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WORKING PAPER ON GENETIC STOCK IDENTIFICATION METHODS FOR SOUTHERN CHUM SALMON

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GENETIC STOCK IDENTIFICATION METHODS FOR SOUTHERN CHUM SALMON

Terms of Reference

The Chum Technical Committee was assigned by the Pacific Salmon Commission three areas of investigation with respect to estimating stock composition using the genetic stock identification method (GSI), namely:

1) Attempt to develop agreed-upon criteria and methods for the application of currently available Genetic Stock Identification data to catch data.

2) Apply the above methodology to catch data for the fisheries for which adequate GSI data are available.

3) Evaluate and develop recommendations for standardization of GSI sampling, processing and analysis methods.

The following report summarizes information on the baseline stocks which have been sampled, the laboratory and statistical methods which are used, and the commercial fisheries that have been sampled. Recommendations are presented for the refinement of GSI studies.

Introduction

In the genetic method of stock identification, genetic variation is measured by examining variation in proteins as determined by electrophoresis. Electrophoresis provides a method to survey genetic variation rapidly in order to identify differences among stocks, and then uses these differences among stocks to estimate stock composition in mixed stock fisheries. Electrophoresis can be used to provide estimates of stock composition during the fishing season, thereby allowing managers to regulate commercial fisheries more effectively.

Collection of Baseline Samples

In order to apply the genetic method of stock identification to estimating stock composition in mixed stock fisheries, it is first necessary to determine the genetic characteristics of the stocks contributing to the fisheries. These characteristics are generally found to be stable on an annual basis.

Canada

In 1981, spawning ground collections of chum salmon were initiated in southern British Columbia in order to examine genetically based protein variation. Since 1981, 21 stocks from the Johnstone Strait and the Strait of Georgia have been surveyed, as well as 15 stocks from the west coast of Vancouver Island, and 12 stocks from the Fraser River and its tributaries (Fig. 1). Approximately 7000 chum salmon have been sampled from these 48 stocks (Table 1). With few exceptions, sample sizes were at least 100 fish per stock. In Canada, seven markers of the ten markers surveyed showed significant variation among Canadian stocks and were subsequently used in estimating stock composition. Nomenclature for the seven markers used are given in Table 2.

Chum salmon were sampled from 48 rivers in southern British Columbia. Although chum salmon spawn in many more rivers than were sampled, generally the sampling concentrated on the major spawning stocks in each region. Stocks that were sampled in the Fraser River generally comprise over 90% of the escapement to the Fraser River and its tributaries. In the South Coast region (east and west coast of Vancouver Island and mainland inlets) stocks sampled comprised in excess of 80% of the regional escapement. The analysis of fishery samples assumes that unsampled stocks within a region have genetic characteristics more similar to the stocks that were sampled in the region than to stocks in another region.

United States

The Washington State baseline data available for use were collected from 1976 through 1984 from a mixture of adult and juvenile fish (Table 3). Data collected in 1983 and 1984 were exclusively from adult fish, while samples from earlier years were primarily from juveniles. Sample sizes ranged from less than 50 fish to over 200 fish. In general, samples were taken from all stocks in Puget Sound which had an escapement of greater than 1000 fish. Stocks not sampled included those along the Washington coast, along the Strait of Juan de Fuca, and in the Puyallup River.

Although 48 markers were screened during the laboratory analysis, only 5 (Table 2) were subsequently used during analysis of the fishery samples. Two of the markers used in the Canadian analysis (Me and 6-Pg) were not used in the US analyses. The 5 markers used were selected for use because: 1) they showed the greatest genetic variation, and 2) they had also been used in the Canadian baseline database.

Collection of Fishery Samples

The methods used to sample fisheries are similar in the US and Canada. Samples are collected from heart, liver and muscle tissue from fish which have been caught within the last 24 hours. Each tissue sample is individually stored and care is taken that contamination from other tissues does not occur. The sample is then frozen and sent to a lab for processing. The fisheries for which samples are available and the methods used for analysis are summarized in Table 4.

Canada

Collection of GSI samples (either test fishing or commercial) between 1982 and 1986 has occurred in the following fishing areas: Johnstone Strait (areas 12 & 13); Mid Vancouver Island (Puntledge, Cape Lazo, Big Qualicum areas: Area 14); Strait of Georgia (Texada Island, Pender Harbour: Area 15); Nanaimo area (Area 17); Cowichan area (Area 18); Roberts Bank, Fraser River (Area 29); Juan de Fuca Strait (Area 20); Nitinat area (Area 21); and the northwest portion of Vancouver Island (areas 126 and 127) (Fig. 2). In general, attempts were made to sample throughout each weekly fishing period. Commercial samples were generally taken from packing vessels or from deliveries of a known origin. Sample size has ranged from approximately 100 to 150 fish with a goal of 150 fish in recent years.

Samples from fish migrating through Johnstone Strait were acquired from a purse seine test fishery which begin in September and continued weekly until early November. Commercial catches have not been sampled. In 1982, each weekly sample was collected during a single day utilizing each of the 5 to 6 test sets of that day. Collection of samples in subsequent years (1983 to 1986) occurred over the duration of daily test fishing (3 to 5 days per week). In 1984 and 1986, additional sampling occurred in lower Johnstone Strait (Area 13) and upper Johnstone Strait (Cracroft Pt. to Robson Bight), respectively.

Mid Vancouver Island (Area 14) sampling has occurred since 1982 utilizing both test fishing and commercial catch sampling (Fig. 3). In 1982, samples were collected using a gillnet test vessel. The 1983 samples were collected from the commercial catch. Extensive GSI sampling occurred throughout various sub-areas from 1984 to 1986. In 1984 and 1985, sampling was conducted in both the commercial and test fisheries. The objective of the test fisheries was to identify areas where Fraser River chum salmon comprised less than 10 percent of the sample. The test fisheries utilized both purse seine and gillnet vessels. Commercial fisheries were sampled to estimate the stock composition of the commercial catch. Based upon the test fishing conducted in 1984 and 1985, it was believed that areas in which Fraser River chum are abundant had been identified. For this reason, sampling in 1986 was limited to the commercial fishery.

Texada Island and Pender Harbour (Area 15) were sampled from a chartered gillnet vessel in 1982 and 1985, respectively. Although no commercial chum fishery has occurred recently in these areas, concerns of stock composition were addressed.

