

**FISHERIES RESOURCES AND FOOD WEB COMPONENTS
OF THE FRASER RIVER ESTUARY AND AN ASSESSMENT
OF THE IMPACTS OF PROPOSED EXPANSION OF THE
VANCOUVER INTERNATIONAL AIRPORT AND OTHER DEVELOPMENTS
ON THESE RESOURCES**

PREPARED BY

DEPARTMENT OF ENVIRONMENT
FISHERIES AND MARINE SERVICE

- Fisheries Operations, Vancouver, B.C.
- Pacific Biological Station, Nanaimo, B.C.
- Pacific Environment Institute, West Vancouver, B.C.

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OF THE FRASER (RIVER) ESTUARY AND AN ASSESSMENT
OF THE IMPACTS OF PROPOSED EXPANSION OF THE
VANCOUVER INTERNATIONAL AIRPORT AND OTHER DEVELOPMENTS
ON THESE RESOURCES**

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FISHERIES AND MARINE SERVICE**

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FEBRUARY, 1975

SECTION I RECOMMENDATIONS

SECTION II A SYNTHESIS OF THE IMPACTS OF PROPOSED EXPANSION
OF THE VANCOUVER INTERNATIONAL AIRPORT AND OTHER
DEVELOPMENTS ON THE FISHERIES RESOURCES OF THE
FRASER RIVER ESTUARY

SECTION III FOOD WEBB COMPONENTS OF THE FRASER RIVER ESTUARY

SECTION IV ECONOMIC AND SOCIAL ASSESSMENT

RECOMMENDATIONS

1. Recommendations

The following recommendations are presented on the basis of existing information concerning the productivity of the Fraser River estuary, its utilization by Pacific salmon, and marine species, the commercial, recreational and preservation values of these resources, and the extent to which past developments have reduced the estuarine zone. They are presented also in full recognition of the critical limitations in our knowledge of the physical and biological factors and interactions which must be clarified before it will be possible to accurately quantify the impact of presently proposed developments on these renewable resources. However, it should be recognized that a loss of estuarine productivity will result from any development in the estuary and that because present knowledge does not permit the replacement of same by compensatory techniques, the losses are irreversible. Accordingly, the following recommendations are dedicated to minimizing the loss or degradation of estuarine habitat.

1.1. Vancouver International Airport Expansion

It is strongly recommended that no development which eliminates or significantly degrades a portion of the intertidal estuarine environment of Sturgeon Bank be permitted.

Further:

1.1.1. The utilization of Sturgeon Bank for the purpose of enlarging or improving the existing Vancouver International Airport facility be confined to the placing of pilings or similar structures to facilitate navigation. The timing and methods of such construction to be subject to conditions prescribed by the Fisheries and Marine Service in concert with other appropriate resource agencies.

1.1.2. That part of Sturgeon Bank located between the mean high water mark and the existing dyke shall remain undeveloped.

1.1.3. In the event that social, economic or other environmental constraints unacceptable to the people of the Lower Mainland British Columbia, and Canada prescribe the construction of an additional runway or ancillary facility, a portion of which occupies the intertidal area of Sturgeon Bank, such construction shall result in the elimination or degradation of not more than 70 acres (M.O.T. Vancouver International Airport Expansion - Concept 1).

Further:

- 1.1.3.1. The construction of this runway, and any ancillary facilities within or adjacent to the estuary shall be subject to conditions prescribed by the Fisheries and Marine Service in concert with other appropriate resource agencies.
- 1.1.3.2. The material required for landfill on estuarine or upland areas shall not originate from any portion of Sturgeon Bank or from the lower Middle Arm of the Fraser River. The location, volume, timing and method of removal of material from any other location in the lower Fraser River and estuary shall be subject to conditions prescribed by the Fisheries and Marine Service in concert with other appropriate resource agencies.
- 1.1.3.3. An assessment of the influence of the proposed intertidal landfill on the dispersal of the present and projected effluent volume originating from the Iona sewerage treatment facility and the probable impact of same on the aquatic productivity of Sturgeon Bank must be undertaken and mitigative measures identified and applied if necessary.

1.2 Ferry Terminal Location

That location of Ferry terminals on Sturgeon Bank be limited to the seaward extremity of the Iona or North Arm jetties. The timing, location of borrow areas, and method of construction shall be subject to conditions prescribed by the Fisheries and Marine Service in concert with other appropriate resource agencies.

1.3 Port Expansion

Provided that the findings of a comprehensive "Pacific Coast Port Requirements Study" identifies expanded port capacity at Roberts Bank as an urgent obligatory component, such expansion shall be limited to not more than 200 acres of land fill. The accreted area shall be placed adjacent to the north-westerly face of the existing bulk loading site, include no separate causeway construction, and a minimum increase in the width of the existing causeway. Details of the confirmation of fill and berth sites must be based on detailed studies of the immediate area. The proposed B.C. Railway barge terminal, involving approximately 45 acres of dredge and fill, should also be located northerly of the existing development.

Further:

1.3.1. The material required for land fill shall be obtained from the area immediately adjacent, northward and seaward of the accreted areas. The timing and method of construction shall be subject to conditions prescribed by the Fisheries and Marine Service in concert with other resource agencies.

In the event that the volume of material resulting from the dredging required to accommodate berths and access channels exceeds that necessary to provide the proposed land fill areas, the excess dredgeate shall be disposed at a marine or landfill site approved by the Fisheries and Marine Service in concert with other appropriate resource agencies.

1.3.2. Pollution abatement facilities and operational procedures shall be such that the activities associated with the expanded Roberts Bank port complex shall prevent the introduction of deleterious substances into the aquatic environment.

1.4. Future Developments

No further development on or adjacent to the estuary should be undertaken until further intensive studies clarify the impact of existing and current developments and demonstrate the feasibility of providing compensation for losses of estuarine habitat.

A SYNTHESIS OF THE IMPACTS OF PROPOSED
EXPANSION OF THE VANCOUVER INTERNATIONAL AIRPORT
AND OTHER DEVELOPMENTS ON THE FISHERIES RESOURCES
OF THE FRASER RIVER ESTUARY

VOLUME I OF II

FEBRUARY, 1975

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Department of Environment
Vancouver, B. C.

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1. Introduction

Development in the British Columbia coastal zone including estuaries has, in the past been relatively unrestricted. Recent scientific and public concern for the biological, recreational, aesthetic and other associated values of these areas has initiated increasing controversy with respect to shoreline developments which border or infringe upon these unique habitats. Biological impact assessment studies of large scale port development proposals in the estuaries of the Squamish, Nanaimo and Cowichan River estuaries and a marina proposal in the Campbell River estuary have shown that these areas are important rearing and feeding areas for juvenile chinook, chum and coho salmon. These studies indicated that a large proportion of the food utilized by juvenile salmon during their occupation of the estuarine zone was comprised of benthic organisms which inhabit the vegetated and mud-flat portions of the estuary.

This report presents the data obtained from a sampling program carried out during the spring and summer of 1973 and the spring of 1974. It constitutes the Fisheries component of an ecological impact assessment undertaken by the Department of Environment in response to a proposal by the Ministry of Transport to expand the Vancouver International Airport onto the Fraser River estuary. The program was designed to determine the relative distribution of juvenile fishes, the timing and duration of residency and their utilization of various food sources in the Fraser River estuary including Sturgeon and Roberts Bank and the North, South and Middle Arms of the river. Data with respect to species other than juvenile salmon and herring are limited to a species list. This information in combination with data from studies of the intertidal benthic communities (Section III, this volume) has formed the basis of recommendations pertaining to proposed expansion of the Vancouver International Airport. The scope of these studies has also permitted the development of recommendations respecting proposals for expansion of port facilities at Roberts Bank and construction of a ferry terminal at the seaward extremity of the Iona, North Arm or Steveston Jetties. It is anticipated that the data base will also be useful in assessing the impact of other developments in the estuary on the fishery resource. There have been many incursions on the estuary of the Fraser River over time however, very little baseline data that would place the river and estuary resources in perspective and before/after data with respect to impacts of these incursions that could serve as a model for predicting impacts of proposed development are lacking.

A review of pertinent literature and an identification of knowledge gaps with respect to fish utilization of the estuary are also provided.

2. Description of the Watershed and Delta

Rising on the western slopes of the Rocky Mountains the Fraser River drains a 90,000 square mile basin which occupies a major portion of the southern half of British Columbia (Figure 1). From its origin, the river flows northwesterly through the Rocky Mountain Trench, skirts the northern tip of the Columbia Mountains and cuts southward across the Interior Plateau before turning westward past the southern end of the Coast Mountains to enter the Strait of Georgia near Vancouver. The following watershed description is taken from a report by the Fraser River Board (1963) except as otherwise referenced.

2.1. Drainage

From the east, the Quesnel and Thompson Rivers, two of the major tributaries, drain the Columbia Mountains to join the Fraser River at central and southern points in the Interior Plateau. The Coast Mountains contribute runoff by way of the Nechako River system in the northwest, the Chilcotin River midway in the Fraser River basin, and through the Harrison and Pitt Rivers at the southern end of the range. In the north, the Stuart River, which forms part of the Nechako River system drains the northern portion of the Interior Plateau, while the McGregor River, flowing from the western slopes of the Rocky Mountains, supplements the Fraser River east of Prince George.

The Fraser River system has numerous lakes. The largest of these are the Stuart, Takla, Trembleur, Nechako Reservoir, Francois, Quesnel, Chilko, Shuswap, Adams, and the Harrison which range in surface area from 45 square miles (Trembleur) to 325 square miles (Nechako Reservoir). The total lake surface area in the Fraser River system of lakes greater than 3 square miles is 1,558 square miles.

From Hope to the mouth, the natural river channel has an average width of 2,000 feet. During freshet, the river channel width expands to more than 3 miles in some areas. Over the 90-mile distance between Hope and the Strait of Georgia, the river falls approximately 125 feet, of which 100 feet occur in the first 43 miles.

2.2. Weather

The extremes of temperatures in the basin, resulting from hot and cold continental air masses which move into the region, are moderated by the maritime air which crosses the Coast Mountains from the Pacific Ocean. Precipitation from this source averages 65 percent rain and 35 percent snow. At higher elevations, however, snow predominates, and it is this snowpack which, under the action of rising temperatures, forms the major source of the annual flood runoff.

2.3. Flow

Data on flood flows at Hope date back to 1912 and include the disastrous flood of 1948, when a peak flow of 536,000 c.f.s. occurred, the highest recorded at that point on the river. Downstream at Mission, records extending back to 1876 show the maximum stage to have occurred in 1894, when a flood, now estimated to have exceeded a peak of 600,000 c.f.s., inundated the Lower Fraser Valley. The third highest flood level at Mission was in 1950, at which time the peak flow at Hope reached 440,000 c.f.s. The average annual discharge at Hope is 95,000 c.f.s. Minimum flow recorded on January 8, 1916 was 12,000 c.f.s. During freshet periods, the river water has a high turbidity and a high suspended solid load (up to 389 mg/l) (Northcote 1974). At New Westminster, the Fraser River trifurcates into the North Arm, Annacis Channel and the South or Main Arm. (Figure 2). Annacis Channel, which draws approximately 8% of incoming river flow, re-enters the South Arm about 3 miles downstream at the end of Annacis Island. The North Arm, which draws approximately 12% of the incoming flow and enters the Strait of Georgia at Point Grey has a branch, the Middle Arm, which enters the Strait on Sturgeon Bank between Sea and Lulu Islands. The Middle Arm draws off about 50% of the North Arm flow. The Main Arm, which draws off approximately 80% of the flow at New Westminster, enters the Strait of Georgia at Steveston. Part of this flow, however, is diverted through Ladner Reach which bifurcates into Sea Reach and Canoe Pass. Sea Reach diverts approximately half of the Ladner Reach flow back into the main channel. Canoe Pass, south of Westham Island, serves as the southernmost exit for Fraser River flow (approximately 5% of the total river flows). Luternauer (1974) reports that approximately 20,000,000 tons of sediment is annually dis-

FIG. 2
FRASER RIVER:
NEW WESTMINSTER TO THE BANKS

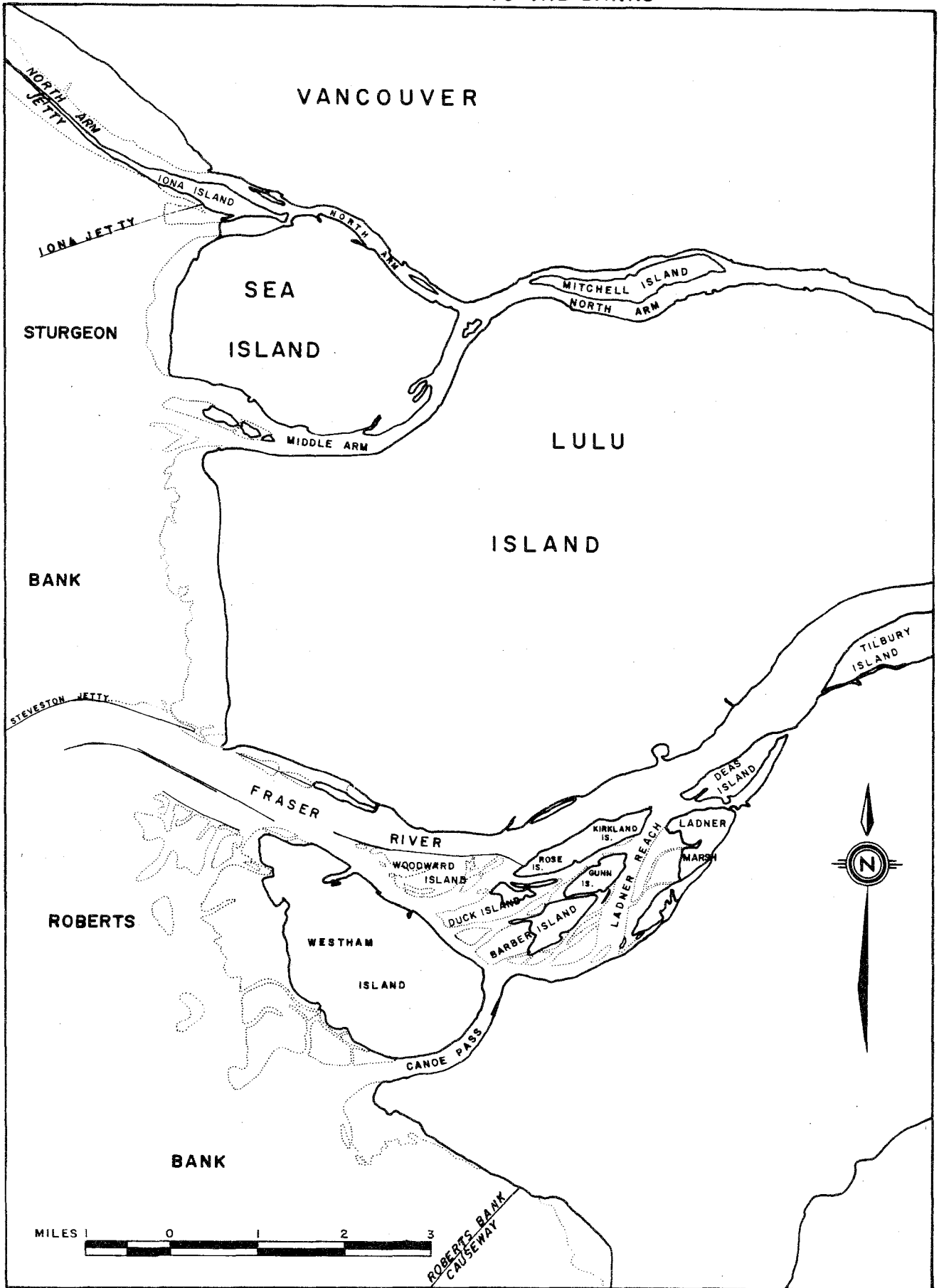


FIG. 2 (CONT'D)

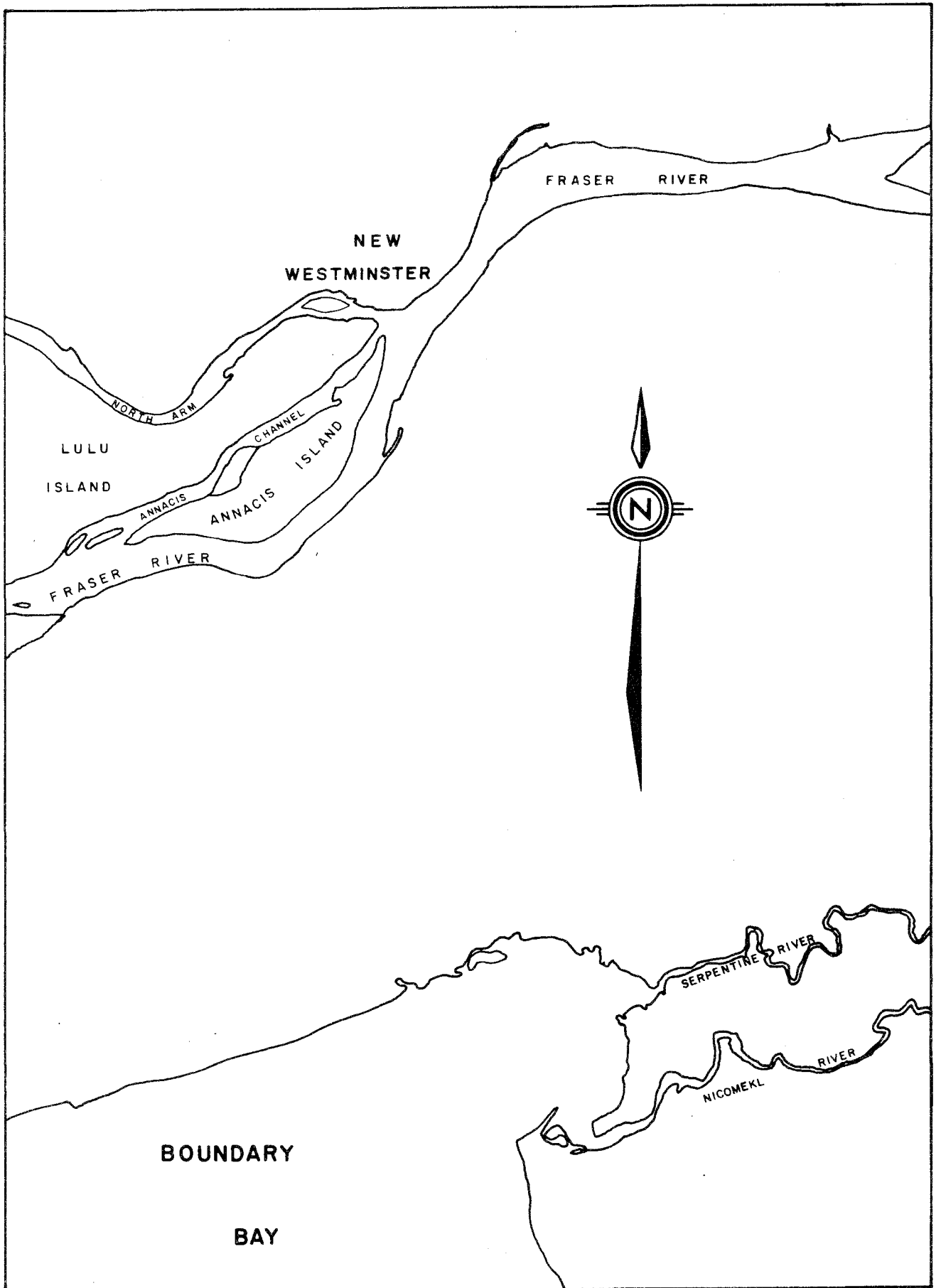
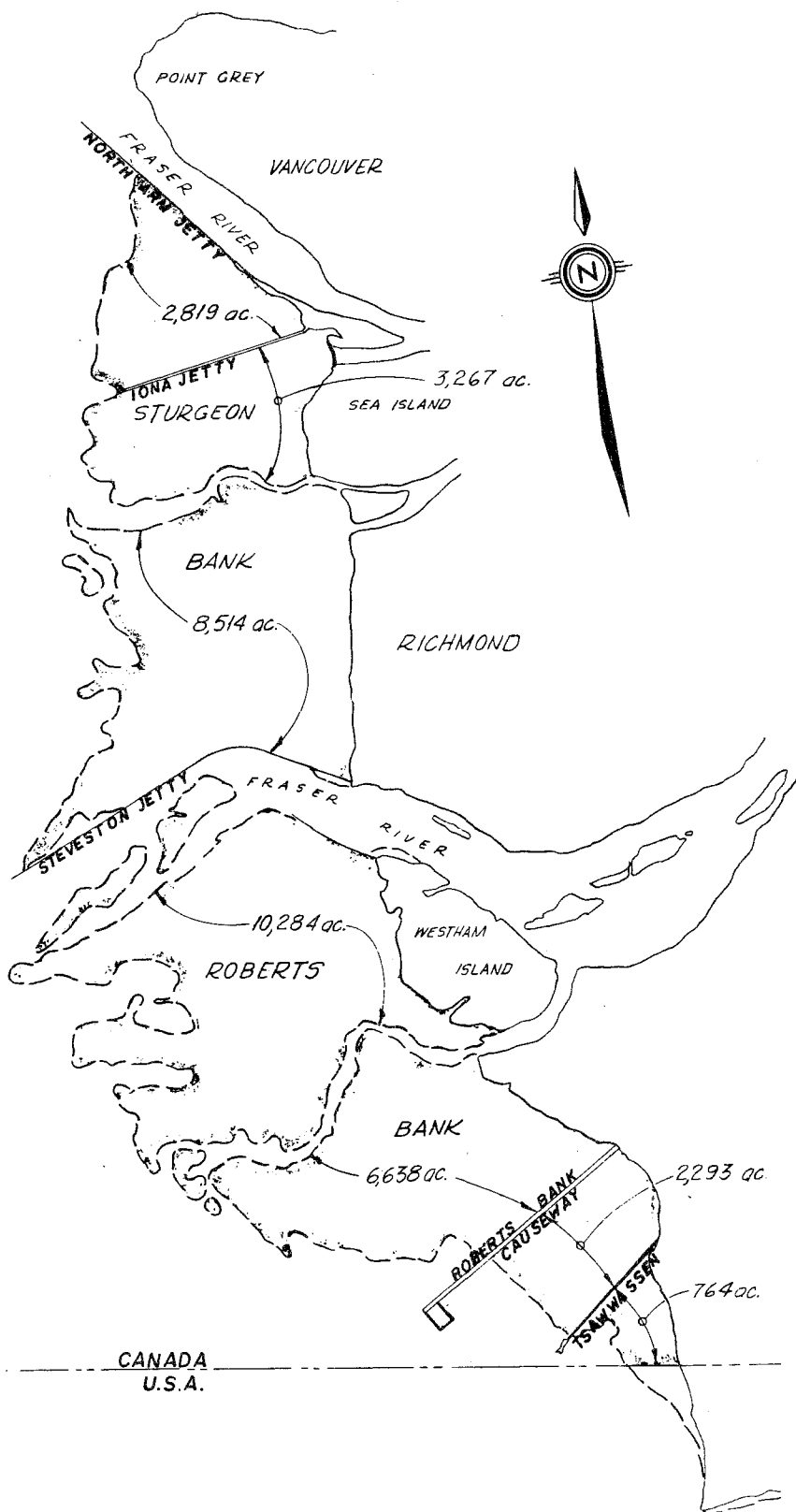


FIG. 3
THE BANKS:
FORESHORE ACREAGES



(ADAPTED FROM INLAND WATERS DIRECTORATE DRAWING # 411-000-D9)

charged past Port Mann (about 3 miles upstream of New Westminster).

2.4. Tidal Flats

Tidal intrusion of salt water is most pronounced during low discharge periods with minor tidal effects evident as far upstream as Chilliwack some 60 miles upstream. The tidal flats, associated with the delta of the Fraser River, extend from Point Grey south, then southeast, and to Point Roberts to include Sturgeon Bank and Roberts Bank. Together, these areas comprise approximately 35,000 intertidal acres (Figure 3).

Sturgeon Bank, consisting of approximately 14,600 intertidal acres, is bounded on the south by the Steveston Jetty (completed in 1932) and on the north by the North Arm Jetty (1935). Between them are the Iona Island Causeway and Sewage Outfall Channel (1961) and the Airport Antennae Causeway (early 1960's). In addition, McDonald Slough was closed at the time of the construction of the Iona Island Sewage plant in 1961. Structures on Roberts Bank (20,000 intertidal acres) include the Tsawwassen causeway and ferry terminal (1960) and the 55 acre Westshore Terminals site (1970) at the end of a 3 mile long causeway. The Tsawwassen ferry terminal, originally completed in 1960, consisted of a fill area of 13.3 acres and concomitant dredging of 450,000 cubic yards. Additions between 1969 and 1974 have resulted in the dredging of approximately 1.2 million cubic yards and a fill area (top area - not including side slopes) of 37.9 acres. The effects of these structures on the distribution of sediments carried by the Fraser River is summarized by Luternauer (1974).

2.5. Alienation of Habitat Types

Dyking for flood control and land reclamation, essentially completed in extent by the turn of the century, has substantially altered the Fraser River delta and estuary. Alienation of former saltmarsh, tidal freshwater marsh and other flooded habitats contributing to productivity of the estuary have been documented by Forrester and Squire (1974). In terms of percentage of former acreage, 71% or 545 acres of saltmarsh, 29% or 1,552 acres of tidal freshwater marsh, and 98.7% or 193 acres of other flooded habitat has been lost. Presently, there are about 43 miles of sea dykes and 29 miles of river

dykes protecting some 46,730 acres of land in the municipalities of Delta and Richmond. (Fraser River Joint Advisory Board, 1963). Harris and Taylor (1972) have summarized the development of these dyking programs, which began after heavy flooding in 1894, as well as agrarian developments in the delta of the Fraser River. In addition to agrarian development and dyking programs, the estuary of the Fraser River has been subject to a variety of developments including dredging, dock construction and bank protection associated with the transportation industry, processing plants and log storage associated with the forest industry, and increasing amounts of industrial and domestic sewage.

3. Development Proposals

3.1. Airport Development

Three expansion concepts have been proposed by the Ministry of Transport to provide for the future development of runways and taxiways as well as space for provision of passenger terminal, cargo, airline operations and related development on Sea Island.

The three concepts are shown on Ministry of Transport Drawings Nos. MVMP-04, MVMP-05, and MVMP-06 as concepts 1, 2 and 3 (Figures 4, 5 and 6). Each concept provides for the construction of a new parallel runway 11,000 feet in length, located 5,700 feet north of the existing runway. Concept 1 shows the new runway constructed primarily on land while concepts 2 and 3 show the runway approximately half on land and half on Sturgeon Bank. While concepts 1 and 2 provide for reclamation on Sturgeon Bank for runway development only, concept 3 provides for reclamation of a portion of the Bank for development of passenger terminals, cargo areas, etc. All development concepts involve the placement of approach lights on pilings or causeway at the end of the runway. Further, it is anticipated that fill material will be required for terminal and other ancillary developments on Sea Island.

3.1.1. Concept 1

This concept requires the reclamation of an area approximately 1,800 feet long and 1,700 feet wide (70 acres). A total of approximately 2 million cubic yards of hydraulic fill will be required for the reclamation and the runway construction on land.

In this concept all future passenger terminal, cargo, airline operations and related development would have to be accommodated within the present boundaries of Sea Island.

3.1.2. Concept 2

To provide for the construction of the new runway will require the reclamation of an area approximately 6,000 feet long and 1,700 feet wide (235 acres). Approximately 4 million cubic yards of hydraulic fill will be required in the reclamation and runway construction. As with Concept 1, all future related development would be accommodated within the confines of Sea Island.

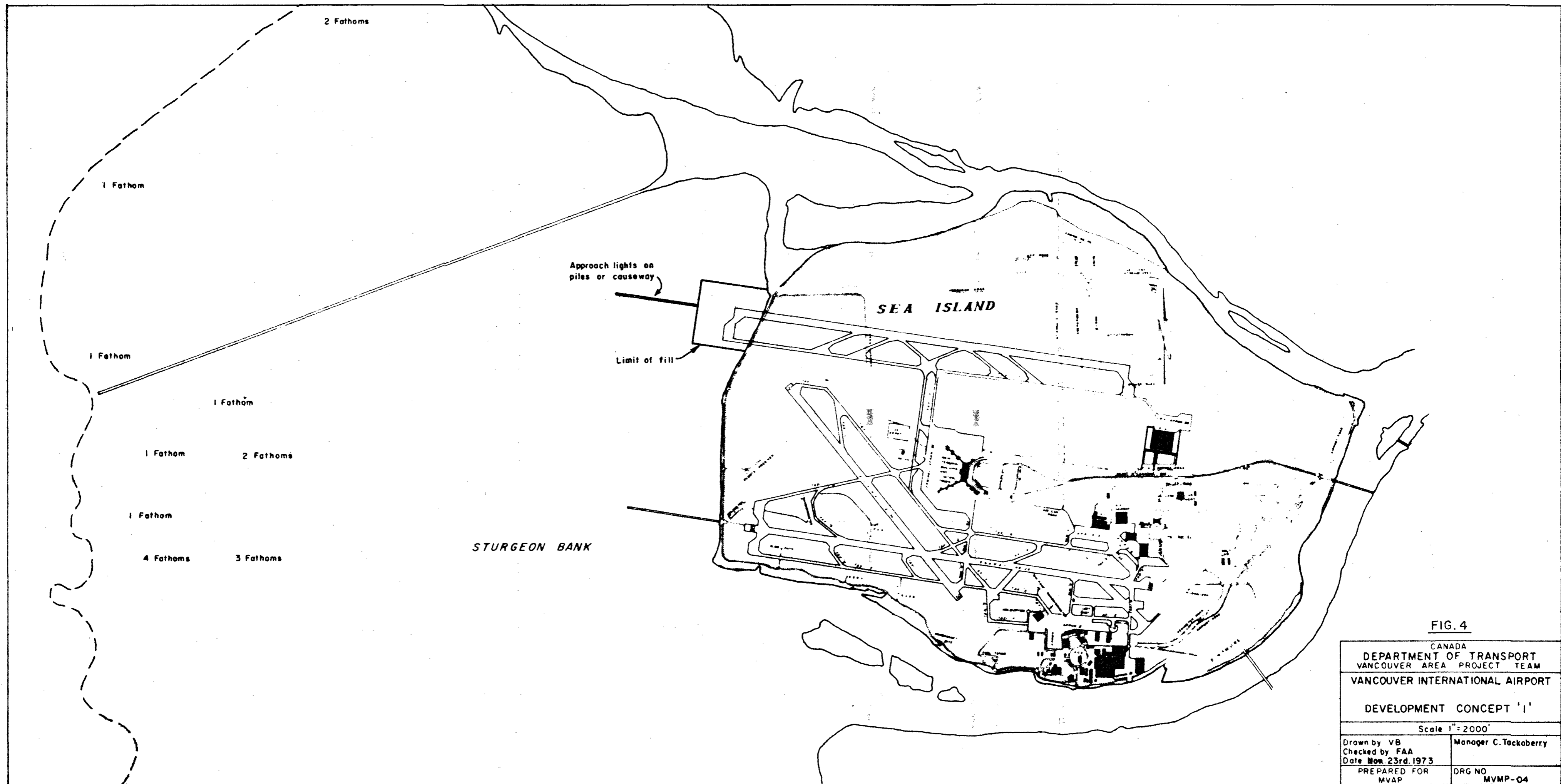


FIG. 4

CANADA DEPARTMENT OF TRANSPORT VANCOUVER AREA PROJECT TEAM	
VANCOUVER INTERNATIONAL AIRPORT	
DEVELOPMENT CONCEPT 'I'	
Scale 1" = 2000'	
Drawn by VB Checked by FAA Date Nov. 23rd. 1973	Manager C. Tackoberry
PREPARED FOR MVAP	DRG NO MVMP-04

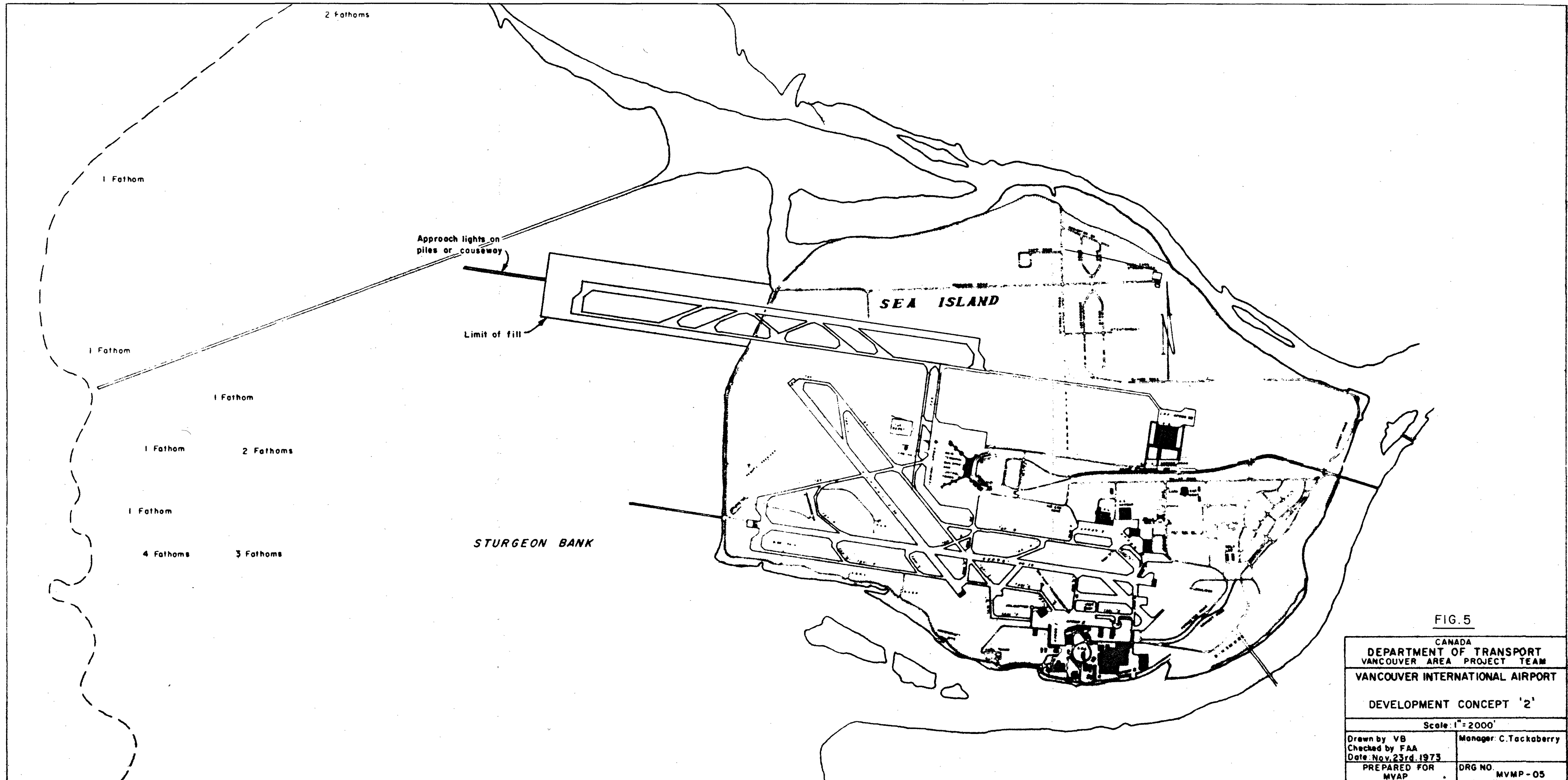


FIG. 5

CANADA DEPARTMENT OF TRANSPORT VANCOUVER AREA PROJECT TEAM	
VANCOUVER INTERNATIONAL AIRPORT	
DEVELOPMENT CONCEPT '2'	
Scale: 1" = 2000'	
Drawn by VB Checked by FAA Date: Nov. 23rd, 1973	Manager: C. Tackaberry
PREPARED FOR MVAP	DRG NO. MVMP-05

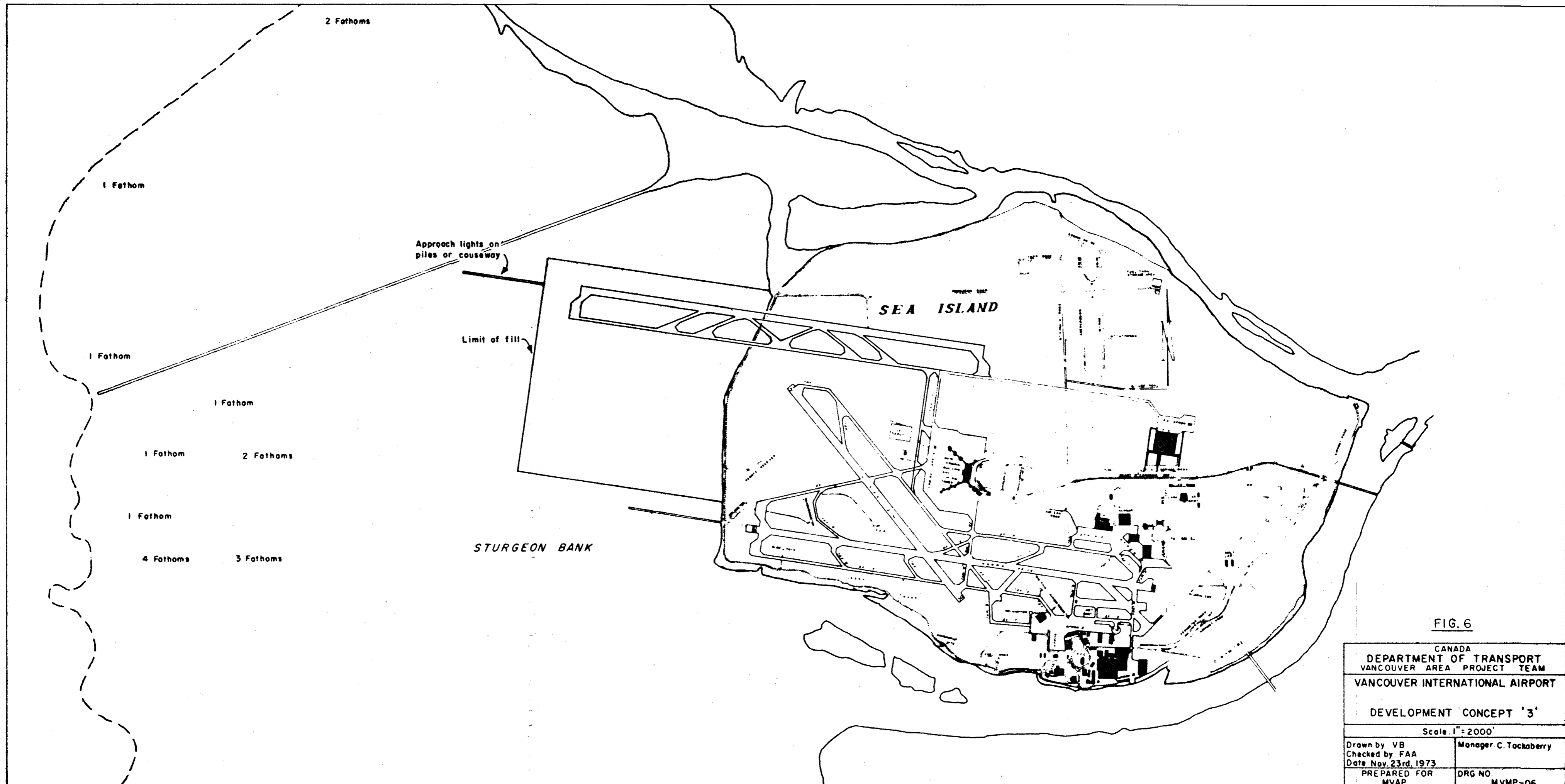


FIG. 6

CANADA DEPARTMENT OF TRANSPORT VANCOUVER AREA PROJECT TEAM	
VANCOUVER INTERNATIONAL AIRPORT	
DEVELOPMENT CONCEPT '3'	
Scale: 1" = 2000'	
Drawn by VB Checked by FAA Date Nov. 23rd. 1973	Manager: C. Tockberry
PREPARED FOR MVAP	DRG NO. MVP-06

3.1.3. Concept 3

This concept requires the reclamation of an area up to about 6,000 feet in length and 5,800 feet wide (755 acres). Approximately 15 million cubic yards of hydraulic fill would be required for reclamation and runway construction. The land being reclaimed additional to that of Concept 2 would be for future terminal, cargo, related development.

However, the total area shown would not be reclaimed immediately. Initially only an area equivalent to Concept 2 would be reclaimed for runway construction. The remaining area, if required, would not likely be reclaimed until the 1990's at the earliest.

3.1.4. Potential Borrow Locations

Potential borrow locations for proposed reclamation have been identified on Department of Transport Drawing MVMP-014 (Figure 7) and are located as follows:-

Phase I	740,000 yards ³)	
Phase III	1,200,000 yards ³)	North Arm
Phase VI	6,000,000 yards ³)	Fraser River
Phase VII	2,100,000 yards ³)	
Phase VIII	700,000 yards ³)	
Phase IV	34,000,000 yards ³	Sturgeon Bank
Phase V	1,500,000 yards ³	Middle Arm Fraser River

3.2. Ferry Terminals

The Government of the Province of British Columbia has proposed a new mainland terminal for the B.C. Ferries Route which links central Vancouver Island to the Lower Mainland. Initially development would include two berths and 30 acres of terminal area with future expansion to 6 berths and addition of land for a truck trailer holding compound. Alternate sites are shown on Swan Wooster Drawing D2947-00-002 (Figure 8) and discussed in a Department of Highways Feasibility Study (Swan Wooster Engineering Company 1973). These sites include a North Arm site, an Iona site, a Middle Arm site and a Steveston site. At all sites,

REV.	DATE	DESCRIPTION	BY
1	1-1-74	Phase I, II, III, IV, V, VI, VII, VIII added	VB
2	3-1-74	Phase I, II, III, IV, V, VI, VII, VIII deleted Phase I, II, III, IV, V, VI, VII, VIII added Phase I, II, III, IV, V, VI, VII, VIII added	VB
3	3-1-74	Phase I borrow regulated Limit of potential Reclamation deleted	VB

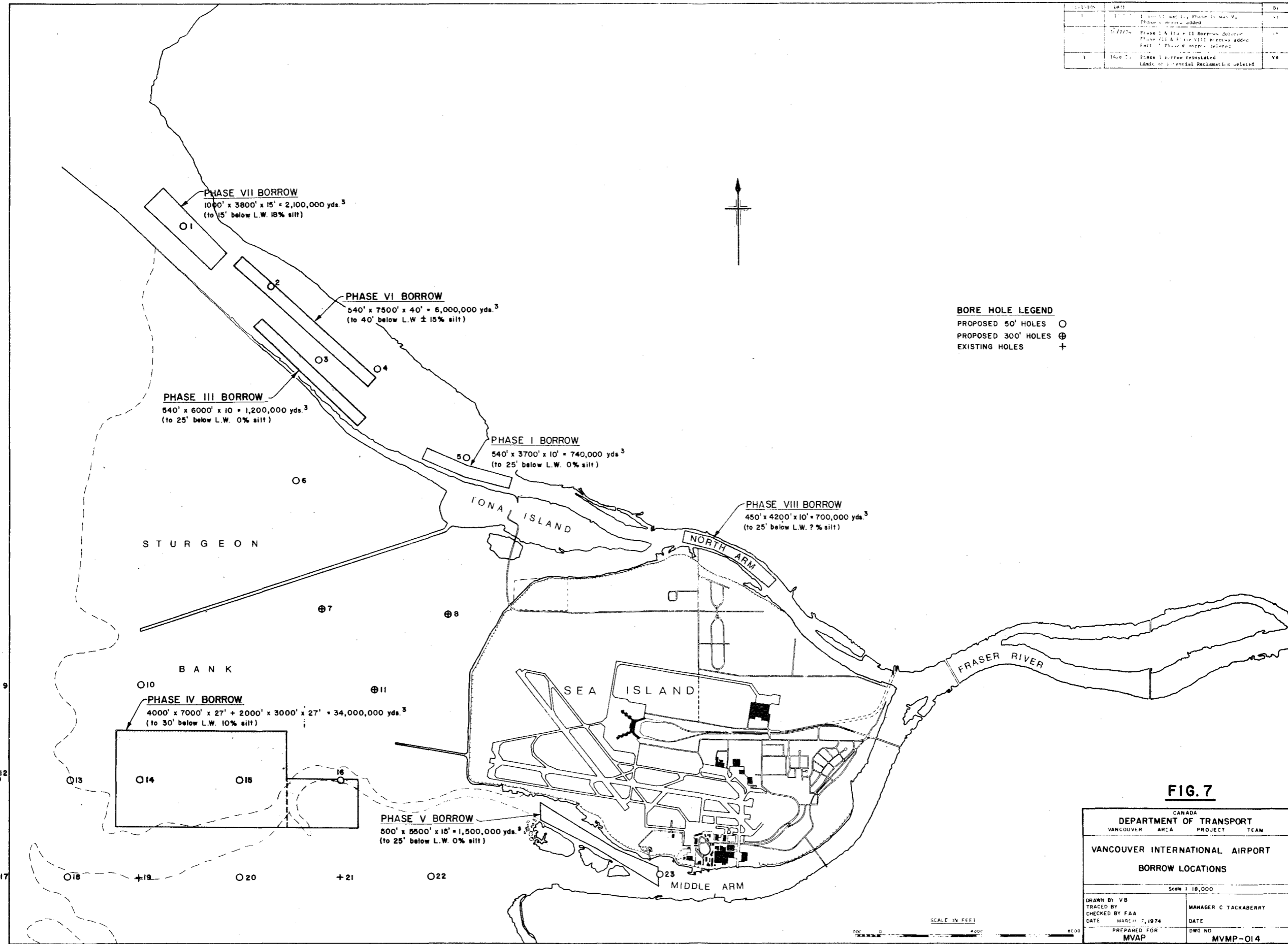


FIG. 7

CANADA DEPARTMENT OF TRANSPORT	
VANCOUVER	ARCA PROJECT TEAM
VANCOUVER INTERNATIONAL AIRPORT BORROW LOCATIONS	
Scale 1/18,000	
DRAWN BY VB TRACED BY FAA DATE MARCH 7, 1974 PREPARED FOR MVAP	MANAGER C TACKABERRY DATE DWG NO MVMP-014

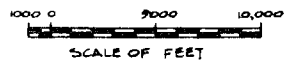
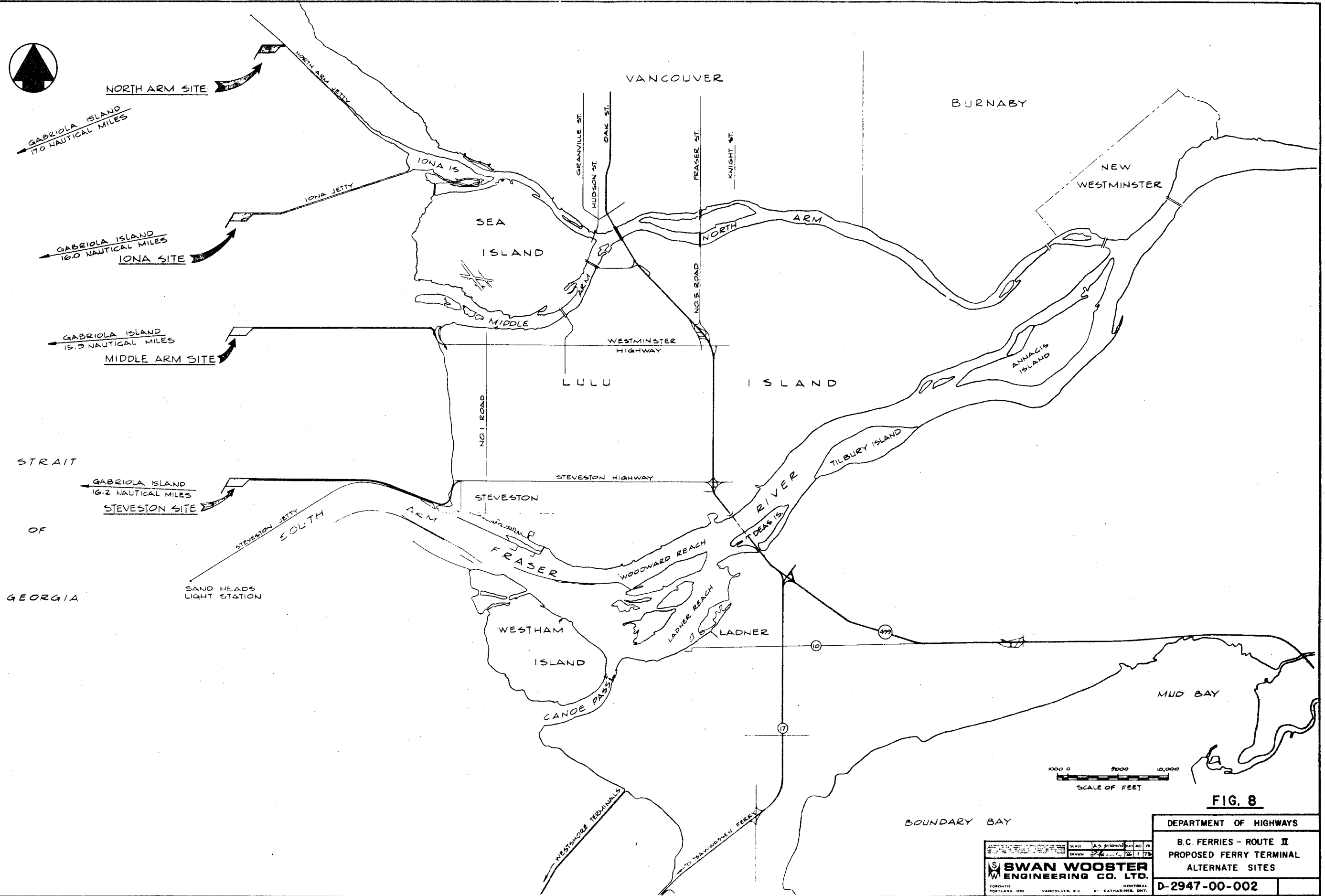


FIG. 8

DEPARTMENT OF HIGHWAYS

B.C. FERRIES - ROUTE II
PROPOSED FERRY TERMINAL
ALTERNATE SITES

D-2947-00-002

		SCALE	A-2	DATE	NO	78
SWAN WOOSTER ENGINEERING CO. LTD.		DRAWN	2/26	DATE	2/26	78
TORONTO	PORTLAND, ORE.	VANCOUVER, B.C.	MONTREAL	ST. CATHARINES, ONT.		

the causeway would have a top width of 72 feet with relatively flat sand slopes of 20 horizontal to 1 vertical in the lower intertidal zone. Development of all sites including the causeway involves approximately 200 acres of fill.

3.2.1. Steveston

The terminal would consist of a causeway approximately 24,000 feet long and an initial 30 acre terminal site located at the delta front. Construction would involve a causeway to a low bridge spanning the "Hole in the Wall" and a 2,000 feet long trestle section located west of the "Hole in the Wall" to allow a portion of the flow of fresh water which overtops the Steveston Jetty to circulate through the causeway and onto the Sturgeon Bank tidelands (Swan Wooster Drawing No. D-2947-00-005) (Figure 9). An estimated 6.9 million cubic yards of dredging would be required for development at the Steveston site.

3.2.2. Middle Arm

Development consists of a sand fill causeway approximately 20,000 feet long with a top width of 72 feet and an initial 30 acre sand fill terminal site (Swan Wooster Drawing No. D-2947-00-006) (Figure 10). An estimated 7.2 million cubic yards of dredging would be required for development at the Middle Arm site.

3.2.3. Iona

Development consists of widening the existing jetty on the north side to a top width of 72 feet and extending the causeway 2,700 feet seaward. The causeway and terminal area would consist of hydraulically dredged sand fill with gravel and riprap protection. The proposed terminal, breakwater and roadway are all similar in layout to Steveston site (Swan Wooster Drawing No. D-2947-00-007) (Figure 11). An estimated 4.15 million cubic yards of dredging would be required for development at the Iona site.

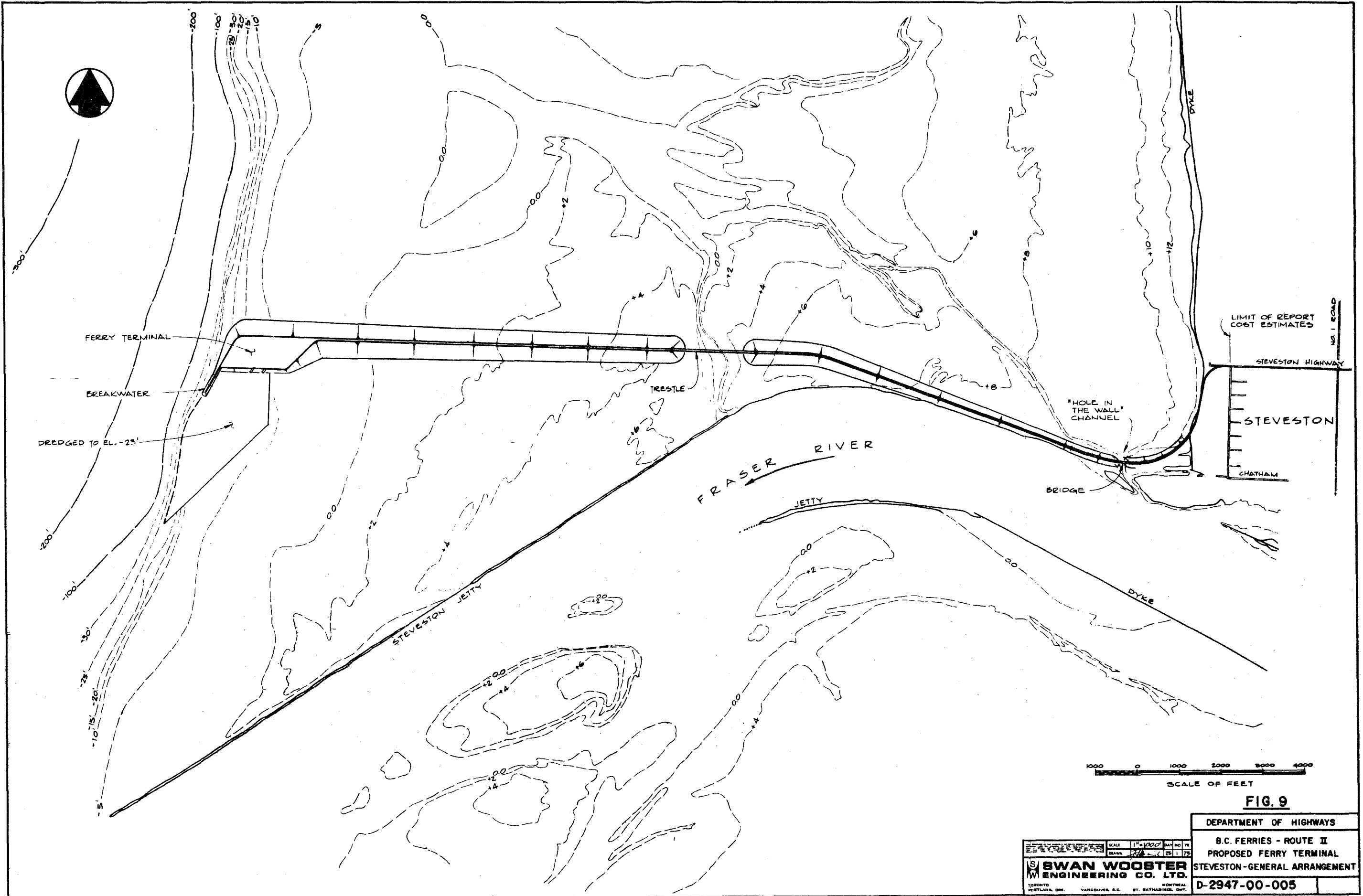


FIG. 9

DEPARTMENT OF HIGHWAYS	
B.C. FERRIES - ROUTE II	
PROPOSED FERRY TERMINAL	
STEVESTON - GENERAL ARRANGEMENT	
D-2947-00-005	

SCALE	1" = 100'	DATE	NO. 1
DRAWN		BY	

SWAN WOOSTER ENGINEERING CO. LTD.
 TORONTO, ONT. VANCOUVER, B.C. MONTREAL, QUE. ST. CATHARINES, ONT.

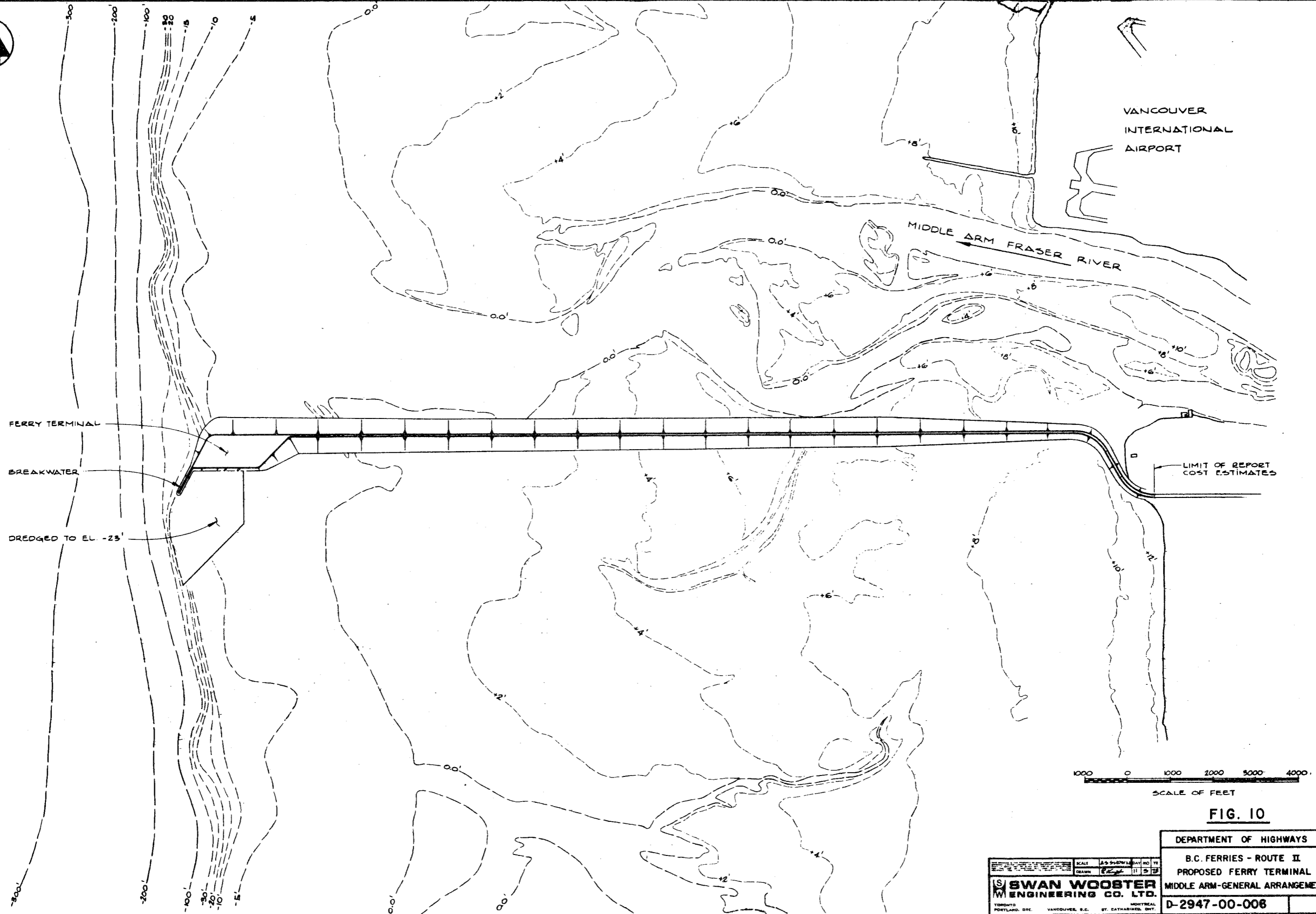
3.2.4. North Arm

Development consists of a 72 foot wide causeway adjacent to the south side of the existing jetty and a terminal area near the offshore end of the jetty. The causeway and the terminal would be constructed of hydraulically dredged sand fill with gravel and riprap protection where required. The top elevation of the existing jetty and sand beaches along the south side of the jetty is already near or above the high water level, so the quantity of sand fill required for other sites (Swan Wooster Drawing No. D-2947-00-008) (Figure 12). An estimated 4.1 million cubic yards of dredging would be required for development at the North Arm site.

3.3. Port Facilities

The National Harbours Board has presented a proposal to proceed with the second stage development at Roberts Bank. This development, south and easterly of the existing site would provide an additional 200 acres comprising four sites of approximately 50 to 55 acres each, suitable for handling coal, sulphur, potash, and any other bulk commodity which may be exported in the future. A channel providing 65 feet depth at low water with potential for a water depth of up to 90 feet, and a turning basin adequate for bulk carriers in the 150,000 DWT range would be dredged (approximately 400 acres). In addition, an area of approximately 200 acres of foreshore would be developed for an industrial park capable of handling vessels of up to 75,000 DWT. The causeway would also be widened to provide for rail and other services.

In addition to the expansion of port facilities, the British Columbia Railway has proposed a rail barge terminal (Figure 13) to be located on the south side of the existing Roberts Bank causeway (Swan Wooster Drawing No. 11323-B15-14). This proposal involves dredging a 2,000 foot diameter turning basin and construction of a 2,400 foot long causeway.



FERRY TERMINAL

BREAKWATER

DREDGED TO EL. -23'

MIDDLE ARM FRASER RIVER

VANCOUVER INTERNATIONAL AIRPORT

LIMIT OF REPORT COST ESTIMATES

1000 0 1000 2000 3000 4000
SCALE OF FEET

FIG. 10

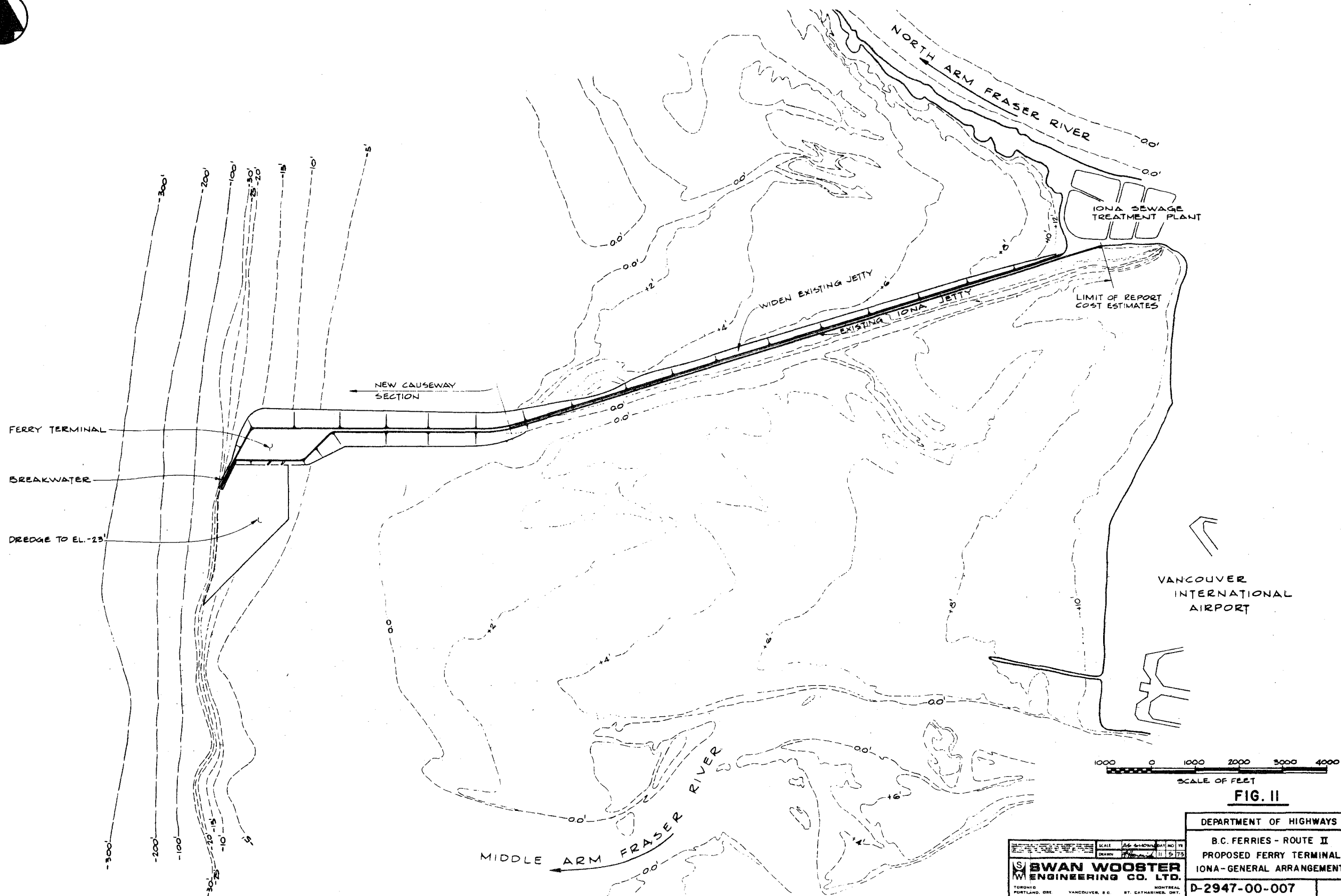
DEPARTMENT OF HIGHWAYS

B.C. FERRIES - ROUTE II

PROPOSED FERRY TERMINAL
MIDDLE ARM-GENERAL ARRANGEMENT

D-2947-00-006

 SWAN WOOSTER ENGINEERING CO. LTD.	SCALE	AS SHOWN	NO. 18
	DRAWN	11	5 17
TORONTO PORTLAND, ORE.		MONTREAL VANCOUVER, B.C. ST. CATHARINES, ONT.	



FERRY TERMINAL

BREAKWATER

DREDGE TO EL. -23'

NEW CAUSEWAY SECTION

WIDEN EXISTING JETTY

EXISTING IONA JETTY

LIMIT OF REPORT COST ESTIMATES

NORTH ARM FRASER RIVER

MIDDLE ARM FRASER RIVER

VANCOUVER INTERNATIONAL AIRPORT

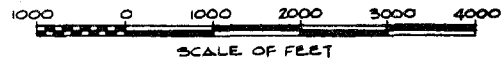


FIG. II

SCALE AS SHOWN
 DRAWN BY [Signature] 11 5 73
BWAN WOOSTER ENGINEERING CO. LTD.
 TORONTO, PORTLAND, ORE. VANCOUVER, B.C. MONTREAL, ST. CATHARINES, ONT.

DEPARTMENT OF HIGHWAYS
 B.C. FERRIES - ROUTE II
 PROPOSED FERRY TERMINAL
 IONA - GENERAL ARRANGEMENT
 D-2947-00-007



STRAIT OF GEORGIA

FERRY TERMINAL
BREAKWATER
DREDGE TO EL. -23'

NORTH ARM JETTY

UNIVERSITY OF
BRITISH COLUMBIA
ENDOWMENT LANDS

NORTH ARM FRASER RIVER

LIMIT OF REPORT
COST ESTIMATES

IONA SEWAGE
TREATMENT PLANT

IONA JETTY

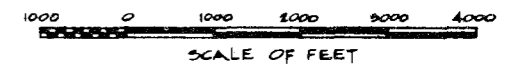


FIG. 12

DEPARTMENT OF HIGHWAYS
B.C. FERRIES - ROUTE II
PROPOSED FERRY TERMINAL
NORTH ARM-GENERAL ARRANGEMENT
D-2947-00-008

SCALE AS SHOWN		DATE NO. 11 5 72
DRAWN 7466		
SWAN WOOSTER ENGINEERING CO. LTD.		
TORONTO PORTLAND, ORE.	VANCOUVER, B.C.	MONTREAL ST. CATHARINES, ONT.

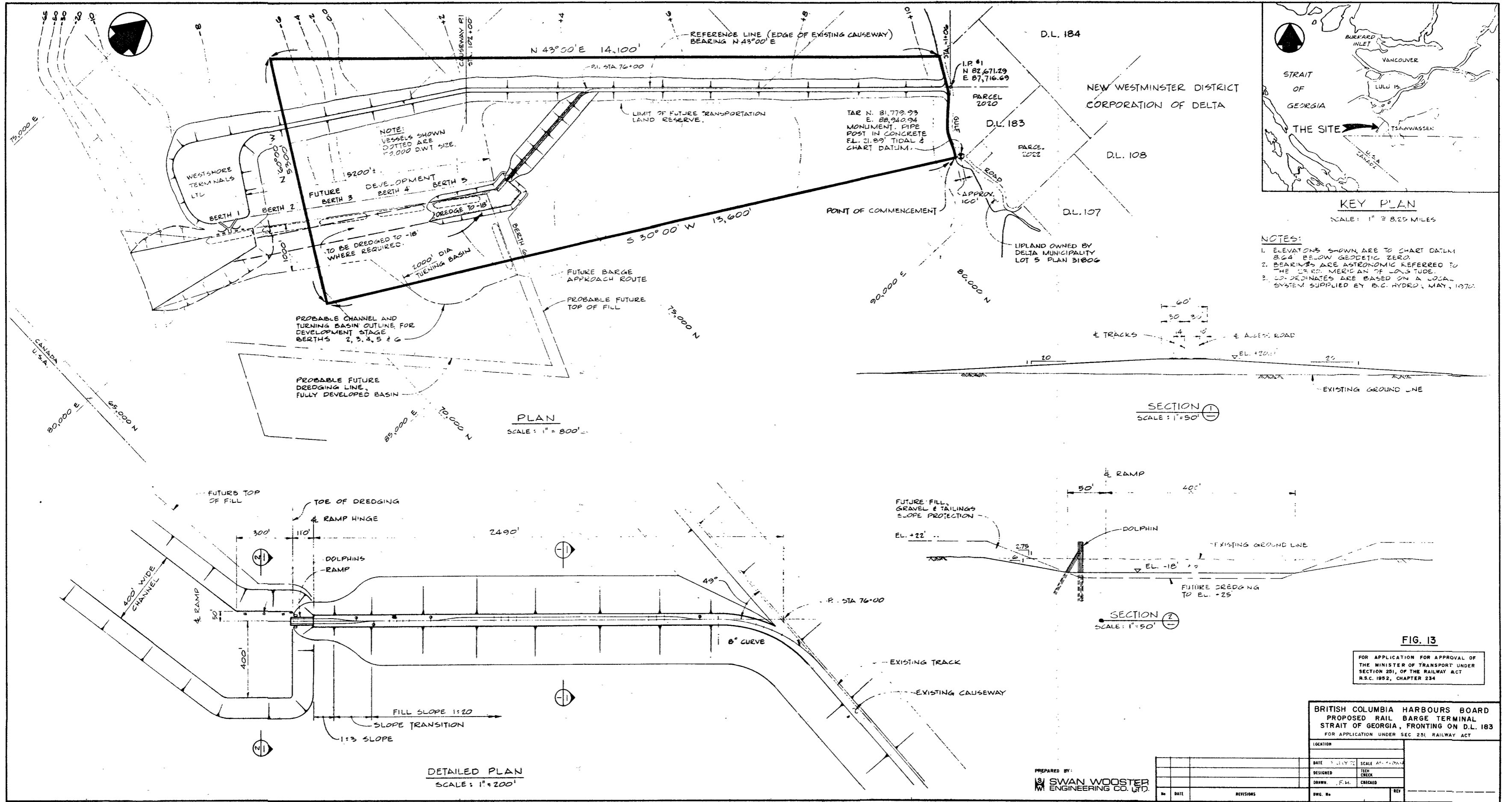


FIG. 13

FOR APPLICATION FOR APPROVAL OF THE MINISTER OF TRANSPORT UNDER SECTION 251, OF THE RAILWAY ACT R.S.C. 1952, CHAPTER 234

BRITISH COLUMBIA HARBOURS BOARD
PROPOSED RAIL BARGE TERMINAL
STRAIT OF GEORGIA, FRONTING ON D.L. 183
FOR APPLICATION UNDER SEC. 251 RAILWAY ACT

PREPARED BY:
SWAN WOOSTER
ENGINEERING CO. LTD.

DATE	SCALE	DESIGNED	TECH. CHECKER
7 JULY 72	AS SHOWN		
DRAWN	CHECKED		

No.	DATE	REVISIONS	ENG. No.	REV.

SUPERSEDES PRINTS PREVIOUS TO

4. Fisheries Resource

4.1. General

The fisheries resources of the Fraser River have recently been reviewed by Northcote (1974). This review lists 38 species that inhabit the lower Fraser system (downstream from Hope), categorizes them as migratory, semi-migratory, and non-migratory, and summarizes some aspects of fish utilization of the lower Fraser. Commercial and recreational utilization of Fraser River salmon and other species including eulachon, surf smelt, cutthroat trout, steelhead trout, white sturgeon, mountain whitefish and dolly varden are also summarized.

4.2. Salmon

Details concerning the life histories, including spawning distribution, spawning and rearing requirements, migration timing, as well as details on present and potential escapements and commercial and recreational catch of Fraser River salmon are outlined by the Department of the Environment, Fisheries Service (1974). The following summary of the life cycle, migration timing, spawning escapements and commercial catch is taken from this report.

In summary, the salmon resources of the Fraser River are estimated to be 9,900,000 fish. Of this total 2,500,000 spawners produce an annual commercial catch of 7,100,000 salmon, a sport catch of 122,000 and an Indian food fishery catch of 170,000 salmon. This salmon resource represents an annual commercial catch valued at \$73 million, and an annual commercial "net" value of \$37 million (1973 prices - Fisheries and Marine Service - Economics Unit). In addition, the salmon of the Fraser River have a total annual recreational value of \$197 million and preservation value of \$106 million (Meyer 1974). Bennett (1973) has reported on the cultural importance of Indian fishing in the Fraser River system. The Department of the Environment, Fisheries Service (1974) has estimated the potential Fraser River salmon resource to be 24,500,000 fish annually. This resource would be comprised of 4,000,000 spawners per year which would produce a catch of 19,800,000, a sport fishery catch of 360,000 and an Indian food fishery catch of 320,000 salmon.

4.2.1. Life Cycle

All five species of Pacific salmon are anadromous; that is, they emerge from eggs spawned in fresh water, migrate as young fish to the sea and upon maturity return to their natal fresh-water stream to spawn. All species follow a similar basic life cycle. There are, however, essential differences with respect to the timing of migration of both adults and young and their environments during variable periods of fresh water residence (Figure 14).

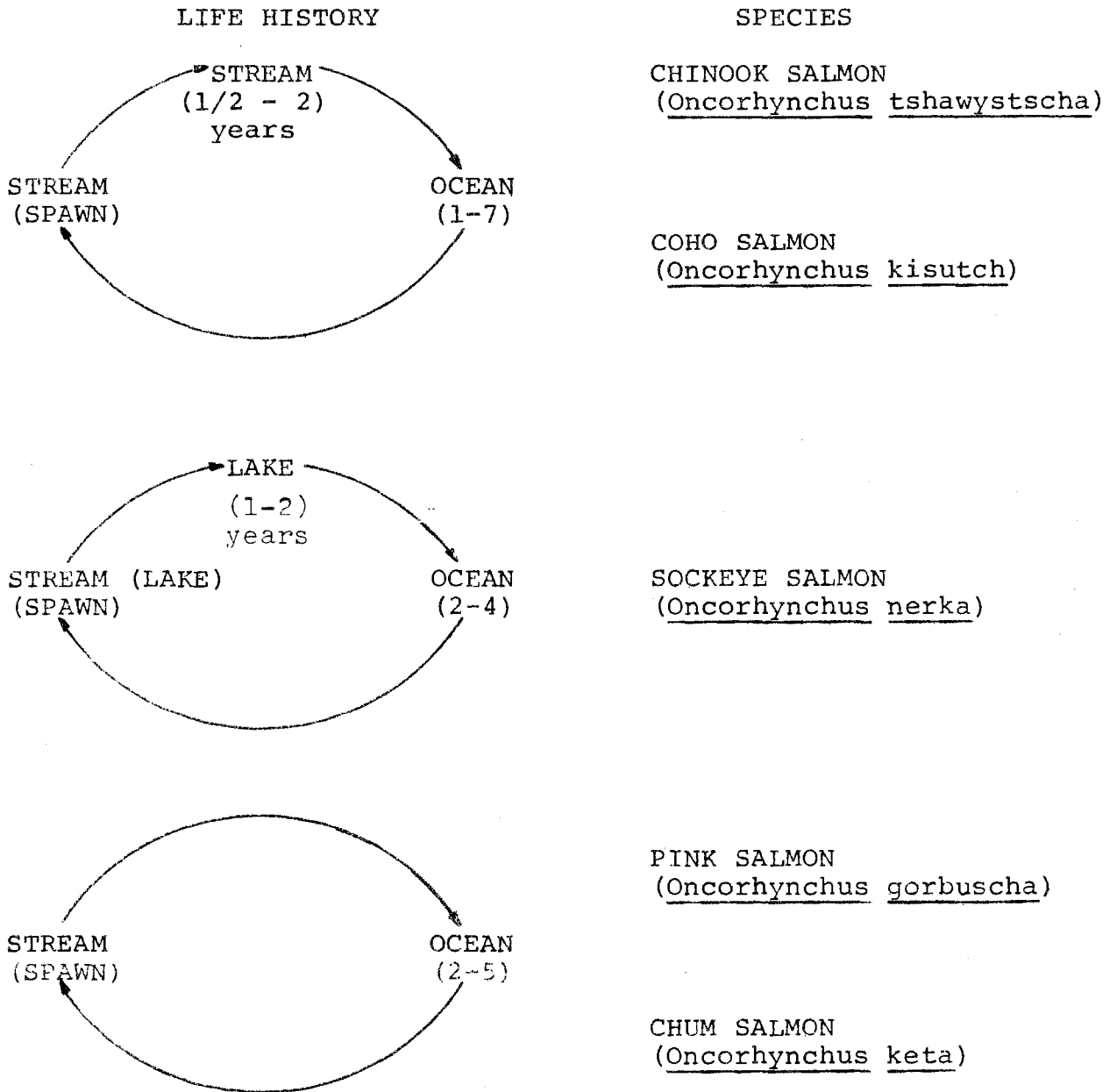
Sockeye generally reach maturity in four years, pink salmon in two years, coho salmon in three to four years, chum salmon in four to five years, and chinook salmon in three to seven years. The adult salmon die soon after spawning.

The varying life cycles and differences in survival rates of each race in any year results in a fluctuation in the total abundance of fish from year to year. Fraser River pink salmon runs are confined almost entirely to the odd-numbered years. Spawning migrations of chum, coho, chinook and sockeye occur each year. The magnitude of annual escapements to the spawning areas depends on the levels of exploitation in commercial and sport fisheries and on environmental influences that have affected survival in fresh water and marine environments. Sockeye exhibit a dominant year cyclic phenomenon which results in large returns every fourth year. Dominant runs occur in the Adams River on the 1970-74 cycle, in the Chilko River on the 1968-72 cycle, and in the Stuart and Quesnel Rivers on the 1969-73 cycle.

The timing of the adult salmon migrations varies with the species and with each race within the species. It is related to the length of their migration route and the environmental characteristics of their spawning areas. With some exceptions, fish with the longest migration path are the first to migrate. Spawning migrations commence in the early spring, reach a peak in the summer and fall, and conclude in the early winter.

Figure 14

Diagrammatic Life Cycles of Fraser River Pacific Salmon from Department of the Environment, Fisheries Service (1974).



In the Fraser River system, spawning runs of chinook begin in late spring and peak in early autumn. Pink salmon migration takes place from August to October and chum occurs from August to mid-January. The Shuswap, Stuart and Chilko systems have both early (late July and early August) and late (September and October) runs of sockeye. Coho migration begins in September and ends in December.

Sockeye spawn from August to November; pink, September to November; chum, October to January; coho, from September to December; and chinook from August to December. Their eggs are usually deposited in the gravel of the streams and in lake beach areas. The eggs develop during the fall and winter months and hatch within the gravel in the spring. After hatching, the fish continue development and emerge from the gravel as free-swimming fry from March to June. Most sockeye fry migrate into a lake where they reside for a year, or rarely two years, before migrating to the ocean as smolts in April to June. Pink and chum salmon fry migrate directly to the ocean. Chinook migrate seaward as advanced fry (from mid-April to late July) or remain in the stream for a year and migrate as smolts. Coho generally remain in streams and lakes for one year before migrating to the ocean.

4.2.2 Spawning Escapements and Catch¹

The estimated average annual (1957 - 1972) escapements of Fraser River salmon, in terms of spawners which reach the spawning grounds are: 51,000 chinook; 1,250,000 sockeye; 63,000 coho; 810,000 pink and 340,000 chum.

Chinook and coho catch/escapement ratios of 4.0:1 and 3.0:1, respectively, are based on marked fish returns to hatcheries on the Columbia River. No comparable data are available for the Fraser River chinook and coho, but recent research (Environment Canada, Fisheries and Marine Service, 1974) substantiates the use of these ratios. This catch includes both commercial and salt-water sport catches.

The proportion of commercial catch to sport catch was determined on the basis of Fraser River chinook and coho residency (Environment Canada, Fisheries and Marine Service, 1974). Seventy percent of Fraser chinook and 60 percent

1. References pertaining to historical stock levels included at the end of the bibliography - see page 137

of Fraser coho migrate to the west and north coasts of Vancouver Island and Juan de Fuca and Johnstone Straits. They remain there until their spawning migration to the Fraser. It is assumed this portion of the total stock is not available to the sport fishery and is entirely available to the commercial fishery. The remaining population (30 percent of Fraser chinook and 40 percent of Fraser coho) reside in the Strait of Georgia. Of this population, the proportion of commercial troll to sport catch was estimated. These assumptions provided a commercial catch of 90 percent of the available marine catch of Fraser River chinook and 76 percent of the available marine catch of Fraser River coho.

