.
TOP	333.	5.	5.	27.	30.
TIP	5.	10.	160.	203.	115.
NO3	175.	5.	5.	10.	5.
OG	5.	5.	10.	0.	0.
NH3	70.	0.	0.	0.	60.

LBF 5	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	424.	1.	483.	42.	
SS	15.	3.	24.	20.	0.
TOP	5.	5.	5.	15.	19.
TIP	280.	205.	322.	205.	132.
NO3	5.	5.	5.	5.	5.
OG	5.	28.	5.	0.	0.
NH3	70.	0.	0.	0.	40.

LBF 6	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	438.	524.	600.	8.	
SS	12.	14	30.	20.	0.
TOP	20.	5.	5.	21.	52.
TIP	420.	258.	232.	225.	73.
NO3	5.	5.	5.	5.	15.
OG	5.	5.	14.	0.	0.
NH3	50.	0.	0.	0.	30.

LBF 7	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	374.		350.	11.	
SS	123.	21.	24.	30.	0.
TOP	15.	5.	5.	16.	10.
TIP	185.	385.	180.	184.	117.
NO3	5.	5.	5.	15.	5.
OG	6.	12.	5.	0.	0.
NH3	30.	0.	0.	0.	30.

LBF 8	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	384.		288.	4.	
SS	26.	11.	17.	20.	0.
TOP	5.	5.	0.	10.	18.
TIP	160.	215.	0.	190.	67.
NO3	5.	5.	0.	5.	5.
OG	5.	0.	0.	0.	0.
NH3	60.	0.	0.	0.	20.

LBF 9	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	224.	2.	580.	0.	
SS	4.	3.	10.	10.	0.
TOP	28.	5.	0.	12.	35.
TIP	420.	96.	0.	158.	50.
NO3	381.	5.	0.	5.	5.
OG	7.	5.	0.	0.	0.
NH3	40.	0.	0.	0.	30.

LBF10	JUL11 LOW	JUL11 HIGH	JUL12 HIGH	AUG 7 LOW	AUG 8 HIGH
COD	[illegible]	[illegible]	764.	0.	
SS	20.	23.	15.	10.	0.
TOP	5.	5.	0.	13.	25.
TIP	400.	218.	0.	137.	41.
NO3	5.	5.	0.	5.	5.
OG	5.	5.	0.	0.	0.
NH3	50.	0.	0.	0.	20.

LPF 1	JUL26 LOW	JUL26 HIGH	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	176.	88.	24.	52.	24.	24.
SS	113.	94.	86.	2.	1.	2.
TOP	88.	145.	148.	16.	120.	56.
TIP	152.	5.	5.	229.	154.	258.
NO3	15.	23.	30.	7.	7.	5.
OG	7.	24.	11.	0.	0.	0.
NH3	0.	0.	110.	0.	0.	240.

LPF 2	JUL26 LOW	JUL26 HIGH	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	32.	8.	40.	40.	28.	16.
SS	142.	234.	133.	1.	3.	2.
TOP	35.	65.	68.	79.	79.	99.
TIP	90.	48.	238.	136.	101.	117.
NO3	5.	13.	15.	10.	5.	5.
OG	7.	15.	8.	0.	0.	0.
NH3	0.	0.	180.	0.	0.	270.

LPF 3	JUL26 LOW	JUL26 HIGH	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	100.	96.	20.	16.	20.	
SS	117.	132.	109.	1.	1.	2.
TOP	35.	159.	168.	116.	120.	100.
TIP	93.	5.	5.	179.	144.	117.
NO3	5.	30.	30.	9.	12.	5.
OG	11.	5.	9.	0.	0.	0.
NH3	0.	0.	190.	0.	0.	20.

LPF 4	JUL26 LOW	JUL26 HIGH	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	56.	100.	28.	40.		4.
SS	122.	169.	113.		7.	3.
TOP	155.	75.	164.	15.	40.	15.
TIP	5.	5.	5.	162.	74.	376.
NO3	10.	8.	15.	5.	5.	5.
OG	8.	5.	5.	0.	0.	0.
NH3	0.	0.	31.	0.	0.	260.

LPF 5	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	32.	24.	28.	
SS	116.	1.	3.	2.
TOP	15.	15.	45.	5.
TIP	32.	135.	43.	202.
NO3	5.	5.	7.	5.
OG	6.	0.	0.	0.
NH3	60.	0.	0.	430.

LPF 6	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	56.	52.	8.	
SS	125.	1.	1.	2.
TOP	30.	76.	43.	20.
TIP	28.	128.	90.	336.
NO3	5.	10.	5.	5.
OG	8.	0.	0.	0.
NH3	610.	0.	0.	20.

LPF 7	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	96.	60.	1.	57.
SS	196.	5.	2.	5.
TOP	30.	50.	56.	20.
TIP	12.	130.	130.	76.
NO3	5.	20.	5.	5.
OG	7.	0.	0.	0.
NH3	1290.	0.	0.	210.

LPF 8	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	36.	28.	44.	12.
SS	133.	1.	4.	2.
TOP	30.	34.	65.	5.
TIP	11.	81.	32.	51.
NO3	5.	5.	5.	5.
OG	5.	0.	0.	0.
NH3	30.	0.	0.	20.

LPF 9	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	48.	4.	4.	8.
SS	118.	3.	1.	2.
TOP	11.	31.	52.	5.
TIP	45.	84.	5.	275.
NO3	5.	5.	5.	5.
OG	6.	0.	0.	0.
NH3	60.	0.	0.	20.

LPF10	JUL27 LOW	AUG20 LOW	AUG20 HIGH	AUG21 HIGH
COD	104.	47.	44.	8.
SS	125.	2.	3.	2.
TOP	17.	35.	5.	5.
TIP	43.	103.	232.	89.
NO3	5.	5.	5.	5.
OG	5.	0.	0.	0.
NH3	20.	0.	0.	20.