Area 17 (Nanaimo area) was sampled in two years (1982 and 1985).

Samples were collected from the commercial gillnet fishery in 1982 and from a gillnet test fishery in 1985. The latter samples were taken in two separate locations near the Nanaimo River.

Cowichan (Area 18) sampling occurred in 1982 and 1985 from gillnet test vessels.

In 1982, Area 29 sampling occurred within the Fraser River at the Albion gillnet test site. Roberts Bank, off the mouth of the Fraser River, was sampled sporadically from late October to late November from 1983 to 1985 using a gillnet test fishing vessel.

Juan de Fuca Strait (Area 20) sampling occurred during 1985 and 1986 and involved weekly sampling aboard a chartered purse seiner. Similar procedures to those used for the Johnstone Strait were adopted for sampling, that is, sampling occurred from all sets during each day to accumulate the weekly sample.

Initial sampling of the Nitinat fishery (Area 21) began in 1984 with more extensive sampling in 1985 and 1986. Collection was from gillnet and/or seine gear during commercial fisheries and from seine gear during test fishing in 1984.

Samples from the 1986 west coast of Vancouver Island troll fishery (areas 126 and 127) were collected from commercial day trollers returning to the northwest portion of Vancouver Island.

United States

Mixed stock smpling has been conducted within two areas in Puget Sound, the Strait of Juan de Fuca (Area 5) and north Puget Sound (Area 7 and Area 7A) (Figs. 4 and 5). The sampling methods used have varied among areas and years.

A test fishery was conducted in Area 7 at two locations (west side of Lummi Island and the Salmon Banks area) in 1983, 1984 and 1986, and at one location in 1985 (west side of Lummi Island). The locations of the test fisheries corresponded with favored commercial locations. A purse seine was used to collect fish in 1983 through 1985, and gillnet and purse seine vessels were used in 1986. Sampling was conducted approximately once weekly from mid-October to late November with a goal of collecting approximately 200 fish per day. A gillnet test fishery was instituted in Area 7A in 1986 which operated once weekly from early October to mid-November.

The commercial fishery in Area 7A (Pt. Roberts) was sampled on one occasion in 1985 and a total of 155 fish collected. Commercial fisheries in both Area 7 and Area 7A were sampled in 1986. A total of 893 fish were sampled in Area 7A and 410 in Area 7. All sampling took place on tender boats.

The commercial gillnet fishery in the Strait of Juan de Fuca

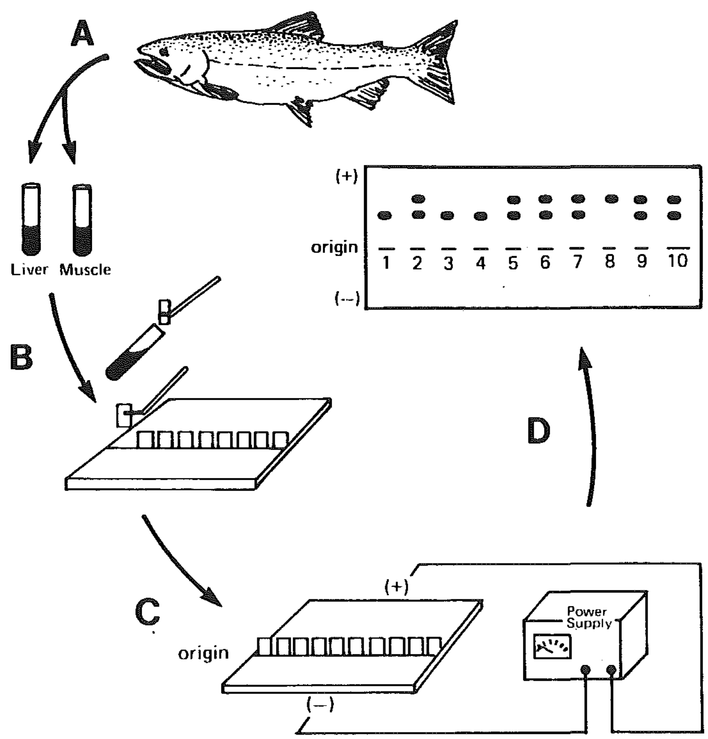
(Area 5) was sampled in the last two weeks of October in 1985 and from early October to early November in 1986. Sampling was conducted at tender boats three to four times weekly with an objective of sampling 200 fish per week. A total of 400 fish were sampled in 1985 and 1200 in 1986.

Analytical Methods

The general method of electrophoretic analysis is outlined in Box A below (from Milner et al 1985).

Box A.—Basic Electrophoretic and Laboratory Procedures.

A. Tissue samples (e.g., muscle, heart, liver, and eye) are taken from each fish and placed in a culture tube with a small amount of water. Cellular proteins in the tissue are released into solution by freeze/thaw and mechanical agitation procedures.
B. A protein extract from each fish is individually absorbed onto a filter paper wick and placed onto the edge of a starch gel at the origin. Samples from 10 fish are shown loaded in the diagram, although typically, samples from 50 fish are loaded on one gel (i.e., with 50 wicks).
C. A direct current is applied across the gel. Protein molecules absorbed on each wick enter and move through the gel because of the molecule's net electrical charge and at a rate proportional to this charge. This charge, in turn, depends on the genetically controlled amino acid substructure of the protein molecules.
D. After about 4 hours, the gel is removed from the power source and the positions of specific proteins (usually enzymes) in the gel are identified by specific histochemical staining procedures (i.e., using general staining reagents or specific procedures involving the enzyme in the staining process). The relative migration distances of the proteins from the origin, indicated by the staining zones, are recorded as the raw data. The simplified genetic model used for interpreting electrophoretic protein variation is that one gene codes for one protein (polypeptide) chain. Therefore, electrophoretic differences between individuals in protein patterns that are based on amino acid differences are a direct reflection of genetic differences between the individuals. The simple extension of genetic differences between individuals to the evaulation of genetic differences between populations is outlined in Box B.

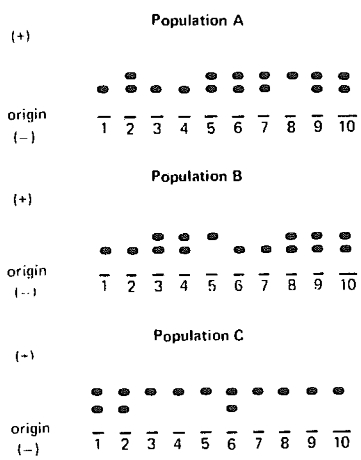


Steps for obtaining electrophoretic data.

