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AN OVERVIEW OF ENVIRONMENTAL QUALITY IN SAINT JOHN HARBOUR, NEW BRUNSWICK

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by

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ABSTRACT

This report is intended as a compendium of scientific information and identified concerns over the environmental quality of the Saint John Harbour environs. Saint John has long been identified as an area of environmental concern, due to the heavy industrialization and large scale dredging and ocean dumping operations in this area. In recent years, numerous claims have been made relating declines in the fishery and degradation of aquatic habitat to these activities, however, a general lack of essential information on source-effect relationships between man's activities in Saint John Harbour and the observed effects has been recognized, and further efforts to improve this understanding are advised.

Résumé

Ce rapport condense l'information scientifique et les inquiétudes exprimées au sujet de la qualité de l'environnement dans la région du Port de Saint-Jean. Depuis longtemps, le Port de Saint-Jean est sujet d'inquiétude au niveau de l'environnement à cause de son degré élevé d'industrialisation, du dragage pratiqué à grande échelle et des opérations d'immersion des déchets qui y ont lieu. Depuis quelques années, plusieurs ont prétendu l'existence d'un lien entre le déclin des ressources de poisson ainsi que la dégradation du milieu aquatique et les activités mentionnées précédemment. Il existe, cependant, un manque évident d'information sur la relation de cause à effet entre les activités de l'homme dans le Port de Saint-Jean et leurs conséquences sur l'environnement. Il est recommandé que des recherches additionnelles soient effectuées afin de mieux clarifier la situation.

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1 INTRODUCTION

Saint John, N.B. is a major east coast port, situated near the mouth of the Bay of Fundy. It is also New Brunswick's main industrial centre and the site of major annual dredging and dumping operations.

This report is a compilation of the existing information sources, both current and historical, concerning the Harbour and surrounding area related to the input, effects and ultimate fate of pollution sources to this environment. A similar report has already been compiled for the Saint John River (Saint John River Basin Board), therefore, the geographical extent of this report is limited, extending from the Reversing Falls down to and including the entire Harbour and the southwest coast as far as Coleson Cove.

Saint John has been identified as an area of high environmental concern in the Maritimes. However, due to the lack of coordinated research effort in this area, the existing information on the Harbour and surrounding area is scattered. This report is an attempt to bring together this information and identify the information gaps. In an effort toward establishing what the major problems are in Saint John, it is necessary to define more clearly the source/effect relationships between man's activities and the local environment.

This report will examine the various components of the environment on the premise that continuing degradation of the Saint John area has resulted from persistent industrial pollution, dredging and ocean dumping.

2 AIR QUALITY

2.1 Physical Characteristics

Air quality observations and measurements for the Saint John area indicate that the City of Saint John is plagued by periodic air pollution problems. Meteorological measurements made by the Atmospheric Environment Service show that the prevailing wind direction is from the southwest and that temperature inversions as well as sea-breeze inversions are a common occurrence in this region especially during the summer. This condition increases the possibility of low level pollution from sources upwind of the city (for example, in the Lorneville or Spruce Lake Industrial Parks) being trapped below these inversions and carried into the residential and business areas of the city. The determination of the exact effect is further complicated by the topography of the Saint John region. The contribution of inversions to possible extended air pollution problems in the Saint John Region is, therefore, important.

2.2 Ambient Air Quality

Air pollution has long been noticeable in highly industrialized Saint John, due to emissions of sulphur compounds from a local refinery, pulp mill and thermal generating stations. These have caused damage to vegetation and, in the case of emissions from the pulp mill, a pervasive and continuing unpleasant odour.

The four air pollutants of most concern in the Saint John area are: sulphur dioxide, suspended particulate matter, ozone and carbon monoxide. These four have been given priority by Environment New Brunswick because of their potential effects on human health and vegetation.

Total reduced sulphur compounds (TRS) are also regularly present in the atmosphere above Saint John. The most important effect of TRS compounds, such as hydrogen sulphide, is their offensive smell. The major source of TRS emissions is the Irving Pulp and Paper Company Ltd. kraft mill. It is important to stress, however, that despite their obnoxious odour, TRS compounds do not represent a hazard to human health or vegetation at the concentration associated with emissions from this mill. Although emissions from the Irving mill in Saint John are no greater than those from comparable mills, the atmospheric conditions in Saint John are not conducive to dispersing them. As a consequence, complaints of odour and dust fall-out are numerous.

There have been a few serious episodes of high air pollution when, with the unfavourable meteorological conditions, the air emissions from industry and other sources become quite concentrated in the city for several hours. The Forest Hills valley in Saint John is a particularly vulnerable area for such episodes, due to its close proximity to industrial sources and the poor dispersion characteristics in the valley. High SO_2 levels can be reached under poor atmospheric conditions and SO_2 levels over three times the provincial ambient air quality limit have been observed during pollution episodes on certain days (e.g. peak hourly concentration of

0.47 ppm SO_2 on July 21, 1975). The Atmospheric Environment Service has confirmed SO_2 damage to vegetation in the Champlain Heights and Forest Hills areas in 1975.

Oxides of nitrogen (NO_x) are potentially important air pollutants in the Saint John area. It is not expected that regular monitoring will detect any significant air quality problems directly linked to oxides of nitrogen, but such testing will be continued for longer-term research purposes. NO_x are of particular interest to air quality specialists, since they play an important part in atmospheric chemical reactions leading to the production of ozone, which absorbs ultraviolet radiation and prevents some heat loss from the earth.

Sources of air pollution other than the Irving Mill include: the Courtenay Bay electric generating plant, the refinery and on occasion, the Coleson Cove electric generating plant.

2.3 Monitoring Programs

In an effort to assess environmental quality, two separate monitoring programs have been established in the Saint John Region. The first is the National Air Pollution Surveillance Program (NAPS) whose purpose it is to monitor and assess, on a continuing basis, the quality of the ambient air in the populated regions of Canada. Within the urban area of Saint John, this program attempts to detect trends in the levels of pollution with the passage of time and with respect to changing industrial activity, population density and progress in air pollution abatement measures. Saint John has two NAPS monitoring station as well as 6 provincially operated stations in the following locations.

TABLE 1 N.B. PROVINCIAL AIR MONITORING STATIONS IN SAINT JOHN

Stations	Measurements
Forest Hills	SO_2, CO, NO_2, O_3
DeMonts Street	SO_2, H_2S
Millidgeville	SO_2
Red Head	SO_2
Champlain Heights	SO_2, COH[1]
Western District Police Station	SO_2, CO, O_3, COH
Post Office[2]	SO_2, NO_2, CO, O_3, COH

1. COH (Soiling Index): Is an indication of the soiling or darkening potential of the pollutants in the atmosphere.

2. NAPS Station (particulates monitored at separate location; 110 Charlotte St.)

Both the provincial and federal programs produce daily averages and monthly summary data.

In 1973, the Saint John Region Air Quality Study Group was formed, composed of a monitoring subcommittee and a modelling subcommittee. The latter group designed several air quality models. These included a relatively sophisticated "episodic" model which provides short-term predictions of air quality; a simpler climatological "land-use" model to provide long-term average predictions for regional planning, and a back-up "historical" model based upon past observations of air quality and meteorological elements. The episodic model is the most important and frequently used model.

These monitoring programs have been in effect since 1974, and reliable data have been available since the early part of 1976.

2.4 Compliance

Environment Canada's policy is that air pollution should be controlled by containment at the source using the best practicable technology. Since 1977, federal emission guidelines have been under development for various industrial sectors in an effort to establish uniform recommendations to the provinces on industrial emissions. The emission guidelines most relevant to the Saint John area, will be those for the thermal power industry, the petroleum refinery industry and the pulp and paper industry. Although thermal power and petroleum refinery guidelines are not yet published, Environment New Brunswick have developed provincial regulations for the pulp and paper industry and have established objectives for the Irving Refinery and the thermal power industry.

The forthcoming federal thermal power guidelines will cover emissions of sulphur dioxide, particulates and oxides of nitrogen; the petroleum refinery guidelines will cover sulphur dioxide, hydrocarbons, carbon monoxide and particulates; and the pulp and paper emission guidelines, which have been published, cover total reduced sulphur compounds (odour producing compounds), particulates and sulphur dioxide. However, these will only be applicable to new or expanded plants if the provincial agency puts the guidelines into their legislation, while the existing plants remain subject to the existing provincial regulations and objectives.

The malodorous air emissions from the Irving Pulp and Paper mill are a severe nuisance to the residents of Saint John. For this reason, Environment New Brunswick requested Environment Canada to permit current work on the remaining water problems at the mill to be held in abeyance until the air problems are brought under control. Environment Canada agreed to this request. Therefore, the N.B. Department of the Environment issued a control order under Regulation 77-6 of the N.B. Clean Environment Act requiring the installation of air pollution control equipment to limit odour and particulate emissions from the Irving mill by April, 1981. Compliance with the specified emission limits will noticeably reduce odour levels in Saint John but will not totally eliminate all odours from the mill.

The Coleson Cove generating station has been suspected of having an influence on the ambient air quality of the Saint John Region. In 1972, before the commissioning of this station, a study of its potential impact on the air quality in the Lorneville/Saint John Region was carried out. The study predicted that on several days per month, the emissions from the generating station could result in concentrations of sulphur dioxide on the ambient air in the Lorneville/Saint John area to exceed the Maximum Acceptable National Air Quality Objective (NAQO) (1 hour average - 0.35 ppm, 24 hour average - 0.11 ppm). In response to this, it was decided that when the episodic model developed by NBDOE and N.B. Power predicts conditions of poor atmospheric dispersion and poor air quality, the station would switch to burning low sulphur oil. However, the Coleson Cove plant is rarely at full capacity during the summer, when atmospheric dispersion conditions are poor. In fact, in the summer, the load factor at Coleson Cove is only about 40%.

In 1975, Environment New Brunswick requested that N.B. Power implement a four-point control program for Coleson Cove:

(a) The fuel used during normal operation will have a sulphur content of 3%; that used during fuel switching will have a sulphur content of 0.45%.

(b) The quantity of low sulphur fuel stored for emergency use will be sufficient for 240 hours at full load.

(c) The ambient air quality limit that will trigger fuel switching (or load reduction) has been tentatively set at 450 micrograms sulphur dioxide per cubic metre (0.17 ppm).

(d) The administrative procedure for control and enforcement is such that the Power Commission will run the dispersion model using the short-term weather forecast from the Atmospheric Environment Service, as well as information from the meteorological tower at Spruce Lake. If hourly concentrations in excess of 450 micrograms per cubic metre are either predicted by the dispersion model or observed by the monitoring network, a decision will be made by the Power Commission to either reduce the load at Coleson Cove or to switch to low sulphur fuel, or a combination thereof.

The compliance procedure consists of a report submitted monthly by the Power Commission to the N.B. Department of the Environment, listing daily meteorological conditions, load conditions, emission rates and predicted and observed SO_2 concentrations.

However, the NBDOE is now finding that the height of the inversions at Coleson Cove are often in the vicinity of 300 metres and that the plume tends to rise into the stable layer and remain there without being dispersed down to the ground level. Thus it appears that the contributory effect of the Coleson Cove plant on the ambient air quality in the City of Saint John may not be as great as previously suspected.

The Atmospheric Environment Service has identified the need for plume tracer studies to more clearly define the source-effect relationships between the major pollutors in the Saint John area and the ambient air quality in the city.

Although the major industries generally succeed in complying with their respective provincial regulations and objectives, they still may contribute a significant amount of pollutants to the local airshed during periodic episodes which occur especially in the summer months. For example, the Coleson Cove plant transformer was knocked out by lightning in late July 1980, and could not direct power into the city. This in combination with poor climatological conditions and the increased load put on the Courtenay Bay generating station, resulted in episodes when SO_2 emissions exceeded the maximum tolerable National Air Quality Objective for several hours at a time.

2.5 Spatial Effects

Of equal importance is the geographical extent of the locally produced atmospheric contaminants. An attempt to understand this was made in a study by Phillips and Puckett (1978) on the deposition patterns of atmospheric contaminants in the Saint John Region. This objective was achieved by monitoring permanent vegetation (lichen) plots for their accumulation of several elements. The choice of elements was based on a knowledge of the nature of the emissions from existing sources in the Saint John area.

The ability of lichens to accumulate metals to a level far greater than their expected requirements has led to their use as biological monitors of atmospheric contaminants. The results of the analyses indicate that the atmospheric contaminants originating from the area of Saint John have dispersed to virtually background levels within 20 miles to the northeast of the city and are not detectable within 10 miles to the north and west. Therefore, it appears that the problem is felt most strongly on a very local scale.

It is felt by the N.B. Department of the Environment that the existing monitoring system provides adequate coverage for the Saint John area in order to decide where to concentrate their efforts concerning air quality monitoring and control in the future. However, it would also suggest that more work is required to determine the source or sources contributing to the high SO_2 episodes.

3 INDUSTRIAL EFFLUENTS

3.1 Introduction

Saint John is the largest city in the Province of New Brunswick and is also N.B.'s main industrial centre. Pulp and paper mills, breweries, oil and sugar refineries, meat packing and many small secondary industries are all located in the city with most discharging their waste into the Saint John River and Harbour. This load of pollution dumped into the mouth of the river has been a great cause for concern. As well, the high tides of the Bay of Fundy appear to aggrevate the problem of waste dispersion, for at certain phases of the tidal cycle, the wastes are not only held in the river at the point of discharge, but are pushed upstream.

In the summer of 1970, a pollution survey was carried out by R. Row in the city of Saint John to determine the pollution load which the industrial community was placing on the river and harbour and to define the effect of this pollution on the water quality. He found that the Irving Pulp Mill, the Irving Oil Refinery and the MacMillan-Rothesay Pulp Mill were the major industrial dischargers (Figure 1).

3.2 Irving Pulp and Paper Co. Ltd.

Irving Pulp and Paper operates a 750 ton per day bleached kraft market pulp mill located at Reversing Falls on the Saint John River. Up until 1977, a 300 ton per day sulphite mill was also operated on the same site.