MOLLUSCA	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
ACMAEA TESTUDINALIS	0.	0.	0.	0.	1.	0.	0.	6.	0.	0.
ADMETE COUTHOUYI	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
ANOMIA ACULEATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CERASTODERMA PINNULATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CINGULA ACULEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CREPIDULA FORNICATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CREPIDULA PLANA	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
DENDRONOTUS FRONDOSUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GEMMA GEMMA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HIATELLA ARCTICA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
ISCHNOCHITON ALBUS	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
ISCHNOCHITON RUBER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LACUNA VINCTA	0.	0.	0.	1.	1.	0.	0.	0.	9.	0.
LITTORINA LITTOREA	13.	241.	0.	0.	0.	0.	1.	81.	11.	0.
LITTORINA OBUSATA	120.	116.	0.	0.	55.	3.	1.	0.	0.	0.
LITTORINA SAXATILIS	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.
LORA BICARINATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LORA NOBILIS	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
MARGARITES COSTALIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MITRELLA LUNATA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
MYA ARENARIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MYTILUS EDULIS	12.	14.	0.	0.	3.	3.	4.	0.	1.	0.
NASSARIUS TRIVITTATUS	0.	0.	47.	5.	1.	0.	0.	0.	2.	0.
ONCHIDORUS ASPERSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PANDORA GOULDIANII	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
PLACOPECTEN MAGELLANICUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RETUSA CANICULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SKENEA PLANORBIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
THAIS LAPILLUS	0.	0.	0.	7.	0.	0.	0.	0.	0.	0.
TURBONILLA INTERRUPTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TURTONIA MINUTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
UROSALPINX CINEREA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
VOLSELLA MODIOLUS	0.	56.	0.	1.	0.	0.	0.	0.	0.	0.
CRUSTACEA										
AEGININA LONGICORNIS	0.	0.	0.	6.	0.	0.	0.	0.	0.	265.
AMPITHOE RUBRICATA	0.	4.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS BALANOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS BALANUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS IMPROVISUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CALLIOPIUS LAEVIUSCULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CANCER IRRORATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
AEGININA LINEARIS	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
COROPHIUM INSIDIOSUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEXAMINE THEA	0.	0.	0.	3.	0.	0.	0.	0.	5.	0.
EUALUS GAIMARDII	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GAMMARID (UNIDENT)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GAMMARUS OCEANICUS	153.	403.	0.	0.	15.	0.	0.	0.	38.	2.
HARPINIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IDOTEA BALTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IDOTEA PHOSPHOREA	0.	0.	0.	1.	0.	0.	0.	0.	12.	6.

CRUSTACEA

	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
ISCHYROCEROS ANGUIPES	0.	0.	0.	1.	0.	0.	0.	0.	0.	1.
JAERA MARINA	5.	12.	0.	0.	0.	0.	11.	0.	0.	0.
JASSA FALCATA	4.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LEMBIUS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MONOCULODES SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MYSIS STENOLEPSIS	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
PAGURUS ACADIANUS	0.	0.	4.	1.	2.	0.	0.	0.	5.	2.
PAGURUS ARCUATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PONTOGENEIA INERMIS	0.	0.	0.	2.	2.	0.	0.	0.	14.	12.
SYMPLEUSTES GLABER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHRIMP UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS CRENATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

POLYCHAETA

	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
CIRRATUS CIRRATULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
EULELIA VIRIDIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HARMOTHOE IMBRICATA	0.	0.	0.	0.	2.	0.	3.	3.	5.	8.
LEPIDONOTUS SQUAMATUS	0.	0.	0.	0.	0.	0.	0.	3.	3.	3.
NEPHTYS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEREIS PELAGICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEREIS ZONATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NINOE NIGRIPES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PECTINARIA GRANULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHOLOE MINUTA	0.	0.	0.	2.	0.	0.	0.	0.	0.	1.
PHYLLODOCE MACULATA	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.
SPIRORBIS BOREALIS	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.

POLYCHAETA

	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
TEREBELLA LAPIDARIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
TEREBELLA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

ECHINODERMATA

	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
ASTERIAS VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ECHINARACHNIUS PARMA	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.
HENRICIA SANGUINOLENTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPHIOPHOLIS ACULEATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPHIURA ROBUSTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPHIURA SARSI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
STRONGYLOCENTROTUS DROEBA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

CNIDARIA

	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
CAMPANULARIA ANGULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CORAL SP1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CORAL SP3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
METRIDIUM SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NEMERTEA

	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
AMPHIPORUS ANGULATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
CEREBRATUS LACTEUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LINEUS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEMERTEAN UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

OLIGOCHAETA

	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
CLITELLIO ARENARIUS	54.	0.	0.	0.	0.	136.	264.	0.	0.	0.

PYCNOGONIDAE

	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
PHOXICHILIDIUM FEMORATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	LBF11	LBF12	LBF13	LBF14	LBF15	LBF21	LBF22	LBF23	LBF24	LBF25
PLATYHELMINTHES										
PROCERODES ULVAE	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ASCIDIACEA										
ASCIDIACEAN UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
NEMATODA										
NEMATODA	1.	0.	0.	0.	0.	1.	301.	0.	0.	0.
BRYOZOA										
BRYOZOA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PISCES										
LYCODES RETICULATA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
TAUTOGA ONITIS	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
PHOLIS GUNNELLIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ALGAE CHLOROPHYCEAE										
CLADOPHORA EXPANSA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
ENTEROMORPHA SP.	0.	0.	0.	0.	0.	0.	0.	0.	35.	0.
ENTOCLADIA VIRIDIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ULVA LACTUCA	0.	38.	0.	0.	6.	0.	0.	0.	0.	0.
ALGAE PHAEOPHYCEAE										
ASCOPHYLLUM NODOSUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHORDA FILIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHORDARIA FLAGELLIFORMIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DESMARESTIA ACULEATA	0.	1.	0.	0.	0.	0.	0.	0.	1.	93.
DICTYOSIPHON FOENICULACEU	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DICTYOSIPHON SP.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
FUCUS EVANESCENS	0.	60.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS SPIRALIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS VESICULOSUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAMINARIA INTERMEDIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAMINARIA LONGICRURIS	0.	0.	0.	4.	75.	0.	0.	0.	0.	0.
LAMINARIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	70.
PETALONIA SP.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
PYLAIELLA SP.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
SACCORHIZA DERMATODEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ALGAE RHODOPHYCEAE										
ANTITHAMNION SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BANGIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHONDRUS CHRISPUS	0.	0.	0.	0.	6.	0.	0.	1.	83.	7.
CORALLINA OFFICINALIS	0.	1.	1.	1.	0.	0.	0.	1.	1.	1.
GIGARTINA STELLATA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
LITHOTHAMNION SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHYCODRYS RUBENS	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
POLYIDES CAPRINUS	0.	0.	0.	0.	3.	0.	0.	0.	0.	6.
POLYSIPHONIA LANOSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
PORPHYRA UMBILICALIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RHODOPHYLLIS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RHODYMENIA PALMATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SPERMOTHAMNION TURNERI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