The analysis of tissue samples has occurred in a number of laboratories. It is assumed that gels have been interpreted in a consistent manner. This assumption is supported by the consistency of the data for stocks which have been analyzed by different laboratories.

Once electrophoretic baseline data are acquired for stocks contributing to a fishery and a sample is available from the fishery, it is possible to estimate the most likely stock composition of the sample. The general method is outlined in Box B (from Milner et al. 1985).

Box B.—The Use of Electrophoretic Data in Applying the GSI Method.



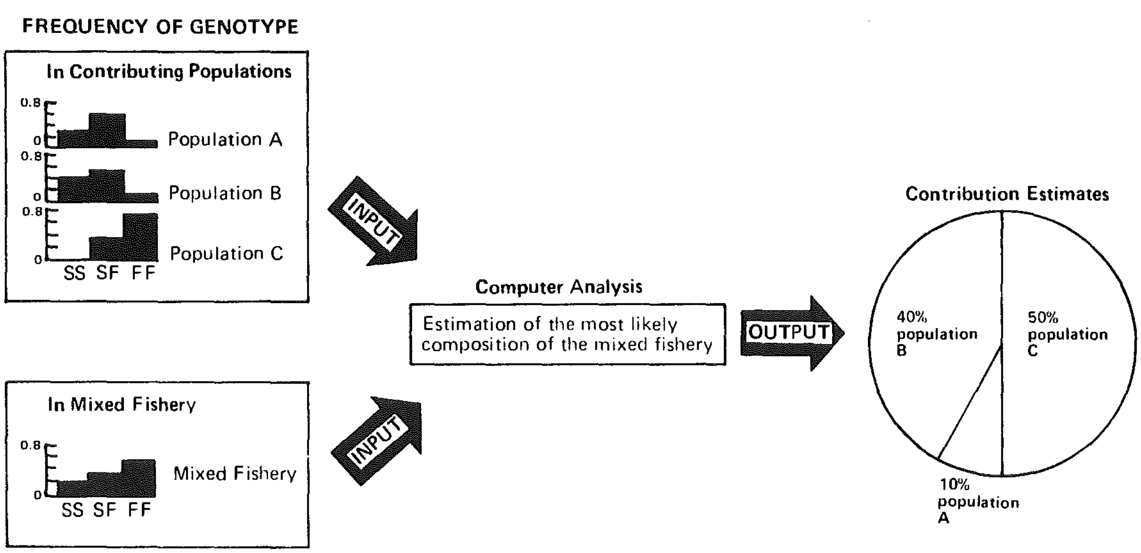
	Genotype frequency SS	SF	FF
Population A	3/10	6/10	1/10
Population B	4/10	5/10	1/10
Population C	0	3/10	7/10

Data from three gels are illustrated here to demonstrate general electrophoretic results and the classification of genotypes. Each gel contains a sample of 10 fish from one of three populations—A, B, or C. The samples are loaded at the origin and subjected to electrophoresis as outlined in Box A. The position of the enzymatic protein phosphoglucomutase (PGM) is made visible by a histochemical staining procedure specific for PGM. Each of the 10 fish in population A expresses one or both of the mobility forms of the protein PGM: A slow migrating form, S, and a fast migrating form, F.

These different electrophoretic expressions are direct reflections of the alleles (alternate forms of a gene) that direct the making of PGM. Fishes 1, 3, and 4 each have a single slow band in Population A. These fish received the same alleles from both parents for the manufacture of the PGM protein and are referred to as SS homozygotes. An SS homozygous individual, therefore, has two doses or copies of the S allele. Fish 8 has a single fast band and is an FF homozygote. Two bands are seen in six individuals of Population A. An individual with a double band has received dissimilar PGM alleles from its parents—here, an S allele from one parent and an F allele from the other—and is referred to as an SF heterozygote. The combination of alleles, e.g., SS, FF, or SF, that an individual possesses is referred to as its genotype. Genotypic frequencies are simply the proportions of homoyzgous and heterozygous genotypes for each protein system that is examined.

We have illustrated electrophoretic patterns for a protein that is functional as a single protein chain (i.e., a monomer). Although more complex staining patterns (i.e., phenotypes) can be seen for proteins functional as two or more protein chains, the genetic interpretation for variations of such proteins is parallel to that of monomeric proteins (Allendorf and Utter, 1979); single or multiple banded patterns are expressed by homozygous or heterozygous genotypes, respectively. We have also presented only two alternate alleles for the PGM protein system (S and F). Many protein systems have several allelic forms which increases their contribution to stock discrimination in GSI.

Genotypic frequencies are the fundamental sets of data that are needed to genetically characterize populations and to apply the GSI method. In the figure below, the genotypic proportions of all individuals sampled from a mixed fishery and those of three potentially contributing populations are jointly examined by a maximum likelihood procedure (outlined in Milner et al., footnote 3) to obtain estimates of the proportion of fish from each potentially contributing stock in the mixture.



Schematic of the GSI method using one variable protein system. In actual application, the power to discriminate between stocks and to estimate their contributions is increased by using the genetic variation found in many protein systems.

When the laboratory results are available, a computerized analysis of the data is required to estimate the stock composition. Both Canadian and United States estimates of stock composition are obtained using maximum likelihood techniques, but specific procedures differ. Different methods are also used to estimate the variance of the point estimate. The variance can be estimated from repeatedly sampling simulated mixtures (bootstrap simulations) (Canada), by the use of large sample maximum likelihood methods (United States), or by the infinitesimal jackknife (United States). Different methods may produce different variance estimates. It is not known which method provides the best estimate of variance.

The methods of analysis used by the US and Canada differ with respect to the aggregation of the baseline (spawning ground) samples. Canadian estimates of stock composition were derived with the individual Canadian stocks remaining discrete while United States stocks were pooled regionally (genotypic frequencies of all stock were not available). Regional estimates for the Canadian stocks were derived by summing the allocations of the individual group mamebers. United States estimates of stock composition were derived by first pooling stocks within each major region, and then using these pooled baseline data for determining stock composition on a regional basis.