Both federal and provincial environmental agencies have been negotiating with Irving since 1969 in an effort to reduce the liquid effluent discharges from the mill. These efforts included two legal actions (one successful) against the mill under the Fisheries Act, because of an almost total lack of progress in clean-up of their effluent discharges. These actions led to the mill conforming with the Biochemical Oxygen Demand (BOD) and suspended solids requirements of the Pulp and Paper Liquid Effluent Regulations (Table 2).

TABLE 2 BOD AND SUSPENDED SOLIDS DISCHARGES FROM THE IRVING PULP AND PAPER MILL; 1970-1980

	BOD5 (lbs/day)	SUSPENDED SOLIDS (lbs/day)
January 1, 1970	205,000	47,500
January 1, 1976	245,000	82,500
After shutdown of sulphite mill in 1977	55,000	82,500
June, 1978	30,000	20,000
Current discharge	45,000	28,000
Allowable Limits	55,000	20,000

However, the most recent effluent monitoring data indicates that although the mill is well in compliance for BOD_5, the suspended solids discharges are now exceeding the allowable limits (Table 2). It appears that the levels of solids discharged over the last 2 years are increasing.

The company has also made progress in reducing the toxicity of the mill effluents, but there still exists a residual toxicity in the effluent, as the mill is presently not treating the foul condensates from the digester and evaporator areas (100% mortality in 3.2%-5.6% conc. of the combined effluents).

The malodourous air emissions from the Irving mill are presently the cause of greatest concern to the residents of the Saint John area. Thus, as noted earlier, the provincial government has requested that all remaining water

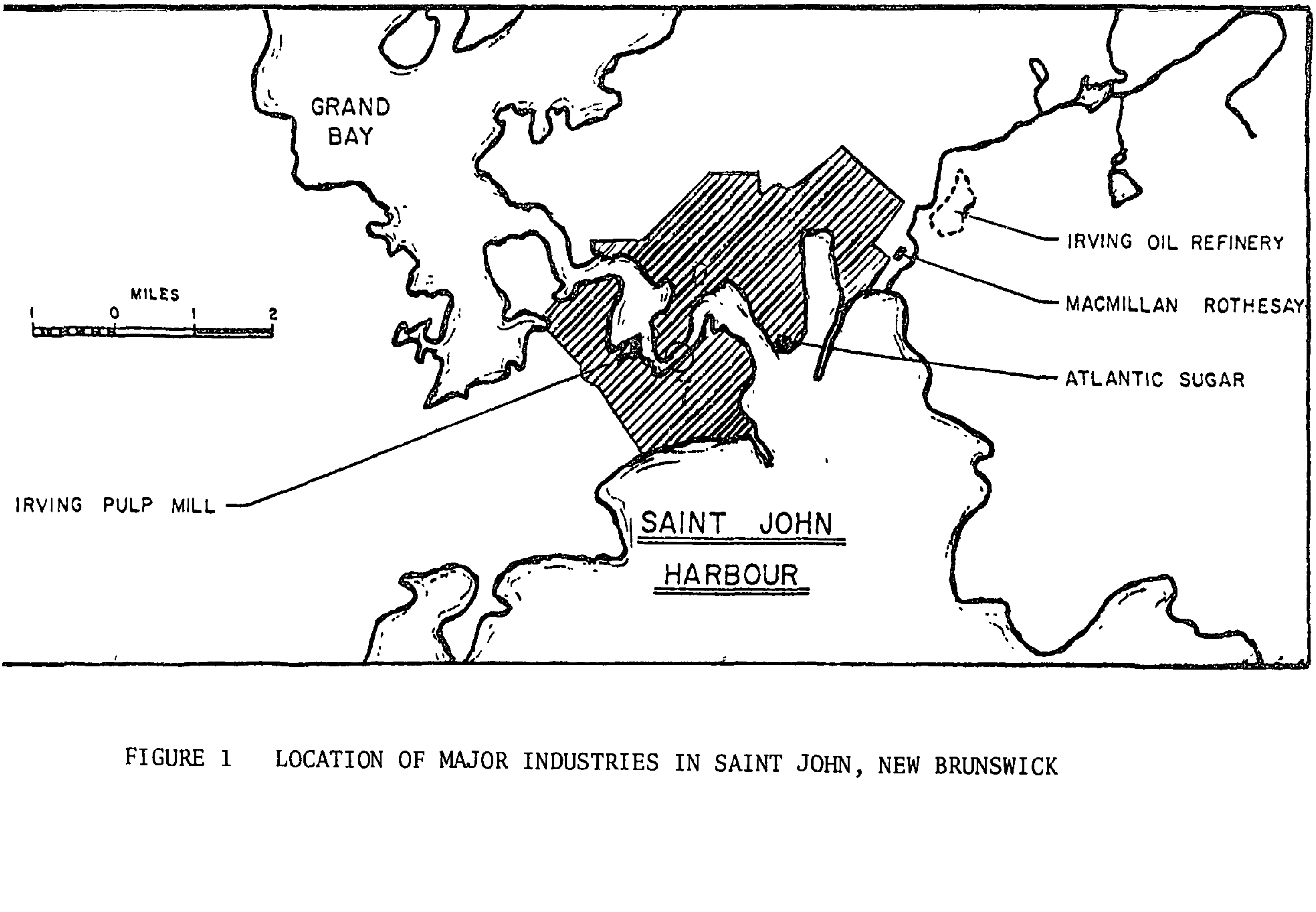

FIGURE 1 LOCATION OF MAJOR INDUSTRIES IN SAINT JOHN, NEW BRUNSWICK

pollution requirements be postponed until the air problem is brought under control in 1981.

3.3 The MacMillan-Rothesay Pulp and Paper Mill

MacMillan-Rothesay operates a 825 ton/day newsprint mill in Saint John. All chemical pulp for the paper furnish is imported, so the mill makes only groundwood pulp on site.

In 1970, the mill had no form of waste treatment with 3 sewers discharging directly into the Little River. However, by 1972, the company had installed a primary clarifier to handle the total mill effluent before discharge but the effluent still exceeded the regulations with respect to suspended solids and toxicity. The suspended solids discharges continued to exceed the allowable limits through 1979, however, company reported data indicate that suspended solids discharges at the present time are 20,600 lbs/day which is in compliance with the allowable limit of 20,997 lbs/day.

The total BOD_5 discharge is 25,000 to 30,000 lbs/day, which is about normal for a mill of this type without treatment. The acute toxicity of the final effluent was tested in 1978 and the static bioassay procedure showed a LT50 of 22 hours at 65% effluent concentration and a 96 hour LC50 of 24%. The toxicity is due, at least in part, to resin acids at a concentration of 5 to 10 ppm in the effluent. The lethal limit is usually taken as 1.0 ppm.

Wood fiber from this mill and sewage from the city have been dumped into Red Head Bay immediately east of the city for several years. The Little River beach area is a natural sedimentation zone and thus there had been an accumulation of these materials off Little River and McNamara beaches before 1972. As a result there had been severe hydrogen sulphide odour problems in the past in this area due to the decomposition of the organic sediments. The gases were released directly to the air at low tides and at higher release rates in the summer sun.

The paper mill has reduced its solids discharges to the point that there has been no build-up in the Little River beach area in the past few years. Thus it is apparent that the discharges still occurring and the washout/exchange of sediment with the main Bay of Fundy are in equilibrium.

3.4 Irving Oil Refinery

The Irving Refinery was originally designed to process 45,000 barrels of crude oil per day. By 1975, the capacity of the refinery was expanded to 280,000 barrels per day. Along with the expansion program, the refinery undertook to construct waste water treatment facilities. These treatment facilities were designed to treat the water to the standards outlined in the Petroleum Refinery Effluent Regulations and Guidelines.

There are two points of waste discharge from the refinery. One is discharged to Courtenay Bay at the end of a breakwater while the other flows to a treatment facility on the refinery property and then into Little River. In 1970, the refinery effluent was low in BOD and phenol discharge but contained high levels of oils and sulphides.

In fact, concentrations of phenols and sulphides in the waste exceeded those levels which are toxic to fish, and no efforts were made at that time to reduce these levels before discharge to the environment.

The results of a toxicity study in 1972 demonstrated that the effluent of the oil refinery was highly toxic to both rainbow trout and lobster larvae. High concentrations of NH_3 and $S^=$ were considered the major toxicants. It was felt that the effluent discharged from the refinery could be expected to have a harmful effect on marine life in the vicinity of the outfall.

Since 1976, the refinery has submitted monthly reports showing the discharge of suspended matter, ammonia, oils, phenols and sulphides. The following graphs (Figures 2 - 6) prepared from these monthly reports, show the actual average monthly discharge of each of these parameters and the amounts that are allowed by the Petroleum Refinery Effluent Regulations and Guidelines. These reports show that the refinery discharge did not comply consistently with the Refinery Liquid Effluent Guidelines before February, 1977. The discharges have, however, been in compliance consistently since that time.

3.5 Saint John Sewerage

The city of Saint John has sewage treatment facilities operating in Lancaster and at Marsh Creek. The Hazen Marsh Plant was completed in 1979 and a plant for the Millidgeville area should be constructed in the next few years. In spite of the progress that has been made, the old part of the city will continue to discharge raw sewage into