MOLLUSCA

	LBF31	LBF32	LBF33	LBF34	LBF41	LBF42	LBF43	LBF44	LBF51	LBF52
ACMAEA TESTUDINALIS	0.	0.	11.	1.	0.	0.	1.	0.	0.	0.
ADMETE COUTHOUYI	0.	0.	0.	0.	0.	0.	0.	2.	0.	0.
ANOMIA ACULEATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CERASTODERMA PINNULATUM	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
CINGULA ACULEA	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
CREPIDULA FORNICATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CREPIDULA PLANA	0.	0.	1.	0.	0.	0.	0.	1.	0.	0.
DENDRONOTUS FRONDOSUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GEMMA GEMMA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HIATELLA ARCTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ISCHNOCHITON ALBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ISCHNOCHITON RUBER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LACUNA VINCTA	0.	20.	14.	32.	0.	0.	23.	0.	0.	0.
LITTORINA LITTOREA	4.	59.	87.	5.	29.	396.	170.	14.	103.	336.
LITTORINA OBTUSATA	0.	322.	0.	10.	0.	0.	13.	0.	70.	356.
LITTORINA SAXATILIS	0.	0.	0.	14.	17.	0.	0.	0.	0.	0.
LORA BICARINATA	0.	0.	3.	0.	0.	0.	0.	0.	0.	0.
LORA NOBILIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MARGARITES COSTALIS	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.
MITRELLA LUNATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MYA ARENARIA	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.
MYTILUS EDULIS	0.	20.	9.	1.	0.	0.	84.	0.	42.	86.
NASSARIUS TRIVITTATUS	0.	0.	0.	1.	0.	0.	2.	0.	0.	0.
ONCHIDORUS ASPERSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PANDORA GOULDIANII	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLACOPECTEN MAGELLANICUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RETUSA CANICULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SKENEA PLANORBIS	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
THAIS LAPILLUS	0.	0.	0.	0.	0.	0.	0.	0.	1.	26.
TURBONILLA INTERRUPTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TURTONIA MINUTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
UROSALPINX CINEREA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
VOLSELLA MODIOLUS	0.	0.	4.	1.	0.	0.	0.	0.	0.	0.
CRUSTACEA										
AEGININA LONGICORNIS	0.	0.	2.	2023.	0.	0.	0.	0.	1.	0.
AMPITHOE RUBRICATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS BALANOIDES	0.	18.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS BALANUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS IMPROVISUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CALLIOPIUS LAEVIUSCULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CANCER IRRORATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
AEGININA LINEARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COROPHIUM INSIDIOSUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEXAMINE THEA	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
EUALUS GAIMARDII	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.
GAMMARID (UNIDENT)	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.
GAMMARUS OCEANICUS	0.	0.	1.	0.	0.	59.	411.	0.	0.	29.
HARPINIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IDOTEA BALTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IDOTEA PHOSPHOREA	0.	0.	12.	13.	0.	0.	27.	0.	0.	0.

CRUSTACEA	LBF31	L3F32	LBF33	LBF34	LBF41	LBF42	LBF43	LBF44	LBF51	LBF52
ISCHYROCEROS ANGUIPES	0.	0.	0.	1.	0.	0.	223.	73.	0.	0.
JAERA MARINA	1.	214.	0.	0.	2.	289.	0.	0.	826.	119.
JASSA FALCATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LEBBEUS SP.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
MONOCULODES SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MYSIS STENOLEPSIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PAGURUS ACADIANUS	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.
PAGURUS ARCUATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PONTOGENEIA INERMIS	0.	0.	3.	1.	0.	0.	0.	1.	0.	0.
SYMPLEUSTES GLABER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHRIMP UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS CRENATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
POLYCHAETA										
CIRRATUS CIRRATULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
EULELIA VIRIDIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HARMOTHOE IMBRICATA	0.	0.	39.	1.	0.	0.	3.	25.	0.	0.
LEPIDONOTUS SQUAMATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEPHTYS SP.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
NEREIS PELAGICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEREIS ZONATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NINOE NIGRIPES	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
PECTINARIA GRANULATA	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
PHOLOE MINUTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHYLLODOCE MACULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SPIRORBIS BOREALIS	0.	0.	1.	1.	0.	0.	3.	3.	0.	0.
TEREBELLA LAPIDARIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TEREBELLA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ECHINODERMATA										
ASTERIAS VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ECHINARACHNIUS PARMA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HENRICIA SANGUINOLENTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPHIOPHOLIS ACULEATA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
OPHIURA ROBUSTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPHIURA SARSI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
STRONGYLOCENTROTUS DROEBA	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
CNIDARIA										
CAMPANULARIA ANGULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CORAL SP1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CORAL SP3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
METRIDIUM SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEMERTEA										
AMPHIPORUS ANGULATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CEREBRATUS LACTEUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LINEUS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEMERTEAN UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OLIGOCHAETA										
CLITELLIO ARENARIUS	83.	33.	0.	0.	7.	13.	0.	0.	12.	15.
PYCNOGONIDAE										
PHOXICHILIDIUM FEMORATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PLATYHELMINTHES	LBF31	LBF32	LBF33	LBF34	LBF41	LBF42	LBF43	LBF44	LBF51	LBF52
PROCERODES ULVAE	0.	1.	0.	0.	0.	0.	0.	0.	19.	15.
ASCIDIACEA										
ASCIDIACEAN UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEMATODA										
NEMATODA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BRYOZOA										
BRYOZOA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PISCES										
LYCODES RETICULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TAUTOGA ONITIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHOLIS GUNNELLIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ALGAE CHLOROPHYCEAE										
CLADOPHORA EXPANSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ENTEROMORPHA SP.	0.	0.	75.	0.	0.	0.	1.	0.	0.	0.
ENTOCLADIA VIRIDIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ULVA LACTUCA	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.
ALGAE PHAEOPHYCEAE										
ASCOPHYLLUM NODOSUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHORDA FILUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHORDARIA FLAGELLIFORMIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DESMARESTIA ACULEATA	0.	0.	37.	40.	0.	0.	750.	3.	0.	0.
DICTYOSIPHON FOENICULACEU	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DICTYOSIPHON SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS EVANESCENS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS SP.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
FUCUS SPIRALIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS VESICULOSUS	0.	163.	0.	0.	0.	0.	0.	0.	35.	0.
LAMINARIA INTERMEDIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAMINARIA LONGICRURIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAMINARIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PETALONIA SP.	0.	0.	0.	0.	0.	0.	0.	37.	0.	0.
PYLAIELLA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SACCORHIZA DERMATODEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ALGAE RHODOPHYCEAE										
ANTITHAMNION SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BANGIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHONDRUS CRISPUS	0.	0.	117.	0.	0.	0.	0.	1.	0.	0.
CORALLINA OFFICINALIS	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
GIGARTINA STELLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LITHOTHAMNION SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHYCODRYS RUBENS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
POLYIDES CAPRINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
POLYSIPHONIA LANOSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PORPHYRA UMBILICALIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RHODOPHYLLIS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RHODYMENIA PALMATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SPERMOTHAMNION TURNERI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