Differences exist in the baseline data used by the US and Canada to represent US stocks. Canadian fisheries estimates relied upon data collected through 1979, while US studies have used data collected after 1979. Bias caused by differences in the specific baseline data used is likely to be small relative to other sources of error as allelle frequencies were fairly similar from 1976 to 1984. However, the Snohomish River was not included in the baseline data used by Canada.

Estimates of Stock Composition

Results from GSI studies in Canada for the years 1982 to 1986 are presented in Tables 5 to 11. Tables 12 to 17 present results from US studies from 1983 to 1985. The 1986 US samples have yet to be analyzed. Each table includes information on the area sampled, the fishing periods sampled, the number of fish sampled, and the estimated stock composition during each fishing period. Temporal trends in stock composition are plotted in Figures 6 to 16 and 17 to 22 for the major Canadian and United States fisheries, respectively. The stock composition estimates currently used for domestic fisheries management in Washington are compared with the estimates obtained from GSI studies in Table 18. Canadian fishery managers rely solely upon GSI estimates at this time.

Discussion

The accuracy and precision, and thus reliability, of the stock composition estimates presented in this report are dependent upon many factors. Among these are:

(1) The accuracy of genotypic frequencies in the baseline.

The sampling of Canadian stocks is believed adequate to provide reasonably accurate estimates of genotypic frequencies for the stocks examined. However, for some of the stocks sampled in Washington, the extensive use of juvenile samples may have resulted in biased estimates of the genotypic frequencies. This might occur if juveniles from a limited number of parents were collected during sampling.

(2) The magnitude and number of the differences in the markers among the stock groups that are to be distinguished.

Canadian managers believe that the current number and quality of markers is adequate to identify the country of origin of chum salmon in specific fisheries. United States managers suggest that it may be necessary to use additional markers in order to obtain reliable estimates of stock composition.

(3) The proportion of stocks that have been sampled that appear in the mixture.

Since stocks contributing to over 90% of the Fraser River escapement and 80% of the South Coast escapement and west coast of Vancouver Island escapement have been sampled, Canadian managers believe that Canadian stocks have been adequately sampled. United States managers believe that the absence of sampling of certain geographic stocks and/or run types in Washington may compromise the adequacy of the baseline samples.

(4) The similarity of genotypic frequencies of the unsampled stocks in a region to those stocks that were sampled.

If the unsampled stocks within a region are not similar to the sampled stocks, then samples from the unsampled stocks may be allocated to the wrong region. Analysis of the patterns of genetic variation in the Canadian stocks surveyed indicate that differences among stocks within a region are substantially less than among regions, and thus unsampled stocks appearing in the mixtures should not be misallocated. United States managers suggest that there may be substantial genetic differentiation among stocks within regions within Washington, and that misallocation may occur.

(5) The representativeness of the fishery sample.

Fishery samples are generally believed to be representative. Concerns which exist include the potential differences between test and commercial fisheries in Johnstone Strait and in US areas 7 and 7A, potential differences between day and freezer boats in the WCVI troll fishery, and the freqency of sampling in Roberts Bank and US areas 5 and 7A in the years prior to 1986.

(6) The number of fish that have been sampled.

Samples from Canadian fisheries have generally ranged between 100 and 150 fish, and those from United States fisheries between 100 and 200 fish. Sample sizes should be adjusted to achieve the desired level of precision and accuracy.

(7) The analytical methods used in estimating stock compositions.

Canadian and US analyses have used the same likelihood function, but different methods are used in the maximization procedure. In addition, several shortcomings exist in the statistical methods used in the analysis of the Washington fishery data. The baseline data were aggregated into stock groupings prior to analysis of the fishery sample, a procedure which can be expected to bias the results of the analysis. Variance estimates were calculated using an asymptotic covariance matrix and may also be biased.

Recommendations

The GSI studies which have been conducted indicate that electrophoretic techniques can be used to estimate the stock composition of chum catches. However, the utility (for Pacific Salmon Commission deliberations) of estimates computed by this technique is limited at this time by questions regarding the consistency of the methods used in the two countries.

To resolve these questions, a review program will be conducted to:

1) Evaluate and compare the statistical methods used to estimate stock composition and the variance of this estimate;

2) Evaluate the sampling design for commercial and test fisheries;

3) Develop a common baseline data base;

4) Incorporate additional stocks in the US baseline;

5) Evaluate the utility of additional markers.

6) Evaluate methods to apply the stock composition estimates to catch data.

The Chum Technical Committee is developing recommendations regarding the specific tasks to be completed and an anticipated time schedule for completion of the review program.

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TABLE 1. NUMBER OF CHUM SALMON SAMPLED FOR ELECTROPHORETIC ANALYSIS IN SOUTHERN BRITISH COLUMBIA STOCKS, 1981-85.

STOCK	1981	1982	1983	1984	1985	TOTAL
SOUTH COAST						
GOLDSTREAM		92				92
COWICHAN		200		84		284
CHEMAINUS	53	100				153
NANAIMO	100	100		108		308
LITTLE QUALICUM	200	100		100		400
BIG QUALICUM	200			101		301
ROSEWALL		92				92
PUNTLEDGE	200	100		101		401
NIMPKISH		87				87
INDIAN	50					50
MAMQUAM		101				101
SQUAMISH			100	101		201
CHEAKAMUS	100			104		204
TZOONIE		107				107
SALTERY BAY		70		97		167
SLIAMMON	100					100
OKEOVER		103				103
TOBA			103	51		154
ORFORD			100			100
HOMATHKO		104				104
SOUTHGATE			106			106
FRASER RIVER						
FRASER		95				95
WAHLEACH		100		100		200
WEAVER	100					100
CHEHALIS		100	100	102	102	404
SQUAKUM	25	100				125
HARRISON	200	100				300
INCH	100	53			103	256
CHILQUA			100			100
VEDDER	200	100				300
STAVE		100				100
BLANEY		100		54		154
ALOUETTE			100	100		200
W.C. VAN. IS.						
NITNAT				100	100	200
CONUMA				100	100	200
SARITA				101	100	201
ATLEO				100	100	200
MARBLE				97		97
STEVENS				100		100
TAHSISH				100		100
THORNTON				100		100
NAHMINT				100		100
TAHSIS				100		100
CANTON					100	100
SUCOWA					100	100
BURMAN					100	100
ZEBALLOS					100	100
MEGIN					100	100

Table 2. Enzymes and tissues used for investigation of protein variability in chum salmon.