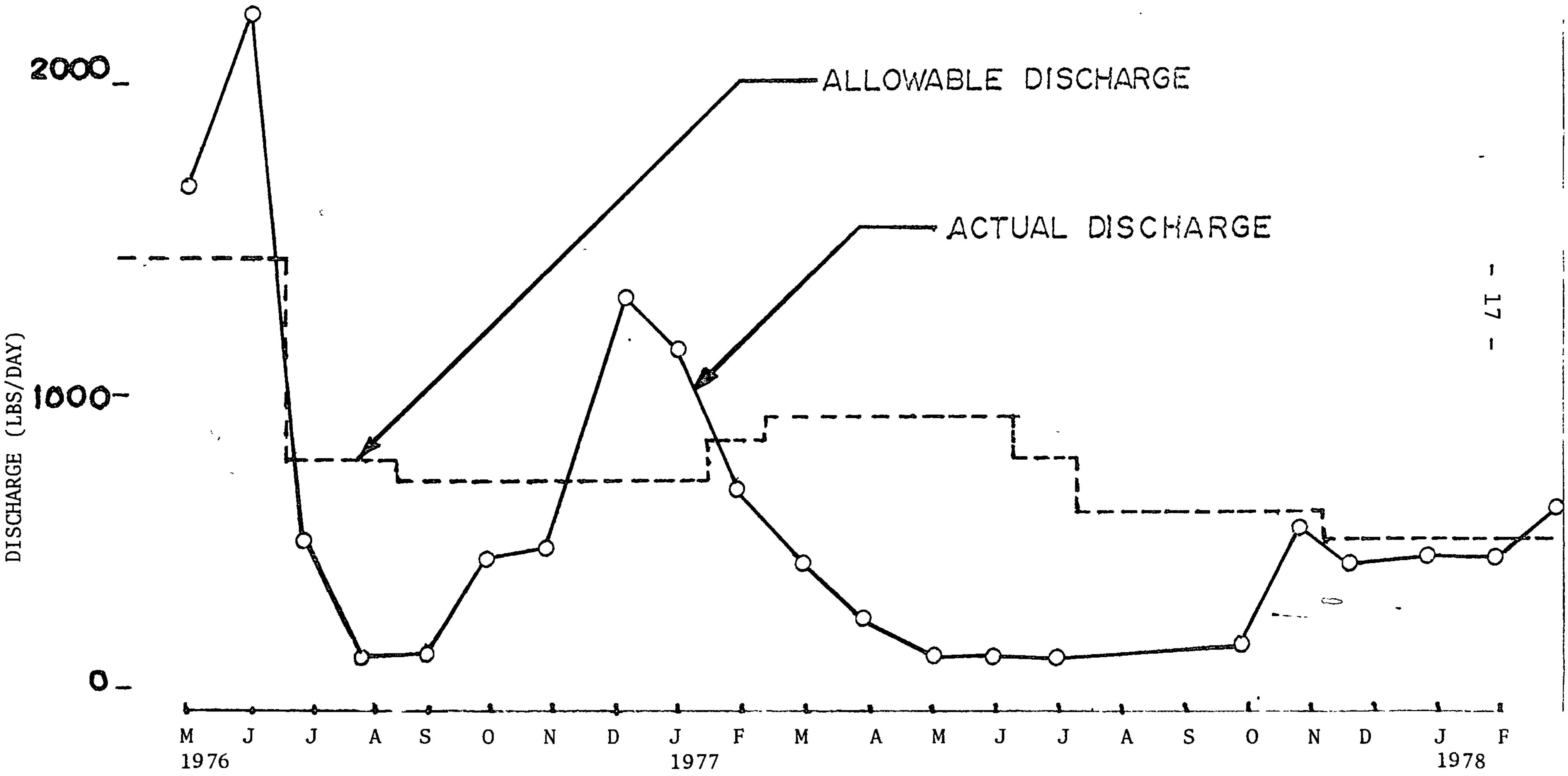

FIGURE 2 AVERAGE DISCHARGE OF OILS

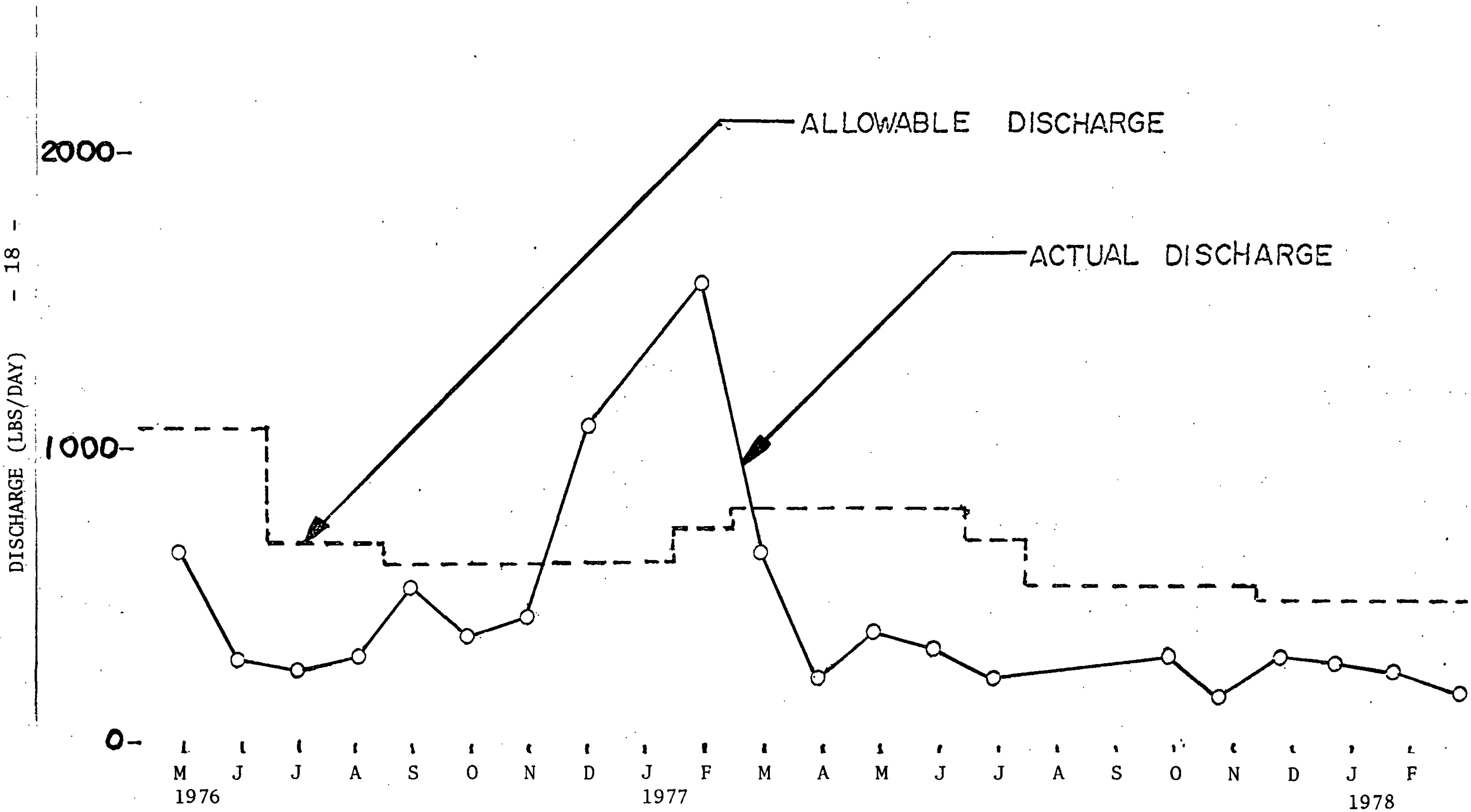

FIGURE 3 AVERAGE DISCHARGE OF AMMONIA

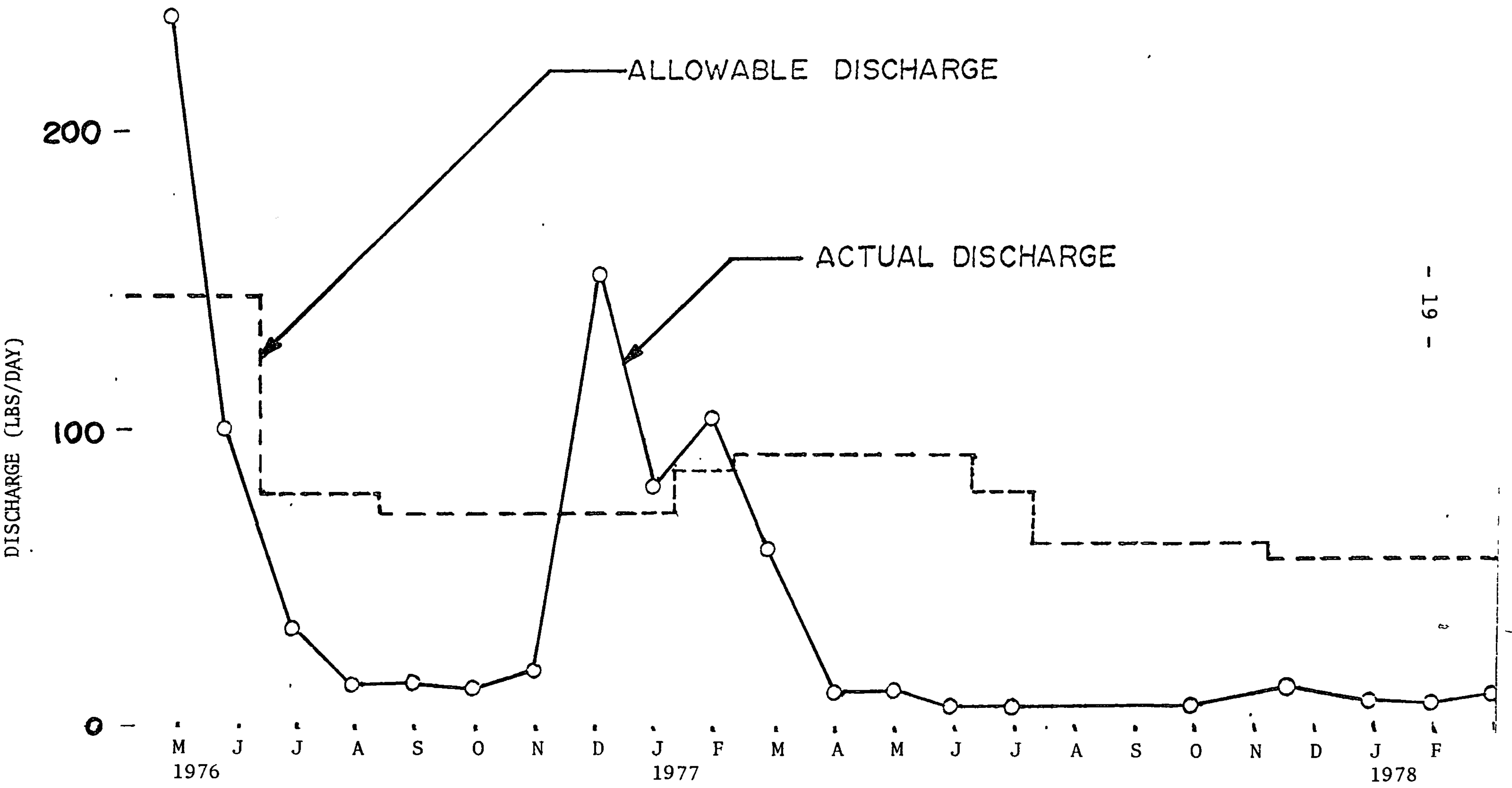

FIGURE 4 AVERAGE DISCHARGE OF PHENOLS

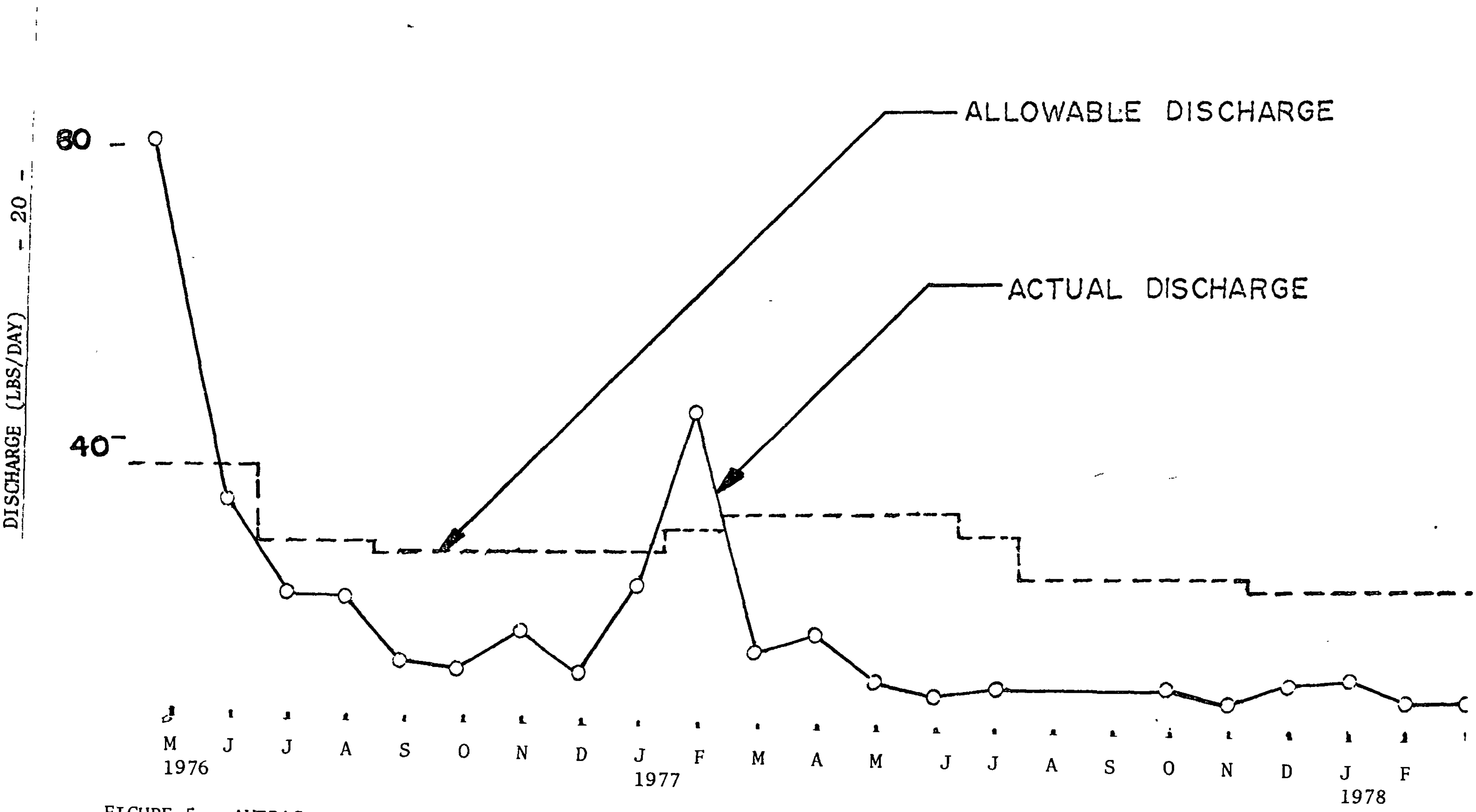

FIGURE 5 AVERAGE DISCHARGE OF SULPHIDES

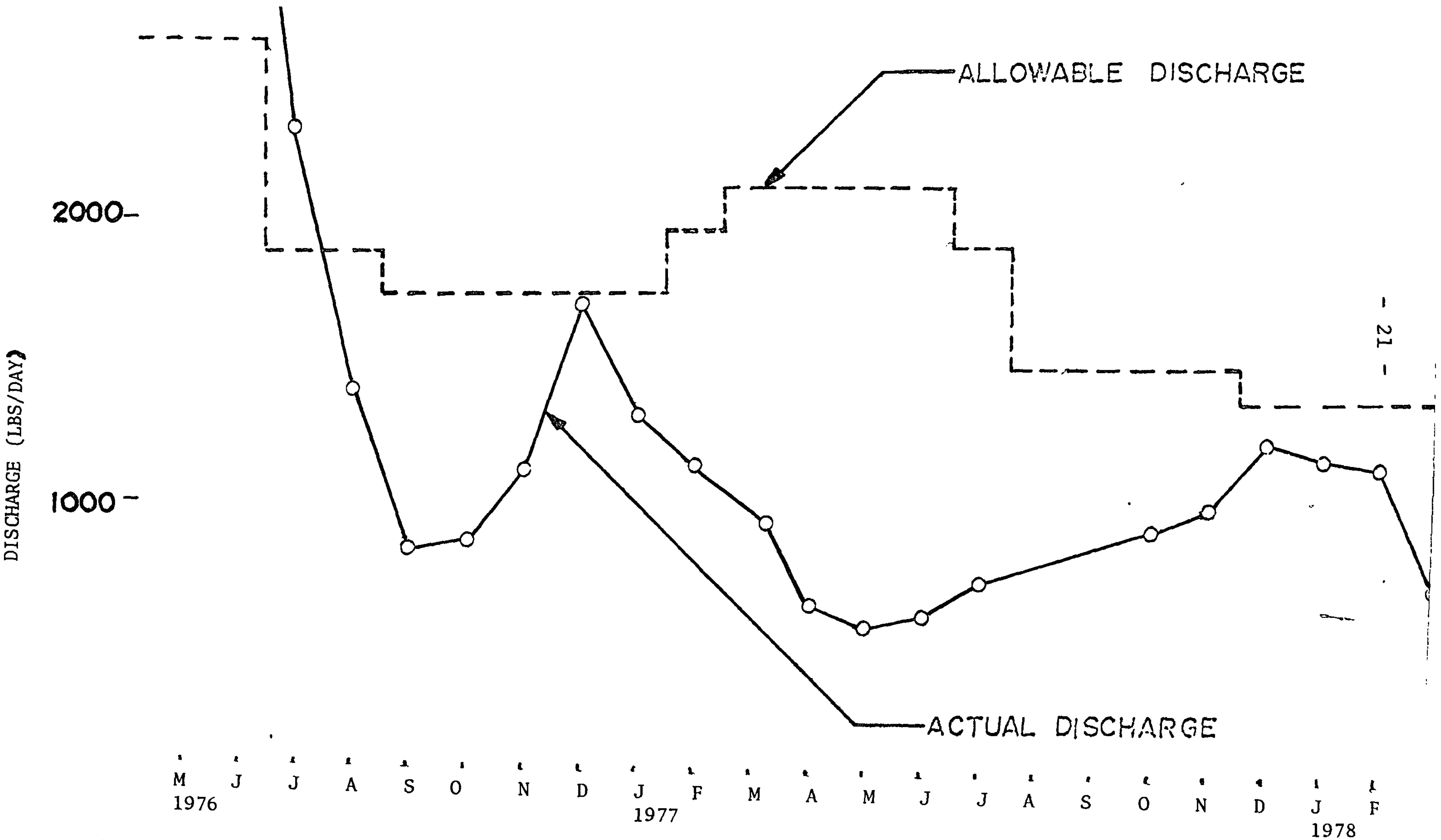

FIGURE 6 AVERAGE DISCHARGE OF TOTAL SUSPENDED MATTER

the harbour area. These outfalls are not monitored and there are no regulations or federal guidelines to control municipal discharges where such discharges cannot be shown to have detrimental effects on fish (including shellfish) or man's use of them. The health of fish and benthos are discussed in following sections.