MOLLUSCA

	LOF53	LOF54	LBC11	LBC12	LBC13	LBC14	LBC15	LBC21	LBC22	LBC23
ACMAEA TESTUDINALIS	4.	0.	3.	26.	6.	16.	0.	0.	0.	1.
ADMETE COUTHOUYI	4.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ANOMIA ACULEATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CERASTODERMA PINNULATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
CINGULA ACULEA	0.	0.	1.	0.	0.	0.	1.	0.	0.	6.
CREPIDULA FORNICATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CREPIDULA PLANA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
DENDRONOTUS FRONDOSUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GEMMA GEMMA	0.	0.	0.	4.	0.	0.	0.	0.	0.	0.
HIATELLA ARCTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	5.
ISCHNOCHITON ALBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ISCHNOCHITON RUBER	0.	0.	0.	0.	1.	2.	1.	0.	0.	0.
LACUNA VINCTA	15.	0.	2.	21.	0.	13.	84.	0.	0.	320.
LITTORINA LITTOREA	0.	35.	276.	194.	51.	35.	0.	0.	16.	60.
LITTORINA OBUSATA	0.	0.	69.	2.	3.	4.	21.	1.	461.	39.
LITTORINA SAXATILIS	0.	0.	5.	0.	0.	0.	0.	0.	7.	0.
LORA BICARINATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LORA NOBILIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MARGARITES COSTALIS	1.	0.	0.	0.	0.	0.	0.	0.	2.	11.
MITRELLA LUNATA	0.	0.	0.	0.	0.	0.	5.	0.	0.	4.
MYA ARENARIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MYTILUS EDULIS	0.	0.	86.	67.	11.	1.	7.	3.	125.	71.
NASSARIUS TRIVITTATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ONCHIDORUS ASPERSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	25.
PANDORA GOULDIANII	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PLACOPECTEN MAGELLANICUS	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
RETUSA CANICULATA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
SKENEA PLANORBIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
THAIS LAPILLUS	0.	0.	12.	24.	0.	0.	0.	0.	0.	0.
TURBONILLA INTERRUPTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TURTONIA MINUTA	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.
UROSALPINX CINEREA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
VOLSELLA MODIOLUS	4.	0.	1.	0.	2.	0.	1.	0.	0.	0.

CRUSTACEA

	LOF53	LOF54	LBC11	LBC12	LBC13	LBC14	LBC15	LBC21	LBC22	LBC23
AEGININA LONGICORNIS	2.	0.	0.	0.	0.	100.	11.	0.	0.	720.
AMPITHOE RUBRICATA	0.	0.	0.	5.	0.	0.	36.	0.	0.	32.
BALANUS BALANOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS BALANUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS IMPROVISUS	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
CALLIOPIUS LAEVIUSCULUS	0.	0.	0.	5.	0.	0.	0.	0.	0.	0.
CANCER IRRORATUS	0.	0.	0.	0.	1.	75.	0.	0.	0.	1.
AEGININA LINEARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COROPHIUM INSIDIOSUM	0.	0.	0.	0.	0.	0.	283.	0.	1.	75.
DEXAMINE THEA	0.	0.	0.	0.	0.	4.	0.	0.	0.	0.
EUALUS GAIMARDII	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GAMMARID (UNIDENT)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GAMMARUS OCEANICUS	0.	0.	57.	22.	2.	0.	0.	0.	102.	0.
HARPINIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IDOTEA BALTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
IDOTEA PHOSPHOREA	4.	0.	11.	36.	16.	0.	1.	0.	0.	61.

	LBF53	LBF54	LBC11	LBC12	LBC13	LBC14	LBC15	LBC21	LBC22	LBC23
CRUSTACEA										
ISCHYROCERUS ANGUIPES	1.	0.	0.	6.	0.	34.	7.	0.	0.	23.
JAERA MARINA	0.	0.	14.	4.	0.	0.	0.	1.	63.	0.
JASSA FALCATA	0.	0.	1.	214.	1.	0.	0.	0.	0.	0.
LEBBEUS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MONOCULODES SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MYSIS STENOLEPSIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PAGURUS ACADIANUS	1.	4.	0.	0.	4.	2.	1.	0.	0.	2.
PAGURUS ARCUATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PONTOGENEIA INERMIS	1.	0.	0.	0.	0.	2.	13.	0.	0.	30.
SYMPLEUSTES GLABER	0.	0.	0.	0.	0.	7.	7.	0.	0.	11.
SHRIMP UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS CRENATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
POLYCHAETA										
CIRRATUS CIRRATULUS	3.	0.	0.	0.	0.	0.	3.	0.	0.	0.
EULELIA VIRIDIS	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HARMOTHOE IMBRICATA	28.	2.	0.	0.	2.	0.	13.	0.	0.	20.
LEPIDONOTUS SQUAMATUS	1.	0.	0.	0.	2.	4.	5.	0.	0.	6.
NEPHTYS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEREIS PELAGICA	0.	0.	0.	1.	2.	0.	8.	0.	0.	2.
NEREIS ZONATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NINOE NIGRIPES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PECTINARIA GRANULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.
PHOLOE MINUTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
PHYLLODOCE MACULATA	4.	0.	0.	0.	0.	1.	1.	0.	0.	2.
SPIRORBIS BOREALIS	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TEREBELLA SP.	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.
ECHINODERMATA										
ASTERIAS VULGARIS	0.	0.	0.	0.	0.	0.	1.	0.	0.	1.
ECHINARACHNIUS PARMA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HENRICIA SANGUINOLENTA	0.	0.	0.	0.	0.	1.	3.	0.	0.	0.
OPHIOPHOLIS ACULEATA	0.	0.	0.	0.	1.	2.	1.	0.	0.	2.
OPHIURA ROBUSTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPHIURA SARSI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
STRONGYLOCENTROTUS DROEBA	0.	0.	0.	0.	6.	3.	0.	0.	0.	1.
CNIDARIA										
CAMPANULARIA ANGULATA	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
CORAL SP1	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
CORAL SP3	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
METRIDIUM SP.	0.	0.	0.	0.	11.	0.	0.	0.	0.	0.
NEMERTEA										
AMPHIPORUS ANGULATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CEREBRATUS LACTEUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LINEUS SP.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.
NEMERTEAN UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OLIGOCHAETA										
CLITELLIO ARENARIUS	0.	0.	0.	35.	0.	0.	0.	71.	1.	0.
PYCNOGONIDAE										
PHOXICHILIDIUM FEMORATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PLATYHELMINTHES	LBF51	LBF54	LBC11	LBC12	LBC13	LBC14	LBC15	LBC21	LBC22	LBC23
PROCERODES ULVAE	0.	0.	0.	0.	0.	0.	0.	0.	7.	0.
ASCIDIACEA										
ASCIDIACEAN UNIDENTIFIED	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
NEMATODA										
NEMATODA	0.	0.	0.	17.	2.	0.	0.	0.	0.	0.
BRYOZOA										
BRYOZOA	0.	0.	1.	1.	0.	0.	1.	0.	0.	1.
PISCES										
LYCODES RETICULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TAUTOGA ONITIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHOLIS GUNNELLIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ALGAE CHLOROPHYCEAE										
CLADOPHORA EXPANSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ENTEROMORPHA SP.	0.	0.	0.	0.	0.	0.	6.	0.	0.	3.
ENTOCLADIA VIRIDIS	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
ULVA LACTUCA	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
ALGAE PHAEOPHYCEAE										
ASCOPHYLLUM NODOSUM	0.	0.	536.	5.	0.	0.	0.	0.	0.	0.
CHORDA FILIUM	0.	0.	0.	0.	0.	0.	22.	0.	0.	0.
CHORDARIA FLAGELLIFORMIS	0.	0.	0.	35.	0.	0.	0.	0.	0.	0.
DESMARESTIA ACULEATA	0.	0.	0.	0.	0.	0.	1.	0.	1.	36.
DICTYOSIPHON FOENICULACEU	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DICTYOSIPHON SP.	0.	0.	0.	0.	0.	0.	3.	0.	0.	0.
FUCUS EVANESCENS	0.	0.	67.	0.	0.	0.	0.	0.	0.	60.
FUCUS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS SPIRALIS	0.	0.	0.	0.	0.	0.	0.	0.	371.	0.
FUCUS VESICULOSUS	0.	0.	109.	0.	0.	0.	0.	0.	0.	0.
LAMINARIA INTERMEDIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	165.
LAMINARIA LONGICRURIS	0.	0.	0.	0.	0.	1.	360.	0.	0.	155.
LAMINARIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PETALONIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PYLAIELLA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
SACCORHIZA DERMATODEA	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
ALGAE RHODOPHYCEAE										
ANTITHAMNION SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BANGIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHONDRUS CRISPUS	79.	0.	73.	53.	0.	0.	80.	0.	3.	340.
CORALLINA OFFICINALIS	1.	1.	1.	1.	1.	1.	15.	0.	0.	1.
GIGARTINA STELLATA	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
LITHOTHAMNION SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHYCODRYS RUBENS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
POLYIDES CAPRINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
POLYSIPHONIA LANOSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PORPHYRA UMBILICALIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RHODOPHYLLIS SP.	0.	0.	0.	0.	0.	0.	18.	0.	0.	0.
RHODYMENIA PALMATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SPERMOTHAMNION TURNERI	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.