ENZYME	TISSUE	LOCUS ABBREVIATION CANADA	U S
Glycerol-3-phosphate dehydrogenase or Alpha-glycerol-3-phosphate dehydrogenase (AGP, EC 1.1.1.8)	Heart	Agp-2	G3pdh-2 or AGP-2
Isocitrate dehydrogenase (IDH, EC 1.1.1.42)	Muscle Liver	Idh-1 Idh-3	
Malate dehydrogenase or[1] Malic enzyme (ME, EC 1.1.1.40)	Muscle	Me	MdhP-2 or ME
Tripeptide aminopeptidase or Peptidase (leucylglycylglycine) (LGG, EC 3.4.14.9)	Muscle	Lgg	Tapep-1 or LGG-mf
Phosphogluconate dehydrogenase[1] 6-Phosphogluconate dehydrogenase (EC 1.1.1.44)	Muscle	6-Pg	Pgdh or 6Pg
Mannose-6-phosphate isomerase Phosphomannoisomerase (PMI, EC 5.3.1.8)	Heart	Pmi	Mpi

1 Not used for Washington analysis.

Table 3. Stocks sampled, stock type, age at time of sample, sample size, and date of collection for stocks currently in the Washington baseline data base. (Source: Wishard 1980; Wishard 1981; Wishard et al. 1985)

Stock	Stock Type	Age	Sample Size	Collection Date
<u>North Puget Sound</u>				
Chuckanut Creek	Normal	Adult	15	1979
Maple Creek	Normal	Adult	25	Dec. 1983
Nooksack River	Normal	Adult	70	Oct. 1980
Nooksack River	Normal	Adult	85	Dec. 1983 Jan. 1984
Kendall Hatchery (Nooksack River)	Normal	Adult	114	Dec. 1983
Samish River	Normal	Adult	210	Dec. 1984
Skagit River				
Skagit Hatchery	Normal	?	92	April 1977
Skagit Hatchery	Normal	?	50	April 1978
Rockport	Normal	?	20	April 1979
Lyman	Normal	?	47	April 1979
Ilabot Slough	Normal	?	67	Dec. 1978
Skagit River	Normal	Adult	96	1979
Skagit River	Normal	Adult	83	1983
Skagit River	Normal	Adult	332	Oct.-Dec. 1984
Skykomish River	Normal	Adult	52	1983
Snohomish River	Normal	Adult	298	Nov.-Dec. 1984
Stillaguamish River				
Ashton	Normal	?	31	Dec. 1978
Jim Creek	Normal	?	47	May 1977
Squire Creek	Normal	?	57	Dec. 1978
Furland Creek	Normal	?	20	Dec. 1978
Stillaguamish River	Normal	Juvenile	97	May 1980
Stillagumaish River	Normal	Adult	141	1983
Stillaguamish River	Normal	Adult	298	Nov.-Dec. 1984
<u>Hood Canal</u>				
Big Beef Creek	Normal	?	15	Dec. 1976
Big Beef Creek	Normal	Juvenile	100	April 1980
Big Mission Creek	Normal	Juvenile	77	April 1980
Big Mission Creek	Normal	Juvenile	146	March 1981
Big Quilcene River	Normal	?	39	Oct. 1976
Dewatto River	Normal	?	49	Dec. 1976
Dewatto River	Normal	Juvenile	99	April 1980
Dewatto River	Early	Juvenile	108	Jan. 1981
Duckabush River	Early	Juvenile	22	Feb. 1981
Eagle Creek	Normal	?	51	1976
Fulton Creek	Late	?	30	1976
Hamma Hamma River	Normal	Juvenile	110	March 1981
Hamma Hamma River	Normal	?	36	Oct. 1976
Hoodsport Hatchery	Normal	?	50	April 1977

Table 3. (continued)

Stock	Stock Type	Age	Sample Size	Collection Date
Hoodsport Hatchery	Normal	?	101	Nov. 1978
Hoodsport Hatchery	Normal	Adult	94	Dec. 1980
Jorstad Creek	Normal	?	50	1976
Jorstad Creek	Normal	?	99	Dec. 1978
Jorstad Creek	Normal	Adult	44	Dec. 1980
Jorstad Creek	Normal	Juvenile	76	March 1981
Lilliwaup Creek	Early	Juvenile	100	Jan. 1981
Lilliwaup Creek	Early	?	50	Dec. 1976
Little Mission Crk.	Normal	Juvenile	100	April 1980
Little Quilcene R.	Normal	?	55	Oct. 1976
N. F. Skokomish R.	Normal	Juvenile	98	March 1980
Seabeck Creek	Normal	Juvenile	100	April 1980
Spencer Creek	Normal	Juvenile	116	March 1980
Tahuya River	Early	?	54	Sept. 1976
Tahuya River	Late	?	54	Dec. 1976
Tahuya River	Normal	?	100	Dec. 1978
Tahuya River	Early	Juvenile	112	Jan. 1981
Tahuya River	Normal	Juvenile	102	March 1981
Twanoh Creek	Normal	Adult	86	Dec. 1980
Union River	Normal	Juvenile	100	March 1981
Walcott Slough	Late	?	100	Dec. 1978
<u>South Puget Sound</u>				
Blackjack Creek	Normal	Juvenile	107	April 1980
Chambers Creek	Normal	?	20	Feb.,March 1977
Chambers Creek	Normal	Juvenile	100	April 1980
Chico Creek	Normal	?	50	Dec. 1976
Chico Creek	Normal	Juvenile	74	April 1980
Chico Creek	Normal	Adult	99	Nov. 1980
Coulter Creek	Normal	?	45	Oct.,Dec. 1976
Coulter Creek	Normal	Juvenile	100	May 1980
Crescent Creek	Normal	Juvenile	81	April 1981
Gorst Creek	Normal	?	54	Jan. 1977
Gorst Creek	Normal	Juvenile	100	April 1981
Johns Creek	Normal	?	100	Oct.,Dec. 1976
Johns Creek	Normal	Juvenile	106	April 1980
Johns Creek H.	Normal	Juvenile	100	April 1980
Kennedy Creek	Normal	?	94	Nov. 1978
Kennedy Creek	Normal	Adult	95	Nov. 1979
Lackey Creek	Normal	?	50	Dec. 1976
Lackey Creek	Normal	Juvenile	100	April 1980
Mill Creek	Normal	Adult	50	Nov. 1977
Mill Creek	Normal	Juvenile	86	March 1980
Minter Creek	Normal	Juvenile	142	May 1980
Muck Creek	Normal	Adult	93	Jan. 1980
Nisqually River	Late	?	55	1976
Nisqually River	Late	Adult	118	Feb. 1978