3.6 Significant Events (Oil Spills)

A further potential source of environmental damage to the harbour area, is the "significant events", or accidental oil spills and leakages in this area. Table 3 lists those events which have occurred since 1973 (over 450 gallons).

Although these events are scattered and have, to date, proven to be of limited evident damage to the harbour, there is always the potential for a sudden catastrophic event, or a possible accumulative impact as a result of these recurring events.

4 OCEAN DUMPING

4.1 Introduction

Saint John Harbour, N.B., is one of the major dredging and dumping sites on the Canadian Atlantic coast. The quantity of material handled annually has varied in the order of 500,000 cubic metres but can on occasion exceed 1,000,000 cubic meters.

TABLE 3 SIGNIFICANT EVENTS (OVER 450 GALLONS)

Location	Source	Hazard	Quantity	Cause	Date	Effect
Monobuoy for Supply to Irving Refinery	CANAPORT Monobuoy	Crude Oil	Unknown		Dec. 26/73	400 yds. of beach oiled at Spencer's Pt.
Mouth of Harbour	Irving Glen (tanker)	Bunker C Residual Oil	Very small amount	Struck submerged rock	July 26/74	Oil on shore
Courtenay Bay near causeway	-	Irving gasoline (Hi-Test)	30,000+gals.	Tanks over-flowed or pipe not connected	Aug. 23/74	-
Saint John	Irving Glen	Bunker C	4,500 gals.	Overflow of tanks	June 1/76	-
Off Mispec Pt.	CANAPORT	Arabian Crude	17,000 gals.	Discharge hose break	June 19/76	Oil moved onshore and down coast
Saint John	Brunswick Petroleum Lines	Gasoline	800-1000 gals.	Punctured tank	Oct. 13/76	Little risk to environment
Saint John	Irving Oil Ltd.	Furnace oil	1000 gals	Truck slipped brakes	Jan. 29/77	Minimal damage
Pier #1 Courtenay Bay	Irving Oil Ltd.	Bunker C	4500 gals.	Pipeline separation during bunkering	Nov. 8/77	-

...Cont'd

TABLE 3 (Cont'd)

Location	Source	Hazard	Quantity	Cause	Date	Effect
Courtenay Bay	Irving Oil Ltd.	Bunker C	875 gals.	Overflow while refueling the Irving Glen	Nov. 13/77	Most of the oil retained
Courtenay Bay Irving Oil Refinery Wharf	"Texaco Melbourne"	Gasoline/ diesel mixture	very small	Broke moorings and ran aground	Jan. 9/78	-
Courtenay Bay	Irving Oil Ltd.	Gasoline	5000 gals.	Broken pipeline	Jan. 17/78	Slick disappeared into Bay of Fundy
Courtenay Bay	Irving Oil Ltd.	Diesel	105,000 gals.	Break in valve	Apr. 24/78	80% recovered
Courtenay Bay (Irving) Refinery)	Irving Oil Ltd.	Diesel-Bunker mixture	700 gals	Line valve opened	June 6/78	Most recovered
Courtenay Bay	"Ocean Faith" #2655	Naptha	1000 gals.	Leak in off-loading line	Oct. 31/78	Slick carried out-dissipated naturally
Anchorage Area B (5 miles south of harbour)	SSH 1070 ore/oil carrier	Fire on board tanker carrying No. 2 oil-diesel stove oil	8.4 million gallons (on board)	Unknown	Dec. 12/78	No environmental damage

...Cont'd

TABLE 3 (Cont'd)

Location	Source	Hazard	Quantity	Cause	Date	Effect
Saint John	Imperial Oil Ltd.	Furnace Oil	700 gallons	Overflow of tanks	Dec. 27/78	Oil disappeared on outgoing tide
Generating Plant, Courtenay Bay	N.B. Power Corporation	Bunker C	35000 gals.	Overflow during refueling	Feb. 16/79	Most oil recovered
CANAPORT Buoy	"George M. Keller"	Crude Oil	500 gals.	Discharge while unloading	Aug. 20/79	Some reached shoreline
Courtenay Bay	"Irving Arctic"	Diesel Fuel	9000 gals.	Overflow in loading	Nov. 11/79	3-4000 gals. escaped to the harbour
Courtenay Bay Irving Oil Refinery	Irving Oil Ltd.	Diesel Oil	175,000 gals.	Break in pipeline	Feb. 5/80	-

In 1958, DPW and NHB asked the National Research Council to study the cause of siltation in the harbour and to locate a suitable dump site which would minimize the return of the disposed silt to the harbour. Neu (1960) concluded that the sediments are composed of sand and colloidal material; the former being supplied by a seaward transport along the coast of New Brunswick and the latter by the river. The colloidal material is carried into the Bay of Saint John at the mouth of the river by the outward flowing fresh water layer where it flocculates on contact with salt water. The water of this Bay, though exposed to clockwise and anticlockwise circulation generated by the large off-shore tidal currents of the Bay of Fundy, is subjected to densimetric two-layer flows initiated by the fresh water of the river (Neu, 1960). This zone of confluence tends to follow the shoreline of the Bay of Fundy toward Tiner Point. As shown in Figure 7, where the net motion of the bottom one metre layer of water is plotted, the residual transport over most of the Bay is inwardly directed. Thus, flocculated material mixed with sand from the Bay of Fundy is carried toward the mouth of the river and into the harbour where it settles in areas of low current velocity such as Courtenay Bay and the harbour slips. The material which remains in the river channel continues upstream over the Reversing Falls and into the river system. Part of this silt will be carried back downstream during spring freshets, but the remainder forms an inverse delta in the lake system above the falls.

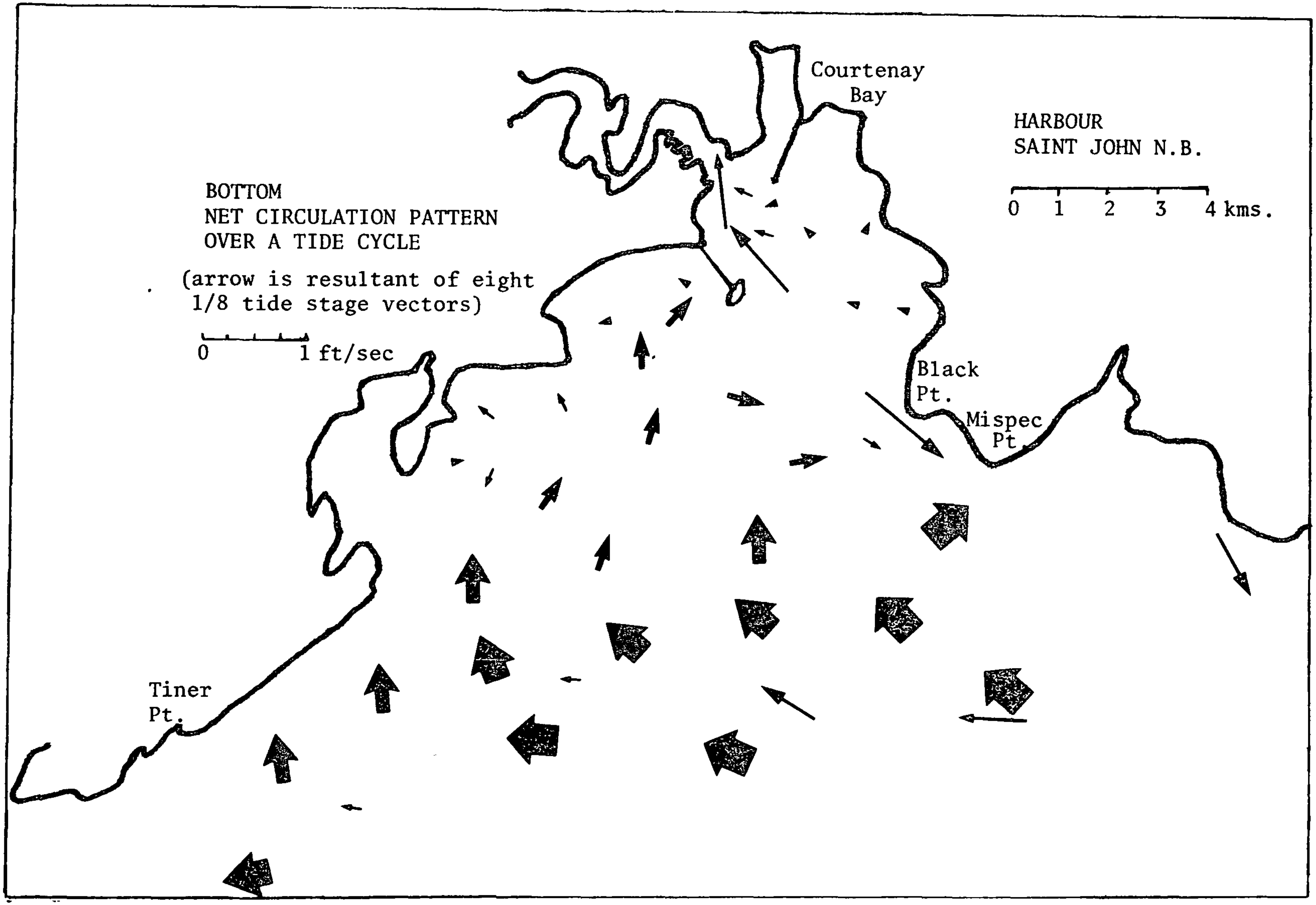

FIGURE 7 BOTTOM NET CIRCULATION PATTERN IN SAINT JOHN HARBOUR
(Reproduced from Neu, 1960)

As is indicated from the transport pattern shown in Figure 8, the only region of the Bay where an efficient seaward transport prevails is along its eastern coast past Black Point and Mispec Point. This transport is at its maximum near the coast and declines quickly off-shore. About 2 km from the shore the residual outward motion ceases and beyond this point its direction is predominantly inward. In order to avoid this region and to utilize the strong outwardly directed current along the shore, the area selected in 1958 for dumping was placed in a 1,000 m. wide strip along the coast from Black Point outward. It was stressed then that the shore side of the strip is more efficient than the open water side in dispersing the dumped spoil.

The material normally dumped is composed predominantly of particles that are easily eroded and transported (silt and clay). As well, the coastal morphology adjacent to the dump site suggests that the dredged material would be periodically subjected to wave generated turbulence. This, in combination with the very strong tidal currents, results in the rapid dispersion of the fine material. Samples obtained by EPS in 1975 indicated a firm fine sand bottom in the area of the dump site with very little silty or organic material present. The majority of this fine material is dispersed into the Bay of Fundy. The question of contaminants contained in dredged material will be discussed in the section on contaminants.

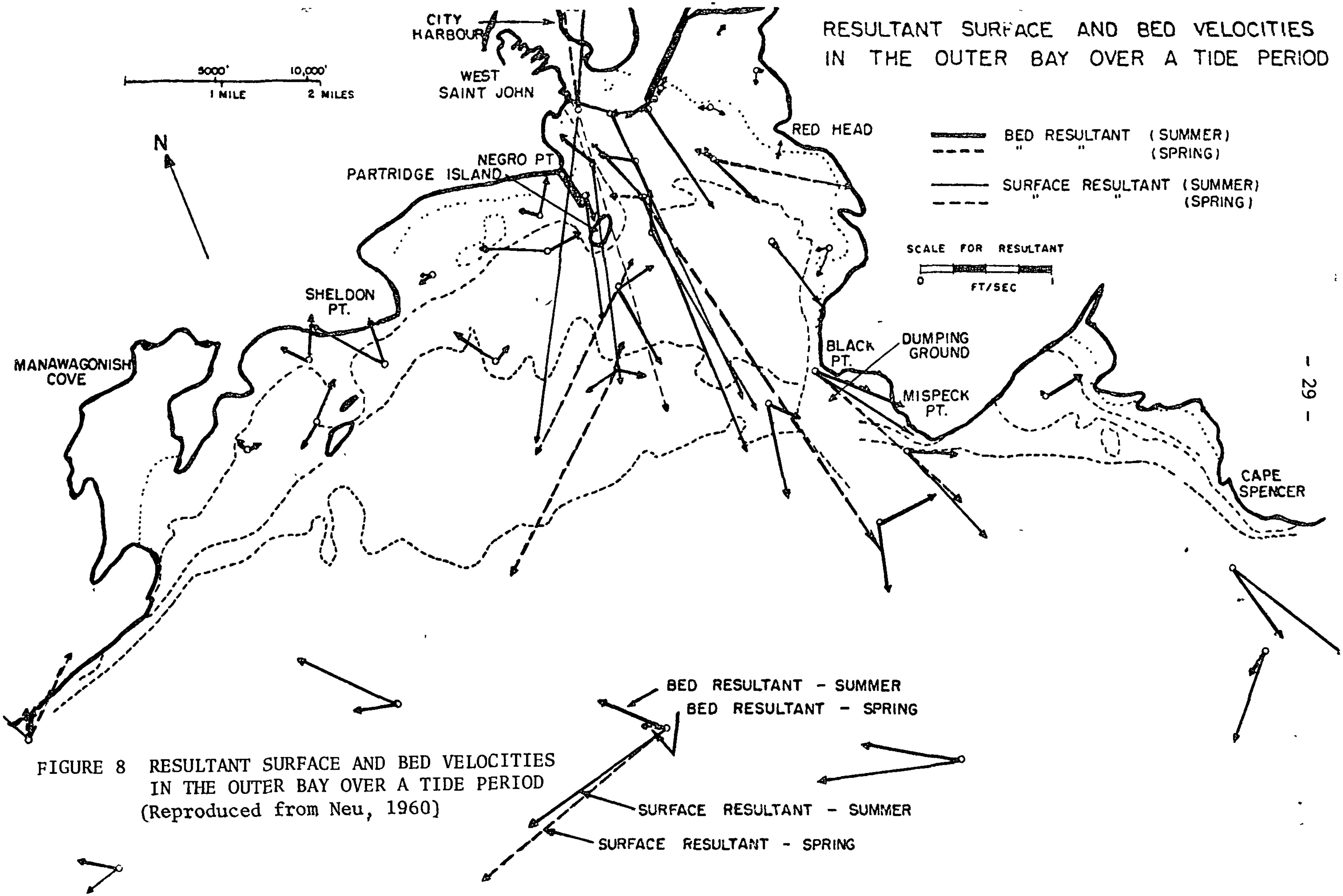

FIGURE 8 RESULTANT SURFACE AND BED VELOCITIES IN THE OUTER BAY OVER A TIDE PERIOD (Reproduced from Neu, 1960)

4.2 Benthic Fauna

Several studies have been conducted over the last 20 years on the benthic communities of the Saint John Harbour area (MacLellan and Sprague, 1966; Wildish, 1976; Wildish and Kristmanson, 1979). Base-line and follow-up information exists, from which we can attempt a temporal comparison of these communities as Saint John has developed over the past few years.