The catch-to-escapement ratio for sockeye of 3.1:1 was determined from catch statistics provided in the International Pacific Salmon Fisheries Commission (IPSFC) Annual Reports for the period 1961 to 1972. The pink salmon ratio of 2.9:1 also was determined from IPSFC catch statistics and was further substantiated by data based on techniques Vernon, (1958) regarding salmon interception. Both sockeye and pink ratios reflect commercial catches only.

The chum salmon catch/escapement ratio of 1.5:1 is taken from Palmer (1972) and reflects only the commercial fishery.

These ratios provide an average annual Fraser River commercial catch of 183,000 chinook; 3,900,000 sockeye; 143,000 coho; 2,300,000 pinks; and 510,000 chum salmon.

4.2.3. Juvenile Downstream Migrations

Bailey and Fraser (1975) have estimated the average annual number of chum, pink and chinook fry migrating in the Fraser River from 1965 to 1974 as follows: chum 75.7 million; pink 193.5 million (even years only); chinook 16.8 million. In that the sampling procedures on which this enumeration is based sample only fry, and because many chinooks migrate after some period of freshwater rearing, and are not sampled, the above referenced authors state that "the total number of chinook juveniles migrating downstream is thought to be considerably larger than the 16.8 million fry". In his review of the biology of the lower Fraser River, Northcote (1974) has reported the total number of juvenile coho and

sockeye migrants to be 2.1 million and 45 million respectively. These figures represent a total of 343.1 million juvenile salmon in even years and 139.6 million in odd years. Northcote (1974) has summarized the timing of these migrations and Bailey and Fraser (1975) have reported on the annual variability in the timing of chum, pink and chinook downstream migrations.

4.3. Herring

The Pacific herring spawn in late winter through early spring with the peak spawning period occurring in March. Adhesive eggs are spawned, mainly within the intertidal zone from 12 feet above to a few feet below the 0 tide level. Eel grass and other vegetation provides the primary substrate for the deposition of spawn; however, occasionally spawning takes place on pilings and rocks. Spawn mortality is usually heavy, with major causes being predation, and the degree of exposure to wave action and air. Hatching normally takes place within 12 to 20 days depending on water temperature. The larval stage extends from hatching when they are approximately 1/4 inch in length for a period of 6 to 10 weeks, at which time they can be readily recognized as being young herring and reach a length of approximately 1 1/2 inches.

Herring stocks are estimated by measuring the area of spawn and then converting to tonnage of spawning adults. In the southern Gulf of Georgia (Statistical areas 17A, 17B, 18, 28 and 29) this tonnage has ranged from 11,684 to 40,480 tons between 1967 and 1973, with an average of 26,036 tons per year for this period. Boundary Bay has contributed between 1% (1973) and 57.4% (1967) of the above tonnage (Webb, 1974). In 1973, 4,599 tons of herring were caught by the commercial fishery in the southern Gulf of Georgia, representing a landed value of \$818,622.

4.4. Crabs

Dungeness crab resources associated with the Fraser River estuary represent a significant portion of total British Columbia stocks. In 1973, 529,000 pounds of crab were harvested from the Fraser River estuary by commercial fishermen (Department of the Environment 1973). This harvest represents \$281,000 paid to fishermen and 20.5% of the B.C. catch.

5. Methods

Various types of nets and traps are used to capture juvenile fish. The efficiencies of any given technique are not only dependent upon the type of gear but to a large extent on the size and species of fish, the general nature of the habitat, tidal fluctuations, light intensity and weather conditions. The techniques chosen for sampling during the present study were conditioned by the large expanse, shallowness and tidal fluctuations of the inshore portions of Sturgeon and Roberts Banks. Adequate sampling of the variety of habitat types both in the lower river and banks necessitated the use of several techniques. Sampling was conducted from April through August of 1973, and from April through June in 1974. These time periods encompass the downstream migration of juvenile salmon in the Fraser River. The 1974 program was conducted primarily to obtain information on juvenile pink salmon distribution and abundance on the banks. In addition, 6 stations in the vicinity of Steveston Island in the South Arm were sampled during 1974.

5.1. Sampling Techniques

5.1.1. Beach Seine

Beach seining was conducted at shoreline stations using a net 27 m in length x 2.4 m in depth with a bridle and towing rope at each end. Mesh size was 6 mm in the bunt and 12 mm at either end. The net was set from a 6 m water jet powered dory and recovered by hand from both ends onto the beach. Approximately the same length of shoreline was sampled with each set, however, the volume of water sampled with each set is a function of water velocity, beach slope and the time required to complete the set. At many sample stations, particularly at low tide, large amounts of substrate were retained by the net as it was retrieved. Since part of the catch was often buried in and mixed throughout this material enumerations were conservative.

5.1.2. Tow Net

Tow netting was conducted using a modified otter trawl designed to sample mid-river surface water. The net opening formed a 3.3 m x .75 m rectangle and was braced open at each side with wooden supports. The 6.4 m net was composed of three sections; 3.4 m of 28 mm mesh, 2 m of 11 mm mesh, and 1 m of 5 mm mesh at the cod end. The floats were aluminum balls and styrofoam gill-net corks and the lead line was 5/8 inch chain with 8 ounce lead weights. The net was towed on 46 meter nylon lines between two water jet-powered boats running parallel 15 m apart.

At the end of each tow, one boat stopped while the other continued until the net was abreast of the stationary boat. As well as expediting net retrieval, this practice ensured that the net closed on the catch. Tows were 15 minutes in duration at 2,000 r.p.m. which corresponds to a relative net speed of approximately 2.4 m/sec. Under these conditions, each tow net sampled a water volume of approximately 5,400 m³. The duration of tows at stations 3, 12 and 16 in the river were limited to 10, 5 and 5 minutes respectively because of the length of the sloughs. Tow netting on Sturgeon and Roberts Banks was conducted during flooding and high slack tides.

5.1.3. Pole Net

Pole netting was conducted during ebbing tides in the tidal sloughs on Duck, Barber and Woodward Islands. Pole nets are hand-held trapping devices constructed from a piece of fine mesh (# 281) marquette, stretched between two wooden poles. The bottom edge of the net was fashioned with a lead-line (3 kg/m) which held the net firmly on the substrate. The net was stretched across the full width of the intertidal channels while fish were chased toward it from an upstream position.

5.1.4. Purse Seine

Purse seining was conducted using a 10.06 meter motor vessel equipped with a hydraulic purse winch and drum. A 182 m. x 12.8 m. fine mesh purse seine was used to sample fish along the "drop off" (5 fathom contour) adjacent to the tide flats. Mesh sizes ranged from 2.54 cm. on the lead to 0.64 cm. stretch mesh on the bunt end. The bunt end efficiently retained fish less than 1 cm. in length. The net was fished on the starboard side and the bunt end retrieved last. The last 10 meters of the bunt end was formed into a "holding pen". This could then be "dried up" by gathering the extra bunt onto the boat by hand. In this manner the fish in the net could be counted, identified and sub-sampled for laboratory analysis. The unpursed volume fished by the purse seine is approximately 33,700 cubic meters. Fishing by this technique was conducted on each of a flooding and ebbing tide every two weeks.

5.1.5. Table Seine

Table seining is essentially fishing with a purse seine retrieved with the aid of an hydraulic

power block rather than a drum. A 8.19 meter research vessel was used to set a purse net 91.4 meters in length by 5.5 meters in depth. Stretch mesh size ranged from 2.5 cm. on the lead to 1.3 cm. on the bunt. The net, set in the normal circular pattern has an unpursed volume of approximately 3,600 cubic meters. Fishing at table seine stations on the banks was conducted during the two hours either side of high tide.

5.2. Fraser River

Sampling in the Fraser River from New Westminster to the mouth was conducted during daylight hours at 35 beach seine, 15 tow net and 6 pole net stations (Figs. 15a - d), at two-week intervals from April 24 to August 21, 1973. Beach seining was conducted from New Westminster to Mission at 8 stations on May 3 and June 13, 1973 (Figure 15e). Sampling in the river in 1974 was limited to 8 beach seine stations on Steveston Island (Figure 15f) which were sampled on April 8, May 1, May 16 and June 12, 1974.

5.2.1. South Arm Tow Net Stations (Location)

- TN 1 - Adjacent to Steveston Island from Buoy 519.
- TN 2 - Parallel to Rose Island from Buoy FIR.
- TN 3 - Deas Slough - from the freeway bridge to top end.
- TN 4 - South shore of river parallel to Deas Island.
- TN 5 - From north side of Buoy 532 (garbage dump).
- TN 6 - Omitted.
- TN 7 - Lower end of Annacis Channel from the upstream end of Don Island.
- TN 8 - From the Gulf Station in City Reach.
- TN 9 - From Buoy Qk FIG at the top of the sheet piling, New Westminster.
- TN 10 - Queensborough - Annacis causeway.
- TN 16 - Green slough (entering Deas Slough).

5.2.2. North Arm Tow Net Stations (Location)

- TN 11 - Poplar Island (New Westminster)
- TN 12 - "Sturgeon Hole" slough - south bank, upstream of the bend between the Queensborough and swing bridges - log booming area.
- TN 13 - From the log splitting operation upstream of Boundary Road, Crown Zellerbach sawmill.
- TN 14 - Mitchell Island - West Coast Street.
- TN 15 - MacDonald Slough - log storage area.

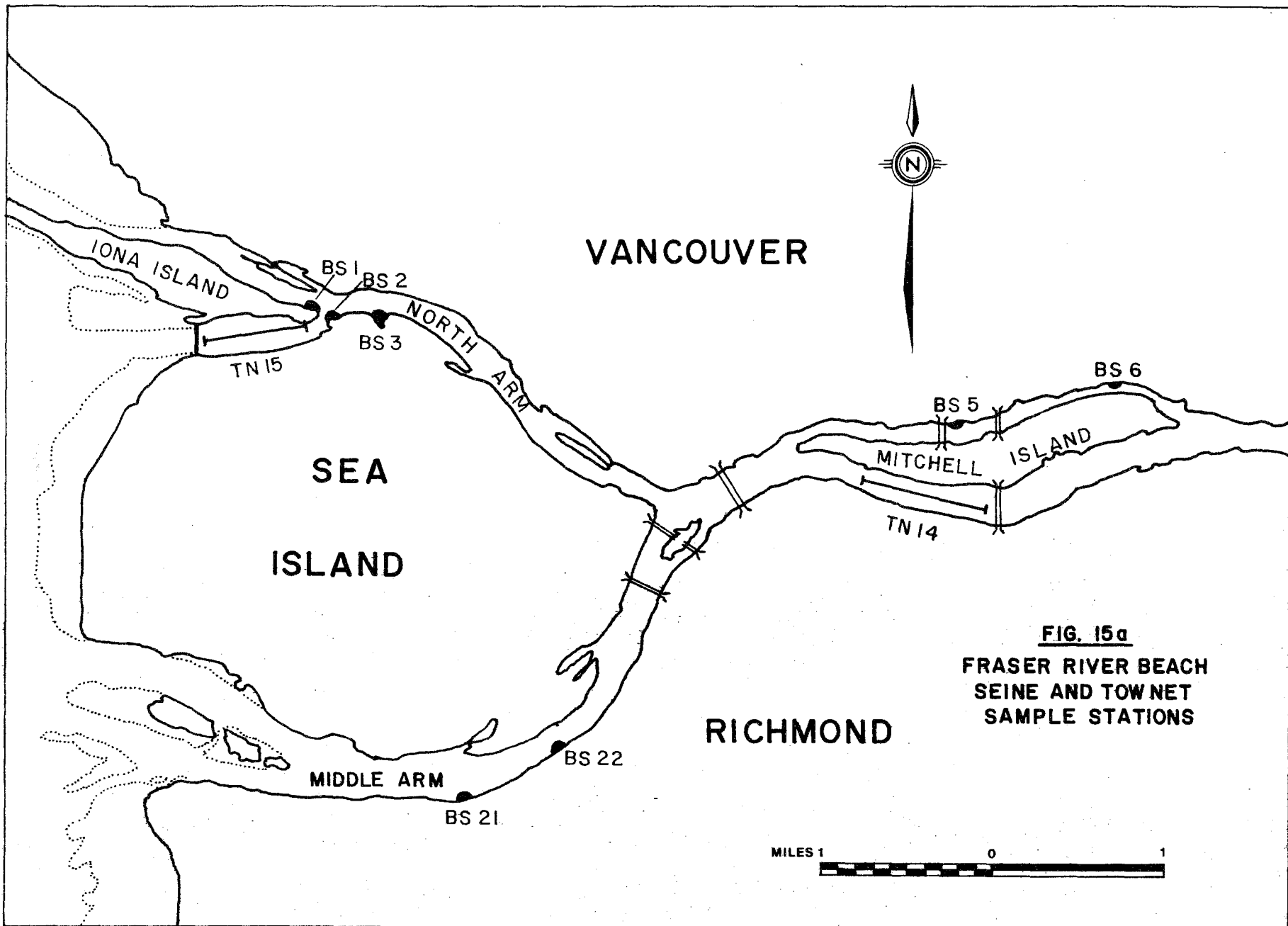


FIG. 15a
FRASER RIVER BEACH
SEINE AND TOW NET
SAMPLE STATIONS

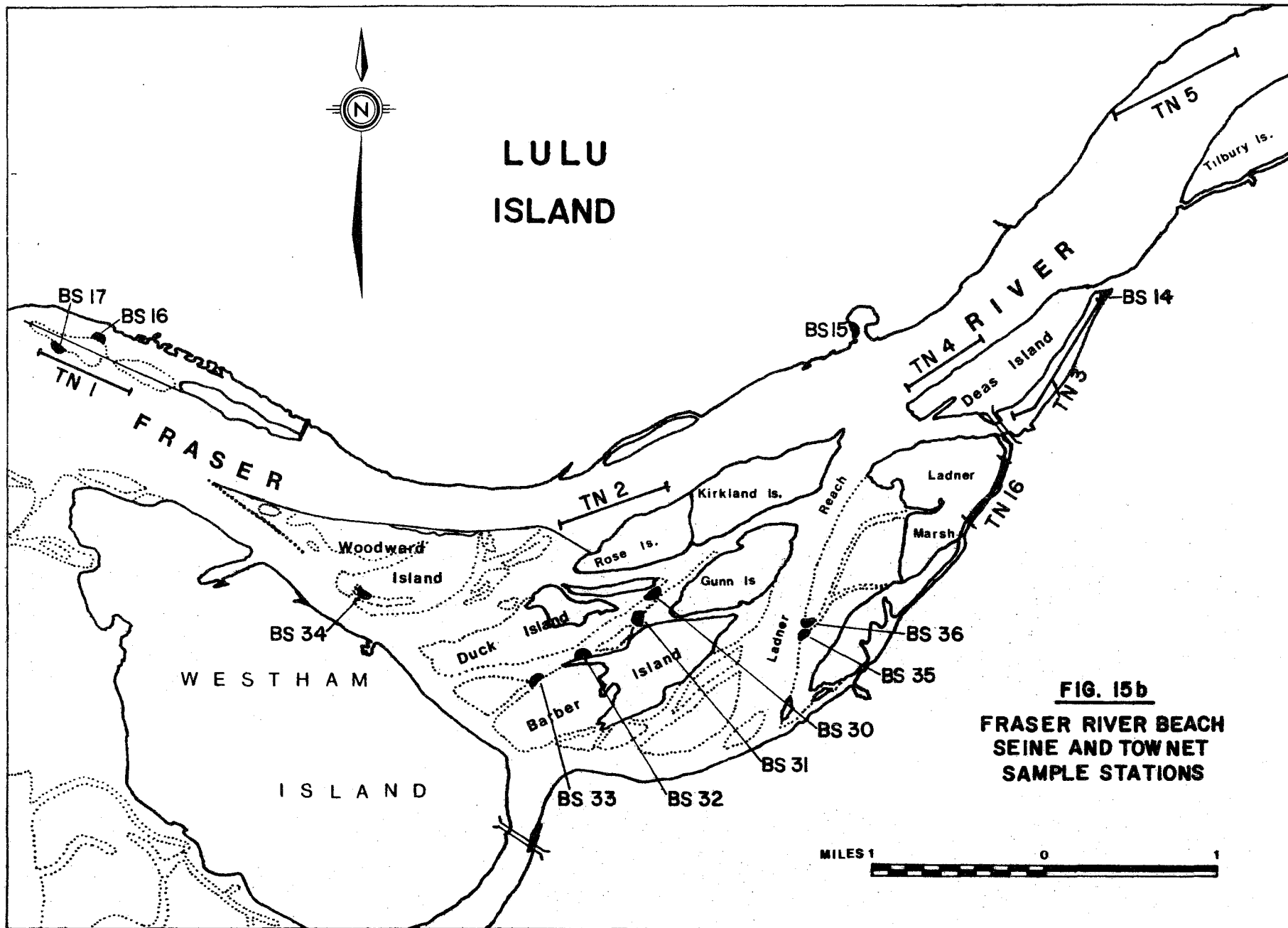


FIG. 15b
FRASER RIVER BEACH
SEINE AND TOWNET
SAMPLE STATIONS

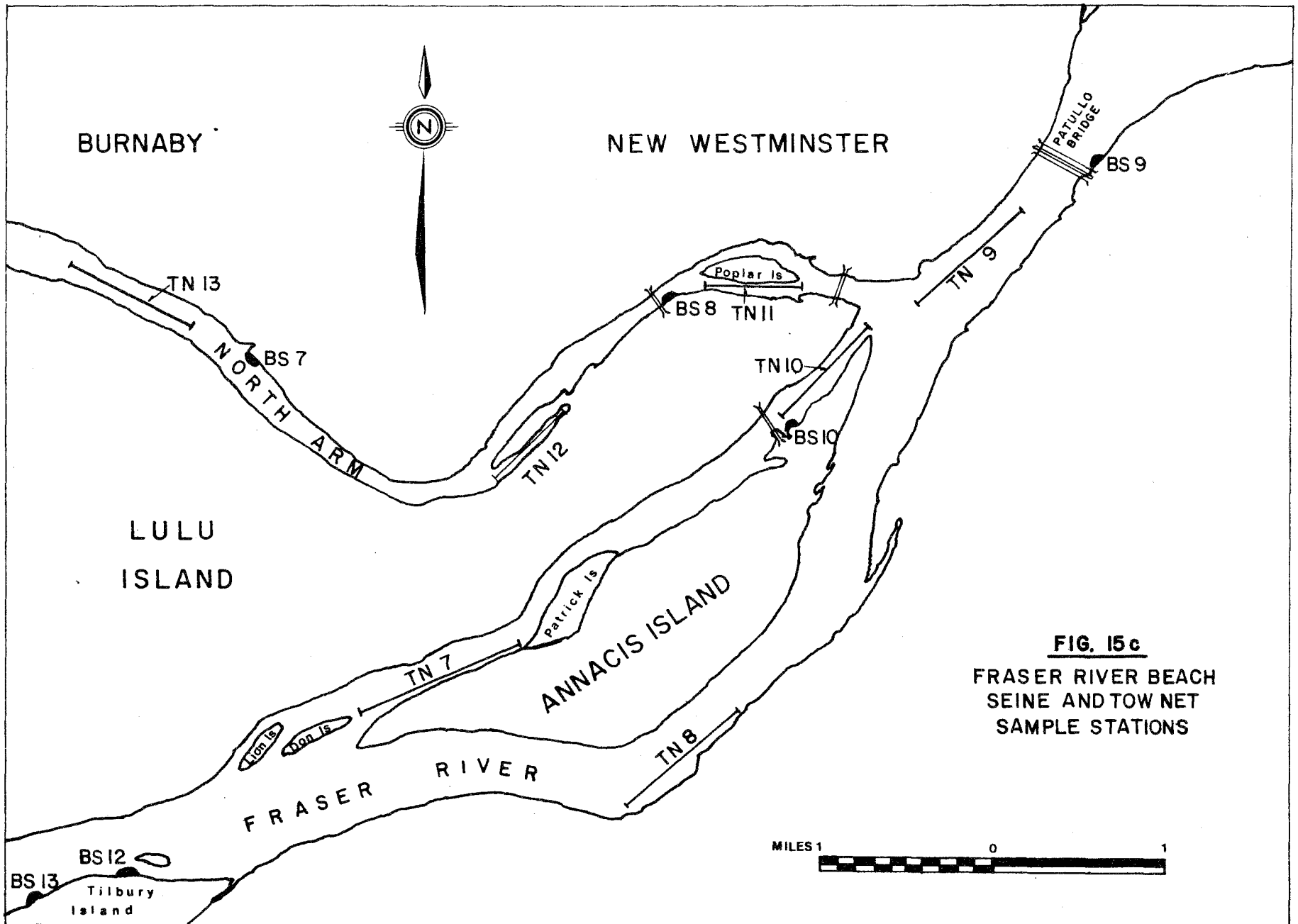


FIG. 15c
FRASER RIVER BEACH
SEINE AND TOW NET
SAMPLE STATIONS

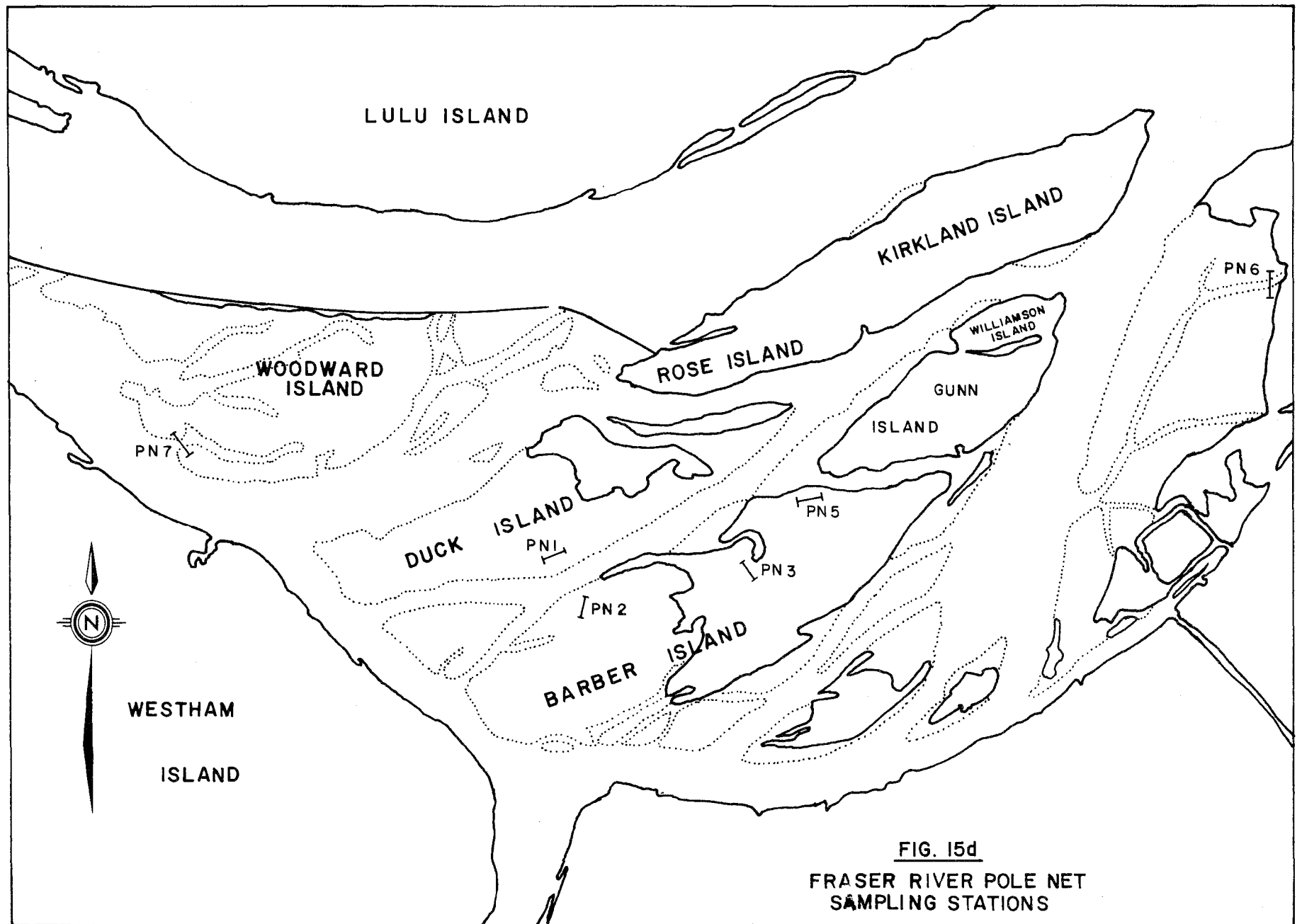


FIG. 15d
FRASER RIVER POLE NET
SAMPLING STATIONS

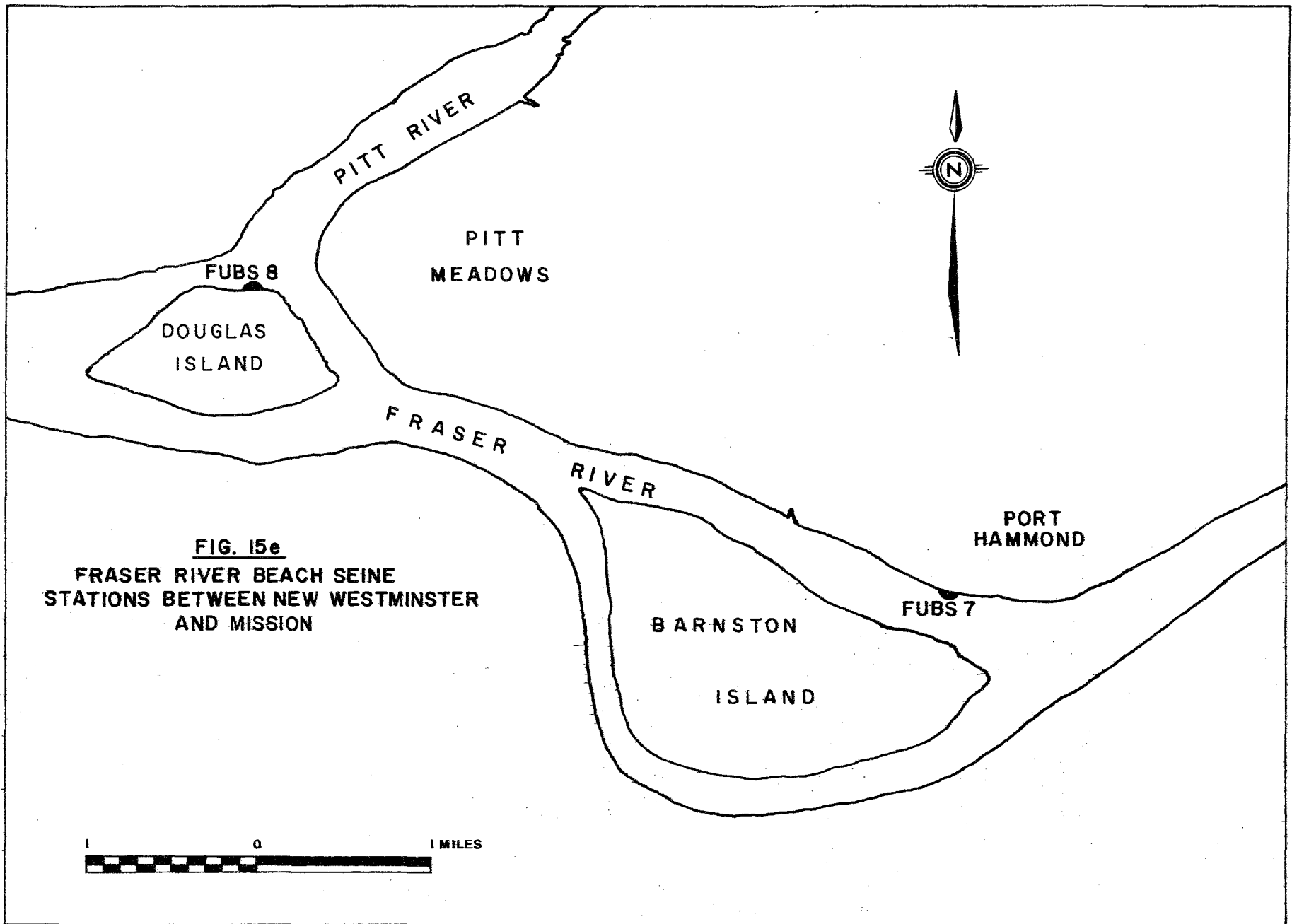


FIG. 15e
FRASER RIVER BEACH SEINE
STATIONS BETWEEN NEW WESTMINSTER
AND MISSION

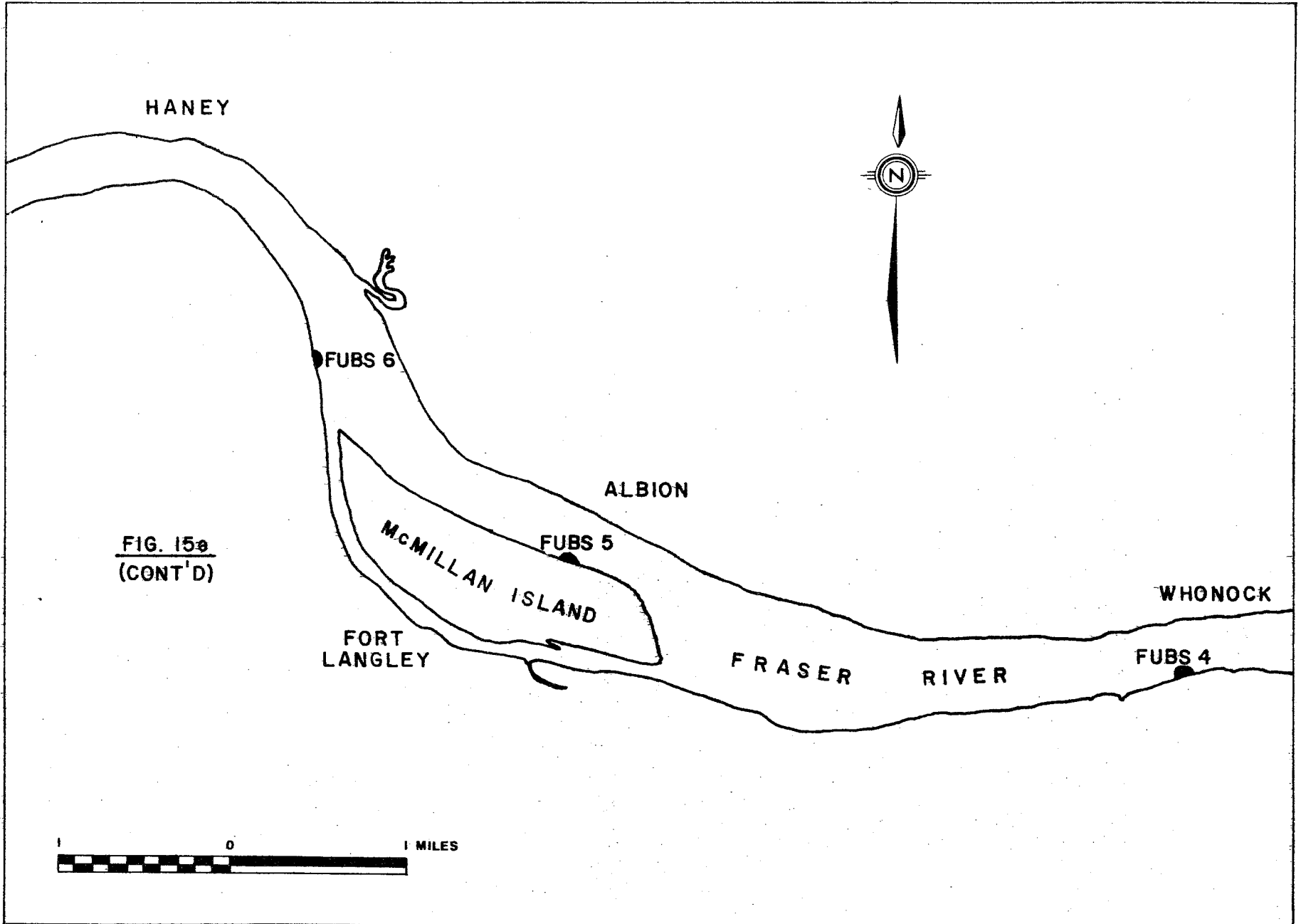


FIG. 15a
(CONT'D)

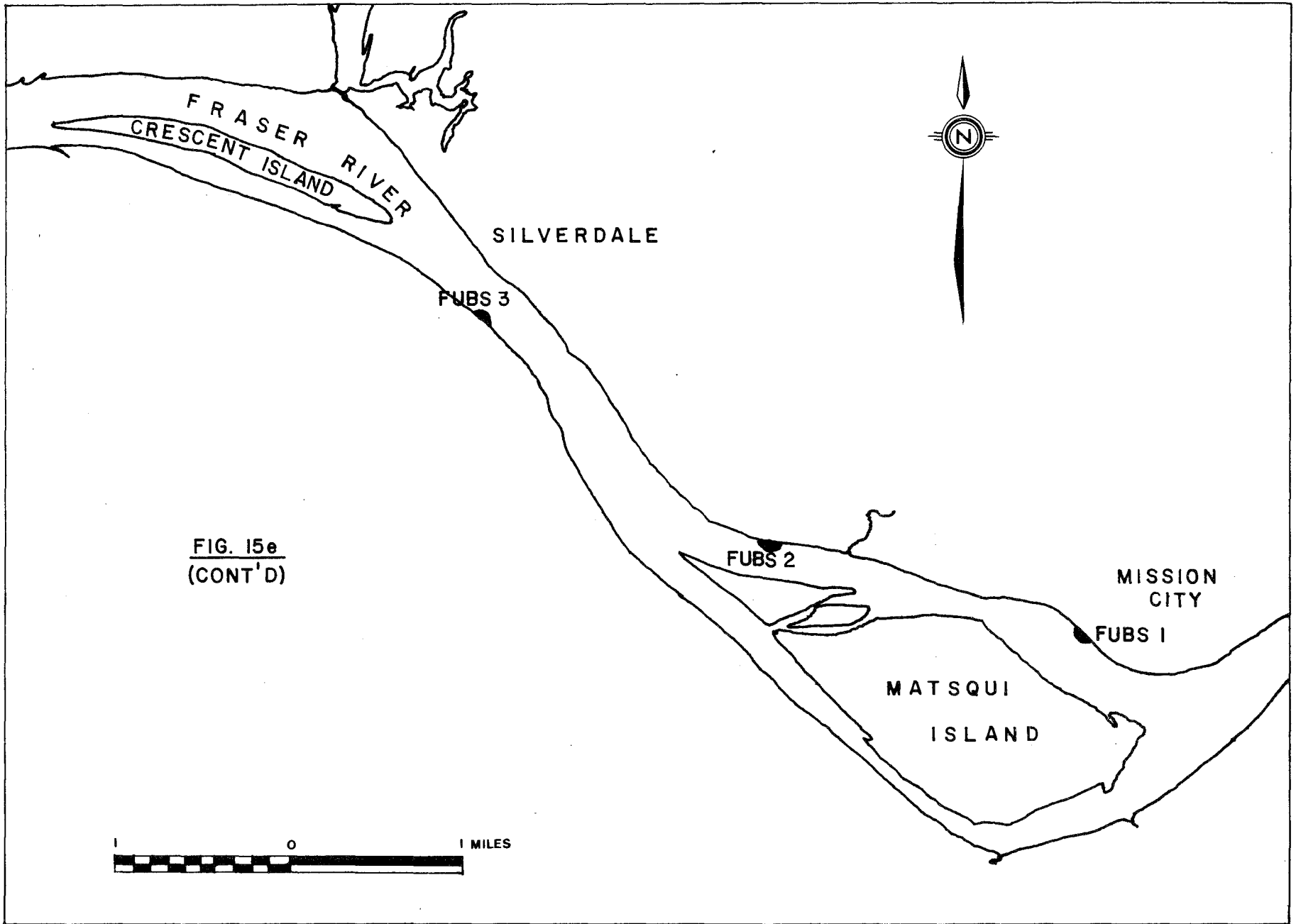
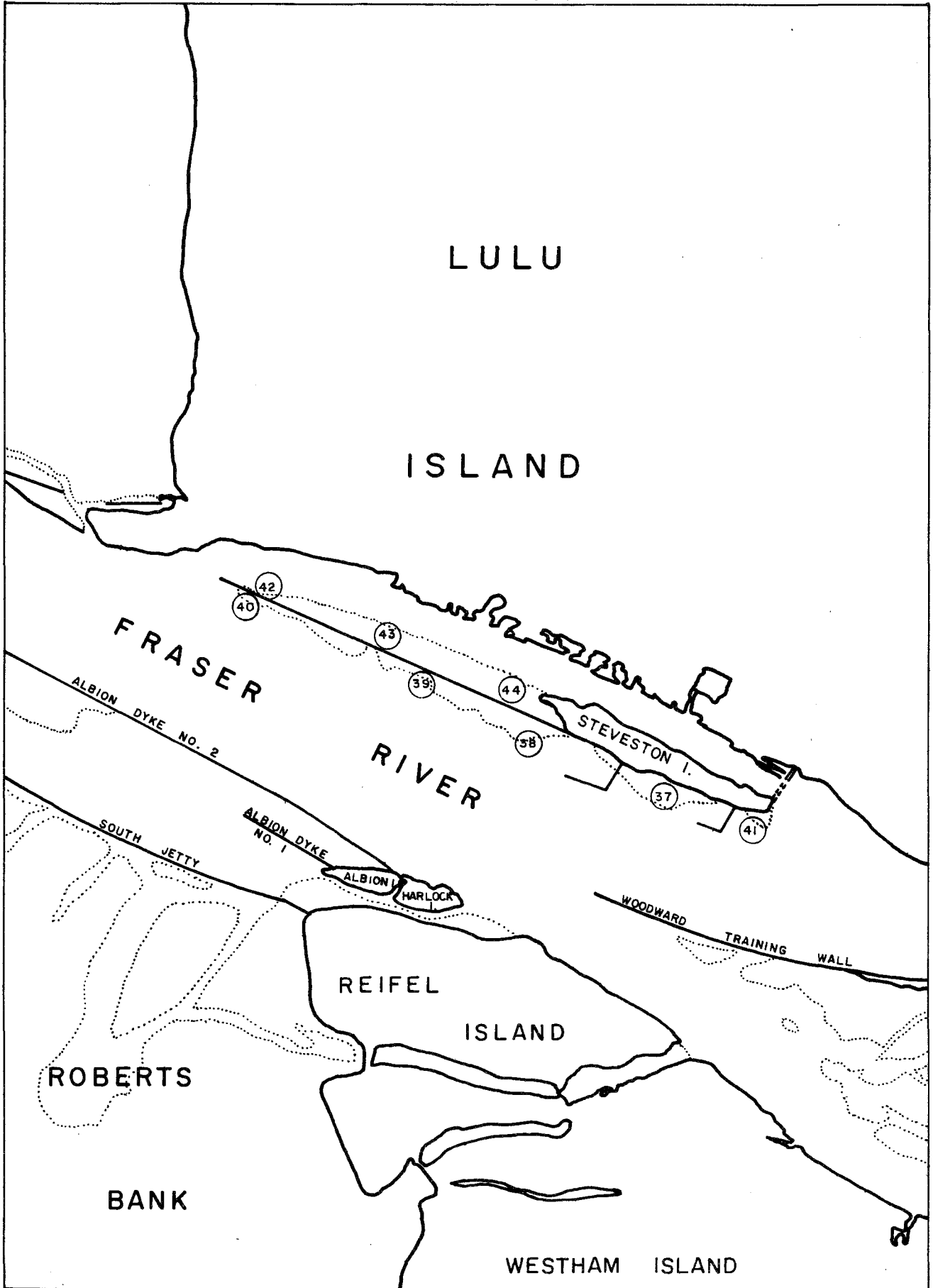


FIG. 15e
(CONT'D)

FIG. 15f
STEVESTON ISLAND
1974 BEACH SEINE
SAMPLE STATIONS



5.2.3. South Arm Beach Seine Stations (Location)

1973

- BS 9 - Upstream of Pattullo Bridge - south shore.
- BS 10 - South shore of Annacis Channel upstream of bridge.
- BS 12 - Small bay downstream of Dow Chemical - south shore.
- BS 13 - South shore upstream of Tilbury dock.
- BS 14 - Upper end of Deas Slough - south shore upstream of flood box for Crescent Slough.
- BS 15 - Small bay at Woodward landing - B.C. Ferries Repair Depot.
- BS 16 - Lower end of Steveston Slough (Cannery Channel) across from Gulf Station.
- BS 17 - Lower end of Steveston Island - river side.
- BS 30-36 Barber, Duck and Woodward Island

1974

- BS 37-44 Steveston Island.

5.2.4. North Arm Beach Seine Stations (Location)

- BS 1 - Downstream of the entrance to MacDonald Slough.
- BS 2 - Upstream of the entrance to MacDonald Slough.
- BS 3 - Small bay used as boat launching ramp - south shore.
- BS 5 - Mitchell Slough - north shore downstream from sawmill and chip barge loading site.
- BS 6 - Mitchell Slough - upstream of Knight Street bridge - north bank.
- BS 7 - At Mackenzie Barge site - 800 meters downstream of CN Railway bridge - north shore.
- BS 8 - South shore - under Queensborough Bridge - downstream from sawmill and barge loading site.

5.2.5. Middle Arm Beach Seine Stations

- BS 21 - South shore below Dinsmore bridge.
- BS 22 - South shore across from float plane dock.

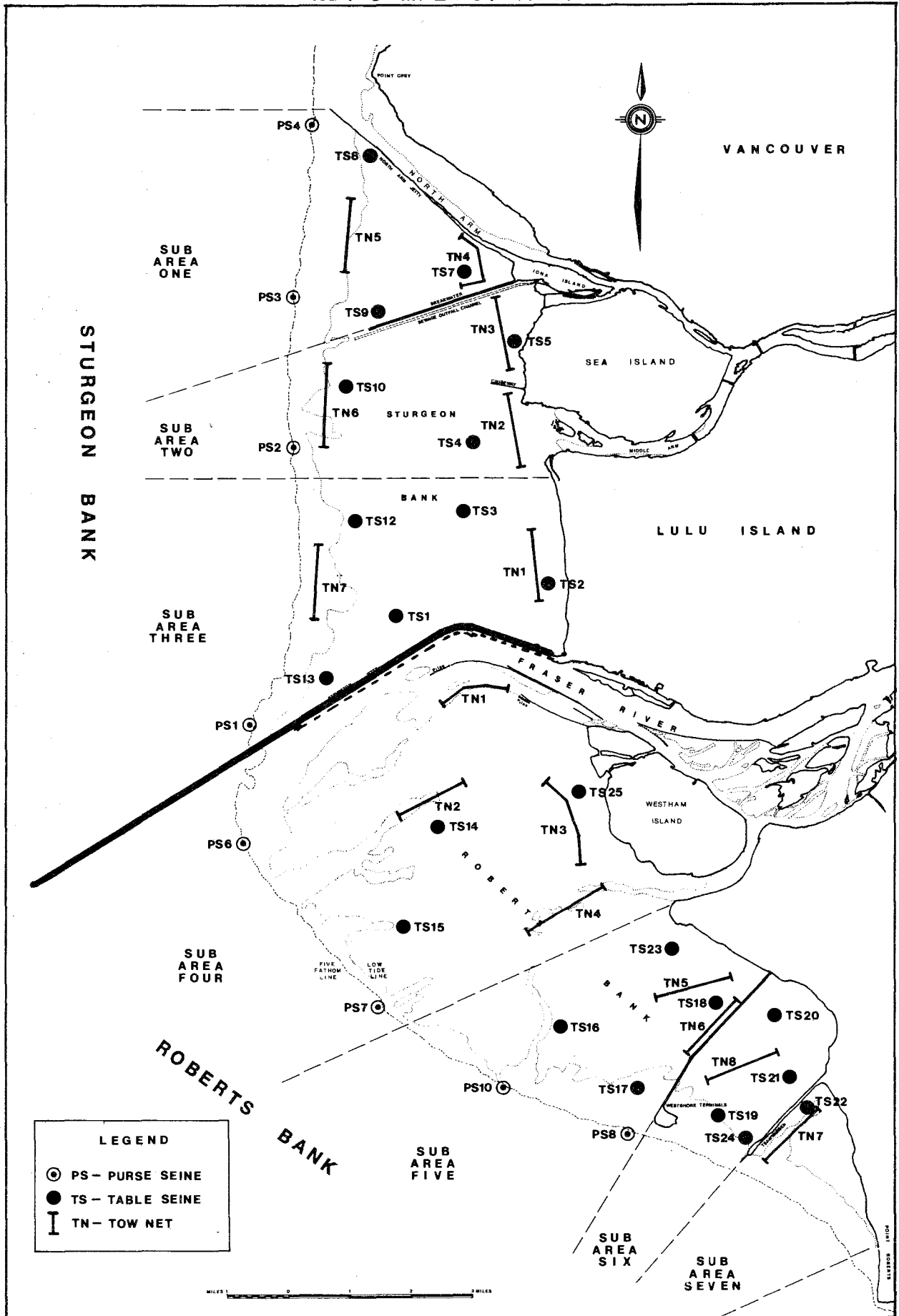
5.2.6. Pole Net Stations

- PN 1-PN 6-Duck, Barber, Woodward Island, Ladner March.

5.3. Sturgeon and Roberts Banks

Sampling on Sturgeon and Roberts Banks was conducted at 10 purse seine, 23 table seine and 15 tow net stations (Figure 16) at two-week intervals from March 28 to

FIG. 16
STURGEON AND ROBERTS BANKS
PURSE SEINE, TABLE SEINE, AND TOW
NET SAMPLE STATIONS



6. Results

For comparative purposes sample sites have been grouped into four major areas with sub-areas as follows:

Sample Area - Fraser River upstream of the Port Mann Bridge

Sample Area - Fraser River downstream of the Port Mann Bridge
sub-area 8 - North and Middle Arms (further reference in test and tables to catches in the North Arm include data from stations in the Middle Arm)
sub-area 9 - South Arm

Sample Area - Sturgeon Bank
sub-area 1 - from the North Arm Jetty to the Iona Jetty
sub-area 2 - from the Iona Jetty to the Middle Arm
sub-area 3 - from the Middle Arm to the Steveston Jetty

Sample Area - Roberts Bank
sub-area 4 - from Steveston Jetty to Canoe Pass
sub-area 5 - from Canoe Pass to the Roberts Bank causeway
sub-area 6 - from Roberts Bank Causeway to the Tsawwassen Ferry Terminal
sub-area 7 - south of the Tsawwassen Ferry Terminal

The codes used to identify the major sample areas and each sub-area are presented in Appendix 1 along with the codes used to identify gear types, fish species and stomach contents. Appendix 2 lists the sample dates and corresponding sample periods with gear type and stations sampled in each area of the Fraser River and estuary.

6.1. Catch Analysis

The total catch of each fish species taken in the Fraser River and estuary during sampling between March 28 - September 12 in 1973 is listed according to the sample areas as outlined above in Appendix 2. In the Fraser River above the Port Mann Bridge, threespine stickleback¹ were the most abundant species in catches followed by coho, chinook and peamouth chub. Seventeen species were present in these catches. Thirty-six species were caught in the Fraser River below the Port Mann Bridge. Threespine stickleback, starry flounder, chinook, coho, peamouth chub, prickly sculpin, chum and sockeye were most numerous in these catches.

Of the 32 species present in the catches on Sturgeon Bank, herring were the most numerous. These were followed by chinook, sand lance, starry flounder, coho, longfin smelt and surf smelt. On Roberts Bank, herring, chinook, shiner perch, threespine stickleback, starry flounder, sand lance, and surf smelt were the most abundant of the 49 species present in catches. Species caught on Roberts Bank which were not present in catches on Sturgeon Bank including pile perch, tube snout, sand

1. The implications of this and similar findings with respect to other non salmon species have not been interpreted.

fish, crescent gunnel, penpoint gunnel and others are typically marine species.

Salmon and herring catch data were compiled according to the number of each species caught by the different gear types for each sample station and day and are listed according to area and sub-area location. Analysis of these data involved summing the individual station catches for each sub-area and calculating the average catch per set by gear type and date for each sub-area (Appendix 3). In addition, the total catch and catch per set of coho, chinook and herring were calculated separately for inshore (intermediate and high intertidal) and offshore (low intertidal and subtidal) table seine and tow net stations on Sturgeon Bank and table seine stations on Roberts Bank. Alignment of tow net stations on Roberts Bank did not permit similar separation of these data. Sample sizes of other salmon species were not large enough to warrant separation into inshore and offshore stations.

The total catch and catch per set of juvenile salmon and herring caught in the Fraser River and on Sturgeon and Roberts Banks during sampling in 1973 are presented in Table 1. These data indicate that in terms of relative abundance, the rank of salmon species in river catches was the same as for catches of the banks, namely chinook, coho, chum and sockeye. However, the catch per set of juvenile chinook on Sturgeon and Roberts Banks was considerably higher than in the river. These data have been calculated separately for the Upper Fraser, the North and South Arms and for Sturgeon and Roberts Banks and are presented in Table 2. Catch per set for chinook was higher than for other salmon species in the South Arm and on Sturgeon and Roberts Banks. Catch per set for coho was higher than for other salmon species in the North Arm and the Fraser River above the Port Mann Bridge. Catch per set for chum was highest in the South Arm and higher than for sockeye in each area. The catch per set for coho, chinook, chum, sockeye and herring was higher on Sturgeon Bank than on Roberts Bank; however, sampling on Sturgeon Bank was begun earlier in the spring than on Roberts Bank.

6.1.1. Fraser River above Port Mann

A total of 373 juvenile salmon were caught during sampling on May 3 and June 13 at beach seine stations above the Port Mann Bridge. This catch was comprised of 284 coho, 80 chinook, 8 chum and 1 sockeye. For all stations (except BS 7) sampled on both dates, catches of coho were significantly lower on June 13 than on May 3. Chinook catches were high only at beach seine stations 4 and 6 on May 3.

TABLE 1. TOTAL CATCH AND CATCH PER SET (ALL GEAR TYPES
COMBINED) OF JUVENILE SALMON AND HERRING CAUGHT IN
THE FRASER RIVER ESTUARY MARCH 28 - SEPTEMBER 12, 1973

A) FRASER RIVER

	<u>Total Catch</u>	<u>No. of Sets</u>	<u>Catch/Set</u>
Coho	1,583	359	4.4
Chinook	1,609	359	4.5
Chum	916	359	2.6
Sockeye	443	359	1.2
TOTAL SALMON	4,551	359	12.7

B) STURGEON AND ROBERTS BANKS

Coho	1,411	371	3.8
Chinook	3,724	371	10.0
Chum	257	371	0.7
Sockeye	133	371	0.4
TOTAL SALMON	5,525	371	14.9
Herring	115,318	371	311.0

TABLE 2. TOTAL CATCH AND CATCH PER SET (ALL GEAR TYPES COMBINED) OF JUVENILE SALMON AND HERRING IN EACH SAMPLE AREA OF THE FRASER RIVER ESTUARY IN 1973

AREA		NO. OF SETS	COHO	CHINOOK	CHUM	SOCKEYE	HERRING
UPPER FRASER RIVER (above Port Mann Bridge)	Total catch	14	284	80	8	1	
	Catch/Set		20.3	5.7	0.6	0.1	
	% of salmon catch		76	21	2	0.3	
LOWER FRASER RIVER - North Arm	Total catch	111	853	191	193	31	
	Catch/Set		7.6	1.7	1.7	2	
	% of salmon catch		67	15	15	2	
LOWER FRASER RIVER - South Arm	Total catch	234	446	1,338	715	411	
	Catch/Set		1.9	5.7	3.0	1.7	
	% of salmon catch		15	46	25	14	
STURGEON BANK	Total catch	199	1,140	2,367	235	125	70,533
	Catch/Set		5.7	11.9	1.2	0.6	354.4
	% of salmon catch		29	61	6	3	
ROBERTS BANK	Total catch	172	271	1,357	22	8	44,785
	Catch/Set		1.6	7.9	0.1	<0.1	260.4
	% of salmon catch		16	82	1	0.5	

6.1.2. Fraser River below Port Mann

6.1.2.1. Coho

Juvenile coho were taken in beach seines from April 24 to June 25, 1973 in both the North, Middle and South Arms of the Fraser River.¹ Over the period sampled, coho formed 70% of the salmon caught by beach seines in the North Arm and only 15% in the South Arm.

Catches were highest on May 14, although good catches were also taken on April 24 and June 4 in the North Arm. Stations in the North Arm were not sampled prior to April 24, however, no coho were taken at beach seine stations in the South Arm between March 14 and April 11 (Table 3).

Over half of the coho caught in the North Arm sub-area were taken at stations 21 and 22 in the Middle Arm. Stations 5, 6 and 8 produced the smallest catches.

In the South Arm, beach seine stations 16, 15 and 12 produced the highest catches of juvenile coho. These stations were in areas of reduced flow with relatively fine substrate and vegetated shores. No coho were taken at beach seine stations 30 to 36 in Ladner Marsh, and Duck, Barber and Woodward Islands during sampling in 1973. Similarly, juvenile coho were not taken at beach seine stations around Steveston Island between April 8 and June 12 in 1974 (Table 4).

Juvenile coho were captured in tow nets from the beginning of sampling on May 9 to June 25. Tow net catches were considerably smaller than beach seine catches, averaging only 2 fish per set over the period sampled in both the North and South Arms. The highest catch per set occurred in the North Arm on May 9; however, good catches were also made between May 24 and May 29 in both the North and South Arms and on June 13 in the South Arm (Table 3). Most tow net stations tended to be equally productive, although station 7 in the South Arm and 11 and 14 in the North Arm had lower than average catches while stations 4 and 5 in the South Arm and 12 and 15 in the North Arm had slightly higher than average catch per set. Coho comprised 44% of the tow net salmon catch in the North Arm but only 22% in the South Arm.

¹ Beach seine stations in the Middle Arm have been combined with North Arm stations for the present analysis.

TABLE 3. CATCH PER SET OF COHO BY SAMPLE DATE AND SUB AREA FOR EACH GEAR TYPE USED IN THE FRASER RIVER IN 1973

GEAR	BEACH SEINE			TOW NET		POLE NET
	LOWER FRASER		UPPER FRASER	LOWER FRASER		LOWER FRASER
	North Arm (sub-area 8)	South Arm (sub-area 9)		North Arm (sub-area 8)	South Arm (sub-area 9)	South Arm (sub-area 9)
DATE						
14 March		0				0
28 March		0				0
11 April		0				0
24 - 25 April	18	4				0
3 May			34			
9 - 11 May		0		12		0
14 - 15 May	43	20		2	1	
24 - 29 May		5		6	9	0
4 June	14	7				0
11 - 13 June	8	3	1	2	7	
20 - 25 June	<1	<1		0	<1	0
4 July		0				0
12 July	0	0		0	0	0
23 - 24 July	0	0		0	0	
2 August		0				0
7 August	0	0		0	0	
21 August				0	0	
TOTAL CATCH	792	277	284	61	169	0
TOTAL SETS	74	123	14	37	71	40
CATCH/SET	11	2	20	2	2	0

TABLE 4 . CATCH PER SET OF JUVENILE SALMON TAKEN WITH BEACH SEINES
IN THE FRASER RIVER, (STEVESTON ISLAND) IN 1974

DATE	BEACH SEINE STATION	PINK	COHO	CHINOOK	CHUM	SOCKEYE	CUT- THROAT
Apr 8	37	0	0	5	5	0	0
	38	0	0	22	4	0	0
	39	0	0	10	0	0	0
	40	0	0	0	0	0	0
May 1	37	0	0	19	0	0	0
	38	0	0	18	0	0	0
	39	0	0	16	0	0	0
	40	0	0	19	0	0	0
	41	0	0	10	0	0	0
	42	0	0	20	0	0	0
	43	0	0	43	0	0	0
	44	1	0	62	5	0	0
May 16	37	0	0	21	0	0	0
	38	0	0	35	0	0	0
	39	0	0	22	0	0	0
	40	0	0	31	0	0	0
	41	0	0	9	0	0	0
	42	0	0	9	1	1	0
	43	0	0	19	2	0	0
	44	0	0	18	0	0	0
Jun 12	37	0	0	0	1	0	0
	38	0	0	2	0	0	0
	39	0	0	1	0	0	0
	40	0	0	0	0	0	0
	41	0	0	4	0	0	0
	42	0	0	5	1	0	0
	43	0	0	9	1	0	0
	44	0	0	13	0	0	1

No coho were taken at pole net stations, all of which were located on Duck, Barber and Woodward Islands.

6.1.2.2. Chinook

Juvenile chinook were caught in 1973 beach seines from April 11 until July 24 in the South Arm and from April 25 until August 27 in the North Arm of the Fraser. The average catch per set and total catch was much lower in the North Arm than in the South Arm (Table 5). The highest catch per set occurred on April 25 in the South Arm but catches averaging 5 fish or more continued until the end of June (Table 5). In the North Arm, catch per set at individual stations was usually less than three fish except at beach seine station 22 on June 11 when 7.0 chinook were taken in one set. In the South Arm, 93% of the beach seine chinook were taken at stations 30 to 36 on Ladner Marsh and Duck, Barber and Woodward Islands (Appendix 3). Forty-six percent of the chinook were taken at beach seine station 35 on the edge of Ladner Marsh on April 25 (Appendix 3). These stations were on shallow, vegetated marshes which are flooded at high tide.

Catch per set of juvenile chinook salmon at beach seine stations around Steveston Island were highest on May 1 and May 16 during sampling in 1974 (Table 4).

Chinook comprised 12% of the beach seine caught salmon in the North Arm compared with 52% in the South Arm.

Juvenile chinook were caught in tow nets throughout the period sampled, except on August 21 in the North Arm. Again, the number of chinook per set for tow net stations was considerably lower than at beach seine stations in the same sub-area (Table 5). Tow net catches were generally similar at all stations sampled.

Chinook comprised 38% of the tow net caught salmon in the North Arm and 25% in the South Arm.

The highest average pole net catch per sets were made at the end of April and beginning of May, when beach seine catches in the South Arm were also high. Pole net stations 5 and 7 had lower than average catches after the first week in May.

TABLE 5. CATCH PER SET OF CHINOOK BY SAMPLE DATE AND SUB AREA FOR EACH GEAR TYPE USED IN THE FRASER RIVER IN 1973

GEAR	BEACH SEINE			TOW NET		POLE NET
	LOWER FRASER		UPPER FRASER	LOWER FRASER		LOWER FRASER
	North Arm (sub-area 8)	South Arm (sub-area 9)		North Arm (sub-area 8)	South Arm (sub-area 9)	South Arm (sub-area 9)
DATE						
14 March		0				0
28 March		0				1
11 April		8				2
24 - 25 April	<1	52				15
3 May			9			
9 - 11 May		17		8		15
14 - 15 May	1	<1		<1	1	
24 - 29 May		7		<1	2	8
4 June	<1	9				1
11 - 13 June	10	<1	1	2	1	
20 - 25 June	3	5		2	2	1
4 July		2				1
12 July	1	1		1	2	0
23 - 24 July	<1	<1		2	8	
2 August		0				0
7 August	<1	0		2	3	
21 August				0	<1	
TOTAL CATCH	138	945	80	53	188	205
TOTAL SETS	74	123	14	37	71	40
CATCH/SET	2	8	6	1	3	5

6.1.2.3. Chum

Most of the juvenile chum salmon caught in the Fraser River were taken by beach seine in the South Arm (Table 6) between March 28 and August 2 with peak catches in mid and late April and mid June. North Arm stations were not sampled frequently prior to June when catches in the South Arm were highest.

In the South Arm, highest catches were made at stations 31 to 33 and 35 and 36 in March and April; at station 16 in May and at stations 12 and 14 in June (Appendix 3). No juvenile chum were taken at stations 9 and 17 and catches were poor at stations 10, 13, 15 and 34. Generally, catches were higher in back-water, slough areas, with soft substrate and shoreline vegetation and lower in those areas characterized by steep shore slopes, fast currents and clean sand substrate.

In the North Arm, catches of juvenile chum salmon were high at stations 3 and 21 during April and May (Appendix 3). Station 3 was a small bay with reduced flow, fine substrate and vegetated shoreline. Station 21 was similarly an area of reduced flow, with vegetated shoreline, however the substrate material was somewhat coarser.

Juvenile chum salmon were caught at tow net stations 11, 13, 14 and 15 in the North Arm and all stations sampled in the South Arm except tow net station 4 (Appendix 3).

Catches of juvenile chum salmon at pole net stations were highest in April and early June as with the beach seine stations.

6.1.2.4. Sockeye

In contrast to chinook, coho and chum, most of the juvenile sockeye caught in the Fraser River during sampling in 1973 were not caught in beach seines (Table 7). Sockeye comprised only 1% of the total beach seine salmon catch in the North Arm and only 3% in the South Arm. These catches were made between June 20 and July 24 at all beach seine stations in the North Arm except station 1 and at stations 9, 12, and 13 to 17 in the South Arm. Juvenile sockeye were not caught at stations 10 and 30 to 36 in the South Arm.

TABLE 6. CATCH PER SET OF CHUM BY SAMPLE DATE AND SUB AREA FOR EACH GEAR TYPE USED IN THE FRASER RIVER IN 1973

GEAR	BEACH SEINE				TOW NET		POLE NET
	LOWER FRASER		UPPER FRASER	LOWER FRASER		LOWER FRASER	
	North Arm (sub-area 8)	South Arm (sub-area 9)		North Arm (sub-area 8)	South Arm (sub-area 9)	South Arm (sub-area 9)	
DATE							
14 March		0				0	
28 March		7				0	
11 April		16				14	
24 - 25 April	8	20				9	
3 May			1				
9 - 11 May		2		1		5	
14 - 15 May	4	6		1	2		
24 - 29 May		1		0	<1	1	
4 June	1	2				1	
11 - 13 June	1	14	<1	1	1		
20 - 25 June	3	1		0	1	<1	
4 July		<1				0	
12 July	0	<1		<1	<1	<1	
23 - 24 July	0	<1		0	0		
2 August		<1				0	
7 August	0	0		0	0		
21 August				0	0		
TOTAL CATCH	183	556	8	10	40	119	
TOTAL SETS	74	123	14	37	71	40	
CATCH/SET	2	4	<1	<1	<1	3	

TABLE 7. CATCH PER SET OF SOCKEYE BY SAMPLE DATE AND SUB AREA FOR EACH GEAR TYPE USED IN THE FRASER RIVER IN 1973

GEAR	BEACH SEINE			TOW NET		POLE NET
	LOWER FRASER		UPPER FRASER	LOWER FRASER		LOWER FRASER
	North Arm (sub-area 8)	South Arm (sub-area 9)		North Arm (sub-area 8)	South Arm (sub-area 9)	South Arm (sub-area 9)
DATE						
14 March		0				0
28 March		0				0
11 April		0				0
24 - 25 April	0	0				0
3 May			<1			
9 - 11 May		0		0		0
14 - 15 May	0	0		0	5	
24 - 29 May		0		<1	22	0
4 June	0	0				0
11 - 13 June	0	0	0	<1	2	
20 - 25 June	<1	1		<1	1	0
4 July		0				0
12 July	<1	2		0	2	0
23 - 24 July	1	<1		1	6	
2 August		0				0
7 August	0	0		1	<1	
21 August				0	0	
TOTAL CATCH	18	50	1	13	361	0
TOTAL SETS	74	123	14	37	71	40
CATCH/SET	<1	<1	<1	<1	5	0

Most of the sockeye taken in the Fraser River were caught in tow nets in the South Arm from mid May to early August (Table 7). The highest catches were made on May 24 at stations 1, 2, 3 and 8 and again on July 23 at station 4 in the South Arm (Appendix 3). In the North Arm, catches of juvenile sockeye were highest at station 15 (McDonald Slough) and station 12 (Sturgeon Hole Slough).

No juvenile sockeye were caught at pole net stations.

6.1.3. Sturgeon and Roberts Banks

On Sturgeon Bank, herring, then chinook were the most numerous in catches followed by Pacific sand lance, starry flounder, and coho. On Roberts Bank, the order of abundance was herring, chinook, shiner perch, threespine stickleback and starry flounder.

A total of 5,525 juvenile salmon and 115,318 herring were caught on Sturgeon and Roberts Banks during sampling in 1973 in 371 sets involving the previously described catch techniques (Table 1). Chinook formed 67% of the total salmon catch, while coho, chum and sockeye formed 25, 5 and 2% respectively. On Sturgeon Bank, chinook and coho made up 61% and 29% respectively of the salmon catch, while on Roberts Bank, 82% of the salmon caught were chinook and only 16% were coho (Table 2). However, proportionate species compositions and total salmon catches on Roberts and Sturgeon Banks are not directly comparable because the number of sets using each gear type varied. Tow nets, table seines and purse seines sample different areas, depths and volumes of water and data on their comparative efficiencies is lacking. Thus, in order to compare the relative abundance of species between Sturgeon and Roberts Banks and between sub-areas within each bank, catches per set for each gear type should be compared separately. In addition, sampling dates must be considered because of the timing of juvenile salmon migrations. Accordingly, catches per set have been listed by gear type and sample date for each sub-area of the banks for coho (Table 8), chinook (Table 9), chum (Table 10), sockeye (Table 11) and herring (Table 12).

6.1.3.1. Coho

Coho were caught by purse seine in 1973 at the edge of the banks from early May to

TABLE 8 . CATCH PER SET¹ OF COHO BY SAMPLE DATE AND SUB AREA FOR EACH GEAR TYPE USED IN THE FRASER RIVER ESTUARY IN 1973

GEAR	PURSE SEINE							TABLE SEINE							TOW NET												
	SB ²				RB ³			SB				RB			SB				RB								
AREA	1	2	3	\bar{X}	4	5	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}		
SUB AREA	(see fig. 16)																										
DATE																											
28 - 29 March	0	0	0	0	0	0	0																				
10 - 11 April	0	0	0	0	0	0	0																				
25 - 26 April	0	0	0	0	0	0	0																				
7 - 9 May	1	2	2	2	0	0	0										3		1	2							
22 May	2	1	2	2	1	1	1										12	85	26	47							
1 June		10	3	7					0	2	1							33	48	40							
4 - 7 June	<1			<1	1	6	3	0			0						46			46	8	0		1	5		
14 June		0	0	0					0	0	0							3	155	64							
17 - 20 June	0			0	0	0	0					1	5	9	13	6	6			6	13	0	0	0	7		
25 - 26 June	0	0	<1	<1				7	14	7	8						0	0	0	0							
3 - 4 July					0	2	1					0	2	0	0	1					0	0	0	0	0		
9 - 11 July	8	1	1	4				0	0	0	0						0	0	0	0							
17 - 18 July					0	1	<1					0	0	0	0	0					0	0	0	0	0		
25 - 26 July	<1	0	2	1				0	0	0	0						0	0	0	0							
30 July - 1 Aug.						4	4					0	1	2	0	1					0	0	0	0	0		
6 - 7 Aug.	0	0	0	0	0		0	0	0	0	0	1				<1	0	0	0	0	0					0	
14 Aug.													0	<1	0	1						0	0	0	0		
21 - 22 Aug.								0	0	0	0						0	0	0	0							
28 - 29 Aug.	14	5	4	4	2	50	18	<1	0	0	0	0	<1	<1	0	1					0	0	0	0	0		
10 - 12 Sept.												0	0	3		1											
TOTAL CATCH	74	32	22		9	72		23	29	41		2	32	56	13		131	329	459		86	0	0	1			
CATCH/SET	2	2	1	2	<1	5	2	1	2	1	1	<1	1	2	2	1	8	14	27	16	3	0	0	<1	2		

1. Calculated from data in Appendix 3
 2. Sturgeon Bank
 3. Roberts Bank

TABLE 9 . CATCH PER SET¹ OF CHINOOK BY SAMPLE DATE AND SUB AREA FOR EACH GEAR TYPE USED IN THE FRASER RIVER ESTUARY IN 1973

GEAR	PURSE SEINE							TABLE SEINE							TOW NET										
	SB ²				RB ³			SB				RB			SB				RB						
AREA	1	2	3	\bar{X}	4	5	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}
SUB AREA (see fig. 16)																									
DATE																									
28 - 29 March	0	0	1	<1	3	0	2																		
10 - 11 April	0	0	0	0	0	0	0																		
25 - 26 April	0	0	0	0	0	0	0																		
7 - 9 May	4	0	0	1	<1	0	<1										1	68	34						
22 May	5	14	1	6	1	2	1										2	10	12	8					
1 June		2	2	2				0	2	1								0	0	0					
4 - 7 June	2				3	4	3	<1		<1							24		24	20	87		22	39	
14 June		36	8	22				8	0	3								99	185	134					
17 - 20 June	58			58	<1	40	14					0	0	6	0	2	23		23	20	17	4	35	19	
25 - 26 June	10	72	7	30				6	1	2	3						26	73	64	57					
3 - 4 July					4	12	6					2	13	11	18	10					2	22	0	6	7
9 - 11 July	5	6	4	5				5	10	5	6						2	6	4	5					
17 - 18 July					14	68	32					2	2	6	0	4					4	44	3	0	13
25 - 26 July	12	3	8	9				8	8	3	6						11	1	7	6					
30 July - 1 Aug.						19	19					8	6	<1	10	5					6	3	0	0	4
6 - 7 Aug.	2	2	4	3	43		43	7	4	<1	3	0				0	2	4	6	4	9				9
14 Aug.													2	1	0	2						1	1	1	1
21 - 22 Aug.								2	2	1	2						2	9	10	7					
28 - 29 Aug.	7	3	1	4	32	50	38	4	2	3	3	3	<1	2	4	2					8	2	0	0	5
10 - 12 Sept.												<1	<1	<1		1									
TOTAL CATCH	361	268	60		172	213		97	62	77		50	98	105	32		188	609	645		261	354	8	64	
CATCH/SET	11	15	3	10	7	15	10	5	4	2	3	3	4	4	5	4	11	26	38	25	10	25	1	9	13

1. Calculated from data in Appendix 3
 2. Sturgeon Bank
 3. Roberts Bank

TABLE 10. CATCH PER SET¹ OF CHUM BY SAMPLE DATE AND SUB AREA FOR EACH GEAR TYPE USED IN THE FRASER RIVER ESTUARY IN 1973

GEAR	PURSE SEINE						TABLE SEINE							TOW NET												
	SB ²			RB ³			SB			RB				SB			RB									
AREA	1	2	3	\bar{X}	4	5	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}	
(see fig. 16)																										
DATE																										
28 - 29 March	0	0	0	0	0	0	0																			
10 - 11 April	0	0	0	0	0	0	0																			
25 - 26 April	52	60	30	49	1	0	1																			
7 - 9 May	0	1	1	1	0	0	0										0		0	0						
22 May	0	0	0	0	0	0	0										0	0	0	0						
1 June		0	2	1					0	0	0							0	<1	<1						
4 - 7 June	0			0	0	2	<1	0			0						0			0	0	0		0	0	
14 June		0	0	0			0		0	0	0							0	0	0						
17 - 20 June	0			0	0	0	0					0	0	0	0	0	0			0	1	<1	0	0	1	
25 - 26 June	2	0	0	<1				0	0	<1	<1						0	0	0	0						
3 - 4 July					0	0	0					0	0	0	0	0					<1	0	1	0	<1	
9 - 11 July	1	0	0	<1				0	0	0	0						0	0	0	0						
17 - 18 July					0	0	0					0	0	0	0	0						0	0	0	0	
25 - 26 July	<1	0	0	<1				0	0	0	0						0	0	0	0						
30 July - 1 Aug.						0	0					0	<1	<1	0	<1					0	0	0	0	0	
6 - 7 Aug.	0	<1	0	<1	0		0	0	0	<1	<1	<1				<1	0	0	0	0	0				0	
14 Aug.													0	0	0	0						0	0	0	0	
21 - 22 Aug.								0	<1	2	1						0	0	0	0						
28 - 29 Aug.	0	4	0	1	0	0	0	1	0	1	1	0	0	<1	0	<1					0	0	0	0	0	
10 - 12 Sept.												0	0	0		0										
TOTAL CATCH	112	66	37		2	3		3	1	15		1	1	7	0		0	0	1		6	1	1	0		
CATCH/SET	3	4	2	3	0	<1	<1	<1	0	<1	<1	0	0	<1	0	<1	0	0	0	0	<1	0	<1	0	<1	

1. Calculated from data in Appendix 3
 2. Sturgeon Bank
 3. Roberts Bank

TABLE 11. CATCH PER SET¹ OF SOCKEYE BY SAMPLE DATE AND SUB AREA FOR EACH GEAR TYPE USED IN THE FRASER RIVER ESTUARY IN 1973

GEAR	PURSE SEINE								TOW NET							
	SB ²				RB ³				SB				RB			
AREA	1	2	3	\bar{X}	4	5	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}
SUB AREA	1	2	3	\bar{X}	4	5	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}
(see fig. 16)																
DATE																
28 - 29 March	0	0	0	0	0	0	0									
10 - 11 April	0	0	0	0	0	0	0									
25 - 26 April	0	0	0	0	0	0	0									
7 - 9 May	25	6	8	14	0	0	0	33		5	19					
22 May	1	0	2	1	0	0	0	2	1	0	1					
1 June		0	<1	<1					0	0	0					
4 - 7 June	<1			<1	1	0	<1	0			0	0	0		0	0
14 June		0	0	0					0	0	0					
17 - 20 June	0			0	0	0	0	0			0	0	<1	0	0	<1
25 - 26 June	0	0	0	0				0	0	0	0					
3 - 4 July					<1	0	<1					0	<1	0	0	<1
9 - 11 July	0	0	0	0				0	0	0	0					
17 - 18 July					0	0	0					<1	0	0	0	<1
25 - 26 July	0	0	0	0				0	0	0	0					
30 July - 1 Aug.						0	0					0	0	0	0	0
6 - 7 Aug.	0	0	0	0	0		0	0	0	0	0	0				0
14 Aug.													0	0	0	0
21 - 22 Aug.								<1	0	0						
28 - 29 Aug.	0	0	0	0	0	0	0					0	0	0	0	0
10 - 12 Sept.																
TOTAL CATCH	55	6	20		4	0		37	2	5		2	2	0	0	
CATCH/SET	2	<1	1	1	<1	0	<1	2	<1	<1	1	0	<1	0	0	<1

1. Calculated from data in Appendix 3
2. Sturgeon Bank
3. Roberts Bank

TABLE 12. CATCH PER SET¹ OF HERRING BY SAMPLE DATE AND SUB AREA FOR EACH GEAR TYPE USED IN THE FRASER RIVER ESTUARY IN 1973

GEAR	PURSE SEINE							TABLE SEINE							TOW NET										
	SB ²			RB ³				SB			RB				SB			RB							
AREA	1	2	3	\bar{X}	4	5	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}	1	2	3	\bar{X}	4	5	6	7	\bar{X}
SUB AREA (see fig. 16)																									
DATE																									
28 - 29 March	0	0	0	0	0	0	0																		
10 - 11 April	68	0	0	34	0	0	0																		
25 - 26 April	0	50	0	12	0	2	1																		
7 - 9 May	8	0	<1	3	4	1	3										15		3	9					
22 May	48	20	6	30	23	27	25										1010	67	4	318					
1 June		64	106	85					<1	52	31							309	12	160					
4 - 7 June	162			162	224	500	316	101			101						90			90	0	30		2007	295
14 June		242	132	188					200	9	73							3369	14	2027					
17 - 20 June	4200			4200	325	350	138					9	128	1128	900	1058	28			28	15	1513	260	16	420
25 - 26 June	114	512	333	320				189	196	147	169						114	127	57	103					
3 - 4 July					1308	404	1006					15	129	133	150	104					11	47	31	30	25
9 - 11 July	2376	868	350	1492				1657	54	46	531						16	30	52	28					
17 - 18 July					300	130	243					52	89	444	50	195					10	175	0	2	49
25 - 26 July	1350	250	200	788				100	180	65	98						76	12	10	29	5	<1			4
30 July - 1 Aug.						200	200					163	663	52	154	292							0	0	0
6 - 7 Aug.	162	110	130	141	3000		3000	742	14	166	308	103				103	155	11	26	56	27				27
14 Aug.													154	653	35	362						1	0	0	<1
21 - 22 Aug.								178	7	60	84						0	3	0	1					
28 - 29 Aug.	1250	250	1500	1062	300	60	220	406	12	105	177	104	26	1223	5	442					30	14	0	0	19
10 - 12 Sept.												165	755	125		418									
TOTAL CATCH	33370	4183	3816		10469	2604		10113	1116	3119		1720	7647	14778	1294		2992	11471	353		365	3562	291	2055	
CATCH/SET	981	232	201	583	403	186	327	482	74	89	202	90	283	568	216	326	176	499	21	260	14	254	48	294	116

1. Calculated from data in Appendix 3
 2. Sturgeon Bank
 3. Roberts Bank

early June, throughout July except between the Steveston Jetty and Canoe Pass, and again at the end of August (Table 8). Generally the highest average catches were made late in August, although relatively high catches were made between the North Arm and Iona Jetties in early July, and in the areas between the Iona Jetty and the Middle Arm and between Canoe Pass and the Roberts Bank Causeway in early June. Catch per set was not consistently high or low in any one area except between the Steveston Jetty and Canoe Pass where catches were consistently low. Highest catch per set varied irregularly between sub-areas. Purse seining was not conducted south of the Roberts Bank Causeway. Coho represented 12% and 17% of the purse seine caught salmon on Sturgeon and Roberts Banks respectively. In 1974, as in 1973, very few coho were caught at purse seine stations on Sturgeon Bank during the first week of April and May (Table 13).

Twenty-seven percent of the salmon caught by table seines on both Sturgeon and Roberts Banks in 1973 were juvenile coho. Most of these were caught in the last two weeks of June although a few were taken early in June and late in August (Table 8). Sampling with table seines was not conducted during the last two weeks in May when tow net catches of coho on Sturgeon Bank were high.

On Sturgeon Bank, the highest table seine catches of coho were made inshore at stations TS7 (between the North Arm and Iona Jetties) and TS5 (between the Iona Jetty and the Middle Arm), and offshore at station TS1 (between the Middle Arm and the Steveston Jetty). Relatively high catches were also made at stations TS9, TS12 and TS2. Over the total sampling period, average catch per set at inshore stations on Sturgeon Bank was only slightly higher than at offshore stations (Table 14). On Roberts Bank, however, average catch per set at offshore stations was twice that of inshore stations (Table 15). As with purse seine catches, table seine catches were consistently low between the Steveston Jetty and Canoe Pass. The average catch per set over the total sampling period was similar for Roberts Bank and Sturgeon Bank (Table 8).

Most of the juvenile coho caught on Sturgeon Bank were taken at tow net, whereas on Roberts Bank there was little difference in catch per set

TABLE 13. CATCH PER SET OF JUVENILE SALMON TAKEN IN PURSE SEINES
ON STURGEON BANK IN 1974

			PINK	COHO	CHINOOK	CHUM	SOCKEYE
DATE	SUB AREA	NO. OF SETS					
April 2, 3	1	2	1.5	0	0	0	0
	2	2	0	<1	0	0	0
	3	4	6.8	0	1	1	0
May 3	1	1	0	0	0	0	0
	2	1	1	0	1	1	0
	3	2	0	0	1	0	0
TOTAL CATCH			31	1	6	3	0
TOTAL SETS			12	12	12	12	12
CATCH/SET			2.6	<1	<1	<1	0

TABLE 14. CATCH PER SET¹ OF COHO TAKEN AT INSHORE AND OFFSHORE TOW NET AND TABLE SEINE STATIONS ON STURGEON BANK IN 1973

GEAR	TOW NET										TABLE SEINE													
	INSHORE					OFFSHORE					INSHORE					OFFSHORE								
SAMPLE STATION	4	3	2	1	\bar{X}	5	6	7	\bar{X}		7	5	4	3	2	\bar{X}	13	12	10	9	8	1	\bar{X}	
DATE																								
7 - 9 May	3			1	2																			
22 May	12	9	161	3	46	12	1	49	21															
1 June			66	78	72		0	18	9		0	0	0	0			0	7	0	0				2
4 - 7 June	78				78	15			15															
14 June		0	8	308	105		0	2	1			0					0	0		0				0
17 - 20 June	11				11	0			0															
25 - 26 June	0	0	0	0	0	0	0	0	0		15	28		2	5	12	3	7	1	7		17	7	
3 - 4 July																								
9 - 11 July	0	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0	0		0	0	0
17 - 18 July																								
25 - 26 July	0	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0	0		0	0	0
30 July - 1 Aug.																								
6 - 7 Aug.	0	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0	0		0	0	0
14 Aug.																								
21 - 22 Aug.	0	0	0	0	0	0	0	0	0		0	0		0	0	0	0	0	0	0		0	0	0
28 - 29 Aug.											0	0		0	0	0	0	0	0	0	1	0	0	<1
10 - 12 Sept.																								
TOTAL CATCH	104	93	235	390		27	1	69			15	28	0	2	5		3	14	1	7	1	17		
TOTAL SETS	9	7	8	9		8	8	8			7	6	2	6	7		8	8	7	7	7	6		
CATCH/SET	12	13	29	43	25	3	<1	9	4		2	5	0	<1	1	2	<1	2	<1	1	<1	3	1	

1. Calculated from data in Appendix 3

TABLE 15. CATCH PER SET¹ OF COHO TAKEN AT INSHORE AND OFFSHORE
TABLE SEINE STATIONS ON ROBERTS BANK IN 1973

GEAR	TABLE SEINES												
	INSHORE							OFFSHORE					
SAMPLE STATION	25	23	18	20	21	22	\bar{X}	15	16	17	19	24	\bar{X}
DATE													
1 June													
4 - 7 June													
14 June													
17 - 20 June			0	0	2	13	4	1	5	11	34	1	10
25 - 26 June													
3 - 4 July	0	0	8	0	0	0	1	0	1	0	0	0	<1
9 - 11 July													
17 - 18 July	0	0	0	0	0	0	0	0	0	0	0	0	0
25 - 26 July													
30 July - 1 Aug.	0	0	0	0	6	0	1	0	0	6	0	4	2
6 - 7 Aug.	0	0					0	1					1
14 Aug.			0	0	0	0	0		0	0	1	0	<1
21 - 22 Aug.													
28 - 29 Aug.	0	0	0	0	0	0	0	0	0	1	2	0	1
10 - 12 Sept.	0	0	0	0			0	0	0	0	6		2
TOTAL CATCH	0	0	8	0	8	13		2	6	18	43	5	
TOTAL SETS	6	6	7	7	6	6		7	7	7	7	6	
CATCH/SET	0	0	1	0	1	2	1	<1	1	3	6	1	2

1. Calculated from data in Appendix 3

between gear types. However, tow netting was not conducted on Roberts Bank on May 22 or June 1 when catches on Sturgeon Bank were high. No coho were caught by tow net on either Sturgeon or Roberts Banks after June 20 (Table 8). On Sturgeon Bank, 37% of the tow net caught salmon were coho compared with 11% on Roberts Bank.