MOLLUSCA

	LBC24	LBC25	LBC31	LBC33	LBC34	LBC35	LBC42	LBC43	LBC44	LBC45
ACHAEA TESTUDINALIS	0.	0.	2.	12.	22.	26.	29.	1.	4.	0.
ADMETE COUTHOUYI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ANOMIA ACULEATA	0.	0.	0.	11.	4.	0.	0.	0.	0.	0.
CERASTODERMA PINNULATUM	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CINGULA ACULEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
CREPIDULA FORNICATA	0.	0.	0.	1.	0.	0.	0.	0.	2.	0.
CREPIDULA PLANA	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.
DENDRONOTUS FRONDOSUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GEMMA GEMMA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HIATELLA ARCTICA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
ISCHNOCHITON ALBUS	0.	0.	0.	0.	0.	2.	0.	0.	0.	0.
ISCHNOCHITON RUBER	0.	0.	0.	2.	8.	3.	0.	0.	0.	0.
LACUNA VINCTA	121.	22.	0.	1.	0.	0.	1204.	1.	45.	41.
LITTORINA LITTOREA	6.	0.	33.	53.	38.	8.	0.	18.	1.	0.
LITTORINA CPUSATA	0.	0.	0.	0.	0.	0.	71.	1.	0.	0.
LITTORINA SAXATILIS	0.	0.	0.	3.	0.	0.	0.	0.	0.	21.
LORA BICARINATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LORA NOBILIS	0.	0.	0.	0.	0.	3.	0.	1.	0.	0.
MARGARITES COSTALIS	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MITRELLA LUNATA	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MYA ARENARIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MYTILUS EDULIS	3.	0.	34.	0.	0.	0.	375.	1.	0.	19.
NASSARIUS TRIVITTATUS	1.	0.	0.	0.	0.	0.	0.	15.	2.	0.
ONCHIDORUS ASPERSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PANDORA GOULDIANII	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
PLACOPECTEN MAGELLANICUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RETUSA CANICULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SKENEA PLANORBIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
THAIS LAPILLUS	0.	0.	13.	0.	0.	0.	0.	0.	0.	0.
TURBONILLA INTERRUPTA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
TURTONIA MINUTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
UROSALPINX CINEREA	0.	0.	0.	3.	0.	0.	0.	0.	0.	0.
VOLSELLA MODIOLUS	113.	1.	0.	4.	1.	0.	0.	0.	3.	9.

CRUSTACEA

	LBC24	LBC25	LBC31	LBC33	LBC34	LBC35	LBC42	LBC43	LBC44	LBC45
AEGININA LONGICORNIS	282.	29.	0.	0.	0.	0.	0.	0.	184.	634.
AMPITHOE RUBRICATA	1.	1.	2.	0.	0.	0.	11.	0.	5.	0.
BALANUS BALANOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS BALANUS	0.	0.	0.	5.	0.	0.	0.	0.	0.	0.
BALANUS IMPROVISUS	0.	0.	0.	0.	0.	14.	0.	0.	0.	0.
CALLIOPIUS LAEVIUSCULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CANCER IRRORATUS	0.	0.	2.	0.	0.	1.	0.	0.	0.	0.
AEGININA LINEARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COROPHIUM INSIDIOSUM	248.	104.	0.	0.	0.	0.	0.	0.	135.	503.
DEXAMINE THEA	0.	1.	0.	2.	0.	0.	0.	0.	17.	2.
EUALUS GAIMARDII	2.	1.	0.	0.	1.	0.	0.	0.	0.	3.
GAMMARID (UNIDENT)	0.	0.	3.	0.	0.	0.	0.	0.	0.	0.
GAMMARUS OCEANICUS	2.	0.	149.	0.	0.	0.	78.	0.	0.	0.
HARPINIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
IDOTEA BALTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	5.
IDOTEA PHOSPHOREA	2.	0.	0.	0.	0.	0.	5.	0.	0.	2.