Table 3. (continued)

Stock	Stock Type	Age	Sample Size	Collection Date
Perry Creek	Normal	?	52	1976
Perry Creek	Normal	Juvenile	100	April 1980
Sherwood Creek	Normal	Juvenile	100	May 1980
Sherwood Creek	Normal	?	50	Oct. 1976
Skookum Creek	Normal	Juvenile	110	April 1980
Swift Creek	Normal	?	50	1976
Swift Creek	Normal	?	99	Dec. 1978
Swift Creek	Normal	Juvenile	100	April 1980

Table 4. Summary of chum fisheries for which electrophoretic estimates of stock composition are available and the methods (see key below) used to compute those estimates.

Fishery	Area	Year	Fishery Type	Point Estimate	Aggregation Method	Variance Estimate
Johnstone Strait	12	82-86	Test	CO	AS	B
Johnstone Strait Cracroft Pt.	12	86	Test	CO	AS	B
Johnstone Strait	13	84	Test	CO	AS	B
Mid-Vancouver Island	14	82,84,85	Test	CO	AS	B
Mid-Vancouver Island	14	83-86	Com	CO	AS	B
Strait of Georgia	15	82,85	Test	CO	AS	B
Nanaimo	17	82	Com	CO	AS	B
Nanaimo	17	85	Test	CO	AS	B
Cowichan	16	82,85	Test	CO	AS	B
Fraser River Albion	29	82	Test	CO	AS	B
Fraser River Roberts Bank	29	83-85	Test	CO	AS	B
Strait Juan de Fuca (Canada)	20	85-86	Test	CO	AS	B
Nitinat	21	84	Test	CO	AS	B
Nitinat	21	85-86	Com	CO	AS	B
NW Vancouver Island	126,127	86	Com	CO	AS	B
San Juans (US)	7	83-86	Test	EM	PA	A
San Juans (US)	7	86	Com	-	-	-
Pt. Roberts	7A	86	Test	-	-	-
Pt. Roberts	7A	85-86	Com	EM	PA	A
Strait Juan de Fuca (US)	5	85-86	Com	EM	PA	A

Point Estimates
- CO Constrained optimization (Fournier et al. 1984)
- EM EM algorithm (Milner et al. 1981)
- \- Analysis not completed.

Aggregation Method
- AS Allocate and sum (Wood et al. 1987). Note: For Canadian studies which used this method, US stocks were pooled into regions prior to analysis.
- PA Pool and allocate (Wood et al. 1987).
- \- Analysis not completed.

Variance Estimates
- B Bootstrap (Fournier et al. 1984)
- A Asymptotic maximum likelihood (Milner et al. 1981)
- \- Analysis not completed.

TABLE 5. G.S.I. RESULTS FROM JOHNSTONE STRAIT TEST FISHING, 1982 TO 1986.
(FR=FRASER, JS,GS=JOHNSTONE/GEORGIA STRAIT, US=WASHINGTON STATE

AREA	WEEK ENDING DATE	SAMP. SIZE	% FR		% JS,GS		% US	
			1982 STOCK COMPOSITION - AREA 12					
12	04-Sep-82	109	50.6	(21.4)	48.1	(21.5)	1.4	(2.8)
12	11-Sep-82	110	32.9	(17.8)	60.3	(16.1)	6.8	(7.1)
12	18-Sep-82	110	34.1	(21.8)	61.6	(22.5)	4.3	(3.5)
12	25-Sep-82	110	24.7	(16.6)	59.9	(15.5)	15.5	(11.0)
12	02-Oct-82	118	16.0	(13.9)	81.7	(13.3)	2.4	(4.8)
12	09-Oct-82	120	2.4	(5.8)	94.0	(6.7)	3.6	(4.2)
12	16-Oct-82	120	32.2	(15.0)	64.3	(16.3)	3.6	(5.8)
12	23-Oct-82	42	14.6	(18.5)	85.1	(18.6)	0.4	(1.0)
12	30-Oct-82	120	18.1	(16.9)	71.7	(16.2)	10.2	(10.1)
			1983 STOCK COMPOSITION - AREA 12					
12	10-Sep-83	77	56.3	(19.7)	42.0	(19.8)	1.7	(4.3)
12	17-Sep-83	101	53.7	(18.2)	43.0	(16.0)	3.4	(4.8)
12	24-Sep-83	100	41.3	(16.2)	58.6	(16.2)	0.1	(0.1)
12	01-Oct-83	100	21.5	(16.9)	71.6	(16.8)	7.0	(7.3)
12	08-Oct-83	99	37.6	(19.0)	57.6	(16.3)	4.8	(7.1)
12	15-Oct-83	100	30.0	(15.8)	65.4	(14.7)	4.7	(4.9)
12	22-Oct-83	100	16.2	(11.6)	83.0	(11.6)	0.9	(1.9)
12	29-Oct-83	100	18.7	(13.2)	81.1	(13.5)	0.3	(0.7)
			1984 STOCK COMPOSITION - AREA 12					
12	08-Sep-84	96	40.0	(21.3)	59.8	(21.0)	0.2	(0.9)
12	15-Sep-84	100	60.6	(14.7)	37.7	(14.5)	1.8	(3.1)
12	22-Sep-84	101	45.8	(19.8)	50.2	(18.9)	4.0	(5.3)
12	29-Sep-84	100	29.9	(17.1)	67.9	(16.6)	2.3	(4.7)
12	06-Oct-84	129	37.2	(15.6)	59.4	(15.0)	3.5	(5.6)
12	13-Oct-84	88	29.6	(16.9)	67.5	(15.9)	3.0	(4.3)
12	20-Oct-84	152	21.2	(11.5)	76.0	(11.2)	2.9	(3.8)
12	27-Oct-84	153	19.6	(14.9)	79.3	(15.1)	1.2	(3.3)
			1985 STOCK COMPOSITION - AREA 12					
12	07-Sep-85	109	73.5	(15.2)	21.5	(13.5)	5.1	(5.4)
12	14-Sep-85	146	72.2	(14.9)	23.8	(15.3)	4.0	(5.8)
12	21-Sep-85	153	40.2	(11.8)	53.0	(12.2)	6.8	(5.7)
12	28-Sep-85	153	43.1	(14.9)	53.1	(15.0)	3.9	(4.3)
12	05-Oct-85	152	30.7	(15.5)	53.4	(13.8)	16.0	(7.5)
12	12-Oct-85	148	29.3	(13.9)	58.3	(15.1)	12.5	(7.5)
12	19-Oct-85	151	28.5	(13.7)	64.1	(14.6)	7.5	(7.6)
12	26-Oct-85	148	4.0	(8.4)	86.6	(9.4)	9.4	(7.5)
12	02-Nov-85	154	23.8	(13.5)	68.6	(13.7)	7.6	(5.8)
			1986 STOCK COMPOSITION - AREA 12					
12	06-Sep-86	141	50.2	(14.4)	45.4	(13.4)	4.5	(6.1)
12	13-Sep-86	153	42.9	(16.1)	52.1	(13.8)	5.0	(6.5)
12	20-Sep-86	150	37.6	(12.1)	62.2	(11.9)	0.2	(0.7)
12	27-Sep-86	150	83.7	(11.1)	16.3	(11.1)	0.0	(0.0)
12	04-Oct-86	150	30.2	(12.1)	67.8	(11.9)	2.0	(3.5)
12	11-Oct-86	150	18.5	(12.0)	78.5	(12.9)	3.1	(5.5)
12	18-Oct-86	150	36.9	(15.3)	60.2	(14.3)	2.9	(3.6)
12	25-Oct-86	150	40.9	(12.8)	58.3	(13.1)	0.8	(1.8)
12	01-Nov-86	150	24.0	(13.8)	68.9	(12.4)	7.1	(6.6)
12	08-Nov-86	150	12.5	(12.1)	67.0	(11.9)	20.5	(10.5)