On Roberts Bank, all but 8 coho were taken at the inshore station TN3. On Sturgeon Bank catch per set was highest between the Steveston Jetty and the Middle Arm and decreased with distance north of the South Arm of the Fraser River. Ninety percent of the tow net caught coho on Sturgeon Bank were taken at inshore stations (Table 14).

6.1.3.2. Chinook

Juvenile chinook salmon were caught at the beginning of the 1973 sampling period at the end of March in the areas between the Middle Arm and the Steveston Jetty on Sturgeon Bank and between the Steveston Jetty and Canoe Pass on Roberts Bank (Table 9). They were caught again on May 7 and catches continued until sampling ceased at the end of August. The highest catches per set were made between early June and the end of July on Sturgeon Bank, while on Roberts Bank, catches per set were highest from mid-June to the end of August. Over the total sampling period, catch per set was highest north of the Middle Arm on Sturgeon Bank, lower in the area between the Steveston Jetty and Canoe Pass, and much lower in the area between the Steveston Jetty and the Middle Arm (Table 9). Chinook made up 62% of the purse seine caught salmon on Sturgeon Bank and 81% on Roberts Bank. In 1974, juvenile chinook were taken at purse seine stations in early April and May but as in 1973 the catch per set was low (Table 13).

Table seine gear accounted for the lowest catch of chinook on the banks, but as for the other gear types, chinook accounted for most of the salmon caught (68% for Sturgeon Bank and 72% for Roberts Bank). Chinook were caught between June 1 and September 10, with the highest catches per set taken in July in all sub-areas (Table 9). Table seine catch per set of chinook over the total sample period ranged between 2 and 5 for all sub-areas.

Offshore table seine stations on both Sturgeon and Roberts Banks produced higher catches of chinook per set than inshore stations until the end of July. After July, average catch per set of chinook at inshore table seine stations was equal or greater than that at offshore table seine stations (Tables 16 and 17).

Most of the chinook caught on Sturgeon and Roberts Banks were taken by tow net. Chinook formed 60% of the salmon tow net catch on Sturgeon Bank and 87% on Roberts Bank. Chinook were caught by tow net throughout the sampling period with highest catches early in the season from May 9 to the end of June (Table 9). The tow net chinook catch per set over the total sampling was considerably lower for Roberts Bank. However, tow netting was not conducted on Roberts Bank during May or the weeks in June when the highest catches per set were made on Sturgeon Bank. Tow net chinook catch per set was similar on Roberts and Sturgeon Banks during sampling periods when both areas were sampled (Table 9). The difference between chinook catches at offshore and inshore tow net stations on Sturgeon Bank was not as great as for coho (Table 16). Inshore catches were highest at stations TN1 off the Richmond dyke, and TN3 immediately south of the Iona Jetty. Catches of chinook at other tow net stations were considerably smaller (Table 16).

6.1.3.3. Chum

Most of the juvenile chum salmon caught on Sturgeon Bank were taken in purse seines on April 25. Chum salmon accounted for 19% of the 1973 purse seine caught salmon on Sturgeon Bank but only 1% on Roberts Bank. No chum were taken by purse seine after the first week in June on Roberts Bank (Table 10).

On Sturgeon Bank, most of the juvenile chum salmon caught by table seine were taken in the area between the Middle Arm and the Steveston Jetty during August. Of the 9 chum salmon caught on Roberts Bank by table seine, 7 were taken in the area between the Roberts Bank Causeway and the Tsawwassen Ferry Terminal during August. No chum were caught by table seine south of the Tsawwassen Ferry Terminal. Chum salmon accounted for only 5% of the table seine caught salmon on Sturgeon Bank and 2% on Roberts Bank (Table 10).

TABLE 16. CATCH PER SET¹ OF CHINOOK TAKEN AT INSHORE AND OFFSHORE TOW NET AND TABLE SEINE STATIONS ON STURGEON BANK IN 1973

GEAR	TOW NET									TABLE SEINE												
	INSHORE					OFFSHORE				INSHORE					OFFSHORE							
SAMPLE STATIONS	4	3	2	1	\bar{X}	5	6	7	\bar{X}	7	5	4	3	2	\bar{X}	13	12	10	9	8	1	\bar{X}
DATE																						
7 - 9 May	1				68 34																	
22 May	4	4	10	0	4	0	17	24	14													
1 June			0	0	0		0	0	0			0		0	0	0	5	0				2
4 - 7 June	45				45	3			3	0					0				1	0		<1
14 June		223	35	309	189		40	61	50			8		8		0	0					0
17 - 20 June	12				12	35			35													
25 - 26 June	16	116	32	100	66	36	70	27	44	0	0		0	0	0	3	6	2	0	19	0	5
3 - 4 July																						
9 - 11 July	4	12	7	6	7	1	0	3	1	4	9		5	0	4	8	9	10	7	3	2	6
17 - 18 July																						
25 - 26 July	12	0	1	11	6	10	3	3	5	3	8		6	2	5	3	4	9	17	4	2	6
30 July - 1 Aug.																						
6 - 7 Aug.	5	12	0	11	7	0	1	2	1	15	4		0	0	5	0	2	3	2	3	0	2
14 Aug.																						
21 - 22 Aug.	2	18	6	18	11	2	2	2	2	3	3		3	0	2	2	2	1	1	2	0	1
28 - 29 Aug.										3	1		0	5	5	0	7	4	2	8	1	4
10 - 12 Sept.																						
TOTAL CATCH	101	385	91	523		87	133	122		28	25	8	14	7		16	35	29	30	39	5	
TOTAL SETS	9	7	8	9		8	8	8		7	6	2	6	7		8	8	7	7	7	6	
CATCH/SET	11	55	11	58	33	11	17	15	14	4	4	4	2	1	3	2	4	4	4	6	1	4

1. Calculated from data in Appendix 3

TABLE 17. CATCH PER SET¹ OF CHINOOK TAKEN AT INSHORE AND OFFSHORE
TABLE SEINE STATIONS ON ROBERTS BANK IN 1973

GEAR	TABLE SEINES												
	INSHORE							OFFSHORE					
SAMPLE STATION	25	23	18	20	21	22	\bar{X}	15	16	17	19	24	\bar{X}
DATE													
1 June													
4 - 7 June													
14 June													
17 - 20 June			0	5	0	0	1	0	0	0	0	17	3
25 - 26 June													
3 - 4 July	0	0	44	4	4	18	12	4	1	7	18	18	10
9 - 11 July													
17 - 18 July	1	0	0	2	1	0	1	3	1	8	0	23	7
25 - 26 July													
30 July - 1 Aug.	5	0	0	2	0	10	3	8	5	19	0	0	6
6 - 7 Aug.	0												0
14 Aug.		4	2	0	1	0	1		1	3	3	0	2
21 - 22 Aug.													
28 - 29 Aug.	1	0	0	0	3	4	1	1	0	1	3	0	1
10 - 12 Sept.	2	0	0	0			<1	0	1	1	1		1
TOTAL CATCH	9	4	46	13	9	32		16	9	39	25	58	
TOTAL SETS	6	6	7	7	6	6		7	7	7	7	6	
CATCH/SET	2	1	7	2	2	5	2	2	1	6	4	10	4

1. Calculated from data in Appendix 3

Very few juvenile chum salmon were taken at tow net stations (Table 10). Chum formed less than 1% of tow net caught salmon on Sturgeon and Roberts Banks. Only one chum was taken on Sturgeon Bank while eight were taken on Roberts Bank; six in the area between the Steveston Jetty and Canoe Pass during late June.

6.1.3.4. Sockeye

Sockeye formed 7% of the 1973 purse seine caught salmon on Sturgeon Bank but less than 1% on Roberts Bank. On Sturgeon Bank, sockeye were present in purse seine catches between May 7 and June 7. Catch per set during this period ranged from 25 fish in the area between the North Arm and Iona Jetties to 0 in the area between the Iona Jetty and the Middle Arm (Table 11). In 1974, juvenile sockeye were not caught in purse seine stations on Sturgeon Bank in the first week of April or May (Table 13). On Roberts Bank, sockeye were present in 1973 purse seine catches in the area between the Steveston Jetty and Canoe Pass in early June and early July. However, catch per set never exceeded 1 fish (Table 11). No juvenile sockeye were caught with table seine gear.

As with purse seine catches, most of the tow net caught sockeye were taken on Sturgeon Bank during May, primarily in the area between the North Arm and Iona Jetties. Catch per set ranged from 0 to 33 sockeye during this time. Roberts Bank tow net catches of sockeye were sparse and spread from mid-June to mid-July averaging only 0.5 sockeye per set.

6.1.3.5. Pink

Only 3 juvenile pink salmon were caught during the 1973 sampling period (Appendix 3). In 1974, 31 pink fry were caught at purse seine stations on Sturgeon Bank on April 2 and 3, and May 3. Twenty-seven of these fish were caught in the area between the Middle Arm and the Steveston Jetty.

6.1.3.6. Herring

During sampling in 1973, juvenile herring were first caught in purse seines on April 10 in the area between the North Arm and Iona Jetties. Juvenile herring were not present in other areas

of the banks until the end of April and the second week in May. The average catch per set in all sub-areas increased throughout May and June and remained high until the end of August when sampling was terminated. Catch size varied considerably with time and area. No migrational pattern or response to observed oceanographic phenomenon could be identified. The highest average catch varied from 500 fish in the area between Canoe Pass and the Roberts Bank Causeway to 4,200 fish in the area between the North Arm and Iona Jetties. Over the period sampled, the highest average catches were made in the area between the North Arm and Iona Jetties where catches averaged twice that of the area between the Steveston Jetty and Canoe Pass and four times that of the other areas on Sturgeon and Roberts Banks. Herring catches were not recorded in 1974 purse seine samples.

As with purse seine catches, the average tow net catches of herring on Sturgeon Bank were highest in the area between the North Arm and Iona Jetties. On Roberts Bank, the highest average catch over the period sampled was in the area between the Roberts Bank Causeway and the Tsawwassen Ferry Terminal (Table 12). The catch per set of herring taken at offshore table seine stations was much higher than at inshore stations for all sample sub-areas on Sturgeon and Roberts Banks except the area between the Iona Jetty and the Middle Arm (Tables 18 and 19). Stations TS 19 and TS 17 on Roberts Bank (Table 19) recorded the highest average catches followed by TS 8 and TS 9 on Sturgeon Bank (Table 18).

Unlike purse and table seine catches, the average tow net catches of herring were highest in June and very low after mid-July, particularly on Roberts Bank (Table 12) and at offshore stations on Sturgeon Bank (Table 18). Except for an exceptionally high catch at station TN3 in mid-June (Table 18), the average tow net catch of herring on Sturgeon Bank was much lower than table seine catches in the same area. Again, except for station TN3, average offshore tow net catches tended to be higher than inshore catches (Tables 18 and 19).

TABLE 18. CATCH PER SET¹ OF HERRING TAKEN AT INSHORE AND OFFSHORE TOW NET AND TABLE SEINE STATIONS ON STURGEON BANK IN 1973

GEAR	TOW NET										TABLE SEINE											
	INSHORE					OFFSHORE					INSHORE					OFFSHORE						
SAMPLE STATION	4	3	2	1	\bar{X}	5	6	7	\bar{X}	7	5	4	3	2	\bar{X}	13	12	10	9	8	1	\bar{X}
DATE																						
7 - 9 May	15			3	9																	
22 May	19	0	0	0	5	2000	200	7	736													
1 June			93	16	54		525	8	266			0		0	0	5	150	1				52
4 - 7 June	175				175	4			4	2				2					300	0		150
14 June		10000	85	7	3364		22	21	21			200		200		5	13					9
17 - 20 June	12				12	45			45													
25 - 26 June	17	160	110	4	73	210	111	110	144	225	310		125	75	184	235	180	70	41	300	118	157
3 - 4 July																						
9 - 11 July	30	80	7	20	34	3	3	85	30	120	100		50	0	68	4	165	9	2850	2000	13	840
17 - 18 July																						
25 - 26 July	152	16	19	19	52	0	0	0	0	30	160		48	200	110	11	60	200	150	120	5	91
30 July - 1 Aug.																						
6 - 7 Aug.	155	20	12	53	60	155	0	0	52	1950	25		1	1	494	790	0	3	275	0	40	185
14 Aug.																						
21 - 22 Aug.	0	8	0	0	2	0	0	0	0	85	1		83	40	52	88	85	13	60	388	21	109
28 - 29 Aug.										17	20		13	26	19	7	71	4	0	1200	410	282
10 - 12 Sept.																						
TOTAL CATCH	595	10284	326	122		2417	861	231		2429	616	200	320	342		1145	724	300	3676	4008	588	
TOTAL SETS	9	7	8	9		8	8	8		7	6	2	6	7		8	8	7	7	7	6	
CATCH/SET	64	1469	41	14	343	302	108	29	146	347	103	100	53	49	139	143	91	43	525	572	98	243

1. Calculated from data in Appendix 3

TABLE 19. CATCH PER SET¹ OF HERRING TAKEN AT INSHORE AND OFFSHORE
TABLE SEINE STATIONS ON ROBERTS BANK IN 1973

GEAR	TABLE SEINES													
	INSHORE							OFFSHORE						
SAMPLE STATION	25	23	18	20	21	22	\bar{X}	15	16	17	19	24	\bar{X}	
DATE														
1 June														
4 - 7 June														
14 June														
17 - 20 June			250	1000	12	900	540		12	53	82	3000	500	729
25 - 26 June														
3 - 4 July	1	0	7	82	150	150	65		40	100	409	200	100	170
9 - 11 July														
17 - 18 July	2	0	132	300	275	50	126		145	150	75	1	1200	314
25 - 26 July														
30 July - 1 Aug.	58	0	150	60	136	154	93		350	1	2500	0	10	572
6 - 7 Aug.	120						120		86					86
14 Aug.		2	2	0	110	35	30			12	600	2500	1	778
21 - 22 Aug.														
28 - 29 Aug.	65	27	65	1	110	5	46		210	0	0	4400	380	998
10 - 12 Sept.	425	120	0	0			136		70	1500	1400	250		805
TOTAL CATCH	671	159	606	1443	793	1294			917	1816	5066	10351	2191	
TOTAL SETS	6	6	7	7	6	6	38		7	7	7	7	6	34
CATCH/SET	112	26	86	207	132	216	131		131	259	724	1479	365	598

1. Calculated from data in Appendix 3

6.2 Length-Weight Analysis

Average lengths and weights for each salmon species caught in 1973 were calculated for each sample date according to gear type, sample station and sub-area. The average, minimum and maximum lengths and weights, total catch and sample size for each station and sub-area are listed in Appendix 4. Stations where samples were not measured are not listed or included in the total catch figures. All salmon to a maximum of 10 of each species at each station were measured for each catch. To illustrate the seasonal changes in the average size of juvenile salmon caught in the Fraser River estuary, average lengths have been plotted by sample date for each species, gear type and sub-area (Figures 17 to 21). The patterns of seasonal changes in average weight were similar to changes in length and have therefore not been described in this text.

Seasonal changes in the average size of juvenile salmon caught in the Fraser River estuary can be attributed to a change in the proportion of different age classes migrating downstream, migration of larger or smaller fish of the same age class into or out of the area, growth of individuals rearing in the area, or a combination of these factors. Determination of the extent to which the change in average length is due to growth of juveniles rearing in the area or a change in the proportion of different age classes cannot be made from the present study and requires further information with respect to downstream migrations along with an extensive mark-recapture program.

By comparing the position of the mean length within the range of lengths recorded for any one species on each sample date, one can estimate the extent to which a change in the average length is due to a change in the proportion of relatively large and small fish. However, because of the considerable size overlap between age classes, and difference in mean size of similar aged fish from different streams, difference in length of juvenile salmon cannot be attributed to age difference except in early spring when the difference between newly emerged and year old or older fish is maximum.

6.2.1 The Fraser River

6.2.1.1 Coho

In the North Arm of the Fraser, the size ranges of coho caught by beach seines and tow nets were similar although the average length of coho caught by tow nets was consistently larger than that of coho taken in beach seines (Figure 17). The average length of coho caught

Fig. 17. Length, Range, Mean (●), and Sample Size (n), of Coho caught by Tow Net (---) and Beach Seine (—) in the Fraser River in 1973.

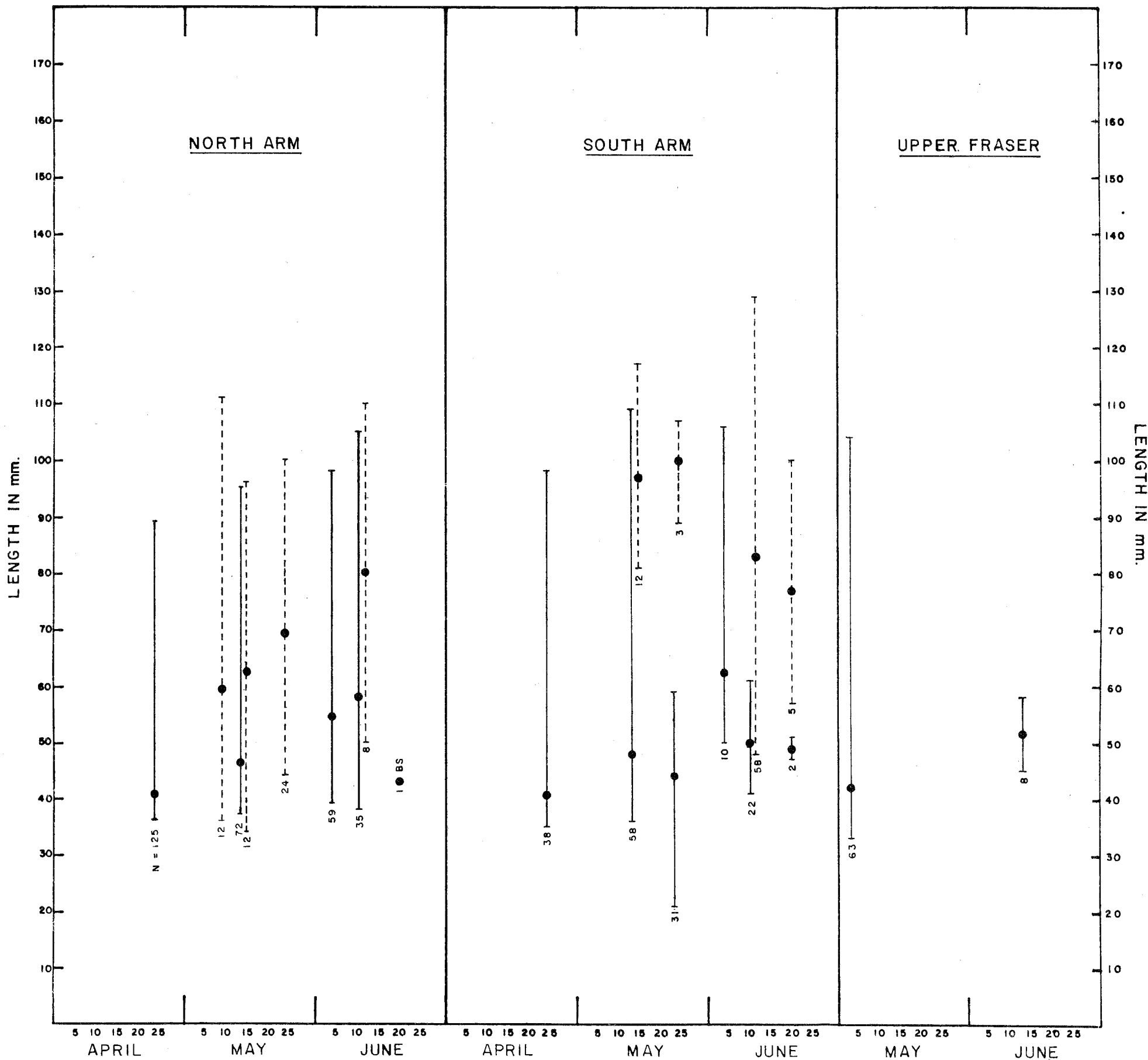


Fig. 18. Length, Range, Mean (●), and Sample Size (n), of Chinook caught by Tow Net (---) and Beach Seine (—) in the Fraser River in 1973.

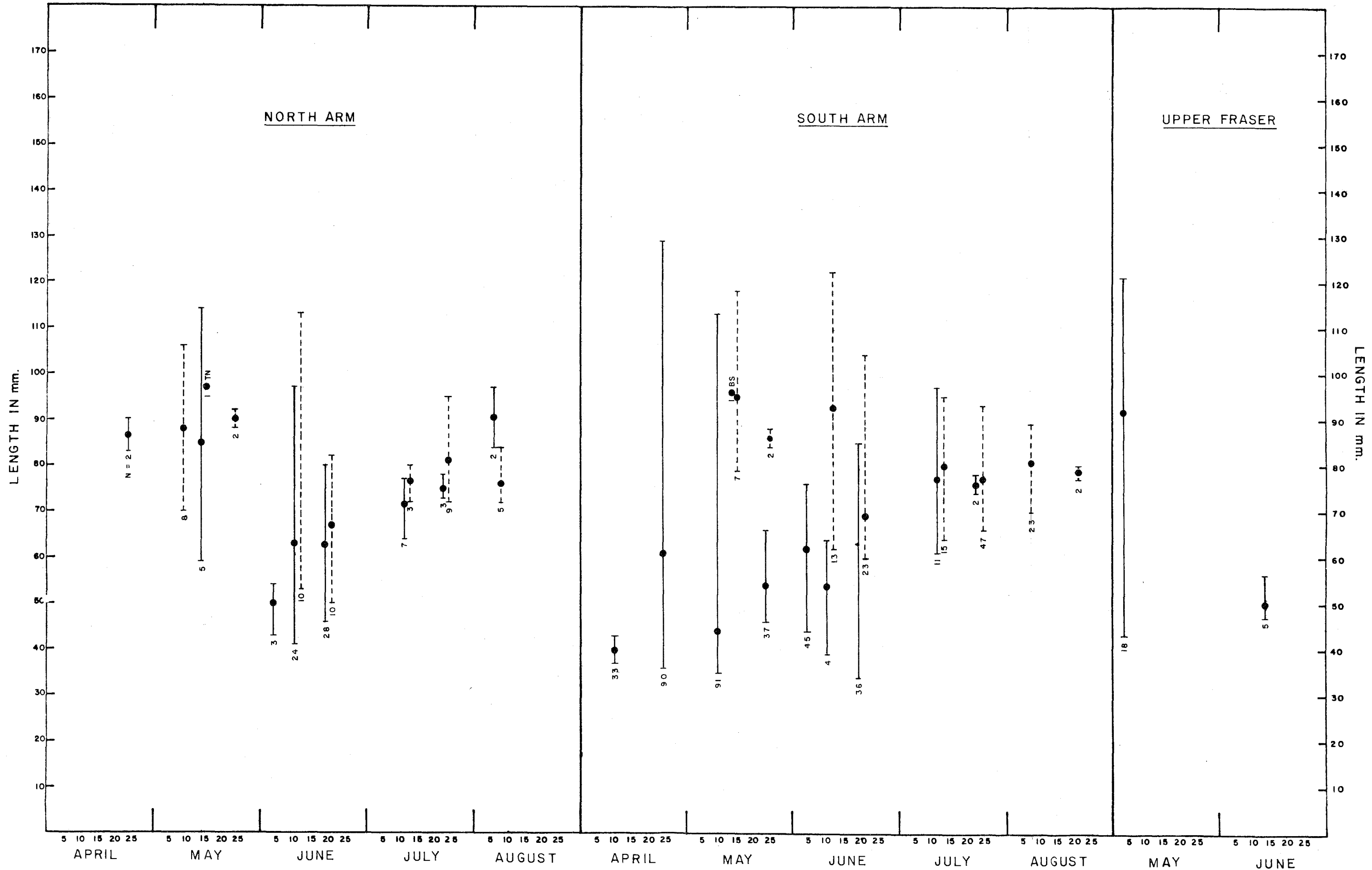


Fig. 19. Length, Range, Mean (●), and Sample Size (n), of Chum caught by Tow Net (---) and Beach Seine (—) in the Fraser River in 1973.

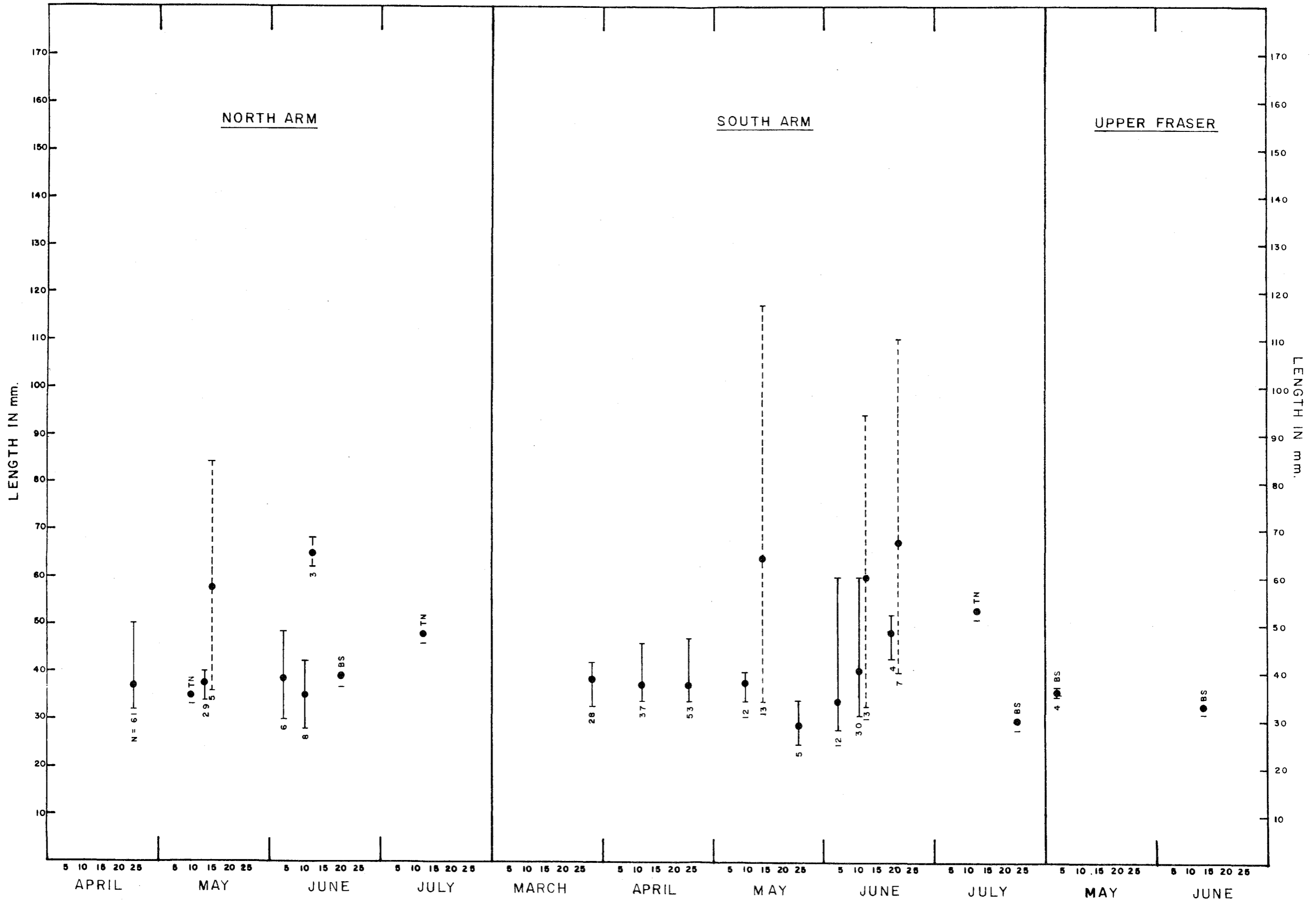


Fig. 20. Length, Range, Mean (●), and Sample Size (n), of Sockeye caught by Tow Net (---) and Beach Seine (—) in the Fraser River in 1973.

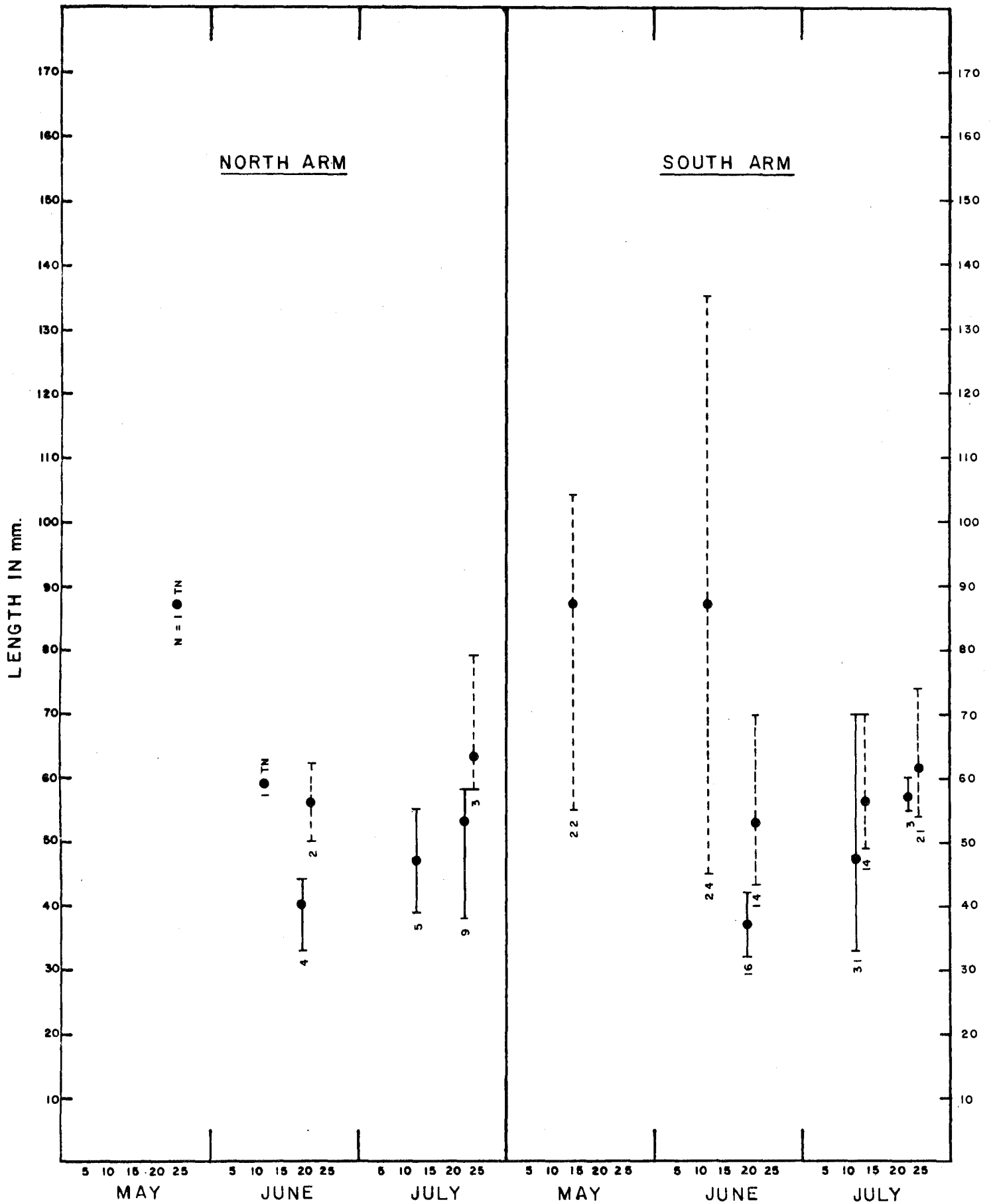
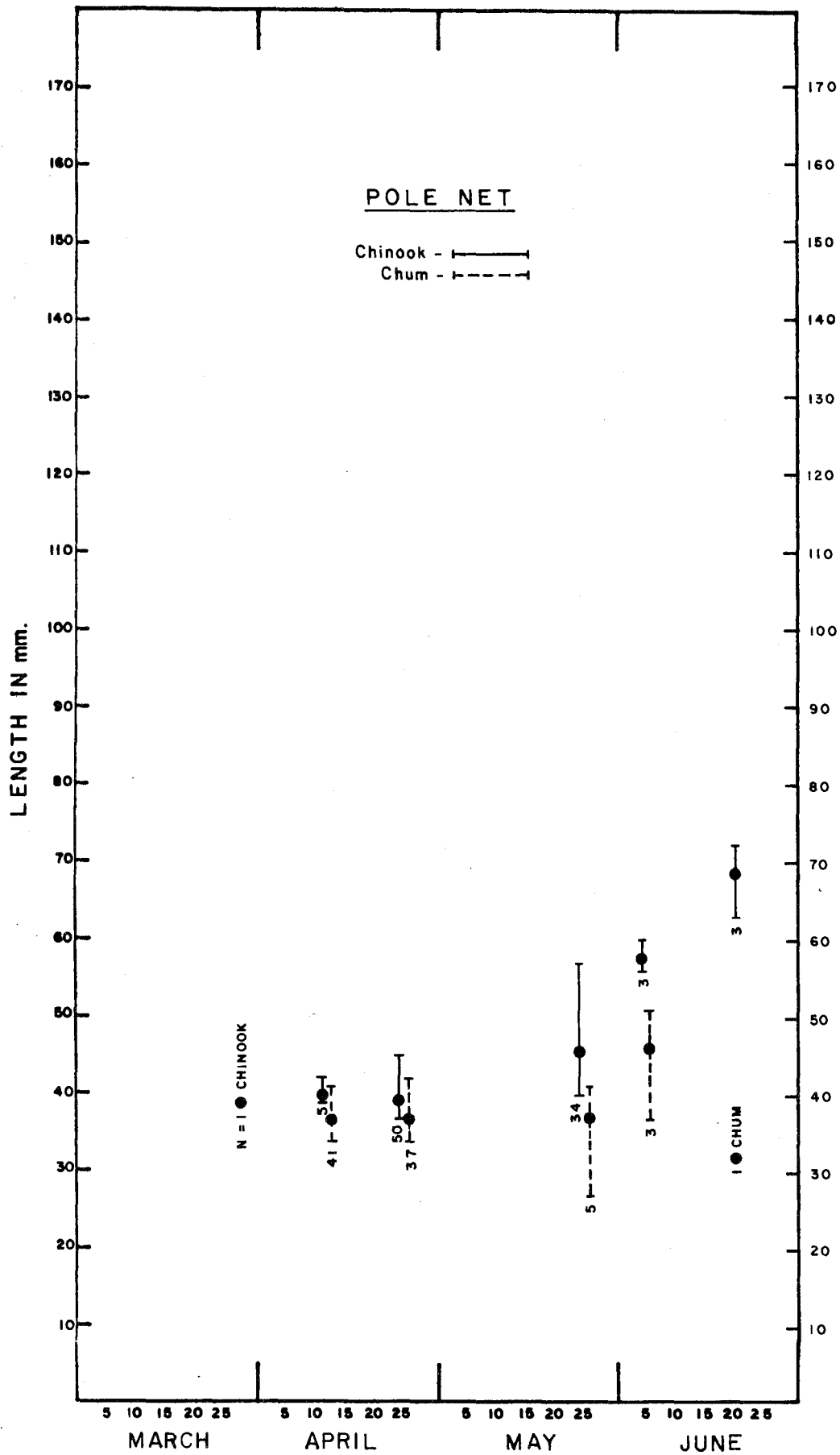


Fig. 21. Length, Range, Mean (●), and Sample Size (n), of Chinook (—) and Chum (---) caught by Pole Net on Duck, Barber, and Woodward Islands in the Fraser River in 1973.



in beach seines increased from 40 to 58mm between April 25 and June 11, while that of tow net caught coho increased from 59 to 79mm between May 9 and June 11. For both gear types, the proportion of larger fish in the catch increased slightly with time.

In the South Arm of the Fraser, the difference between the average size of coho caught in tow nets and beach seines was more pronounced than in the North Arm. No juvenile coho smaller than 80mm were taken in tow nets prior to June and on several days no coho larger than 61 mm were taken in beach seines (Figure 17). From April 24 to June 20 the size of coho caught by beach seines in the South Arm ranged from 21 to 109mm. The average length increased from 41mm in April to 62mm on June 4 then decreased to 50mm for the remainder of June. Few coho over 60mm were caught at beach seines in the South Arm except on June 4.

The average size of coho caught by tow nets in May in the South Arm indicates that they were probably a year older than the comparatively small coho caught by beach seines throughout the period sampled. In June, the average size of tow net caught coho in the South Arm decreased as the proportion of smaller fish in the catch increased.

The average size of coho caught by beach seines in the Upper Fraser was similar to that of coho caught in the Lower Fraser when sampled at the same time (Figure 17).

6.2.1.2. Chinook

As for the coho, the average length of chinook taken in tow nets in the North Arm was only slightly greater than that of chinook caught by beach seines in the same area. Changes with time were also similar (Figure 18). In April and May the catch with both gear types consisted of large (means = 85-90 mm; range = 59-106 mm) juveniles, most of which were probably yearlings. In June the average length of chinook decreased as the proportion of chinook smaller than 70 mm increased markedly. These fish are assumed to be young of the year. The average length of chinook increased again in July and August.

In the South Arm, during May and early June the average length of chinook caught in tow nets was much greater than for those caught in beach seines. This relationship did not persist in July and August (Figure 18). In early April, chinook caught in beach seines in the South Arm averaged only 40mm with none larger than 45mm, however by the end of April the average size increased to 61 mm. After May, the average length of beach seine caught chinook increased steadily to 78 mm by the end of July. The average length of chinook taken in pole nets was similar to that of beach seine caught chinook for the same sample periods. Except in late April, beach seine and pole net caught chinook in the South Arm were primarily young of the year fish, while tow net caught chinook in May and early June were year old fish.

6.2.1.3. Chum

Where sample size was sufficient for comparison, the mean length of tow net caught juvenile chum was greater than that of chum taken in beach seines or pole nets. Tow net caught chum average 56 to 68 mm in length and ranged from 33 to 117 mm, whereas no chum greater than 60 mm were taken in beach seines or pole nets. The larger juvenile chum (>70mm) caught in tow nets were presumably year old fish while beach seine and pole net caught chum were all fish of the year.

6.2.1.4. Sockeye

The average length of sockeye first taken in beach seines on June 20 was smaller than that of sockeye caught by tow net on the same day. However, by the end of July beach seine caught sockeye were as large as those caught in tow nets. Tow net caught sockeye at the end of May and in early June averaged 86 mm and ranged in size from 45 to 135 mm. By mid June the average length of sockeye caught in tow nets decreased to 52mm and did not include any fish over 70 mm long.

6.2.2 Sturgeon and Roberts Bank

6.2.2.1 Coho

During May and early June when the largest number of juvenile coho were taken both in the Fraser and on the banks, the size of coho taken on the banks ranged from 38 to 136 mm in length for purse seine caught fish and from 48 to 119 mm for tow net caught fish (Figure 22). Most of the coho taken on the banks at this time were longer than 60 mm, and are comparable in size to the larger juveniles taken primarily by tow nets in the Fraser River, particularly the south arm, in May (Figure 17).

During sampling periods when the numbers of coho caught by each gear type were sufficient to allow comparisons, the average length of juvenile coho caught in purse seines was greater than that of coho taken in tow nets or table seines (Figures 22 and 26). From mid-June to the end of August, the average length of coho more than doubled in all sub-areas where samples were taken. This rapid growth of juveniles evident in summer on the banks may also occur during spring, and in part, account for the lack of coho smaller than 50 mm in the catch during May and June. However, this absence of small coho, and the difference in average length of coho between gear types may also be due to difference in net selectivity, depth sampled and ability of different-sized fish to avoid capture in the open waters of the banks.

Sample sizes were not large enough to determine if the average size of coho varied with sub-area.

6.2.2.2 Chinook

On both banks, the average length of juvenile chinook salmon taken in purse seines was greater than that of chinook caught in table seines. Table seine caught chinook were, in turn, larger than chinook taken in tow nets (Figures 23 and 27). The average length of chinook taken at offshore table seine stations tended to be greater than that of chinook taken at inshore stations in the areas south of the Iona jetty on Sturgeon Bank and south

of Canoe Pass on Roberts Bank. The average length of chinook caught at in-shore table seine stations was greater than that of chinook caught at offshore stations in the area between the North Arm and Iona jetties. Tow net catches of chinook showed a trend for larger fish at offshore stations only in the area between the Middle Arm and the Steveston Jetty (Appendix 4).

During May, chinook caught in purse seines ranged from 60 to 400mm in length, whereas those taken in tow nets ranged from 50 mm to only 120 mm in length. Both gear types caught predominately 80 to 110mm fish presumed to be year-old juveniles. However, tow net catches contained a greater proportion of small fish comparable in size to young of the year fry taken by beach seines in the river.

The average length of purse seine caught chinook decreased in June as no fish longer than 200 mm were taken but increased through July and August. Table seine caught chinook also showed an increase in average length, however, this trend was not obvious for chinook caught in tow nets except in the area between the Steveston Jetty and Canoe Pass and between the North Arm Jetty and the Middle Arm in August (**Figures 23 and 27**)

Because of the wide size range in lengths of chinook taken on the banks and small sample sizes in most sample areas at the beginning and end of the sample program, it is difficult to detect changes in the average length of chinook taken by the same gear in different sample areas. However, in the area between the North Arm and Iona Jetties where the largest number of chinook were measured, the purse seine catch included a larger number of fish greater than 300 mm in length than for other sample areas. In addition, for similar sample periods the average length of purse seine caught chinook in this area was generally greater than in other areas sampled. During May, the average length of tow net caught chinook was also greater in the area between the North Arm and Iona Jetties than in other areas, while in the area between the Steveston Jetty and Canoe Pass the average length of tow net caught chinook was smaller than in other sample areas.

6.2.2.3. Chum

Juvenile chum salmon taken in purse seines on Sturgeon Bank during April averaged 40 mm and ranged from 33 to 54 mm in length (Figure 24). These were comparable in size to chum taken at the same time by beach seines and pole nets in the Fraser (Figure 17). Although only seven chum were taken by purse seines in July and August, they were over three times as large as chum taken in April, ranging in size from 130 to 220 mm.

6.2.2.4. Sockeye

Sample sizes of juvenile sockeye are too small for conclusions to be drawn, although juveniles taken in the area between the North Arm and Iona Jetty and between the Middle Arm and the Steveston Jetty on Sturgeon Bank in May were similar in size to those taken in the Fraser at the same time (Figure 25).

Fig. 22a. Length, Range, Mean (\bar{x}), and Sample Size (n), of Coho caught by Tow Net (---), Purse Seine (—), and Table Seine (.....) between North Arm Jetty and Iona Island Jetty on Sturgeon Bank in 1973.

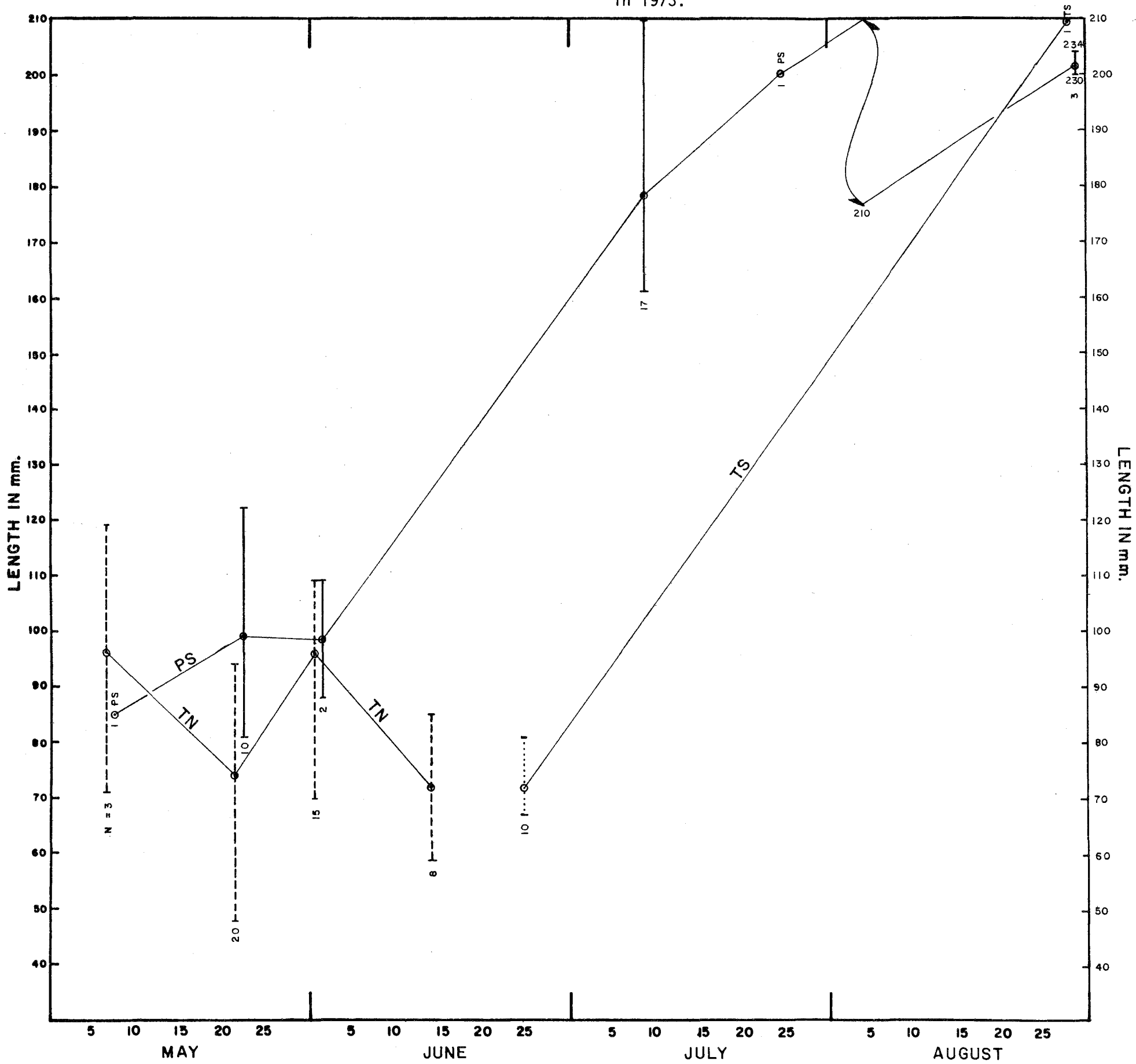


Fig. 22b. Length, Range, Mean (\odot), and Sample Size (n), of Coho caught by Tow Net (---), Purse Seine (—), and Table Seine (.....) between Iona Island and Middle Arm on Sturgeon Bank in 1973.

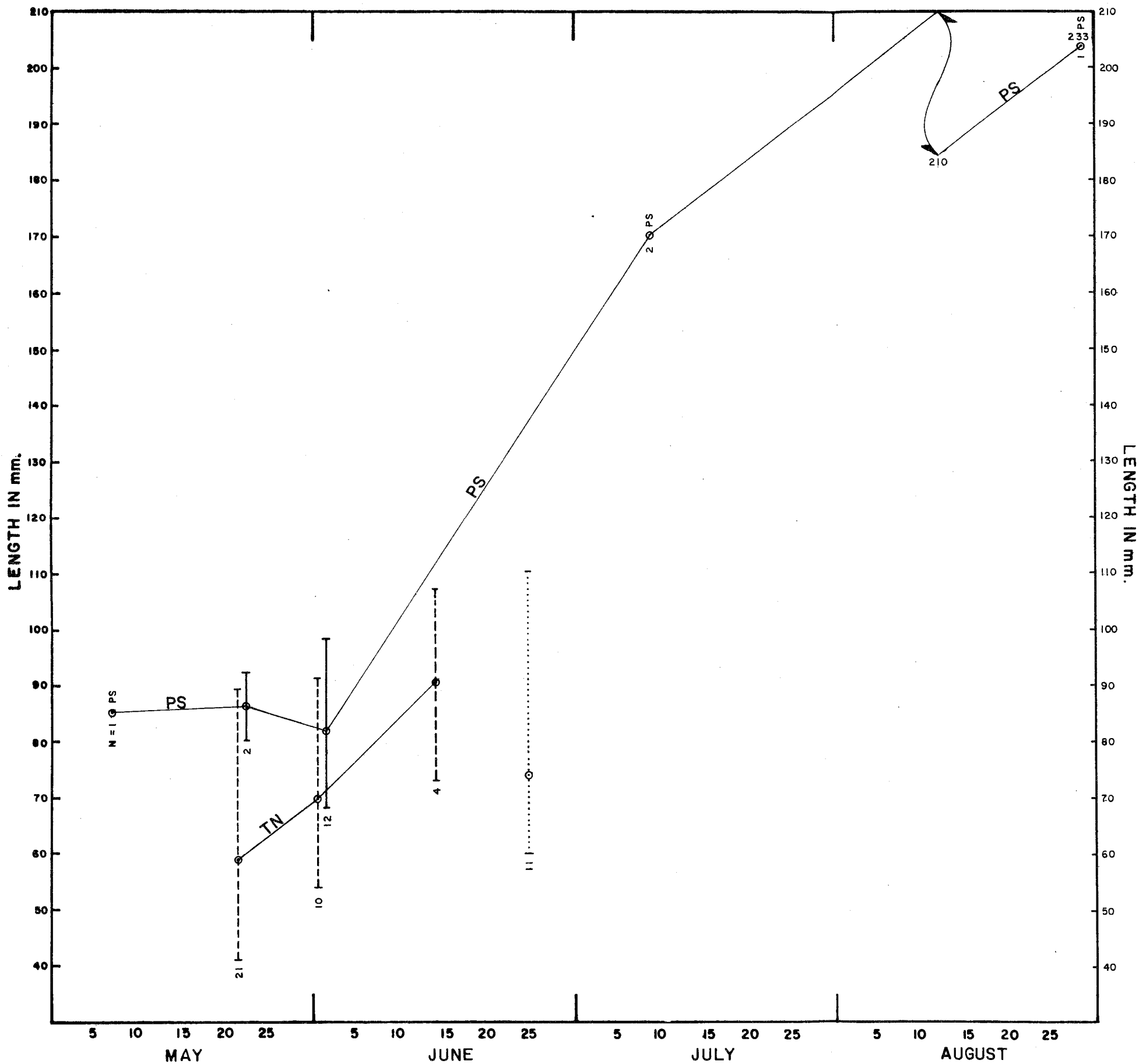


Fig. 22c. Length, Range, Mean (\odot), and Sample Size (n), of Coho caught by Tow Net (---), Purse Seine (—), and Table Seine (.....) between Middle Arm and Steveston on Sturgeon Bank in 1973.

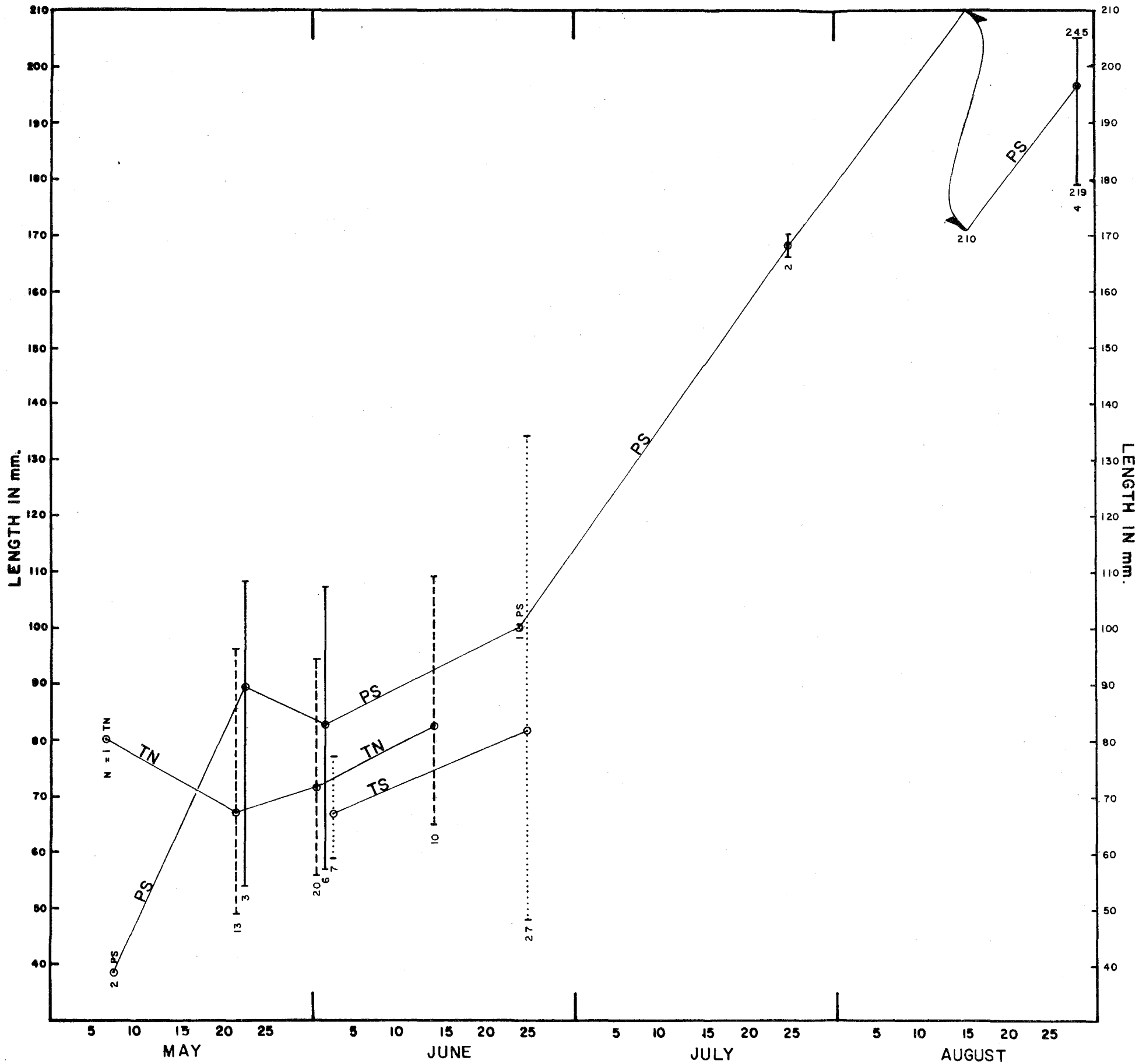


Fig. 23a. Length, Range, Mean (\odot), and Sample Size (n), of Chinook caught by Tow Net (---), Purse Seine (—), and Table Seine (.....) between North Arm Jetty and Iona Island Jetty on Sturgeon Bank in 1973.

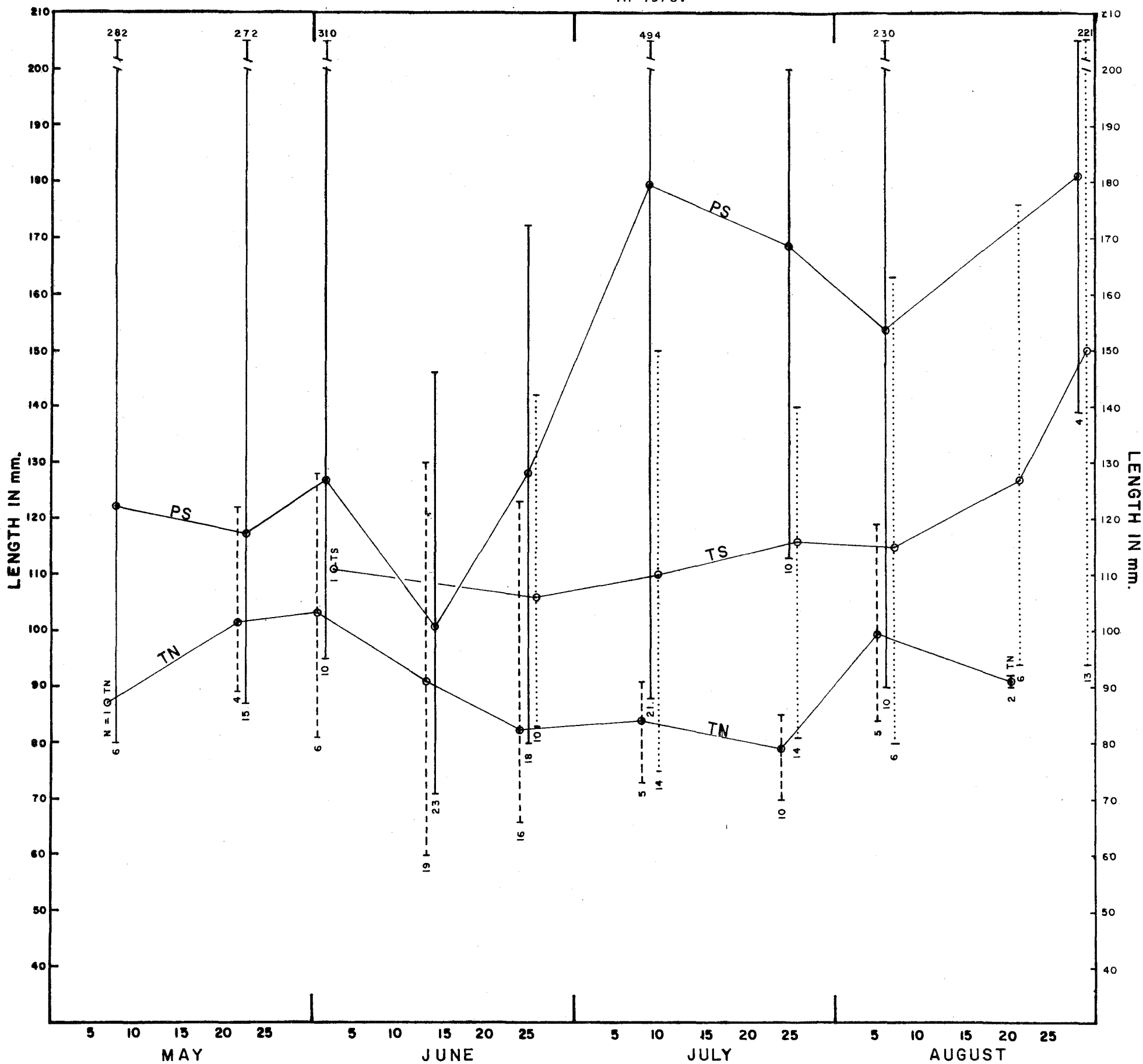


Fig. 23b. Length, Range, Mean (\odot), and Sample Size (n), of Chinook caught by Tow Net (---), Purse Seine (—), and Table Seine (.....) between Iona Island and Middle Arm on Sturgeon Bank in 1973.

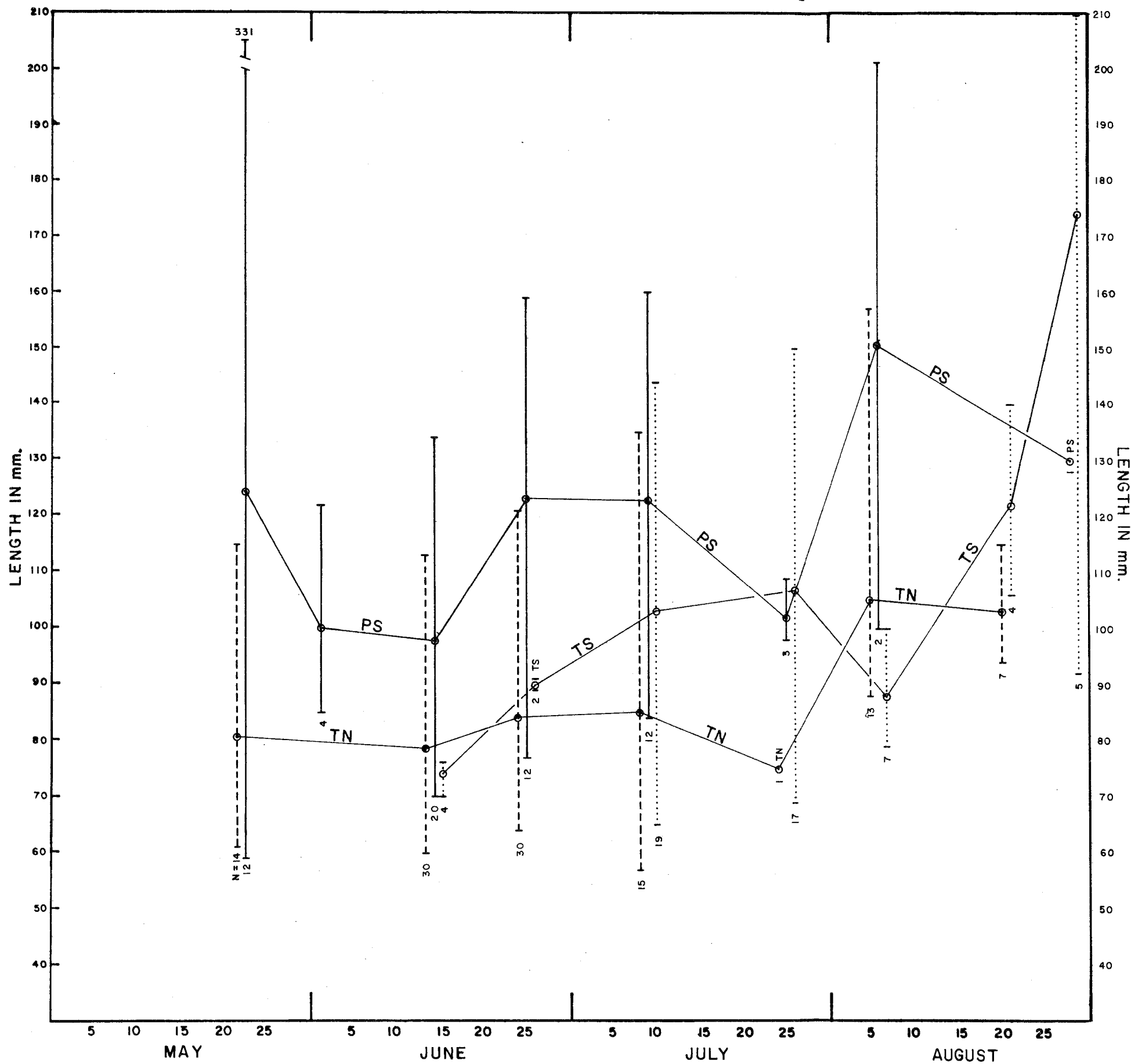


Fig. 23c. Length, Range, Mean (\circ), and Sample Size (n), of Chinook caught by Tow Net (---), Purse Seine (—), and Table Seine (.....) between Middle Arm and Steveston on Sturgeon Bank in 1973.

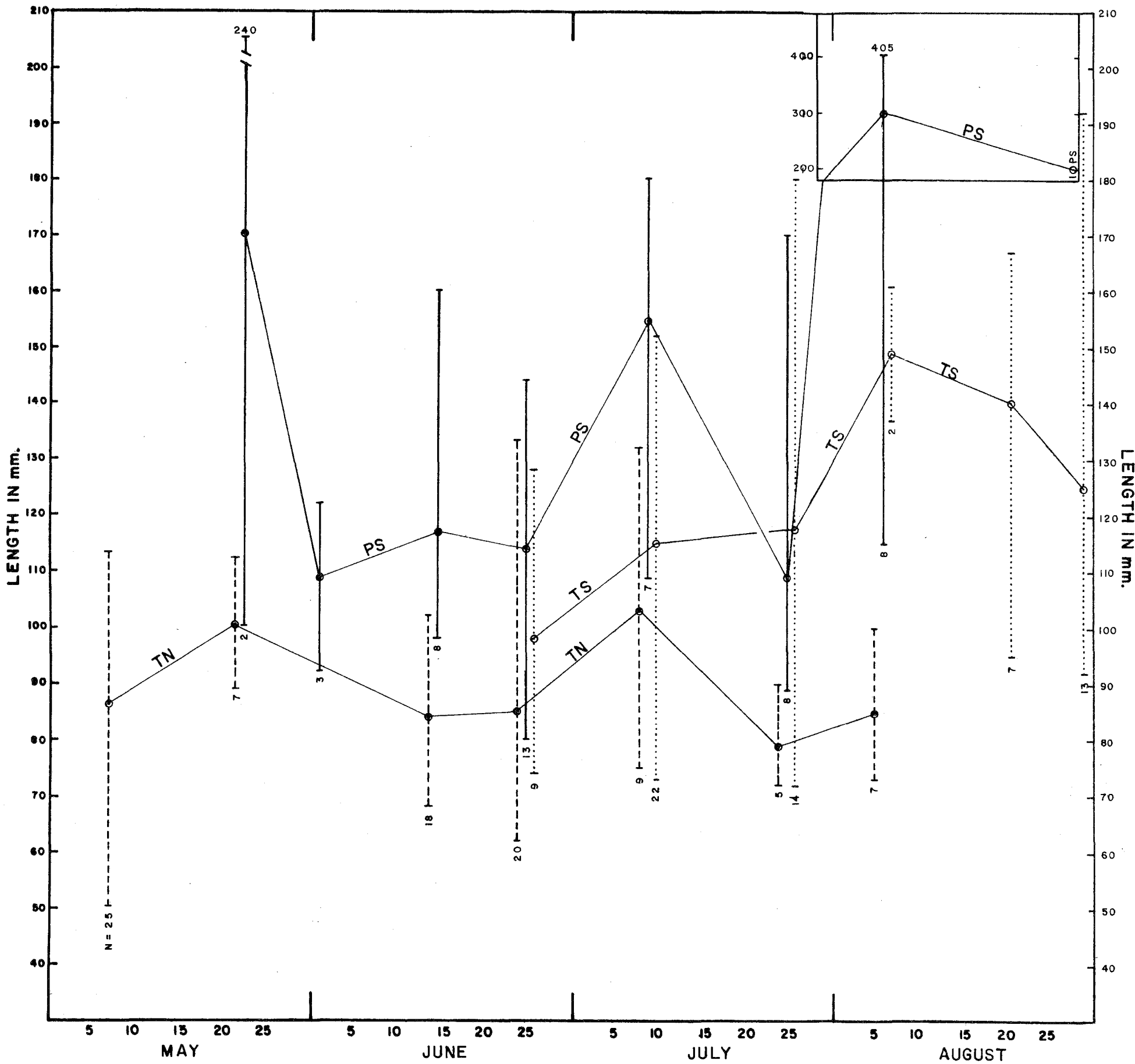


Fig. 24a. Length, Range, Mean (\odot), and Sample Size (n), of Chum caught by Purse Seine (—) and Table Seine (.....) between North Arm Jetty and Iona Island Jetty on Sturgeon Bank in 1973.

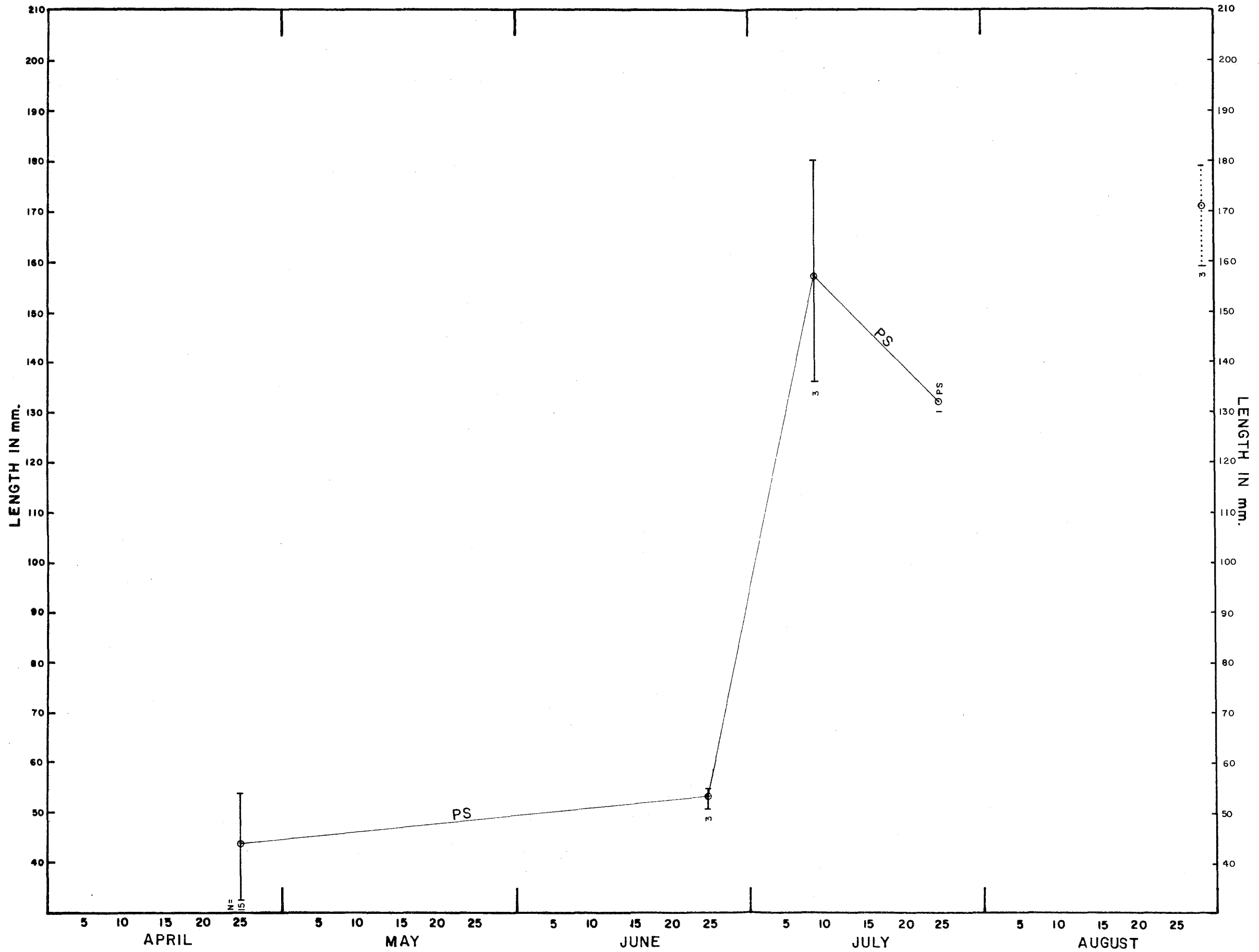


Fig. 24b. Length, Range, Mean (\odot), and Sample Size (n), of Chum caught by Purse Seine (—) and Table Seine (.....) between Iona Island and Middle Arm on Sturgeon Bank in 1973.

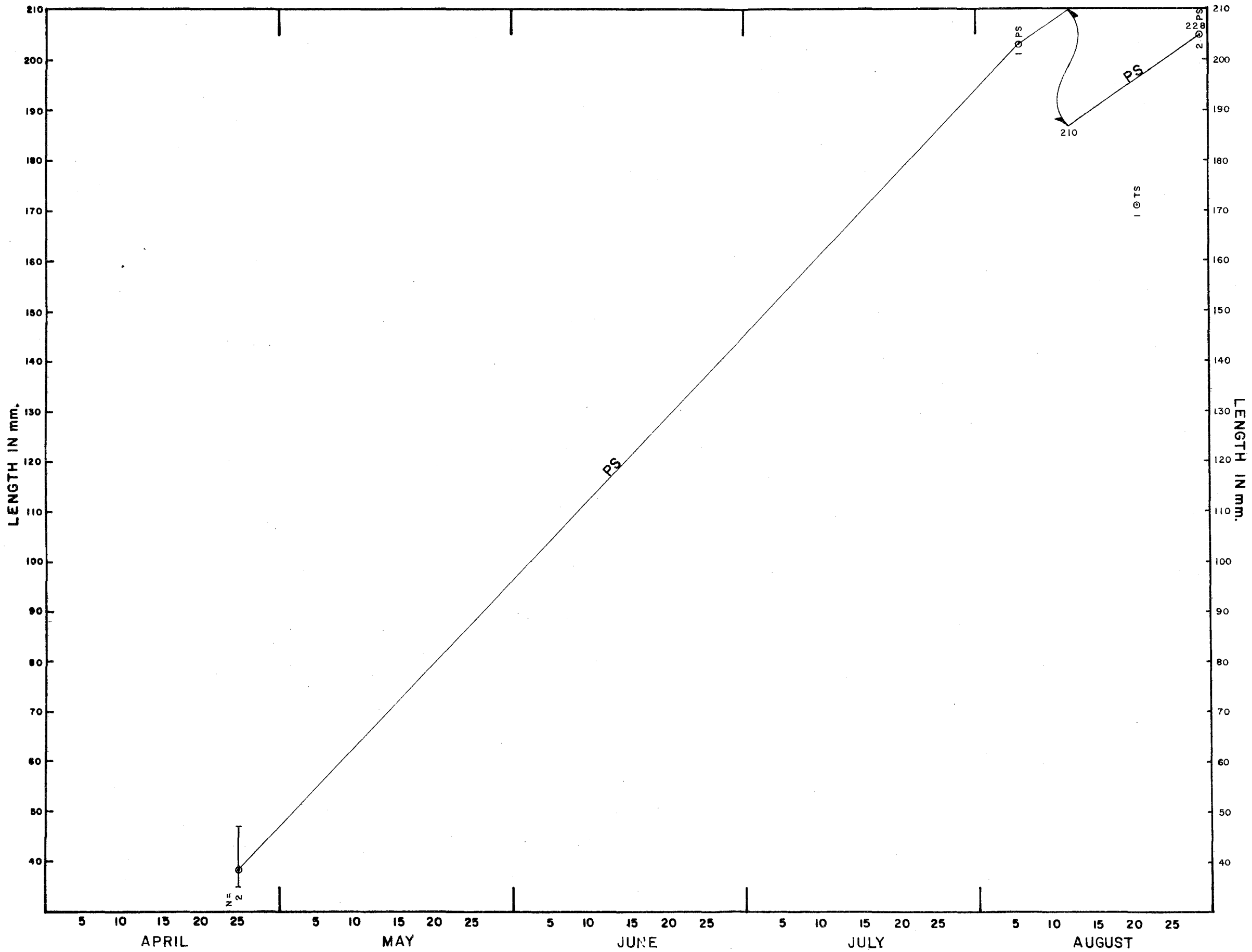


Fig. 24c. Length, Range, Mean (\odot), and Sample Size (n), of Chum caught by Tow Net (---), Purse Seine (—), and Table Seine (····) between Middle Arm and Steveston on Sturgeon Bank in 1973.

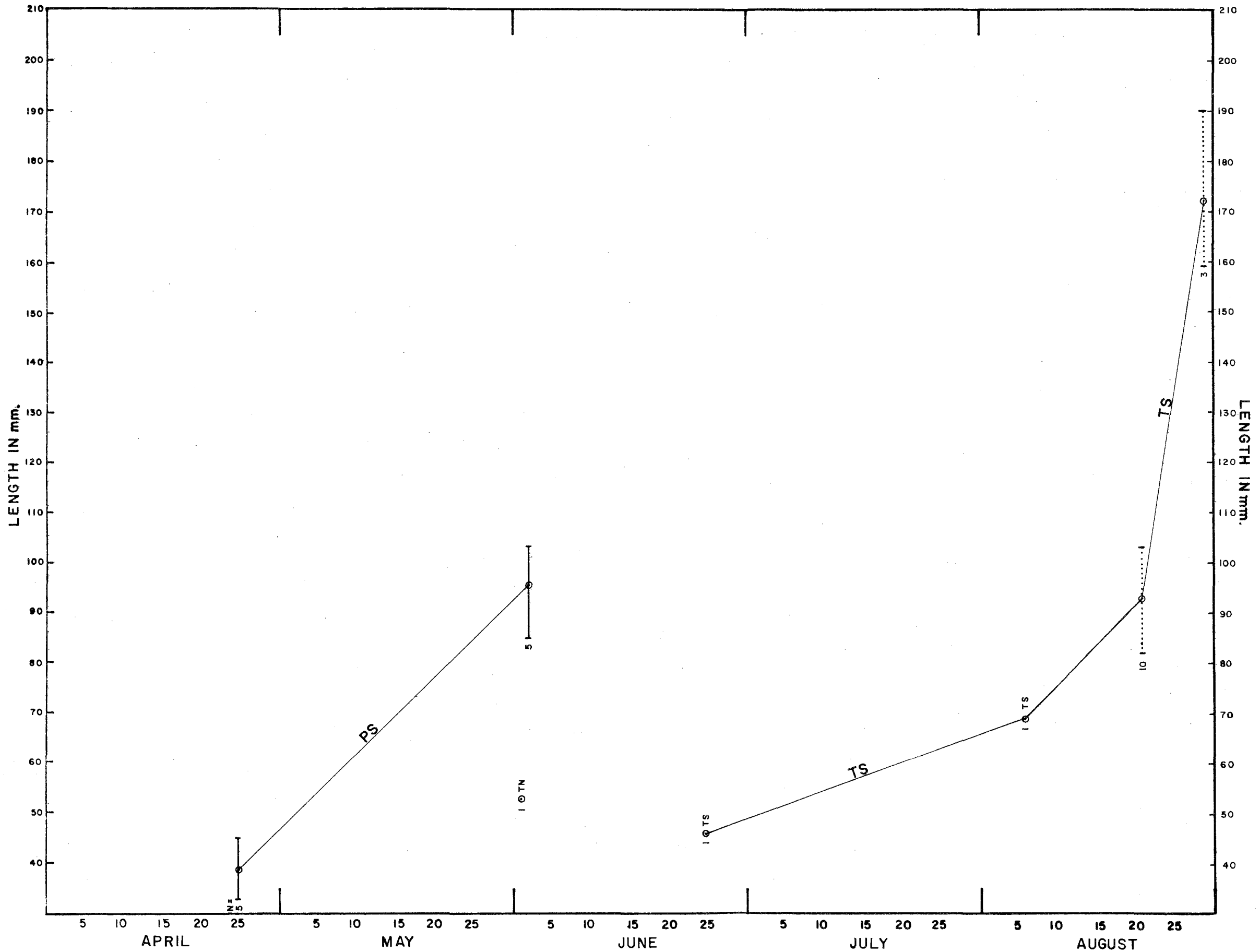


Fig. 25a. Length, Range, Mean (\odot), and Sample Size (n), of Sockeye caught by Tow Net (---) and Purse Seine (—) between North Arm Jetty and Iona Island Jetty on Sturgeon Bank in 1973.

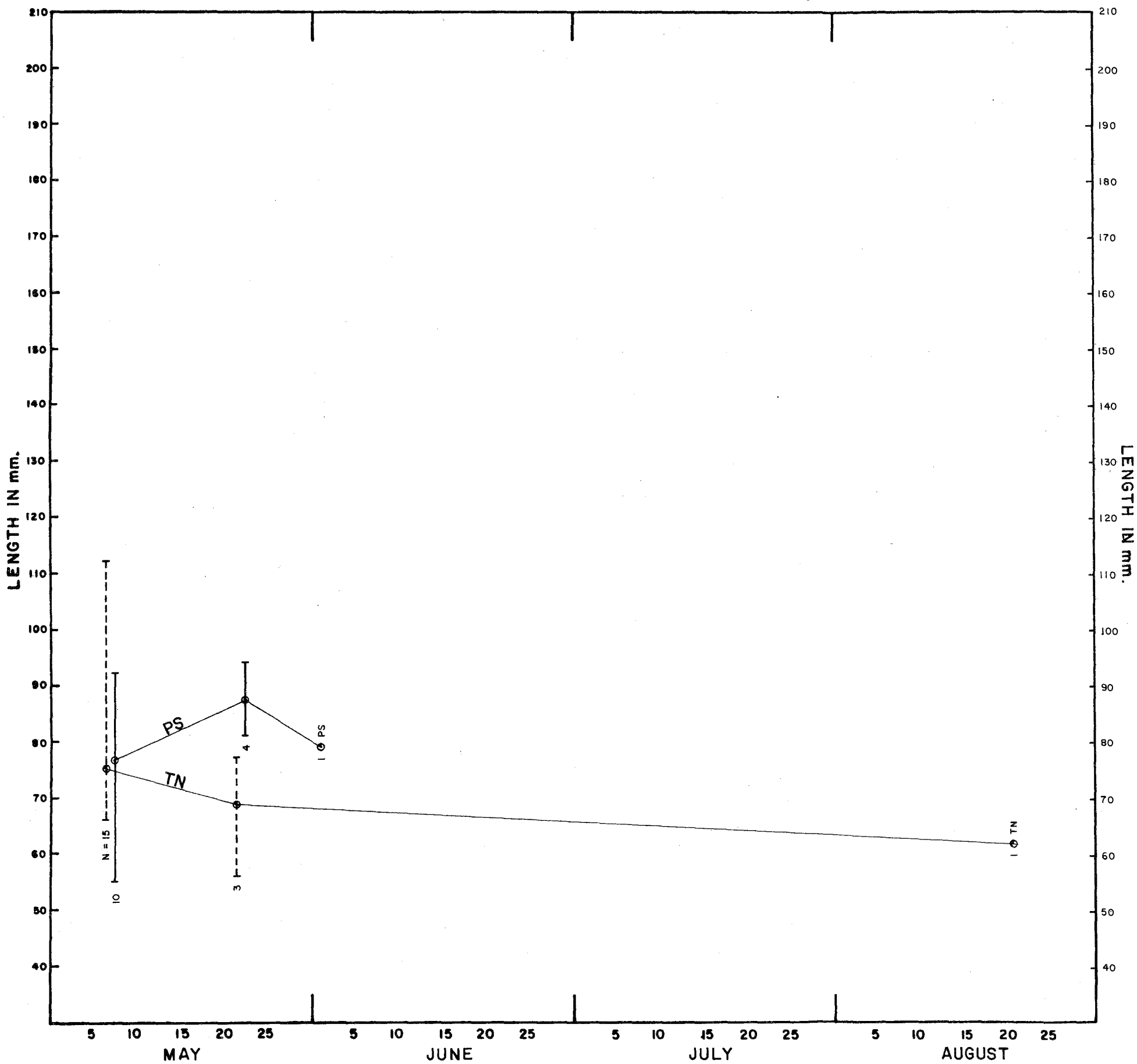


Fig. 25b. Length, Range, Mean (\odot), and Sample Size (n), of Sockeye caught by Tow Net (---), and Purse Seine (—) between Iona Island and Middle Arm, and Between Middle Arm and Steveston on Sturgeon Bank in 1973.