CRUSTACEA	LBC24	LBC25	LBC31	LBC33	LBC34	LBC35	LBC42	LBC43	LBC44	LBC45
ISCHYROCEROS ANGUIPES	32.	0.	0.	2.	1.	0.	3.	0.	97.	224.
JAERA MARINA	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
JASSA FALCATA	0.	0.	7.	0.	0.	0.	0.	0.	0.	0.
LEBBEUS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MONOCULODES SP.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.
MYSIS STENOLEPSIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PAGURUS ACADIANUS	0.	0.	0.	0.	0.	3.	0.	5.	5.	0.
PAGURUS ARCUATUS	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
PONTOGENEIA INERMIS	67.	30.	0.	0.	0.	0.	0.	0.	54.	14.
SYMPLEUSTES GLABER	0.	0.	0.	0.	0.	0.	0.	0.	2.	3.
SHRIMP UNIDENTIFIED	500.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BALANUS CRENATUS	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.
POLYCHAETA										
CIRRATUS CIRRATULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
EULELIA VIRIDIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HARMOTHOE IMBRICATA	1.	5.	1.	1.	6.	3.	0.	2.	8.	13.
LEPIDONOTUS SQUAMATUS	0.	0.	0.	2.	0.	0.	0.	0.	0.	1.
NEPHTYS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEREIS PELAGICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEREIS ZONATA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
NINOE NIGRIPES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PECTINARIA GRANULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHOLOE MINUTA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
PHYLLODOCE MACULATA	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
SPIRORBIS BOREALIS	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.
TEREBELLA LAPIDARIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TEREBELLA SP.	0.	0.	3.	0.	0.	0.	0.	0.	0.	0.
ECHINODERMATA										
ASTERIAS VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ECHINARACHNIUS PARMA	0.	0.	0.	0.	0.	0.	0.	41.	0.	0.
HENRICIA SANGUINOLENTA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OPHIOPHOLIS ACULEATA	0.	0.	0.	0.	0.	0.	0.	0.	1.	14.
OPHIURA ROBUSTA	1.	5.	0.	0.	0.	0.	0.	0.	0.	2.
OPHIURA SARSI	3.	0.	0.	0.	0.	0.	0.	0.	1.	0.
STRONGYLOCENTROTUS DROEBA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CNIDARIA										
CAMPANULARIA ANGULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CORAL SP1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CORAL SP3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
METRIDIUM SP.	0.	0.	0.	0.	19.	0.	0.	0.	0.	0.
NEMERTEA										
AMPHIPORUS ANGULATUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CEREBRATUS LACTEUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LINEUS SP.	0.	0.	0.	0.	0.	0.	3.	0.	0.	0.
NEMERTEAN UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
OLIGOCHAETA										
CLITELLIO ARENARIUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PYCNOGONIDAE										
PHOXICHILIDIUM FEMORATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	LBC24	LBC25	LBC31	LBC33	LBC34	LBC39	LBC42	LBC43	LBC44	LBC45
PLATYHELMINTHES										
PROCERODES ULVAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ASCIDIACEA										
ASCIDIACEAN UNIDENTIFIED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEMATODA										
NEMATODA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
BRYOZOA										
BRYOZOA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
PISCES										
LYCODES RETICULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TAUTOGA ONITIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHOLIS GUNNELLIS	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
ALGAE CHLOROPHYCEAE										
CLADOPHORA EXPANSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ENTEROMORPHA SP.	1.	0.	0.	0.	0.	1.	0.	0.	0.	1.
ENTOCLADIA VIRIDIS	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ULVA LACTUCA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ALGAE PHAEOPHYCEAE										
ASCOPHYLLUM NODOSUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHORDA FILIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHORDARIA FLAGELLIFORMIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DESMARESTIA ACULEATA	451.	45.	0.	1.	0.	0.	1.	0.	69.	34.
DICTYOSIPHON FOENICULACEU	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DICTYOSIPHON SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS EVANESCENS	0.	0.	0.	0.	0.	0.	5.	0.	1.	0.
FUCUS SP.	0.	0.	0.	0.	127.	0.	0.	0.	0.	0.
FUCUS SPIRALIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS VESICULOSUS	0.	0.	5.	0.	0.	0.	0.	0.	0.	0.
LAMINARIA INTERMEDIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAMINARIA LONGICRURIS	0.	0.	0.	0.	0.	0.	0.	0.	92.	2.
LAMINARIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PETALONIA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PYLAIELLA SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
SACCORHIZA DERMATODEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ALGAE RHODOPHYCEAE										
ANTITHAMNION SP.	0.	0.	0.	0.	0.	0.	0.	0.	5.	0.
BANGIA SP.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHONDRUS CRISPUS	0.	0.	0.	0.	0.	6.	0.	23.	45.	1.
CORALLINA OFFICINALIS	0.	0.	0.	1.	1.	1.	0.	1.	0.	1.
GIGARTINA STELLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LITHOTHAMNION SP.	0.	0.	0.	1.	35.	1.	0.	0.	1.	0.
PHYCODRYS RUBENS	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
POLYIDES CAPRINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
POLYSIPHONIA LANOSA	0.	90.	0.	0.	0.	0.	0.	0.	1.	0.
PORPHYRA UMBILICALIS	0.	0.	25.	0.	0.	0.	0.	0.	0.	0.
RHODOPHYLLIS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RHODYMENIA PALMATA	0.	0.	0.	0.	0.	0.	0.	0.	40.	1.
SPERMOTHAMNION TURNERI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

MOLLUSCA

	LBC51	LBC52	LBC53	LBC54	LBC55
ACMAEA TESTUDINALIS	0.	1.	6.	0.	0.
ADMETE COUTHOUYI	0.	0.	0.	0.	0.
ANOMIA ACULEATA	0.	0.	0.	0.	0.
CERASTODERMA PINNULATUM	0.	0.	0.	0.	0.
CINGULA ACULEA	0.	0.	2.	0.	0.
CREPIDULA FORNICATA	0.	0.	0.	0.	0.
CREPIDULA PLANA	0.	0.	4.	0.	0.
DENDRONOTUS FRONDOSUS	0.	0.	0.	0.	0.
GEMMA GEMMA	0.	0.	0.	0.	0.
HIATELLA ARCTICA	0.	0.	4.	0.	0.
ISCHNOCHITON ALBUS	0.	0.	0.	0.	0.
ISCHNOCHITON RUBER	0.	0.	0.	0.	0.
LACUNA VINCTA	0.	0.	43.	49.	0.
LITTORINA LITTOREA	2.	206.	16.	0.	0.
LITTORINA OBUSATA	0.	3.	0.	15.	0.
LITTORINA SAXATILIS	0.	0.	0.	0.	0.
LORA BICARINATA	0.	0.	0.	0.	0.
LORA NOBILIS	0.	0.	0.	0.	0.
MARGARITES COSTALIS	0.	0.	0.	0.	0.
MITRELLA LUNATA	0.	0.	0.	0.	0.
MYA ARENARIA	0.	1.	0.	0.	0.
MYTILUS EDULIS	0.	6.	17.	0.	0.
NASSARIUS TRIVITTATUS	0.	0.	0.	0.	0.
ONCHIDORUS ASPERSA	0.	0.	15.	0.	0.
PANDORA GOULDIANII	0.	0.	0.	0.	0.
PLACOPECTEN MAGELLANICUS	0.	0.	0.	0.	0.
RETUSA CANICULATA	0.	0.	0.	0.	0.
SKENEA PLANORBIS	0.	0.	0.	0.	0.
THAIS LAPILLUS	0.	11.	0.	0.	0.
TURBONILLA INTERRUPTA	0.	0.	0.	0.	0.
TURTONIA MINUTA	0.	0.	0.	0.	0.
UROSALPINX CINEREA	0.	0.	0.	0.	0.
VOLSELLA MODIOLUS	0.	0.	0.	13.	0.