Because many benthic organisms are relatively immobile and because they form characteristic assemblages related to specific water quality parameters and substrate characteristics, these organisms are frequently used as indicators of ecological effects.

A base-line survey of the harbour was carried out in 1959 and 1961 by MacLellan and Sprague (1966) which provided a species list for the area. A further study by Wildish and Kristmanson (1979) demonstrated that the benthos consisted of only a few species which were deposit feeders and/or predators, of low species diversity and biomass. There is no strong evidence to suggest that any changes have taken place in the benthic communities since 1959/61, except for a slight reduction in the numbers of individuals per species near the Irving Refinery outfall, 16 months after start-up of production there.

The features found in the harbour are characteristic of an impoverished community (Wildish, 1979). The question which arises, therefore, is what is the controlling factor for this impoverishment?

Wildish and Kristmanson (1979) suggest that current velocity and turbulence at the sediment-water interface control the numbers, biomass and growth of suspension-feeding macrobenthic animals. These two factors would influence the supply of food to these communities and affect the cycles of sediment erosion and deposition. Sediment erosion results in an unstable sediment, unsuitable for larger suspension feeders, particularly at the time of larval settlement. These considerations suggest that the absence of suspension feeders is due to the dominant effect of tidal energy, either through sediment instability or by direct inhibitory effects on the feeding of the suspension-feeding animals. What this implies is that the benthic communities in Saint John Harbour have long been naturally impoverished by the locally rigorous physical conditions.

Since 1974, Marine Research Associates have been conducting benthic surveys between Saint John Harbour and Point Lepreau. They have found growing evidence of impoverishment outside the harbour and along the southwest coast (A. MacKay, pers. comm., 1980). Species diversity has been declining and local fishermen are reporting increased fouling of gear by silt and debris (L. Wilson, pers. comm., 1980). While it is believed that ecological changes are taking place, it is not fully certain at this time whether these changes are the result of natural physical processes or part of a general progressive degradation of the coast resulting from pollution or dredging and dumping operations, or a combination of these factors. The essential link between cause and effect is lacking at this time.

Recent sedimentological studies carried out by the Coastal Oceanography group at BIO and further benthic surveys by St. Andrews Biological Station are currently being reviewed in an effort to resolve this question.

4.3 Effects on Fisheries

For a number of years now, the Fishermen of the Saint John region have expressed increasing concern over the apparent reduction of fishing potential in Saint John Harbour and the surrounding area. They believe that the continuing degradation of fish and lobster habitat is related to persistent industrial pollution, dredging and ocean dumping.

In an effort to assess the magnitude and nature of the problems faced in the fisheries sector, it is necessary to determine as well, which factors could have an impact on the fishery. Should a controllable factor such as the disposal of dredge spoils or pollutants be implicated, then possible alternatives can be investigated and proposed.

No data have yet been obtained which establish that a reduction in the biological potential of this area has in fact occurred, or that the contaminants present in the spoil have or are causing any deterioration of the habitat. There are statistics (Figures 9-12) which may loosely suggest such trends, but attempts to interpret the data on catches in relation to the information on these activities are suspect since there are so many other variables, particularly natural fluctuations, which can affect catches. The catch figures may appear to substantiate that fishing has been declining in the last 20 years, but this cannot be correlated to dredging or industrial pollution, other than superficially. More information is needed on the relative significance of dredged spoils and pollutants in the habour and adjacent parts of the Bay. The concerted effort necessary to substantiate these figures or the fishermen's

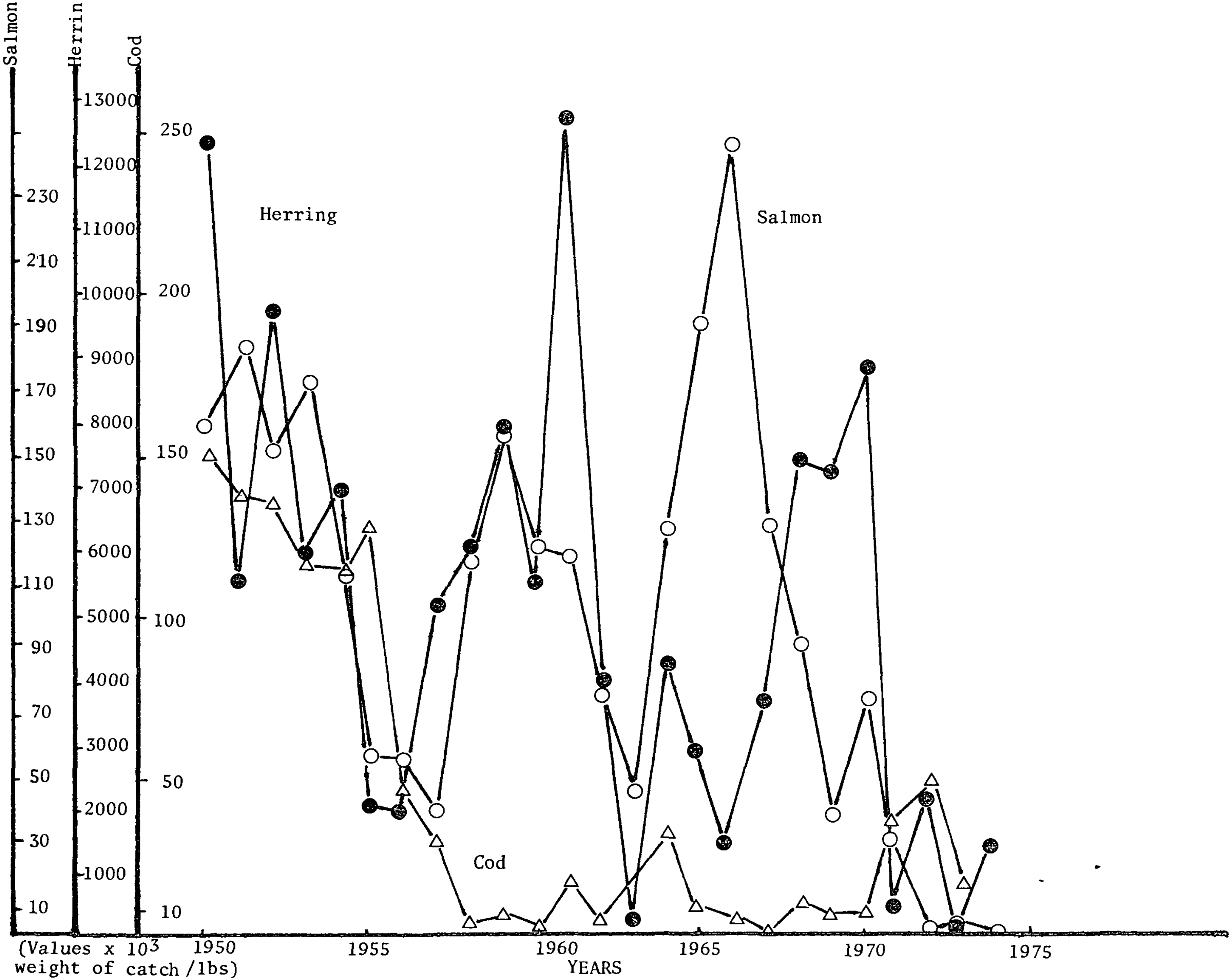

FIGURE 9 FISH LANDINGS, SAINT JOHN, N.B. (FISHERIES STATISTICAL DISTRICTS 48 AND 49)

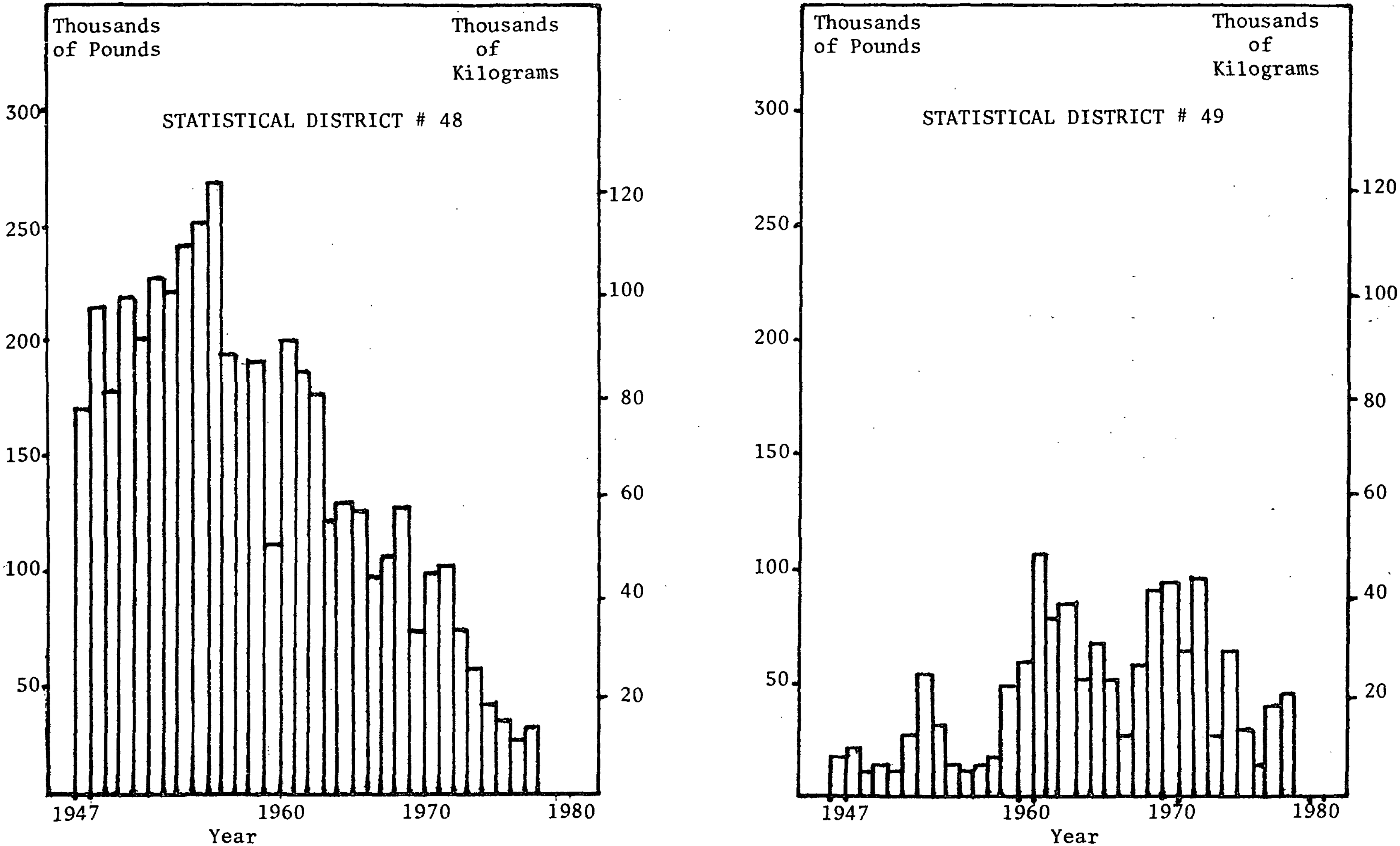

FIGURE 10 LOBSTER LANDINGS SAINT JOHN COUNTY, N.B.