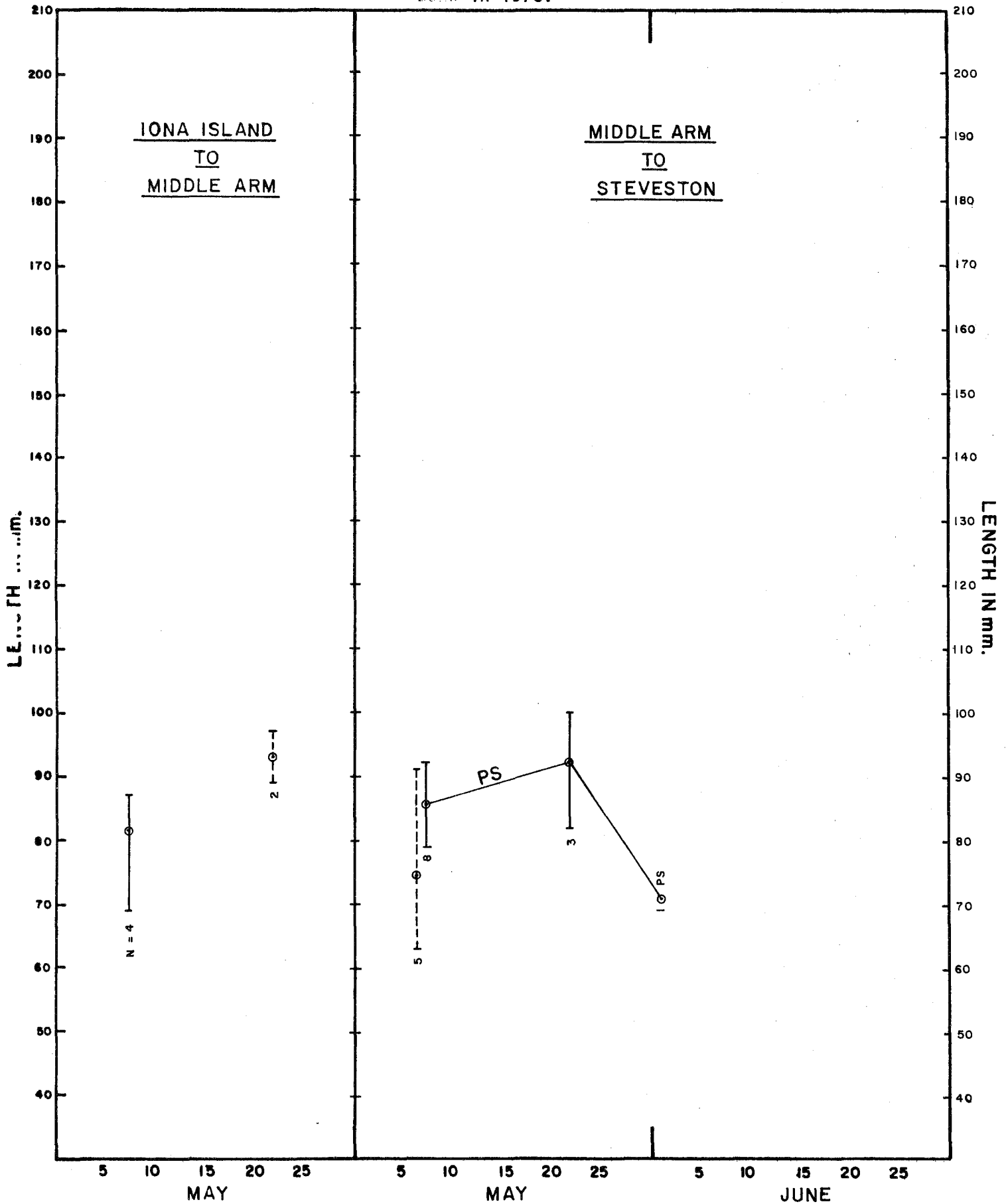


Fig. 26a. Length, Range, Mean (\odot), and Sample Size (n), of Coho Caught by Tow Net (---), Purse Seine (—), and Table Seine (····) between Steveston and Canoe Pass on Roberts Bank in 1973.

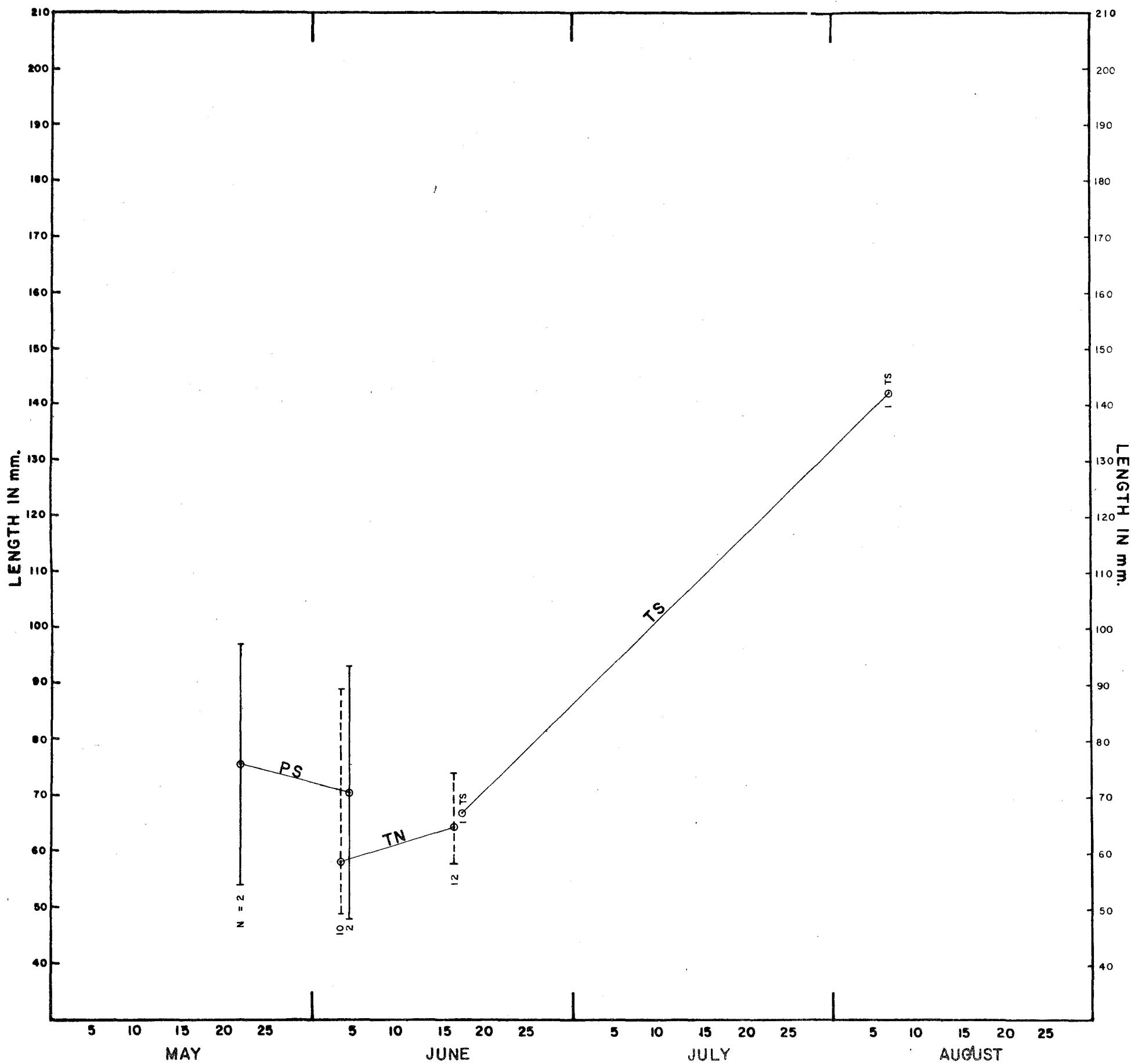


Fig. 26b. Length, Range, Mean (\odot), and Sample Size (n), of Coho caught by Tow Net (---), Purse Seine (—), and Table Seine (.....) between Canoe Pass and Roberts Bank Superport on Roberts Bank in 1973.

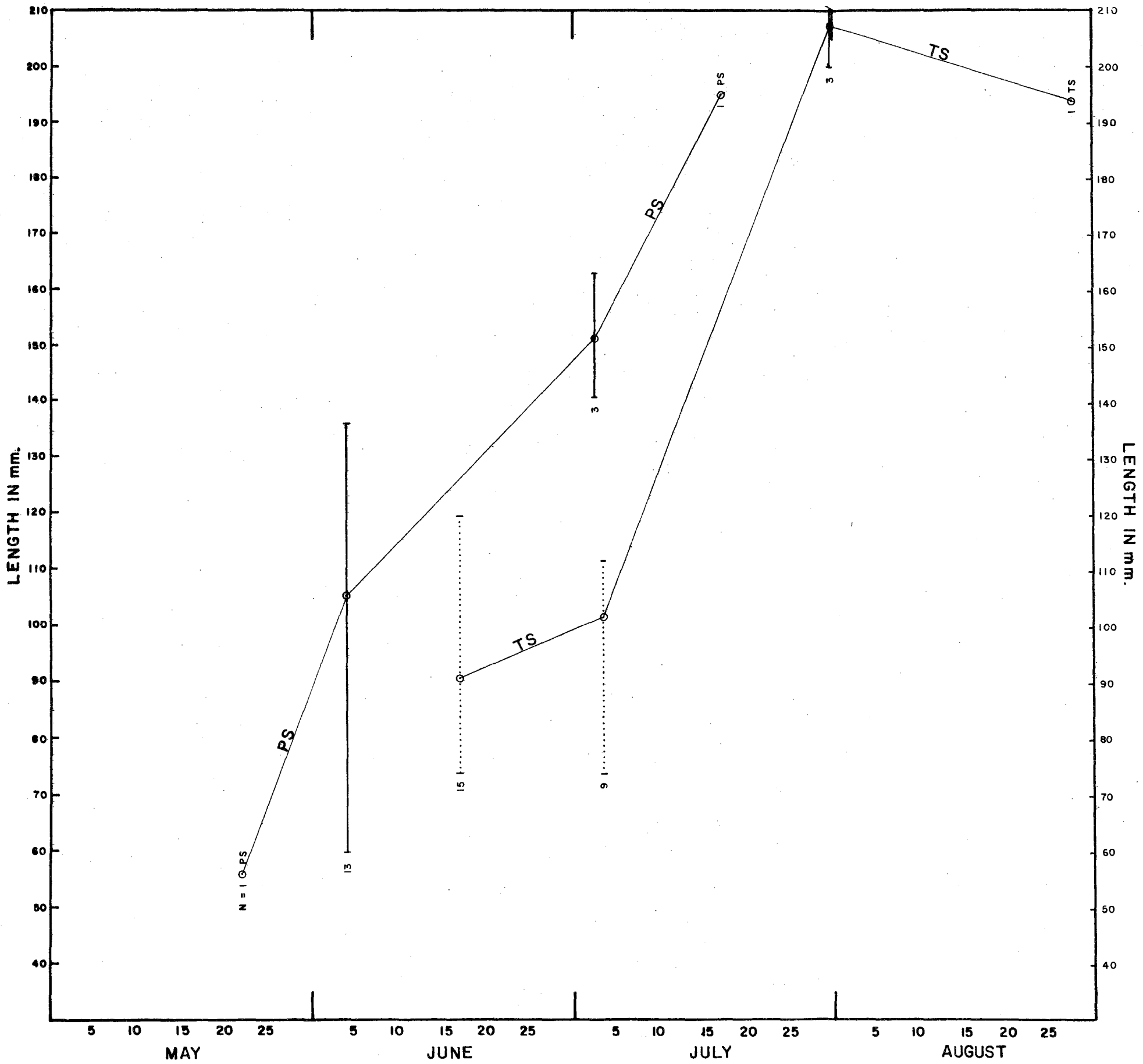


Fig. 26c. Length, Range, Mean (\odot), and Sample Size (n) of Coho caught by Tow Net (---), and Table seine (.....) between Roberts Bank Superport and Tsawwassen, and Tsawwassen to points south on Roberts Bank in 1973.

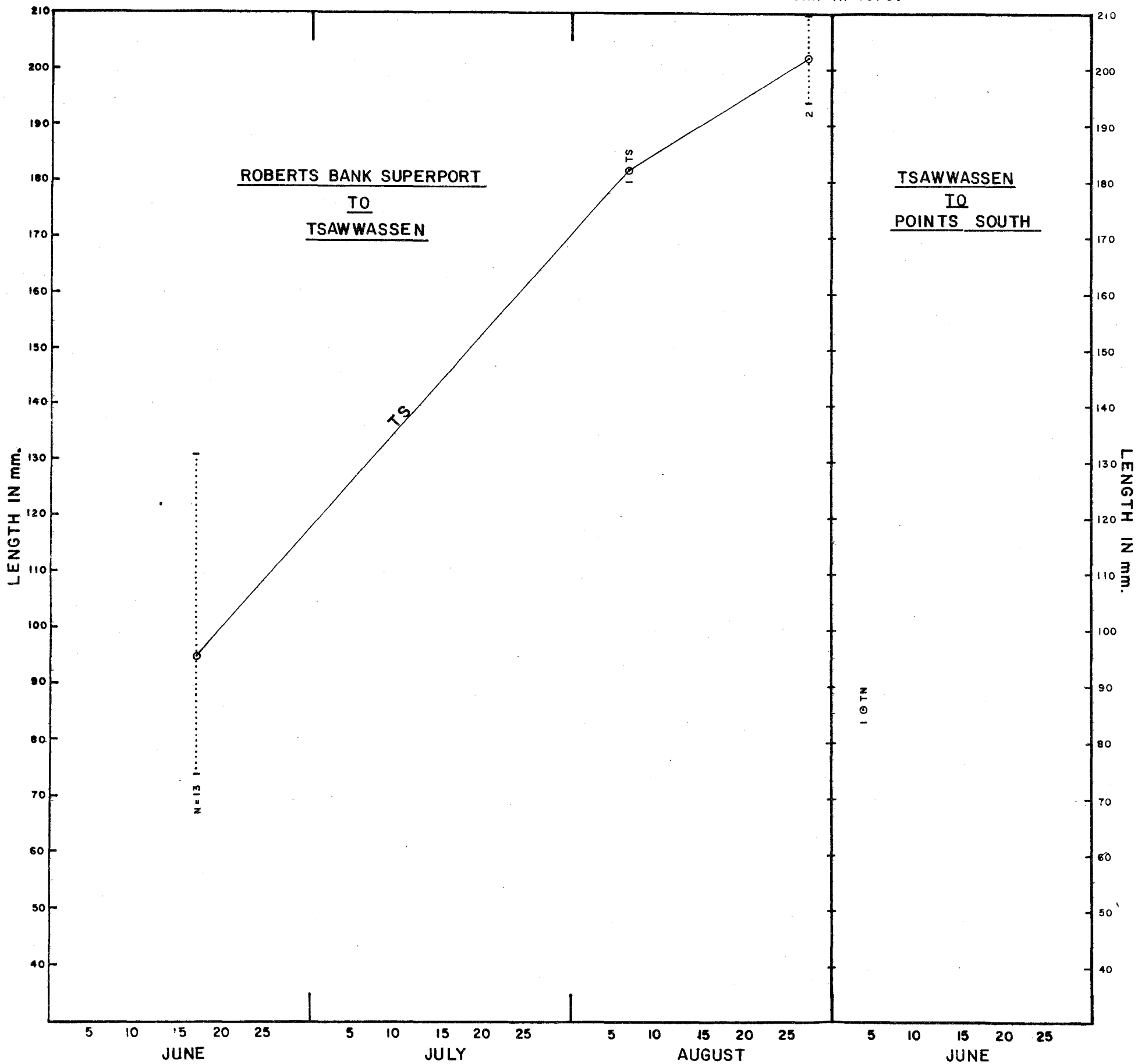


Fig. 27a. Length, Range, Mean (\bar{x}), and Sample Size (n), of Chinook caught by Tow Net (---), Purse Seine (—), and Table Seine (.....) between Steveston and Canoe Pass on Roberts Bank in 1973.

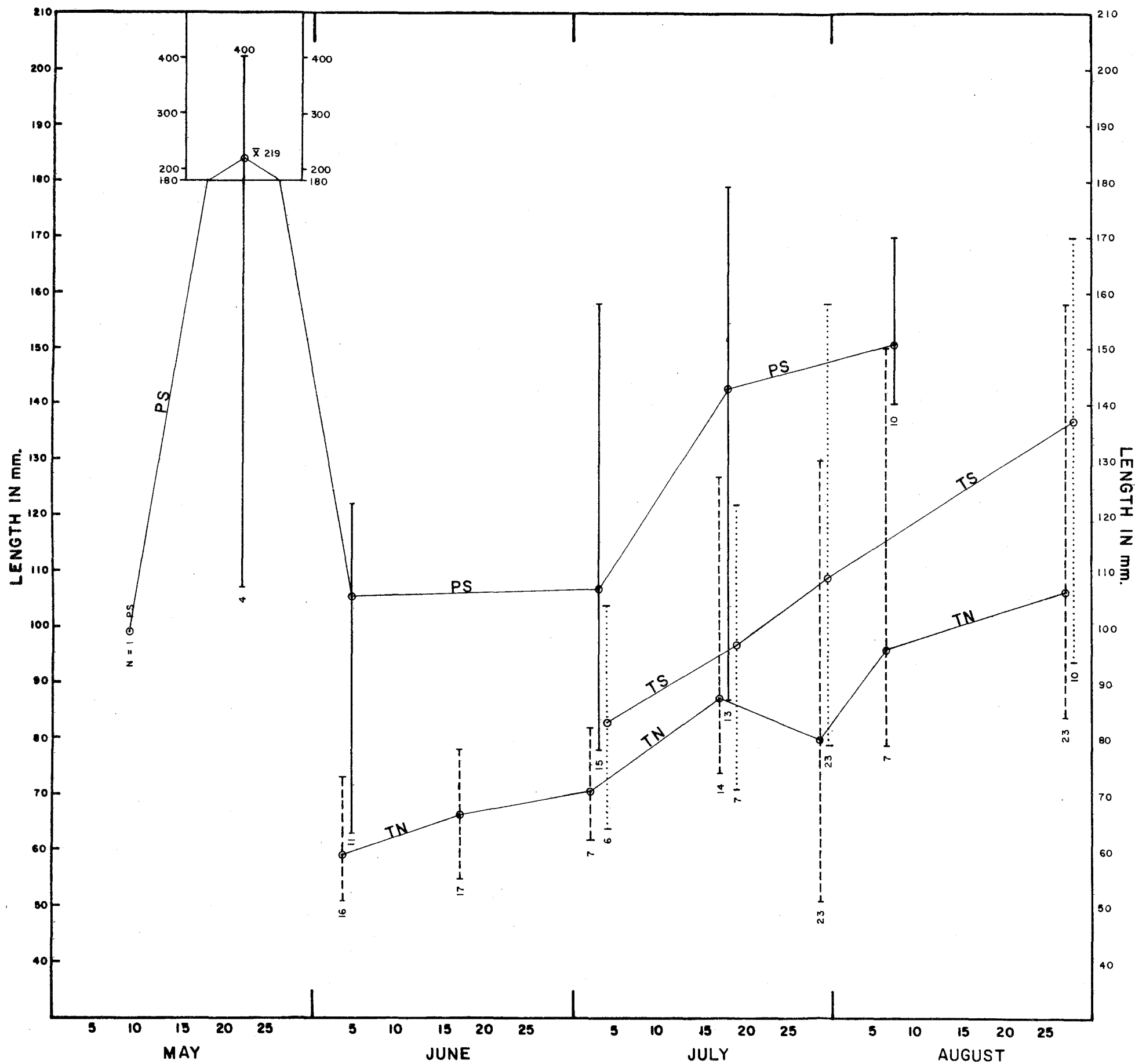


Fig. 27b. Length, Range, Mean (\odot), and Sample Size (n), of Chinook caught by Tow Net (---), Purse Seine (—), and Table Seine (.....) between Canoe Pass and Roberts Bank Superport on Roberts Bank in 1973.

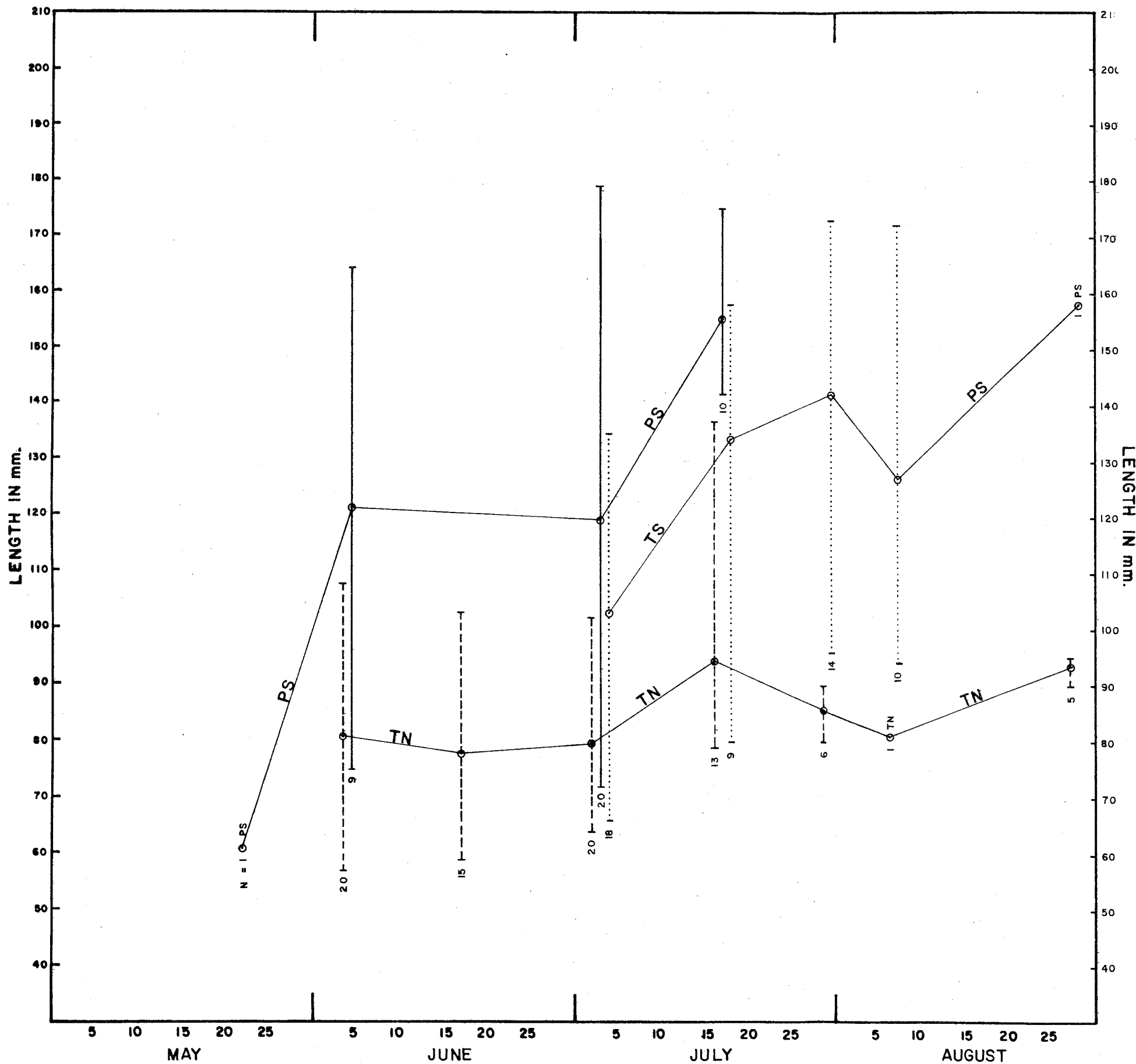


Fig. 27c. Length, Range, Mean (\odot), and Sample Size (n), of Chinook caught by Tow Net (---) and Table Seine (.....) between Roberts Bank Superport and Tsawwassen on Roberts Bank in 1973.

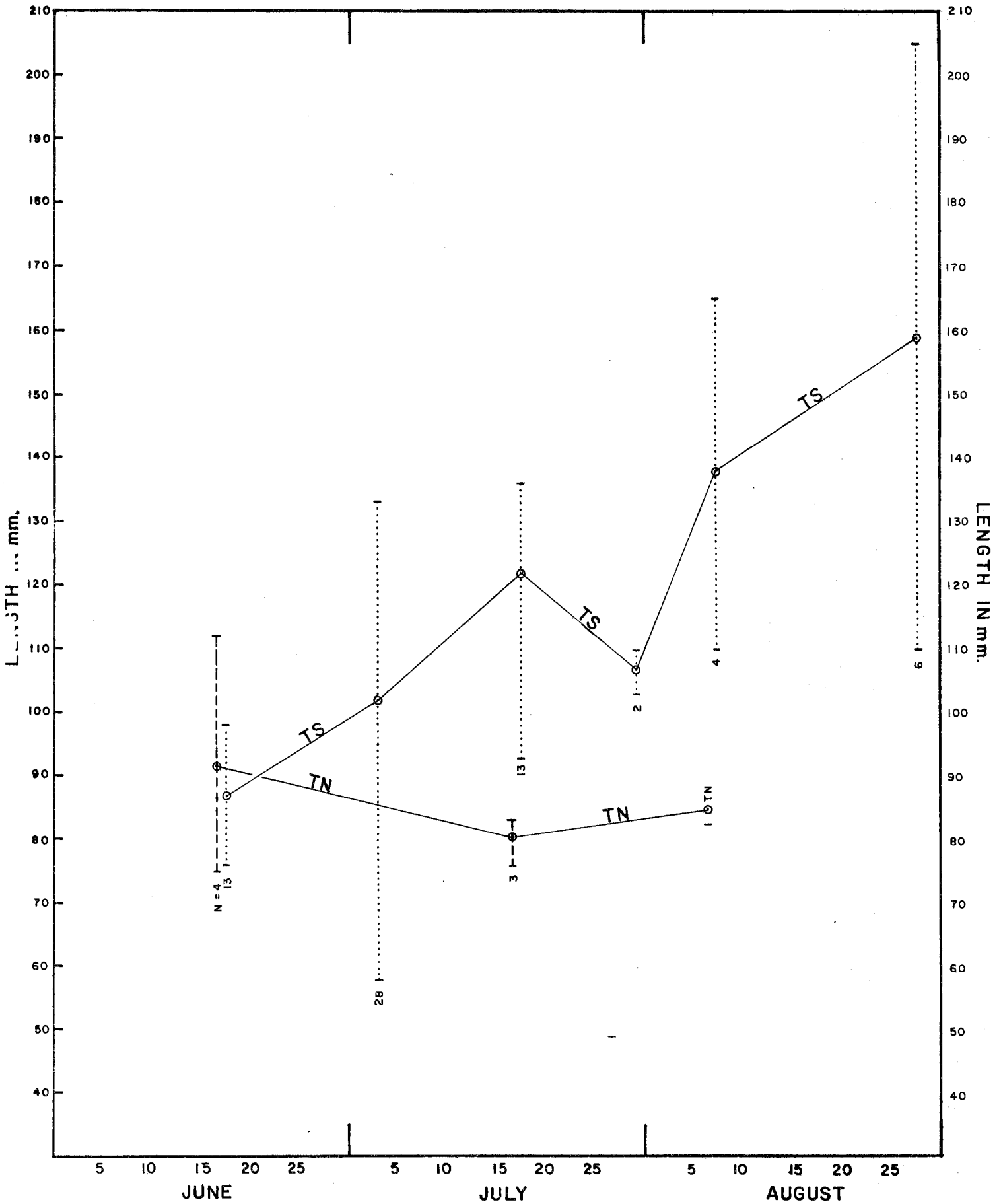


Fig. 27d. Length, Range, Mean (\odot), and Sample Size (n), of Chinook caught by Tow Net (---) and Table Seine (.....) from Tsawwassen to Points South on Roberts Bank in 1973.

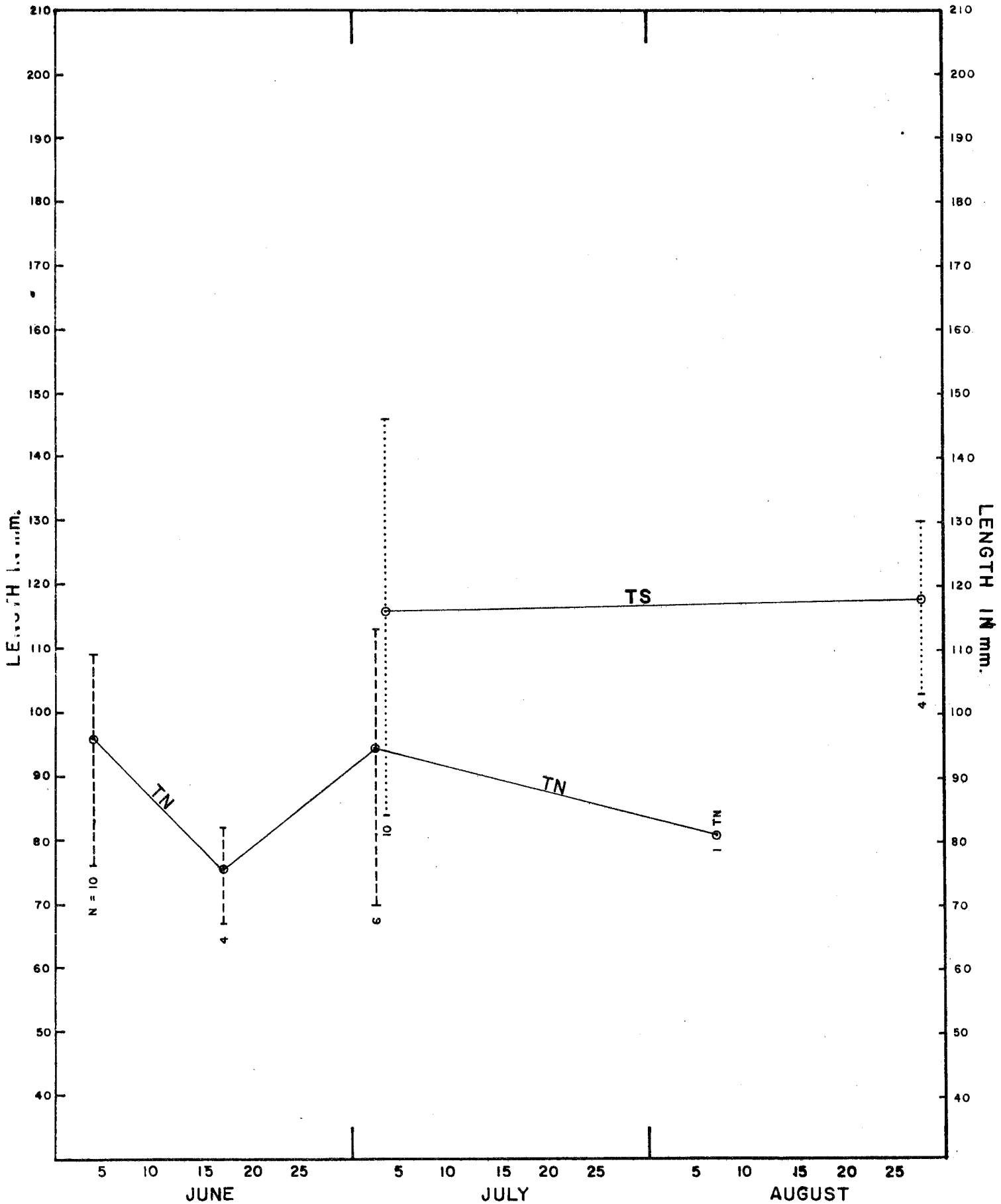


Fig. 28a. Length, Range, Mean (\odot), and Sample Size (n), of Chum caught by Tow Net (---) and Table Seine (.....) between Steveston and Canoe Pass on Roberts Bank in 1973.

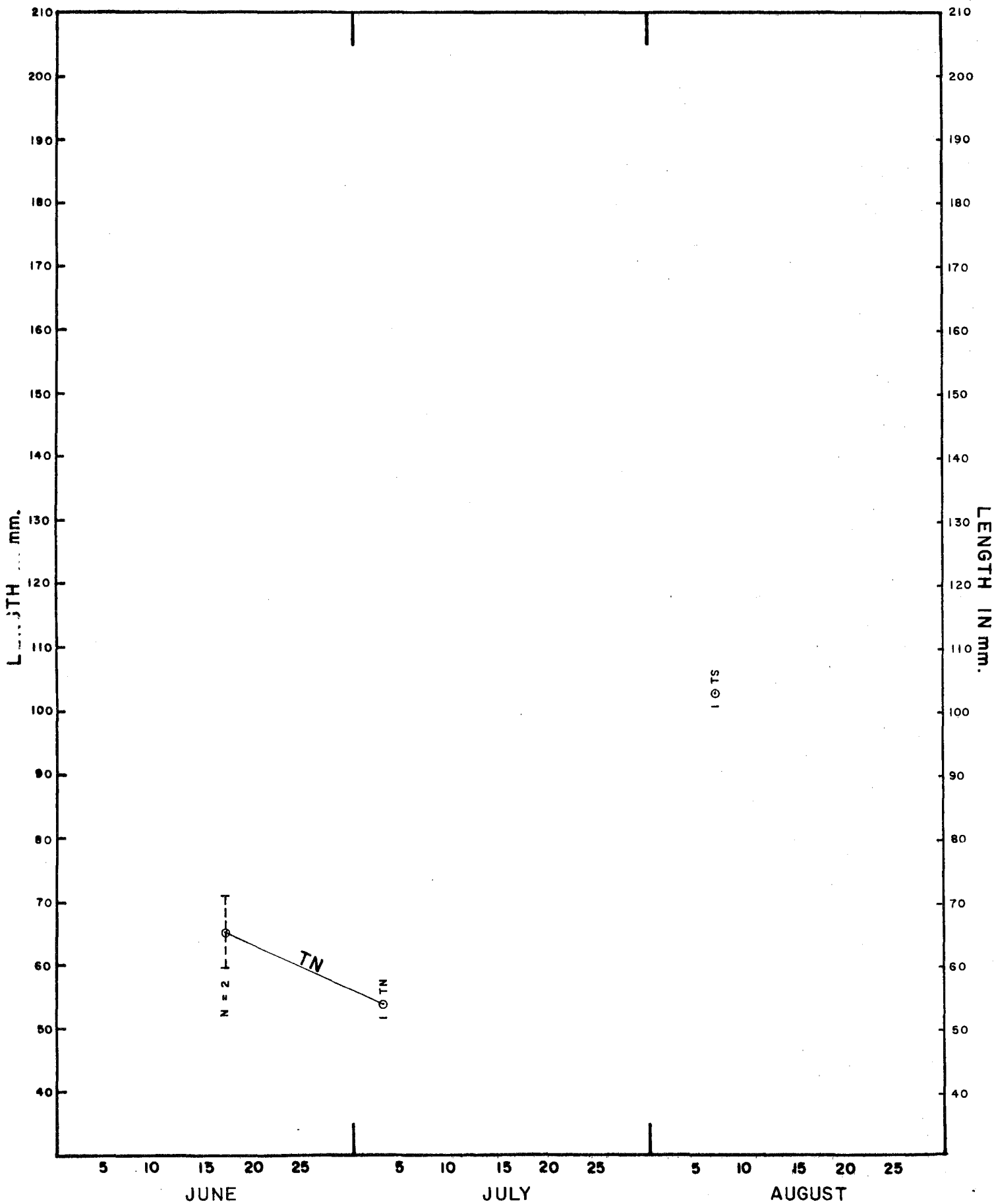


Fig. 28b. Length, Range, Mean (⊙), and Sample Size (n), of Chum caught by Tow Net (---), Purse Seine (—), and Table Seine (····) between Roberts Bank Superport and Tsawwassen, and from Tsawwassen to Points South on Roberts Bank in 1973.

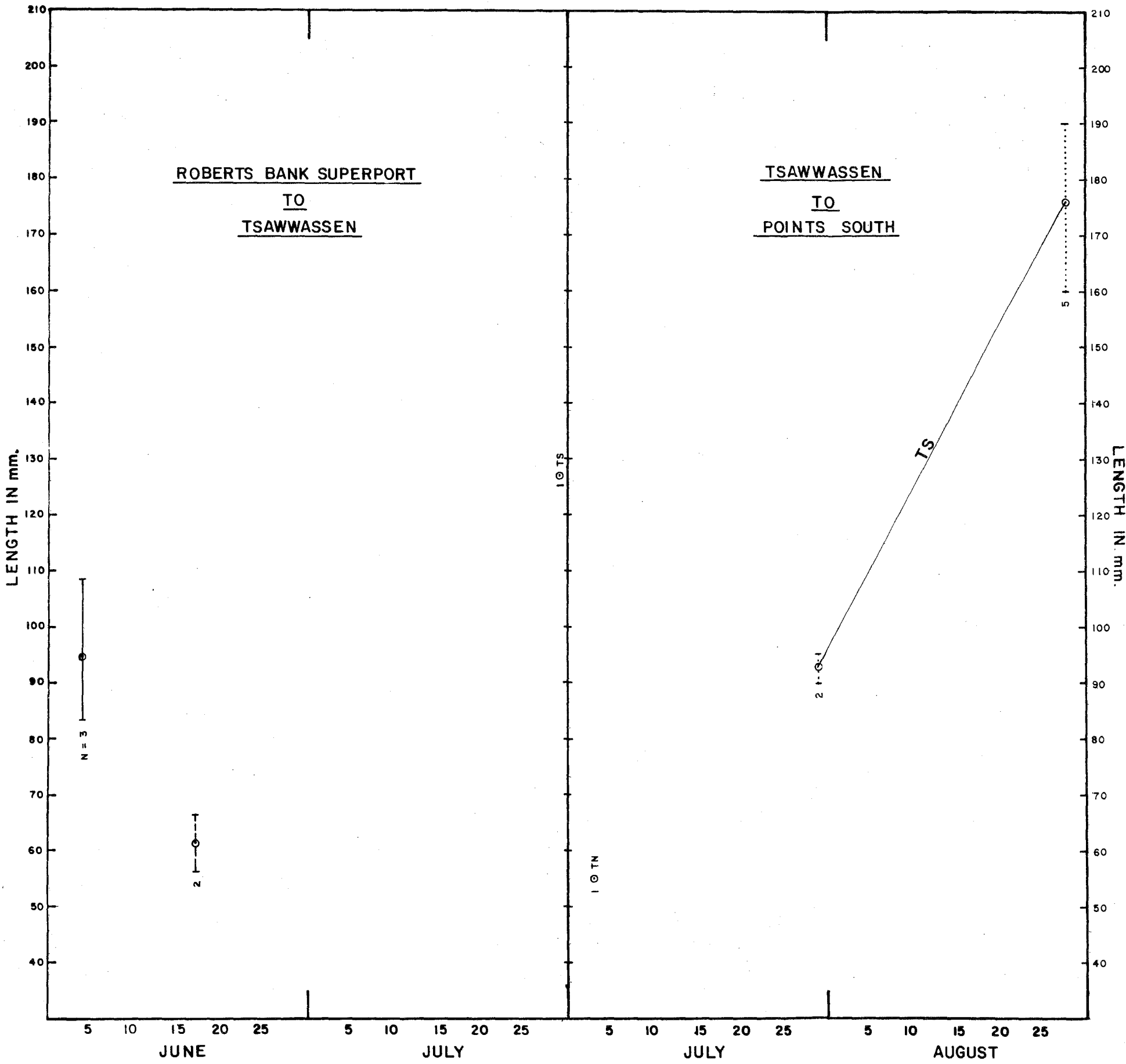
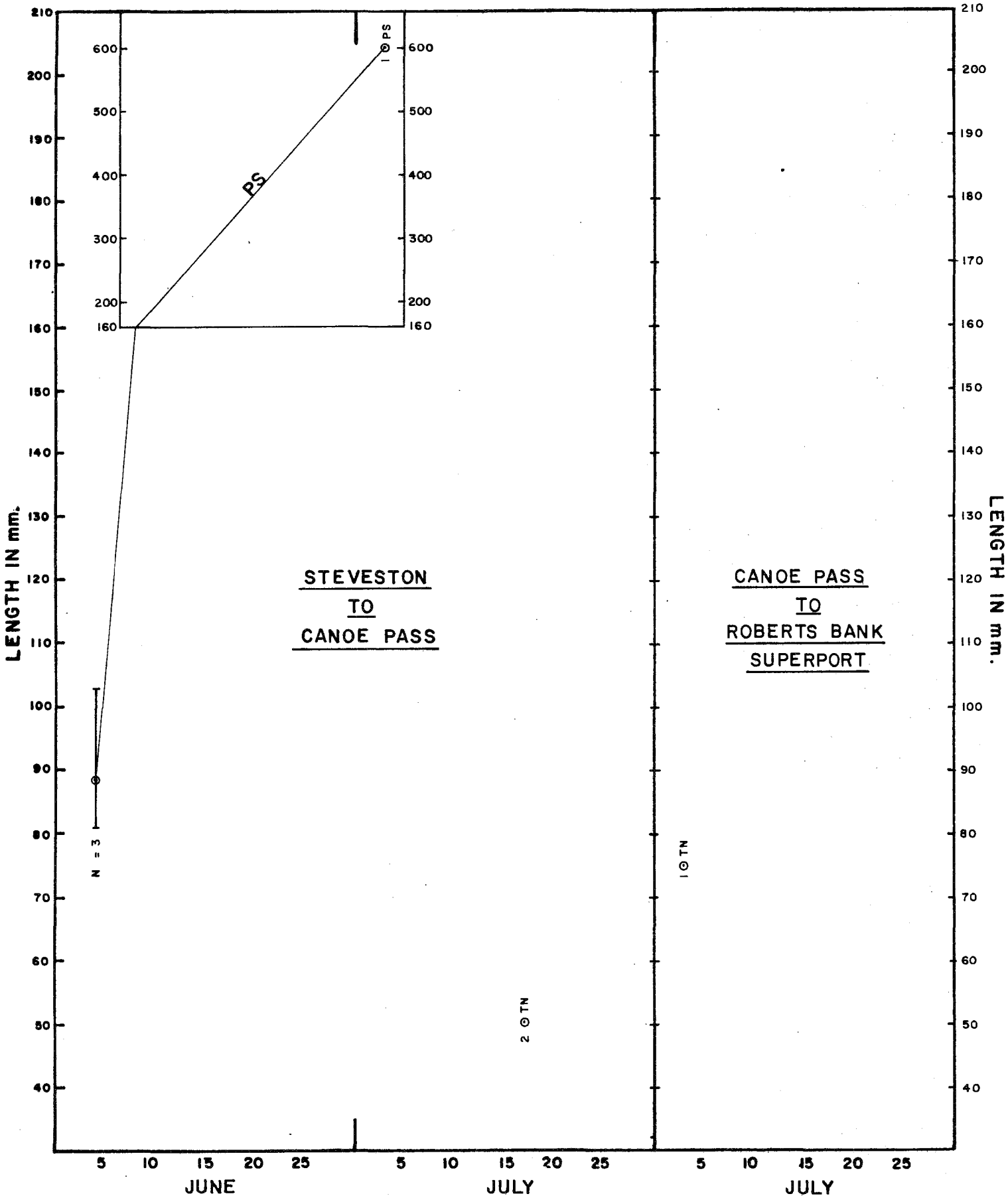


Fig. 29 . Length, Range, Mean (\odot), and Sample Size (n), of Sockeye caught by Tow Net (---) and Purse Seine (—) between Steveston and Canoe Pass, and between Canoe Pass and Roberts Bank Superport on Roberts Bank in 1973.



6.3 Stomach Contents Analysis

Data from the analysis of stomach contents of juvenile salmon from the Fraser River and juvenile salmon and herring from Sturgeon and Roberts Bank are presented in Appendix 5. Data in this appendix are percent biomass.

6.3.1. Fraser River - Upstream of the Port Mann Bridge

Analysis of stomachs from fish caught in the Fraser River above Port Mann was carried out from sub-samples of catches taken on May 3 and June 13, 1973. Thirty-six coho stomachs examined from catches on May 3 contained mainly salmon and chironomid larvae. Nine chinook stomachs contained almost entirely larval fish (unidentified). The single chum stomach examined from catches on May 3 was empty, while the single sockeye stomach contained unidentified amphipods.¹ Three coho stomachs examined from catches above Port Mann on June 13 contained mainly plecoptera (70.6%) while 2 chinook stomachs contained mainly mysids (83.3%) (Appendix 5 pp. 6 - 7).

6.3.2. Fraser River - Downstream of the Port Mann Bridge

Page 101 of Appendix 5 presents the summary of stomach contents of juvenile salmon (coho, chinook, chum and sockeye) captured in the North, South and Middle Arms. Freshwater and terrestrial invertebrates were present in these stomachs on every sampling date (range 30% to 100% biomass) and comprised greater than 80% of the stomach biomass on 5 of the 13 sampling dates between March 28 and August 21. Estuarine benthos were present in the stomachs on every sampling date but one with a range from 1.2% to 69.5% biomass when present. Larval and juvenile fish were present in the stomachs on 6 sampling dates between April 24 and July 12 with a range from 0.1% to 61.7% biomass. Larval and juvenile fishes were not present in the stomachs of fish before or after these dates. Marine plankton were present in the stomachs in small amounts on 7 sampling dates with a range from 0.1% to 4.0% (Appendix 5 p. 101).

1. Amphipods in this stomach were not counted and do not appear in the printout (Appendix 5 p. 6).

6.3.2.1. North and Middle Arms

One hundred seventy-eight coho, 69 chinook, 59 chum and 28 sockeye stomachs were examined from catches in the North and Middle Arms. A relatively small proportion of these stomachs were empty - ranging from 0% for sockeye to 15% for coho (Appendix 5 pp. 56-57).

Coho stomachs contained mainly larval fish (unidentified), Anisogammarus sp. and mysids. Chinook stomachs contained mainly mysids, larval fish (unidentified) and Anisogammarus sp. Chum salmon had eaten mainly chironomid larvae and Anisogammarus sp. and sockeye mainly chironomid larvae and diptera (Appendix 5 pp. 56 - 57). Throughout the sampling period, stomach contents showed little variation in terms of those organisms comprising greater than 10% biomass (Appendix 5 pp. 16-35).

In summary, coho utilized larval and juvenile fish as the major source of food; estuarine benthos served as the major source of food for chinook and freshwater and terrestrial invertebrates served as the major food source for chum and sockeye (Appendix 5 p. 95).

6.3.2.2. South Arm

One hundred seventeen coho, 529 chinook, 293 chum and 101 sockeye stomachs were examined from 1973 catches in the South Arm. Of these, a smaller percentage were empty (range 0.1% for sockeye to 8.5% for coho) than those stomachs examined from catches in the North and Middle Arms (Appendix 5 pp. 58-59).

Coho stomachs contained mainly chironomid larvae and salmon, chinook mainly insect larvae (unidentified), and chum, mainly Anisogammarus sp. and chironomid larvae. Juvenile sockeye had fed mainly on chironomid larvae, cladocera (unidentified), Bosmina sp. and harpacticoid copepods (Appendix 5 pp. 58 - 59). In general, the stomachs of juvenile salmon examined from catches in the South Arm contained a wider variety of organisms than those from the North and Middle Arms. No seasonal change in stomach contents is apparent throughout the sampling period.

In summary, freshwater and terrestrial invertebrates served as the major source of food for coho, chinook, chum and sockeye in the South Arm, ranging from 99% biomass for chinook to 59% biomass for chum (Appendix 5 p. 95).

6.3.3. Sturgeon and Roberts Bank

A total of 1,188 juvenile salmon and herring stomachs were examined from sub-samples of catches on Sturgeon and Roberts Banks. One hundred forty-eight coho, 397 chinook, 47 chum, 38 sockeye, and 122 herring stomachs were examined from catches on Sturgeon Bank. From catches on Roberts Bank, 52 coho, 322 chinook, 13 chum, 5 sockeye and 46 herring stomachs were examined. Data from the analysis of these stomachs is presented by sampling sub-area in Appendix 5.

In terms of biomass, larval and juvenile herring and other fishes were the major component of the stomach contents of juvenile coho and chinook on both Sturgeon and Roberts Banks as well as sockeye on Roberts Bank. Plankton was the major food item in the stomachs of herring and juvenile chum salmon taken on both Sturgeon and Roberts Banks.

Sturgeon Bank

6.3.3.1. North Arm Jetty to Iona Jetty

Stomachs of juvenile coho from sub-samples of catches in this area (sub-area 1) contained mainly herring, crab megalops and mysids (58.9%, 14.5% and 12.3% respectively) Appendix 5 pp. 155-156). Chinook contained mainly herring (79.9%) and unidentified larval fish (11.5%). Juvenile chum salmon had eaten larval fish (30.1%), Calanus glacialis (20.1%), tunicates (18.4%) and Eurytemora sp. (11.4%). Stomachs from juvenile sockeye contained mainly tunicates (64.6%), while herring stomachs contained mainly Calanus glacialis (46.0%), and Euphausia pacifica (36.2%).

1. All %'s are percent biomass

6.3.3.2. Iona Jetty to Middle Arm

As for the area between the North Arm jetties, juvenile coho taken from the area between the Iona jetty and the Middle Arm (sub area 2) contained mainly herring (55.6%) Holopedium sp. also represented a considerable portion (24.3%) of the stomach biomass of coho from this sampling area. Chinook stomachs contained mainly unidentified larval fish (42.3%), mysids (22.2%), and herring (17.0%). Calanus glacialis was the major constituent (75.4%) of the stomach contents of juvenile chum salmon. Holopedium sp. made up 98.3% of the biomass of the three sockeye stomachs examined from catches in this area. Herring stomachs contained mainly Euphausia pacifica (43.0%), Calanus glacialis (21.3%), harpacticoid copepods (12.5%) and unidentified larval fish (11.5%).

6.3.3.3. Middle Arm to Steveston Jetty

Coho stomachs from sub-samples in this area (sub area 3) contained mainly herring (36.4%) and mysids (17.4%). Chinook stomachs contained mainly herring (35.5%) and unidentified fish larvae (44.0%) as in sub-areas 1 and 2. Juvenile sockeye stomachs examined from catches in this area contained mainly unidentified fish larvae (63.0%) and Holopedium sp. (23.7%) while Beudocalanus minutus (42.2%), unidentified fish larvae (26.0%) and mysids (14.9%) contributed most to the biomass of herring stomachs.

A summary analysis of the stomach contents of coho, chinook, chum, sockeye and herring together reveals that on Sturgeon Bank, zooplankton contributed more than 17% of the stomach content biomass from April 10 to June 1 and on August 6. Larval and juvenile fishes represented more than 40% of the biomass on all but four sampling dates between April 10 and August 29 greater than 72% on 7 of the 12 sampling dates. Estuarine benthic organisms accounted for 38.4% of the biomass of herring stomachs taken on April 25. The foregoing reveals a general trend in stomach contents wherein the percent biomass of estuarine benthic organisms shows a marked increase when the percent biomass of zooplankton decreases rather abruptly after June 1 (Appendix 5 p. 218). Estuarine benthos contributed between 6.8% and 35.2% of the stomach content biomass of salmon and herring taken between June 14 and August 29. The percent biomass of freshwater and terrestrial

invertebrates ranged from 0% on April 10 to 26.2% on August 6 with a substantial increase from that time until the end of sampling on August 29 (Appendix 5 p. 218).

The relative importance of food groups in the stomachs of coho, chinook, chum, sockeye and herring in the sampling sub-areas of Sturgeon Bank are summarized in Table 20. The above data have been presented in terms of sampling area rather than in terms of the location of fish either in-shore or off-shore, however, data from the Squamish (Department of Environment 1972) and Nanaimo (Parker and Goodman 1974) estuaries suggests that for those fish caught inshore, dependence on benthic invertebrates may be significantly higher than indicated by lumping in-shore and off-shore catches within each sampling area.

Roberts Bank

6.3.3.4. Steveston Jetty to Canoe Pass

Coho stomachs examined from catches in this area (sub-area 4) contained mainly plankton (Parathemisto pacifica 47.1%) and estuarine benthic organisms (mostly cumaceans 39.7%). Chinook stomachs contained mainly larval and juvenile herring (78.7%) and estuarine benthic organisms (mysids 14.0%). Stomachs of the 3 juvenile chum salmon examined contained larval and juvenile fish (38.7%), estuarine benthos (gammarid amphipods and cumaceans) and plankton (Calanus glacialis). The biomass of sockeye stomachs was comprised of 63.5% larval benthos (crab zoea and megalops) and 35.5% larval and juvenile fish. Herring stomachs contained mainly larval benthos (shrimp) and plankton (Euphausia pacifica).

6.3.3.5. Canoe Pass to the Roberts Bank Causeway

Larval and juvenile fish were the major food item for all species for which stomachs were examined from catches in this sampling area (sub-area 5). Coho stomachs contained 85.9% larval and juvenile fish and 12.0% larval benthos. Plankton and estuarine benthos which contributed most to the diet of coho in the area between the Steveston Jetty and Canoe Pass were relatively unimportant (0.9%) and 1.2% respectively) in the coho stomachs from this sampling area. Chinook stomachs contained 61.5% larval and juvenile fish, 18.0% estuarine benthos (mysids) and 14.9% plankton (Euphausia pacifica). Stomachs of juvenile chum salmon from this sampling

TABLE 20. RELATIVE IMPORTANCE¹ OF FOOD GROUPS IN THE STOMACHS OF JUVENILE COHO, CHINOOK, CHUM, SOCKEYE AND HERRING ON STURGEON BANK. (MARCH 28 - SEPTEMBER 12, 1973)

	COHO	CHINOOK	CHUM	SOCKEYE	HERRING
NORTH ARM JETTY TO IONA JETTY					
Highest % biomass	LJF	LJF	P	P	P
2nd highest % biomass	LB		LJF		
3rd highest % biomass	EB		EB		
IONA JETTY TO MIDDLE ARM					
Highest % biomass	LJF	LJF	P	FT	P
2nd highest % biomass	FT	EB			EB
3rd highest % biomass		FT			LJF
MIDDLE ARM TO STEVESTON JETTY					
Highest % biomass	LJF	LJF	LJF	LJF	P
2nd highest % biomass	EB	EB	FT	FT	LJF
3rd highest % biomass			EB		EB
STURGEON BANK (sub areas combined)					
Highest % biomass	LJF	LJF	P	P	P
2nd highest % biomass	EB		LJF	LJF	
3rd highest % biomass	FT		EB		

¹ Only those food groups representing 10% biomass are indicated.

P Plankton
LJF Larval and juvenile fish
EB Estuarine Benthos
LB Larval Benthos
FT Freshwater and terrestrial

area contained 54.3% larval and juvenile fish and 38.2% larval benthos (shrimp) while herring stomachs contained 69.3% larval and juvenile fish and 25.2% plankton (Euphausia pacifica).

6.3.3.6. Roberts Bank Causeway to Tsawwassen Ferry Terminal

Juvenile coho and chinook salmon stomachs from this sample area (sub-area 6) contained almost entirely larval and juvenile fish (99.6% and 92.7% respectively) while the stomachs of chum salmon contained 99.3% plankton (Parathemisto pacifica). No sockeye or herring stomachs from this area were examined.

6.3.3.7. South of Tsawwassen Ferry Terminal

No coho, chum or sockeye stomachs were examined from catches in this sampling area (sub-area 7). Chinook stomachs contained mainly larval and juvenile fish while herring stomachs contained mainly plankton (Pseudocalanus minutus 63.9% and Centrophages abdominalis 34.9%).

In summary for all species combined, larval and juvenile fish formed the major portion of the stomach contents biomass on Roberts Bank on every sampling date between April 25 and September 10. Plankton accounted for 0% of the stomach biomass in April and early May, increased to greater than 20% in late May and early June and generally decreased from then on with the exception of September 10. Estuarine benthos accounted for only a small portion of the diets (1.2% to 2.9%) from May to mid July, increased (12.2% to 42.0% between July 30 and August 28 and then decreased to 0.4% on September 10. Larval benthos accounted for greater than 10% of the biomass on only 3 sampling dates. Freshwater and terrestrial organisms ranged between 0 and 8.1% of the stomach biomass.

The stomach contents of juvenile coho, chinook, chum, sockeye and herring for each sampling area of Roberts Bank are summarized in Table 21. As for the Sturgeon Bank data, it is anticipated that the utilization of benthic invertebrates as a food source by those fish caught in the inshore areas may be higher than that indicated by grouping the sampling stations as presented.

TABLE 21. RELATIVE IMPORTANCE¹ OF FOOD GROUPS IN THE STOMACHS OF JUVENILE COHO, CHINOOK, CHUM, SOCKEYE AND HERRING ON ROBERTS BANK (MARCH 28 - SEPTEMBER 12, 1973)

	COHO	CHINOOK	CHUM	SOCKEYE	HERRING
STEVESTON JETTY TO CANOE PASS					
Highest % biomass	P	LJF	LJF	LB	LB
2nd highest % biomass	EB	EB	EB	LJF	P
3rd highest % biomass			P		
CANOE PASS TO ROBERTS BANK CAUSEWAY					
Highest % biomass	LJF	LJF	LJF		LJF
2nd highest % biomass	LB	EB	LB		P
3rd highest % biomass		P			
ROBERTS BANK CAUSEWAY TO TSAWWASSEN FERRY TERMINAL					
Highest % biomass	LJF	LJF	P		
SOUTH OF TSAWWASSEN FERRY TERMINAL					
Highest % biomass		LJF			P

¹ Only those food groups representing 10% biomass are indicated.

P Plankton
 LJF Larval and juvenile fish
 EB Estuarine Benthos
 LB Larval Benthos
 FT Freshwater and terrestrial

7. Discussion and Summary

7.1. Previous Estuary Studies

The physical, chemical and biological processes associated with the estuarine environment are relatively complex, compared with other ecosystems. Because of this complexity, and the logistical constraints imposed on sampling procedures by the alternate flooding and ebbing of the tide and the access limitations imposed by the unconsolidated substrate common to these areas, estuarine studies of fishes have been largely confined to adjacent offshore waters. These studies have centred mainly on the role of the estuary as a transition zone between fresh and salt water; an area where juvenile salmon migrants can acclimate prior to their seaward migration. Otto (1971) has shown enhanced growth capacity and rapid acclimation of juvenile coho salmon at dilute salinities and has suggested that combined with the high food production capabilities of estuarine systems, these areas may play an important role in survival, particularly of pre-smolt coho emigrants.

7.1.1. Food Web

Investigations in the intertidal portions of British Columbia estuaries have been confined mainly to inventories of marsh vegetation, species, abundance, distribution and duration of occupation by key fish species and identification of the importance of secondary food web components in the diets of juvenile fishes.

These studies (Department of Environment, 1972 and Parker and Goodman 1974) have provided information necessary to construct an estuarine food web tracing the pathway of food resources or energy from the ultimate source (sunlight) to its final destination (fishes). Although many minor links in these food webs are missing and the energetics and mechanisms of most of the links poorly understood a diagrammatic representation of energy transfer illustrates the relationship of the various habitat types to each other and to fishes. The simplified food web as it relates to juvenile salmon and herring in the estuary (Figure 30) shows that the saltmarsh and associated high intertidal portions of the estuary as well as the freshwater (river) and marine habitats all provide a source of food for these fish. The food web also illustrates the contribution of organic material (detritus) from the high intertidal portions of the estuary to production in the offshore estuarine and marine environments.

OFFSHORE ESTUARINE & MARINE

INTERTIDAL ESTUARINE & FRESHWATER

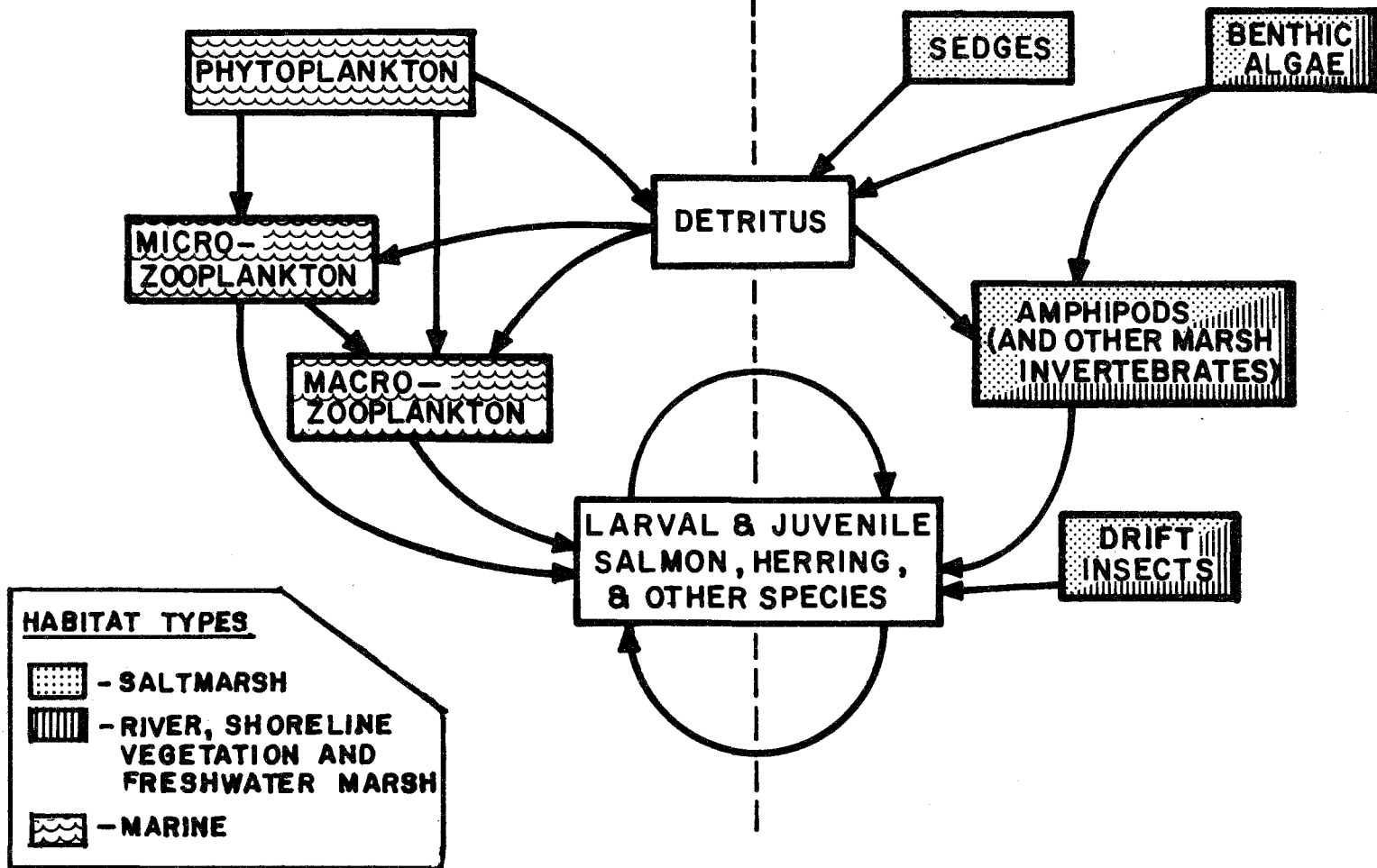


FIG.30

FOOD WEB SHOWING THE PRODUCTION OF FISH FOOD FROM SALTMARSH, RIVER AND FRESHWATER MARSH, AND OFFSHORE ESTUARINE AND MARINE ENVIRONMENT.

Studies in the estuaries of the Squamish (Department of Environment 1972), Nanaimo (Parker and Goodman 1974), Campbell (Goodman and Vroom 1974) and Cowichan (Department of Environment - Fisheries and Marine Service - unpublished data) Rivers, from which the above food web was constructed, have shown that juvenile salmon and other fishes inhabit the estuarine area for extended periods of time and that the organisms produced in the salt-marsh and intertidal areas of the estuary formed a significant portion of the diet of these fishes. Data from these studies does not provide sufficient information on the population dynamics of juvenile salmon in the estuary to determine whether these fish are temporary residents or in transition with continual replacement of numbers.

Other studies, Kask and Parker (1972) reported that the amphipod Anisogammarus confervicolus, which is common in periphyton on floating logs was the predominant food item of juvenile chinook salmon in the Somass River Estuary. Anisogammarus sp. was also the predominant food organism in the stomachs of juvenile chum, chinook, coho, sculpins and starry flounder in the Squamish estuary during various periods from April to August (Goodman and Vroom 1972). Anisogammarus sp. was also closely associated with the vegetated marsh areas of the Squamish estuary (Levings, 1972). Feller and Clayton (1973) have examined the stomach contents of beach-seined juvenile pink and chum salmon (60 mm.) from intertidal waters of Puget Sound. They reported that the chief prey of chum salmon were epibenthic organisms, mainly harpacticoid copepods, gammarid amphipods and barnacle naupli. Pink salmon showed an overall similarity in diet, however, chums ate significantly more harpacticoid copepods and adult diptera while pink fry fed more on invertebrate eggs. Fish stomach contents showed almost a total lack of correlation with respect to the abundance of marine zooplankton. Mason (1970) showed that chum fry in a small estuary exploited freshwater, estuarine and marine food chains prior to entry into the sea.

Reimers (1971) has shown that over 90% of successful chinook spawners in the Sixes River, Oregon, were those fish whose life cycle involved an extended period of estuarine rearing prior to entering the ocean. No such quantitative studies on chinook or any other species have been conducted in a British Columbia estuary.

7.2. Status of Present Knowledge Concerning the Fraser River Estuary

7.2.1. Alienated Habitat

Forrester and Squire (Section III, this volume) have reported that of the former salt-marsh habitat in the Fraser River estuary (totalling 765 acres), only 29% remains, and that 26% of the former 5,839 acres of tidal freshwater marsh have been alienated. Quantification of the impact of these habitat losses on the fishery resources requires a correlation of population trends with a host of other factors including environmental loss and/or degradation of spawning areas, stream rearing habitat and water quality.

7.2.2. Delta Growth and Erosion

Mathews and Shepard (1962) estimated that the 4½ mile portion of the delta-front centred on the main channel mouth was advancing at a rate of about 7½ feet per year near the low water mark, at about 15 feet per year at the -125 foot level, and about 28 feet per year at the -300 foot level. On the other hand, Luternauer and Murray (1973) have suggested that portions of the upper foreslope off southern Roberts Bank may have retreated as much as 40 feet per year at the -130 foot level, at least since 1968. There is no information on the rate of advance or erosion of the saltmarsh habitat.

7.2.3. Effect of Jetties and Causeways on Sediment Migration

Luternauer (1974) has reported that "since 1914, when the first jetties were erected at the mouth of the main channel of the Fraser River, sediment migration across the tidal flats of the western delta-front has been increasingly obstructed by a succession of structures, including the Steveston North Jetty (completed in 1932), the North Arm Jetty (1935), the breakwater at the mouth of the North Arm (1951), the Tsawwassen Causeway (1960), the Iona Island Causeway and Sewage Outfall Channel (1961), the Antennae (Approach Lights) Causeway (early 1960's), and the Westshore Terminals (1970)."

The physical effects of altered sediment migration can, in some areas be inferred from an analysis of sediment size distribution on the banks, however, extrapolation of such in-

formation to the biological processes associated with estuarine productivity is complicated by the natural variability of biological phenomena as well as the variability of other physical parameters affecting these phenomena.

7.2.4. Benthic Invertebrates

Levings and Coustalin (Section III, this volume) have reported that except for southern Roberts Bank, the intermediate and high intertidal zones are dominated by estuarine species, while fauna in the lower intertidal zone is characteristic of marine environments.

Maximum biomass and number of species of benthic invertebrates occurred at the stations highest in the intertidal zone (except between the Tsawwassen and Roberts Bank causeways). Transects with many stations characterized by silt rather than sand yielded more biomass per station because these finer sediments contained highest densities of benthic invertebrates. These data indicate that if the construction of breakwaters, jetties or other structures result in the growth or erosion of areas with fine sediments the productive capacity of the estuary may be altered accordingly. The entrapment of nutrient loads and/or toxic materials by such structures may offset gains in productive potential.

For those transects perpendicular to the shoreline, biomass per station was highest on the transects off Sea Island and between the Tsawwassen and Roberts Bank causeways. For the transect parallel to the shoreline in the high intertidal zone biomass was highest off Lulu Island, the Middle Arm and between the Tsawwassen and Roberts Bank causeways.

Crustaceans and polychaetes dominated the benthic fauna at higher elevations in the intertidal zone except between the Roberts Bank causeway and the Tsawwassen Ferry Terminal. Polychaetes were, however, only rarely found in the stomachs of fish examined from catches on Sturgeon and Roberts Banks. It is possible that the behavioral characteristics of these organisms make them less available as food for fish than the crustaceans, or that they are ingested in significant numbers but digested more readily making their identification in the stomach contents almost impossible.

Levings and Coustalin (Section III, this volume) also reported that their sampling verified the degradation of benthic communities immediately adjacent to the Iona Island sewage outfall as documented by B. C. Research (1973).

7.2.5. Fish

Using an otter trawl to sample the bottom at depths from 5 to 25 fathoms at stations near Point Grey, Levings (1973) reported that except for the black belly eel-pout, most of the fishes captured were juveniles less than 10 cm. in length. Levings suggests that "apparently the shallow areas around Point Grey were used as nursery grounds by several species of flatfish, some of which are commercially important". Significant numbers of flatfish, including starry flounder, sand sole and lemon sole were also caught on Sturgeon and Roberts Banks in the present study (Appendix 2).

With reference to the Fraser River estuary, Le Brasseur et al (1969) reported that at least for juvenile salmon, the concentrations of zooplankton under the freshwater plume were sufficient to provide the estimated population of juvenile salmon with an adequate supply of food. They note, however, that these studies were conducted during the spring of 1967 when the total effect of juvenile fish grazing was small compared with that in 1966 or 1968 when the number of juvenile salmon entering the straits was considerably greater than in 1967. It is clear that in years of maximum salmon and herring fry abundance, the occurrence of coincident peaks in fry migration and zooplankton production under the plume could be a major factor in determining survival. The demonstrated availability and utilization of estuarine benthic organisms and terrestrial invertebrates throughout this critical period and the subsequent period of depressed zooplankton production suggests that food organisms originating in the intertidal and saltmarsh portions of the estuary may perform a key role in maintaining the viability of these fish stocks. Other data (Barracough 1967, Barracough and Fulton 1967, Robinson, Barracough and Fulton, 1968) indicate that from late April to early June, the food of juvenile salmon caught at stations along the drop-off on Sturgeon and Roberts Banks was comprised mainly of insects, fish, copepods and amphipods. More detailed classification of these food items is required

prior to assessing the respective contribution of estuarine and/or marine food chains to the diets of these fish.

7.2.5.1 The Fisheries Resource

The salmon resources of the Fraser River are estimated to be 9,900,000 fish. Of this total 2,500,000 spawners produce a commercial catch of 7,100,000 salmon, a sport catch of 122,000 and an Indian food fishery catch of 170,000 salmon. This resource represents an annual commercial catch valued at \$73 million and an annual commercial "net" value of \$37 million (1973 prices). In addition, the salmon of the Fraser River have a total annual recreational value of \$ 197 million and preservation value of \$ 106 million.

Based on estimates of unutilized natural habitat and presently planned artificial enhancement projects, the estimated potential annual production of salmon in the Fraser River is 24.5 million.

The estimated average annual (1957-1972) spawning escapements of Fraser River salmon by species are: 51,000 chinook; 1,250,000 sockeye; 63,000 coho; 810,000 pink (odd years only); and 340,000 chum. Catch to escapement ratios provide an average annual Fraser River commercial catch of 183,000 chinook; 3,900,000 sockeye; 143,000 coho; 2,300,000 pinks; and 510,000 chum salmon.

The estimated average annual (1965-1974) number of downstream juvenile salmon migrating in the Fraser River are: chum - 75.7 million; pink - 193.5 million; chinook - 16.8 million; sockeye - 45 million; and coho - 2.1 million.

Other commercially and recreationally unutilized species of the Fraser River include eulachon, surf smelt, cutthroat trout, steelhead trout, white sturgeon, mountain whitefish, dolly varden, herring and dungeness crab.

7.2.5.2 River and Estuaries Utilization Data
Summary - Catches - Fraser River

- i) In the Fraser River above the Port Mann Bridge, three spine stickleback were the most abundant species in catches followed by coho, chinook and peamouth chub. Seventeen species were present in these catches.
- ii) Thirty-six species were caught in the Fraser River below the Port Mann Bridge. Threespine stickleback, starry flounder, chinook, coho, peamouth chub, prickly sculpin, chum and sockeye were most numerous in these catches.
- iii) A total of 373 juvenile salmon were caught during sampling on May 3 and June 13 at beach seine stations above the Port Mann Bridge. This catch was comprised of 284 coho, 80 chinook, 8 chum and 1 sockeye. For all stations (except BS 7) sampled on both dates, catches of coho were significantly lower on June 13 than on May 3.
- iv) In the North, Middle and South Arms of the Fraser River, juvenile coho were caught in beach seines from April 24 to June 25, 1973. Over the period sampled, coho formed 70% of the salmon caught by beach seines in the North Arm and only 15% in the South Arm.
- v) Over half of the coho caught in the North and Middle Arms were taken in the Middle Arm.
- vi) In the South Arm, highest catches of juvenile coho were taken at those stations characterized by reduced flow, relatively fine substrate and vegetated shores. No juvenile coho were taken at beach seines in Ladner Marsh, Duck, Barber and Woodward Island during sampling in 1973 or at beach seine stations around Steveston Island in 1974.
- vii) Juvenile chinook were caught in 1973 beach seines from April 11 until July 24 in the South Arm and from April 25 until August 27 in the North Arm of the Fraser. The average catch per set and total catch was much lower in the North Arm than in the South Arm.

viii) In the South Arm, 93% of the beach seine caught chinook were taken at stations on Ladner Marsh and Duck, Barber and Woodward Islands. These stations were on shallow, vegetated marshes which are flooded at high tide.

ix) Chinook comprised 12% of the beach seine caught salmon in the North Arm compared with 52% in the South Arm.

x) Most of the juvenile chum salmon caught in the Fraser River were taken by beach seine in the South Arm between March 28 and August 2 with peak catches in mid and late April and mid June. North Arm stations were not sampled frequently prior to June when catches in the South Arm were highest.

xi) In the South Arm, catches of juvenile chum salmon were generally higher in backwater, slough areas, with soft substrate and shoreline vegetation and lower in those areas characterized by steep shore slopes, fast currents and clean sand substrate. Similarly, those stations in the North Arm which produced the highest catches were those with reduced flows and vegetated shorelines.

xii) In contrast to chinook, coho and chum, most of the juvenile sockeye caught in the Fraser River during sampling in 1973 were not caught in beach seines. Sockeye comprised only 1% of the total beach seine salmon catch in the North Arm and only 3% in the South Arm. These catches were made between June 20 and July 24.

xiii) Most of the sockeye taken in the Fraser River were caught in tow nets in the South Arm from mid May to early August.

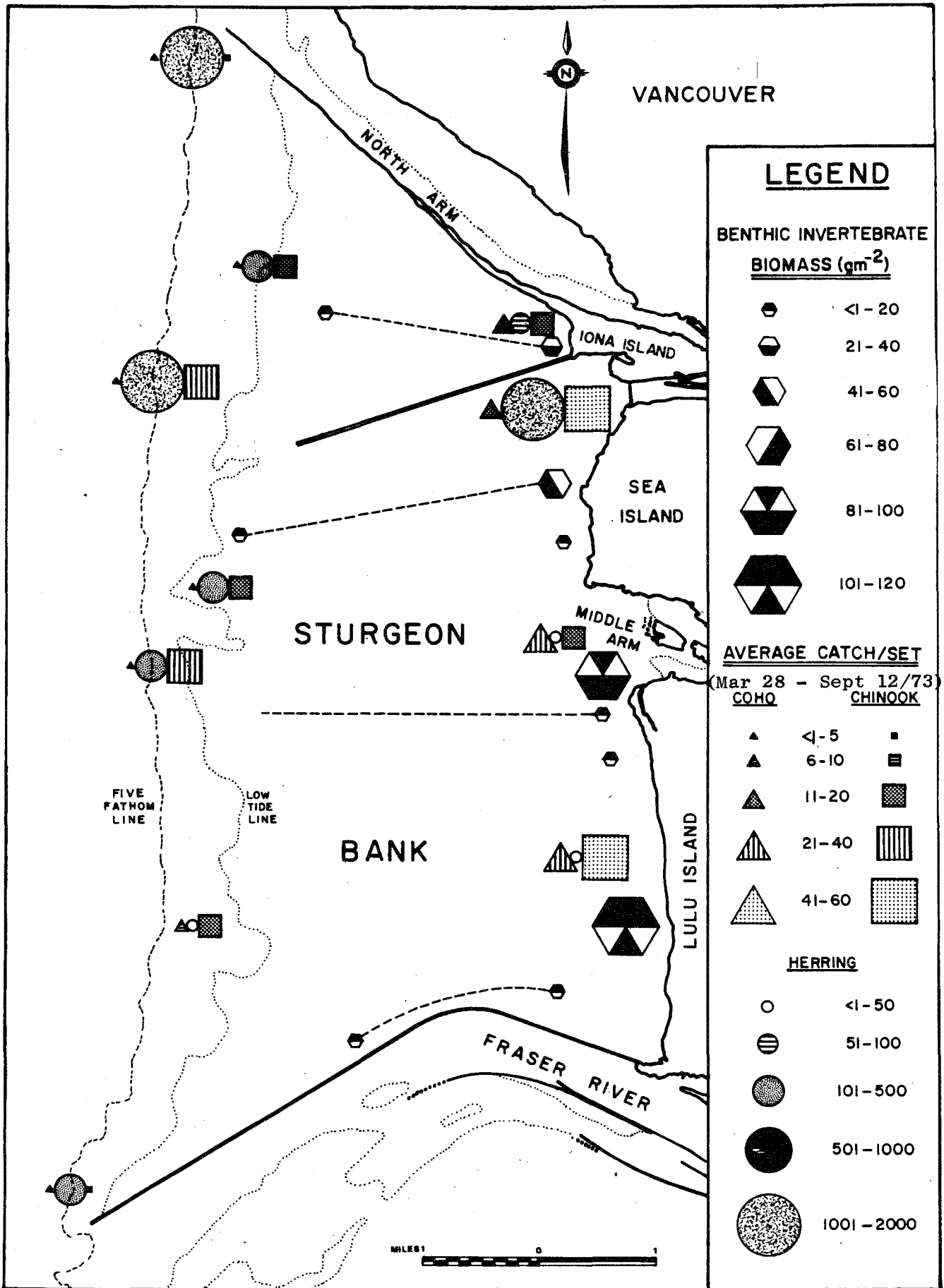
Sturgeon and Roberts Banks

On Sturgeon Bank, catches of juvenile fishes revealed that the order of abundance was herring, chinook salmon, Pacific Sand lance, starry flounder, and coho salmon, whereas on Roberts Bank, herring, then chinook were most numerous in catches followed by shiner perch, threespine stickleback and starry flounder. The combined catch of juvenile salmon on Sturgeon and Roberts Banks was comprised of 67% chinook, 25% coho, 5% chum and 2% sockeye.

- xv) Catches of coho on Sturgeon Bank were consistently higher in the high intertidal areas than in the lower intertidal areas. These catches were highest at stations between the Steveston Jetty and the Middle Arm and decreased progressively north.
- xvi) The difference between chinook catches in the high and low intertidal portions of Sturgeon Bank were not as great as for coho. Catches in the higher intertidal areas were largest at Stations TN1 off the Richmond dyke and TN3 immediately south of the Iona Jetty. Catches of chinook in the intertidal portions of Roberts and Sturgeon Bank were, for the most part, similar during sampling periods when both areas were sampled.
- xvii) Most of the chum salmon taken on Sturgeon Bank were taken by purse seines at offshore stations on April 25, 1973.
- xviii) Catches of juvenile sockeye salmon were significantly higher on Sturgeon Bank than on Roberts Bank at offshore as well as intertidal stations.
- xix) Sockeye were present in the offshore purse seine catches on Sturgeon Bank between May 7 and June 7, 1973.
- xx) Catches of sockeye on Sturgeon Bank (for both offshore and inshore areas) were highest in the area between the North Arm and Iona jetties.
- xxi) On Sturgeon Bank, highest catches of herring were made in the area between the North Arm and Iona Jetties. Catches were higher at offshore stations until the end of June. After June, catches of herring at inshore stations were higher.
- xxii) On Roberts Bank, catches of herring were highest at the offshore stations between the Roberts Bank and Tsawwassen causeways.