CRUSTACEA

	LBC51	LBC52	LBC53	LBC54	LBC55
AEGININA LONGICORNIS	0.	0.	17.	4.	0.
AMPITHOE RUBRICATA	0.	0.	69.	12.	0.
BALANUS BALANOIDES	0.	0.	0.	0.	0.
BALANUS BALANUS	0.	0.	0.	0.	0.
BALANUS IMPROVISUS	0.	0.	0.	0.	0.
CALLIOPIUS LAEVIUSCULUS	0.	1.	0.	0.	0.
CANCER IRRORATUS	0.	0.	0.	1.	0.
AEGININA LINEARIS	0.	0.	0.	0.	0.
COROPHIUM INSIDIOSUM	0.	0.	19.	0.	0.
DEXAMINE THEA	0.	0.	4.	6.	0.
EUALUS GAIMARDII	0.	0.	0.	1.	0.
GAMMARID (UNIDENT)	0.	0.	0.	0.	0.
GAMMARUS OCEANICUS	17.	38.	0.	8.	0.
HARPINIA SP.	0.	0.	0.	0.	0.
IDOTEA BALTICA	0.	0.	0.	0.	0.
IDOTEA PHOSPHOREA	0.	1.	1.	13.	0.

CRUSTACEA	LBC51	LBC52	LBC53	LBC54	LBC55
ISCHYROCERUS ANGUIPES	0.	0.	43.	28.	0.
JAERA MARINA	0.	4.	0.	0.	0.
JASSA FALCATA	0.	0.	1.	0.	0.
LEBBEUS SP.	0.	0.	0.	0.	0.
MONOCULODES SP.	0.	0.	0.	0.	0.
MYSIS STENOLEPSIS	0.	0.	0.	0.	0.
PAGURUS ACADIANUS	0.	0.	12.	1.	3.
PAGURUS ARCUATUS	0.	0.	0.	0.	0.
PONTOGENEIA INERMIS	0.	0.	13.	79.	2.
SYMPLEUSTES GLABER	0.	0.	15.	0.	0.
SHRIMP UNIDENTIFIED	0.	0.	0.	0.	0.
BALANUS CRENATUS	0.	0.	0.	0.	0.
POLYCHAETA					
CIRRATUS CIRRATULUS	0.	0.	0.	0.	0.
EULALIA VIRIDIS	0.	0.	0.	0.	0.
HARMOTHOE IMBRICATA	0.	0.	8.	2.	0.
LEPIDONOTUS SQUAMATUS	0.	0.	0.	0.	0.
NEPHTYS SP.	0.	0.	0.	0.	0.
NEREIS PELAGICA	0.	0.	0.	0.	0.
NEREIS ZONATA	0.	0.	0.	0.	0.
NINOE NIGRIPES	0.	0.	0.	0.	0.
PECTINARIA GRANULATA	0.	0.	0.	0.	0.
PHOLOE MINUTA	0.	0.	0.	0.	0.
PHYLLODOCE MACULATA	0.	0.	0.	0.	0.
SPIRORBIS BOREALIS	0.	0.	0.	0.	0.
TEREBELLA LAPIDARIA	0.	0.	0.	0.	0.
TEREBELLA SP.	0.	0.	0.	0.	0.
ECHINODERMATA					
ASTERIAS VULGARIS	0.	0.	0.	0.	0.
ECHINARACHNIUS PARMA	0.	0.	0.	0.	0.
HENRICIA SANGUINOLENTA	0.	0.	0.	0.	0.
OPHIOPHOLIS ACULEATA	0.	0.	0.	0.	0.
OPHIURA ROBUSTA	0.	0.	0.	0.	0.
OPHIURA SARSI	0.	0.	0.	0.	0.
STRONGYLOCENTROTUS DROEBA	0.	0.	0.	0.	0.
CNIDARIA					
CAMPANULARIA ANGULATA	0.	0.	0.	0.	0.
CORAL SP1	0.	0.	0.	0.	0.
CORAL SP3	0.	0.	0.	0.	0.
METRIDIUM SP.	0.	0.	0.	0.	0.
NEMERTEA					
AMPHIPORUS ANGULATUS	0.	0.	0.	0.	0.
CEREBRATUS LACTEUS	0.	1.	0.	0.	0.
LINEUS SP.	0.	3.	0.	0.	0.
NEMERTEAN UNIDENTIFIED	0.	0.	0.	0.	0.
OLIGOCHAETA					
CLITELLIO ARENARIUS	63.	48.	0.	0.	0.
PYCNOGONIDAE					
PHOXICHILIDIUM FEMORATUM	0.	0.	1.	0.	0.