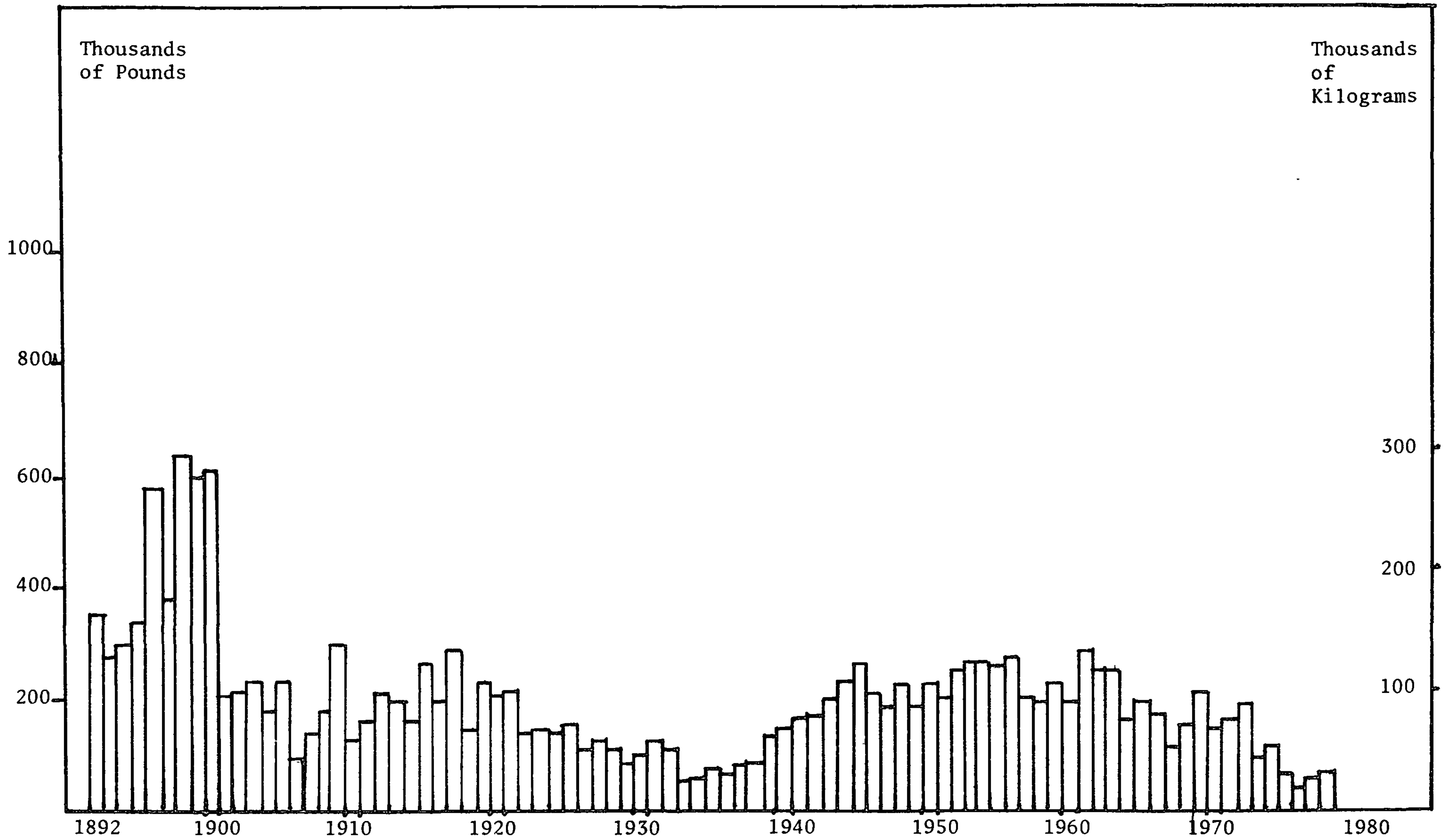

FIGURE 11 LOBSTER LANDINGS, SAINT JOHN COUNTY, N.B. (1892-1979)

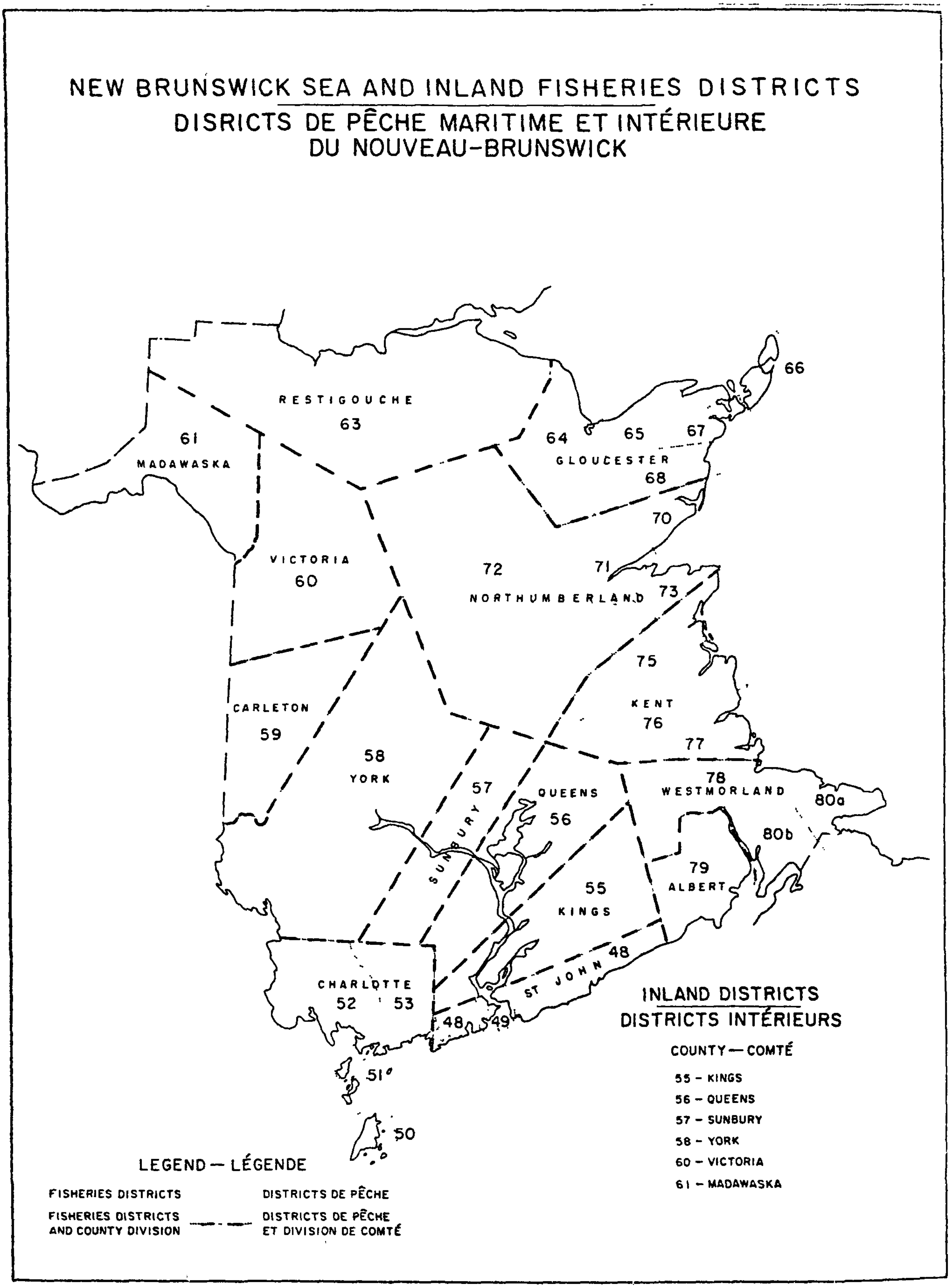

FIGURE 12 NEW BRUNSWICK SEA AND INLAND FISHERIES DISTRICTS

claims is also lacking, so the evidence is merely circumstantial, based on their observations and intuition. However, on the same basis one could equally say that industrial pollution is probably not implicated in the decline of fish stocks, given the progress in effluent control reported in Section 4.

Further, observations by these fishermen supported by diving surveys in this area suggest that lobster grounds are being damaged as siltation increases along the coast (S.W.) of Saint John Harbour. This damage has reportedly increased greatly in recent times, and it is felt by a consultant working in this area that recent greatly increased sediment transport is having an adverse impact on that fishery.

Sedimentation and biological studies have been carried out in an effort to determine what resource and environmental impacts, if any, can be attributed to the use of Black Point dredge disposal site. Sedimentation studies were carried out in 1977 and 1978 by OAS to determine the extent and nature of sediment dispersion from the dump site. Biological studies conducted by consultants (MacLaren Marex and Martec, 1978) indicated that a site degradation has occurred over the years to the extent that there are fewer benthic species now present at the dump site and smaller numbers of each species. The point has been made by researchers at St. Andrews Biological Station that the dump site, as described, would not be attractive to lobsters (and probably has not been so for many years even prior to dumping) because of the natural sediment load carried into the harbour from the Bay of Fundy and the fine nature of the spoil.

A firm conclusion cannot be drawn on the ultimate fate and impact of spoil disposal at Black Point dumpsite until the results of the sedimentation studies have been thoroughly analyzed. However, recent findings have indicated that the contribution of dumping at Black Point to the sediment budget of Saint John Harbour is minimal. It appears at this time, that natural sediment transport is the dominant factor in the sedimentary processes occurring in the harbour (D. Bezanson, pers. comm., 1980). Further results will be available in late 1980.

On the basis of available information, fisheries personnel are not in a position to indicate what the impacts are with respect to the Black Point dumpsite, nor what the likely impacts would be if an alternative disposal site were selected. However, it was indicated in the 1978 Martec report that dumping elsewhere within Saint John Harbour could have undesirable effects by destroying desirable habitat for indigenous species. Although there is insufficient evidence to warrant denial of ocean dumping permits, any permits involving long-term commitment to a particular dump site should stipulate additional research leading to an adequate evaluation of the effects of continued dumping at that site.

The Department of Fisheries and Oceans identified a potential problem with the timing of dredging operations. There are no seasonal restrictions for dredging in the harbour, thus there has always been an overlap of these operations with the inward migration of salmon to the Saint John River. Since these spoils are predominantly lighter fractions (silt and clay) it was suggested that migrating salmon might be repulsed by heavy siltation in the water column. It was, therefore, recommended that the entire dredging operation be completed between September and March 31 to alleviate any alleged interference with the salmon run. However, no evidence beyond limited observations exist to support these contentions and the problem has never been formally addressed. Furthermore, naturally occurring storms have been noted to perturb the estuary to a much greater extent than any of the current scale dredging operations (Bezanson and Neu, pers. comm., 1980). Therefore, it appears that this recommendation has no basis in fact.

As a result of the poorly defined fate of the material dumped from dredging operations and its ultimate effect on the fisheries, it has been suggested by the Saint John County Fishermen's Association that land disposal for the spoils might be preferable to ocean dumping.

A pertinent issue at present is the proposed potash terminal at Broad Street South, Courtenay Bay. This will require a relatively large construction operation, involving the dredging of 500,000 cubic yards of sediment, all of the spoil having a high silt and clay content. There is not, however, any new information that would allow an evaluation of the effect of the ocean disposal from this development on the fishery. However, an Environmental Overview Report prepared by the NHB for this operation in April, 1980, concluded that this project "is unlikely to cause significant adverse environmental effects", and that the project should proceed as planned. The local fishermen do not agree with this conclusion, however, and have requested that an alternative to the offshore dump site be identified and used.

4.4 Contaminants

There has been concern over the reported elevated levels of contaminants (particularly Cd) in the dredge spoils in Saint John Harbour. In February, 1978, a complete review of all analytical data on record for sediments from Courtenay Bay was conducted by the Department of Fisheries and Environment who found that there was virtually no consensus on the reported levels of Cd present in the spoils to be dredged. Without a verification program between the various labs performing analysis on Saint John sediments (EPS, FMS, St. Andrews, Atlantic Analytical and MacLaren Atlantic) it had been necessary to opt in favour of caution and accept the highest results (with the awareness that these values may not necessarily be reliable and that all the cadmium reported may not necessarily be available to biota). However, this would be the most cautious approach toward protecting the marine resource.

In the spring of 1979, Samant, et. al. performed a quality control laboratory evaluation in an effort to confirm the varying reported levels in the sediments. However, the method and interlaboratory comparisons generally showed poor accuracy, frequently coupled with inadequate limits of detection. A concerted effort toward improved analytical consistency is needed.

In a review of data collected as part of the Ocean Dumping Control Act application review process, it became apparent that the concentrations of Schedule I substances (Appendix I), in many cases, exceeds those limits currently specified in the Regulations. The limited knowledge of natural background concentrations of Cd in marine sediments for instance suggests a range from 0.04 to 1.9 mg/kg (ppm) with a mean value of 0.55 mg/kg. These values would support the belief that concentrations of Cd in dredged material considered for ocean disposal as high as 0.6 mg/kg (solid phase) would not differ appreciably from concentrations naturally occurring in marine sediments.

Swiss, et. al. (1980) noted that the potential danger of high concentrations of cadmium in marine sediments (>0.6 ppm) is related to the form in which it exists and thus the rate at which cadmium may enter the water column or otherwise become available for uptake by marine organisms. There is little evidence that cadmium is released into the water column from dredge spoils under a variety of situations, however, the potential for incorporation into the tissue of deposit feeding organisms cannot be discounted and the possibility of damage, however small, still exists. Other contaminants could also be present, although it should be noted that to date no sediment exceeding the acceptable limits of any contaminants has been disposed of at the Black Point dump site.

The following levels (in solid phase) have been considered background by consultants performing geochemical analysis from the Saint John area.

Copper	20 ppm
Lead	40 ppm
Zinc	100 ppm
Nickel	20 ppm
Arsenic	5 ppm
Mercury	0.1 ppm
Cadmium	should not be present in amounts greater than 0.6 ppm.

Although high concentrations of Cd have been reported in certain Saint John sediments (i.e. 1.4 ppm near the channel to Courtenay Bay, 2.4 ppm around the wharves in the main harbour and 4.2 ppm in upper Courtenay Bay), it is felt that on the average, there is not a Cd problem in Saint John Harbour (Bezanson, pers. comm., 1980). Although there are a few very high values (usually in areas not normally dredged) the average Cd value for the areas which are normally dredged is at an acceptable level (average of 0.46 ppm - from D. Bezanson's 1977 summer study).

It appears, however, that the dredging and dumping activities in the harbour are contributing to the anomalously high metal levels, near the dump site. A regional survey of heavy metals in the Bay of Fundy by Loring (1979) identified high metal anomalies which are a reflection of the anthropogenic inputs (Figures 13 - 19). However, even the highest concentrations in the sediments are below the limits set by the Regulations, and it appears that dispersion within the Bay of Fundy could reduce any immediate problem on a regional scale. It should be pointed out, however, that there are limits to the amounts of pollutants and interferences which this marine environment can ultimately accommodate.

4.5 Recommendations for Improvements to the Harbour

In 1960, a N.R.C. Mechanical Engineering Report entitled "Recommendations for improvements to Saint John Harbour, N.B." by H.J.A. Neu was written, outlining a series of recommendations for improving the siltation problem in Saint John Harbour. H. Neu's recommendations are presented here, as they still offer an alternative to the annual cycle of dredging and disposal.