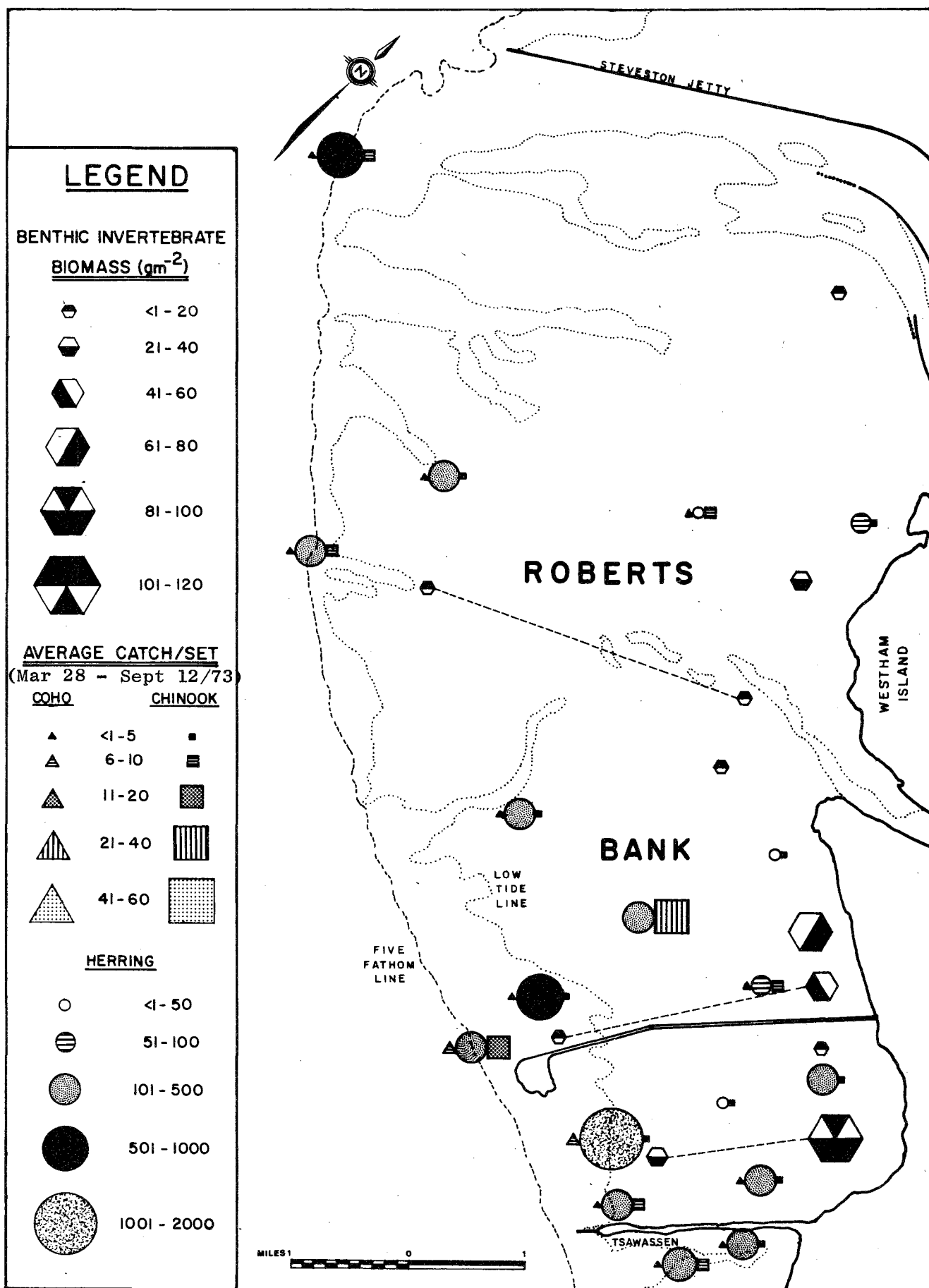
The relative distribution of juvenile chinook, coho and herring on Roberts and Sturgeon Banks as summarized above is presented on Figures 31 and 32. It should be

Figure 31 - Relative distribution of benthic invertebrate biomass¹, juvenile coho, chinook and herring on Sturgeon Bank



¹From Levings and Coustalin (Section III)

Figure 32 - Relative distribution of benthic invertebrate biomass¹, juvenile coho, chinook and herring on Roberts Bank



¹From Levings and Coustalin (Section III)

noted that the different techniques utilized to capture fish strain different volumes of water and sample different habitat types. For this reason, the numbers and corresponding symbols representing average catch per set along the five fathom line are comparable only with the other symbols along this line and are not comparable to the intertidal sample locations in the estuary. Average catch per set for those areas of Roberts Bank which were sampled less frequently were adjusted by applying the ratio of the number of fish caught on Sturgeon Bank during the extra sampling period to the number of fish caught over the remaining period. The distribution of benthic invertebrate biomass (from Levings and Coustalin, Section III this volume)¹ has also been included in these figures because of their importance as a food source for juvenile salmon.

Data Summary - Stomach Contents -
Fraser River

- xxiii) Juvenile coho stomachs examined from catches upstream of the Port Mann Bridge contained mainly salmon and chironomid larvae. Chinook stomachs contained almost entirely unidentified larval fish. The single chum stomach examined from these catches was empty, while the single sockeye stomach contained unidentified amphipods.
- xxiv) Analysis of stomach contents of juvenile salmon caught in the North and Middle Arms revealed that coho utilized larval and juvenile fish as the major source of food; estuarine benthos served as the major source of food for chinook and freshwater and terrestrial invertebrates served as the major food source for chum and sockeye.
- xxv) Freshwater and terrestrial invertebrates served as the major source of food for coho, chinook, chum and sockeye in the South Arm, ranging from 99% biomass for chinook to 59% biomass for chum.

1 The biomass of only the highest and lowest intertidal stations on East-West transects have been indicated.

Sturgeon and Roberts Banks

- xxvi) In terms of biomass, larval and juvenile herring and other fishes were the major component of the stomach contents of coho and chinook on both Sturgeon and Roberts Banks as well as sockeye on Roberts Bank.
- xxvii) Plankton was the major food item in the stomach contents of chum and herring taken on both Sturgeon and Roberts Banks.
- xxviii) The general trend in the stomach contents is that when the percent biomass of plankton decreases rather abruptly after June 1st, the percent biomass of estuarine benthic organisms shows a marked increase.
- xxix) On Sturgeon Bank, estuarine benthic organisms were important components ($\geq 10\%$ biomass) in the diet of: coho and chum in the area between the North Arm and Iona Jetties; chinook and herring in the area between the Iona Jetty and the Middle Arm and coho, chinook, chum and herring in the area between the Middle Arm and the Steveston Jetty.
- xxx) On Roberts Bank, estuarine benthic organisms comprised $\geq 10\%$ of the stomach content biomass of coho, chinook, and chum in the area between the South Arm and Canoe Pass and of chinook between Canoe Pass and the Roberts Bank causeway.
- xxxii) Freshwater and terrestrial invertebrates comprised $\geq 10\%$ of the stomach content biomass of coho, chinook and sockeye in the area between the Iona Jetty and the Middle Arm and chinook and chum in the area between the Middle Arm and the Steveston Jetty on Sturgeon Bank and of chum salmon in the area between the South Arm and Canoe Pass on Roberts Bank.
- xxxiii) Calanus glacialis, Euphausia pacifica and Pseudocalanus minutus were the predominant marine zooplankton species in the fish stomachs examined.
- xxxiiii) Mysids, harpacticoid copepods, cumaceans and amphipods were the predominant estuarine benthic organisms in the fish stomachs examined.

The above summary of the relative abundance, distribution and timing of juvenile salmon and their utilization of various food organisms in the Fraser River and estuary are presented in Table 22.

The stomach contents of juvenile coho, chinook, chum, sockeye and herring has indicated that the diet of these fish is comprised of marine, estuarine and freshwater organisms. This composition no doubt reflects the movement of fish on and off the intertidal portion of the estuary with flooding and ebbing tides. These data indicate that the inshore areas of Sturgeon Bank between the Steveston and Iona Jetties serve as an important rearing and feeding area for coho, chinook and herring. The southern portion of Roberts Bank, between the Tsawwassen Ferry Terminal and the Roberts Bank causeway and the inshore area immediately north of the Roberts Bank causeway, are similarly important areas of the estuary.

Catches of fish in the river indicate that the sloughs and bays along the shoreline characterized by upland vegetation and the marsh habitats such as Duck and Barber Islands and Ladner Marsh, are utilized as rearing areas by coho, chinook and chum. Food organisms produced in these areas are extensively utilized by these fish.

Comparison of the percentage of the total juvenile salmon catch represented by each species on Sturgeon and Roberts Banks with the estimated number of downstream migrants (Table 22) indicates that the level of estuarine utilization differs for each species. Estuarine utilization appears to be greatest for coho and chinook, and significantly less for chum and sockeye. It is felt that the level of intertidal estuarine utilization by pink salmon is less than that indicated for chum and chinook and that pink fry do not inhabit those areas in the river sampled by beach seines. The validity of this generalization is conditioned by a paucity of data from the mid-stream portion of the Fraser River and the intertidal portion of Sturgeon

TABLE 22. SUMMARY OF FRASER RIVER ADULT ESCAPEMENTS AND JUVENILE EMIGRATION, DISTRIBUTION, RELATIVE ABUNDANCE AND FOOD UTILIZATION IN THE LOWER FRASER RIVER, ROBERTS AND STURGEON BANKS

TABLE 22

	RIVER													BANKS																						
					RELATIVE ABUNDANCE AND AREAS OF HIGHEST CATCHES									RELATIVE ABUNDANCE AND AREAS OF HIGHEST CATCHES						RELATIVE ABUNDANCE AND AREAS OF HIGHEST CATCHES																
	Estimated Ave. Annual (1957-1972) Spawning Escapement ¹	Estimated Ave. Annual (1965-1974) Number of Downstream Juveniles	Median of Duration of Downstream Migration 1974 ³	Peak of Downstream Migration 1974 ³	Upper Fraser		Lower Fraser - North & Middle Arms			Lower Fraser - South Arm			Timing of Catches			Length			Stomach Contents Fraser River			Sturgeon Bank		Roberts Bank		Timing of Catches		Lengths		Stomach Contents						
					Catch/Set	% of Salmon Catch	Catch/Set	% of Salmon Catch	Areas of Highest Catches	Catch/Set	% of Salmon Catch	Areas of Highest Catches	Timing of Catches in Upper River	Timing of Catches North and Middle Arms	Timing of Catches South Arm	Above Port Mann Range (mm.)	North & Middle Arm Range (mm)	South Arm Range (mm)	Above Port Mann	North & Middle Arm	South Arm	Catch/Set	% of Salmon Catch	Inshore	Offshore	Catch/Set	% of Salmon Catch	Inshore	Offshore	Inshore	Offshore	Inshore	Offshore	Sturgeon Bank Range (mm)	Roberts Bank Range (mm)	Sturgeon Bank
Coho	63,000	2.1 million ²	-	-	20.3	76	7.6	67	-shoreline -Middle Arm across from Float Plane dock	1.9	15	-small bay at Woodward Landing B.C. Ferries repair depot -inside Cannery channel -small bay downstream of Dow Chemical on south shore of south arm -Tilbury Island	* May 3 - June 13 +	* April 24 - June 25	April 25 - June 20	33-104	34-111	21-129	-salmon -chironomid larvae -plecoptera	-larval fish -Anisogammarus -Mysids	-chironomid larvae -salmon	5.7	29	-off middle arm -between middle arm and Steveston Jetty	-between middle arm and Steveston Jetty	1.6	16	-between Roberts Bank and Tsawwassen causeways	* May 7 - June 26	May 22 - August 29*	* June 17 - August 1	May 22 - Sept 12+	38-245	48-218	-larval and juvenile fish -Estuarine Benthos -Freshwater & terrestrial invertebrates	-larval and juvenile fish -Plankton -Estuarine Benthos
Chinook	51,000	16.8 million ³	April 16	May 3	5.7	21	1.7	15	-shoreline -Middle Arm across from Float Plane dock	5.7	46	-shoreline -Ladner Marsh -Duck & Barber Island	* May 3 - June 13 +	* April 24 - August 7	March 28 - August 21 +	43-121	41-114	34-129	-larval fish -mysids	-mysids -larval fish -Anisogammarus	-insect larvae	11.9	61	-south of Iona Island -between middle arm and Steveston Jetty	-off middle arm -between North Arm and Iona Jetties	7.9	82	-between Canoe Pass and Roberts Bank causeway	* May 7 - August 19+	* March 28 - August 29+	* June 17 - Sept 10+	* March 29 - Sept 12+	50-405	51-400	-larval and juvenile fish	-larval and juvenile fish -Estuarine Benthos
Chum	340,000	75.7 million ³	April 11	May 1	0.6	2	1.7	15	-shoreline -adjacent to the boat basin upstream from McDonald Slough -middle Arm across from Float Plane dock	3.0	25	-shoreline -Duck & Barber Is -Ladner Reach -inside Cannery channel -top end of Deas Slough -top end of Tilbury Island	* May 3 - June 13 +	* April 24 - July 12	March 28 - August 2	33-37	28-84	25-117	-larval fish -chironomid larvae -diptera	-Anisogammarus -chironomid larvae		1.2	6	-between Middle Arm & Steveston Jetty	-between North Arm and Iona Jetties	0.1	1	-immediately north of and adjacent to Roberts Bank Terminal	August 6 - August 21	April 25 - August 29+		April 25 - August 28	33-228	54-190	-Plankton -larval and juvenile fish -Estuarine Benthos	-larval and juvenile fish -Plankton -Freshwater & terrestrial invertebrates
Sockeye	1,250,000	45 million ²	-	-	0.1	0.3	2	2	-midchannel in McDonald Slough and Sturgeon Hole slough (between Queensborough bridge and Swing bridge)	1.7	14	-Mid-channel	* May 3 (only)	May 29 - August 7	May 14 - August 7	-	33-87	32-135	-chironomid larvae -diptera	-chironomid larvae -cladocera -harpacticoid copepods		0.6	3	-between North Arm and Iona Jetties	-between North Arm and Iona Jetties	<0.1	0.5		* May 7 - August 22	May 7 - June 4		June 4 - July 3	55-112	50-600	-Plankton -larval and juvenile fish	-larval benthos -larval and juvenile fish
Pink	810,000	193.5 million Even years only ³	April 10	April 5																		2.6 - 1974 purse seines only									31-36 (1974)		-Plankton -Estuarine Benthos			
Herring														May 15 only	May 14 only							354.4		-south of Iona Island	-between North Arm and Iona Jetties	260.4		-between Tsawwassen and Roberts Bank causeways	* May 7 - August 29+	April 10 - August 29+	* June 17 - Sept 11+	May 9 - Sept 12+	34-237	40-250	-Plankton	-Plankton -Larval Benthos -larval and juvenile fish

1 Department of Environment (1974)
2 Northcote (1974)
3 Bailey and Fraser (1975)

* First day of sampling
+ Last day of sampling

* First day of sampling
+ Last day of sampling

and Roberts Banks which were not sampled during 1974 due to equipment failure. Unpublished data from the International Pacific Salmon Fisheries Commission on the early sea life of pink salmon indicates a rapid dispersal of downstream migrants throughout the Gulf of Georgia.

7.3 Effects of Proposed Airport Expansion

7.3.1. Dredge and Fill Operations

Those portions of the intertidal zone covered with fill material become permanently unavailable as either a habitat for fish or for the production of benthic organisms that are potentially available as food for fish. The highest biomass of food organisms potentially available for salmon was found (Levings and Coustalin, Section III, this volume) in the high and intermediate zones. Accordingly, filling of these areas as proposed for expansion of the Vancouver International Airport will have a greater impact than an equal area of fill on the lower portion of the intertidal zone. In addition, the proliferation of sediments associated with the dredging operation will temporarily smother benthic populations. Intertidal fauna will also be eliminated as a result of physical changes in substrate levels. Recovery rates of these populations is largely dependent on the rate of infill. Accordingly, those borrow sites identified by the Ministry of Transport that infringe on the intertidal portions of the lower river and Sturgeon Bank are viewed as having potentially high, long term impacts on the fishery resources of the Fraser River and estuary.

With reference to Ministry of Transport proposed borrow sites in the North Arm of the Fraser River (Phase I, II, III, VI and VII DPW Drawing MVMP-014) some perspective is necessary. Together, these borrow areas would provide 10,340,000 cubic yards of fill. This compares with an annual amount of 2-3 million cubic yards removed from the North, Middle and South Arms by maintenance dredging (Pollutech 1974). While the volume to be removed from these borrow areas is large, the impact on fish and the benthic organisms utilized as fish food is determined by the location of borrow areas rather than the amount of material removed. Since it is assumed that the highest production of benthic organisms potentially available as fish food occurs along the shoreline, the impact of dredging on this production should be minimal for mid-channel sites (phases I, III and VIII) and highest for dredging of near-shore areas (phases VI and VII).

7.3.2. Contaminants from Airport Operations

Potentially toxic pollutants resulting from airport operations as identified by Scott (1974) include aircraft de-icers, chemicals used in fire training procedures and fuel resulting from spills. Introduction of these materials into water courses leading to the lower river and estuary could effect various components of estuarine food chains in addition to fish. In his report, Scott (1974) has identified the need for implementation of measures to control the quality of storm drainage runoff.

7.4 Rationale for Concern with Proposed Developments

The present concern with plans for industrial and other development in and adjacent to the estuary of the Fraser River is based on the foregoing knowledge of the utilization of the Fraser River estuary as a feeding and rearing area for juvenile salmon and other fishes, the irreversible effects of development involving dredging and filling and the absence of techniques for the reestablishment, compensation or enhancement of degraded or alienated estuarine habitat. This concern is compounded by the fact that 70% of the saltmarsh habitat of the Fraser River estuary has already been alienated (Forrester, Squire and North Section III this volume).

The high and mid-intertidal portions of Sturgeon Bank off Sea and Lulu Islands and the entire intertidal zone between the Roberts Bank causeway and the Tsawwassen Ferry Terminal on Roberts Bank have been identified as the most valuable areas of the banks in terms of fish utilization and fish food production. Accordingly, the impact of development in these areas will be directly related to the amount of this habitat removed or degraded. Specifically, airport development concept 1 would remove 70 acres of this valuable habitat plus an additional amount if associated dredging were carried out on Sturgeon Bank. Airport expansion Concept 2, involving 235 acres and Concept 3 (755 acres) will substantially increase the loss of intertidal habitat. In addition, the physical obstruction and alteration of existing current patterns could result in extension of the habitat loss imposed by the Iona Island Sewage Treatment Plant effluent.

The proposed expansion of port facilities on Roberts Bank, south and easterly of the existing development would eliminate approximately 200 acres of productive habitat for additional terminal sites, 200 acres of foreshore for an industrial park, and approximately 400 acres which will be dredged to 65 ft. below low water for a turning basin. Additional habitat will be alienated by causeway widening. The loss of intertidal habitat associated with the development of a Ferry Terminal at the end of the North Arm or Iona jetties would be limited to the area required for the widening of causeways.

8. Further Study Requirements

There are a number of biological and bio-physical interrelationships which must be more clearly defined before the Fraser River Estuary can be intelligently managed and protected.

8.1. Quantification of Impacts

Quantitative assessment of the impacts of degradation or elimination of estuarine habitat and alteration of oceanographic features on the fisheries resources of the Fraser River and estuary is contingent upon obtaining a clear understanding of the following:

- 8.1.1. The numbers of juvenile salmon and other species utilizing the estuary in relation to total populations.
- 8.1.2. The utilization of the estuary as a rearing area by non-indigenous stocks.
- 8.1.3. The significance of variable periods of estuarine occupation with respect to survival rates and stock viability.
- 8.1.4. Annual and seasonal fluctuations in the abundance, distribution and utilization of acceptable fish food organisms in the intertidal estuarine zone as well as the offshore areas.
- 8.1.5. The effects of intertidal breakwaters and causeways on ocean currents, salinity, sediment transport, saltmarsh and delta growth or erosion, water quality and the relationships between these parameters and estuarine productivity and utilization by salmon, herring and other species.

8.2. Rehabilitation

- 8.2.1. A detailed assessment of the restorational benefits of reopening McDonald Slough in terms of alleviating the eutrophication of the area of Sturgeon Bank affected by sewage from the Iona Island sewage treatment plant is required.
- 8.2.2. Studies should be initiated with respect to developing methods for the rehabilitation and enhancement of degraded or less productive estuarine areas.

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FOOD WEB COMPONENTS OF THE FRASER RIVER ESTUARY

1. LOWER FRASER FLOOD PLAIN STUDY
- E.A.M. Forrester, G.B. Squire and
M.E.A. North
2. STANDING CROP OF FUNCTIONAL CHLOROPHYLL
IN THE SEDIMENTS OF THE FRASER RIVER DELTA
January - March 1974
- S.C. Lindstrom and R.E. Foreman
3. VANCOUVER INTERNATIONAL AIRPORT EFFECTS
STUDY - SUBTIDAL MACROFAUNA
4. BENTHIC ECOLOGY STUDIES ON THE TIDAL FLATS
OF STURGEON AND ROBERTS BANK IN RELATION TO
PRESENT AND PROJECTED INDUSTRIAL DEVELOPMENT
- C.D. Levings and J.B. Coustalin

LOWER FRASER FLOOD PLAIN STUDY

PHASE I

- a) To determine the acreage of flood land which has been altered from the natural ecosystem by dyking in the area downstream from Mission, B.C.
- b) To determine the acreage of flood land remaining in natural ecosystems, and,
- c) To subdivide these areas into 5 or 6 vegetation associations.

PREPARED FOR THE DEPARTMENT OF THE ENVIRONMENT

BY

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C O N T E N T S

Basis for Delimitation of Ecosystems

Quantitative Evaluation of Ecosystems

Results

Recommendations

Phase II

Basis for Delimitation of Ecosystems - M.E.A. North

1. Field reconnaissance established eleven visually distinguishable ecosystems described by the dominant plant species, including systems 1, 2, 3 and 4 which extend beyond the shoreline, as shown on the topographic maps.
2. 1963 Air photos were used to delimit areas of remnant vegetation (see note below), which were transferred to 1:25,000 topographic maps.
3. Extension from remnant areas to areas now under cultivation or urban use was made by the following methods:
 - a) Use of Soil Maps and Reports. If remnant vegetation occurred on a certain soil series then that soil series was assumed to support the same vegetation wherever it occurred. The soils reports also contain a certain amount of information on the vegetation present on many, but not all, soil series. This information was used both to check the accuracy of photo identification of ecosystems, and was used where no remnants could be identified.
 - b) Two vegetation map sources were used:
 - (i) K.A. McLaren's 1972 which showed present vegetation on the islands downstream from the Deas Island tunnel on the south area of the Fraser (1).
 - (ii) A map of the vegetation of Pitt Polder obtained from Dr C.V. Brink (2).

- c) Where there was a complete lack of direct evidence from Air photos, or indirectly from soils reports, extrapolation from the nearest known ecosystem was made using major changes in the soil series to establish boundaries.
- d) Some archival sources have been used to establish the dominant ecosystems on Lulu Island.
- e) Where possible, rapid field surveys were made to ensure that all remnant vegetation, however small in area, within each delimited ecosystem was of the type described in each system.

NOTE: Remnants of ecosystems were assumed to be all areas which appeared to support natural vegetation in the 1963 air photos; this assumption may be erroneous. All systems extrapolated from remnant ecosystems by the above methods are referred to as reconstructed systems.

Quantitative Evaluation of Ecosystems - E.A.M. Forrester,
G.B. Squire

Using maps and rapid field reconnaissance, the location of dykes and the upper limits of flood plains were determined for the Fraser (below Mission), Pitt, Serpentine, and Nicomekl river systems.

As photos were not yet available, the dykes and upper limits were marked directly on 1:25,000 topographic maps; these were

then combined with the information from the ecosystem evaluation and areas were determined using polar planimeters.

The flood land was divided into two categories: dyked and undyked; each of these was further subdivided into remnant and reconstructed ecosystems.

FOOTNOTES

- (1) McLaren, K.A. 1972. A Vegetation Study of the Islands and Associated Marshes in the south Arm of the Fraser River, B.C., from the Deas Island tunnel to Westham Island Foreshore. Fish and Wildlife Branch B.C., Department of Recreation and Conservation, Victoria, B.C.. Published January 1972.
- (2) Burrard, T. 1974. Manuscript Map, untitled, for Masters Thesis in Plant Science, U.B.C. Unpublished.

Results - based on 1963 Photography

Fraser (below Mission), Pitt, Serpentine & Nicomekl Flood Lands

Ecosystem Type	Undyked		Dyked		Total
	Remnant Acres	Recon-structed Acres	Remnant Acres	Recon-structed Acres	
1	943	-	15	4,563	5,521
2	3,689	-	663	-	4,352
3	2,155	117	1,012	201	3,485
4	392	15	132	494	1,033
5	1,536	508	4,792	23,820	30,656
6	338	430	276	4,762	5,806
7	1,167	1,132	352	10,724	13,375
8	345	138	-	17,587	18,070
9	1,760	2,812	1,125	16,435	22,132
10	695	3,003	881	9,253	13,832
11	1,451	1,201	6,594	19,620	28,866
Total Acreage	14,471	9,356	15,842	107,459	147,128

Summary

Dyked	- Remnant	15,842	10.8%
	- Reconstructed	107,459	73.0%
Undyked	- Remnant	14,471	9.8%
	- Reconstructed	9,356	6.4%
		<u>147,128</u>	<u>100.0%</u>

Ecosystem Legend

Each ecosystem is defined by the dominant plant species; many other species are also present.

1. SALT MARSH
2. TIDAL MARSH - BULRUSH
3. TIDAL MARSH - SEDGE
4. TIDAL MARSH - CATTAIL
5. WET GRASSLAND - GRASS AND HARDHACK (SPIREA)
6. WILLOW SCRUB
7. COTTONWOOD AND ALDER
8. COTTONWOOD, CRABAPPLE AND ELDERBERRY
9. SWAMP FOREST - CEDAR, SPRUCE (SITKA) AND COTTONWOOD
10. COAST FOREST - CEDAR, DOUGLAS FIR AND COTTONWOOD
11. PEAT-BOG FOREST - PINE, BIRCH AND HEMLOCK

Recommendations

This research has revealed the need for a more detailed survey of the Fraser, Pitt, Serpentine and Nicomekl rivers flood plains. From the information already gathered, it appears that a summer's field work and library research could result in a reliable map of remnant and reconstructed ecosystems. Such a map, to this date, has never been published nor, to our knowledge, has ever been attempted.

If this was carried out, Phase II of this project should be incorporated into it.

Phase II

The following refinements are deemed necessary in Phase II:

- (a) Updating of information based on 1963 photos by use of 1971 photos which are now available.
- (b) Field checks to confirm aerial photo analysis.

- (c) Refinement of ecosystem classification and boundaries, development of taxonomic lists.
- (d) Use of 1948 flood photos as a check for the upper boundaries of the Fraser River flood plain in the Mission - Fort Langley area.
- (e) Intensify field checks of dykes and upper flood plain limits, especially those of Serpentine and Nicomekl.
- (f) Refine area calculations based on refinements (a) - (e).

LOWER FRASER FLOOD PLAIN STUDY PHASE II

OBJECTIVES

1. Dyked and undyked floodland to be delineated on large scale maps.
2. Floodland to be redefined with more conservative flood levels with emphasis on the duration of the flood.
3. The study area to be restricted to the Fraser floodplain and delta from New Westminster to the coast.
4. The delimitation of plant communities to be refined by use of more recent photos, additional field checks and archival research.

Prepared for the Department of the
Environment

by

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LOWER FRASER FLOODPLAIN STUDY

PHASE II

Basis for Delimitation of Plant Communities - M.E.A. North

Sixteen plant communities have been mapped in the floodplain of the Fraser River, downstream from New Westminster. Two of these communities extend beyond the shore line as shown on the topographic maps.

The delimitation of plant communities is based on the dominant species as recorded by field checking of remnant 'natural' areas, and as recorded by the original land surveyors and other archival sources. No attempt has been or could be made to provide complete floristic or phytosociologic information on these communities. The lack of these details is due to (i) the impossibility of identifying the herbaceous flora before it flowered, and (ii) the lack of such information in the available archival records.

There are a number of major problems in mapping natural plant communities on the Fraser floodplain:

- i) All communities can be assumed to be successional. The speed and direction of succession are likely to vary spatially depending on rates of sedimentation, frequency of flooding, and texture of soils, etc.
- ii) The archival material covers a span of thirty years, sufficient time for the dominant species of any one community to change drastically.

iii) The earliest archival material (1859) already records the presence of non-Indian settlers as well as of Indian villages, and notes that vegetation in different areas has been burnt or cut over, and that dykes have been constructed in some areas.

For these reasons the lines drawn to delimit communities have to be considered as tentative, and the map has not yet been sufficiently cross-checked to be made available for inspection.

The communities identified are as follows:

1. Salt marsh (Glasswort)
2. Tidal marshes¹ - A (Bulrush)²
B (Sedge)
C (Cattail)
3. Wet grass prairie (Grass, Peavine)³
4. Grass (Redtop grass)⁴
5. Grass - Willow - Crabapple - Hardhack
6. Willow scrub
7. Crabapple thickets
8. Spruce - Willow - Crabapple - Alder - Briars - Vine maple⁵
9. Cottonwood - Alder - Willows⁶
10. Spruce - Cedar - Fir - Alder - Hemlock⁷
11. Swamp forest - Spruce - Cedar - Willow - Hemlock - Alder - Vine maple - Briars.
12. Former swamp forest⁸
13. Coarse grass⁹
14. Peat bog - sphagnum dominant, scattered hemlock - spruce
15. Peat bog - pine - labrador tea - cranberry - sphagnum
16. Douglas fir¹⁰

Methods and Sources used to delimit the plant communities

Essentially two different methods and sources were used:

(i) archival (ii) field study backed by air photo interpretation.

(i) Archival Sources

(a) Survey reports filed in the Department of Land Surveyors' archives in Victoria.

1859 - Sea Island
Lulu Island (except Southern portion)
South bank of Fraser opposite New Westminster

1870-1874 Ladner area

1874 Westham Island

1876 and 1883 Annacis Island

1876 and 1888 North bank of North Arm, eastwards from Musqueam. Royal Engineers surveys of west part of same area.

(b) History of Lulu Island, Thomas Kidd, 1927

(c) Map 1859-60. Fraser River and Burrard Inlet surveyed by Capt. G.H. Richards, R.N.

Information from the surveyors reports is in the form of notes on soils, vegetation and water features encountered whilst the surveyors were walking along a compass bearing in the course of staking out quarter sections of land or marking the boundaries of previously alienated land, often of irregular shape. The information on vegetation was noted on 1 to 20 chain land survey maps. This information was then grouped into the 16 communities listed, and the lines transferred to the 1:25,000 topographic sheets. The

History of Lulu Island and the map of Fraser River and Burrard Inlet were used to cross-check the surveyor's reports.

All remnant areas of 'natural' vegetation were identified from air photos (1 to 40 chain and 1 to 20 chain), most of these were checked in the field. There were two types of checking: (a) Quadrats were measured out and systematically traversed, the dominant species in three height classes were noted and their sociability; (b) Other areas were spot checked on the ground to establish their similarity to areas already studied in detail. In both types of checking a note was made as to whether the area appeared natural, i.e. no signs of cutting or burning, or interferred with. (These two divisions of the remnant vegetation have been mapped separately). All areas which were not field checked have been assumed to be interferred with when they occur within the dykes, and natural when unprotected by dykes.

After assembling these two sources of information it became obvious that there were some sizeable areas where there is scant archival information and very little remnant vegetation. Therefore, large parts of Westham Islands, Ladner area, Annacis and Tilbury Islands had the plant communities reconstructed by the following techniques:

- (a) extrapolation of known plant communities into areas of the same soil type.

- (b) extrapolation of known plant communities into areas of the same elevation.

Methods used to delimit the dyked and undyked floodplain -
E. Forrester, G.B. Squire

Phase I

Lack of time permitted the delimitation of the dyked and undyked land only as shown on the 1:25,000 map sheets. The limits of the floodplain were used as the upper limits of floodland. These more or less coincided with the 1948 flood extent. Evidence used for this upstream was air photos and field checks and was later confirmed by profiles obtained from the Inland Waters Directorate in Vancouver.

Phase II

We were requested to choose a less extreme river flood level to delimit the floodland than that for 1948. After we had consulted with the Dykes Inspector, Mr Meighen, and Inland Water Directorate personnel, principally Mr Preston, the I.W.D. prepared a map showing floodland with the following flood frequencies:

- (a) Mission to New Westminster: once in 3 years
- (b) New Westminster to Steveston: once in 1.3. years which coincides with the 7 foot contour.

A meeting with Dr. McAlistair and Dr. Narver revealed that the crucial information required was related to spring flooding and its effect on survival of migrating salmonids. Because the

I.W.D. map indicated floodland at the time of the January high tides (below New Westminster) it became obvious that this map was actually irrelevant for a region where tidal action determines flooding.

At this meeting the scope of the study was restricted to the most critical area which was from New Westminster to the coast; therefore, the Pitt, Serpentine, Nicomekl and Fraser, upstream from New Westminster were not considered thereafter.

It was decided to approach the "floodland" from two points of view:

1. To determine the average height to which the river and tide floods during the four month period April - July. This was done by taking the average daily peaks for these four months of the year over an eleven year period 1958-1968 for four stations; New Westminster, Deas Island, Fraser St. Bridge, and Steveston (see Table 1).
2. In the survival of the salmonids, the duration of the flood is more significant than the height of the flood. Therefore within April - July for the eleven year period the daily peaks were examined to determine the average height above which there was a daily flood for (a) 60 days and (b) 90 days. Because of topographic variations, natural levees and coastal sand and gravel beaches, a large portion of the flood land below heights as calcu-

lated for (a) and (b) could be considered to be continually flooded during the respective time periods.

Results from these two approaches are given in Table 1.

TABLE 1

Mean Daily Peaks 1958-68

	April	May	June	July	Average
	Ft.	Ft.	Ft.	Ft.	Ft.
New Westminster	4.37	5.51	7.03	6.10	5.76
N. Arm Fraser (Fraser St. Bridge)	4.44	4.98	5.34	5.13	4.97
Deas Island	4.38	5.00	5.58	5.12	5.04
Steveston	4.17	4.63	4.90	4.81	4.62

Height Above Which Water Rises Daily

	60 Days	90 Days
New Westminster	5.6	9.0
N. Arm Fraser (Fraser St. Bridge)	5.0	4.9
Deas Island	5.0	4.8
Steveston	5.2	4.8

Source: Surface Water Data, Water Surveys of Canada, 1958-68.

In view of these results, we chose the 5 foot contour to delineate the floodland which provided a suitable habitat for migrating salmonids.

Despite the availability of more detailed elevations on large scale maps, the areal differences which might be arrived at by drawing boundaries which, at most, would differ by 0.8 foot elevation are not significant to warrant the extra expense necessary to obtain them.

To determine dyked and undyked land we referred to the dykes shown on the 1:25,000 maps and conducted some field checks in doubtful areas.

N.B. There are areas included in undyked land which have been so changed by man in other ways (e.g. fill) that they could be classed more realistically as dyked land, for example, the North tip of Annacis Island.

Using the "floodland" as defined on the previous page and the maps of plant communities prepared by Mrs North, we calculated the areas of dyked and undyked land in the different communities. These results are given in Table 2.

TABLE 2: ACREAGES BY PLANT COMMUNITIES IN DYKED AND UNDYKED FLOODLAND^(a)

Plant Community ^(b)	Acreage of Undyked Land			Acreage of Dyked Land		
	Natural ^(c)	Inter-fered ^(c)	Recon-structed ^(d)	Natural	Inter-fered	Recon-structed
1. Salt Marsh	220		100			445
2. Tidal Marsh total	<u>5,220</u>		174			1,378
A Bulrush	(3,285					
B Sedge	(1,561					
C Cattail	(374					
3. Wetgrass Prairie			217			3,957
4. Grass						1,594
5. Grass-Willow, Etc			25			1,422
6. Willow Scrub						333
7. Crabapple thickets			99			564
8. Spruce - willow, etc						1,313
9. Cottonwood - alder, etc	193	16	205			273
10. Spruce - cedar, etc			93		151	1,266
11. Swamp Forest			789	15		849
12. Former swamp forest						693
13. Coarse grass						588
14. Peat bog - sphagnum						
15. Peat bog - pine		39		76	177	251
16. Douglas Fir			3		15	
TOTALS	<u>5,633</u>	<u>55</u>	<u>1,705</u>	<u>91</u>	<u>343</u>	<u>14,926</u>

(a) See page 7 of definition of "floodland";

(b) See page 2 for more detailed classification;

(c) See page 4, first paragraph for explanation of 'natural' and 'interfered';

(d) See page 4, last

SUMMARY - Table 3

	Acres	
Total acreage of land below 5 feet in the Fraser Delta	22,752	100.0%
Total acreage of undyked	7,393	32.5%
Total acreage of dyked	15,359	67.5%
 <u>Plant Communities</u>		
Natural - undyked	5,633	24.8%
- dyked	91	0.4%
Interfered with - undyked	55	0.2%
- dyked	343	1.5%
Totally altered - undyked	1,705	7.5%
- dyked	14,926	65.6%

FOOTNOTES

- 1 Tidal marshes in archival sources are not differentiated into A, B and C; the general description given is cattails, grass, rushes, reeds and flags.
- 2 The subdivision of the tidal marshes into the three successional stages each dominated by a different species is based almost exclusively on K.A. McLaren's map published in 1972 (for full reference see Phase I report).
- 3 This wet prairie was noted by surveyors in the areas in 1870's; however, the areas were already inhabited either by Indian or white settlers, hence it may not be a 'natural' grassland.
- 4 Redtop grass was extensively recorded on Lulu Island pre-white settlement.
- 5 This forest type is probably a successional stage following 6 or 7 and changing to 10 or 11.
- 6 Cottonwood is found only on coarser-textured, better draining sites.
- 7 This forest type is characterized, though not dominated by, Douglas Fir which implies a site less subject to flooding.
- 8 This category may be included with community 11; it is separated because on the earliest archival sources it

is recorded as 'former swamp forest', i.e. it had already been cut and/or burnt.

9

Coarse grass was recorded in the early surveyor's reports as being formerly peat bog, it is found adjacent to existing peat bogs, and the 'natural' vegetation now present in these areas is dominated by birch. There is no record in the early surveys of birch in any of the areas where it is now seen in abundance, hence it is not mapped as such.

10

Douglas Fir stands occur only on the driest sites which were probably not subject to either frequent or prolonged flooding.

STANDING CROP OF FUNCTIONAL CHLOROPHYLL
IN THE SEDIMENTS OF THE FRASER RIVER DELTA

JANUARY - MARCH 1974

by

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and

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March 1974

Report No. 3 to: Environment Canada, Fisheries and
Marine Service, FRB - Nanaimo
Contract No. PO F 100595

ABSTRACT

Measurement of functional chlorophyll in the sediment of the Fraser River delta in January to March 1974 gave a range of values from 4 to 225 mg chl a/m² with a mean of 70 mg/m². These values are similar to those obtained during the summer of 1972 and to values of phytoplankton chlorophyll a in moderately to highly productive oceanic and coastal waters.

Seasonal rates of primary production by microalgae in an intertidal mudflat have been shown to be correlated with the standing crop of functional chlorophyll (Leach, 1970.) Because chlorophyll a concentrations are relatively easy to measure and comparative data for the Fraser River delta are available, this method was utilized to sample microalgae of the Fraser delta in January to March, 1974.

Samples were collected on January 29 (Stations I-1 to I-4), February 12 (Stations II-1 and II-7); and March 11 (Stations III-1 to III-7). Sampling stations are indicated on the map in Figure 1. Chlorophyll a concentrations were determined using the acetone extraction and spectrophotometric procedure outlined by Bawden, Heath and Norton (1973). Results are given in Table 1.

The species of diatoms in the mud samples were not identified. Except for Station III-7, all samples appeared to contain only pennate diatoms. Station III-7 contained a colonial Navicula-type diatom species and a species of centric chain diatom. Carole Bawden (personal communication) is working on the identification of diatoms she has collected from the Fraser delta.

Continuation of the benthic macrophyte sampling program using the procedure described by Lindstrom and Foreman (1973) at the II Stations yielded no algae within a 30 m radius of the point at which the chlorophyll sample was collected,

except for Stations II-3 and II-6. At Station II-3, a fisherman's net, mostly buried in the mud, contained a healthy population of sterile Enteromorpha linza. A large tree trunk at Station II-6 was covered with a sparse growth of sterile Enteromorpha intestinalis var. cylindracea and unilocular and plurilocular Pilayella littoralis f. littoralis. Neither station was sampled quantitatively because of the unrepresentativeness of these algal populations to the delta as a whole, which appeared totally devoid of macrophytic algae. Several small clumps of Lola lubrica were found near Station I-3 in January, but no macrophytic algae were observed along the March 11 transect.

The chlorophyll a concentrations on the Fraser delta appear to be of approximately the same order of magnitude as phytoplankton chlorophyll a concentrations in moderately to highly productive oceanic and coastal waters. Values of chlorophyll a concentration may reach 100 mg/m^2 in the relatively rich coastal waters off the coast of New York. Closer to home, values of chlorophyll a concentration for Departure Bay reach about 70 mg/m^2 during periods of peak phytoplankton productivity in late spring (adapted from Parsons, 1963).

Comparison of the chlorophyll a concentrations from samples collected on the Fraser delta in the summer of 1972 (Bawden, Heath and Norton, 1973) with those collected by us in the winter of 1974 give similar values. The range for

the summer values is 26 to 245 mg/m² with a mean of 77 mg/m² compared to winter values of 4 to 225 mg/m² with a mean of 70 mg/m². Unfortunately, the same areas were not sampled by the two groups so that the results are not directly comparable. However, they indicate a characteristic of estuarine mudflats noted by other authors (Riznyk and Phinney, 1972; Pomeroy, 1959; and Odum, 1961;) i.e., the lack of seasonal fluctuations in standing crop resulting in similar levels of primary production throughout the year in dramatic contrast to the marked seasonality of phytoplankton and benthic macrophytes. Riznyk and Phinney (1972) attributed the absence of seasonality to a continuously regenerating supply of nutrients originating from the sediment, and Pomeroy (1959) found that light, temperature and tidal fluctuations through the various seasons interacted in such a manner to ensure continuous year-round production.

Attempts to estimate photosynthetic rates of the diatoms in the laboratory with a polarographic oxygen electrode were unsuccessful. Time and logistic problems did not permit in situ measurement.

ACKNOWLEDGEMENTS:

We would particularly like to thank the people of the Canadian Coast Guard Hovercraft Unit for their co-operation and help in sampling Stations II. Julie Celestino aided in the species identifications of the macrophytic algae.

Figure 1. Sediment chlorophyll sampling stations on the Fraser River delta.

+ January 29, 1974

O February 12, 1974

● March 11, 1974

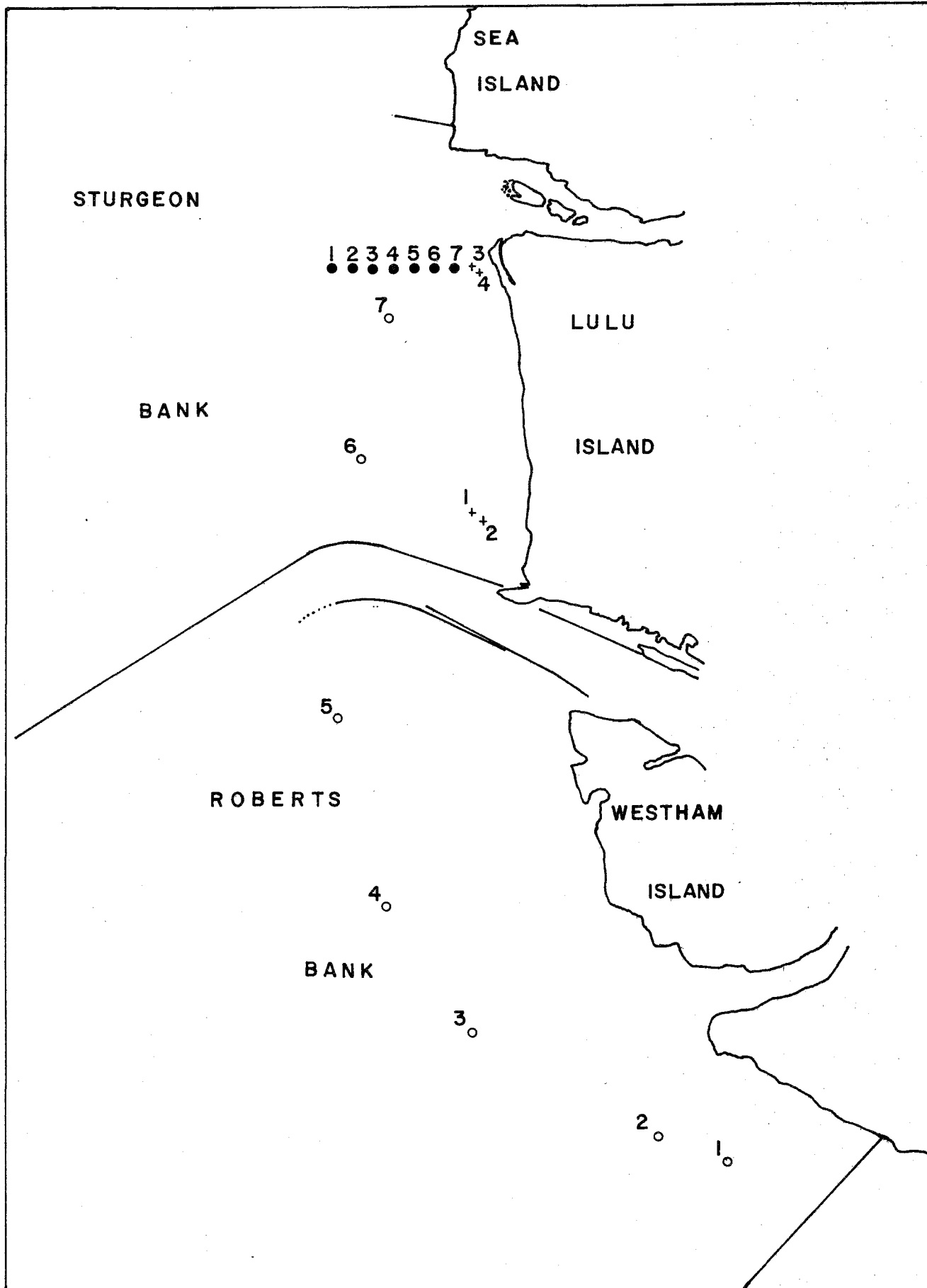


Table I. Chlorophyll a concentrations at selected stations on the Fraser River delta, January to March, 1974.

Station	mg chl <u>a</u> /m ²
January 29, 1974	
I-1	66.1
I-2	32.2
I-3	40.5
I-4	53.9
February 12, 1974	
II-1	51.1
II-2	103.2
II-3	3.7
II-4	35.7
II-5	113.5
II-6	39.6
II-7	70.6
March 11, 1974	
III-1a	30.0
III-1b	37.1
III-2a	66.0
III-2b	91.0
III-3a	48.8
III-3b	57.8
III-4a	69.3
III-4b	48.8
III-5a	103.0
III-5b	76.8
III-6a	82.0
III-6b	87.4
III-7a	125.8
III-7b	225.1

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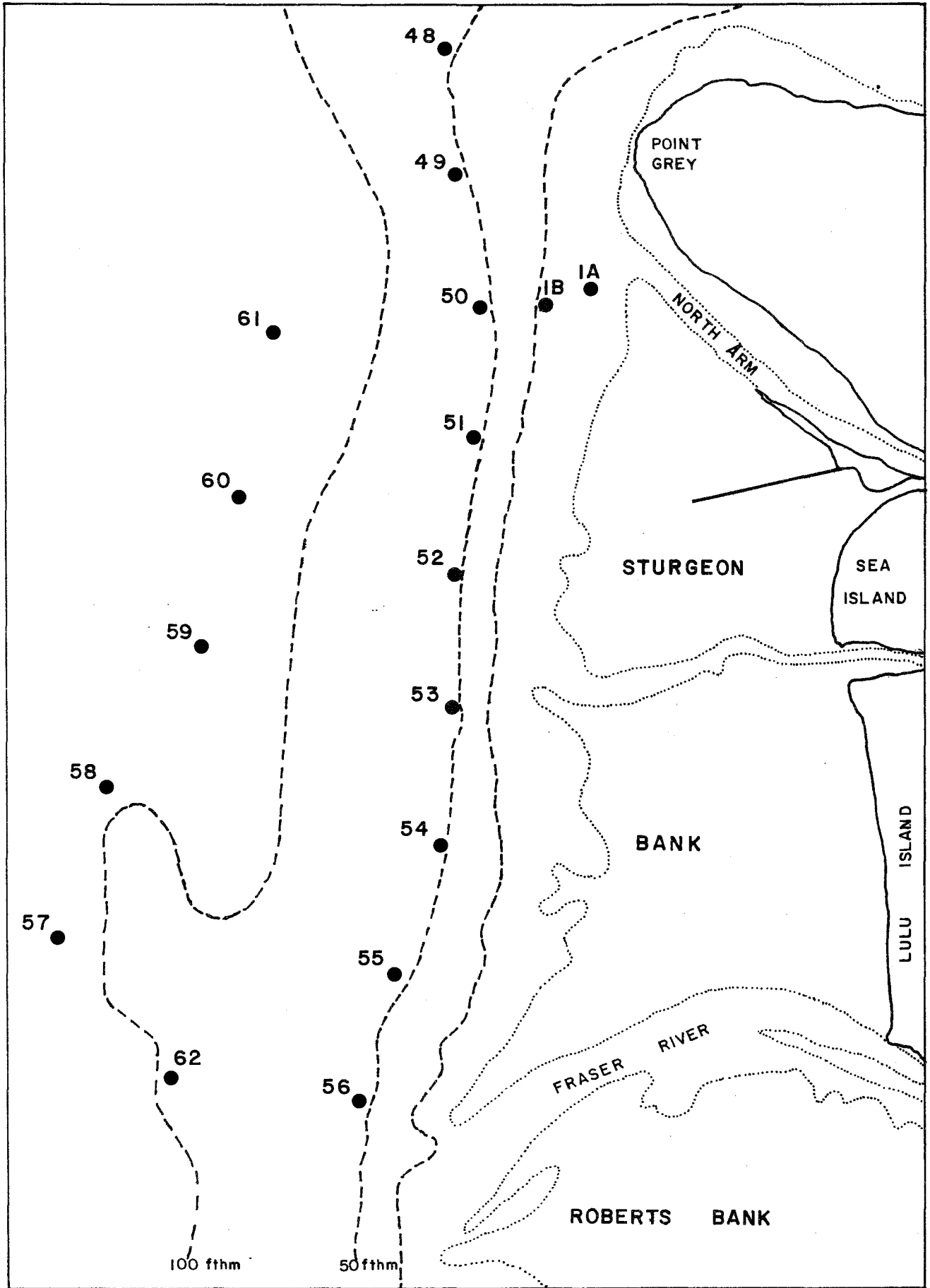
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VANCOUVER INTERNATIONAL AIRPORT ENVIRONMENTAL EFFECTS STUDY
SUBTIDAL MACROFAUNA

A series of VanVeen and Petersen quantitative grab stations were occupied off Sea Island (positions on chart). The wet and dry biomasses and sampling depth are given in Table 1. Table 2 lists the organisms and numbers collected. Table 3 presents Margalef's index of diversity (no. of species/log no. of specimens), together with a rough estimate of particle size distribution, expressed as percentage retrieval by test screens.

At 100 M and deeper the fauna is typical deeper infauna characteristic of the Strait. Margalef's index is based upon molluscs, echinoderms, and polychaetes only, and is directly correlated to particle size. There is no evidence from previous work to suggest significant seasonal variation in species representation, but number of specimens do undergo cyclic variations with minima in January. The greater part of standing stock in the 100+ M stations consists of burrowing infauna - stalked holothurians and tubicolous polychaetes.

The steep delta face comprises loose detrital material; the 9 M sample is composed of extremely fine silt with a large infauna of small ephemeral organisms. The 15 M sample contains coarser material, mixed with much wood detritus, this also contains many young organisms. It is apparent that the delta face is a zone of instability with a substantial population of small



opportunistic organisms - the relatively low biomass is offset by the rapid turnover and ready availability to predators (chiefly commercial crabs and perhaps also flatfish) of shallow infauna such as juvenile errant polychaetes and small bivalves. The larger biomass of the deeper regions, chiefly composed of clays, is deeply buried, slow-growing, and probably not available to the majority of predators.

The productive delta face is dependent upon the river contribution. It is doubtful that loss of a portion of the extensive tidal flats will effect the subtidal zone, provided that waterflow patterns are not modified. Extensive dredging will of course ruin this habitat, though it is probable that it could re-establish itself.

Table 1. Station list, depth, and biomass/M²

Station	Date	Depth (M)	Gear ^a	Biomass/M ²	
				Wet ^b	Dry
1A	Dec. 11, 1973	9	V	67.4	8.3
1B	Dec. 11, 1973	15	V	2.1	0.4
74-48	Jan. 31, 1974	112	P	193.6	29.0
49	Jan. 31, 1974	101	P	7.8	1.6
50	Jan. 31, 1974	119	P	326.3	49.2
51	Jan. 31, 1974	110	P	106.4	11.7
52	Jan. 31, 1974	119	P	7.0	1.3
53	Jan. 31, 1974	106	P	167.3	27.5
54	Jan. 31, 1974	108	P	494.7	29.5
55	Jan. 31, 1974	102	P	1263.4	166.2
56	Jan. 31, 1974	101	P	214.9	36.16
57	Jan. 31, 1974	207	P	144.5	20.1
58	Jan. 31, 1974	242	P	0.4	0.07
59	Jan. 31, 1974	238	P	57.7	10.2
60	Jan. 31, 1974	231	P	9.45	2.3
61	Jan. 31, 1974	231	P	54.8	6.2

^aV = Van Veen grab 0.1 M²

P = Modified Petersen grab 0.2 M²

^bWet weight measured after removal of calcite.

TABLE 3. Margalef's index of diversity (\underline{d}) and grain size

Station	\underline{d}	Grain size % weight				→
		500 μ	250 μ	105 μ	53 μ	
74-48	0.69	-	-	3	2	95
49	0.43	-	-	1	1	98
50	0.57	-	-	4	8	88
51	1.42	2	6	13	3	76
52	0.62	-	4	11	18	67
53	1.13	-	19	10	21	50
54	0.48	-	1	6	2	91
55	0.71	-	-	6	4	90
56	1.57	2	11	14	3	70
57	0.26	-	-	-	4	96
58	0.37	no sample				
59	0.76	-	1	-	11	88
60	0.84	-	5	2	3	90
61	0.96	-	6	18	21	55
1A	0.60	-	-	-	-	99
1B	0.17	-	-	15	12	73

BENTHIC ECOLOGY STUDIES ON THE TIDAL FLATS
OF STURGEON AND ROBERTS BANK IN RELATION
TO PRESENT AND PROJECTED INDUSTRIAL DEVELOPMENT

by

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INTRODUCTION

Environmental assessment studies on the Fraser River estuary have considered the impact of a number of construction projects (e.g. runway extension for the Vancouver International Airport, extension of Roberts Bank port facilities) on the aquatic ecosystems and fisheries in the area. In association with salmon feeding habits, there was a requirement to identify habitats of benthic invertebrate communities that are significant food resources for the juvenile salmonids. This paper presents the results of these investigations.

The data presented in this report deal particularly with benthic organisms that are potentially available as prey for secondary consumers such as fishes, crab, and shorebirds. The sampling emphasized benthos living in the surface of the sediments, and on Sturgeon Bank included plankton tows to establish if benthic organisms appeared in the water column at high tide, where they would become potentially available to juvenile salmonids. Zonation of benthos and sediment — organism relationships were two ecological phenomena that were examined in some detail in this study. The latter relationship enables prediction of the significance of particular sites for benthos by measurement of a geological parameter such as grain size. Some comments on how existing structures such as jetties and causeways can affect zonation of benthos have been also provided.

FIELD METHODS

A. Quadrat Sampling at Low Tide

One hundred and sixteen stations were sampled with quadrats at low tide. One hundred and four of these stations were occupied using the radar-equipped Hovercraft SRN-021 kindly provided by the Canadian Coast Guard. Twelve quadrat samples near the Westshore Terminal causeway (Roberts Bank) were obtained on foot, and positions for the stations were located using a truck odometer and by walking 50m north of the high-tide line on the causeway. The stations were usually 20m north from the foot of the rock "rip-rap" on the causeway.

Ninety-two samples were located on transects perpendicular to the shoreline (Fig. 1) and stations were either 0.23 or 0.46 km apart. The seaward edge of the marsh vegetation was chosen as the upper level of each transect. Where sedges (*Carex* sp.) are the dominant shoreline flora, the seaward edge of the vegetation demarcates the lower edge of the intermediate tide zone (i.e. approximately 2.4m O.D. (above chart datum)). A "perimeter" transect, which involved 24 stations parallel to the shoreline, was sampled from Iona Island to the Tsawwassen ferry terminal at 0.92 km intervals. Samples on this transect were obtained immediately seaward of the marsh vegetation.

The seaward extent of the transect sampling depended on the amplitude of the low tide on the day of sampling:

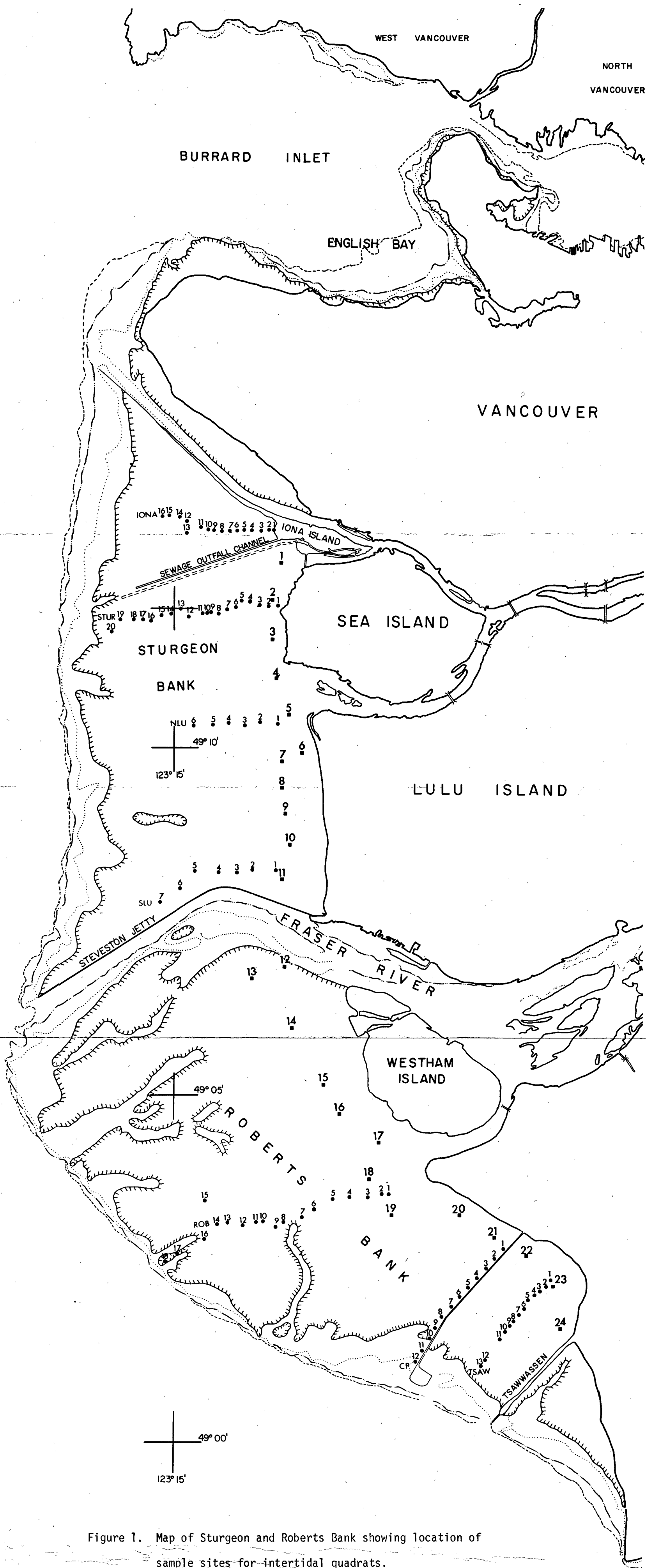


Figure 1. Map of Sturgeon and Roberts Bank showing location of sample sites for intertidal quadrats.

<u>Transect (see Fig. 1)</u>	<u>Date</u>	<u>Maximum Distance (km) From Marsh</u>	<u>No. of Stations</u>	<u>Low Tide Amplitude (m, O.D.)</u>
North Sturgeon Bank (ION)	July 27, 1973	4.0	16	0.6
Mid Sturgeon Bank (STUR)	June 2, 1973	5.7	20	0.0
North Lulu Island (NLU)	Oct. 7, 1973	3.0	6	2.0
South Lulu Island (SLU)	Oct. 8, 1973	3.7	7	2.0
Roberts Bank (ROB)	Dec. 10, 1973	7.5	18	0.1
Westshore Terminals (CP)	Jan. 9, 1974	4.6	12	0.2
Tsawwassen (TSAW)	Oct. 20, 1973 Feb. 9, 1974	3.5	13	1.1

At each station, the sediment from within a 0.06 m^2 quadrat was scraped with a trowel to a depth of 2 cm. Samples from the stations parallel to the shoreline were obtained with 0.25 m^2 quadrats. The material collected was placed in plastic bags and returned to the laboratory. Sediment temperature was measured by pushing a thermometer about 5 cm into the sediment, and temperature was read after about 5 min. A sample of surficial sediments for grain size analysis (app. 300ml) was obtained close to each quadrat site. The sediment sample was frozen on return to the laboratory, usually within 6 hours of collection. Biological samples were sieved through a 0.5 mm screen and preserved in 10% formalin.

During trips with Geological Survey of Canada geologists (Feb. 5 to 7, 1974) we obtained samples of water from the surface of sediments at 65 stations on the delta (Fig. 2). A small hole about 5 cm deep was dug adjacent to each sampling site, and the water drained into it was collected for salinity determination. Rain was not falling on the nights of these collections, so water on the surface of the sediment reflected the salinity of water draining from the previous high tide.

B. Plankton Sampling and Hydrography at High Tide

Locations for plankton sampling at high tide were established on grids with stations 0.4 km apart, and covered all of the tide flats from the mouth of the Middle Arm to the North Arm jetty (Fig. 3). The stations south of the Iona sewage causeway (Stations A S to T S; Fig. 3) were occupied on July 3 and 4, 1973. The stations north of the causeway (Stations A I to U I; Fig. 3) were occupied on July 30 and 31, 1973. At both areas, stations were occupied at high tide \pm 2 hours. The tides on these dates ranged from 4.5 to 4.6 m in amplitude. Plankton tows were completed using an outboard motor boat equipped with a radar reflector. Radio contact was maintained with CFAV LAYMORE or ST. ANTHONY, which were providing radar positioning for the boat from their anchorages offshore.

A SCOR/UNESCO plankton net with a mesh size of 350 μ m (micrometers) was used in all sampling, and the area of the net opening was 0.25 m². The net was towed so that the top of the net frame was just below the

Figure 2. Salinity of water near surface of sediments at low tide on Sturgeon and Roberts Bank, February 5 to 7, 1974. Station designations are those of the Geological Survey of Canada (Dr. J. Luternauer).

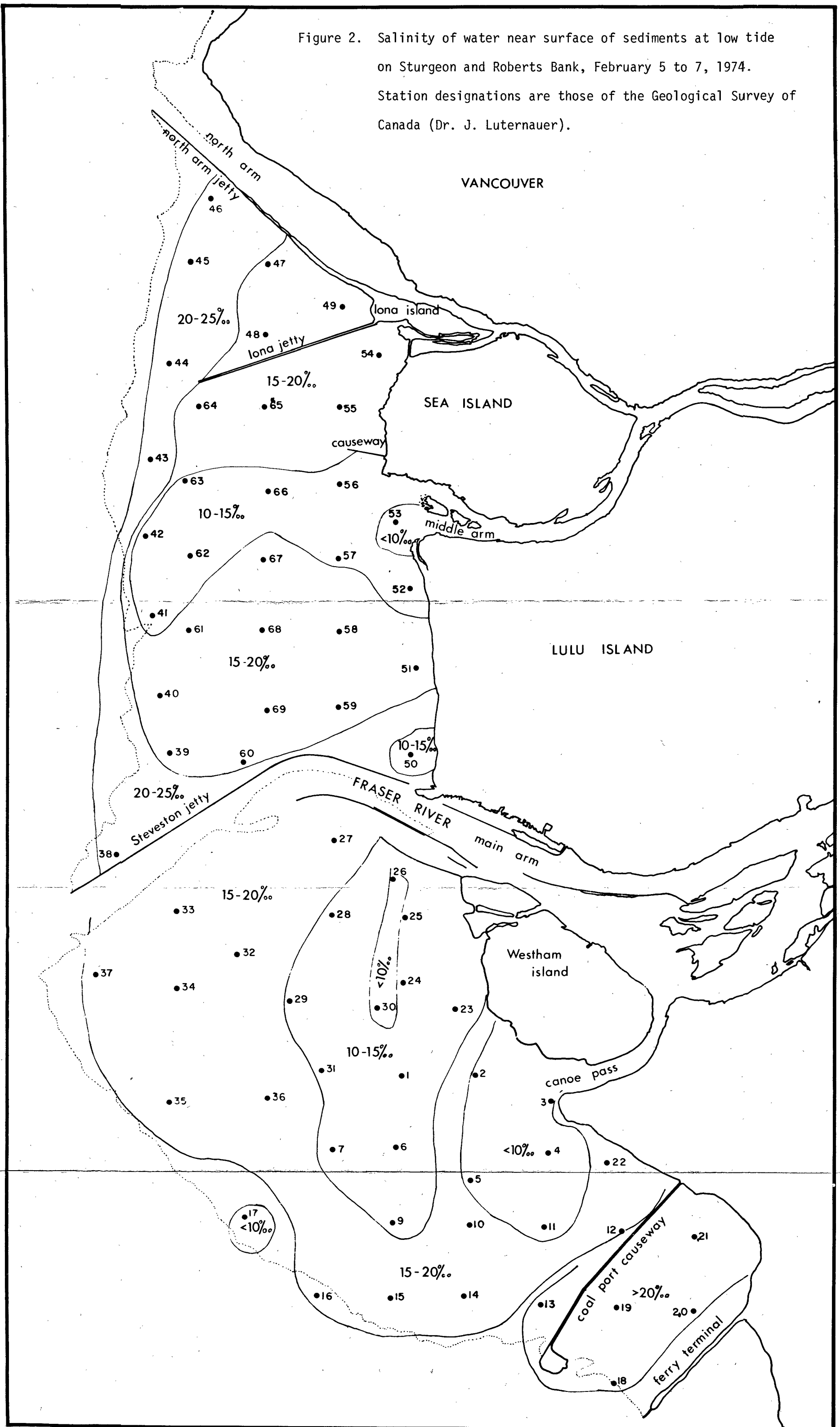
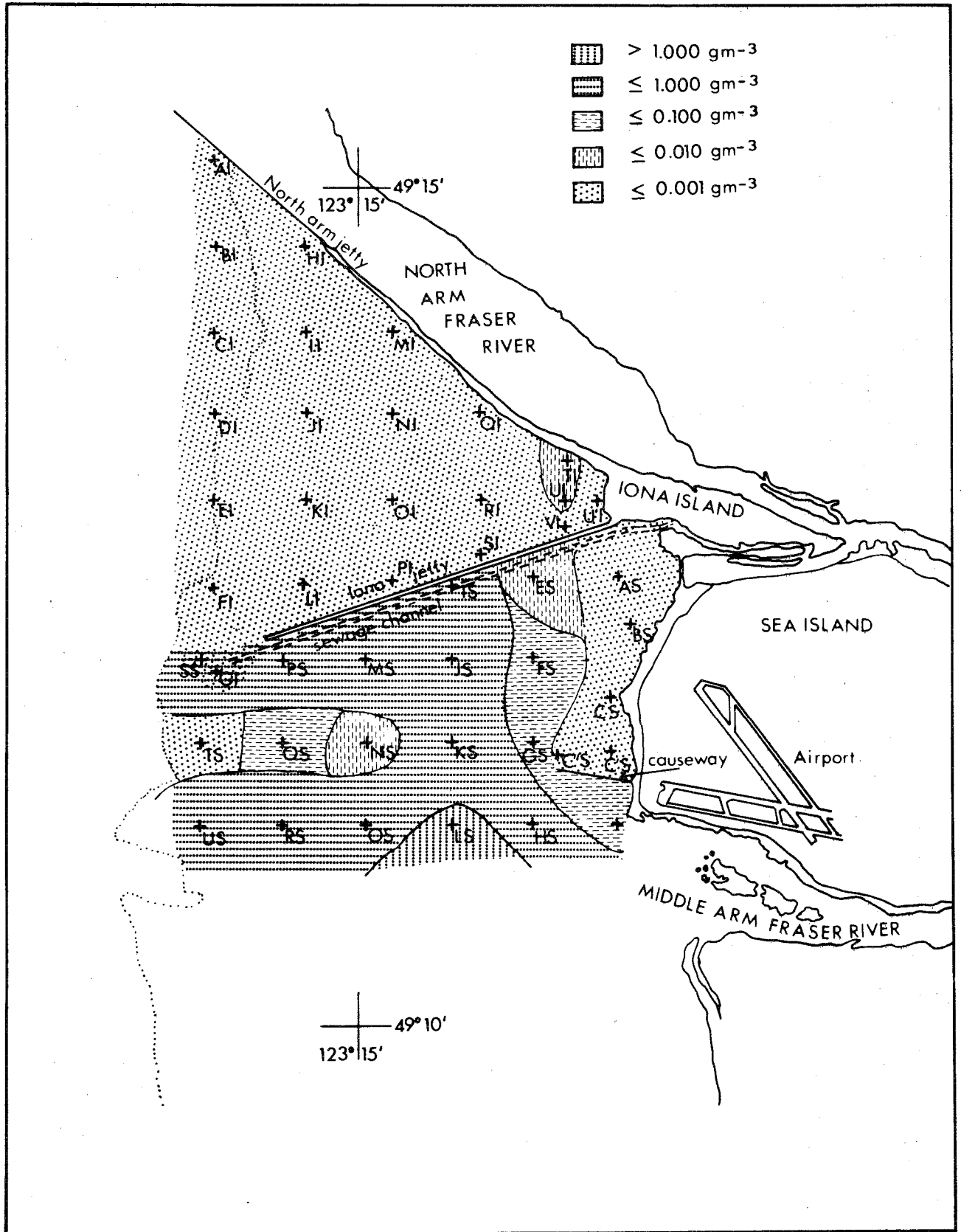


Figure 3. Location of plankton tow stations at high tide over Sturgeon Bank on July 3, 4, and 30, 31, 1973. The distribution of biomass (wet wt. $g\ m^{-3}$) is also shown.



surface of the water, at a speed of 1.5 to 2.5 kts. Samples were preserved in 10% formalin.

At each station, the temperature and salinity of the surface water was measured with a YSI Model 33 salinometer. One litre samples of surface waters for analyses of particulate organic material were also obtained.

LABORATORY PROCEDURES

A. Sorting Samples

Quadrat and plankton samples were sorted after sub-sampling by wet weight or with a Folsom plankton splitter. The organisms were then separated from sediments and debris by thorough searching with a 12x binocular microscope. Wet weight determinations were made with preserved specimens, which were damp-dried before weighing. The shells of adult molluscs were removed with dilute hydrochloric acid (5-10%) and therefore weights do not include shell mass.

B. Identification of Fauna

Polychaetes were identified using the unpublished keys and verifications of K. Hobson, B.C. Provincial Museum, Victoria, B.C. Amphipods were identified using the descriptions provided by Barnard (1954, 1969) and Shoemaker (1949). Molluscs were identified using the descriptions provided by Quayle (1960), Rice (1972), and Johnson and Snook (1955),

and Bernard's (1970) check list was consulted. Isopods were identified using the keys of Schultz (1969). Some of the planktonic forms were identified using the information provided by Fulton (MS, 1972), and by personal communication with J. Fulton. Many of the organisms of all phyla were juveniles, and were too small to be identified to the specific level.

C. Sediment Analyses

1. Samples from STUR transect

In order to remove salt from the sediments, samples were washed in about 500 ml of distilled water, and then they were centrifuged at 10,000 rpm for 20 min. A comparison of dried samples before and after this washing procedure showed some measurable amount of salt was present in sediments from all stations. Organic material was then oxidized from the samples by treatment with hydrogen peroxide (H_2O_2). First, 6% H_2O_2 was applied, and then, after 12 hrs. 50%. The reaction was allowed to proceed for at least 48 hrs., unless it had ceased before. The samples were then washed with distilled water, centrifuged at 10,000 rpm for 20 min. and dried.

Grain size analyses for sands (particles $\geq 63\mu m$) were performed using the settling tube method described by Rukavina and Duncan (1970). Silts and clays were analyzed using a Sedigraph 5000 particle size analyzer (Micromeritics Instrument Corp.)

The amount of organic material in sediments was estimated by the following procedure. Sediments were first dried for 24 hours at 100°C. The samples were then ashed in a muffle furnace at 550°C for 24 hours. Organic content was estimated by the difference in weight between the dried and ashed samples.

2. Samples from other Stations

Sediment samples from the other quadrat stations of Banks were analyzed courtesy of the Water Survey of Canada (Environmental Management Service, DOE).

The samples were washed with tap water, then divided into sand (particles $\geq 63 \mu\text{m}$) and silt and clay (particle $< 63 \mu\text{m}$) using a wet sieving technique. The sands were then analyzed by dry sieving using the following sieve sizes: 1000 μm , 500 μm , 250 μm , 125 μm and 62 μm . A mechanical shaker was used for the sieving. The silt and clay fraction was analyzed using the hydrometer technique described in Buoyoucos (1951). Sodium silicate (10% solution) was used as a dispersing agent.

D. Elevation Data

It was not possible for us to determine elevations in the field, because of manpower and time limitations. Bench marks were often located at considerable distances from our sampling sites. Therefore, we were obligated to use the most recent data gathered by other workers, namely those obtained by an engineering company in 1967 (Swan Wooster, 1967). Some of these data, especially those from the lower tide zone, may be invalid for use in 1973, since geological work (Luternauer and Murray, 1973) suggested some portions of the Banks are retreating while others are advancing.

The data presented by the engineering company were presented in map form, with contours of 2 ft. (0.6 m) intervals. This elevation map was reduced to a scale of 1 to 50,000, enabling us to overlay the map on C.H.S. Chart No. 3480 which we used in field work. We were then able to position our quadrat stations on the elevation map. Stations are referred to the mid-point of the contour lines, e.g. stations between the 2.43 and 3.05 m contours would be referred to the 2.73 elevation.

E. Analyses of Particulate Organic Material in Water Samples

Water samples for analyses of particulate organic material were filtered through 0.45 μ m Watson GFC filters using a vacuum of 10 mm of mercury. The preweighed filters were then dried at 90°C for 24 hours and reweighed. The organic material present on the filter was calculated from the loss in weight after ashing the dried filters in a muffle furnace for 24 hours at a temperature of 550°C.

F. Salinity Determinations

The salinity of surface water in sediments was determined using a Bissett-Berman (Model #6230) inductive salinometer.

DESCRIPTION OF THE STUDY AREA

A. Prevailing temperature, salinity and Oxygen Conditions

A few data are currently available on the temperature, salinity, and oxygen conditions of the intertidal habitats of the Fraser delta. A comprehensive survey, which would involve seasonal and hourly (tidal) changes, has not yet been done. Since a "salt wedge" is present in the estuary, data collected near bottom at high tide at the edges of the Banks are representative of water-column conditions in the lower part of the intertidal zone, while data from shallow depths or surface is representative for habitats in the intermediate or upper zone.

Temperature

Intertidal organisms, especially those living in the surface of sediments, are exposed to marked variations in sediment temperature. In June, at low tide, we recorded sediment temperatures (surface) of up to 22.0°C on Sturgeon Bank (Table 2). In January, on Roberts Bank, temperatures as low as -2.0 (Table 6) were recorded in sediments, and organisms were collected from frozen mud and debris. Sediment temperatures at low tide follow seasonal trends in air temperature, but are more extreme because of reflection and absorption of heat. (Perkins, 1974).

Data from 5 m near the Sand Heads Light (Fig. 1) (outer edge of Banks) are available (Bawden et al, MS, 1973) and are shown in Fig. 4. These data show that organisms in the lower sections of the intertidal zone are subjected to temperatures varying from 5.0 to 15°C.

Our data from Sturgeon Bank (Tables 9, 10) show that surface temperatures can range from 14.5 to 22.5°C in July, which are slightly higher than those recorded from Roberts Bank (1 m) during July to September (11.0 to 17.5°C; DOE, Ms, 1974). At Garry Point, near Steveston; Fig. 5), which is representative of habitats influenced directly by the main river, temperatures from February to May (1 m) ranged from 2.3 to 6.9°C, while in the Middle Arm (Dinsmore Bridge; Fig. 6), which receives a small flow from the main river, temperatures varied from 3.3 to 10.0°C. (Hall et al, MS, 1974).

Salinity

Considerable variation in salinity at the Fraser estuary has been observed. Habitats at the higher elevations of the intertidal zone are exposed to greater fluctuations in salinity than those in the lower section of the beach. Habitats which are close to freshwater discharge from the Fraser River encounter wider variations in salinity than sectors further from the channels.

Organisms in habitats at the lower intertidal zone encounter annual salinity variations ranging from approximately 15‰ to 31‰, as estimated from Bawden et al's (MS, 1973) data (Fig. 4) from near the Sand Heads light. Lower values are probably present during freshet, when

Figure 4. Seasonal changes in temperature, salinity, and oxygen at 5 m near the Sand Heads Light, mouth of the South Arm of the Fraser River. Data from Bawden et al (MS, 1973).

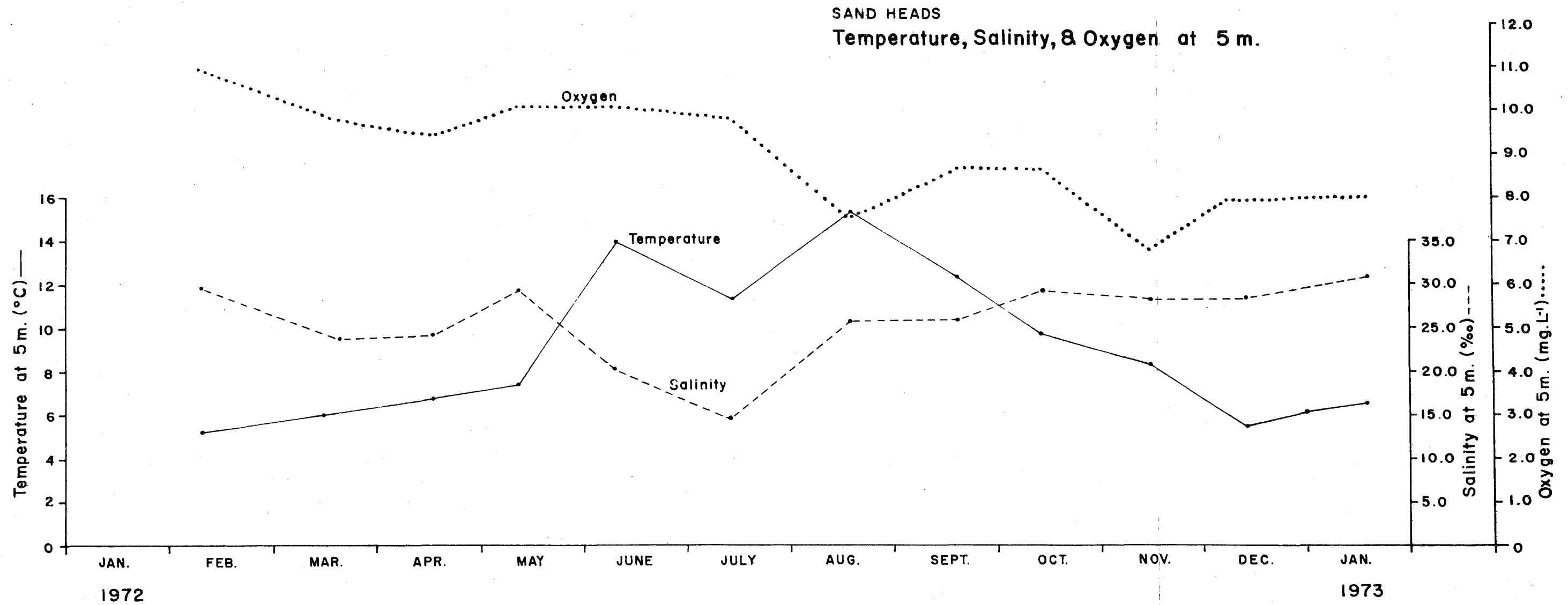
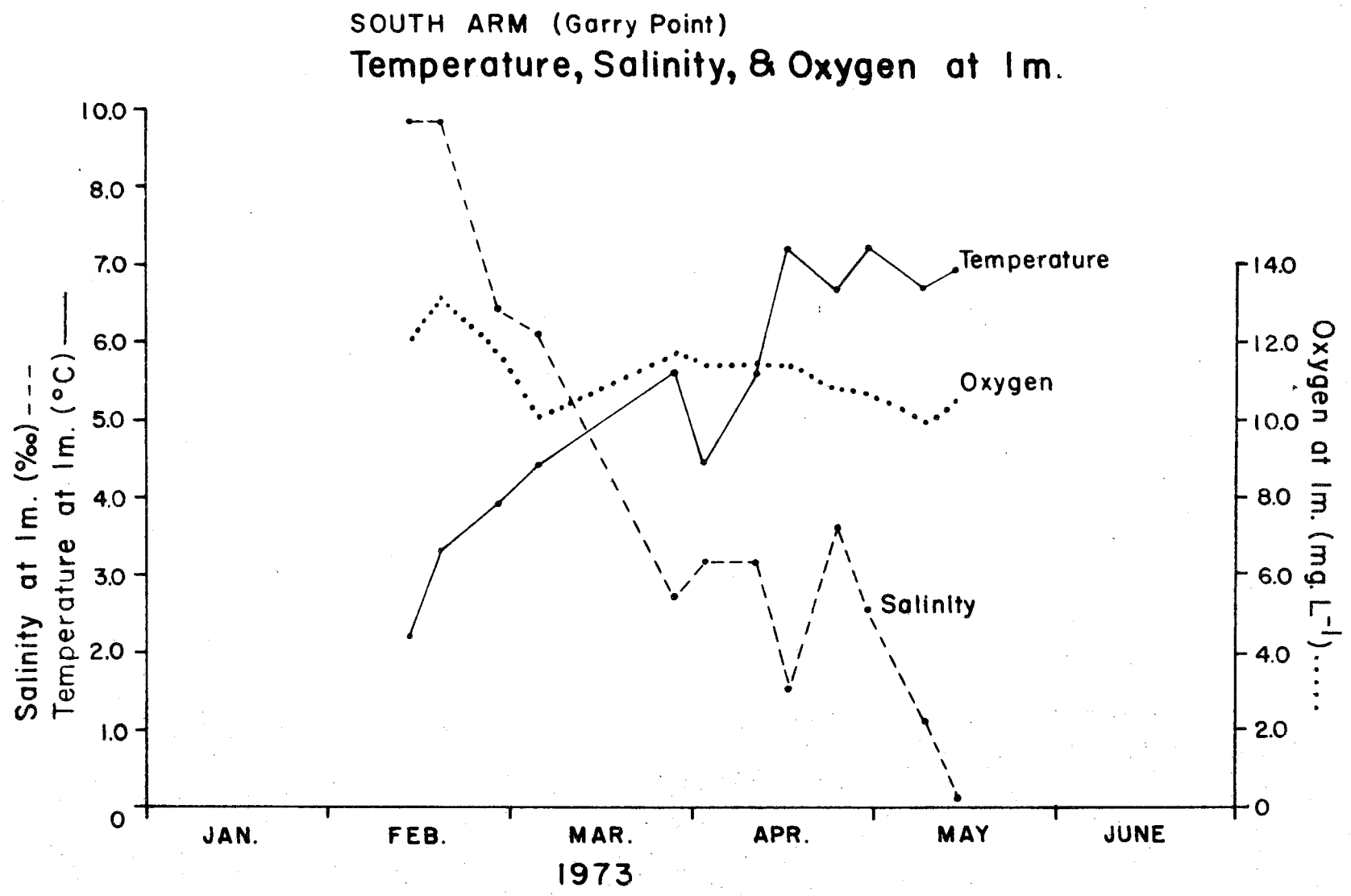


Figure 5. Temporal fluctuations in temperature, salinity, and oxygen at app. 1 m near Garry Point, upstream of Sand Heads Light, mouth of the South Arm of the Fraser River. Data from Hall et al (MS, 1974).