GSI DATA 1982 TO 1985 FROM BEACHAM ET AL. 1987
GSI DATA 1987 FROM JOHNSTONE STRAIT MANAGEMENT GROUP
( ) = Standard Deviation
FILE..TFALL.WK1 DISK..UPP. JOHNSTONE ST TEST FISH #3 (T)

TABLE 6. G.S.I. RESULTS FROM JOHNSTONE STRAIT TEST FISHING, 1984 AND 1986.
(FR=FRASER, JS,GS=JOHNSTONE/GEORGIA STRAIT, US=WASHINGTON STATE

1984 STOCK COMPOSITION - AREA 13

AREA	WEEK ENDING DATE	SAMP. SIZE	% FR		% JS,GS		% US	
13	06-Oct-86	265	14.7	*	82.8	*	2.6	*
13	13-Oct-86	149	51.9	*	48.0	*	4.2	*
13	20-Oct-86	150	41.6	*	58.4	*	0.1	*
13	27-Oct-86	151	35.9	*	56.3	*	7.9	*
			1986 STOCK COMPOSITION - AREA 12					
			Cracroft Pt. - Robson Bight (vessel 2)					
12	27-Sep-86	150	54.4	(14.1)	43.6	(13.7)	2.0	(3.9)
12	04-Oct-86	150	30.3	(15.9)	65.8	(15.8)	3.9	(4.6)
12	11-Oct-86	150	30.8	(17.4)	68.8	(17.6)	0.4	(1.6)
12	18-Oct-86	150	16.9	(13.2)	81.8	(13.3)	1.4	(3.4)
12	25-Oct-86	150	52.2	(16.3)	39.8	(16.5)	8.0	(6.7)
12	01-Nov-86	150	28.3	(15.0)	70.1	(15.9)	1.7	(4.1)
12	08-Nov-86	148	35.4	(19.4)	60.8	(18.5)	3.9	(4.3)

DATA SOURCE : JOHNSTONE STRAIT MANAGEMENT GROUP
( ) = Standard Deviation
* = Point estimate
FILE..TFALL.WK1 DISKDISK..UPPER JOHNSTONE ST TEST FISH #3

TABLE 7. G.S.I. AREA 14 (QUALICUM) SAMPLING, 1982 AND 1986.
(FR=FRASER, JS,GS=JOHNSTONE/GEORGIA STRAIT, US=WASHINGTON STATE

1982 AND 1983 STOCK COMPOSITION - AREA 14

AREA		WEEK ENDING DATE	SAMP. SIZE	% FR		% JS,GS		% US	
14-11		1982	255	6.7	(5.9)	86.0	(8.4)	7.4	(7.1)
14-12	C	1983	100	37.0	(12.3)	60.2	(12.7)	2.8	(5.1)
1984 STOCK COMPOSITION - AREA 14									
14-5		13-Oct-84	179	35.8	*	63.8	*	3.1	*
14-5		20-Oct-84	65	2.3	*	97.4	*	0.1	*
14-5		27-Oct-84	155	21.9	*	64.5	*	13.7	*
14-7		27-Oct-84	82	1.2	*	86.1	*	12.6	*
14-9		20-Oct-84	106	3.6	*	81.8	*	14.9	*
14-9		27-Oct-84	153	11.8	*	84.5	*	3.8	*
14-10		20-Oct-84	108	15.5	*	72.3	*	12.2	*
14-10		27-Oct-84	145	29.1	*	65.2	*	5.7	*
14-5,7	C	20-Oct-84	147	1.5	*	98.0	*	0.3	*
14-5,7	C	27-Oct-84	140	0.2	*	98.9	*	0.6	*
14-5,7	C	03-Nov-84	146	1.6	*	94.6	*	3.8	*
14-5,7	C	10-Nov-84	153	1.8	*	88.4	*	9.9	*
1985 STOCK COMPOSITION - AREA 14									
14-10		19-Oct-85	95	34.6	*	41.3	*	24.4	*
14-9		19-Oct-85	83	1.7	*	88.5	*	9.8	*
14-9		19-Oct-85	128	0.9	*	94.3	*	5.0	*
14-10		19-Oct-85	47	44.3	*	55.6	*	1.0	*
14-10		26-Oct-85	150	2.6	*	91.6	*	5.7	*
14-5		26-Oct-85	147	0.3	*	82.6	*	17.1	*
14-9		26-Oct-85	100	14.9	*	72.0	*	13.4	*
14-9		02-Nov-85	149	4.8	*	87.4	*	7.9	*
14-10		02-Nov-85	150	8.8	*	84.9	*	6.4	*
14-5	C	12-Oct-85	150	35.3a	*	64.5	*	0.1	*
14-4	C	19-Oct-85	104	1.1	*	93.1	*	5.9	*
14-11	C	19-Oct-85	150	0.3	*	99.2	*	0.0	*
14-4,5	C	26-Oct-85	145	5.5	*	84.6	*	9.6	*
14-11	C	26-Oct-85	146	15.1	*	83.5	*	1.7	*
14-4,5	C	02-Nov-85	149	1.8	*	98.0	*	0.1	*
1986 STOCK COMPOSITION (AREA 14)									
14-5,7	C	11-Oct-86	109	9.1	(12.4)	66.5	(11.8)	24.4	(9.4)
14-5,7	C	18-Oct-86	150	16.9	(12.5)	74.9	(12.6)	8.3	(6.3)
14-5,7	C	25-Oct-86	144	37.5	(15.0)	54.0	(14.7)	8.5	(7.7)
14-9	C	25-Oct-86	150	9.6	(7.9)	88.7	(9.4)	1.7	(3.6)
14-5,7	C	01-Nov-86	142	27.1	(12.5)	71.9	(12.6)	1.0	(2.5)
14-9	C	01-Nov-86	140	17.9	(11.7)	74.0	(12.6)	8.1	(7.5)
14-5,7	C	08-Nov-86	150	18.1	(13.4)	76.5	(13.9)	5.4	(5.2)
14-9	C	08-Nov-86	149	20.2	(9.8)	78.3	(10.2)	1.5	(3.9)