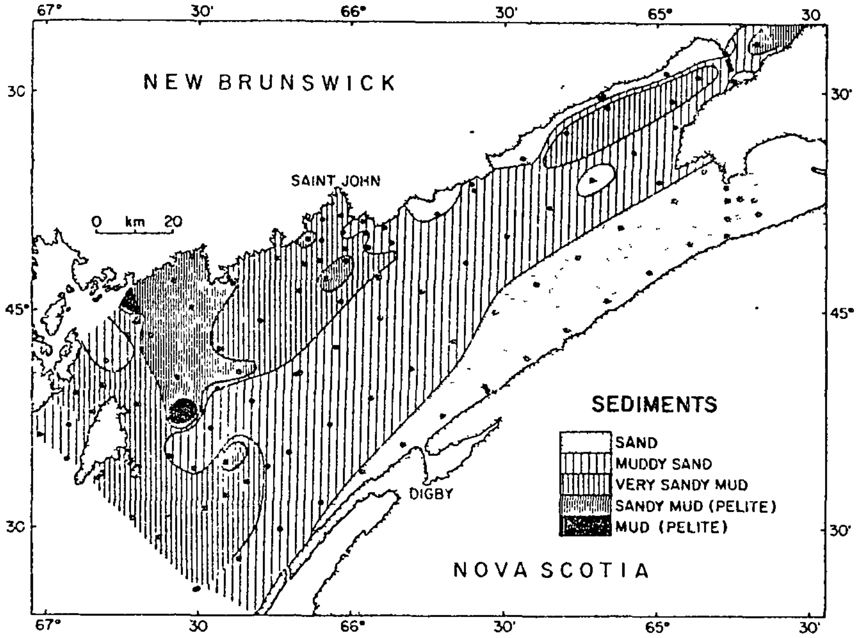

FIGURE 13 SEDIMENT DISTRIBUTION OF MATERIAL <2 mm IN THE BAY OF FUNDY, NOMENCLATURE OF LORING AND NOTA, 1973

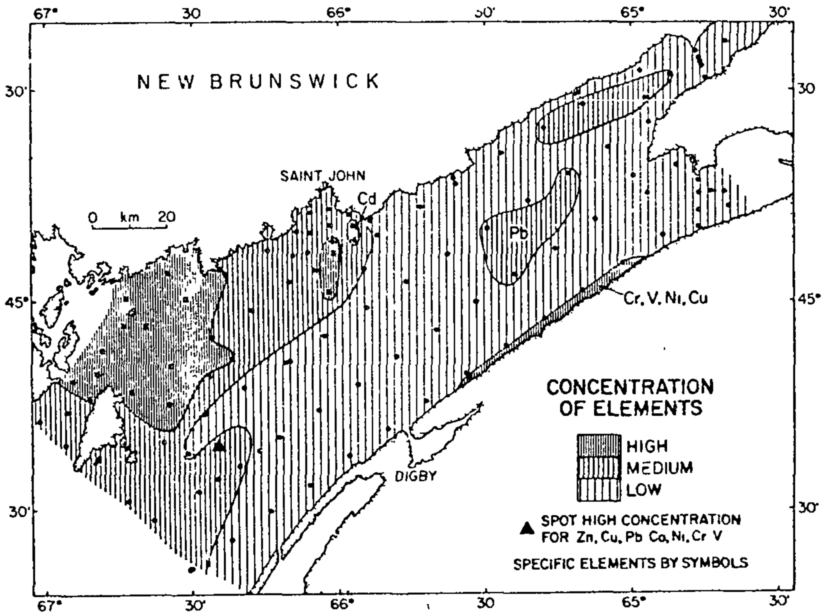

FIGURE 14 DISTRIBUTION OF THE RELATIVELY HIGH, MEDIUM, AND LOW CONCENTRATIONS OF Zn, Cu, Pb, Co, Ni, Cr, V, Be, Ba, Se, Hg, AND Cd IN THE SURFACE SEDIMENTS (<2 mm)

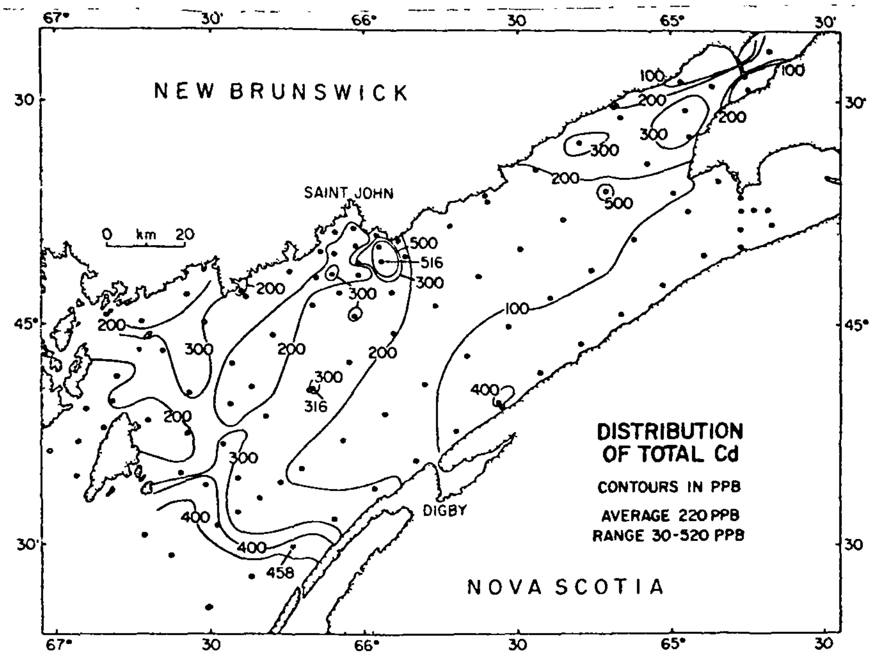

FIGURE 15 DISTRIBUTION OF TOTAL Cd IN THE SURFACE SEDIMENTS (<2 mm)

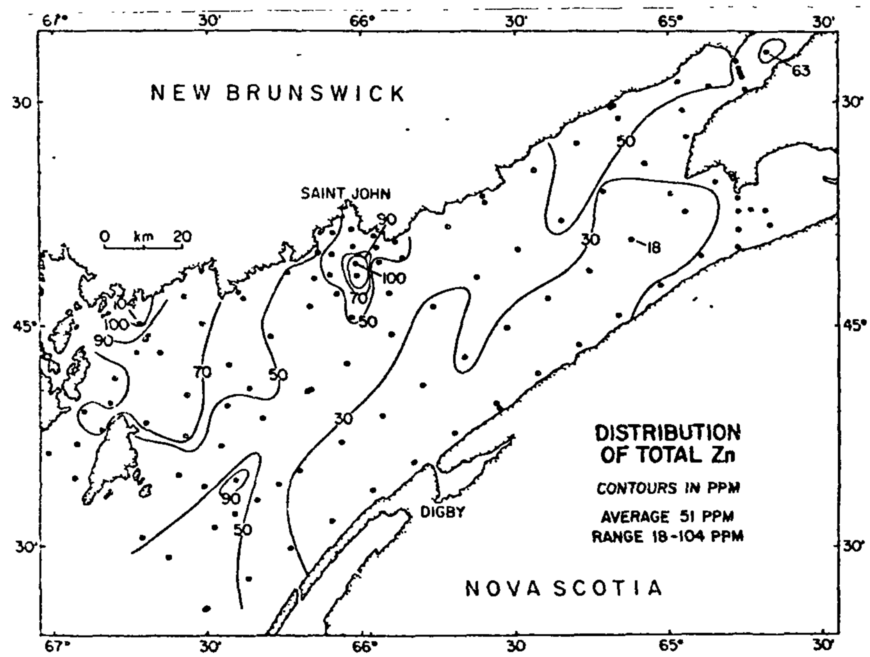

FIGURE 16 DISTRIBUTION OF TOTAL Zn IN THE SURFACE SEDIMENTS (<2 mm). DOTS SHOW SAMPLE LOCATIONS

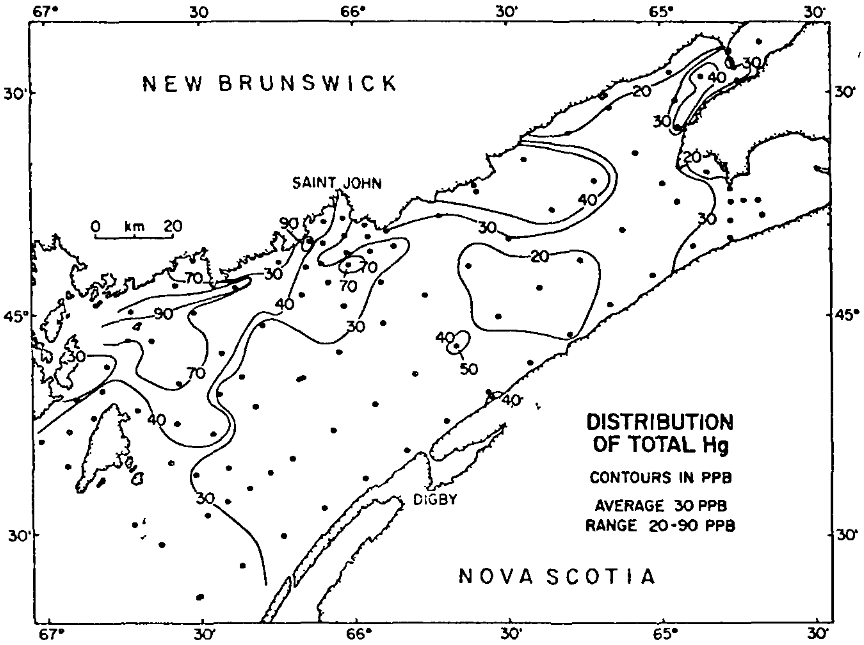

FIGURE 17 DISTRIBUTION OF TOTAL Hg IN THE SURFACE SEDIMENTS (<2 mm)

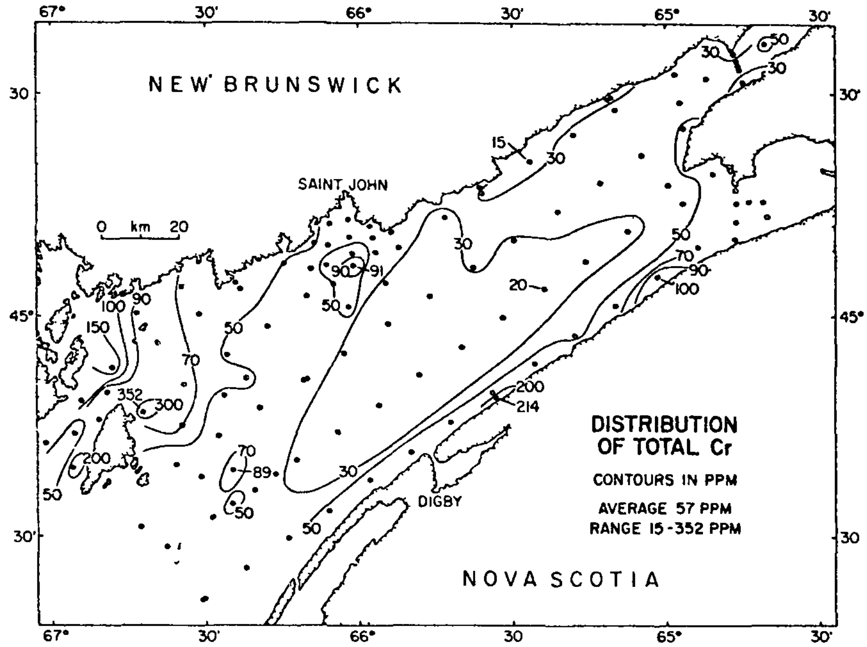

FIGURE 18 DISTRIBUTION OF TOTAL Cr IN THE SURFACE SEDIMENTS (<2 mm)

"A hydrographic survey of Saint John Harbour and adjacent waters was conducted in the summer of 1958 and spring of 1959 to obtain data on the basic causes of shoaling in the harbour and navigation channels. A study of these data shows that the harbour may be enlarged and improved and that maintenance dredging may be greatly reduced or eliminated."

Improvement and Developments Without Changing Present Hydraulic Conditions

"To prevent shoaling in navigation areas, the bed velocities should be equal to the scouring velocity at the depth required. This may be achieved by increasing the existing velocities, or by placing harbour facilities in areas where these velocities exist. Harbour facilities could be extended from Slip No. 1 to Partridge Island and from the Sugar Refinery to America Rock (Figure 19). Increased protection could be obtained by constructing a small breakwater east of Partridge Island for protection against long period waves which occasionally disturb navigation entering the City Harbour (Figure 19).

"Courtenay Bay Harbour, unfortunately, does not have the same hydraulic structure as the City Harbour and the Partridge Island area. The Bay is essentially a short channel leading to a still-water basin. There is a direct relation between the velocities in the channel and the tidal prism of the Bay. Construction of the causeway in Courtenay Bay was expected to reduce the area of the Bay and consequently the tidal prism substantially. As a result, the velocities in all parts of the Bay would be reduced and the rate of siltation increased. This, in fact, has occurred.