MIDDLE ARM (Dinsmore Bridge)

Temperature, Salinity, & Oxygen at 1 m.

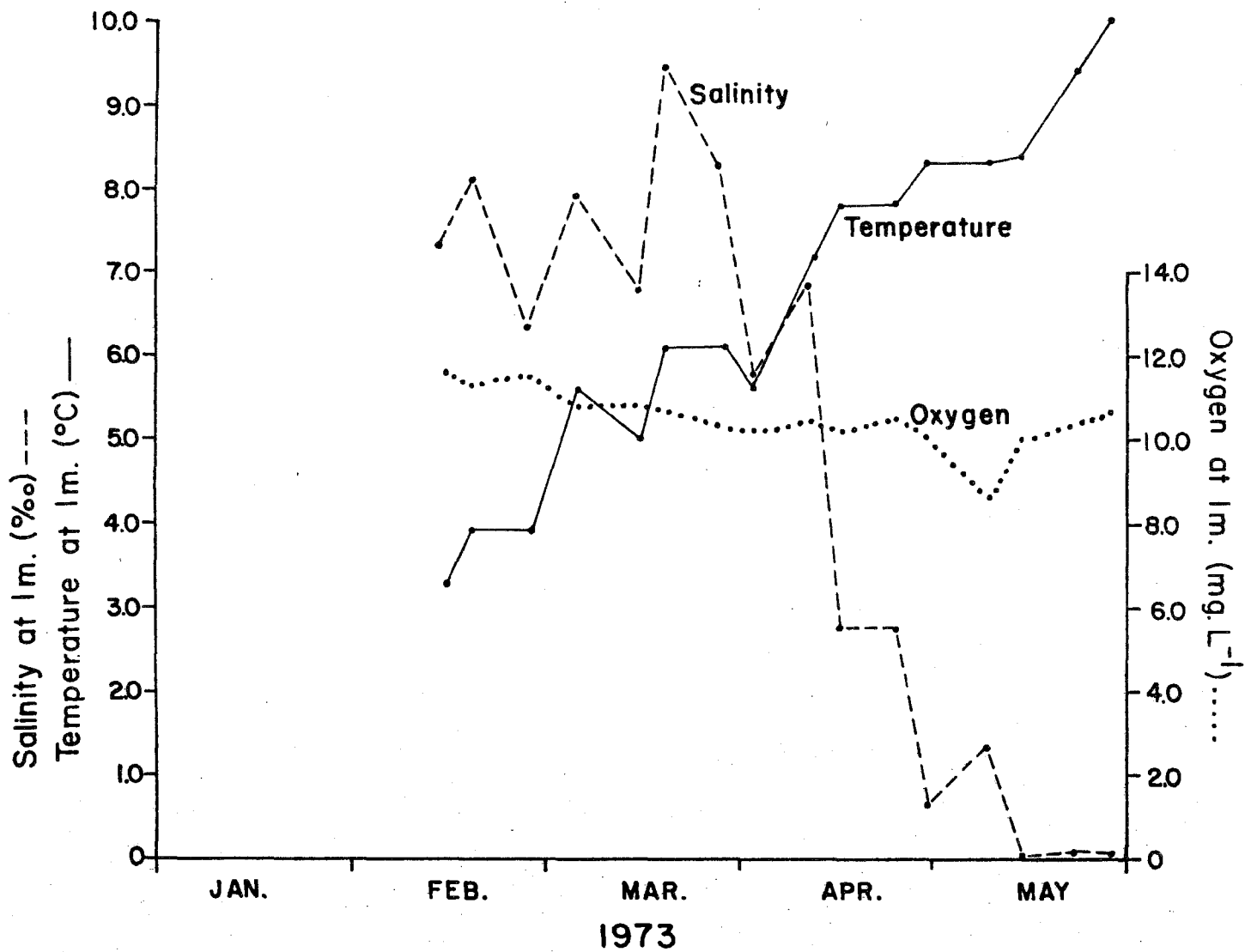


Figure 6. Temporal fluctuations in temperature, salinity, and oxygen at app. 1 m at the Dinsmore Bridge, Middle Arm of the Fraser River. Data from Hall et al (MS, 1974).

shallow channels such as Canoe Pass discharge over the entire intertidal zone at low tide. Surface (or 1 m) data from our work on Sturgeon Bank (Tables 9, 10), from Hall et al's work at Garry Point and at the Middle Arm, (MS, 1973), (Fig. 5, 6), and from DOE (MS, 1974) on Roberts Bank show that salinities for intermediate or upper intertidal habitats range from fresh water to 33.0‰. Areas protected from the main river discharge, by jetties or causeways, were characterized by higher salinities. For example, north of the Iona sewage causeway, salinities varied from 8.5 to 14.8‰, whereas south of the jetty, where freshwater influence from the Middle Arm is more widespread, salinities ranged from 0 to 10.5‰. (Tables 9, 10; Fig. 7). Our sediment salinity data from Roberts Bank show a similar phenomenon. Salinities between the Tsawwassen and Westshore causeways were higher than north of the Westshore causeway (Fig. 2, Table 11).

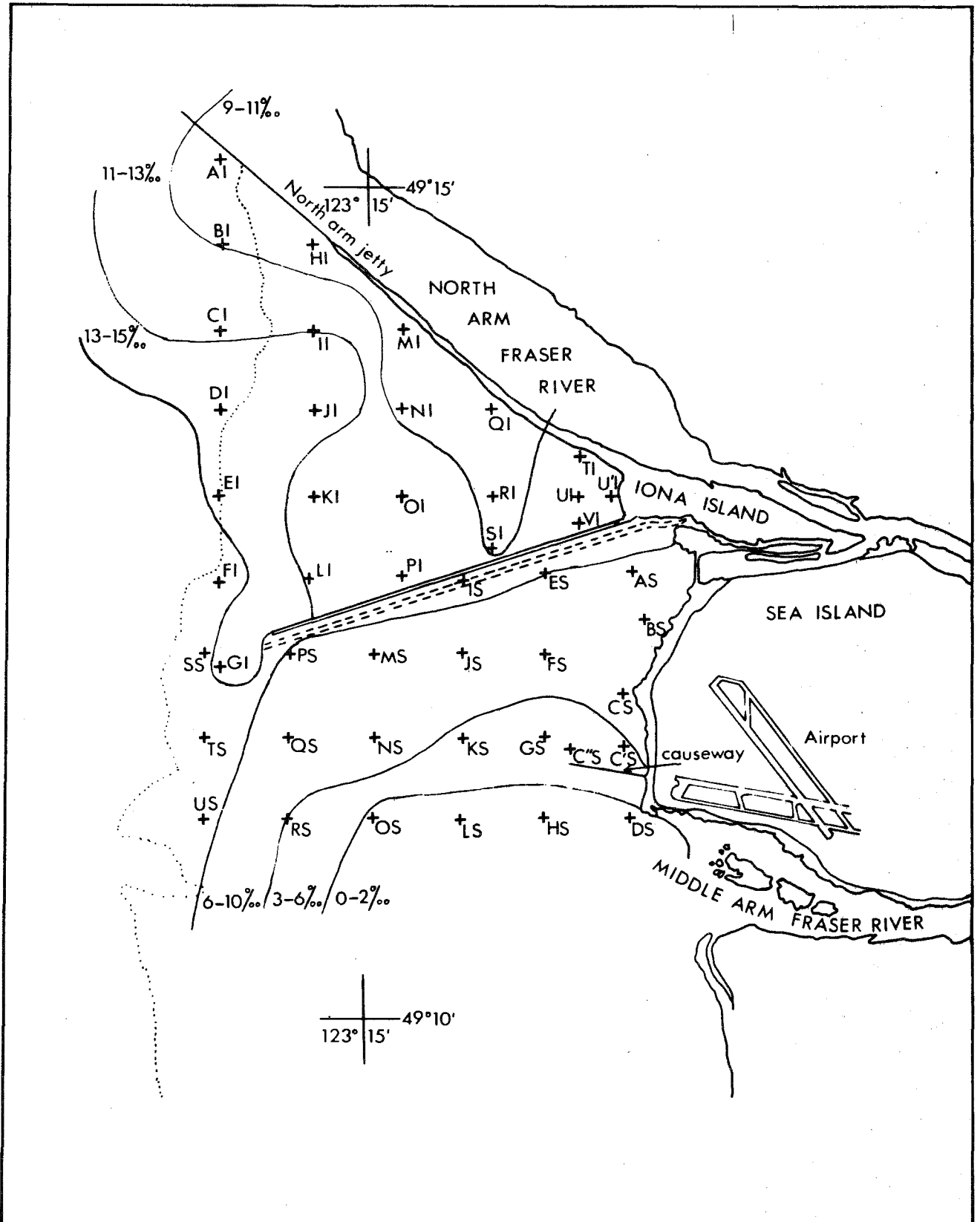
Oxygen

When tides flood over intertidal zones, oxygen is mixed into the water, so surface oxygen values are rarely low at high tide.

Data available from our study area show that oxygen levels in the surface (or 1 m) usually vary seasonally, from approximately 9.0 to 13.0 mg L⁻¹ (Figs. 5, 6; Garry Point and Middle Arm). Oxygen levels at "deeper" levels (5 m; Sand Heads Light; Fig. 4) vary from about 7.0 to 11.0 mg L⁻¹. Brackish water can contain more oxygen than "normal" coastal sea water.

The only location on the tidal flats where abnormally low oxygen values in water have been recorded is at the Iona sewage outfall, where near-bottom oxygen levels very close to zero have been observed on certain tidal cycles (Otte and Levings, MS in preparation).

Figure 7. Salinity of surface water at high tide over Sturgeon Bank on July 3, 4 and July 30, 31, 1973.



At low tide, the interstitial water of sediments is probably anoxic at many locations on the Fraser Delta, because of the presence of organic debris. At sediment depth of 2 to 10 cm, reduced sediments were observed at many quadrat stations, especially muddy stations close to stands of vascular plants.

B. GEOLOGICAL DESCRIPTION

The geology of Sturgeon and Roberts Bank has been described recently by Luternauer and Murray (1973) and their description, in most cases, matches observations made during our field work.

Our perimeter transect (FRAPER stations) were located in the zone that Luternauer and Murray (1973) described as the salt marsh -- "a generally vegetated bank of flat to hummocky muddy sediment, lying near the high tide level. Along Roberts Bank the marsh apparently is more stable and has finer sediment, than along Sturgeon Bank." Our observations and those of botanists (eg. McLaren, MS, 1972) suggest that the term "salt marsh" may be slightly incorrect; most of the plants we observed were sedges (*Carex* sp.) and bullrushes (*Scirpus* sp.) which require more fresh water than salt. On Roberts Bank, especially south of Station FRAPER 20, (Fig. 1) we noted an embankment adjacent to the vegetation. This embankment was characterized by crumbling sediment. Elsewhere on Roberts and Sturgeon Bank, except at disrupted areas, the marsh showed signs of emerging i.e. the sediments close to the marsh were flattened, and isolated clumps of vegetation were growing seaward.

The remainder of the shallow portions of the Bank were classified by Luternauer and Murray (1973) as the main platform -- "the area that

gently slopes for about 6 km from the salt marsh to the level of the most distinct, first break-in-slope (9 m below lowest normal tide level). This zone is mantled mainly with well-sorted 0.35 mm to 0.125 mm sand. It is generally featureless except for the presence of tidal channels (more prominent on Roberts Bank) and current and wave ripples.

Sturgeon Bank is covered almost entirely by sand-sized sediment. The North Arm jetty and Iona Island causeway have effectively prevented dispersal of sediment from the north or south into the V-shaped section of Sturgeon Bank off Iona Island. Sediments north of the Iona Island causeway tend to be coarser than those immediately to the south. The Middle Arm and the South Arm apparently supply medium and fine sands, respectively, to maintain the southern portion of Sturgeon Bank.

The portion of Roberts Bank immediately to the north of the Westshore Terminals causeway is covered by sand-size sediment, but a lobe of relatively fine sediment (very fine sand and silt) extends from the dyke just north of the inshore end of the Westshore causeway, almost to the edge of the tidal flats. The remaining portion of Roberts Bank, south of the causeway, lies within the sedimentation "shadow" of both this structure and that of the Tsawwassen Ferry Terminal causeway. These features prevent any southward migration of sand-sized sediment, so material in this area is generally mud or silt."

During our field work on the southern portion of Roberts Bank, we observed eel grass (*Zostera marina*) beds, and the extent of these

beds was determined using colour aerial photographs (National Air Photo Library Nos. RSA 30518-58 to RSA 30518-62). The eel grass bed between the Tsawwassen causeway and the Roberts Bank causeway extends from the low tide mark to about halfway up the beach. A depression devoid of plants separates the bed into two sectors. North of the Westshore causeway, a smaller bed was observed. The centre of this bed is near Geological Survey of Canada Station No. 14 (Fig. 2), and it extends only about one-third of the distance from low to high tide.

FAUNA OF STURGEON AND ROBERTS BANK

Because of the large expanse of gently sloping tidal flats on the Fraser delta, intertidal sampling is a severe problem. The problem of access probably explains why there have been few data reported on the benthos of the area.

The only previous quantitative sampling was done by Bawden et al (MS, 1973) but their methods were radically different than ours. Bawden et al sampled with a "box corer" which penetrated sediments to an average depth of 16.9 cm (27 stations of varying sediment type); the samples were sieved with a 4 mm screen. Their data are therefore biased toward the larger, deeper benthos, which were not generally sampled in our study. For example, Bawden et al (MS, 1973) record the ghost shrimp (*Callinassa californiensis*) from northern Sturgeon Bank and southern Roberts Bank, but this species was not recorded in our

studies. Conversely, we report huge numbers of small organisms at many stations on the delta that were not reported by Bawden et al because of the large mesh they used. For example, the small polychaete *Manayunkia aestaurina* was the most abundant organism at many of the stations in the upper or intermediate intertidal zones, but these worms pass through any sieve larger than about 1 mm.

When our data (Tables 1 to 10; 81 types of organisms or taxa) are combined with that of Bawden et al (MS, 1973) (46 taxa) a total of 127 types of benthic organisms have been recorded so far from Sturgeon and Roberts Banks. These data are subject to taxonomic error because of problems in identification. Since the estuarine fauna of British Columbia is poorly known, these problems are significant. There was considerable variation in the morphology of many species, which is common for estuarine organisms (Kinne, 1971).

The benthic organisms we detected in our samples were mainly estuarine and marine forms, primarily crustaceans, polychaetes and molluscs. Stations near the Middle Arm of the Fraser River (STUR transect) were sampled in summer, when freshwater drift organisms (e.g. insect larvae) are generally abundant in rivers, but few were recorded (Table 2). Except on the Tsawwassen transect, estuarine species (e.g. *Manayunkia aestuarina*, (Polychaeta, Sabellidae); *Corophium* spp. (Amphipoda, Corophiidae) dominated in the intermediate or high intertidal zone. The fauna in the lower intertidal zone was characteristic of marine environments (e.g. *Cumella* sp. (Crustacea,

Cumacea); *Eohaustorius washingtonianus* (Crustacea, Amphipoda)). This pattern, which is linked with sediment type because finer sediments occur in the higher zones of the beach, suggests that marine processes are more influential in the lower intertidal zone. At Tsawwassen, the composition of the fauna suggests that marine influences are prominent over the entire intertidal zone. Cumaceans, for example, were recorded at almost all stations on this transect.

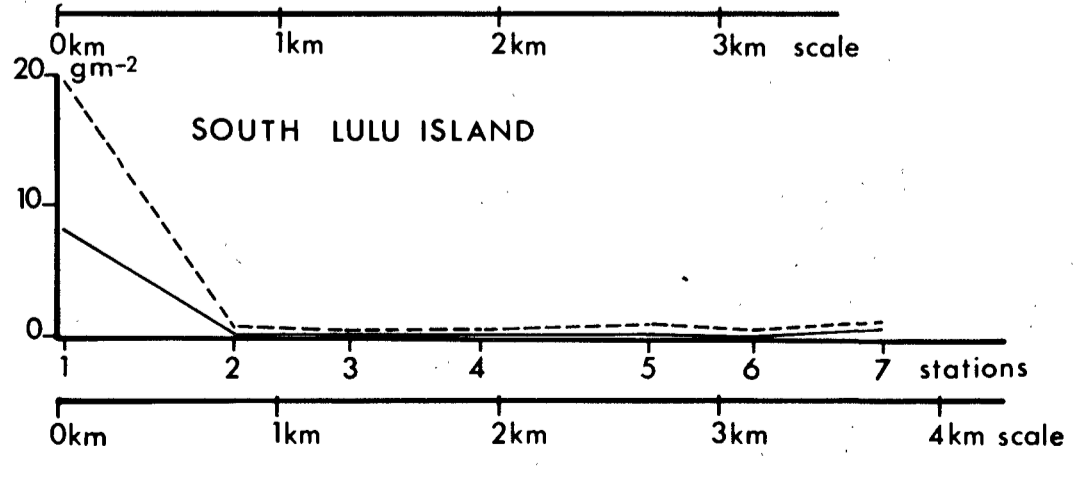
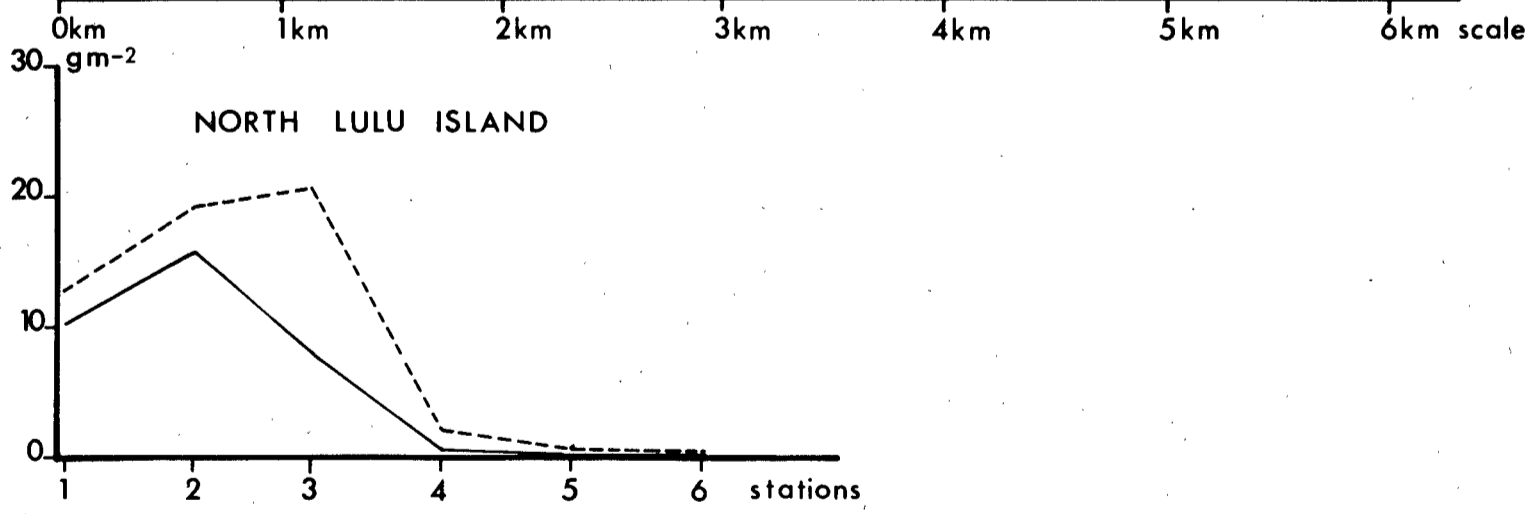
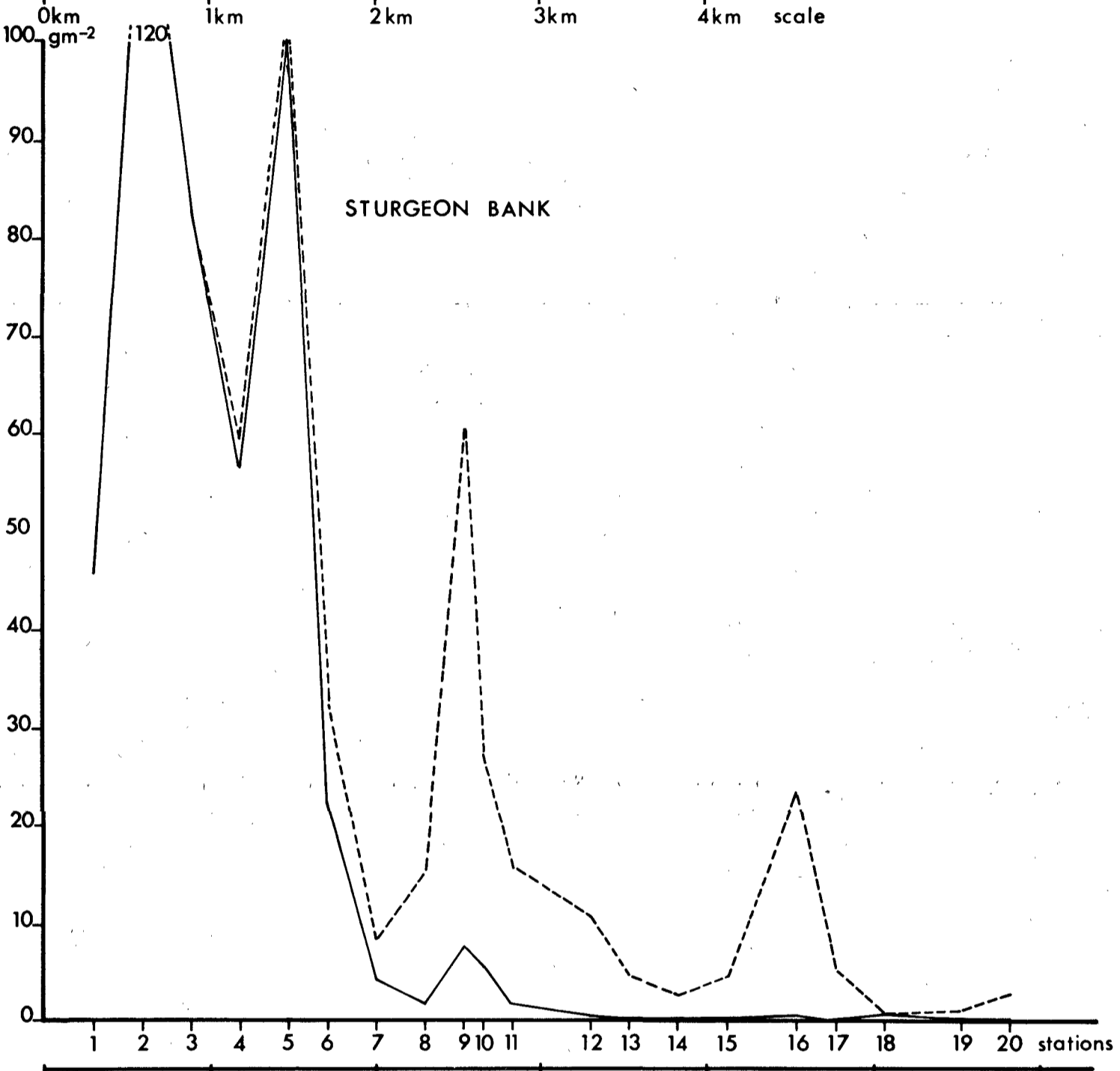
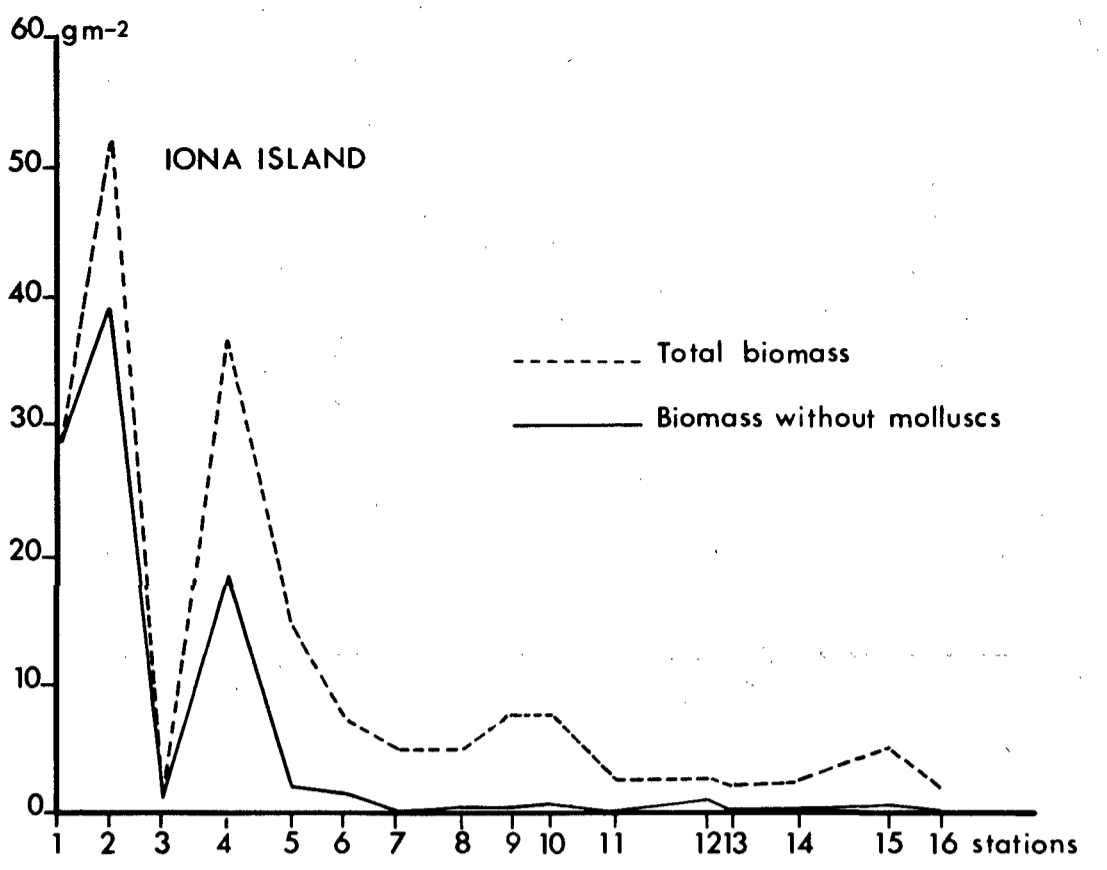
The presence of ctenophores (*Pleurobrachia* sp.) and medusae (*Phialidium* sp.) in plankton tows over Sturgeon Bank indicates that a marine planktonic community can occupy the overlying waters at high tide. However, it was noted that some calanoid copepods obtained in the tows were freshwater forms (e.g. *Epischura* sp.), suggesting plankton from the Fraser River may be distributed over Sturgeon Bank.

DISTRIBUTION OF BIOMASS AND SPECIES

A. Distribution and Elevation: Zonation

The highest stations on all transects yielded the maximum biomass, except at Tsawwassen where peaks in biomass were observed on both high and low sections of the beach (Fig. 8). Biomass values in the higher sections ranged from 10 to 100 g wet weight m^{-2} . Excluding the data from Tsawwassen, biomass in the low stations ranged from close to 0 to about 20 g wet weight m^{-2} . The lower stations at Tsawwassen were in an eel grass bed (*Zostera marina*) where very rich benthic communities are usually found.

Figure 8. Biomass (wet weight $g\ m^{-2}$) in seven transects on Sturgeon and Roberts Bank (see Figure 1), at right angles to the shoreline. Stations which were further seaward (increasing kilometres) were at lower elevations on the tidal flats.



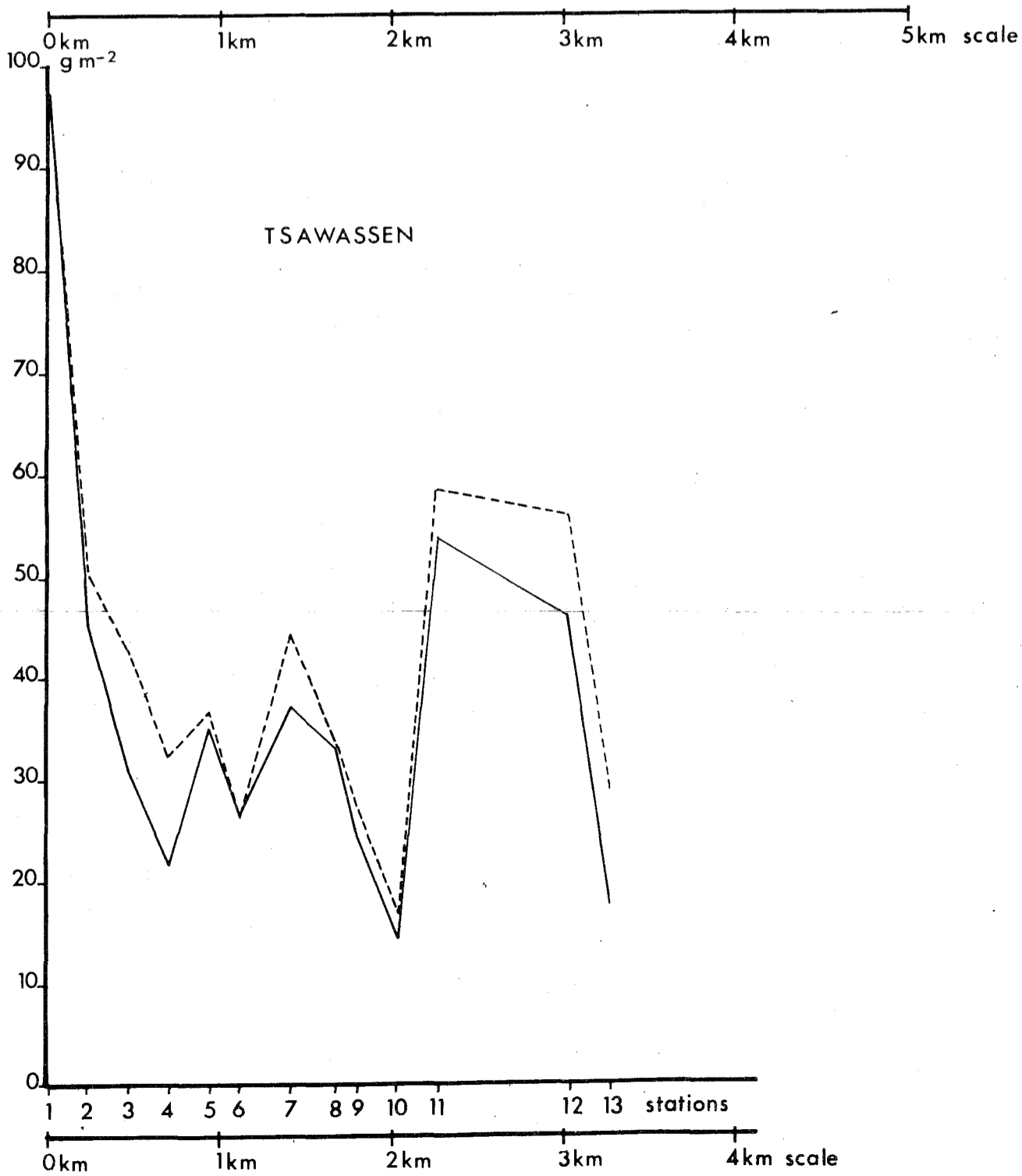
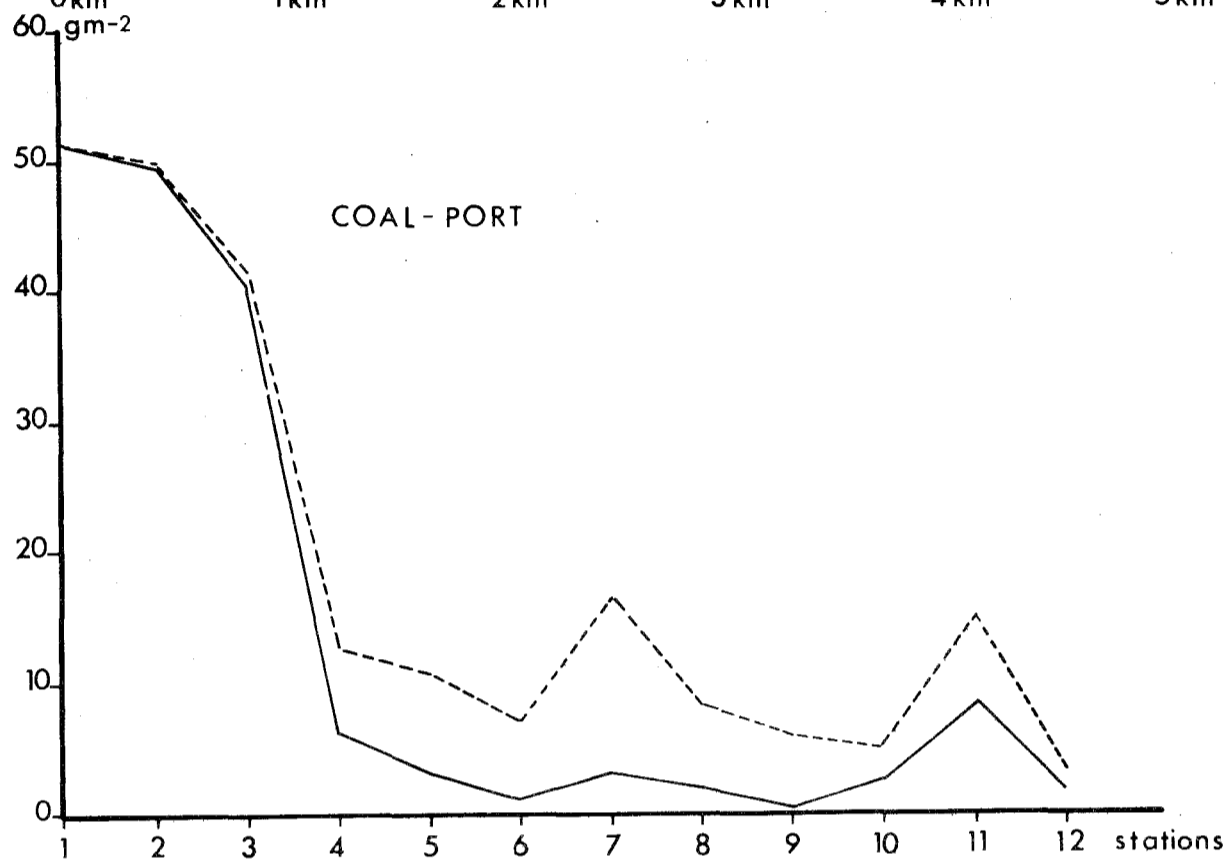
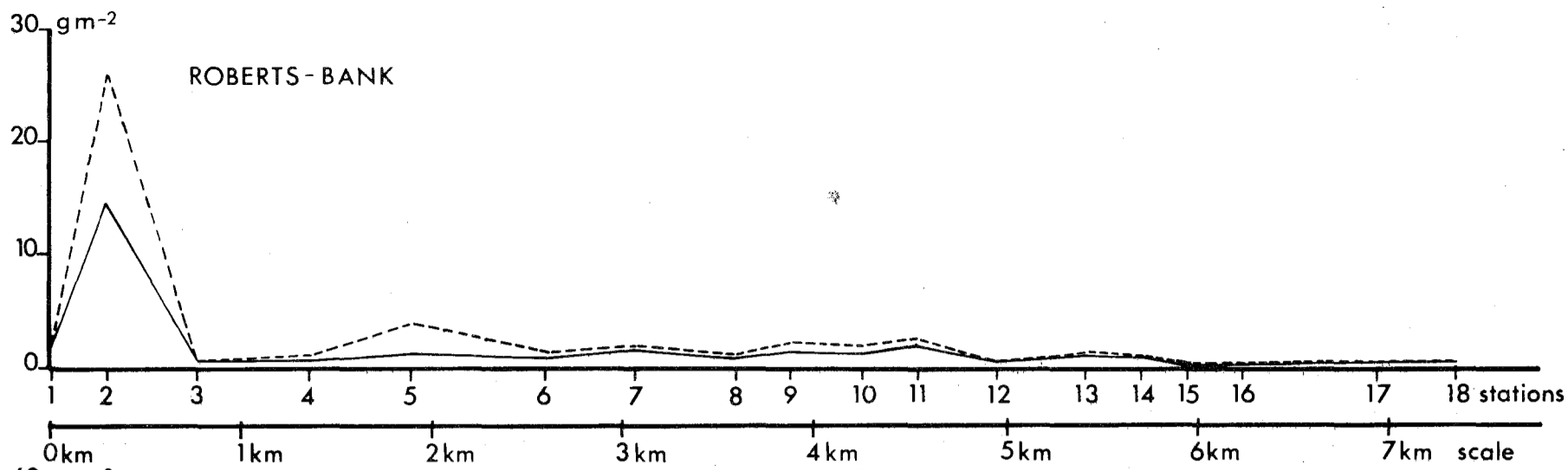


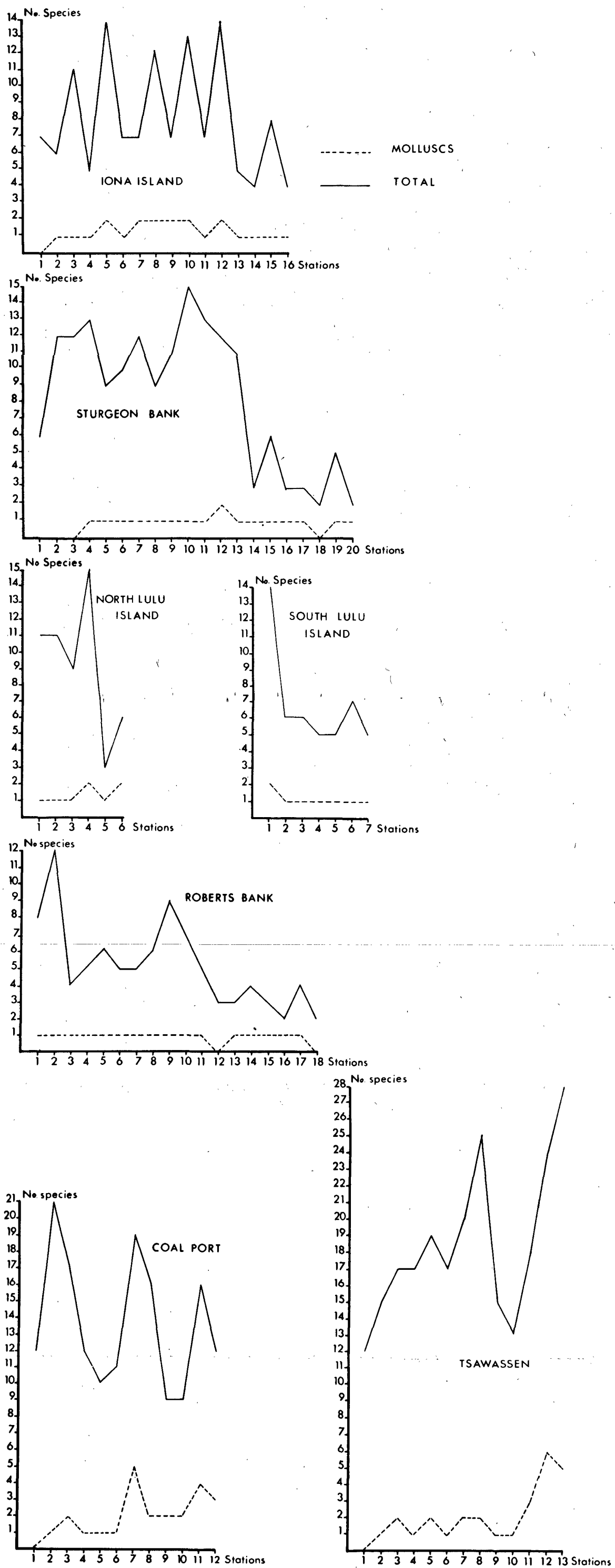
FIG. 8 (cont'd)

There was a major difference in the kinds of animals that occupy the elevations of the intertidal areas on the Fraser delta. Excluding the Tsawwassen stations, molluscs were most abundant in the lower sections, whereas crustaceans and polychaetes dominated at higher elevations (Fig. 8).

There was also a clear zonation in the number of species at various elevations on the transects. The number of species per quadrat reached a maximum in the higher parts of the beach, except at Tsawwassen where the maximum was reached in the eel grass bed at the lower intertidal levels (Fig. 9).

On Sturgeon Banks, in the vicinity of the STUR transect, the spatial distribution of the biomass from plankton tows differed from the patterns observed in intertidal quadrats. In particular, the highest biomass values were not recorded from stations overlying the higher parts of the beach, but were found adjacent to the Middle Arm, and in a "plume" leading northwest from the mouth of this channel (Fig. 3). Large species (especially *Crangon franciscorum* (Decapod shrimp)) contributed to very high biomass values in these areas (Table 10) but were not recorded from quadrats at low tide. The biomass in plankton tows in the Iona Island sector was low (Fig. 3) compared to south of the Iona breakwater, which coincides with the results from the quadrat samples (Fig. 7, Iona Island vs Sturgeon Bank).

Figure 9. Number of species per quadrat in seven transects on Sturgeon and Roberts Bank (see Figure 1). Stations which were further seaward (increasing kilometres) were at lower elevation on the tidal flats.



B. Horizontal Distribution

Biomass per station was highest on STUR and TSAW transects, and the maximum number of taxa was found on the Tsawwassen transect:

<u>Transect</u>	<u>No. Stations</u>	<u>Kilometres from Marsh Edge</u>	<u>Biomass per Station (g wet wt. m⁻²)</u>	<u>Taxa per Station</u>
ION	16	4.9	11.5	1.6
STUR	20	5.7	31.4	1.4
NLU	6	3.0	9.2	3.3
SLU	7	3.7	3.5	3.5
ROB	18	7.5	2.5	1.3
CP	12	4.6	19.1	3.4
TSAW	13	3.5	41.9	4.6

The results of the transect sampling show that more species were found on the southern portion of Roberts Bank (CP, TSAW transects) compared to transects on the remainder of Roberts Bank or on Sturgeon Bank. An increase in the number of species indicates that more marine conditions prevail over most habitats on southern Roberts Bank, and the influence of the freshwater discharge seems to be approximately inversely proportional to distance from the mouth of the South Arm. Transects with many stations characterized by silt (STUR, CP, TSAW) yielded more biomass per station because fine sediments contained the highest density of benthos (see below).

There was little evidence from the perimeter transect that biomass adjacent to the marsh habitats was correlated with distance from the channel mouths (freshwater discharge) except directly adjacent to the

mouths where deposition of coarse sediment has occurred. The biomass per kilometer surveyed was 20.4 g wet weight (24 stations) and a trend in distribution was not evident (Fig. 10). Application of a one-sample runs test (Siegel, 1956) verified this conclusion ($P < 0.05$). There is graphic evidence that more species were found on the southern portion of the transect (Fig. 11) but application of a runs test (Siegel, 1956) did not confirm this conclusion.

C. Sediment-Organism Relationships

Sediment and organism data from the Sturgeon Bank samples (STUR transect) showed there is a clear relationship between the abundance of small crustaceans and polychaetes (e.g. *Corophium*, *Manayunkia*) and the grain size of the sediments. These organisms were most numerous in sediments between 30 and 70 μ m in diameter (Fig. 12). Most of the crustaceans and polychaetes in the samples are detritivores and utilize organic material or "detritus" (algae, decomposing vascular plants) which was more abundant in the finer sediments (Fig. 13). Molluscs (e.g. *Macoma* spp.) which were more common in the coarser sediments, are suspension feeders and utilize organic material dispersed in the water.

The relationship between sediments and animals enables prediction of the suitability of habitats for the smaller invertebrates. Geological studies (Luternauer and Murray, 1973) show that finer sediments on the Fraser delta occur in a band along the seaward edge of the vegetation

Biomass in $g\ m^{-2}$

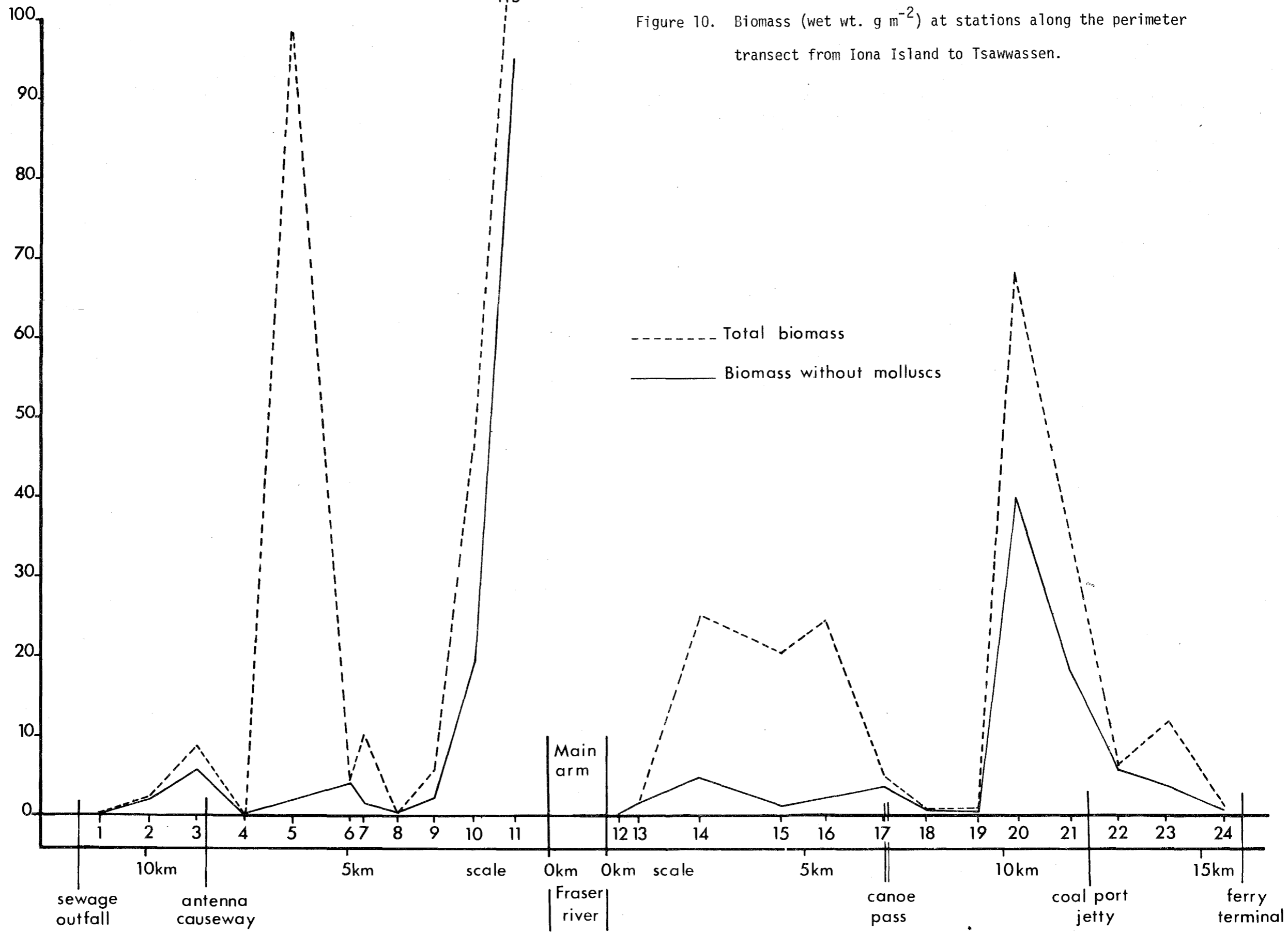


Figure 11. Number of species per quadrat at stations along the perimeter transect (see Figure 1) from Iona Island to Tsawwassen.

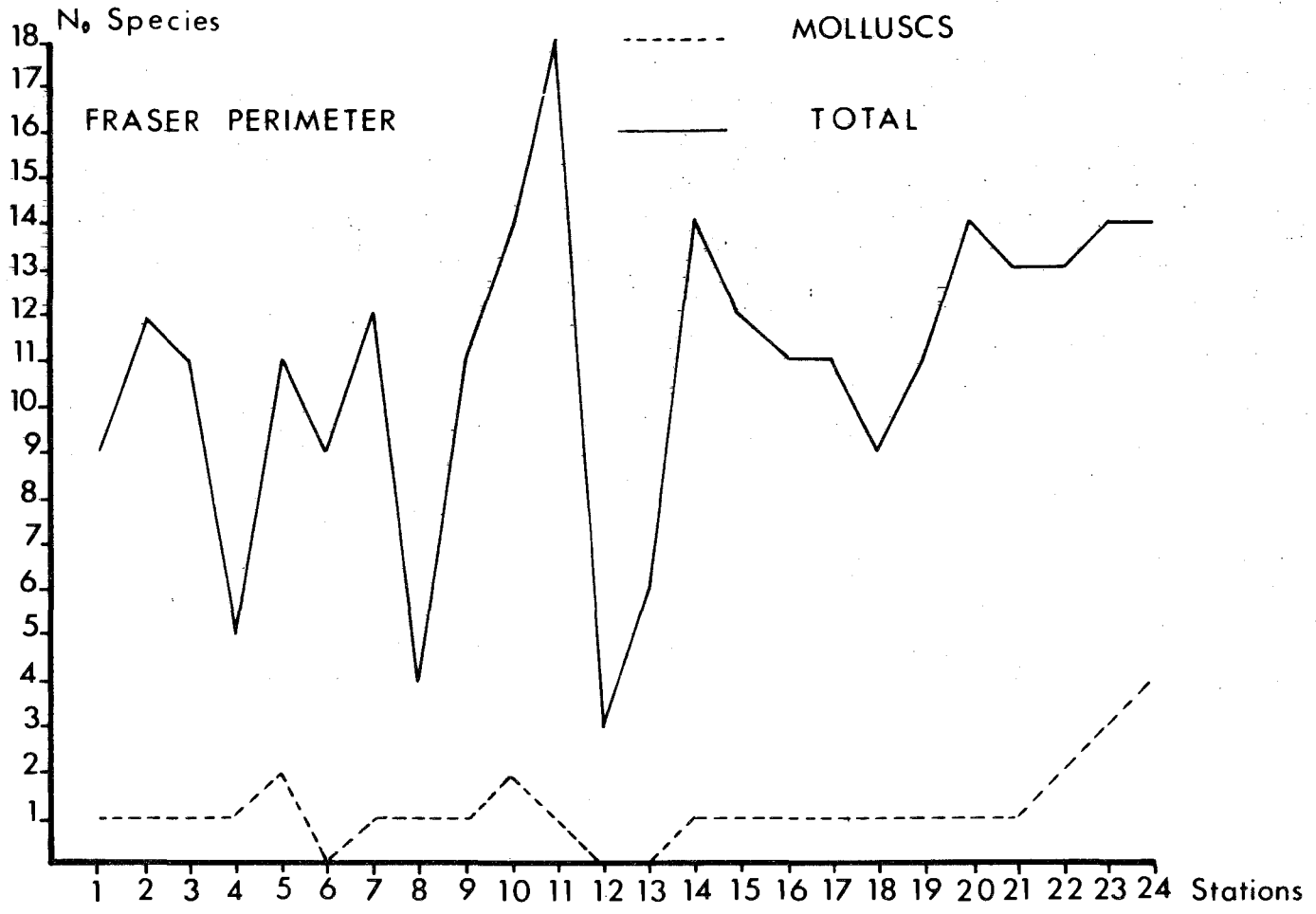


Figure 12. Relationship between median grain size (μm) of sediments, total number of benthos (m^{-2}) (left hand ordinate), and percent (number) of polychaetes and crustaceans (right hand ordinate). Data from Sturgeon Bank sampling in June 1973. Lines fitted by eye.

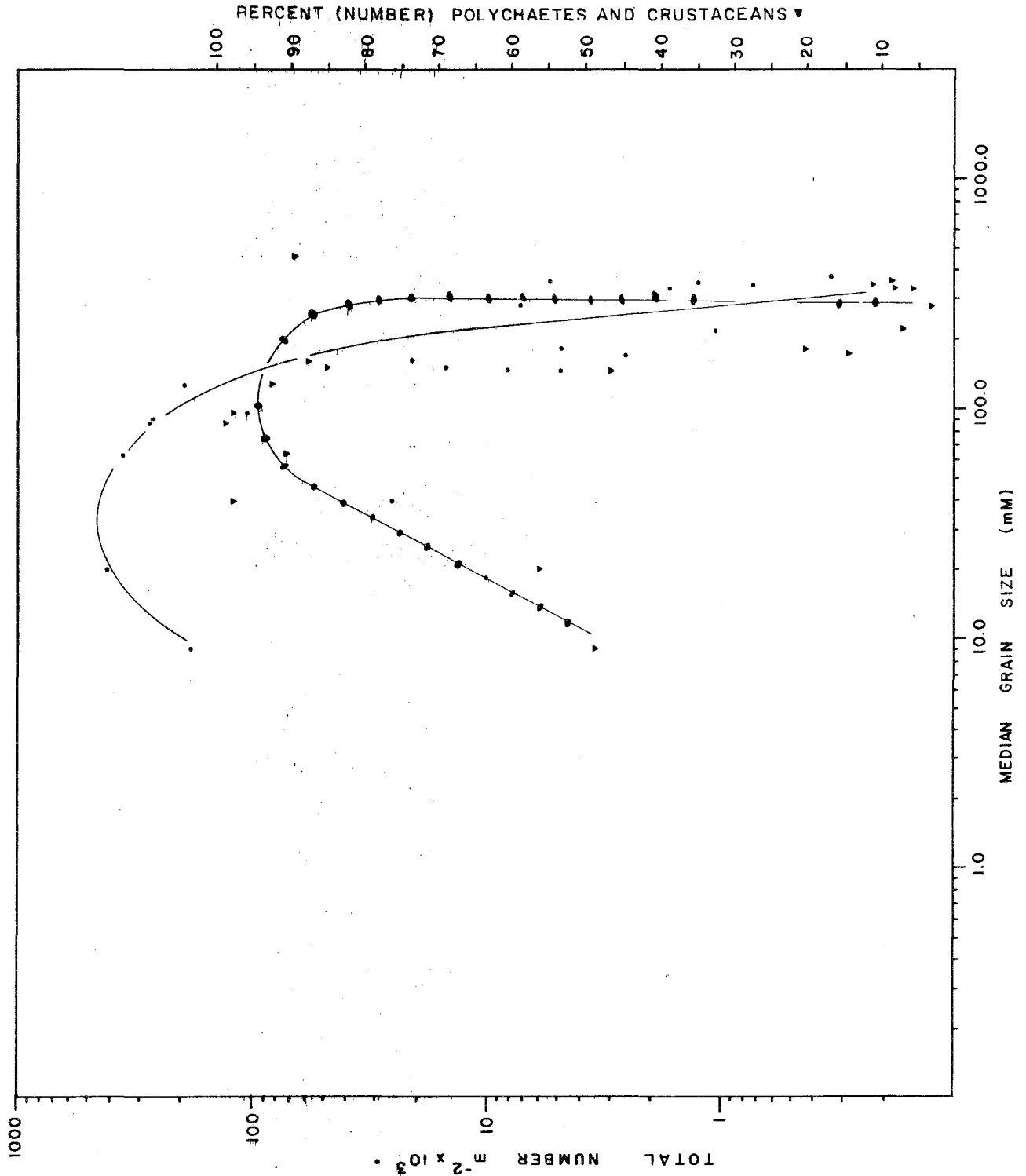
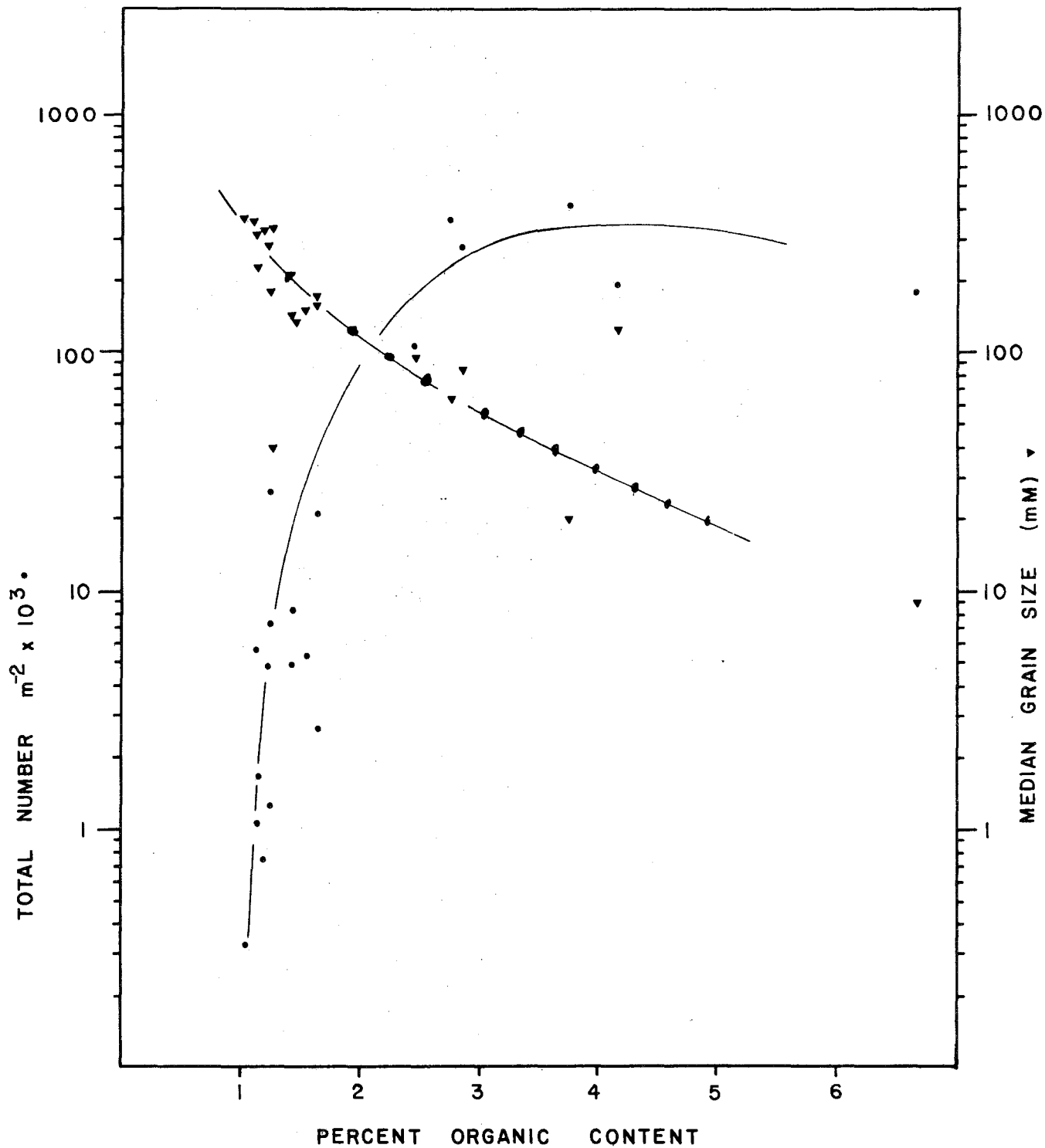


Figure 13. Relationship between sediment organic content, total number of benthos (m^{-2}) (left hand ordinate), and median grain size (right hand ordinate). Data from Sturgeon Bank sampling in June 1973. Lines fitted by eye.



(intermediate or upper intertidal zone), except on the southern part of Roberts Bank near Tsawwassen. This zone represents optimum habitat for polychaetes and crustaceans, whereas the lower zone represents the area where molluscs are more common.

The zonation of sediments and organisms allows some prediction of the suitability of the various portions of the Fraser delta for secondary consumers. Since juvenile salmonids and shorebirds can utilize polychaetes and crustaceans as food, the zone of fine sediments is of greatest significance for these predators. Dungeness crabs (*Cancer magister*), on the other hand, prefer molluscs in their diet (Butler, 1954 and personal communication) and therefore the lower sections of the delta (coarse sediments) are their preferred habitat. A viable crab fishery is pursued along the lower section of the intertidal zone on Sturgeon and Roberts Bank.

PRESENT DISRUPTION AND DISTRIBUTION OF BENTHOS

There are no data describing the distribution and abundance of benthos on the Fraser delta before man-made structures existed. However, data collected in our study enable some comparisons to be made at sites close to certain structures and at nearly intact sites. These are locations, for example, where features such as jetties and causeways seem to have modified the natural distribution of properties such as salinity and sediment type. The changing of these parameters can affect the benthic organisms.

A. Sturgeon Bank

The benthic biomass between the Iona and North Arm jetties is significantly lower compared to the area south of the Iona jetty. The jetties must impair the flow of silt-laden freshwater over the northern part of Sturgeon Bank, and this may have led to modifications in sediments and decreased abundance of benthos. Our salinity data show that north of the Iona causeway, salinities are generally higher than south of this structure. (Figs. 2, 7). Between the jetties, sediments are coarser, suggesting that silt deposition is not a dominant process in this sector (Luternauer, 1974). Dumping of dredge spoil in the upper intertidal area between the jetties (Matthews and Murray, 1966) may have been more severe, since this has apparently prohibited the development of mud algae and marsh plants (sedges, etc.) which contribute detritus to the sediment where it is available as food for benthic animals.

In some instances, the construction of the jetties has provided a stable, hard substrate for epifaunal organisms such as oysters, mussels, and barnacles. We observed these organisms in moderate abundance on the rocks forming the Iona causeway. Other workers (B.C. Research, MS, 1973) have documented the relative abundance of these organisms in the causeway near the sewage outfall.

A portion of Sturgeon Bank receives primary treated sewage from the Iona Island sewage plant. This input of organic matter may be responsible for eutrophication and increased abundance of benthos. The

biomass on the STUR transect was higher, at all elevations, than any of the other transects on Sturgeon Bank.

Data reported elsewhere (B.C. Research, MS, 1973) document the disruption of the benthic environment immediately adjacent to the Iona Island sewage outfall. Our sampling verified the degradation of benthic communities in this area. Parsons et al (1973) observed that benthic organisms from Sturgeon Bank contained more heavy metals than benthos from elsewhere on the Fraser delta, and the Iona sewage outfall was implicated as the source of these contaminants. However, the sewage is responsible for a variety of environmental effects, including depressed oxygen values at high tide (Otte and Levings, MS in prep.), so heavy metal toxicity cannot be easily implicated as a factor leading to degradation.

B. Roberts Bank

On Roberts Bank, the Westshore Terminal causeway appears to be related to differences in sediment type between this causeway and the B.C. Ferry terminal. Grain size interpretations are incomplete, but observations during our work and geological data (Luternauer and Murray, 1973) showed that sediments between the causeways were muddy at all elevations, whereas north of Westshore Terminals (ROB transect) a "normal" zonation of fine sediments at higher elevations and coarse sediments at low elevations was observed. The fauna between the jetties is typical of marine bays, and the existence of an eel grass bed,

with its accompanying benthic communities, implies stable conditions.

The Westshore terminal jetty also appears to modify the flow of freshwater over the southern portion of Roberts Bank. Salinities of the sediment water between the jetties were higher than at stations north of the jetty (Fig. 2). The high salinities probably contribute to the maintenance of the eel grass bed.

The rock rip-rap on the seaward end of the Westshore Terminal jetty has been colonized by subtidal macrophytic algae (probably *Nereocystis*). The floating thalli of these plants were observed during a sampling trip on September 11, 1973.

EFFECTS OF DREDGE AND FILL OPERATIONS ON BENTHOS

The portions of the intertidal zone that are covered by fill material for runway extensions, ferry terminals, etc. are permanently unavailable as habitat for soft-bottom benthos. However, the effects of filling are not necessarily proportional to surface area for the following reasons.

First, benthic communities are zoned in the intertidal areas. The highest biomass of food organisms (crustaceans, polychaetes) potentially available for salmon was found in the high and intermediate zones, and therefore 100 hec of fill material in these zones will have more impact on these organisms than the same area of coverage on the lower portion of the intertidal area. Similar arguments prevail

regarding impact on the Dungeness crab (*Cancer magister*) population in the lower intertidal zone. Habitat loss for these crabs and their molluscan food supply will occur if fill affects the lower intertidal zone.

Secondly, the distribution of effects resulting from construction activities cannot be accurately predicted at this time, but without preventative measures certain effects are going to be evident at a distance from the area being filled. Spillage of silt may result in the dispersion of fine sediment over wider areas than the fill itself occupies. This silt can temporarily smother benthic populations.

Sediments for fill operations may be sought in the intertidal zones adjacent to the area to be filled, and the intertidal fauna in these "borrow areas" will, of course, be annihilated. If the depressions created by removal of sediment persist, fauna adapted to live at lower elevations (probably subtidal organisms) will colonize the area.

PROSPECTS OF RECOLONIZATION

The habitats covered by fill and pavement, are, of course, permanently excluded from biological processes, but the intertidal portion of the fill material presents benthic organisms with a new habitat. The composition and abundance of the communities that would colonize the new habitat, and the speed at which colonization would occur, are dependent on a number of physical and geological factors.

If the borders of the new jetties and terminals were composed of rock "rip-rap", epifauna (barnacles, mussels) would settle on this material, as has occurred on other man-made structures on Sturgeon and Roberts Bank. Colonization would be most rapid in spring and summer when larvae from epifauna are most abundant. At Friday Harbour, Puget Sound, (about 90 km south of the Fraser delta), barnacles were observed to colonize bare beach rocks within two months (Pierron and Huang, 1926). The Friday Harbour experiment was carried out in June, and probably represents a maximal speed for recolonization. Temperature and salinity are other important variables, but we can infer they do not limit epifauna on the Fraser delta because the organisms are found on the Iona and Westshore Terminal jetties and other hard substrates.

Natural mud flats grow through interacting biological and geological processes. Vascular plants (e.g. sedges) and algae grow seaward and trap sediment, thereby providing a substrate for further encroachment (Ranwell, 1972). The gentle slopes of mud flats provide maximum surface area, at specific elevations with optimum sediment type, for development of benthic communities dominated by amphipods and polychaetes.

Recolonization of the infaunal community that currently exists on the intermediate and high intertidal areas on Sturgeon Bank is unlikely unless special measures are taken for planned restoration. There is no evidence that fine-grained sediments settle in the "rip-rap"

on other structures on the Bank. For example, rocks on the Iona jetty are barren of sediments, presumably because wave action prevents settling of silt. The wave action at the site also would probably prevent the use of artificial sediment traps such as wire mesh or vegetation (e.g. willow trees). The shores of the runway extension would be considerably steeper than a natural mud flat, so that even if mud communities were established, a much smaller area at the proper elevation would be available.

In order to compensate for habitat lost by construction on mudflats, one possible alternative is to develop mudflat communities at nearby sites. For example, the sector between the Iona and North Arm jetties might be rehabilitated by regulating the dumping of dredge spoil and by allowing controlled flow of freshwater over the beach. Experimental transplanting of sedges and algae could accompany this work. Benthic invertebrates from intact areas would probably soon colonize the improved habitat, but it might be necessary to introduce "parent" populations of benthos.

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Table 1: Location and environmental data for ION transect, seaward of Iona Island.

Station	ION 1	ION 2	ION 3
Date (1973)	July 27	July 27	July 27
Time (PST)	1200	1155	1148
Position N. lat.	49 ⁰ 13.13	49 ⁰ 13.13	49 ⁰ 13.10
W. long.	123 ⁰ 12.79	123 ⁰ 12.95	123 ⁰ 13.10
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	3.34	2.74	2.13
Grain size (visual)	sand	silt-sand	silt
Silt/sand ratio	N/A	N/A	N/A
Temperature (sediment surface, °C)	26.2	26.0	25.2
Remarks	- <i>Ulva</i> fragments abundant		- <i>Ulva</i> <i>thalli</i> abundant

Table 1: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ION transect, seaward of Iona Island. See Table 12 for classification of organisms

Station Date (1973)	ION 1 July 27		ION 2 July 27		ION 3 July 27	
Taxa	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}
Nemertea	--	--	--	--	--	--
<i>Eteone</i>	0.154	128	--	--	0.150	48
<i>Nereis</i>	0.794	256	--	--	0.074	16
<i>Scoloplos</i>	--	--	--	--	--	--
<i>Paraonis</i>	--	--	--	--	--	--
<i>Polydora</i> l.	--	--	--	--	0.002	16
<i>Polydora</i> k.	0.166	384	0.307	1280	0.648	1296
<i>Pygospio</i>	--	--	--	--	0.030	48
<i>Capitella</i> sp.I	--	--	0.102	512	0.008	16
<i>Amphicteis</i>	1.344	2816	2.995	11264	0.187	448
<i>Manayunkia</i>	1.715	10240	30.720	223488	0.326	3120
Polychaeta dam.	--	--	--	--	--	--
Oligochaeta	23.578	127744	4.864	33280	--	--
<i>Corophium sal</i>	--	--	--	--	--	--
<i>Corophium</i>	--	--	--	--	--	--
<i>Corophium</i> juv.	--	--	--	--	--	--
<i>Corophium</i> dam.	--	--	--	--	0.003	16
<i>Calliopius</i>	--	--	--	--	--	--
<i>Anisogammarus</i> juv.	--	--	--	--	0.005	16
<i>Anisogammarus</i> con.	0.781	128	--	--	--	--
<i>Paraphoxus</i>	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Gnorimosphaeroma</i>	--	--	--	--	--	--
Mysid juv.	--	--	--	--	--	--
<i>Y. ensifera</i>	--	--	--	--	--	--
<i>Macoma</i>	--	--	12.979	256	0.102	336
TOTAL	28.532	141696	51.967	659968	1.535	5376

Table 1: Location and environmental data for ION transect, seaward of Iona Island.

Station	ION 4	ION 5	ION 6
Date (1973)	July 27	July 27	July 27
Time (PST)	1143	1138	1134
Position N. lat.	49 ⁰ 13.13	49 ⁰ 13.13	49 ⁰ 13.11
W. long.	123 ⁰ 13.28	123 ⁰ 13.42	123 ⁰ 13.62
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.13	2.13	1.52
Grain size (visual)	silt	silt	silt-sand
Silt/sand ratio	N/A	N/A	N/A
Temperature (sediment surface, °C)	23.0	24.1	25.4
Remarks	<i>Ulva</i> thalli abundant	--	Patches of silt among sand

Table 1: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ION transect, seaward of Iona Island. See Table 12 for classification of organisms

Station Date (1973)	ION 4 July 27		ION 5 July 27		ION 6 July 27	
Taxa	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}
Nemertea	--	--	0.138	64	--	--
<i>Eteone</i>	0.064	128	0.120	48	0.108	48
<i>Nereis</i>	0.128	128	--	--	--	--
<i>Scoloplos</i>	--	--	--	--	--	--
<i>Paraonis</i>	--	--	--	--	--	--
<i>Polydora</i> l.	0.243	128	--	--	--	--
<i>Polydora</i> k.	2.214	5888	1.003	2896	1.288	2912
<i>Pygospio</i>	0.832	3712	0.035	320	0.022	128
<i>Capitella</i> sp. I	--	--	0.008	48	0.016	32
<i>Amphicteis</i>	2.086	3456	0.280	1008	0.099	16
<i>Manayunkia</i>	11.866	90240	0.098	1328	--	--
<i>Polychaeta</i> dam.	--	--	--	--	--	--
Oligochaeta	1.178	10112	0.480	3984	0.054	784
<i>Corophium</i> sal	--	--	--	--	--	--
<i>Corophium</i>	--	--	--	--	0.035	32
<i>Corophium</i> juv.	--	--	--	--	--	--
<i>Corophium</i> dam.	--	--	--	--	--	--
<i>Calliopius</i>	--	--	--	--	--	--
<i>Anisogammarus</i> juv.	--	--	--	--	--	--
<i>Anisogammarus</i> con.	--	--	--	--	--	--
<i>Paraphoxus</i>	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Gnorimosphaeroma</i>	--	--	--	--	--	--
Mysid juv.	--	--	--	--	--	--
<i>Y. ensifera</i>	0.102	128	0.235	16	0.138	16
<i>Macoma</i>	18.112	3712	12.341	1408	5.731	1200
TOTAL	36.825	117632	14.738	11120	7.491	5168

Table 1: Location and environmental data for ION transect, seaward of Iona Island.

Station	ION 7	ION 8	ION 9
Date (1973)	July 27	July 27	July 27
Time (PST)	1128	1125	1115
Position N. lat.	49 ⁰ 13.10	49 ⁰ 13.10	49 ⁰ 13.11
W. long.	123 ⁰ 13.80	123 ⁰ 14.00	123 ⁰ 14.15
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	1.52	1.52	1.52
Grain size (visual)	silt	silt	silt
Silt/sand ratio	N/A	N/A	N/A
Temperature (sediment surface, °C)	25.8	26.2	25.2

Remarks

-patches
of silt
among
sand

Table 1: Biomass (wet wt. $g\ m^{-2}$), number of individuals (number m^{-2}) and species composition from ION transect, seaward of Iona Island. See Table 12 for classification of organisms

Station Date (1973)	ION 7 July 27		ION 8 July 27		ION 9 July 27	
Taxa	Biomass $g\ m^{-2}$	No.Ind. m^{-2}	Biomass $g\ m^{-2}$	No.Ind. m^{-2}	Biomass $g\ m^{-2}$	No.Ind. m^{-2}
Nemertea	--	--	--	--	--	--
<i>Eteone</i>	0.085	48	0.190	128	0.234	160
<i>Nereis</i>	--	--	--	--	--	--
<i>Scoloplos</i>	--	--	0.008	16	--	--
<i>Paraonis</i>	--	--	0.003	48	0.002	32
<i>Polydora</i> i.	--	--	--	--	--	--
<i>Polydora</i> k.	0.248	592	0.379	1696	0.424	1200
<i>Pygospio</i>	0.003	16	0.005	64	0.003	48
<i>Capitella</i> sp.I	--	--	--	--	--	--
<i>Amphicteis</i>	0.085	64	0.021	32	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
Polychaeta dam.	--	--	--	--	--	--
Oligochaeta	0.016	48	0.029	80	0.021	160
<i>Corophium</i> sal.	--	--	0.034	32	--	--
<i>Corophium</i>	--	--	--	--	--	--
<i>Corophium</i> juv.	--	--	--	--	--	--
<i>Corophium</i> dam.	--	--	--	--	--	--
<i>Calliopius</i>	--	--	--	--	--	--
<i>Anisogammarus</i> juv.	--	--	0.005	16	--	--
<i>Anisogammarus</i> con.	--	--	--	--	--	--
<i>Parapoxus</i>	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Gnorimosphaeroma</i>	--	--	0.034	16	--	--
Mysid juv.	--	--	--	--	--	--
<i>Y. ensifera</i>	0.379	80	0.262	64	0.099	32
<i>Macoma</i>	4.368	3088	4.219	2976	6.963	1936
TOTAL	5.184	3936	5.189	5168	7.746	3568

Table 1: Location and environmental data for ION transect, seaward of Iona Island.

Station	ION 10	ION 10R	ION 11
Date (1973)	July 27	July 27	July 27
Time (PST)	1107	1107	1100
Position N. lat.	49 ⁰ 13.12	49 ⁰ 13.12	49 ⁰ 13.16
W. long.	123 ⁰ 14.30	123 ⁰ 14.30	123 ⁰ 14.45
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	1.52	1.52	1.52
Grain size (visual)	silt	silt-sand	silt-sand
Silt/sand ratio	N/A	N/A	N/A
Temperature (sediment surface, °C)	24.9	24.9	25.4
Remarks		-replicate adjacent (~5 m) to ION 10 station	-patches of silt among sand

Table 1: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ION transect, seaward of Iona Island. See Table 12 for classification of organisms

Station Date (1973)	ION 10 July 27		ION 10R* July 27		ION 11 July 27	
Taxa	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}
Nemertea	--	--	0.010	16	0.032	32
<i>Eteone</i>	0.147	64	0.083	32	0.046	16
<i>Nereis</i>	--	--	--	--	--	--
<i>Scoloplos</i>	0.008	16	0.008	16	--	--
<i>Paraonis</i>	0.010	64	0.016	272	--	--
<i>Polydora</i> t.	--	--	--	--	--	--
<i>Polydora</i> k.	0.053	48	0.093	304	--	--
<i>Pygospio</i>	0.015	48	0.004	16	--	--
<i>Capitella</i> sp.I	0.008	16	0.008	16	--	--
<i>Amphicteis</i>	0.085	16	--	--	--	--
<i>Manayunkia</i>	--	--	0.002	32	--	--
Polychaeta dam.	--	--	--	--	--	--
Oligochaeta	0.007	96	0.003	368	0.002	32
<i>Corophium sal.</i>	--	--	--	--	--	--
<i>Corophium</i>	--	--	--	--	--	--
<i>Corophium</i> juv.	--	--	--	--	--	--
<i>Corophium</i> dam.	--	--	--	--	--	--
<i>Calliopius</i>	--	--	--	--	--	--
<i>Anisogammarus</i> juv.	0.062	64	--	--	0.003	16
<i>Anisogammarus</i> con.	0.550	192	--	--	--	--
<i>Paraphoxus</i>	--	--	--	--	0.062	16
<i>Cumella</i>	0.022	64	0.019	32	0.011	48
<i>Gnorimosphaeroma</i>	--	--	--	--	--	--
Mysid juv.	--	--	--	--	--	--
<i>Y. ensifera</i>	0.250	80	0.158	16	--	--
<i>Macoma</i>	6.435	1392	3.483	928	2.728	576
TOTAL	7.652	2160	3.918	2048	2.884	736

*replicate adjacent (~ 5 m) to Station ION 10.

Table 1: Location and environmental data for ION transect, seaward of Iona Island.