PLATYHELMINTHES	LB051	LB052	LB053	LB054	LB055
PROCERODES ULVAE	0.	0.	0.	0.	0.
ASCIDIACEA					
ASCIDIACEAN UNIDENTIFIED	0.	0.	0.	0.	0.
NEMATODA					
NEMATODA	0.	47.	0.	0.	0.
BRYOZOA					
BRYOZOA	0.	0.	1.	1.	0.
PISCES					
LYCODES RETICULATA	0.	0.	0.	0.	0.
TAUTOGA ONITIS	0.	0.	0.	0.	0.
PHOLIS GUNNELLIS	0.	0.	0.	0.	0.
ALGAE CHLOROPHYCEAE					
CLADOPHORA EXPANSA	0.	0.	0.	0.	0.
ENTEROMORPHA SP.	0.	0.	0.	0.	0.
ENTOCLADIA VIRIDIS	0.	0.	0.	0.	0.
ULVA LACTUCA	0.	0.	0.	0.	0.
ALGAE PHAEOPHYCEAE					
ASCOPHYLLUM NODOSUM	0.	0.	0.	0.	0.
CHORDA FILIUM	0.	0.	0.	0.	0.
CHORDARIA FLAGELLIFORMIS	0.	0.	0.	1.	0.
DESMARESTIA ACULEATA	0.	0.	0.	0.	0.
DICTYOSIPHON FOENICULACEU	0.	0.	0.	10.	0.
DICTYOSIPHON SP.	0.	0.	1.	5.	1.
FUCUS EVANESCENS	0.	0.	13.	0.	0.
FUCUS SP.	0.	0.	0.	0.	0.
FUCUS SPIRALIS	0.	35.	15.	0.	0.
FUCUS VESICULOSUS	0.	0.	0.	0.	0.
LAMINARIA INTERMEDIA	0.	0.	0.	0.	0.
LAMINARIA LONGICRURIS	0.	0.	0.	1.	0.
LAMINARIA SP.	0.	0.	13.	0.	0.
PETALONIA SP.	0.	0.	0.	5.	0.
PYLAIELLA SP.	0.	0.	0.	0.	0.
SACCORHIZA DERMATODEA	0.	0.	0.	0.	0.
ALGAE RHODOPHYCEAE					
ANTITHAMNION SP.	0.	0.	0.	0.	0.
BANGIA SP.	0.	0.	0.	0.	0.
CHONDRUS CRISPUS	0.	5.	102.	10.	0.
CORALLINA OFFICINALIS	0.	0.	1.	0.	0.
GIGARTINA STELLATA	0.	0.	0.	0.	0.
LITHOTHAMNION SP.	0.	0.	0.	0.	0.
PHYCODRYS RUBENS	0.	0.	0.	0.	0.
POLYIDES CAPRINUS	0.	0.	0.	0.	0.
POLYSIPHONIA LANOSA	0.	0.	0.	10.	0.
PORPHYRA UMBILICALIS	0.	0.	0.	0.	0.
RHODOPHYLLIS SP.	0.	0.	0.	0.	0.
RHODYMENIA PALMATA	0.	0.	0.	1.	0.
SPERMOTHAMNION TURNERI	0.	0.	0.	0.	0.

	LPF13	LPF25	LPF31	LPF53	LPC11	LPC13	LPC21	LPC23	LPC31	LPC33	LPC43	LPC53
MOLLUSCA												
ACMAEA TESTUDINALIS	5.	0.	8.	4.	0.	0.	1.	0.	0.	0.	0.	0.
CREPIDULA FORNICATA	0.	0.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HIATELLA ARCTICA	0.	0.	12.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ISCHNOCHITON RUBER	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
LACUNA VINCTA	32.	0.	122.	12.	0.	0.	0.	0.	1.	0.	0.	0.
LITTORINA LITTOREA	50.	0.	50.	0.	69.	9.	31.	8.	15.	6.	1.	26.
LITTORINA OBTUSATA	7.	0.	107.	0.	32.	0.	1.	0.	36.	0.	0.	0.
LITTORINA SAXATILIS	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MYTILUS EDULIS	4.	0.	79.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ONCHIDORUS ASPERSA	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.
HAIS LAPILLUS	0.	0.	0.	0.	5.	0.	2.	0.	3.	0.	0.	0.
OLSELLA MODIOLUS	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
ONICELLA MARMOREA	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.
EPTUNEA DECEMCOSTATA	0.	0.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.
ACOMA BALTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
CRUSTACEA												
ESIMINA LONGICORNIS	0.	0.	0.	29.	0.	0.	0.	0.	0.	0.	2.	0.
ALANUS IMPROVISUS	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OROPHIUM INSIDIOSUM	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
EXAMINE THEA	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
AMMARUS OCEANICUS	282.	0.	0.	0.	0.	0.	4.	0.	5.	0.	0.	0.
DOTEA BALTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	0.
DOTEA PHOSPHOREA	9.	0.	0.	0.	0.	0.	0.	0.	0.	0.	6.	0.
SCHYROCEROS ANGUIPES	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ERA MARINA	0.	0.	0.	0.	0.	0.	2.	0.	6.	0.	0.	0.
CHIMONELLA PINGUIS	0.	10.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ANGON SP.	0.	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.
POLYCHAETA												
RMOTHOE IMBRICATA	6.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PIDONOTUS SQUAMATUS	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TINARIA GRANULATA	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OLOE MINUTA	0.	42.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LLODOCE MACULATA	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ALOPHAMUS CIRCINATA	0.	97.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IO SETOSA	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PHITRITE SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
ECHINODERMATA												
TERIAS VULGARIS	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	3.	1.
ICIA SANGUINOLENTA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
IOPHOLIS ACULEATA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
INODERMS UNIDENTIFIED	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
CNIDARIA												
RIDIUM SP.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OZOAN-CNIDARIAN UNID	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NEMERTEA												
RATULUS LACTEUS	0.	0.	0.	0.	5.	0.	0.	0.	3.	0.	0.	0.
OLIGOCHAETA												
TELLIO ARENARIUS	0.	8.	0.	0.	8.	0.	3.	0.	1.	0.	7.	0.

	LPF13	LPF25	LPF33	LPF53	LPC11	LPC13	LPC21	LPC23	LPC31	LPC33	LPC43	LPC53
ASCIDIACEA												
ASCIDIACEAN UNIDENTIFIED	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.	0.
HALOCYNTHIA PYRIFORMIS	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.
NEMATODA												
NEMATODA	0.	0.	0.	0.	5.	0.	0.	0.	4.	0.	0.	0.
BRYOZOA												
BRYOZOA	0.	0.	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.
ALGAE CHLOROPHYCEAE												
ENTEROMORPHA SP.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	35.	0.
ULVA LACTUCA	215.	0.	2.	3.	0.	0.	0.	0.	0.	0.	0.	0.
ALGAE PHAEOPHYCEAE												
ASCOPHYLLUM NODOSUM	0.	0.	0.	0.	5.	0.	0.	0.	0.	0.	0.	0.
DESMARESTIA ACULEATA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
FUCUS SP.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
FUCUS VESICULOSUS	0.	0.	0.	0.	59.	0.	15.	0.	0.	0.	0.	0.
PETALONIA SP.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ALGAE RHODOPHYCEAE												
CORALLINA OFFICINALIS	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GYMNOGONGRUS NORVEGICUS	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
POLYSIPHONIA LANOSA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
RHODYMENIA PALMATA	0.	0.	0.	10.	0.	0.	0.	0.	0.	0.	0.	0.
PORIFERA												
HALICLONA OCULATA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.

ANGIOSPERM	LPF13	LPF25	LPF33	LPF53	LPC11	LPC13	LPC21	LPC23	LPC31	LPC33	LPC43	LPC53
ZOSTERA MARINA	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	465.	0.
PROTOCHORDATA												
PROTOCHORDATE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.