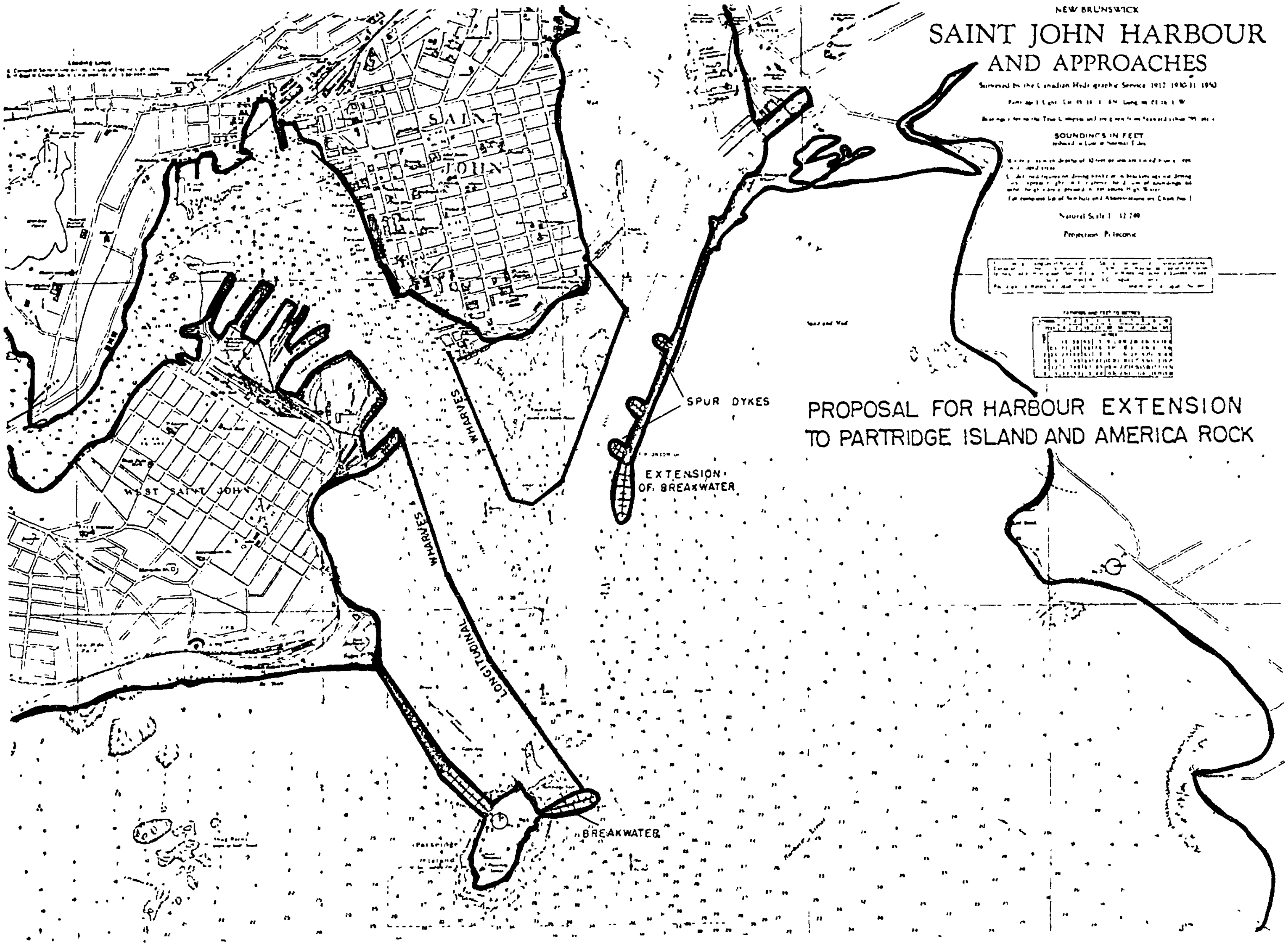

FIGURE 10 PROPOSAL FOR HARBOUR EXTENSION TO PARTRIDGE ISLAND AND AMERICA ROCK

"Because greater depths are required in Courtenay Bay for navigation, the question arose as to how much the annual dredging would be increased to maintain these greater depths. To maintain the depth at 20 feet, an average of 1.8 to 2.0 feet of silt must be removed annually. An earlier attempt to maintain a depth of 32 feet resulted in the deposition of an average depth of 5.2 feet annually. This agrees with the theory established by Lervi, Goutscharow and Niebuhr - that the amount of sandy silt transported depends approximately on the second to third power of the bed velocities. The bed velocities in the channel changed from approximately 1.0 to 0.75 ft/sec and in the Bay from 0.6 to 0.4 ft/sec. as a result of the causeway construction. The transporting forces in both cases were reduced by 60 to 70 percent of the initial value, consequently siltation increased 2 to 3 times.

"Siltation in Courtenay Bay can be reduced only by increasing the bed velocities. This can be achieved mainly by restricting the flow section of the channel. A wharf from America Rock along the navigation lane and spur dykes from Courtenay Bay breakwater would probably increase the current in the channel sufficiently to maintain a 30 foot depth at low water without dredging (Figure 19). No solution can be offered for the still-water area of the Bay."

Proposals Based on Changes in the Hydraulic Environment of the Estuary

"Engineers engaged in solving shoaling problems in estuaries are keenly aware that the mixing of fresh and salt water is the major factor in causing shoaling in an estuary.

Schultz and Simmons (1957) state that if the basic cause of shoaling is density currents, then the only real solution to shoaling problems is to prevent the upland discharge from entering the estuary by diverting it to the sea by some other route. The following proposal is based on this conclusion.

"Abolishing the density difference would change the harbour and adjacent area from an estuary into a bay having no density current.

"The most satisfactory solution would be to close the river at the Reversing Falls and divert it to the sea by a channel from South Bay to Manawoganish Cove, 7 miles west of Saint John (Figure 20). This would abolish the inward density current and would generally reduce tidal currents, since only the Bay and not the river system would be subjected to tidal variation. The sand supply from the Bay of Fundy would be reduced and the colloidal material would be excluded entirely. This would only be a partial solution as long as there was no breakwater to protect the Bay from the sand which would still be carried in by fall and winter storms. A breakwater between Red Head and Partridge Island would give this protection and provide a harbour area of 3.6 square miles. A marine dredging plant may be required to clear littoral drift from the entrance.

"A power plant could be installed in the diversion channel, operating as either a continuous-load or a peak-load station. With a storage area of 260 square miles in the lake-like river system a yearly output of 384 million kilowatt hours appears practicable. A deep-sea harbour and low-cost electricity supplied by the diversion scheme, would evidently be advantageous."

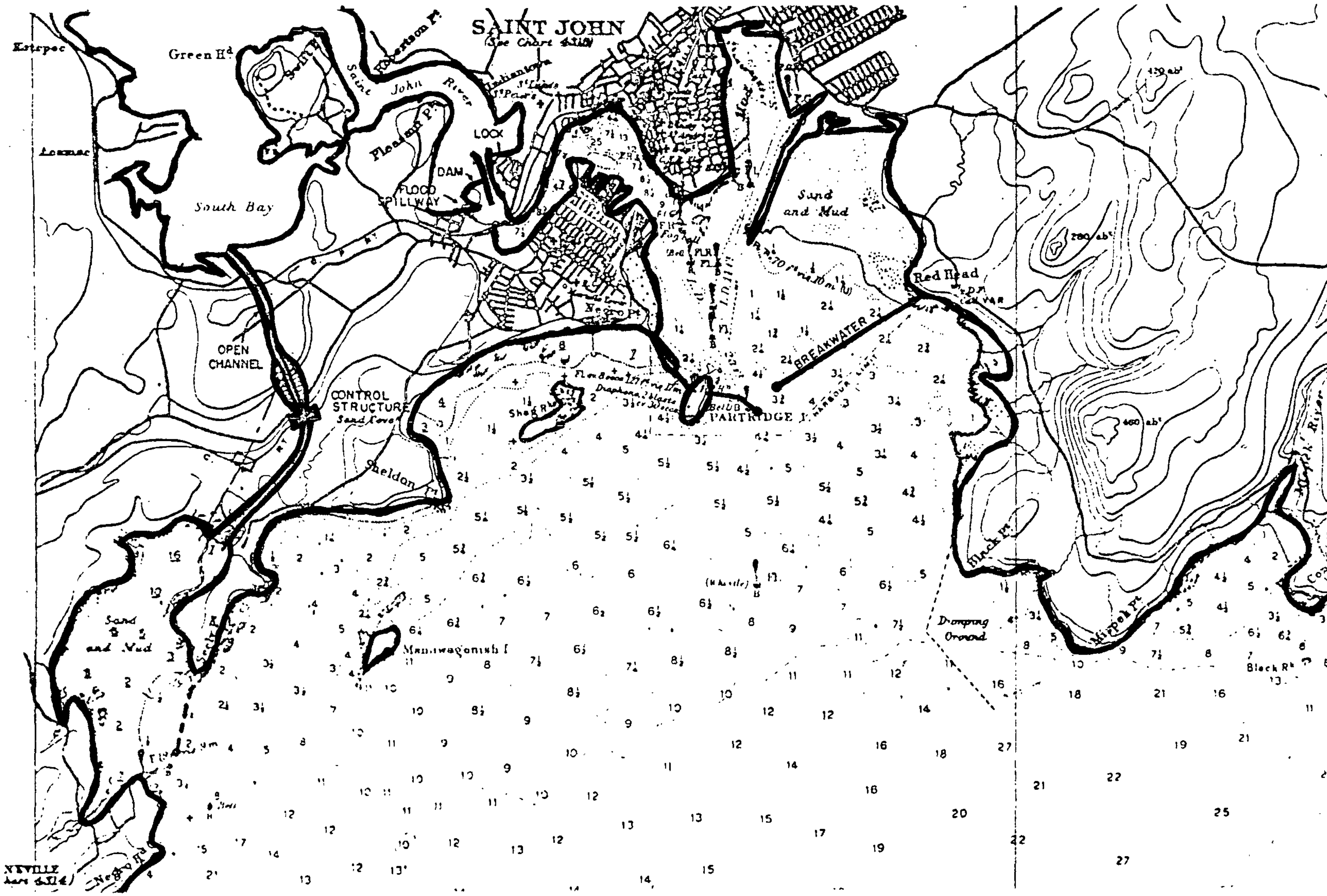

FIGURE 20 PROPOSAL FOR DIVERTING THE SAINT JOHN RIVER

5 IDENTIFIED INFORMATION GAPS

It has become obvious that we lack essential information on source-effect relationships between man's activities in Saint John Harbour and the observed effects. The following points identify the additional information we require to resolve the questions still unanswered about the environmental quality of the harbour.

1. That a comprehensive study be initiated to examine the overall impact of industrial effluents from Saint John on the biota of the surrounding area.

2. That although the major industries have just recently improved their effluent quality enough to meet most of their respective regulations, an attempt should be made to assess the impacts they have had on the surrounding area and to monitor and evaluate the environmental effect of the improved effluent quality.

3. That the discharge of raw municipal sewage be monitored, and regulations to control these discharges be developed in relation to effects on the fishery or man's use of them.

4. To resolve the question of whether pollution and/or ocean dumping play a significant role in the degradation of the Saint John estuary.

5. To obtain information in the form of scientific evidence to determine whether the decline in the fisheries is related to the increased industrial and dredging activity in the harbour.

6. To examine the possibility of interference with the salmon migrations due to increased sediment loading in the water.

7. That the possible benefits or disbenefits from disposal of the dredge spoils in deeper waters be considered, particularly in relation to the lobster fishery.

8. That the accumulation of heavy metals, organohalogens and other toxic chemicals in the food chain be investigated and monitored along with any continued use of the marine disposal of dredge spoils.

9. That consideration be given to land disposal of the dredge spoils but that a full evaluation of the potential effects be given consideration.

10. To make a concerted effort toward improved interlaboratory, geochemical analytical consistency with an emphasis on improved limits of detection in the analyses.

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4443-0994	4886-NB/9

APPENDIX

APPENDIX I SCHEDULE I AND II SUBSTANCES IN THE OCEAN DUMPING CONTROL ACT

Schedule I

Prohibited Substances

1) Organohalogen Compounds - that quantity not exceeding 0.01 parts of a concentration shown to be toxic to marine, animal and plant sensitive organisms in a bioassay sample and test carried out in accordance with procedures established or approved by the Minister.

2) Mercury and Mercury Compounds - in a solid phase of a waste, 0.75 mg/kg; and in the liquid phase of a waste, 1.5 mg/kg.

3) Cadmium and Cadmium Compounds - in a solid phase of a waste, 0.6 mg/kg; and in the liquid phase of a waste, 3.0 mg/kg.

4) Persistent Plastics and Other Persistent Synthetic Materials - four percent by volume, in a suitably comminuted form.

APPENDIX I (Cont'd)

5) Crude Oil, Fuel Oil, Heavy Diesel Oil and Lubricating Oil, Hydraulic Fluids and any Mixtures Containing any of them - any quantity that yields more than 10.0 mg/kg of n-hexane soluble substances.

6) High-level radioactive wastes or other high-level Radioactive matter that may be prescribed.

7) Substances in whatever form produced for biological and chemical warfare.

Schedule II

Restricted Substances

1) Arsenic and its compounds
2) Lead and its compounds
3) Copper and its compounds
4) Zinc and its compounds
5) Organosilicon compounds
6) Cyanides
7) Fluorides
8) Pesticides and their by-products not included in Schedule I
9) Beryllium and its compounds
10) Chromium and its compounds
11) Nickel and its compounds
12) Vanadium and its compounds
13) Container and scrap metal
14) Radioactive wastes or other radioactive matter not included in Schedule I
15) Substances by reason of their bulk would interfere with fishing

APPENDIX II - SAINT JOHN, NEW BRUNSWICK - HISTORICAL DREDGING RECORD

Year	Quantity (cubic yards)		Year	Quantity (cubic yards)	
	Total	Maintenance		Total	Maintenance
1950	588,014	588,014	1966	590,691	553,212
1951	567,750	567,750	1967	562,421	530,704
1952	650,977	650,977	1968	203,108	66,752
1953	225,977	137,415	1969	436,895	436,895
1954	117,564	117,564	1970	334,923	288,859
1955	156,740	156,740	1971	292,486	292,486
1956	597,238	597,238	1972	505,937	505,937
1957	733,869	733,869	1973	967,949	382,461
1958	521,741	521,741	1974	852,853	95,903
1959	1,534,458	1,534,458	1975	94,900	94,900
1960	495,950	495,950	1976	485,931	485,931
1961	1,034,602	791,503	1977	507,269	507,269
1962	852,213	657,604	1978	667,889	504,893
1963	623,678	623,678	1979	792,282	366,712
1964	657,725	657,725	1980	2,323,008(P)	2,323,008
1965	605,000	605,000	1981	654,000(P)	-

(P) Permit Quantity