Station	ION 12	ION 13	ION 14
Date (1973)	July 27	July 27	July 27
Time (PST)	1058	1047	1041
Position N. lat.	49 ⁰ 13.09	49 ⁰ 13.23	49 ⁰ 13.30
W. long.	123 ⁰ 14.75	123 ⁰ 14.72	123 ⁰ 14.91
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	0.91	0.91	0.91
Grain size (visual)	sand	sand	sand
Silt/sand ratio	N/A	N/A	N/A
Temperature (sediment surface, °C)	24.1	23.0	22.0
Remarks	-ripples ca. 3 cm amplitude	-ripples ca. 5 cm amplitude	-ripples ca. 5 cm amplitude

Table 1: Biomass (wet wt. $g\ m^{-2}$), number of individuals (number m^{-2}) and species composition from ION transect, seaward of Iona Island. See Table 12 for classification of organisms

Station Date (1973)	ION 12 July 27		ION 13 July 27		ION 14 July 27	
Taxa	Biomass $g\ m^{-2}$	No.Ind. m^{-2}	Biomass $g\ m^{-2}$	No.Ind. m^{-2}	Biomass $g\ m^{-2}$	No.Ind. m^{-2}
Nemertea	0.024	16	--	--	--	--
<i>Eteone</i>	1.251	32	0.083	16	--	--
<i>Nereis</i>	--	--	--	--	--	--
<i>Scoloplos</i>	0.008	16	0.008	16	--	--
<i>Paraonis</i>	--	--	--	--	--	--
<i>Polydora</i> f.	--	--	--	--	--	--
<i>Polydora</i> k.	--	--	--	--	--	--
<i>Pygospio</i>	0.030	48	--	--	--	--
<i>Capitella</i> sp.I	--	--	--	--	--	--
<i>Amphicteis</i>	--	--	--	--	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
<i>Polychaeta</i> dam.	--	--	--	--	--	--
Oligochaeta	--	--	--	--	0.085	1616
<i>Corophium</i> sal.	--	--	--	--	--	--
<i>Corophium</i>	--	--	--	--	--	--
<i>Corophium</i> juv.	0.013	16	--	--	--	--
<i>Corophium</i> dam.	--	--	--	--	--	--
<i>Calliopius</i>	0.019	16	--	--	--	--
<i>Anisogammarus</i> juv.	0.510	1392	--	--	--	--
<i>Anisogammarus</i> con.	0.397	144	--	--	--	--
<i>Parapoxus</i>	0.019	16	0.069	64	0.102	112
<i>Cumella</i>	0.027	80	0.016	32	0.010	16
<i>Gnorimosphaeroma</i>	0.030	16	--	--	--	--
Mysid juv.	0.030	16	--	--	--	--
<i>Y. ensifera</i>	0.051	32	--	--	--	--
<i>Macoma</i>	1.462	304	2.322	832	2.392	544
TOTAL	2.745	2144	2.498	960	2.589	2288

Table 1: Location and environmental data for ION transect, seaward of Iona Island.

Station	ION 15	ION 16
Date (1973)	July 27	July 27
Time (PST)	1135	1130
Position N. lat.	49 ⁰ 13.33	49 ⁰ 13.32
W. long.	123 ⁰ 15.12	123 ⁰ 15.29
Quadrat Size (m ²)	.06	.06
Elevation (m, O.D.)	0.91	0.60
Grain size (visual)	sand	sand
Silt/sand ratio	N/A	N/A
Temperature (sediment surface, °C)	22.9	21.0
Remarks	-ripples ca. 5 cm amplitude	-ripples ca. 5 cm amplitude

Table 1: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ION transect, seaward of Iona Island. See Table 12 for classification of organisms

Station Date (1973)	ION 15 July 27		ION 16 July 27	
Taxa	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}
Nemertea	--	--	--	--
<i>Eteone</i>	0.083	16	--	--
<i>Nereis</i>	--	--	--	--
<i>Scoloplos</i>	--	--	--	--
<i>Paraonis</i>	--	--	--	--
<i>Polydora</i> l.	--	--	--	--
<i>Polydora</i> k.	0.025	16	--	--
<i>Pygospio</i>	--	--	--	--
<i>Capitella</i> sp.I	--	--	--	--
<i>Amphicteis</i>	0.122	80	--	--
<i>Manayunkia</i>	--	--	--	--
Polychaeta dam.	--	--	--	--
Oligochaeta	0.160	3200	0.181	1568
<i>Corophium</i> sal.	--	--	--	--
* <i>Corophium</i>	--	--	--	--
<i>Corophium</i> juv.	--	--	--	--
<i>Corophium</i> dam.	--	--	--	--
<i>Calliopius</i>	--	--	--	--
<i>Anisogammarus</i> juv.	--	--	--	--
<i>Anisogammarus</i> con.	0.075	16	0.046	32
<i>Paraphoxus</i>	0.264	80	0.085	48
<i>Cumella</i>	0.030	96	--	--
<i>Gnorimosphaeroma</i>	--	--	--	--
Mysid juv.	--	--	--	--
<i>Y. ensifera</i>	--	--	--	--
<i>Macoma</i>	4.274	656	1.886	528
TOTAL	5.033	4160	2.198	2176

Table 2: Location and environmental data for STUR transect, seaward of Sea Island.

Station	STUR 1	STUR 2	STUR 3
Date (1973)	June 2	June 2	June 2
Time (PST)	1043.	1050.	1000
Position N. lat.	49°12.03	49°12.02	49°12.03
W. long.	123°12.21	123°12.91	123°13.11
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.70	2.70	2.12
Grain size (μ m, median)	9	20	86
Silt/sand ratio	4.000	49.000	0.785
Temperature (sediment surface, °C)	16.1	16.0	16.1
Remarks	mud	mud	mud
	- seaward edge of marsh	- reduced layer ca. 5cm be- neath surface	- plant fragments in sediment

Table 2: Biomass (wet wt. g m⁻²), number of individuals (number m⁻²), and species composition from STUR transect, seaward of Sea Island. See Table 12 for classification of organisms.

Station	STUR 1		STUR 2		STUR 3	
Date (1973)	June 2		June 2		June 2	
Taxa	Biomass g m ⁻²	No.Ind. m ⁻²	Biomass g m ⁻²	No.Ind. m ⁻²	Biomass g m ⁻²	No.Ind. m ⁻²
Insect larvae	1.382	1024	--	--	--	--
Turbellaria	--	--	--	--	0.010	160
Nemertea	--	--	--	--	--	--
<i>Dendrostoma</i>	--	--	--	--	0.016	160
<i>Eteone</i>	--	--	--	--	--	--
<i>Nereis</i>	--	--	--	--	0.384	160
<i>Paraonis</i>	--	--	--	--	--	--
<i>Pygospio</i>	0.005	128	0.080	320	--	--
<i>Polydora i.</i>	--	--	--	--	--	--
<i>Polydora k.</i>	--	--	--	--	--	--
<i>Capitella sp.I</i>	--	--	--	--	--	--
<i>Amphicteis</i>	0.230	128	16.704	9280	--	--
<i>Manayunkia</i>	18.394	75392	47.488	151360	68.848	221440
<i>Polychaeta dam.</i>	2.598	12800	4.800	48000	--	--
Oligochaeta	23.170	91264	42.030	172160	--	--
<i>Corophium sal.</i>	--	--	11.744	14720	8.608	10.720
<i>Corophium juv.</i>	--	--	0.416	4160	3.744	37440
<i>Corophium dam.</i>	--	--	0.256	1280	0.224	1120
<i>Anisogammarus con.</i>	--	--	--	--	0.864	160
<i>Anisogammarus juv.</i>	--	--	0.896	960	--	--
<i>Paraphoxus</i>	--	--	--	--	--	--
<i>Pontogeneia</i>	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	--	--	0.128	640	0.016	260
<i>Yoldia</i>	--	--	--	--	--	--
<i>Macoma</i>	--	--	--	--	--	--
TOTAL	45.779	180736	120.222	402800	82.724	274060

Table 2 (cont'd) Location and environmental data for STUR transect, seaward of Sea Island.

Station	STUR 4	STUR 5	STUR 6
Date (1973)	June 2	June 2	June 2
Time (PST)	1005	1015	1018
Position N. lat.	49°12.10	49°12.11	49°12.01
W. long.	123°13.31	123°13.52	123°13.62
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.12	2.12	2.12
Grain size (μ m, median)	125	64	96
Silt/sand ratio	0.149	1.325	0.639
Temperature (sediment surface, °C)	15.3	15.1	15.2
Remarks	- mud-sand	- mud	- mud

Table 2: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}), and species composition from STUR transect, seaward of Sea Island. See Table 12 for classification of organisms.

Station	STUR 4		STUR 5		STUR 6	
Date (1973)	June 2		June 2		June 2	
Taxa	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}
Insect larvae	--	--	--	--	--	--
Turbellaria	--	--	0.030	320	--	--
Nemertea	--	--	--	--	--	--
<i>Dendrostoma</i>	0.371	64	--	--	--	--
<i>Eteone</i>	0.141	64	--	--	--	--
<i>Nereis</i>	--	--	--	--	0.560	160
<i>Paraonis</i>	--	--	--	--	--	--
<i>Pygospio</i>	--	--	--	--	0.160	320
<i>Polydora i.</i>	--	--	--	--	--	--
<i>Polydora k.</i>	0.045	128	3.840	7680	--	--
<i>Capitella sp.I</i>	--	--	--	--	--	--
<i>Amphicteis</i>	0.230	128	0.576	320	--	--
<i>Manayunkia</i>	53.837	172288	88.992	296640	18.480	85440
<i>Polychaeta dam.</i>	--	--	--	--	--	--
Oligochaeta	0.781	13055	3.210	30400	0.544	2240
<i>Corophium sal.</i>	0.218	420	2.880	2880	0.512	640
<i>Corophium juv.</i>	1.107	11072	1.408	14080	1.472	14720
<i>Corophium dam.</i>	0.166	832	--	--	0.096	480
<i>Anisogammarus con.</i>	--	--	--	--	--	--
<i>Anisogammarus juv.</i>	--	--	--	--	--	--
<i>Paraphoxus</i>	--	--	--	--	--	--
<i>Pontogeneia</i>	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	0.013	64	--	--	0.416	2240
<i>Yoldia</i>	--	--	--	--	--	--
<i>Macoma</i>	2.342	192	2.579	1280	10.720	640
TOTAL	59.255	198976	103.526	356480	32.960	106880

Table 2 (cont'd) Location and environmental data for STUR transect

Station	STUR 7	STUR 8	STUR 9
Date	June 2	June 2	June 2
Time (PST)	1030	1035	1045
Position N. lat.	49°12.00	49°11.91	49°11.94
W. long.	123°13.82	123°14.03	123°14.21
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.12	1.51	1.51
Grain size (μ m, median)	40	145	160
Silt/ sand ratio	1.564	0.061	0.041
Temperature (sediment surface, °C)	15.2	15.0	19.8
Remarks	-mud	-mud-sand	-mud-sand

Table 2: Biomass (wet wt. $g\ m^{-2}$), number of individuals (number m^{-2}), and species composition from STUR transect, seaward of Sea Island. See Table 12 for classification of organisms.

Station	STUR 7		STUR 8		STUR 9	
Date (1973)	June 2		June 2		June 2	
Taxa	Biomass $g\ m^{-2}$	No. Ind. m^{-2}	Biomass $g\ m^{-2}$	No. Ind. m^{-2}	Biomass $g\ m^{-2}$	No. Ind. m^{-2}
Insect larvae	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--
Nemertea	0.140	048	--	--	1080	80
<i>Dendrostoma</i>	--	--	--	--	--	--
<i>Eteone</i>	--	--	0.214	128	0.320	80
<i>Nereis</i>	--	--	--	--	--	--
<i>Paraonis</i>	--	--	--	--	--	--
<i>Pygospio</i>	--	--	--	--	--	--
<i>Polydora i.</i>	--	--	--	--	0.005	80
<i>Polydora k.</i>	0.022	96	--	--	0.752	1200
<i>Capitella sp. I</i>	--	--	--	--	--	--
<i>Amphicteis</i>	0.058	32	0.029	16	--	--
<i>Manayunkia</i>	1.075	3684	0.010	32	--	--
<i>Polychaeta dam.</i>	0.010	96	--	--	--	--
Oligochaeta	0.022	96	--	--	0.096	400
<i>Corophium sal.</i>	0.781	1088	0.994	1296	4.248	5040
<i>Corophium juv.</i>	1.821	18208	0.526	5264	1.216	12160
<i>Corophium dam.</i>	0.378	1888	0.086	432	--	--
<i>Anisogammarus con.</i>	--	--	--	--	--	--
<i>Anisogammarus juv.</i>	--	--	--	--	--	--
<i>Paraphoxus</i>	--	--	--	--	--	--
<i>Pontogeneia</i>	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	0.024	80
<i>Tanais</i>	0.006	32	--	--	--	--
<i>Yoldia</i>	--	--	--	--	--	--
<i>Macoma</i>	3.933	384	13.451	976	52.768	2000
TOTAL	8.270	25552	15.310	8044	60.509	21120

Table 2 (Cont'd) Location and environmental data for STUR transect

Station	STUR 10	STUR 11	STUR 12
Date (1973)	June 2	June 2	June 2
Time (PST)	1050	1100	1105
Position N. lat.	49°11.94	49°11.94	49°11.88
W. long.	123°14.30	123°14.40	123°14.71
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	1.51	1.51	0.91
Grain size (μ m, median)	150	145	180
Silt/sand ratio	0.123	0.041	0.023
Temperature (sediment surface, °C)	15.3	14.8	13.0
Remarks	-sand	-sand	-sand

Table 2: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}), and species composition from STUR transect, seaward of Sea Island. See Table 12 for classification of organisms.

Station	STUR 10		STUR 11		STUR 12	
Date (1973)	June 2		June 2		June 2	
Taxa	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}
Insect larvae	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--
Nemertea	--	--	0.301	128	0.218	32
<i>Dendrostoma</i>	--	--	--	--	--	--
<i>Eteone</i>	0.342	320	0.198	160	0.174	376
<i>Nereis</i>	0.224	32	--	--	--	--
<i>Paraonis</i>	--	--	0.032	320	0.051	512
<i>Pygospio</i>	0.176	352	0.016	32	--	--
<i>Polydora i.</i>	0.016	32	--	--	--	--
<i>Polydora k.</i>	0.128	256	--	--	--	--
<i>Capitella sp.I</i>	0.240	388	--	--	--	--
<i>Amphicteis</i>	--	--	--	--	--	--
<i>Manayunkia</i>	0.029	96	--	--	--	--
<i>Polychaeta dam.</i>	--	--	--	--	--	--
Oligochaeta	--	--	--	--	0.016	256
<i>Corophium sal.</i>	3.741	4576	1.014	1168	0.103	228
<i>Corophium juv.</i>	0.569	5888	0.046	464	0.011	112
<i>Corophium dam.</i>	0.102	512	0.026	128	--	--
<i>Anisogammarus con.</i>	--	--	0.042	16	--	--
<i>Anisogammarus juv.</i>	0.013	32	--	--	--	--
<i>Paraphoxus</i>	--	--	0.010	16	--	--
<i>Pontogeneia</i>	--	--	--	--	0.056	16
<i>Cumella</i>	0.106	640	0.008	32	0.013	32
<i>Tanais</i>	--	--	--	--	--	--
<i>Yoldia</i>	--	--	--	--	0.086	16
<i>Macoma</i>	21.898	2240	14.074	2448	9.886	3552
TOTAL	27.604	15364	15.767	4912	10.614	4832

Table 2 (cont'd) Location and environmental data for STUR transect

Station	STUR 13	STUR 14	STUR 15
Date (1973)	June 2	June 2	June 2
Time (PST)	1120	1125	1135
Position N. lat.	49°12.00	49°11.98	49°11.97
W. long.	123°14.90	123°15.10	123°15.31
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	0.91	0.30	0.30
Grain size (μ m, median)	170	325	315
Silt/sand ratio	0.075	0.010	0.010
Temperature (sediment surface, °C)	19.4	13.8	13.9
Remarks	-sand	-sand ripples ~ 3 cm high	-sand ripples ~ 3 cm high

Table 2: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}), and species composition from STUR transect, seaward of Sea Island. See Table 12 for classification of organisms.

Station	STUR 13		STUR 14		STUR 15	
Date (1973)	June 2		June 2		June 2	
Taxa	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}
Insect larvae	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--
Nemertea	--	--	--	--	0.067	32
<i>Dendrostroma</i>	--	--	--	--	--	--
<i>Eteone</i>	0.008	48	0.090	64	0.102	32
<i>Nereis</i>	--	--	--	--	--	--
<i>Paraonis</i>	0.003	32	--	--	--	--
<i>Pygospio</i>	0.040	180	--	--	0.016	32
<i>Polydora i.</i>	0.001	16	--	--	--	--
<i>Polydora k.</i>	0.008	16	--	--	--	--
<i>Capitella</i> sp.I	--	--	--	--	--	--
<i>Amphicteis</i>	--	--	--	--	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
Polychaeta dam.	--	--	--	--	--	--
Oligochaeta	--	--	0.080	336	0.115	480
<i>Corophium sal.</i>	0.091	112	--	--	--	--
<i>Corophium</i> juv.	0.003	32	--	--	--	--
<i>Corophium</i> dam.	--	--	--	--	--	--
<i>Anisogammarus</i> con.	--	--	--	--	--	--
<i>Anisogammarus</i> juv.	--	--	--	--	--	--
<i>Paraphoxus</i>	--	--	--	--	0.090	64
<i>Pontogeneia</i>	--	--	--	--	--	--
<i>Cumella</i>	0.006	32	--	--	--	--
<i>Tanais</i>	--	--	--	--	--	--
<i>Yoldia</i>	--	--	--	--	--	--
<i>Macoma</i>	4.344	2192	2.624	832	4.362	1024
TOTAL	4.505	2560	2.794	1232	4.752	1664

Table 2 (cont'd) Location and environmental data for STUR transect

Station	STUR 16	STUR 17	STUR 18
Date (1973)	June 2	June 2	June 2
Time (PST)	1230	1225	1220
Position N. lat.	49°11.71	49°11.83	49°11.84
W. long.	123°15.53	123°15.70	123°15.92
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	0.30	0.30	0.30
Grain size (μ m, median)	280	355	365
Silt/sand ratio	0.020	0.015	0.005
Temperature (sediment surface, °C)	N/A	N/A	N/A
Remarks	- sand ripples ~ 3 cm high	- sand ripples ~ 4 cm high	- sand ripples ~ 4 cm high

Table 2: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}), and species composition from STUR transect, seaward of Sea Island. See Table 12 for classification of organisms.

Station	STUR 16		STUR 17		STUR 18	
Date (1973)	June 2		June 2		June 2	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--
Nemertea	--	--	--	--	--	--
<i>Dendrostoma</i>	--	--	--	--	--	--
<i>Eteone</i>	--	--	--	--	--	--
<i>Nereis</i>	--	--	--	--	--	--
<i>Paraonis</i>	--	--	--	--	--	--
<i>Pygospio</i>	--	--	--	--	--	--
<i>Polydora i.</i>	--	--	--	--	--	--
<i>Polydora k.</i>	--	--	--	--	--	--
<i>Capitella sp. I</i>	--	--	--	--	--	--
<i>Amphicteis</i>	--	--	--	--	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
Polychaeta dam.	0.320	3200	--	--	--	--
Oligochaeta	--	--	0.056	400	--	--
<i>Corophium sal.</i>	--	--	--	--	--	--
<i>Corophium juv.</i>	--	--	--	--	--	--
<i>Corophium dam.</i>	--	--	--	--	--	--
<i>Anisogammarus con.</i>	--	--	--	--	0.576	160
<i>Anisogammarus juv.</i>	--	--	0.008	80	--	--
<i>Paraphoxus</i>	0.288	160	--	--	0.288	160
<i>Pontogeneia</i>	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	--	--	--	--	--	--
<i>Yoldia</i>	--	--	--	--	--	--
<i>Macoma</i>	22.800	3680	5.384	480	--	--
TOTAL	23.408	7040	5.448	960	0.864	320

Table 2 (cont'd) Location and environmental data for STUR transect

Station	STUR 19	STUR 20
Date (1973)	June 2	June 2
Time (PST)	1145	1210
Position N. lat.	49°11.88	49°11.65
W. long.	123°16.21	123°16.40
Quadrat Size (m ²)	.06	.06
Elevation (m, O.D.)	0.30	0.30
Grain size (μ m, median)	220	320
Silt/sand ratio	0.017	0.017
Temperature (sediment surface, °C)	14.0	15.3
Remarks	-Jelly-like sand -ripples ~ 5 cm high	-Jelly-like sand -ripples ~ 5 cm high -sewage debris nearby

Table 2: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}), and species composition from STUR transect, seaward of Sea Island. See Table 12 for classification of organisms.

Station	STUR 19		STUR 20	
Date (1973)	June 2		June 2	
Taxa	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}
Insect larvae	--	--	--	--
Turbellaria	--	--	--	--
Nemertea	--	--	--	--
<i>Dendrostoma</i>	--	--	--	--
<i>Eteone</i>	0.026	16	0.056	80
<i>Nereis</i>	--	--	--	--
<i>Paraonis</i>	--	--	--	--
<i>Pygospio</i>	--	--	--	--
<i>Polydora i.</i>	--	--	--	--
<i>Polydora k.</i>	--	--	--	--
<i>Capitella sp.I</i>	--	--	--	--
<i>Amphicteis</i>	--	--	--	--
<i>Manayunkia</i>	--	--	--	--
Polychaeta dam.	--	--	--	--
Oligochaeta	0.061	256	--	--
<i>Corophium sal.</i>	--	--	--	--
<i>Corophium juv.</i>	--	--	--	--
<i>Corophium dam.</i>	--	--	--	--
<i>Anisogammarus con.</i>	0.203	16	--	--
<i>Anisogammarus juv.</i>	--	--	--	--
<i>Paraphoxus</i>	0.086	48	--	--
<i>Pontogeneia</i>	--	--	--	--
<i>Cumella</i>	--	--	--	--
<i>Tanais</i>	--	--	--	--
<i>Yoldia</i>	--	--	--	--
<i>Macoma</i>	0.704	704	2.760	640
TOTAL	1.170	1040	2.816	720

Table 3: Location and environmental data from NLU transect, seaward of the north tip of Lulu Island.

Station	NLU 1	NLU 2
Date (1973)	Oct. 7	Oct. 7
Time (PST)	0830	0815
Position N. lat.	49°10.38	49°10.40
W. long.	123°12.20	123°13.08
Quadrat Size (m ²)	.06	.06
Elevation (m, O.D.)	2.13	2.13
Grain size (μ m, median)	22	55
Silt/sand ratio	14.384	1.272
Temperature (sediment surface, °C)	N/A	N/A
Remarks	-mud -among marsh plants -infaunal tubes present	-mud -ripples with infauna tubes -seaward edge of marsh

Table 3: Biomass (wet wt. g m⁻²) and number (m⁻²) and species composition from NLU transect seaward of the north tip of Lulu Island. See Table 12 for classification of organisms.

Station	NLU 1		NLU 2		NLU 2SL ¹	
Date (1973)	Oct. 7		Oct. 7		Oct. 7	
Taxa	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²
Nemertea	0.502	32	0.851	64	-	-
<i>Eteone</i>	-	-	1.504	384	0.016	16
<i>Nereis</i>	3.402	800	3.955	640	0.597	128
<i>Paraonis</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
<i>Polydora</i> dam.	-	-	-	-	-	-
<i>Amphicteis</i>	0.416	224	1.517	1664	2.026	768
<i>Manayunkia</i>	0.995	12608	5.286	39104	0.307	2160
Polychaeta dam.	-	-	-	-	-	-
Oligochaeta	0.090	352	0.122	128	0.152	256
<i>Corophium</i> sal.	3.839	2912	1.152	1280	0.166	160
<i>Corophium</i> juv.	0.637	1824	1.280	3200	0.070	192
<i>Corophium</i> dam.	0.435	320	0.237	384	0.016	48
<i>Eohaustorius</i>	-	-	-	-	-	-
<i>Paraphoxus</i>	-	-	-	-	-	-
<i>Cumella</i>	-	-	-	-	-	-
<i>Macoma nasuta</i>	-	-	-	-	-	-
<i>Macoma</i> sp.	2.656	128	3.319	1045	46.784	1056
TOTAL	12.972	19200	19.223	47893	50.134	4784

¹Replicate at Station NLU 2: sample from 2 to 5 cm in sediments.

Table 3: Location and environmental data for NLU transect.

Station	NLU 3	NLU 4
Date (1973)	Oct. 7	Oct. 7
Time (PST)	0752	0745
Position N. lat.	49°10.32	49°10.39
W. long.	123°13.41	123°13.80
Quadrat Size (m ²)	.06	.06
Elevation (m, O.D.)	2.13	1.52
Grain size (μ m, median)	89	132
Silt/sand ratio	0.652	0.063
Temperature (sediment surface, °C)	N/A	N/A
Remarks	- muddy sand - <i>mya arenaria</i> observed	- sand, trace of mud - infauna tubes

Table 3: Biomass (wet wt. g m^{-2}) and number (m^{-2}) and species composition from NLU transect seaward of the north tip of Lulu Island. See Table 12 for classification of organisms.

Station	NLU 3		NLU 3SL ¹		NLU 4	
Date	Oct. 7		Oct. 7		Oct. 7	
Taxa	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}	Biomass g m^{-2}	No.Ind. m^{-2}
Nemertea	-	-	0.352	32	0.193	48
<i>Eteone</i>	0.141	128	0.010	32	0.085	96
<i>Nereis</i>	1.926	960	0.634	256	0.250	112
<i>Paraonis</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	0.003	32	0.032	64
<i>Polydora</i> dam.	-	-	0.010	96	0.001	16
<i>Amphicteis</i>	4.371	6720	3.472	2464	0.195	144
<i>Manayunkia</i>	0.320	4992	0.032	192	-	-
<i>Polychaeta</i> dam.	-	-	-	-	-	-
Oligochaeta	-	-	-	-	0.001	16
<i>Corophium</i> sal.	0.653	768	0.032	32	0.009	32
<i>Corophium</i> juv.	0.525	1792	0.032	128	0.022	64
<i>Corophium</i> dam.	0.211	384	0.128	160	0.019	32
<i>Eohaustorius</i>	-	-	-	-	-	-
<i>Paraphoxus</i>	-	-	-	-	0.011	16
<i>Cumella</i>	-	-	-	-	0.019	64
<i>Macoma nasuta</i>	-	-	3.322	480	0.669	640
<i>Macoma</i> sp.	11.930	5056	52.160	1600	0.875	1888
TOTAL	20.077	20800	60.187	5504	2.311	3232

Table 3: Location and environmental data for NLU transect

Station	NLU 5	NLU 6
Date (1973)	Oct. 7	Oct. 7
Time (PST)	0740	0730
Position N. lat.	49°10.34	49°10.31
W. long.	123°14.15	123°14.50
Quadrat Size (m ²)	.06	.06
Elevation (m, O.D.)	1.83	1.22
Grain size (μ m, median)	230	230
Silt/sand ratio	silt absent	silt absent
Temperature (sediment surface, °C)	N/A	N/A
Remarks	- sand, with ripples	- sand, with ripples

Table 3: Biomass (wet wt. g m^{-2}) and number (m^{-2}) and species composition from NLU transect seaward of the north tip of Lulu Island. See Table 12 for classification of organisms.

Station	NLU 5		NLU 6	
Date (1963)	Oct. 7		Oct. 7	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Nemertea	-	-	-	-
<i>Eteone</i>	0.030	16	-	-
<i>Nereis</i>	-	-	-	-
<i>Paraonis</i>	-	-	0.056	32
<i>Pygospio</i>	-	-	-	-
<i>Polydora</i> dam.	-	-	-	-
<i>Amphicteis</i>	-	-	-	-
<i>Manayunkia</i>	-	-	-	-
Polychaeta dam.	-	-	0.001	16
Oligochaeta	-	-	-	-
<i>Corophium</i> sal.	-	-	-	-
<i>Corophium</i> juv.	-	-	-	-
<i>Corophium</i> dam.	-	-	-	-
<i>Eohaustorius</i>	-	-	0.046	48
<i>Parapionus</i>	0.326	48	0.125	112
<i>Cumella</i>	-	-	-	-
<i>Macoma nasuta</i>	-	-	0.122	80
<i>Macoma</i> sp.	0.542	544	0.238	432
TOTAL	0.898	608	0.588	720

Table 4: Location and environmental data for SLU transect, seaward of the south tip of Lulu Island

Station	SLU 1	SLU 2	SLU 3
Date (1973)	Oct. 8	Oct. 8	Oct. 8
Time (PST)	0920	0905	0952
Position N. lat.	49° 8.29	49° 8.27	49° 8.23
W. long.	123°12.78	123°13.29	123°13.61
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.13	1.52	2.13
Grain size (μ m, median)	36	190	159
Silt/sand ratio	5.666	0.003	0.021
Temperature (sediment surface, °C)	11.0	11.1	11.2
Remarks	-mud -infauna tubes -50 m seaward of marsh	-sand, with ripples	-sand, trace of mud -few infauna tubes

Table 4: Biomass (set wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from SLU transect, seaward of the south tip of Lulu Island. See Table 12 for classification of organisms.

Station	SLU 1		SLU 2		SLU 3	
Date 1973	Oct. 8		Oct. 8		Oct. 8	
Taxa	Biomass	No. Ind.	Biomass	No. Ind.	Biomass	No. Ind.
	g m^{-2}	m^{-2}	g m^{-2}	m^{-2}	g m^{-2}	m^{-2}
Insect larvae	-	-	-	-	-	-
Nemertea	-	-	-	-	-	-
<i>Eteone</i>	0.198	192	0.178	48	0.067	48
<i>Nereis</i>	1.402	448	-	-	-	-
Nereidae juv.	-	-	0.099	48	0.040	-
<i>Paraonis</i>	-	-	0.018	16	-	-
<i>Pygospio</i>	0.851	2880	-	-	-	-
<i>Polydora</i> dam.	0.397	256	-	-	-	-
<i>Capitella</i>	0.090	512	-	-	-	-
<i>Amphiteis</i>	2.912	3968	-	-	-	-
<i>Manayunkia</i>	1.818	27328	-	-	-	-
Oligochaeta	0.026	256	-	-	-	-
<i>Corophium</i> sal	0.026	128	-	-	-	-
<i>Corophium</i> juv	0.467	2048	-	-	-	-
<i>Anisogammarus</i> juv.	-	-	-	-	-	-
Gammarid dam.	-	-	0.006	16	-	-
<i>Eohaustorius</i>	-	-	-	-	-	-
<i>Parapionus</i>	-	-	0.102	64	0.078	48
<i>Lamprops</i>	-	-	-	-	-	-
<i>Cumella</i>	0.006	64	-	-	0.006	32
<i>Neomysis</i>	-	-	-	-	-	-
<i>Gnorimosphaeroma</i>	-	-	-	-	-	-
<i>Macoma nasuta</i>	0.192	512	-	-	-	-
<i>Macoma</i> sp.	11.360	2816	0.528	608	0.384	1152
TOTAL	19.745	41408	0.931	800	0.636	1360

Table 4: Location and environmental data for SLU transect

Station	SLU 4	SLU 5	SLU 6
Date (1973)	Oct.8	Oct.8	Oct.8
Time (PST)	0935	0805	0815
Position N. lat.	49° 8.24	49° 8.25	49° 8.00
W. long.	123°14.01	123°14.58	123°14.90
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	1.52	0.91	0.91
Grain size (μ m, median)	199	210	180
Silt/sand ratio	0.001	0.001	silt absent
Temperature (sediment surface, °C)	11.1	9.9	11.0
Remarks	-sand, trace of mud -ripples	-sand, rippled	-sand, rippled

Table 4: Biomass (set wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from SLU transect, seaward of the south tip of Lulu Island. See Table 12 for classification of organisms.

Station	SLU 4		SLU 5		SLU 6	
Date 1973	Oct. 8		Oct. 8		Oct. 8	
Taxa	Biomass	No. Ind.	Biomass	No. Ind.	Biomass	No. Ind.
	g m^{-2}	m^{-2}	g m^{-2}	m^{-2}	g m^{-2}	m^{-2}
Insect larvae	-	-	0.029	16	-	-
Nemertea	-	-	-	-	-	-
<i>Eteone</i>	1.174	32	0.096	16	-	-
<i>Nereis</i>	-	-	-	-	-	-
Nereidae juv.	0.001	16	-	-	-	-
<i>Paraonis</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	0.043	80
<i>Polydora</i> dam.	-	-	-	-	-	-
<i>Capitella</i>	-	-	-	-	-	-
<i>Amphiteis</i>	-	-	-	-	-	-
<i>Manayunkia</i>	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Corophium</i> sal	-	-	-	-	-	-
<i>Corophium</i> juv	-	-	-	-	-	-
<i>Anisogammarus</i> juv.	-	-	-	-	0.006	64
Gammarid dam.	-	-	-	-	0.133	16
<i>Eohaustorius</i>	0.003	16	0.037	80	0.013	16
<i>Parapoxus</i>	0.091	48	0.270	64	0.078	48
<i>Lamprops</i>	-	-	-	-	-	-
<i>Cumella</i>	-	-	-	-	-	-
<i>Neomysis</i>	-	-	-	-	-	-
<i>Gnorimosphaeroma</i>	-	-	-	-	0.006	64
<i>Macoma nasuta</i>	-	-	-	-	-	-
<i>Macoma</i> sp.	0.416	512	0.570	608	0.254	496
TOTAL	0.685	624	1.002	784	0.533	784

Table 4: Location and environmental data for SLU transect

Station	SLU 7
Date (1973)	Oct.8
Time (PST)	0812
Position N. lat.	49° 7.70
W. long.	123°15.30
Quadrat Size (m ²)	.06
Elevation (m, O.D.)	1.52
Grain size (μ m, median)	250
Silt/sand ratio	0.001
Temperature (sediment surface, °C)	9.5
Remarks	-sand, rippled

Table 4: Biomass (set wt. $g\ m^{-2}$), number of individuals (number m^{-2}) and species composition from SLU transect, seaward of the south tip of Lulu Island. See Table 12 for classification of organisms.

Station SLU 7
Date 1973 Oct. 8

Taxa	Biomass No. Ind.	
	$g\ m^{-2}$	m^{-2}
Insect larvae	-	-
Nemertea	-	-
<i>Eteone</i>	-	-
<i>Nereis</i>	-	-
Nereidae juv.	-	-
<i>Paraonis</i>	-	-
<i>Pygospio</i>	-	-
<i>Polydora</i> dam.	-	-
<i>Capitella</i>	-	-
<i>Amphiteis</i>	-	-
<i>Manayunkia</i>	-	-
Oligochaeta	-	-
<i>Corophium</i> sal	-	-
<i>Corophium</i> juv.	-	-
<i>Anisogammarus</i> juv.	-	-
Gammarid dam.	-	-
<i>Eohaustorius</i>	0.291	48
<i>Paraphoxus</i>	0.549	160
<i>Lamprops</i>	0.024	16
<i>Cumella</i>	-	-
<i>Neomysis</i>	0.131	16
<i>Gnorimosphaeroma</i>	-	-
<i>Macoma nasuta</i>	-	-
<i>Macoma</i> sp.	0.333	224
TOTAL	1.328	464

Table 5: Location and environmental data for ROB transect, across the middle section of Roberts Bank.

Station	ROB 1	ROB 2	ROB 3
Date (1973)	Dec.11	Dec.11	Dec.11
Time (PST)	0100	0055	0045
Position N. lat.	49° 3.61	49° 3.60	49° 3.55
W. long.	123°10.20	123°10.35	123°10.65
Quadrat Size (m ²)	0.06	0.06	0.06
Elevation (m, O.D.)	2.74	3.04	2.74
Grain size (μ m, median)	88	23	205
Silt/sand ratio	0.869	2.389	.010
Temperature (sediment surface, °C)	6.2	6.6	6.6
Remarks	-mud with light algal mat -seaward edge of marsh	-mud	-muddy sand

Table 5: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ROB transect, across the middle section of Roberts Bank. See Table 12 for classification of organisms.

Stations	ROB 1		ROB 2		ROB 3	
Date	Dec. 11		Dec. 11		Dec. 11	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	0.112	128	0.006	64	-	-
Nemertea	0.027	16	-	-	0.182	64
<i>Eteone</i>	0.008	16	0.320	704	-	-
<i>Nereis</i>	-	-	7.238	1600	0.176	80
<i>Glycinde</i>	-	-	-	-	-	-
<i>Paraonis</i>	-	-	-	-	-	-
<i>Armandia</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
Capitellidae dam	-	-	-	-	-	-
<i>Amphiteis</i> juv.	0.016	16	3.219	3008	-	-
<i>Manayunkia</i>	1.256	12736	2.861	25664	-	-
Oligochaeta	0.168	928	-	-	-	-
<i>Corophium</i> sal.	-	-	0.307	192	-	-
<i>Corophium</i> juv.	-	-	0.192	320	-	-
<i>Corophium</i> dam.	-	-	0.064	128	-	-
<i>Anisogammarus</i> con.	-	-	-	-	-	-
<i>Eohaustorius</i>	-	-	-	-	-	-
<i>Paraphoxus</i>	-	-	-	-	-	-
Harpacticoids	-	-	0.006	64	-	-
Ostracods	0.006	32	0.698	3264	0.051	64
<i>Neomysis</i>	-	-	-	-	-	-
<i>Tanais</i>	-	-	0.006	64	-	-
<i>Musculus</i>	0.002	16	-	-	-	-
<i>Macoma</i>	-	-	11.648	576	0.160	304
TOTAL	1.595	13888	25.965	35648	0.569	512

Table 5: Location and environmental data for ROB transect

Station	ROB 4	ROB 5	ROB 6
Date (1973)	Dec.11	Dec.11	Dec.11
Time (PST)	0040	0033	0027
Position N. lat.	49° 3.53	49° 3.52	49° 3.39
W. long.	123°11.07	123°11.45	123°11.89
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.74	2.13	0.91
Grain size (μ m, median)	198	185	215
Silt/sand ratio	0.010	0.010	0.025
Temperature (sediment surface, °C)	6.6	N/A	6.5
Remarks	-muddy- sand	-sand, rippled	-sand

Table 5: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ROB transect, across the middle section of Roberts Bank. See Table 12 for classification of organisms.

Station	ROB 4	ROB 5	ROB 6			
Date	Dec. 11	Dec. 11	Dec. 11			
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	-	-	-	-	-	-
Nemertea	-	-	0.096	16	0.106	16
<i>Eteone</i>	0.030	32	0.061	16	-	-
<i>Nereis</i>	0.358	80	-	-	-	-
<i>Glycinde</i>	-	-	-	-	-	-
<i>Paraonis</i>	0.077	16	0.538	112	0.538	112
<i>Armandia</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	0.010	32	-	-
Capitellidae dam	-	-	-	-	-	-
<i>Amphicteis</i> juv.	-	-	-	-	-	-
<i>Manayunkia</i>	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Corophium</i> sal.	-	-	-	-	-	-
<i>Corophium</i> juv.	0.019	32	-	-	-	-
<i>Corophium</i> dam.	-	-	-	-	-	-
<i>Anisogammarus</i> con.	-	-	-	-	0.008	16
<i>Eohaustorius</i>	-	-	0.280	32	0.120	48
<i>Paraphoxus</i>	-	-	-	-	-	-
Harpacticoids	-	-	-	-	-	-
Ostracods	-	-	-	-	-	-
<i>Neomysis</i>	-	-	-	-	-	-
<i>Tanais</i>	-	-	-	-	-	-
<i>Musculus</i>	-	-	-	-	-	-
<i>Macoma</i>	0.464	272	2.816	384	0.672	352
TOTAL	0.948	432	3.801	592	1.444	544

Table 5: Location and environmental data for ROB transect

Station	ROB 7	ROB 8	ROB 9
Date (1973)	Dec.11	Dec.11	Dec.11
Time (PST)	0017	0012	0005
Position N. lat.	49° 3.29	49° 3.18	49° 3.12
W. long.	123°12.18	123°12.51	123°12.70
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	0.91	1.52	1.52
Grain size (μ m, median)	224	231	200
Silt/sand ratio	0.005	0.002	0.010
Temperature (sediment surface, °C)	6.2	6.2	6.5
Remarks	-muddy sand -ripples ~ 2 cm amplitude	-sand -ripples ~ 4 cm amplitude	-muddy sand - <i>Abarenicola</i> castings

Table 5: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ROB transect, across the middle section of Roberts Bank. See Table 12 for classification of organisms.

Station	ROB 7		ROB 8		ROB 9	
Date	Dec. 11		Dec. 11		Dec. 11	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	-	-	-	-	-	-
Nemertea	0.094	16	-	-	0.493	96
<i>Eteone</i>	-	-	0.059	16	0.414	16
<i>Nereis</i>	-	-	-	-	-	-
<i>Glycinde</i>	-	-	-	-	0.051	16
<i>Paraonis</i>	0.614	128	0.614	128	0.384	80
<i>Armandia</i>	-	-	-	-	0.027	16
<i>Pygospio</i>	-	-	-	-	0.016	16
Capitellidae dam	-	-	0.001	n/a	-	-
<i>Amphicteis</i> juv.	-	-	-	-	-	-
<i>Manayunkia</i>	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Corophium</i> sal.	-	-	-	-	-	-
<i>Corophium</i> juv.	-	-	-	-	-	-
<i>Corophium</i> dam.	-	-	-	-	-	-
<i>Anisogammarus</i> con.	-	-	-	-	-	-
<i>Eohaustorius</i>	0.416	176	0.085	64	0.016	16
<i>Paraphoxus</i>	0.400	80	0.027	32	0.037	16
Harpacticoids	-	-	-	-	-	-
Ostracods	-	-	-	-	-	-
<i>Neomysis</i>	-	-	-	-	-	-
<i>Tanais</i>	-	-	-	-	-	-
<i>Musculus</i>	-	-	-	-	-	-
<i>Macoma</i>	0.400	112	0.336	112	0.704	272
TOTAL	1.924	512	1.122	352	2.142	544

Table 5: Location and environmental data for ROB transect

Station	ROB 10	ROB 11	ROB 12
Date (1973)	Dec.11	Dec.10	Dec.10
Time (PST)	0000	2353	2345
Position N. lat.	49° 3.20	49° 3.18	49° 3.13
W. long.	123°13.00	123°13.16	123°13.45
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	0.91	0.91	0.91
Grain size (μ m, median)	200	177	182
Silt/sand ratio	0.010	0.041	0.015
Temperature (sediment surface, °C)	6.2	6.6	6.2
Remarks	-sand jelly- like	-sand	-sand

Table 5: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ROB transect, across the middle section of Roberts Bank. See Table 12 for classification of organisms.

Station	ROB 10		ROB 11		ROB 12	
Date	Dec. 11		Dec. 10		Dec. 10	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	-	-	-	-	-	-
Nemertea	0.174	32	0.534	32	-	-
<i>Eteone</i>	0.029	16	-	-	0.080	112
<i>Nereis</i>	0.160	48	-	-	-	-
<i>Glycinde</i>	-	-	-	-	-	-
<i>Paraonis</i>	0.614	128	0.154	32	-	-
<i>Armandia</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
Capitellidae dam	-	-	-	-	-	-
<i>Amphicteis</i> juv.	0.001	16	-	-	-	-
<i>Manayunkia</i>	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Corophium sal.</i>	-	-	-	-	-	-
<i>Corophium</i> juv.	-	-	-	-	-	-
<i>Corophium</i> dam.	-	-	-	-	-	-
<i>Anisogammarus</i> con.	-	-	-	-	-	-
<i>Eohaustorius</i>	0.155	144	0.301	144	0.336	400
<i>Paraphoxus</i>	-	-	0.640	48	0.019	16
Harpacticoids	-	-	-	-	-	-
Ostracods	-	-	-	-	-	-
<i>Neomysis</i>	-	-	-	-	-	-
<i>Tanais</i>	-	-	-	-	-	-
<i>Musculus</i>	-	-	-	-	-	-
<i>Macoma</i>	0.656	256	0.656	272	-	-
TOTAL	1.789	640	2.285	528	0.435	528

Table 5: Location and environmental data for ROB transect.

Station	ROB 13	ROB 14	ROB 15
Date (1973)	Dec.10	Dec.10	Dec.10
Time (PST)	2244	2305	2255
Position N. lat.	49° 3.19	49° 3.13	49° 3.49
W. long.	123°13.79	123°14.01	123°14.30
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	0.91	0.91	0.91
Grain size (μ m, median)	188	210	241
Silt/sand ratio	0.010	0.005	0.005
Temperature (sediment surface, °C)	6.6	6.5	6.2
Remarks	-sand -ripples ~ 2 cm amplitude	-sand -ripples ~ 5 cm amplitude	-sand -ripples ~ 4 cm amplitude

Table 5: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ROB transect, across the middle section of Roberts Bank. See Table 12 for classification of organisms.

Station	ROB 13		ROB 14		ROB 15	
Date	Dec. 10		Dec. 10		Dec. 10	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	-	-	-	-	-	-
Nemertea	-	-	0.093	32	0.064	16
<i>Eteone</i>	-	-	-	-	-	-
<i>Nereis</i>	-	-	-	-	-	-
<i>Glycinde</i>	-	-	-	-	-	-
<i>Paraonis</i>	-	-	-	-	-	-
<i>Armandia</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
Capitellidae dam	-	-	-	-	-	-
<i>Amphicteis</i> juv.	-	-	-	-	-	-
<i>Manayunkia</i>	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Corophium</i> sal.	-	-	-	-	-	-
<i>Corophium</i> juv.	-	-	-	-	-	-
<i>Corophium</i> dam.	-	-	-	-	-	-
<i>Anisogammarus</i> con.	-	-	-	-	-	-
<i>Eohaustorius</i>	0.626	448	0.563	336	-	-
<i>Paraphoxus</i>	-	-	0.320	96	0.029	16
Harpacticoids	-	-	-	-	-	-
Ostracods	-	-	-	-	-	-
<i>Neomysis</i>	0.350	16	-	-	-	-
<i>Tanais</i>	-	-	-	-	-	-
<i>Musculus</i>	-	-	-	-	-	-
<i>Macoma</i>	0.144	16	0.001	16	0.080	32
TOTAL	1.120	480	0.977	464	0.173	64

Table 5: Location and environmental data for ROB transect

Station	ROB 16	ROB 17	ROB 18
Date (1973)	Dec.10	Dec.10	Dec.10
Time (PST)	2307	2223	2331
Position N. lat.	49° 2.95	49° 2.70	49° 2.59
W. long.	123°14.30	123°14.90	123°15.15
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	0.91	0.30	0.30
Grain size (μ m, median)	200	180	180
Silt/sand ratio	0.010	0.010	0.005
Temperature (sediment surface, °C)	6.8	6.8	6.5
Remarks	-sand -ripples ~ 3 cm amplitude -infauna castings	-sand	-sand

Table 5: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from ROB transect, across the middle section of Roberts Bank. See Table 12 for classification of organisms.

Station	ROB 16	ROB 17	ROB 18			
Date	Dec. 10	Dec. 10	Dec. 10			
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	-	-	-	-	-	-
Nemertea	-	-	-	-	-	-
<i>Eteone</i>	-	-	0.064	16	-	-
<i>Nereis</i>	-	-	-	-	-	-
<i>Glycinde</i>	-	-	-	-	-	-
<i>Paraonis</i>	-	-	-	-	-	-
<i>Armandia</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
Capitellidae dam	-	-	-	-	-	-
<i>Amphicteis</i> juv.	-	-	-	-	-	-
<i>Manayunkia</i>	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Corophium</i> sal.	-	-	-	-	-	-
<i>Corophium</i> juv.	-	-	-	-	-	-
<i>Corophium</i> dam.	-	-	-	-	-	-
<i>Anisogammarus</i> con.	-	-	-	-	0.168	96
<i>Eohaustorius</i>	-	-	0.224	96	0.016	32
<i>Paraphoxus</i>	0.214	64	0.043	16	-	-
Harpacticoids	-	-	-	-	-	-
Ostracods	-	-	-	-	-	-
<i>Neomysis</i>	-	-	-	-	-	-
<i>Tanais</i>	-	-	-	-	-	-
<i>Musculus</i>	-	-	-	-	-	-
<i>Macoma</i>	0.032	80	0.032	16	-	-
TOTAL	0.246	144	0.363	144	0.184	128

Table 6: Location and environmental data for CP transect, adjacent to the Westshore Terminals causeway (north side)

Station	CP 1	CP 2	CP 3
Date (1973)	Jan. 9	Jan. 9	Jan. 9
Time (PST)	0210	0150	0137
Position N. lat.	49° 2.80	49° 2.68	49° 2.50
W. long.	123° 7.65	123° 7.84	123° 8.03
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.74	2.74	2.13
Grain size (μ m, median)	114	19	48
Silt/sand ratio	0.324	4.263	1.222
Temperature (sediment surface, °C)	-2.0	-1.0	-1.5
Remarks	-mud -reduced ~ 5 cm beneath	-mud -reduced ~ 5 cm beneath	-mud -reduced ~ 5 cm beneath

Table 6: Biomass (wet wt. $g\ m^{-2}$) and number of individuals (number m^{-2}) and species composition from CP transect, adjacent to the Westshore Terminals causeway. See Table 12 for classification of organisms.

Station	CP 1		CP 2		CP 3	
Date (1974)	Jan. 9		Jan. 9		Jan. 9	
Taxa	Biomass $g\ m^{-2}$	No.Ind. m^{-2}	Biomass $g\ m^{-2}$	No.Ind. m^{-2}	Biomass $g\ m^{-2}$	No.Ind. m^{-2}
Insect larvae	3.379	2328	0.038	256	-	-
Nemertea	-	-	10.764	384	-	-
<i>Eteone</i>	-	-	1.382	256	0.666	256
<i>Glycinde</i>	-	-	-	-	3.302	256
<i>Scoloplos</i>	-	-	-	-	-	-
<i>Paraonis</i>	-	-	-	-	-	-
<i>Pygospio</i>	9.805	14840	12.915	65664	1.408	4352
<i>Pseudopolydora k</i>	2.304	1280	-	-	-	-
<i>Polydora l</i>	3.354	256	-	-	-	-
<i>Polydora dam</i>	-	-	-	-	-	-
<i>Armandia</i>	-	-	-	-	-	-
<i>Capitella</i>	0.435	512	0.666	2176	1.178	1792
Malidanidae juv.	-	-	0.026	256	1.229	1536
<i>Amparete</i>	-	-	0.397	512	-	-
<i>Amphicteis</i>	2.611	256	1.498	896	-	-
<i>Manayunkia</i>	19.200	120320	5.440	133248	12.954	163584
<i>Polychaeta dam.</i>	-	-	2.394	N/A	-	-
Oligochaeta	5.939	27136	0.896	2816	0.896	768
<i>Dendrostoma</i>	-	-	2.291	1408	5.094	1536
<i>Ampelisca</i>	-	-	-	-	-	-
<i>Corophium insid</i>	1.613	512	3.916	7424	3.207	4352
<i>Corophium juv.</i>	0.768	2304	2.893	14080	3.046	8960
<i>Corophium dam.</i>	0.563	1024	1.907	4992	1.664	3328
Gammarid dam.	-	-	-	-	-	-
<i>Eohaustorius</i>	-	-	-	-	-	-
Isaeidae dam.	-	-	-	-	-	-
<i>Paraphoxus</i>	-	-	-	-	-	-
Harpacticoid	-	-	0.243	1408	0.010	256
<i>Lamprops</i>	-	-	-	-	-	-
<i>Cumella</i>	-	-	0.077	256	2.637	15872
<i>Tanais</i>	0.256	512	2.202	14208	3.226	13824
<i>Gastropteron</i>	-	-	-	-	-	-
<i>Macoma nasuta</i>	-	-	-	-	-	-
<i>Macoma incon</i>	-	-	-	-	-	-
<i>Macoma sp.</i>	-	-	0.026	256	0.026	512
<i>Mytilus edulis</i>	-	-	-	-	-	-
<i>Venerupis japon</i>	-	-	-	-	1.024	-
<i>Clinocardium sp.</i>	-	-	-	-	-	-
<i>Mya. juv.</i>	-	-	-	-	-	-
TOTAL	51.227	171288	49.971	250496	41.637	221440

Table 6: Location and environment data for CP transect

Station	CP 4	CP 5	CP 6
Date (1974)	Jan.9	Jan.9	Jan.9
Time (PST)	0126	0117	0105
Position N. lat.	49° 2.39	49° 2.22	49° 2.10
W. long.	123° 8.24	123° 8.42	123° 7.62
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.13	1.52	1.52
Grain size (μ m, median)	149	160	190
Silt/sand ratio	0.046	0.028	0.010
Temperature (sediment surface, °C)	0.0	-1.5	-1.0
Remarks	-muddy sand <i>Enteromorpha</i> on rocks - <i>Zostera</i> fragments	-muddy sand - <i>Zostera</i> fragments	-sand ripples

Table 6: Biomass (wet wt. $g\ m^{-2}$) and number of individuals (number m^{-2}) and species composition from CP transect, adjacent to the Westshore Terminals causeway. See Table 12 for classification of organisms.

Station	CP 4		CP 5		CP 6	
Date (1974)	Jan. 9		Jan. 9		Jan. 9	
Taxa	Biomass $g\ m^{-2}$	No. Ind. m^{-2}	Biomass $g\ m^{-2}$	No. Ind. m^{-2}	Biomass $g\ m^{-2}$	No. Ind. m^{-2}
Insect larvae	-	-	-	-	-	-
Nemertea	-	-	-	-	-	-
<i>Eteone</i>	2.579	288	1.578	528	0.158	176
<i>Glycinde</i>	0.086	32	-	-	0.118	16
<i>Scoloplos</i>	-	-	-	-	0.563	64
<i>Paraonis</i>	0.157	224	0.061	160	0.091	256
<i>Pygospio</i>	2.410	9344	1.197	4336	0.338	976
<i>Pseudopolydora k</i>	-	-	0.096	48	0.114	96
<i>Polydora l</i>	-	-	-	-	-	-
<i>Polydora dam</i>	-	-	-	-	-	-
<i>Armandia</i>	-	-	-	-	-	-
<i>Capitella</i>	0.474	1184	0.027	64	0.002	16
Maldanidae juv.	-	-	-	-	-	-
<i>Amparete</i>	-	-	-	-	-	-
<i>Amphiteis</i>	-	-	-	-	-	-
<i>Manayunkia</i>	0.230	3488	0.001	32	-	-
Polychaeta dam.	0.314	N/A	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Dendrostoma</i>	-	-	-	-	-	-
<i>Ampelisca</i>	-	-	-	-	-	-
<i>Corophium insid</i>	0.058	64	-	-	-	-
<i>Corophium juv.</i>	0.067	160	0.016	32	-	-
<i>Corophium dam.</i>	0.022	96	-	-	-	-
Gammarid dam.	-	-	-	-	0.002	16
<i>Eohaustorius</i>	-	-	-	-	-	-
Isaeidae dam.	-	-	-	-	-	-
<i>Paraphoxus</i>	-	-	-	-	-	-
Harpacticoid	-	-	-	-	0.001	16
<i>Lamprops</i>	-	-	-	-	-	-
<i>Cumella</i>	0.192	1152	0.090	400	0.002	16
<i>Tanais</i>	0.684	4576	0.102	352	-	-
<i>Gastropteron</i>	-	-	-	-	-	-
<i>Macoma nasuta</i>	-	-	-	-	-	-
<i>Macoma incon</i>	-	-	-	-	-	-
<i>Macoma sp.</i>	6.512	1312	7.883	1024	6.016	1664
<i>Mytilus edulis</i>	-	-	-	-	-	-
<i>Venerupis japon</i>	-	-	-	-	-	-
<i>Clinocardium sp.</i>	-	-	-	-	-	-
<i>Mya. juv.</i>	-	-	-	-	0.576	N/A
TOTAL	12.909	21920	11.051	6976	7.405	3312

Table 6: Location and environmental data for CP transect

Station	CP 7	CP 8	CP 9
Date (1973)	Jan. 9	Jan. 9	Jan. 9
Time (PST)	0054	0042	0020
Position N. lat.	49° 1.98	49° 1.81	49° 1.66
W. long.	123° 8.80	123° 9.00	123° 9.15
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	0.91	0.91	0.30
Grain size (μ m, median)	158	152	252
Silt/sand ratio	0.060	0.015	0.002
Temperature (sediment surface, °C)	-0.5	-1.0	N/A
Remarks	-muddy sand - <i>Macoma</i> abundant	-muddy sand	-sand, with ripples

Table 6: Biomass (wet wt. g m⁻²) and number of individuals (number m⁻²) and species composition from CP transect, adjacent to the Westshore Terminals causeway. See Table 12 for classification of organisms.

Station	CP 7		CP 8		CP 9	
Date (1974)	Jan. 9		Jan. 9		Jan. 9	
Taxa	Biomass g m ⁻²	No.Ind. m ⁻²	Biomass g m ⁻²	No.Ind. m ⁻²	Biomass g m ⁻²	No.Ind. m ⁻²
Insect larvae	-	-	-	-	-	-
Nemertea	0.355	16	0.067	16	0.442	48
<i>Eteone</i>	1.651	176	1.856	208	0.026	16
<i>Glycinde</i>	0.251	48	0.520	48	0.080	16
<i>Scoloplos</i>	0.453	112	0.842	432	-	-
<i>Paraonis</i>	0.019	160	0.182	736	-	-
<i>Pygospio</i>	0.075	448	0.346	848	0.046	48
<i>Pseudopolydora k</i>	-	-	-	-	-	-
<i>Polydora l</i>	-	-	-	-	-	-
<i>Polydora dam</i>	-	-	0.001	16	-	-
<i>Armandia</i>	0.197	32	-	-	-	-
<i>Capitella</i>	0.037	208	0.019	128	-	-
Maldanidae juv.	0.006	64	-	-	-	-
<i>Amparete</i>	-	-	-	-	-	-
<i>Amphicteis</i>	-	-	-	-	-	-
<i>Manayunkia</i>	0.002	48	0.001	16	0.001	16
Polychaeta dam.	-	-	0.016	N/A	-	-
Oligochaeta	-	-	0.002	16	-	-
<i>Dendrostoma</i>	-	-	-	-	-	-
<i>Ampelisca</i>	-	-	-	-	-	-
<i>Corophium insid</i>	-	-	-	-	-	-
<i>Corophium juv.</i>	-	-	-	-	0.003	16
<i>Corophium dam.</i>	-	-	-	-	-	-
Gammarid dam.	0.002	16	-	-	-	-
<i>Eohaustorius</i>	-	-	0.008	16	-	-
Isaeidae dam.	-	-	0.099	32	-	-
<i>Paraphoxus</i>	-	-	-	-	0.062	48
Harpacticoid	0.003	160	-	-	-	-
<i>Lamprops</i>	-	-	-	-	-	-
<i>Cumella</i>	0.061	256	0.045	64	0.003	16
<i>Tanais</i>	0.003	32	-	-	-	-
<i>Gastropteron</i>	0.102	16	-	-	-	-
<i>Macoma nasuta</i>	-	-	0.205	80	-	-
<i>Macoma incon</i>	3.677	48	-	-	-	-
<i>Macoma sp.</i>	9.211	4080	4.208	3088	5.459	2304
<i>Mytilus edulis</i>	-	-	-	-	-	-
<i>Venerupis japon</i>	0.021	16	-	-	-	-
<i>Clinocardium sp.</i>	-	-	-	-	-	-
<i>Mya. juv.</i>	0.576	176	-	-	-	-
TOTAL	16.702	6112	8.417	5744	6.122	2528

Table 6: Location and environmental data for CP transect

Station	CP 10	CP 11	CP 12
Date (1974)	Jan.9	Jan.8	Jan.8
Time (PST)	0009	2357	2340
Position N. lat.	49° 1.15	49° 1.34	49° 1.19
W. long.	123° 9.30	123° 9.42	123° 9.60
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	~0.0	~0.0	~0.0
Grain size (μ m, median)	228	240	262
Silt/sand ratio	0.005	0.005	0.005
Temperature (sediment surface, °C)	0.0	1.5	2.0
Remarks	-sand -large ripples	-sand -large ripples	-sand

Table 6: Biomass (wet wt. g m^{-2}) and number of individuals (number m^{-2}) and species composition from CP transect, adjacent to the Westshore Terminals causeway. See Table 12 for classification of organisms.

Station	CP 10		CP 11		CP 12	
Date (1974)	Jan. 9		Jan. 9		Jan. 9	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	-	-	-	-	-	-
Nemertea	1.184	96	0.363	32	-	-
<i>Eteane</i>	-	-	0.038	48	-	-
<i>Glycinde</i>	0.243	48	0.485	96	0.160	32
<i>Scoloplos</i>	1.010	208	5.178	1536	-	-
<i>Paraonis</i>	0.011	16	0.034	32	-	-
<i>Pygospio</i>	0.011	16	0.190	144	0.030	48
<i>Pseudopolydora k</i>	-	-	-	-	-	-
<i>Polydora l</i>	-	-	-	-	-	-
<i>Polydora dam</i>	-	-	-	-	-	-
<i>Armandia</i>	-	-	-	-	-	-
<i>Capitella</i>	-	-	-	-	-	-
Maldanidae juv.	-	-	-	-	-	-
<i>Amparete</i>	-	-	-	-	-	-
<i>Amphicteis</i>	-	-	-	-	-	-
<i>Manayunkia</i>	0.001	16	-	-	-	-
Polychaeta dam.	-	-	0.224	N/A	-	-
Oligochaeta	-	-	-	-	-	-
<i>Dendrostoma</i>	-	-	-	-	-	-
<i>Ampelisca</i>	-	-	0.008	16	-	-
<i>Corophium insid</i>	-	-	-	-	-	-
<i>Corophium juv.</i>	-	-	-	-	-	-
<i>Corophium dam.</i>	-	-	-	-	-	-
Gammarid dam.	-	-	-	-	-	-
<i>Eohaustorius</i>	0.050	32	1.179	464	0.115	48
Isaeidae dam.	-	-	-	-	0.014	16
<i>Paraphosus</i>	0.102	64	0.709	80	0.918	128
Harpacticoid	-	-	-	-	-	-
<i>Lamprops</i>	-	-	0.086	16	0.461	144
<i>Cumella</i>	-	-	0.006	32	-	-
<i>Tanais</i>	-	-	-	-	-	-
<i>Gastropteron</i>	-	-	0.034	32	-	-
<i>Macoma nasuta</i>	-	-	0.011	16	-	-
<i>Macoma incon</i>	-	-	-	-	-	-
<i>Macoma sp.</i>	2.587	768	6.584	2224	1.238	1376
<i>Mytilus edulis</i>	-	-	-	-	0.430	96
<i>Venerupis japon</i>	-	-	-	-	-	-
<i>Clinocardium sp.</i>	-	-	-	-	-	-
<i>Mya. juv.</i>	-	-	0.061	16	0.058	16
TOTAL	5.199	1264	15.190	4784	3.424	1904

Table 7: Location and environmental data from TSAW transect, between the Tsawwassen ferry terminal and Westshore terminals causeway.

Station	TSAW 1	TSAW 2	TSAW 3
Date (1973)	Oct.20	Oct.20	Oct.20
Time (PST)	0830	0810	0800
Position N. lat.	49° 2.34	49° 2.28	49° 2.19
W. long.	123° 6.69	123° 6.73	123° 6.81
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.74	2.74	2.74
Grain size (μ m, median)	56	98	104
Silt/sand ratio	1.298	0.092	0.041
Temperature (sediment surface, °C)	11.8	11.5	12.0

Remarks	TSAW 1	TSAW 2	TSAW 3
	-soft mud	-mud	-mud
	-reduced	-tidal	- <i>Abarenicola</i>
	~ 5 cm	creeks	castings
	beneath	present	-marginal
	surface	-reduced	<i>Zostera</i>
	-~ 40 m	~ 5 cm	
	seaward	beneath	
	of marsh	surface	
		- <i>Abarenicola</i>	
		castings	

Table 7: Biomass (wet wt. g m⁻²) and number (m⁻²) and species composition from TSAW transect, between the Tsawwassen ferry terminal and the Westshore Terminals causeway. See Table 12 for classification of organisms.

Stations	TSAW 1		TSAW 2		TSAW 3	
Date (Oct. '73; Feb. '74)	Oct. 20		Oct. 20		Oct. 20	
Taxa	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²
Nemertea	1.178	1024	5.683	128	--	--
<i>Pholoe</i>	--	--	--	--	--	--
<i>Eulalia</i>	--	--	--	--	--	--
<i>Eteone</i>	3.226	1024	8.128	256	0.960	768
<i>Platynereis</i>	--	--	0.128	--	--	--
<i>Nephtys ferrug.</i>	--	--	--	--	--	--
<i>Nephtys cornuta</i>	--	--	--	--	--	--
Nephtyidae dam	--	--	--	--	--	--
Syllidae dam	--	--	--	--	--	--
<i>Glycinde</i>	--	--	--	--	1.178	128
<i>Scoloplos</i>	--	--	--	--	1.446	128
<i>Paraonis</i>	--	--	0.614	128	--	--
<i>Pygospio</i>	22.067	89600	6.861	136	2.982	8576
<i>Polydora quad</i>	--	--	--	--	--	--
<i>Polydora l</i>	--	--	--	--	0.845	256
<i>Pseudopolydora k</i>	7.987	6144	3.059	2176	3.162	2432
Spionidae dam	--	--	--	--	--	--
<i>Armandia</i>	--	--	--	--	--	--
<i>Mediomastus</i>	--	--	--	--	--	--
<i>Capitella</i>	2.560	5120	8.576	136	4.800	10624
Maldanidae juv.	0.768	1536	--	--	5.133	16128
<i>Owenia</i>	--	--	--	--	--	--
<i>Eupolyornia</i>	--	--	--	--	--	--
<i>Ampharete</i>	--	--	--	--	--	--
<i>Pseudosabellides</i>	--	--	--	--	--	--
<i>Manayunkia</i>	36.403	417792	3.405	365	--	--
Polychaeta dam	--	--	--	--	--	--
Oligochaeta	13.772	92672	6.042	163	2.854	5760
<i>Atylus</i>	--	--	--	--	--	--
<i>Corophium insid</i>	0.256	512	0.064	128	2.368	2816
<i>Corophium juv</i>	4.198	7680	0.538	1024	2.573	5120
<i>Corophium dam</i>	--	--	0.154	256	--	--
<i>Anisogammarus con</i>	--	--	--	--	--	--
<i>Anisogammarus pug.</i>	--	--	--	--	--	--
<i>Photis</i>	--	--	--	--	--	--
Gammarid dam	--	--	--	--	--	--
<i>Caprella</i>	--	--	--	--	--	--
Ostracods	--	--	--	--	--	--
Harpacticoids	--	--	--	--	--	--
<i>Lamprops</i>	--	--	--	--	--	--
<i>Cumella</i>	0.025	512	0.371	768	1.843	2176
<i>Tanais</i>	5.325	25088	1.613	512	0.538	384
<i>Leptocheilia</i>	--	--	--	--	--	--
<i>Synidotea</i>	--	--	--	--	--	--
<i>Pentidotea</i>	--	--	--	--	--	--
<i>Crangon</i> --	--	--	--	--	--	--
Brachyuran juv.	--	--	--	--	--	--
<i>Halosoma</i>	--	--	--	--	--	--
Halacaridae	--	--	--	--	--	--
<i>Gastropteron</i>	--	--	--	--	6.067	256
<i>Littorina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	--	--	--	--
<i>Polinices</i>	--	--	--	--	--	--
<i>Macoma sp.</i>	--	--	5.760	128	5.760	256
<i>Musculus</i>	--	--	--	--	--	--
<i>Clinocardium</i>	--	--	--	--	--	--
<i>Protothaca</i>	--	--	--	--	--	--
<i>Kellia</i>	--	--	--	--	--	--
TOTAL	97.765	648704	50.996	3637	43.003	55808

Table 7: Location and environmental data from TSAW transect.

Station	TSAW 4	TSAW 5	TSAW 6
Date (1973)	Oct.20	Oct.20	Oct.20
Time (PST)	0745	0736	0728
Position N. lat.	49° 2.13	49° 2.19	49° 1.93
W. long.	123° 6.98	123° 7.08	123° 7.16
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	2.13	2.13	2.13
Grain size (μ m, median)	118	115	119
Silt/sand ratio	0.030	0.036	0.053
Temperature (sediment surface, °C)	11.6	11.8	11.5
Remarks	-mud, trace of sand - <i>Abarenicola</i> castings - <i>Zostera</i> , sponges	-mud, trace of sand -marginal <i>Zostera</i>	-mud, trace of sand -infaunal holes (<i>Mya</i> , <i>Abarenicola</i>)

Table 7: Biomass (wet wt. g m⁻²) and number (m⁻²) and species composition from TSAW transect, between the Tsawwassen ferry terminal and the Westshore Terminals causeway. See Table 12 for classification of organisms.

Stations	TSAW 4		TSAW 5		TSAW 6	
Date (Oct. '73; Feb. '74)	Oct. 20		Oct. 20		Oct. 20	
Taxa	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²
Nemertea	--	--	--	--	--	--
<i>Pholoe</i>	--	--	--	--	--	--
<i>Eulalia</i>	--	--	--	--	--	--
<i>Eteone</i>	--	--	0.838	256	--	--
<i>Platynereis</i>	0.032	N/A	--	--	0.025	64
<i>Nephtys ferrug.</i>	--	--	--	--	--	--
<i>Nephtys cornuta</i>	--	--	--	--	--	--
Nephtyidae dam	--	--	--	--	--	--
Syllidae dam	--	--	--	--	--	--
<i>Glycinde</i>	--	--	--	--	--	--
<i>Scoloplos</i>	--	--	4.051	64	--	--
<i>Paraonis</i>	0.640	192	--	--	0.723	192
<i>Pygospio</i>	--	--	0.614	128	--	--
<i>Polydora quad</i>	4.314	21056	2.477	17216	4.141	19328
<i>Polydora l</i>	--	--	--	--	--	--
<i>Pseudopolydora k</i>	--	--	0.928	64	0.051	192
Spionidae dam	3.347	3264	6.048	5440	6.906	5504
<i>Armandia</i>	--	--	--	--	0.307	192
<i>Mediomastus</i>	--	--	--	--	--	--
<i>Capitella</i>	--	--	--	--	--	--
Maldanidae juv.	2.528	5056	3.232	6592	4.838	9408
<i>Owenia</i>	2.810	10304	5.773	9408	3.200	2304
<i>Eupolyornia</i>	--	--	--	--	--	--
<i>Ampharete</i>	--	--	--	--	--	--
<i>Pseudosabellides</i>	--	--	--	--	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
Polychaeta dam	--	--	--	--	--	--
Oligochaeta	--	--	0.704	N/A	--	--
<i>Atylus</i>	0.083	384	0.115	384	0.141	1472
<i>Corophium insid</i>	2.275	4392	4.679	5312	2.457	4992
<i>Corophium juv</i>	1.440	5376	2.970	5824	2.662	10368
<i>Corophium dam</i>	0.026	128	1.485	896	0.134	576
<i>Anisogammarus con</i>	--	--	--	--	--	--
<i>Anisogammarus pug.</i>	--	--	--	--	--	--
<i>Photis</i>	--	--	--	--	--	--
Gammarid dam	--	--	--	--	--	--
<i>Caprella</i>	--	--	--	--	--	--
Ostracods	--	--	--	--	--	--
Harpacticoids	--	--	--	--	--	--
<i>Lamprope</i>	--	--	--	--	--	--
<i>Cumella</i>	0.461	2752	0.499	6016	0.781	5248
<i>Tanais</i>	0.005	64	--	--	--	--
<i>Leptocheilia</i>	--	--	--	--	0.090	128
<i>Synidotea</i>	--	--	--	--	--	--
<i>Pentidotea</i>	--	--	--	--	--	--
<i>Crangon</i>	--	--	--	--	--	--
Brachyuran juv.	3.546	N/A	--	--	--	--
<i>Halosoma</i>	--	--	--	--	--	--
Halacaridae	--	--	--	--	--	--
<i>Gastropteron</i>	--	--	--	--	--	--
<i>Littorina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	0.064	128	--	--
<i>Polinices</i>	--	--	--	--	--	--
<i>Macoma sp.</i>	10.432	448	1.408	128	0.002	128
<i>Musculus</i>	--	--	--	--	--	--
<i>Clinocardium</i>	--	--	--	--	--	--
<i>Protothaca</i>	--	--	--	--	--	--
<i>Xellia</i>	--	--	--	--	--	--
TOTAL	32.161	53376	36.621	57856	26.458	60096

Table 7: Location and environmental data from TSAW transect.

Station	TSAW 7	TSAW 8	TSAW 9
Date (1974)	Oct.20	Oct.20	Feb.5
Time (PST)	0718	0700	2354
Position N. lat.	49° 1.88	49° 1.78	49° 1.71
W. long.	123° 7.30	123° 7.41	123° 7.49
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	1.52	1.52	1.52
Grain size (μ m, median)	130	100	165
Silt/sand ratio	0.052	0.219	0.156
Temperature (sediment surface, °C)	11.9	11.5	N/A
Remarks	-muddy sand - <i>Zostera</i> present -infaunal holes (<i>Mya</i> , <i>Abarenicola</i>)	-mud, traces of sand - <i>Zostera</i> present	-sand, with ripples -at seaward edge of thick <i>Zostera</i> meadow

Table 7: Biomass (wet wt. g m⁻²) and number (m⁻²) and species composition from TSAW transect, between the Tsawwassen ferry terminal and the Westshore Terminals causeway. See Table 12 for classification of organisms.

Stations	TSAW 7		TSAW 8		TSAW 9	
Date (Oct. '73; Feb. '74)	Oct. 20		Oct. 20		Feb. 5	
Taxa	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²
Nemertea	--	--	--	--	--	--
<i>Pholoe</i>	0.154	N/A	--	--	--	--
<i>Eulalia</i>	--	--	--	--	--	--
<i>Eteone</i>	1.254	384	--	--	1.741	384
<i>Platynereis</i>	--	--	--	--	--	--
<i>Nephtys ferrug.</i>	--	--	--	--	--	--
<i>Nephtys cornuta</i>	--	--	0.966	64	--	--
Nephtyidae dam	--	--	--	--	--	--
Syllidae dam	--	--	--	--	--	--
<i>Glycinde</i>	5.145	128	3.014	512	2.803	384
<i>Scoloplos</i>	1.254	640	1.024	256	0.499	384
<i>Paraonis</i>	--	--	--	--	--	--
<i>Pygospio</i>	6.554	20608	3.923	16704	6.656	11904
<i>Polydora quad</i>	--	--	--	--	--	--
<i>Polydora l</i>	0.294	256	0.154	128	0.422	128
<i>Pseudopolydora k</i>	8.486	5376	7.174	3840	3.661	2816
Spionidae dam	0.819	512	2.246	1408	--	--
<i>Armandia</i>	0.973	128	1.018	128	--	--
<i>Mediomastus</i>	--	--	--	--	--	--
<i>Capitella</i>	0.576	1152	0.288	576	1.216	2432
Maldanidae juv.	0.640	1280	0.064	128	0.474	768
<i>Owenia</i>	--	--	--	--	--	--
<i>Eupolytmia</i>	--	--	--	--	--	--
<i>Ampharete</i>	--	--	--	--	--	--
<i>Pseudoabellides</i>	--	--	--	--	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
Polychaeta dam	--	--	--	--	--	--
Oligochaeta	3.277	4864	0.787	5312	4.595	20096
<i>Atylus</i>	--	--	--	--	--	--
<i>Corophium insid</i>	2.512	4352	2.707	3392	--	--
<i>Corophium juv</i>	2.624	13568	3.706	16384	0.333	256
<i>Corophium dam</i>	0.282	640	0.646	1088	0.064	128
<i>Anisogammarus con</i>	0.410	128	--	--	--	--
<i>Anisogammarus pug.</i>	--	--	--	--	--	--
<i>Photis</i>	--	--	--	--	--	--
Gammarid dam	0.013	128	<0.001	64	--	--
<i>Caprella</i>	--	--	0.032	64	--	--
Ostracods	--	--	--	--	--	--
Harpacticoids	--	--	--	--	--	--
<i>Lamprops</i>	--	--	--	--	0.006	256
<i>Cumella</i>	1.869	5120	1.229	7808	2.419	896
<i>Tanais</i>	--	--	--	--	--	--
<i>Leptocheilia</i>	--	--	0.294	896	0.006	256
<i>Synidotea</i>	--	--	--	--	--	--
<i>Pentidotea</i>	--	--	--	--	--	--
<i>Crangon</i>	--	--	3.014	128	--	--
Brachyuran juv.	--	--	--	--	--	--
<i>Halosoma</i>	--	--	0.051	64	--	--
Halacaridae	--	--	--	--	--	--
<i>Gastropteron</i>	1.165	128	--	--	--	--
<i>Littorina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	--	--	--	--
<i>Polinices</i>	--	--	--	--	--	--
<i>Macoma sp.</i>	6.400	3456	0.576	1344	2.176	2432
<i>Musculus</i>	--	--	0.003	64	--	--
<i>Clinocardium</i>	--	--	--	--	--	--
<i>Protothaca</i>	--	--	--	--	--	--
<i>Kellia</i>	--	--	--	--	--	--
TOTAL	44.647	62848	33.596	60352	27.071	43520

Table 7: Location and environmental data from TSAW transect

Station	TSAW 10	TSAW 11	TSAW 12
Date (1974)	Feb.5	Feb.5	Feb.5
Time (PST)	2351	2345	2339
Position N. lat.	49° 1.66	49° 1.52	49° 1.26
W. long.	123° 7.61	123° 7.72	123° 8.02
Quadrat Size (m ²)	.06	.06	.06
Elevation (m, O.D.)	1.52	0.91	0.30
Grain size (μ m, median)	121	136	176
Silt/sand ratio	0.047	0.052	0.025
Temperature (sediment surface, °C)	N/A	N/A	N/A
Remarks	-mud -marginal <i>Zostera</i> -tidal pool present	-sand reduced ~ 5 cm beneath surface -empty <i>Clinocardium</i> shells abundant - <i>Zostera</i> abundant	-sand -tidal pool present - <i>Zostera</i> abundant

Table 7: Biomass (wet wt. g m⁻²) and number (m⁻²) and species composition from TSAW transect, between the Tsawwassen ferry terminal and the Westshore Terminals causeway. See Table 12 for classification of organisms.

Stations	TSAW 10		TSAW 11		TSAW 12	
Date (Oct. '73; Feb. '74)	Feb. 5		Feb. 5		Feb. 5	
Taxa	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²	Biomass g m ⁻²	No. Ind. m ⁻²
Nemertea	--	--	--	--	--	--
<i>Pholoe</i>	--	--	0.218	128	--	--
<i>Eulalia</i>	--	--	--	--	0.141	128
<i>Eteone</i>	0.186	256	0.192	128	--	--
<i>Platynereis</i>	--	--	--	--	9.933	768
<i>Nephtys ferrug.</i>	--	--	0.166	128	--	--
<i>Nephtys cornuta</i>	--	--	--	--	--	--
Nephtyidae dam	0.070	64	--	--	--	--
Syllidae dam	--	--	--	--	0.077	128
<i>Glycinde</i>	8.243	256	22.170	1336	3.443	512
<i>Scaloplos</i>	0.659	256	--	--	--	--
<i>Paraonis</i>	--	--	--	--	--	--
<i>Pygospio</i>	0.890	1664	0.576	896	1.190	768
<i>Polydora quad</i>	--	--	0.294	128	--	--
<i>Polydora l</i>	--	--	--	--	--	--
<i>Pseudopolydora k</i>	0.499	384	--	--	--	--
Spionidae dam	0.070	64	1.203	512	--	--
<i>Armandia</i>	--	--	0.909	256	6.989	896
<i>Mediomastus</i>	--	--	--	--	--	--
<i>Capitella</i>	0.166	512	0.576	1152	--	--
Maldanidae juv.	0.205	448	0.128	128	0.806	1152
<i>Owenia</i>	--	--	--	--	0.960	384
<i>Eupolyornia</i>	--	--	--	--	2.957	128
<i>Ampharete</i>	--	--	--	--	--	--
<i>Pseudosabellides</i>	--	--	--	--	2.432	128
<i>Manayunkia</i>	0.141	1600	--	--	--	--
Polychaeta dam	--	--	--	--	--	--
Oligochaeta	3.546	19776	23.104	75904	1.370	8832
<i>Atylus</i>	--	--	--	--	0.128	128
<i>Corophium insid</i>	--	--	--	--	--	--
<i>Corophium juv</i>	--	--	--	--	--	--
<i>Corophium dam</i>	--	--	--	--	--	--
<i>Anisogammarus con</i>	--	--	--	--	--	--
<i>Anisogammarus pug.</i>	--	--	1.357	128	--	--
<i>Photis</i>	--	--	--	--	1.664	1792
Gammarid dam	--	--	--	--	--	--
<i>Caprella</i>	--	--	--	--	--	--
Ostracods	--	--	0.960	768	0.230	384
Harpacticoids	--	--	--	--	--	--
<i>Lamprops</i>	--	--	--	--	--	--
<i>Cumella</i>	--	--	0.870	640	--	--
<i>Tanais</i>	--	--	--	--	--	--
<i>Leptocheilia</i>	0.064	128	1.293	2304	9.318	4134
<i>Synidotea</i>	--	--	--	--	--	--
<i>Pentidotea</i>	--	--	--	--	2.342	128
<i>Crangon</i>	--	--	--	--	--	--
Brachyuran juv.	--	--	--	--	2.112	128
<i>Halosoma</i>	--	--	--	--	0.225	256
Halacaridae	--	--	--	--	--	--
<i>Gastropteron</i>	--	--	--	--	--	--
<i>Littorina</i>	--	--	--	--	1.024	768
<i>Batillaria</i>	--	--	--	--	--	--
<i>Polinices</i>	--	--	0.896	1280	3.584	5760
<i>Macoma sp.</i>	1.920	576	3.520	1280	2.688	2432
<i>Musculus</i>	--	--	0.128	128	0.128	512
<i>Clinocardium</i>	--	--	--	--	--	--
<i>Protothaca</i>	--	--	--	--	2.176	128
<i>Kellia</i>	--	--	--	--	0.256	128
TOTAL	16.659	25984	58.560	87424	56.173	30502

Table 7: Location and environmental data from TSAW transect.

Station	TSAW 13
Date (1974)	Feb.5
Time (PST)	2335
Position N. lat.	49° 1.19
W. long.	123° 8.12
Quadrat Size (m ²)	.06
Elevation (m, O.D.)	0.30
Grain size (μ m, median)	180
Silt/sand ratio	0.010
Temperature (sediment surface, °C)	N/A
Remarks	-sand - <i>Zostera</i> very abundant

Table 7: Biomass (wet wt. g m⁻²) and number (m⁻²) and species composition from TSAW transect, between the Tsawwassen ferry terminal and the Westshore Terminal's causeway. See Table 12 for classification of organisms.

Stations TSAW 13
Date (Oct. '73; Feb. '74) Feb. 5

Taxa	Biomass g m ⁻²	No.Ind. m ⁻²
Nemertea	--	--
<i>Pholoe</i>	0.077	32
<i>Eulalia</i>	--	--
<i>Eteone</i>	--	--
<i>Platynereis</i>	3.094	640
<i>Nephtys ferrug.</i>	0.483	32
<i>Nephtys cornuta</i>	--	--
Nephtyidae dam	--	--
Syllidae dam	--	--
<i>Glycinde</i>	2.320	160
<i>Scoloplos</i>	0.032	32
<i>Paraonis</i>	--	--
<i>Pygospio</i>	0.070	64
<i>Polydora quad</i>	--	--
<i>Polydora l</i>	--	--
<i>Pseudopolydora k</i>	--	--
Spionidae dam	--	--
<i>Armandia</i>	--	--
<i>Mediomastus</i>	0.016	32
<i>Capitella</i>	--	--
Maldanidae juv.	0.016	32
<i>Owenia</i>	2.899	1120
<i>Eupolyornia</i>	1.478	64
<i>Ampharete</i>	0.576	96
<i>Pseudosabellides</i>	0.608	32
<i>Manayunkia</i>	--	--
Polychaeta dam	--	--
Oligochaeta	0.538	3584
<i>Atylus</i>	--	--
<i>Corophium insid</i>	--	--
<i>Corophium juv</i>	--	--
<i>Corophium dam</i>	0.166	128
<i>Anisogammarus con</i>	--	--
<i>Anisogammarus pug.</i>	--	--
<i>Photis</i>	3.126	3296
Gammarid dam	--	--
<i>Caprella</i>	--	--
Ostracods	0.054	416
Harpacticoids	0.006	192
<i>Lamprose</i>	--	--
<i>Cumella</i>	--	--
<i>Tanais</i>	--	--
<i>Leptochelia</i>	0.774	2400
<i>Synidotea</i>	0.854	224
<i>Pentidotea</i>	--	--
<i>Crangon</i>	--	--
Brachyuran juv.	0.048	32
<i>Balosoma</i>	0.509	544
Halacaridae	0.003	832
<i>Gastropteron</i>	--	--
<i>Littorina</i>	0.768	736
<i>Batillaria</i>	--	--
<i>Polinices</i>	0.192	576
<i>Macoma sp.</i>	0.416	864
<i>Musculus</i>	2.528	1280
<i>Clinocardium</i>	0.192	96
<i>Protothoa</i>	--	--
<i>Kellia</i>	--	--
TOTAL	21.891.	17536

Table 8: Location and environmental data for FRAPER stations, around the periphery of the marsh zone from Iona Island to Tsawwassen.

Station	FRAPER 1	FRAPER 2	FRAPER 3
Date (1973)	Sept. 10	Sept. 10	Sept. 10
Time (PST)	0830	0835	0900
Position N. lat.	49°12.63	49°12.10	49°11.55
W. long.	123°12.63	123°12.85	123°12.88
Quadrat Size (m ²)	0.25	0.25	0.25
Elevation (m, O.D.)	2.13	2.74	2.74
Grain size (μ m, median)	13	150	12
Silt/sand ratio	24.000	0.562	49.000
Temperature (sediment surface, °C)	18.1	19.1	19.1
Remarks	-brown diatoms very sticky mud -reduced sediments ~ 1 cm be- neath sur- face	-gray mud -among marsh plants (<i>Carex</i> sp.)	-gray mud -reduced sediments ~ 3 cm beneath surface -among marsh plants (<i>Scirpus</i> sp.)

Table 8: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from FRAPER transect, around the periphery of the Fraser delta from Iona Island to Tsawwassen. See Table 12 for classification of organisms.

Station	FRAPER 1		FRAPER 2		FRAPER 3	
Date	Sept. 10		Sept. 10		Sept. 10	
Taxa	Biomass	No. Ind.	Biomass	No. Ind.	Biomass	No. Ind.
	g m^{-2}	m^{-2}	g m^{-2}	m^{-2}	g m^{-2}	m^{-2}
Insect larvae	--	--	--	--	--	--
Nemertea	--	--	--	--	--	--
<i>Dendros toma</i>	--	--	--	--	--	--
<i>Eteone</i>	0.003	80	--	--	--	--
<i>Nereis</i>	--	--	0.254	272	1.844	840
<i>Pygospio</i>	--	--	--	--	--	--
<i>Polydora dam</i>	--	--	0.002	16	--	--
<i>Capitella</i>	--	--	--	--	--	--
<i>Amphicteis</i>	0.029	224	0.069	192	2.556	3840
<i>Manayunkia</i>	0.083	4560	0.163	6224	0.830	17640
Oligochaeta	0.029	1080	0.018	80	0.068	480
<i>Corophium insid</i>	--	--	--	--	--	--
<i>Corophium sal</i>	0.009	48	1.181	1088	0.276	280
<i>Corophium juv</i>	--	--	0.090	896	0.016	160
<i>Corophium dam</i>	0.005	96	0.294	1472	0.048	120
<i>Anisogammarus con</i>	--	--	--	--	--	--
<i>Anisogammarus juv</i>	--	--	--	--	--	--
<i>Anisogammarus dam</i>	--	--	--	--	--	--
<i>Geosia</i>	--	--	--	--	--	--
Gammarids dam	--	--	--	--	--	--
Harpacticoid	--	--	--	--	0.004	560
Ostracods	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	0.001	208	0.270	2224	0.120	1280
<i>Crangon</i>	--	--	--	--	--	--
Brachyuran juv	--	--	--	--	--	--
<i>Hermisenda</i>	--	--	--	--	--	--
<i>Acteocina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	--	--	--	--
<i>Macoma juv</i>	0.010	176	0.096	320	3.096	80
<i>Macoma ineon.</i>	--	--	--	--	--	--
<i>Macoma inq.</i>	--	--	--	--	--	--
<i>Macoma nasuta</i>	--	--	--	--	--	--
<i>Venerupis japon</i>	--	--	--	--	--	--
TOTAL	0.169	6472	2.437	12784	8.908	25380

Table 8: Location and environmental data for FRAPER stations

Station	FRAPER 4	FRAPER 5	FRAPER 6
Date (1973)	Sept. 10	Sept. 10	Sept. 10
Time (PST)	1020	1028	1045
Position N. lat.	49°11.00	49°10.49	49° 9.94
W. long.	123°12.74	123°12.46	123°12.15
Quadrat Size (m ²)	0.25	0.25	0.25
Elevation (m, O.D.)	2.13	2.13	2.74
Grain size (μ m, median)	188	51	61
Silt/sand ratio	0.008	1.409	1.173
Temperature (sediment surface, °C)	20.2	21.9	21.8
Remarks	-sand -ripple marks ~ 5 cm amplitude	-mud -many <i>Macoma</i> spp. deeper in sediment -moderate abundance of <i>Ulva</i> - <i>Mya arenaria</i> in eroded ambankment	-mud -in tidal creek surrounded by sedge marsh -reduced ~ 2 cm beneath surface

Table 8: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from FRAPER transect, around the periphery of the Fraser delta from Iona Island to Tsawwassen. See Table 12 for classification of organisms.

Station	FRAPER 4		FRAPER 5		FRAPER 6	
Date	Sept. 10		Sept. 10		Sept. 10	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	--	--	--	--	--	--
Nemertea	--	--	--	--	--	--
<i>Dendros toma</i>	--	--	--	--	--	--
<i>Eteone</i>	0.006	20	0.029	128	--	--
<i>Nereis</i>	0.004	12	1.226	1184	1.244	600
<i>Pygospio</i>	--	--	--	--	--	--
<i>Polydora</i> dam	--	--	--	--	--	--
<i>Capitella</i>	--	--	--	--	--	--
<i>Amphicteis</i>	--	--	0.122	192	1.092	1600
<i>Manayunkia</i>	--	--	0.038	1184	0.140	2840
Oligochaeta	--	--	0.048	32	0.068	640
<i>Corophium</i> insid	--	--	--	--	--	--
<i>Corophium</i> sal	--	--	0.064	64	0.608	600
<i>Corophium</i> juv	--	--	0.013	64	0.032	160
<i>Corophium</i> dam	0.006	4	0.051	128	0.380	2200
<i>Anisogammarus</i> con	--	--	0.320	32	--	--
<i>Anisogammarus</i> juv	--	--	--	--	--	--
<i>Anisogammarus</i> dam	--	--	--	--	--	--
<i>Geosia</i>	--	--	--	--	--	--
Gammarids dam	0.002	8	--	--	--	--
Harpacticoid	--	--	--	--	--	--
Ostracods	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	--	--	--	--	--	--
<i>Crangon</i>	--	--	--	--	--	--
Brachyuran juv	--	--	--	--	--	--
<i>Hermisenda</i>	--	--	--	--	--	--
<i>Acteocina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	--	--	--	--
<i>Macoma</i> juv	0.038	108	--	--	--	--
<i>Macoma</i> incon.	--	--	40.589	672	--	--
<i>Macoma</i> inq.	--	--	56.170	1600	--	--
<i>Macoma</i> nasuta	--	--	--	--	--	--
<i>Venerupis</i> japon	--	--	--	--	--	--
TOTAL	0.056	152	98.670	5280	4.064	3640

Table 8: Location and environmental data for FRAPER stations

Station	FRAPER 7	FRAPER 8	FRAPER 9
Date (1973)	Sept.10	Sept. 10	Sept. 10
Time (PST)	1100	1113	1120
Position N. lat.	49° 9.80	49° 9.45	49° 9.08
W. long.	123°12.60	123°12.60	123°12.52
Quadrat Size (m ²)	0.25	0.25	0.25
Elevation (m, O.D.)	2.74	2.74	2.74
Grain size (μ m, median)	100	253	94
Silt/sand ratio	0.111	silt absent	0.117
Temperature (sediment surface, °C)	22.5	23.5	22.0
Remarks	-muddy sand -ripple marks ~ 5 cm amplitude - <i>Enteromorpha</i> in moderate abundance -at seaward edge of marsh	-sand, ripples 2 cm amplitude -seaward edge of marsh - <i>Ulva</i> in moderate abundance with gammarid amphipods beneath	-muddy sand -ripples 2 cm amplitude - <i>Ulva</i> observed

Table 8: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from FRAPER transect, around the periphery of the Fraser delta from Iona Island to Tsawwassen. See Table 12 for classification of organisms.

Station	FRAPER 7		FRAPER 8		FRAPER 9	
Date	Sept. 10		Sept. 10		Sept. 10	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	--	--	--	--	--	--
Nemertea	0.126	48	--	--	0.058	8
<i>Dendros toma</i>	--	--	--	--	--	--
<i>Eteone</i>	0.205	272	0.018	36	0.020	64
<i>Nereis</i>	0.890	528	0.044	28	0.336	296
<i>Pygospio</i>	--	--	--	--	--	--
<i>Polydora dam</i>	0.013	80	--	--	--	--
<i>Capitella</i>	--	--	--	--	--	--
<i>Amphicteis</i>	0.163	176	--	--	0.633	1208
<i>Manayunkia</i>	0.027	560	--	--	0.013	256
Oligochaeta	0.034	144	0.001	8	--	--
<i>Corophium insid</i>	--	--	--	--	--	--
<i>Corophium sal</i>	0.016	16	--	--	0.041	32
<i>Corophium juv</i>	0.003	16	--	--	0.006	32
<i>Corophium dam</i>	0.006	16	--	--	0.017	16
<i>Anisogammarus con</i>	--	--	--	--	--	--
<i>Anisogammarus juv</i>	--	--	--	--	--	--
<i>Anisogammarus dam</i>	--	--	--	--	--	--
<i>Geosia</i>	--	--	--	--	--	--
Gammarids dam	--	--	--	--	--	--
Harpacticoid	--	--	--	--	--	--
Ostracods	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	0.002	8
<i>Tanais</i>	0.019	80	--	--	--	--
<i>Crangon</i>	--	--	--	--	1.017	8
Brachyuran juv	--	--	--	--	--	--
<i>Hermisenda</i>	--	--	--	--	--	--
<i>Acteocina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	--	--	--	--
<i>Macoma juv</i>	8.701	816	0.007	76	3.764	2120
<i>Macoma incon.</i>	--	--	--	--	--	--
<i>Macoma inq.</i>	--	--	--	--	--	--
<i>Macoma nasuta</i>	--	--	--	--	--	--
<i>Venerupis japon</i>	--	--	--	--	--	--
TOTAL	10.203	2752	0.070	148	5.907	4048

Table 8: Location and environmental data for FRAPER stations

Station	FRAPER 10	FRAPER 11	FRAPER 12
Date (1973)	Sept. 10	Sept. 10	Sept. 10
Time (PST)	1125	1130	1205
Position N. lat.	49° 8.60	49° 8.15	49° 6.90
W. long.	123°12.41	123°12.60	123°12.52
Quadrat Size (m ²)	0.25	0.25	0.25
Elevation (m, O.D.)	2.74	2.13	2.40
Grain size (μ m, median)	45	41	36
Silt/sand ratio	2.703	2.846	2.225
Temperature (sediment surface, °C)	22.0	23.5	23.5
Remarks	-mud hummocks -15 m seaward of marsh -reduced 10 cm beneath sur- face - <i>Mya arenaria</i> in deep sediment	-mud with algal mat -at seaward edge of marsh	-mud with encrusted algal mat -0.45 km to interior of marsh edge

Table 8: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from FRAPER transect, around the periphery of the Fraser delta from Iona Island to Tsawwassen. See Table 12 for classification of organisms.

Station	FRAPER 10		FRAPER 11		FRAPER 12	
Date	Sept. 10		Sept. 10		Sept. 10	
Taxa	Biomass g m^{-2}	No. Inc. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Inc. m^{-2}
Insect larvae	--	--	--	--	0.284	120
Nemertea	--	--	--	--	--	--
<i>Dendros toma</i>	4.520	5280	--	--	--	--
<i>E teone</i>	--	--	--	--	--	--
<i>Nereis</i>	1.704	960	2.140	1800	--	--
<i>Pygospio</i>	0.368	1840	0.280	800	--	--
<i>Polydora dam</i>	1.176	3200	0.900	2000	--	--
<i>Capitella</i>	0.136	2160	0.010	200	--	--
<i>Amphic teis</i>	1.896	2640	1.820	6800	--	--
<i>Manayunkia</i>	3.576	89040	12.200	244600	0.002	40
Oligochaeta	0.352	2800	0.220	5400	0.124	280
<i>Corophium insid</i>	--	--	--	--	--	--
<i>Corophium sal</i>	--	--	8.620	5600	--	--
<i>Corophium juv</i>	0.288	1440	3.540	18800	--	--
<i>Corophium dam</i>	0.256	640	3.620	8800	--	--
<i>Anisogammarus con</i>	--	--	42.820	11800	--	--
<i>Anisogammarus juv</i>	--	--	0.940	1000	--	--
<i>Anisogammarus dam</i>	--	--	18.140	7200	--	--
<i>Geosia</i>	0.160	400	--	--	--	--
Gammarids dam	--	--	--	--	--	--
Harpacticoid	--	--	--	--	--	--
Ostracods	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	4.608	24560	0.060	1000	--	--
<i>Crangon</i>	--	--	--	--	--	--
Brachyuran juv	--	--	--	--	--	--
<i>Hemissenda</i>	0.008	80	--	--	--	--
<i>Acteocina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	--	--	--	--
<i>Macoma juv</i>	26.768	2560	17.860	5800	--	--
<i>Macoma incon.</i>	--	--	--	--	--	--
<i>Macoma inq.</i>	--	--	--	--	--	--
<i>Macoma nasuta</i>	--	--	--	--	--	--
<i>Venerupis japon</i>	--	--	--	--	--	--
TOTAL	45.816	137600	113.170	321200	0.410	440

Table 8: Location and environmental data for FRAPER stations

Station	FRAPER 13	FRAPER 14
Date (1973)	Sept. 10	Sept. 10
Time (PST)	1222	1230
Position N. lat.	49° 6.70	49° 5.99
W. long.	123°13.23	123°12.40
Quadrat Size (m ²)	0.25	0.25
Elevation (m, O.D.)	2.13	2.13
Grain size (μ m, median)	272	221
Silt/sand ratio	0.010	10.764
Temperature (sediment surface, °C)	22.2	23.0
Remarks	-sand -seaward edge of marsh -ripples ~ 24 cm amplitude	-muddy sand -seaward edge of marsh -reduced ~ 10 cm beneath surface

Table 8: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from FRAPER transect, around the periphery of the Fraser delta from Iona Island to Tsawwassen. See Table 12 for classification of organisms.

Station	FRAPER 13		FRAPER 14		FRAPER 14.SL ¹	
Date	Sept. 10		Sept. 10		Sept. 10	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	--	--	--	--	--	--
Nemertea	--	--	0.186	16	0.146	16
<i>Dendros toma</i>	--	--	--	--	0.126	32
<i>Eteone</i>	--	--	0.024	80	--	--
<i>Nereis</i>	0.112	152	0.908	944	0.484	224
<i>Pygospio</i>	--	--	--	--	--	--
<i>Polydora</i> dam	--	--	--	--	--	--
<i>Capitella</i>	--	--	--	--	--	--
<i>Amphiteis</i>	--	--	0.986	1152	0.435	400
<i>Manayunkia</i>	--	--	0.001	16	--	--
Oligochaeta	--	--	--	--	--	--
<i>Corophium</i> insid	--	--	--	--	--	--
<i>Corophium</i> sal	0.630	612	1.085	1088	0.061	64
<i>Corophium</i> juv	0.112	560	0.259	1296	--	--
<i>Corophium</i> dam	0.696	1740	1.459	3648	--	--
<i>Anisogammarus</i> con	--	--	--	--	--	--
<i>Anisogammarus</i> juv	--	--	--	--	--	--
<i>Anisogammarus</i> dam	--	--	--	--	--	--
<i>Geosia</i>	--	--	--	--	--	--
Gammarids dam	--	--	--	--	--	--
Harpacticoid	--	--	0.001	16	--	--
Ostracods	--	--	--	--	--	--
<i>Cumella</i>	--	--	0.003	16	--	--
<i>Tanais</i>	--	--	0.011	32	--	--
<i>Crangon</i>	--	--	--	--	--	--
Brachyuran juv	--	--	--	--	--	--
<i>Hermisenda</i>	--	--	--	--	--	--
<i>Acteocina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	--	--	--	--
<i>Macoma</i> juv	--	--	20.442	1152	--	--
<i>Macoma</i> incon.	--	--	--	--	9.646	192
<i>Macoma</i> inq.	--	--	--	--	17.062	240
<i>Macoma</i> nasuta	--	--	--	--	--	--
<i>Venerupis</i> japon	--	--	--	--	--	--
TOTAL	1.550	3064	25.365	9456	27.960	1168

Table 8: Location and environmental data for FRAPER stations.

Station	FRAPER 15	FRAPER 16	FRAPER 17
Date (1973)	Sept. 11	Sept. 11	Sept. 11
Time (PST)	0848	0900	0915
Position N. lat.	49° 5.18	49° 5.71	49° 4.35
W. long.	123°11.29	123°11.29	123°10.45
Quadrat Size (m ²)	0.25	0.25	0.25
Elevation (m, O.D.)	2.13	2.74	2.13
Grain size (μ m, median)	28	29	217
Silt/sand ratio	4.000	5.060	0.042
Temperature (sediment surface, °C)	19.5	19.5	18.2
Remarks	-mud -seaward edge of marsh	-mud -seaward edge of marsh	-muddy sand -seaward edge of marsh

Table 8: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from FRAPER transect, around the periphery of the Fraser delta from Iona Island to Tsawwassen. See Table 12 for classification of organisms.

Station	FRAPER 15		FRAPER 16		FRAPER 17	
Date	Sept. 11		Sept. 11		Sept. 11	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	--	--	--	--	0.018	48
Nemertea	--	--	--	--	--	--
<i>Dendros toma</i>	--	--	--	--	--	--
<i>Eteone</i>	0.005	16	0.032	80	--	--
<i>Nereis</i>	0.722	768	0.238	384	0.048	48
<i>Pygospio</i>	--	--	--	--	--	--
<i>Polydora</i> dam	--	--	--	--	--	--
<i>Capitella</i>	--	--	--	--	--	--
<i>Amphicteis</i>	0.890	1200	0.214	192	0.581	240
<i>Manayunkia</i>	0.147	3072	0.008	144	--	--
Oligochaeta	0.022	48	--	--	0.651	3440
<i>Corophium insid</i>	--	--	--	--	--	--
<i>Corophium sal</i>	0.018	16	0.873	624	0.499	400
<i>Corophium</i> juv	0.026	128	0.366	1072	0.050	352
<i>Corophium</i> dam	0.064	160	0.627	1632	1.816	3040
<i>Anisogammarus</i> con	0.048	16	--	--	--	--
<i>Anisogammarus</i> juv	--	--	--	--	--	--
<i>Anisogammarus</i> dam	--	--	--	--	--	--
<i>Geosia</i>	--	--	--	--	--	--
Gammarids dam	--	--	--	--	--	--
Harpacticoid	0.005	96	0.002	48	0.024	496
Ostracods	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	0.022	32	--	--	--	--
<i>Crangon</i>	--	--	--	--	--	--
Brachyuran juv	--	--	--	--	--	--
<i>Hermisenda</i>	--	--	--	--	--	--
<i>Acteocina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	--	--	--	--
<i>Macoma</i> juv	18.546	3200	22.323	720	1.310	48
<i>Macoma</i> incon.	--	--	--	--	--	--
<i>Macoma</i> inq.	--	--	--	--	--	--
<i>Macoma</i> nasuta	--	--	--	--	--	--
<i>Venerupis japon</i>	--	--	--	--	--	--
TOTAL	20.515	8752	24.693	4896	4.997	8112

Table 8: Location and environmental data for FRAPER stations.

Station	FRAPER 18	FRAPER 19	FRAPER 20
Date (1973)	Sept. 11	Sept. 11	Sept. 11
Time (PST)	0925	0938	0945
Position N. lat.	49° 3.81	49° 3.29	49° 3.30
W. long.	123°10.60	123°10.11	123° 8.61
Quadrat Size (m ²)	0.25	0.25	0.25
Elevation (m, O.D.)	2.74	2.74	2.74
Grain size (μ m, median)	190	41	20
Silt/sand ratio	0.156	1.816	4.714
Temperature (sediment surface, °C)	21.0	22.0	20.8
Remarks	-fine sand -patchy marsh plants	-coarse silt -ripples ~3 cm amplitude -seaward edge of marsh	-medium silt -~ 0.7 km seaward of marsh -copious algae atop mud -reduced ~ 5 cm beneath surface of sedi- ments - <i>Abarenicola</i> castings

Table 8: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from FRAPER transect, around the periphery of the Fraser delta from Iona Island to Tsawwassen. See Table 12 for classification of organisms.

Station	FRAPER 18		FRAPER 19		FRAPER 20	
Date	Sept. 11		Sept. 11		Sept. 11	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	--	--	--	--	--	--
Nemertea	--	--	0.072	8	0.650	300
<i>Dendros toma</i>	--	--	--	--	--	--
<i>Eteone</i>	--	--	0.003	12	--	--
<i>Nereis</i>	--	--	0.127	184	--	--
<i>Pygospio</i>	--	--	--	--	--	--
<i>Polydora</i> dam	--	--	--	--	0.050	300
<i>Capitella</i>	--	--	--	--	--	--
<i>Amphiteis</i>	--	--	--	--	1.340	1600
<i>Manayunkia</i>	--	--	--	--	6.230	139700
Oligochaeta	--	--	--	--	0.270	800
<i>Corophium</i> insid	--	--	--	--	6.560	5800
<i>Corophium</i> sal	0.282	196	0.074	51	--	--
<i>Corophium</i> juv	0.047	236	0.094	372	2.340	11700
<i>Corophium</i> dam	0.411	1028	0.044	240	1.480	3700
<i>Anisogammarus</i> con	--	--	--	--	--	--
<i>Anisogammarus</i> juv	--	--	--	--	--	--
<i>Anisogammarus</i> dam	0.008	4	--	--	--	--
<i>Geosia</i>	0.006	4	--	--	9.760	4500
Gammarids dam	--	--	--	--	--	--
Harpacticoid	--	--	--	--	--	--
Ostracods	--	--	0.044	292	--	--
<i>Cumella</i>	--	--	0.002	16	--	--
<i>Tanais</i>	0.001	8	--	--	11.420	69600
<i>Crangon</i>	--	--	--	--	--	--
Brachyuran juv	--	--	--	--	--	--
<i>Hermisenda</i>	--	--	--	--	--	--
<i>Acteocina</i>	--	--	--	--	--	--
<i>Batillaria</i>	--	--	--	--	--	--
<i>Macoma</i> juv	<0.001	11	0.460	380	27.550	800
<i>Macoma</i> inco.	--	--	--	--	--	--
<i>Macoma</i> inq.	--	--	--	--	--	--
<i>Macoma</i> nasuta	--	--	--	--	--	--
<i>Venerupis</i> japon	--	--	--	--	--	--
TOTAL	0.755	1571	0.920	1555	67.660	239400

Table 8: Location and environmental data for FRAPER stations

Station	FRAPER 21	FRAPER 22	FRAPER 23
Date (1973)	Sept. 21	Sept. 21	Sept. 21
Time (PST)	1009	1035	1050
Position N. lat.	49° 2.98	49° 2.72	49° 2.73
W. long.	123° 7.85	123° 7.11	123° 6.51
Quadrat Size (m ²)	0.25	0.25	0.25
Elevation (m, O.D.)	2.74	2.74	2.74
Grain size (μ m, median)	64	60	59
Silt/sand ratio	1.083	1.222	0.369
Temperature (sediment surface, °C)	21.5	20.1	21.5
Remarks	-~ 0.5 km seaward of marsh -mud - <i>Ulva</i> thalli abundant -reduced ~ 1 cm beneath surface - <i>Zostera</i> debris - <i>Abarenicola</i> castings - <i>Hemigrapsus oregonensis</i>	-algal mats on mud - <i>Zostera</i> debris -reduced ~ 1 cm beneath surface - <i>Abarenicola</i> castings - <i>Hemigrapsus oregonensis</i>	-tidal creeks present -~ 30 m from marsh edge -mud with algal film - <i>Abarenicola</i> castings - <i>Hemigrapsus oregonensis</i> -reduced ~ 1 cm beneath surface - <i>Zostera</i> debris with gammarid amphipods underneath

Table 8: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from FRAPER transect, around the periphery of the Fraser delta from Iona Island to Tsawwassen. See Table 12 for classification of organisms.

Station	FRAPER 21		FRAPER 22		FRAPER 23	
Date	Sept. 11		Sept. 11		Sept. 11	
Taxa	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	--	--	--	--	0.237	48
Nemertea	--	--	0.334	80	0.722	611
<i>Dendros toma</i>	--	--	--	--	--	--
<i>Eteone</i>	0.016	80	0.016	32	--	--
<i>Nereis</i>	--	--	--	--	--	--
<i>Pygospio</i>	--	--	--	--	0.035	144
<i>Polydora</i> dam	--	--	--	--	0.107	16
<i>Capitella</i>	--	--	--	--	--	--
<i>Amphiteis</i>	0.328	960	--	--	--	--
<i>Manayunkia</i>	2.000	40080	0.015	304	0.211	2528
Oligochaeta	0.216	1280	--	--	0.101	336
<i>Corophium</i> insid	1.248	2720	0.195	192	1.610	4416
<i>Corophium</i> sal	--	--	--	--	--	--
<i>Corophium</i> juv	0.472	2560	0.006	32	--	--
<i>Corophium</i> dam	0.616	1680	0.083	208	0.418	1120
<i>Anisogammarus</i> con	--	--	--	--	--	--
<i>Anisogammarus</i> juv	--	--	--	--	--	--
<i>Anisogammarus</i> dam	--	--	--	--	--	--
<i>Geosia</i>	1.120	400	0.952	608	--	--
Gammarids dam	--	--	--	--	--	--
Harpacticoid	--	--	--	--	--	--
Ostracods	--	--	--	--	--	--
<i>Cumella</i>	0.008	80	0.005	32	--	--
<i>Tanais</i>	12.448	54000	3.979	11664	0.104	560
<i>Crangon</i>	--	--	--	--	--	--
Brachyuran juv	--	--	0.029	16	--	--
<i>Hermisenda</i>	--	--	0.100	16	--	--
<i>Acteocina</i>	--	--	--	--	0.141	48
<i>Batillaria</i>	--	--	--	--	5.162	32
<i>Macoma</i> juv	17.472	480	0.861	80	2.918	64
<i>Macoma</i> incon.	--	--	--	--	--	--
<i>Macoma</i> inq.	--	--	--	--	--	--
<i>Macoma</i> nasuta	--	--	--	--	--	--
<i>Venerupis</i> japon	--	--	--	--	--	--
TOTAL	35.944	104320	6.485	13264	11.766	9923

Table 8: Location and environmental data for FRAPER stations.

Station	FRAPER 24
Date (1973)	Sept. 11
Time (PST)	1103
Position N. lat.	49° 1.70
W. long.	123° 6.35
Quadrat Size (m ²)	0.25
Elevation (m, O.D.)	2.13
Grain size (μ m, median)	N/A
Silt/sand ratio	N/A
Temperature (sediment surface, °C)	22.9
Remarks	-mud -large nereid observed - <i>Ulva</i> . <i>Monostroma</i> abundant - <i>Callianassa</i> present -marginal <i>Zostera</i>

Table 8: Biomass (wet wt. g m^{-2}), number of individuals (number m^{-2}) and species composition from FRAPER transect, around the periphery of the Fraser delta from Iona Island to Tsawwassen. See Table 12 for classification of organisms.

Station FRAPER 24

Date Sept. 11

Taxa	Biomass g m^{-2}	No. Ind. m^{-2}
Insect larvae	--	--
Nemertea	--	--
<i>Dendros toma</i>	-	--
<i>Eteone</i>	0.007	4
<i>Nereis</i>	--	--
<i>Pygospio</i>	--	--
<i>Polydora</i> dam	--	--
<i>Capitella</i>	--	--
<i>Amphiteis</i>	0.004	8
<i>Manayunkia</i>	--	--
Oligochaeta	0.011	24
<i>Corophium</i> insid	0.519	520
<i>Corophium</i> sal	--	--
<i>Corophium</i> juv	0.153	764
<i>Corophium</i> dam	0.146	364
<i>Anisogammarus</i> con	--	--
<i>Anisogammarus</i> juv	--	--
<i>Anisogammarus</i> dam	--	--
<i>Geosia</i>	--	--
Gammarids dam	--	--
Harpacticoid	--	--
Ostracods	--	--
<i>Cumella</i>	0.015	124
<i>Tanais</i>	0.026	172
<i>Crangon</i>	--	--
Brachyuran juv	--	--
<i>Hermisenda</i>	--	--
<i>Acteocina</i>	0.026	8
<i>Batillaria</i>	--	--
<i>Macoma</i> juv	0.001	8
<i>Macoma</i> incon.	--	--
<i>Macoma</i> inq.	--	--
<i>Macoma</i> nasuta	0.001	8
<i>Venerupis</i> japon	0.348	4
TOTAL	1.257	2008

Table 9: Biomass (wet wt. $g\ m^{-3}$), number of individuals (number in 4 min tow) and species composition from plankton tows seaward of Iona Island. See Table 12 for classification of organisms. Surface salinity, temperature and seston data are also given.

Station	A I		B I		C I	
Date (1973)	July 31		July 31		July 30	
Time (PST)	1732		1708		1940	
Temperature ($^{\circ}C$)	21.0		20.2		19.5	
Salinity ($^{\circ}/_{\infty}$)	8.5		10.7		12.0	
Organic mat. mg litre $^{-1}$	3.0		2.6		2.9	
Taxa	Biomass $g\ m^{-3}$	No.Ind.	Biomass $g\ m^{-3}$	No.Ind.	Biomass $g\ m^{-3}$	No.Ind.
<i>Phialidium</i>	<1 mg	1	<1 mg	1	0.040	57
<i>Pleurobrachia</i>	-	-	-	-	0.217	54
Calanoids	<1 mg	23	<1 mg	13	<1 mg	63
Harpacticoids	-	-	-	-	-	-
<i>M. oculata</i>	-	-	-	-	-	-
Brachyuran zoea	-	-	-	-	-	-
Natantia juv.	-	-	-	-	<1 mg	1
Hyperiid	-	-	-	-	<1 mg	4
Fish larvae	-	-	-	-	-	-
<i>Eteone</i>	-	-	-	-	-	-
Polyodontidae juv.	-	-	-	-	-	-
<i>Polydora</i> K.	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
Capitellidae	-	-	-	-	-	-
<i>Amphicteis</i>	-	-	-	-	-	-
<i>M. aestaurina</i>	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Cumella</i>	-	-	-	-	-	-
<i>Macoma</i> Juv.	-	-	-	-	-	-
TOTAL	<1 mg	24	<1 mg	14	0.257	179

Table 9: Biomass (wet wt. g m^{-3}), number of individuals (number in 4 min tow) and species composition from plankton tows seaward of Iona Island. See Table 12 for classification of organisms. Surface salinity, temperature and seston data are also given.

Station	D I	E I	F I
Date (1973)	July 30	July 30	July 30
Time (PST)	1626	1930	1921
Temperature ($^{\circ}\text{C}$)	19.0	21.3	21.0
Salinity ($^{\circ}/\text{oo}$)	13.8	14.0	10.0
Organic mat. mg litre $^{-1}$	3.4	1.8	2.2

Taxa	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.
<i>Phialidium</i>	-	-	0.004	12	<1 mg	3
<i>Pleurobrachia</i>	-	-	0.034	46	0.002	5
Calanoids	<1 mg	68	<1 mg	72	<1 mg	34
Harpacticoids	-	-	-	-	-	-
<i>M. oculata</i>	-	-	-	-	-	-
Brachyuran zoea	-	-	<1 mg	1	-	-
Natantia juv.	-	-	<1 mg	1	-	-
Hyperiid	<1 mg	1	<1 mg	1	-	-
Fish larvae	-	-	-	-	-	-
<i>Eteone</i>	-	-	-	-	-	-
Polyodontidae juv.	-	-	<1 mg	-	-	-
<i>Polydora K.</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
Capitellidae	-	-	-	-	-	-
<i>Amphiteis</i>	-	-	-	-	-	-
<i>M. aestaurina</i>	-	-	<1 mg	1	<1 mg	1
Oligochaeta	-	-	-	-	-	-
<i>Cumella</i>	-	-	-	-	-	-
<i>Macoma</i> Juv.	<1 mg	1	-	-	-	-
TOTAL	<1 mg	70	0.038	135	0.002	43

Table 9: Biomass (wet wt. g m^{-3}), number of individuals (number in 4 min tow) and species composition from plankton tows seaward of Iona Island. See Table 12 for classification of organisms. Surface salinity, temperature and seston data are also given.

Station	G I		H I		I I	
Date (1973)	July 30		July 31		July 31	
Time (PST)	1908		1721		1656	
Temperature ($^{\circ}\text{C}$)	20.0		21.0		19.8	
Salinity (‰)	14.8		9.7		12.0	
Organic mat. mg litre^{-1}	1.9		2.2		2.8	
Taxa	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.
<i>Phialidium</i>	0.003	12	<1 mg	4	<1 mg	1
<i>Pleurobrachia</i>	0.006	24	-	-	-	-
Calanoids	<1 mg	13	<1 mg	7	<1 mg	14
Harpacticoids	<1 mg	1	-	-	-	-
<i>M. oculata</i>	-	-	-	-	-	-
Brachyuran zoea	-	-	-	-	-	-
Natantia juv.	-	-	-	-	<1 mg	1
Hyperiid	-	-	-	-	-	-
Fish larvae	-	-	-	-	-	-
<i>Eteone</i>	-	-	-	-	-	-
Polyodontidae juv.	-	-	-	-	-	-
<i>Polydora</i> K.	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
Capitellidae	-	-	-	-	-	-
<i>Amphicteis</i>	-	-	-	-	-	-
<i>M. aestaurina</i>	-	-	<1 mg	1	-	-
Oligochaeta	-	-	-	-	-	-
<i>Cumella</i>	-	-	-	-	-	-
<i>Macoma</i> Juv.	-	-	-	-	-	-
TOTAL	0.009	50	<1 mg	12	<1 mg	16

Table 9: Biomass (wet wt. g m^{-3}), number of individuals (number in 4 min tow) and species composition from plankton tows seaward of Iona Island. See Table 12 for classification of organisms. Surface salinity, temperature and seston data are also given.

Station	J I	K I	L I
Date (1973)	July 30	July 31	July 30
Time (PST)	1440	1613	1858
Temperature ($^{\circ}\text{C}$)	20.0	20.8	21.0
Salinity ($^{\circ}/\text{oo}$)	13.2	12.3	11.9
Organic mat. mg litre $^{-1}$	2.6	2.2	1.7

Taxa	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.
<i>Phialidium</i>	<1 mg	2	0.004	8	<1 mg	6
<i>Pleurobrachia</i>	-	-	-	-	-	-
Calanoids	<1 mg	43	<1 mg	29	<1 mg	39
Harpacticoids	-	-	-	-	-	-
<i>M. oculata</i>	-	-	-	-	-	-
Brachyuran zoea	-	-	<1 mg	2	-	-
Natantia juv.	-	-	-	-	<1 mg	-
Hyperiid	-	-	<1 mg	1	<1 mg	2
Fish larvae	-	-	-	-	-	-
<i>Eteone</i>	-	-	-	-	-	-
Polyodontidae juv.	-	-	-	-	-	-
<i>Polydora K.</i>	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
Capitellidae	-	-	-	-	-	-
<i>Amphicteis</i>	-	-	-	-	-	-
<i>M. aestaurina</i>	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Cumella</i>	-	-	-	-	-	-
<i>Macoma</i> Juv.	<1 mg	32	<1 mg	4	-	-
TOTAL	<1 mg	77	0.010	45	0.001	50

Table 9: Biomass (wet wt. g m^{-3}), number of individuals (number in 4 min tow) and species composition from plankton tows seaward of Iona Island. See Table 12 for classification of organisms. Surface salinity, temperature and seston data are also given.

Station	M I		N I		O I	
Date (1973)	July 31		July 30		July 31	
Time (PST)	1746		1655		1923	
Temperature ($^{\circ}\text{C}$)	20.3		20.0		19.5	
Salinity (‰)	10.7		11.0		11.2	
Organic mat. mg litre $^{-1}$	3.0		2.2		2.6	
Taxa	Biomass No.Ind. g m^{-3}		Biomass No.Ind. g m^{-3}		Biomass No.Ind. g m^{-3}	
<i>Phialidium</i>	-	-	<1 mg	1	0.001	4
<i>Pleurobrachia</i>	-	-	-	-	<1 mg	1
Calanoids	<1 mg	17	<1 mg	72	<1 mg	10
Harpacticoids	<1 mg	1	-	-	-	-
<i>M. oculata</i>	-	-	-	-	0.001	3
Brachyuran zoea	-	-	-	-	-	-
Natantia juv.	-	-	<1 mg	1	-	-
Hyperiid	-	-	<1 mg	2	-	-
Fish larvae	<1 mg	9	<1 mg	1	-	-
<i>Eteone</i>	-	-	-	-	-	-
Polyodontidae juv.	-	-	-	-	-	-
<i>Polydora</i> K.	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	-	-
Capitellidae	-	-	-	-	-	-
<i>Amphicteis</i>	-	-	-	-	-	-
<i>M. aestaurina</i>	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-
<i>Cumella</i>	<1 mg	1	-	-	-	-
<i>Macoma</i> Juv.	<1 mg	3	<1 mg	3	-	-
TOTAL	<1 mg	31	<1 mg	80	0.002	18

Table 9: Biomass (wet wt. $g\ m^{-3}$), number of individuals (number in 4 min tow) and species composition from plankton tows seaward of Iona Island. See Table 12 for classification of organisms. Surface salinity, temperature and seston data are also given.

Station	P I		Q I		R I	
Date (1973)	July 30		July 30		July 30	
Time (PST)	1839		1710		1829	
Temperature ($^{\circ}C$)	21.5		21.0		21.0	
Salinity ($^{\circ}/_{oo}$)	11.5		9.9		10.5	
Organic mat. mg litre $^{-1}$	1.6		3.2		2.2	
Taxa	Biomass No.Ind. $g\ m^{-3}$		Biomass No.Ind. $g\ m^{-3}$		Biomass No.Ind. $g\ m^{-3}$	
<i>Phialidium</i>	0.001	2	<1 mg	1	-	-
<i>Pleurobrachia</i>	0.004	9	-	-	-	-
Calanoids	<1 mg	18	<1 mg	12	<1 mg	9
Harpacticoids	-	-	-	-	-	-
<i>M. oculata</i>	-	-	-	-	-	-
Brachyuran zoea	<1 mg	1	-	-	-	-
Natantia juv.	<1 mg	1	-	-	-	-
Hyperiid	-	-	-	-	-	-
Fish larvae	<1 mg	1	-	-	-	-
<i>Eteone</i>	-	-	-	-	-	-
Polyodontidae juv.	-	-	-	-	-	-
<i>Polydora</i> K.	-	-	-	-	-	-
<i>Pygospio</i>	-	-	-	-	<1 mg	1
Capitellidae	-	-	-	-	-	-
<i>Amphicteis</i>	-	-	-	-	-	-
<i>M. aestaurina</i>	<1 mg	4	-	-	<1 mg	3
Oligochaeta	-	-	-	-	-	-
<i>Cumella</i>	-	-	-	-	-	-
<i>Macoma</i> Juv.	-	-	<1 mg	1	-	-
TOTAL	0.005	36	<1 mg	14	<1 mg	13

Table 9: Biomass (wet wt. g m^{-3}), number of individuals (number in 4 min tow) and species composition from plankton tows seaward of Iona Island. See Table 12 for classification of organisms. Surface salinity, temperature and seston data are also given.

Station	S I		T I		U I	
Date (1973)	July 30		July 30		July 30	
Time (PST)	1817		1721		1730	
Temperature ($^{\circ}\text{C}$)	21.0		22.0		22.0	
Salinity ($^{\circ}/\text{oo}$)	10.8		12.5		11.8	
Organic mat. mg litre $^{-1}$	1.1		2.8		2.3	
Taxa	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.
<i>Phialidium</i>	-	-	-	-	-	-
<i>Pleurobrachia</i>	-	-	-	-	-	-
Calanoids	<1 mg	11	<1 mg	12	<1 mg	6
Harpacticoids	-	-	-	-	-	-
<i>M. oculata</i>	-	-	-	-	-	-
Brachyuran zoea	-	-	<1 mg	1	-	-
Natantia juv.	-	-	-	-	-	-
Hyperiid	-	-	<1 mg	1	-	-
Fish larvae	-	-	-	-	-	-
<i>Eteone</i>	-	-	<1 mg	1	-	-
Polyodontidae juv.	-	-	-	-	-	-
<i>Polydora</i> K.	-	-	<1 mg	4	<1 mg	1
<i>Pygospio</i>	-	-	<1 mg	14	<1 mg	1
Capitellidae	-	-	<1 mg	4	-	-
<i>Amphicteis</i>	-	-	<1 mg	3	<1 mg	2
<i>M. aestaurina</i>	<1 mg	2	0.004	350	0.002	163
Oligochaeta	-	-	<1 mg	15	<1 mg	6
<i>Cumella</i>	-	-	-	-	-	-
<i>Macoma</i> Juv.	-	-	<1 mg	27	<1 mg	1
TOTAL	<1 mg	13	0.004	432	0.002	180

Table 9: Biomass (wet wt. g m^{-3}), number of individuals (number in 4 min tow) and species composition from plankton tows seaward of Iona Island. See Table 12 for classification of organisms. Surface salinity, temperature and seston data are also given.

Station	U ¹ I	V I
Date (1973)	July 30	July 30
Time (PST)	1800	1749
Temperature ($^{\circ}\text{C}$)	22.5	22.0
Salinity (‰)	11.8	11.0
Organic mat. mg litre ⁻¹	2.7	1.7

Taxa	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.
<i>Phialidium</i>	-	-	-	-
<i>Pleurobrachia</i>	-	-	-	-
Calanoids	<1 mg	1	<1 mg	6
Harpacticoids	-	-	-	-
<i>M. oculata</i>	-	-	-	-
Brachyuran zoea	-	-	-	-
Natantia juv.	-	-	-	-
Hyperiid	-	-	-	-
Fish larvae	-	-	-	-
<i>Eteone</i>	-	-	<1 mg	1
Polyodontidae juv.	-	-	-	-
<i>Polydora</i> K.	-	-	-	-
<i>Pygospio</i>	-	-	-	-
Capitellidae	-	-	-	-
<i>Amphicteis</i>	<1 mg	1	<1 mg	2
<i>M. aestaurina</i>	<1 mg	20	<1 mg	31
Oligochaeta	-	-	-	-
<i>Cumella</i>	-	-	-	-
<i>Macoma</i> Juv.	<1 mg	1	-	-
TOTAL	<1 mg	23	<1 mg	40

Table 10: Biomass (wet wt. g m⁻³), number of individuals (number of 4 min tow), and species composition from plankton tows in front of Sea Island. See Table 12 for classification of organisms. Surface salinity, temperature, and seston data are also given.

Station	A S		B S		C S	
Date (1973)	July 3		July 3		July 3	
Time (PST)	1945		1930		1955	
Temperature (°C)	16.2		17.0		16.8	
Salinity (‰)	6.5		7.5		7.0	
Organic mat. (mg litre ⁻¹)	2.4		3.4		2.2	
Taxa	Biomass g m ⁻³	No. Ind.	Biomass g m ⁻³	No. Ind.	Biomass g m ⁻³	No. Ind.
Insecta	0.002	31	--	--	0.002	8
Calanoids	<1 mg	49	<1 mg	41	<1 mg	55
Harpacticoids	--	--	<1 mg	2	--	--
<i>Neomysis</i>	--	--	--	--	<1 mg	2
<i>Acanthomysis</i>	--	--	--	--	--	--
Mysid juv.	--	--	--	--	--	--
Brachyuran juv.	--	--	--	--	--	--
Decapod zoea	--	--	--	--	--	--
Fish larvae	0.007	24	0.001	36	0.002	29
Nemertea	--	--	--	--	--	--
<i>Eteone</i>	--	--	--	--	--	--
<i>Nereis</i> juv.	--	--	--	--	--	--
<i>P. elegans</i>	--	--	--	--	--	--
Spionidae juv.	--	--	--	--	--	--
Ampharetidae juv.	--	--	--	--	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
Polychaeta dam.	--	--	--	--	--	--
Oligochaeta	--	--	<1 mg	4	0.001	33
<i>Corophium</i> juv.	<1 mg	1	<1 mg	3	<1 mg	14
<i>Corophium</i> sal.	--	--	--	--	--	--
<i>Anisogammarus</i> juv.	--	--	--	--	<1 mg	3
<i>Anisogammarus</i> con.	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	--	--	<1 mg	1	--	--
<i>Gnorrinosphaeroma</i>	--	--	--	--	--	--
<i>Crangon</i>	--	--	--	--	--	--
Nudibranch juv.	--	--	--	--	<1 mg	5
<i>Macoma</i> juv.	--	--	--	--	--	--
<i>Oncorhynchus</i>	--	--	--	--	--	--
<i>Gasterosteus</i>	--	--	--	--	1.843	5
<i>Pladichthys</i>	--	--	--	--	--	--
TOTAL	0.009	105	0.001	87	1.848	154

Table 10: Biomass (wet wt. $g\ m^{-3}$), number of individuals (number of 4 min tow), and species composition from plankton tows in front of Sea Island. See Table 12 for classification of organisms. Surface salinity, temperature, and seston data are also given.

Station	C ¹ S	C ¹¹ S	D S
Date (1973)	July 3	July 3	July 4
Time (PST)	2000	1915	1830
Temperature (°C)	16.5	17.2	14.8
Salinity (‰)	5.0	5.2	0.3
Organic mat. (mg litre ⁻¹)	3.4	1.8	3.0

Taxa	Biomass $g\ m^{-3}$	No.Ind.	Biomass $g\ m^{-3}$	No.Ind.	Biomass $g\ m^{-3}$	No.Ind.
Insecta	0.014	65	--	--	<1 mg	16
Calanoids	<1 mg	4	<1 mg	5	0.001	80
Harpacticoids	--	--	--	--	<1 mg	16
<i>Neomysis</i>	--	--	0.130	52	0.443	248
<i>Acanthomysis</i>	--	--	--	--	--	--
Mysid juv.	--	--	--	--	--	--
Brachyuran juv.	--	--	--	--	--	--
Decapod zoea	--	--	--	--	--	--
Fish larvae	0.005	42	0.002	4	0.003	80
Nemertea	--	--	<1 mg	3	0.001	8
<i>Eteone</i>	--	--	--	--	--	--
<i>Nereis</i> juv.	--	--	--	--	--	--
<i>P. elegans</i>	--	--	--	--	--	--
Spionidae juv.	--	--	--	--	--	--
Ampharetidae juv. <1 mg.	--	1	--	--	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
<i>Polychaeta</i> dam.	--	--	--	--	--	--
Oligochaeta	<1 mg	10	--	--	0.005	584
<i>Corophium</i> juv.	<1 mg	1	--	--	0.002	88
<i>Corophium</i> sal.	--	--	<1 mg	1	0.003	32
<i>Anisogammarus</i> juv.	--	--	<1 mg	4	--	--
<i>Anisogammarus</i> con <1 mg	--	1	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	<1 mg	8	--	--	--	--
<i>Gnathinosphaeroma</i>	<1 mg	2	--	--	--	--
<i>Crangon</i>	--	--	--	--	--	--
Nudibranch juv.	0.001	22	--	--	--	--
<i>Macoma</i> juv.	--	--	<1 mg	20	--	--
<i>Oncorhynchus</i>	--	--	--	--	--	--
<i>Gasterosteus</i>	--	--	--	--	--	--
<i>Pladichthys</i>	--	--	--	--	--	--
TOTAL	0.020	156	0.132	89	0.458	1152

Table 10: Biomass (wet wt. g m^{-3}), number of individuals (number of 4 min tow), and species composition from plankton tows in front of Sea Island. See Table 12 for classification of organisms. Surface salinity, temperature, and seston data are also given.

Station	E S	F S	G S
Date (1973)	July 4	July 4	July 4
Time (PST)	1925	1905	1840
Temperature ($^{\circ}\text{C}$)	14.5	14.8	16.0
Salinity (‰)	8.7	6.0	3.7
Organic mat. (mg litre^{-1})	3.0	5.0	15.4

Taxa	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.
Insecta	--	--	<1 mg	4	--	--
Calanoids	0.001	82	<1 mg	48	0.001	144
Harpacticoids	<1 mg	2	<1 mg	16	--	--
<i>Neomysis</i>	0.010	5	0.012	12	1.005	480
<i>Acanthomysis</i>	<1 mg	5	0.004	12	--	--
Mysid juv.	<1 mg	11	0.001	92	--	--
Brachyuran juv.	--	--	--	--	--	--
Decapod zoea	--	--	--	--	--	--
Fish larvae	0.005	38	0.004	60	0.164	524
Nemertea	--	--	--	--	0.002	16
<i>Eteone</i>	--	--	--	--	--	--
<i>Nereis</i> juv.	--	--	<1 mg	8	--	--
<i>P. elegans</i>	--	--	--	--	--	--
Spionidae juv.	<1 mg	1	--	--	--	--
Ampharetidae juv.	<1 mg	1	--	--	--	--
<i>Manayunkia</i>	<1 mg	6	--	--	--	--
Polychaeta dam.	--	--	--	--	--	--
Oligochaeta	<1 mg	31	<1 mg	12	<1 mg	64
<i>Corophium</i> juv.	0.002	122	0.003	144	0.005	240
<i>Corophium</i> sal.	--	--	0.002	12	0.007	64
<i>Anisogammarus</i> juv.	<1 mg	1	<1 mg	8	--	--
<i>Anisogammarus</i> con.	<1 mg	1	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	<1 mg	1	0.001	32	0.001	48
<i>Gnoringosphaeroma</i>	--	--	<1 mg	4	--	--
<i>Crangon</i>	--	--	0.035	1	--	--
Nudibranch juv.	<1 mg	1	--	--	--	--
<i>Macoma</i> juv.	0.001	47	0.003	248	0.014	108
<i>Oncorhynchus</i>	--	--	--	--	0.435	1
<i>Gasterosteus</i>	--	--	--	--	0.227	1
<i>Pladichthys</i>	--	--	--	--	--	--
TOTAL	0.019	355	0.061	713	1.861	1809

Table 10: Biomass (wet wt. g m^{-3}), number of individuals (number of 4 min tow), and species composition from plankton tows in front of Sea Island. See Table 12 for classification of organisms. Surface salinity, temperature, and seston data are also given.

Station	I S	J S	K S
Date (1973)	July 4	July 4	July 3
Time (PST)	1450	1700	1750
Temperature ($^{\circ}\text{C}$)	N/A	16.5	16.3
Salinity ($^{\circ}/\text{oo}$)	N/A	7.7	5.3
Organic mat. (mg litre^{-1})	N/A	1.4	2.0

Taxa	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.
Insecta	--	--	--	--	--	--
Calanoids	0.002	262	0.004	608	0.001	160
Harpacticoids	--	--	<1 mg	40	<1 mg	8
<i>Neomysis</i>	0.004	55	0.018	48	0.003	56
<i>Acanthomysis</i>	0.012	34	--	--	--	--
Mysid juv.	--	--	0.001	88	--	--
Brachyuran juv.	--	--	--	--	--	--
Decapod zoea	--	--	--	--	--	--
Fish larvae	0.010	57	0.002	160	0.029	208
Nemertea	--	--	0.002	48	<1 mg	16
<i>Eteone</i>	--	--	0.001	8	--	--
<i>Nereis</i> juv.	--	--	--	--	--	--
<i>P. elegans</i>	--	--	<1 mg	8	--	--
Spionidae juv.	--	--	--	--	--	--
Ampharetidae juv.	--	--	--	--	--	--
<i>Manayunkia</i>	--	--	<1 mg	24	--	--
Polychaeta dam.	--	--	<1 mg	8	--	--
Oligochaeta	--	--	0.022	248	<1 mg	8
<i>Corophium</i> juv.	--	--	0.006	688	0.002	88
<i>Corophium</i> sal	--	--	0.007	56	0.008	48
<i>Anisogammarus</i> juv.	<1 mg	10	0.003	32	0.006	240
<i>Anisogammarus</i> con	--	--	--	--	--	--
<i>Cumella</i>	<1 mg	13	0.001	24	<1 mg	16
<i>Tanais</i>	<1 mg	1	--	--	--	--
<i>Gnoringosphaeroma</i>	--	--	--	--	--	--
<i>Crangon</i>	0.158	2	0.199	9	0.302	5
Nudibranch juv.	--	--	--	--	--	--
<i>Macoma</i> juv.	--	--	0.004	3320	--	--
<i>Oncorhynchus</i>	--	--	--	--	--	--
<i>Gasterosteus</i>	--	--	--	--	--	--
<i>Pladichthys</i>	--	--	0.098	2	--	--
TOTAL	0.186	434	0.348	5419	0.351	853

Table 10: Biomass (wet wt. g m^{-3}), number of individuals (number of 4 min tow), and species composition from plankton tows in front of Sea Island. See Table 12 for classification of organisms. Surface salinity, temperature, and seston data are also given.

Station	L S		M S		N S	
Date (1973)	July 3		July 3		July 3	
Time (PST)	1755		1850		1530	
Temperature ($^{\circ}\text{C}$)	15.0		15.5		16.0	
Salinity ($^{\circ}/\text{oo}$)	2.0		7.0		7.8	
Organic mat. (mg litre $^{-1}$)	1.4		1.9		1.4	

Taxa	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.
Insecta	<1 mg	1	--	--	--	--
Calanoids	<1 mg	16	0.002	344	0.015	2296
Harpacticoids	--	--	--	--	<1 mg	8
<i>Naomysis</i>	0.230	224	0.001	40	0.005	256
<i>Acanthomysis</i>	--	--	--	--	0.001	16
Mysid juv.	--	--	--	--	--	--
Brachyuran juv.	--	--	--	--	--	--
Decapod zoea	--	--	--	--	--	--
Fish larvae	0.002	80	0.002	96	0.002	80
Nemertea	0.004	32	0.001	8	--	--
<i>Eteone</i>	--	--	0.001	4	--	--
<i>Nereis</i> juv.	--	--	--	--	--	--
<i>P. elegans</i>	--	--	<1 mg	4	--	--
Spionidae juv.	--	--	--	--	<1 mg	144
Ampharetidae juv.	--	--	--	--	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
Polychaeta dam.	--	--	--	--	--	--
Oligochaeta	0.004	608	<1 mg	12	--	--
<i>Corophium</i> juv.	0.003	48	0.011	300	<1 mg	6
<i>Corophium</i> sal	0.003	32	0.011	100	0.002	40
<i>Anisogammarus</i> juv.	0.001	64	0.008	348	0.001	152
<i>Anisogammarus</i> con	--	--	0.002	16	0.001	8
<i>Cumella</i>	--	--	0.001	112	<1 mg	8
<i>Tanais</i>	--	--	--	--	--	--
<i>Gnoringosphaeroma</i>	--	--	--	--	--	--
<i>Crangon</i>	3.841	29	0.219	2	--	--
Nudibranch juv.	--	--	--	--	--	--
<i>Macoma</i> juv.	<1 mg	16	--	--	0.002	112
<i>Oncorhynchus</i>	--	--	--	--	--	--
<i>Gasterosteus</i>	--	--	--	--	--	--
<i>Pladichthys</i>	--	--	--	--	--	--
TOTAL	4.088	1149	0.259	1386	0.029	3168

Table 10: Biomass (wet wt. g m^{-3}), number of individuals (number of 4 min tow), and species composition from plankton tows in front of Sea Island. See Table 12 for classification of organisms. Surface salinity, temperature, and seston data are also given.

Station	O S		P S		Q S	
Date (1973)	July 3		July 3		July 3	
Time (PST)	1735		1630		1730	
Temperature ($^{\circ}\text{C}$)	15.0		16.5		16.0	
Salinity ($^{\circ}/\text{oo}$)	0.7		7.5		10.5	
Organic mat. (mg litre^{-1})	3.8		2.0		1.4	

Taxa	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.	Biomass g m^{-3}	No.Ind.
Insecta	--	--	--	--	--	--
Calanoids	0.001	124	<1 mg	58	0.018	2752
Harpacticoids	<1 mg	12	--	--	--	--
<i>Naomysis</i>	0.187	1140	0.008	276	0.014	928
<i>Acanthomysis</i>	--	--	<1 mg	4	0.002	64
Mysid juv.	--	--	--	--	--	--
Brachyuran juv.	--	--	0.001	4	--	--
Decapod zoea	--	--	--	--	0.001	96
Fish larvae	0.038	88	0.002	80	<1 mg	16
Nemertea	0.002	20	<1 mg	4	--	--
<i>Eteone</i>	--	--	--	--	--	--
<i>Nereis</i> juv.	--	--	--	--	--	--
<i>P. elegans</i>	--	--	--	--	--	--
Spionidae juv.	--	--	<1 mg	16	<1 mg	16
Ampharetidae juv.	--	--	<1 mg	12	--	--
<i>Manayunkia</i>	--	--	--	--	--	--
Polychaeta dam.	--	--	--	--	--	--
Oligochaeta	<1 mg	40	--	--	<1 mg	48
<i>Corophium</i> juv.	0.003	68	<1 mg	8	0.001	16
<i>Corophium</i> sal	0.008	60	--	--	0.008	96
<i>Anisogammarus</i> juv.	0.005	168	0.001	68	0.007	496
<i>Anisogammarus</i> con	0.003	40	--	--	--	--
<i>Cumella</i>	--	--	0.004	344	0.001	64
<i>Tanais</i>	--	--	--	--	--	--
<i>Groenimphaeroma</i>	--	--	--	--	--	--
<i>Crangon</i>	0.137	5	0.143	1	--	--
Nudibranch juv.	--	--	--	--	--	--
<i>Macoma</i> juv.	--	--	--	--	0.004	320
<i>Oncorhynchus</i>	--	--	--	--	--	--
<i>Gasterosteus</i>	--	--	--	--	--	--
<i>Fladichthys</i>	--	--	--	--	--	--
TOTAL	0.383	1765	0.159	875	0.056	4912

Table 10: Biomass (wet wt. $g\ m^{-3}$), number of individuals (number of 4 min tow), and species composition from plankton tows in front of Sea Island. See Table 12 for classification of organisms. Surface salinity, temperature, and seston data are also given.

Station	R S	S S	T S
Date (1973)	July 4	July 4	July 4
Time (PST)	1725	1435	1445
Temperature ($^{\circ}C$)	15.0	16.2	15.7
Salinity ($^{\circ}/_{oo}$)	5.7	6.0	1.5
Organic mat. (mg litre $^{-1}$)	3.2	3.2	2.4

Taxa	Biomass $g\ m^{-3}$	No.Ind.	Biomass $g\ m^{-3}$	No.Ind.	Biomass $g\ m^{-3}$	No.Ind.
Insecta	--	--	<1 mg	1	--	--
Calanoids	0.002	312	<1 mg	34	0.001	162
Harpacticoids	<1 mg	8	--	--	<1 mg	1
<i>Neomysis</i>	0.013	304	<1 mg	3	0.005	200
<i>Acanthomysis</i>	--	--	--	--	<1 mg	1
Mysid juv.	--	--	--	--	--	--
Brachyuran juv.	--	--	--	--	--	--
Decapod zoea	--	--	--	--	--	--
Fish larvae	0.007	256	0.010	15	<1 mg	4
Nemertea	0.001	24	--	--	--	--
<i>Eteone</i>	--	--	--	--	--	--
<i>Nereis</i> juv.	--	--	--	--	--	--
<i>P. elegans</i>	--	--	--	--	--	--
Spionidae juv.	--	--	--	--	<1 mg	1
Ampharetidae juv.	--	--	--	--	--	--
<i>Manayunkia</i>	--	--	<1 mg	29	--	--
Polychaeta dam.	--	--	--	--	--	--
Oligochaeta	0.001	48	--	--	<1 mg	5
<i>Corophium</i> juv.	--	--	--	--	<1 mg	1
<i>Corophium</i> sal.	--	--	--	--	<1 mg	2
<i>Anisogammarus</i> juv.	0.006	136	--	--	<1 mg	13
<i>Anisogammarus</i> con.	--	--	--	--	--	--
<i>Cumella</i>	--	--	--	--	--	--
<i>Tanais</i>	--	--	<1 mg	2	--	--
<i>Gnoringosphaeroma</i>	--	--	--	--	--	--
<i>Crangon</i>	0.595	5	0.239	2	--	--
Nudibranch juv.	--	--	--	--	--	--
<i>Macoma</i> juv.	<1 mg	32	--	--	<1 mg	9
<i>Oncorhynchus</i>	--	--	--	--	--	--
<i>Gasterosteus</i>	--	--	--	--	--	--
<i>Pladichthys</i>	--	--	--	--	--	--
TOTAL	0.625	1125	0.249	86	0.006	419

Table 11: Salinity (‰) of surface water from sediments on Sturgeon and Roberts Banks, February 5 to 7, 1974. Stations (Fig.2) were occupied during hovercraft trips of the Geological Survey of Canada (Dr. J. Luternauer), whose station designation is used in this table.

Station	N. Lat.,	W. Long.	Salinity(‰)	Station	N. Lat.,	W. Long.	Salinity(‰)
1	49°4.25,	123°12.03	14.66	30	49°5.00,	123°12.44	9.72
2	49°4.28,	123°10.73	7.15	31	49°4.39,	123°14.40	12.76
3	49°4.05,	123° 9.37	3.78	32	49°5.53,	123°15.00	19.82
4	49°4.35,	123° 9.49	6.34	33	49°6.02,	123°16.08	16.42
5	49°3.00,	123°10.90	8.48	34	49°5.13,	123°16.07	18.97
6	49°3.40,	123°12.08	14.23	35	49°3.80,	123°16.08	19.69
7	49°3.30,	123°13.40	11.93	36	49°3.90,	123°14.38	15.40
8	N/A	N/A	N/A	37	49°5.25,	123°17.46	20.72
9	49°2.60,	123°12.21	15.08	38	49°6.88,	123°17.28	22.13
10	49°2.82,	123°10.07	N/A	39	49°8.08,	123°16.31	17.71
11	49°2.60,	123° 9.39	9.84	40	49°8.70,	123°16.50	17.25
12	49°2.61,	123° 8.02	14.86	41	49°9.65,	123°16.62	14.94
13	49°1.65,	123° 9.40	20.65	42	49°10.57,	123°16.73	14.81
14	49°1.70,	123°10.78	18.32	43	49°11.47,	123°16.68	20.72
15	49°1.62,	123°14.10	16.97	44	49°12.45,	123°16.38	20.83
16	49°1.68,	123°13.50	15.35	45	49°13.64,	123°16.00	21.38
17	49°2.23,	123°15.00	5.73	46	49°14.38,	123°15.61	21.59
18	49°0.70,	123° 8.03	26.99	47	49°13.63,	123°14.62	20.33
19	49°1.45,	123° 2.63	N/A	48	49°12.80,	123°14.63	19.48
20	49°1.59,	123° 1.77	26.72	49	49°13.15,	123°13.28	18.42
21	49°2.50,	123° 6.71	26.54	50	49°8.08,	123°12.00	13.91
22	49°3.30,	123° 8.32	N/A	51	49°9.06,	123°11.91	16.59
23	49°5.00,	123°11.05	11.02	52	49°9.80,	123°12.08	14.42
24	49°5.30,	123°12.02	14.76	53	49°10.74,	123°12.30	9.56
25	49°6.32,	123°12.00	18.65	54	49°12.66,	123°12.60	18.41
26	49°6.48,	123°12.28	8.82	55	49°12.06,	123°13.30	18.36
27	49°6.93,	123°13.32	16.58	56	49°11.18,	123°13.30	14.14
28	49°6.03,	123°13.32	12.54	57	49°10.30,	123°13.30	14.98
29	49°5.00,	123°14.01	13.88	58	49°9.45,	123°13.30	18.36

Table 11:(cont'd) Salinity of surface water from sediments on Sturgeon and Roberts Banks, February 5 to 7, 1974

Station	N. Lat., W. Long.	Salinity(‰)
59	49° 8.60, 123°13.30	18.44
60	49° 7.98, 123°15.00	18.53
61	49° 9.48, 123°16.00	16.80
62	49°10.35, 123°15.95	12.67
63	49°11.20, 123°16.09	13.95
64	49°12.07, 123°15.84	18.67
65	49°12.03, 123°14.68	19.67
66	49°10.10, 123°14.59	12.45
67	49°10.30, 123°14.65	18.85
68	49° 9.50, 123°14.68	17.41
69	49° 8.57, 123°14.58	19.30

Table 12 - List of organisms obtained in sampling on Sturgeon and Roberts Bank. Major group headings from Meglitsch, 1972.

CNIDARIA

- Cl. Scyphozoa
Phialidium sp.

CTENOPHORA

- Cl. Tentaculata
Pleurobrachia sp.

PLATYHELMINTHES

- Cl. Turbellaria
Dendrosoma sp.

NEMERTINA

ANNELIDA

- Cl. Polychaeta
S-C Errantia
Eteone longa
Eulalia sp.
Glycinde picta
Nephtys ferruginea
Nephtys cornuta franciscana
Nereis (Neanthes) limnicola
Polyodontidae
Platynereis bicanaliculata
Syllidae
S-C Sedentaria
Ampharete arctica
Ampharetidae juveniles
Amphicteis sp.
Armandia brevis
Capitella sp. I
Eupolyornia heterobranchia
Maldanidae juvenile
Mediomastus sp.

Manayunkia aestuarina
Owenia fusiformis
Paranois platybranchia
Polydora ligni
Pseudopolydora kempii japonica
Pseudosabellides littoralis
Pygospio elegans
Scoloplos armiger
Spionidae juveniles

Polychaeta damaged

Cl. Oligochaeta

MOLLUSCA

Cl. Gastropoda

Acteocina eximia
Batillaria zonalis
Hermisenda crassicornis
Polinices sp.

Cl. Pelecypoda

Clinocardium sp.
Kellia suborbicularis
Macoma inconspicua
Macoma inquinata
Macoma nasuta
Macoma sp.
Musculus substriatus
Mya sp. (juveniles)
Mytilus edulis
Prothaca staminea
Venerupis japonica
Yoldia ensifera

ARTHROPODA

Cl. Pycnogonida

Halosoma viridintestina

Cl. Crustacea

S-C Copepoda

O. Calanoida
O. Harpacticoida

S-C Malacostraca

O. Mysidacea
Neomysis mercedis
Mysis oculata
Acanthomysis macrops
Mysid juveniles

- 0. Cumacea
 - Cumella vulgaris*
 - Lamprops* sp. 1
- 0. Tanaidacea
 - Leptochelia filum*
 - Tanais* sp. 1
- 0. Isopoda
 - Gnorimosphaeroma oregonensis*
 - Pendideia resecta*
 - Synideia nebulosa*
- 0. Oecapoda
 - S.O. Natantia
 - Crangon franciscorum*
 - Natantia juvenile
 - S.O. Reptantia
 - Brachyuran juvenile

Decapoda zoea

- 0. Amphipoda
 - S.O. Hyperiidea
 - S.O. Gammaridea
 - Ampelisca* sp. 1
 - Anisogammarus confervicolus*
 - Anisogammarus* juveniles
 - Atylus* sp. 1
 - Calliopius laeviusculus*
 - S.O. Caprellidea
 - Caprella* sp. 1
 - Corophium salmonis*
 - Corophium insidiosum*
 - Corophium* spp. (juveniles)
 - Corophium* damaged
 - Eohaustorius washingtonianus*
 - Geosia* sp. 1
 - Paraphoxus* sp. 1.
 - Pontogeneia* sp. 1

- Cl. Insecta
 - Insect larvae
- Cl. Arachnida
 - 0. Acarina
 - Halacaridae

SIPUNCULA

CHORDATA

- Cl. Osteichthyes
 - Gasterosteus aculeatus*
 - Oncorhynchus kisutch*
 - Platichthys stellatus*

ECONOMIC AND SOCIAL ASSESSMENT

The Economic Importance of the
Fishery Resources of the Fraser
River and its Estuary

Fisheries and Marine Service,
Department of the Environment.

Social Science Unit,
Southern Operations Branch.

February, 1975

A. The Fraser River Commercial Salmon Resource

1. Average Annual Commercial Catches of Fraser River Salmon

An average annual commercial catch of Fraser River salmon was estimated in a recent Fisheries report prepared for the Upstream Storage Committee, studying the System E flood control proposals.¹ These quantities are outlined in Table I.

Table I

Estimated Average Annual Commercial Catch of
Fraser River Salmon

<u>Species</u>	<u>Commercial Catch (pieces)</u>	<u>Average* Weight Per Fish</u>	<u>Average Commercial Catch</u>
Chinook	182,948	13.0	2,378,300
Sockeye	3,920,539	6.0	23,523,200
Coho	142,731	8.0	1,141,800
Pink	2,338,154	5.7	13,327,500
Chum	509,505	11.0	5,604,600
TOTAL	7,093,877		45,975,439

*Estimated average

¹An Assessment of the Effects of the System E Flood Control Proposal on the Salmon Resource of the Fraser River System prepared for the Ecology Subcommittee of the Fraser River Upstream Storage Steering Committee, by Environment Canada, Fisheries and Marine Service, Vancouver, British Columbia, January, 1974

2. Net Economic Value of Fraser River Salmon

The gross value of the Fraser River salmon catch at retail is estimated to approximate \$73 million, expressed in 1973 dollars. Following standard benefit-cost procedures however, calculation of the value of the Fraser River salmon fishery in the present analysis will be conducted in net, rather than gross, terms. Net value is understood to mean the difference between gross value of fish produce at the consumer level and the cost of putting the product there - assuming the economy is pursuing a policy of revenue maximization. In reality, data available falls short of this idealized model. The people of Canada are not pursuing a pure revenue goal with regard to the commercial fishery. Rather, they are using the resource to meet employment and subsistence objectives, and to meet the requirements of traditional native customs, as well as to produce revenue. Consequently, an estimate of a least cost-position for the fishery if revenue maximization pertained is required. It is estimated that, using primarily traps and weirs, fish could be caught and landed for 15 percent of current landed values. By the use of steps such as more freezing to smooth processing curves and the further horizontal integration of processors, it is estimated that processing costs would be held to 50 percent of the wholesale value increment. These calculations are presented in Table II.

Table II

Calculation of 1973 Net Value of Fraser River

Salmon to the Commercial Fishery

	<u>Landed Value</u> ¢/lb.	<u>Net Value Landed*</u> ¢/lb.	<u>Wholesale Value Increment</u> ¢/lb.	<u>Net Value Wholesale Increment**</u> ¢/lb.	<u>Net Value to Wholesale</u> ¢/lb.
Chinook	84	71	39	20	91
Sockeye	56	48	89	44	92
Coho	76	65	36	18	83
Pink	27	23	66	33	56
Chum	45	38	33	16	54

* landed value less 15 percent.

** wholesale increment less 50 percent.

At the retail level, it is estimated that a further markup of 22 percent takes place for canned salmon, and 43 percent for salmon fresh, frozen and otherwise treated. Weighting these figures by the value of the product, by type of disposition, produces an estimate of retail markup for all salmon of 31.5 percent. Examining fish retailing operations, a return of 15 percent on value added is utilized for this study. This figure seems conservative, as the product actually passes through a "jobber" level between wholesaler and retailer, where a profit is also extracted. The result of these calculations is a further increment to net value of 5 percent of the wholesale price, when averaged across all species.

An additional adjustment is required to deduct the portion of government management costs applicable to the Fraser River salmon catch from the net values determined in Table 2. The management cost adjustment is based upon an approximate expenditure of \$1.1 million annually. These final calculations are made in Table III.

Table III

Final Net Value (\$1973) of Fraser River Salmon

	<u>Net Value at Wholesale ¢/lb.</u>	<u>Increment to Net Value - Retail ¢/lb.</u>	<u>Management Cost Adjustment ¢/lb.</u>	<u>Final Net Value ¢/lb.</u>
Chinook	91	6	-2	95
Sockeye	92	7	-3	96
Coho	83	6	-2	87
Pink	56	5	-1	60
Chum	54	4	-1	57

By combining the information contained in the previous Tables, it is now possible to estimate the total economic value of the Fraser River commercial salmon catch by species. This is done in Table IV.

Table IV

Total Net Economic Value of the Fraser River

Commercial Salmon Catch by Specie (\$1973)

	<u>Average Commercial Catch lbs.</u>	<u>Net Value Per Pound ¢/lb.</u>	<u>Total Net Value \$</u>
Chinook	2,378,300	95	2,259,400
Sockeye	23,523,200	96	22,582,300
Coho	1,141,800	87	993,400
Pink	13,327,500	60	7,996,500
Chum	5,604,600	57	3,194,600
			<u>37,026,200</u>

Thus, it is estimated that the total net value associated with an annual average catch of Fraser River salmon amounts to \$37 million.

3. Employment in the Commercial Industry

The activities evaluated above provide employment for a considerable number of British Columbians. Fully 25 percent of the salmon produced from British Columbia's rivers are of Fraser origin. It is clear then that the Fraser represents a critical difference between profit and loss, not only for many of British Columbia's 10,000 fishermen, but for the industry as a whole. Further, at the processing level, it is estimated that there are approximately 2,500 processing employees and 240 tendermen employed in the Greater Vancouver area - and the major portion of their efforts are associated with Fraser River salmon. A significant number of these individuals, because of lack of skills and/or training, have little or no opportunity for alternative employment.

B. Recreation Associated With Fraser River Salmon

1. The Value of Recreation

The products of a rich estuarine environment are perhaps most valuable to the people as a whole. These "products" are associated with fish and wildlife of all sorts, and are related to a range of recreational activities which include fishing, hunting, viewing, and simply knowing that such fauna exists for possible future use. Although British Columbians have chosen to guarantee the public availability of these products - and not, by and large, commit them to the private market, they are nevertheless valuable. A recent study² has estimated such values, for salmon in the Fraser River system, based upon household interviews of approximately 4,000 river basin residents. Annual mean values per household were established for sport fishing, boating, swimming, viewing, picnicking and hiking, and the component value associated with the salmon resource identified. The study sought recreational values within the context of community decision making with regard to public expenditure alternatives. The results of that study are presented in Table V.

² Philip A. Meyer, Recreational and Preservation Values Associated with the Salmon of the Fraser River, Environment Canada, Fisheries & Marine Service, 1974.

Table V

Annual Value of Fraser River Salmon -
Related Recreation

	<u>No. of</u> <u>Households</u> ³	<u>Value Per</u> <u>Household</u> ⁴ \$annual	<u>Regional</u> <u>Salmon-Related</u> <u>Recreation Value</u> \$'000
Lower Mainland ¹	399,500	462	184,600
Upriver Communities ²	65,404	188	12,300
TOTAL			196,900

¹ Defined as the referent area between Hope and the sea.

² Defined as all other areas of the Fraser River Basin

³ 1971 population data were adjusted by 3.1 percent annually to 1973 levels and divided by 3.2, the mean number of people per household.

⁴ Study values were expressed in 1972 dollars and have been increased by 3% to provide 1973 estimates.

It can be observed from Table V that the total annual Fraser River salmon-related recreational value for the residents of the river basin approximate \$197 million annually.

It should be noted that values associated with Fraser River salmon by residents of Vancouver Island, other residents of British Columbia, and visitors from outside the province are not included in this total.

2. Preservation of Fraser River Salmon

In addition to the values just noted, the value of preserving³ the salmon of the Fraser River was estimated in the previously cited study.⁴

Resultant preservation values are presented in Table VI.

³ Preservation value is defined as the value associated with knowing a resource or activity option is available, irrespective of use. In order for it to be "counted" in assessment of an environmental impact, there must be a reasonable presumption that (a) the resource is relatively unique, and (b) the negative resource impact will be irreversible.

⁴ P.A. Meyer, op.cit.

Table VI

Annual Preservation Value - Fraser River Salmon

	<u>No. of Households</u> ³	<u>Value Per Household</u> ⁴ \$ annual	<u>Fraser River Preservation Value</u> \$'000
Lower Mainland ¹	399,500	230	91,900
Upriver communities ²	65,404	230	15,000
TOTAL			106,000

¹ Defined as the referent area between Hope and the sea.

² Defined as all other area of the Fraser River Basin.

³ 1971 population data were adjusted by 3.1 percent annually to 1973 levels and divided by 3.2, the mean number of people per household.

⁴ Study values were expressed in 1972 dollars, and have been increased by 3 percent to provide 1973 estimates.

Again, only values associated with British Columbians resident in the Fraser River drainage basin are included. Total annual preservation values are seen to approximate \$106 million.

C. The Value of Fraser River Salmon to Indian Peoples

There are 91 Indian bands, with a non-reserve population of 11,800 and a full population of 17,900 located in the Fraser River area. This represents 48 percent of all bands and 37 percent of the total population of Indian peoples in British Columbia.

There is no accurate method of measuring in dollars the losses to the native peoples of the Fraser River Basin resulting from degradation of salmon stocks. In 1973 a study of the cultural relationship between native peoples and the salmon of the Fraser River - jointly sponsored by the Department of the Environment and the Union of British Columbia Indian Chiefs⁵ - was completed. Some of its conclusions follow.

⁵ Marilyn G. Bennett; Indian Fishing and its Cultural Importance in the Fraser River System, Department of the Environment, Fisheries Service, Pacific Region, and Union of British Columbia Indian Chiefs, Vancouver, 1973.

"First, the water itself is part of the traditional Indian way of life. Most reserves are located on or within one-half mile of the system's waterways. Changes in the riverine environment would disrupt the established link between the people and the river - a significant aspect of Indian existence.

Second, the fishery resource provides part of the food supply for a very high proportion of Indian families. If the fishery were adversely affected, a large number of Indians would be without sufficient food. It is doubtful whether alternative forms of sustenance would be acceptable. Most of those sampled said they would not substitute other foods in place of fish in their diet. Furthermore, because of the fact that fishing is a fundamental part of their lives, the loss of the fishery would detach the Indian people from the culture which they have developed throughout the centuries.

Third, while the fishery is a prime concern, other faunal and floral resources of the system play important roles in the continuing native subsistence effort.

Fourth, the major focus should be directed toward Region 3 - that part of the system from Lillooet upstream. It is here, where traditional culture is very pronounced, that food fishing is most intensively practised. Moreover, it is in Region 3 where threat of forced removal and resettlement is greatest. Although Indian reserves are often impoverished, the people find acceptance and stability within their surroundings. Were relocation to occur, the social consequences would be immeasurable. Alienation from one's roots of origin, dis-orientation and loss of purpose and identity in strange and new environments are factors which have been studied and analyzed with reference to other areas. Only one conclusion has remained clear: social costs are huge and monetary compensation has never proved adequate. The Indian's land, and the fish and other faunal and floral features upon it, are unquestionably the main remaining

ingredients of his traditional existence - an existence the deprivation of which is amply documented in both past and recent history."

Consequently, the native peoples of the Fraser River can be observed to have a direct and historic interest in the salmon stocks of the Fraser River system, and can be identified as possessing a major vulnerability with regard to negative impacts upon the system.

E. Summary and Conclusion

The Fraser River supports a commercial fishing industry worth in excess of \$73 million annually, and plays a major role in the livelihood of British Columbia's 10,000 fishermen. It also supports almost 3,000 processing and tendering employees in the Greater Vancouver area.

Recreational values associated with the Fraser salmon resource by residents of British Columbia are estimated at \$197 million annually and if the survival of total salmon stocks themselves were threatened, a further \$106 million would have to be added to this total. Further, the salmon resource generates substantial benefits to tourism, and the business activities associated therewith, which have not been calculated in the present report.

Ninety-one Fraser River Indian bands representing 17,900 native people view their land, and the fish and other faunal and floral features upon it, as the main remaining ingredients of their traditional existence. They would suffer serious economic, social and cultural deprivation if the salmon resources presently available to them were lost.

It can thus be observed that the beneficiaries of the living resources of the Fraser River include a broad cross-section of British Columbians. Further, associated as these benefits are, with the salmon resource - they are renewable. Benefits have been generated on the Fraser for centuries - and - with proper care of the natural riverine and estuarine environment, will continue to be generated for decades to come. It follows that any development that would risk these real and continuing benefits must bear the onus of a clear demonstration of greater rewards for the people of British Columbia, both now and in the future.

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