DATA SOURCE : 1982, 1983 DATA FROM BEACHAM ET AL. 1987
1984 TO 1986 DATA FROM JOHNSTONE STRAIT MANAGEMENT GROUP
C = Commercial Fishery Sample ( ) = Standard Deviation * = Point Estimate

TABLE 8. G.S.I. RESULTS FROM AREA 16, 17 & 18 SAMPLING, 1982 AND 1985.
(FR=FRASER, JS,GS=JOHNSTONE/GEORGIA STRAIT, US=WASHINGTON STATE

LOCATION	WEEK ENDING DATE	SAMP. SIZE	% FR		% JS,GS		% US	
			1982 & 1985 STOCK COMPOSITION - AREA 16					
TEXADA	1982	116	4.3	(5.1)	94.6	(6.2)	1.1	(2.1)
PENDER H.	02-Nov-85	143	37.2	*	51.9	*	11.0	*
PENDER H.	02-Nov-85	110	32.6	*	65.0	*	2.4	*
			1982 & 1985 STOCK COMPOSITION - AREA 17					
NANAIMO C	1982	98	24.7	(18.8)	43.2	(15.1)	32.2	(14.0)
NECK PT.	26-Oct-85	88	16.3	*	73.8	*	9.9	*
ENTRANCE	02-Nov-85	50	26.9	*	53.1	*	20.1	*
ENTRANCE	16-Nov-85	133	36.9	*	61.6	*	1.5	*
ENTRANCE	26-Oct-85	148	28.6	*	62.2	*	9.2	*
NEWCASTLE	26-Oct-85	118	16.0	*	77.9	*	6.1	*
NEWCASTLE	02-Nov-85	162	4.4	*	86.3	*	9.3	*
NEWCASTLE	16-Nov-85	150	13.9	*	83.4	*	2.7	*
				*		*		*
			1982 & 1985 STOCK COMPOSITION - AREA 18					
COWICHAN C	1982	191	10.0	(8.3)	86.4	(9.0)	3.7	(4.7)
SATELITE	09-Nov-85	150	11.5	*	78.4	*	10.1	*

DATA SOURCE : 1982 DATA FROM BEACHAM ET AL. 1987
1985 DATA FROM JOHNSTONE STRAIT MANAGEMENT GROUP

C = Commercial Fishery Sample
( ) = Standard Deviation
* = Point Estimate

TABLE 9. G.S.I. RESULTS FROM STRAIT OF JUAN DE FUCA SAMPLING, 1985 & 1986.
(FR=FRASER, JS,GS=JOHNSTONE/GEORGIA STRAIT, US=WASHINGTON STATE, WCVI=W. C. VAN. IS.)

AREA	WEEK ENDING	SAMPLE SIZE	% FR		% GS		% US		% WCVI	
			1985 STOCK COMPOSITION - AREA 20							
20	05-Oct-85	150	50.6	(13.9)	12.3	(11.0)	6.3	(5.3)	30.8	(10.2)
20	12-Oct-85	150	12.0	(12.1)	20.7	(10.9)	25.2	(9.1)	42.1	(8.7)
20	19-Oct-85	97	18.8	(11.9)	7.2	(8.3)	6.1	(7.8)	68.0	(11.2)
			1986 STOCK COMPOSITION - AREA 20							
20	27-Sep-86	151	44.5	(14.8)	54.7	(14.4)	0.7	(1.5)	0.1	(0.1)
20	04-Oct-86	150	67.2	(18.2)	20.0	(15.2)	9.5	(8.1)	3.4	(5.0)
20	11-Oct-86	150	27.7	(14.6)	49.0	(14.4)	10.1	(6.4)	21.2	(57.8)
20	18-Oct-86	150	19.0	(13.2)	13.9	(9.8)	43.7	(10.0)	23.3	(9.6)
20	25-Oct-86	100	6.4	(7.6)	49.6	(11.1)	26.0	(8.5)	18.0	(8.1)
20	01-Nov-86	200	4.7	(5.4)	15.5	(8.8)	26.7	(4.9)	53.2	(9.1)

DATA SOURCE : JOHNSTONE STRAIT MANAGEMENT GROUP
( ) = STANDARD DEVIATION
FILE..20TF8586
DISK..UPPER JOHNSTONE STRAIT TEST FISHING #3

TABLE 10. G.S.I. RESULTS FROM NITNAT (AREA 21) SAMPLING, 1984 TO 1986.
(FR=FRASER, JS,GS=JOHNSTONE/GEORGIA STRAIT, US=WASHINGTON STATE, WCVI=W.C. VAN. IS.)

AREA	WEEK ENDING	SAMPLE SIZE	% FR	% GS	% US	% WCVI
			1984 STOCK COMPOSITION - AREA 21			
21	1984	249	3.1 (4.1)	17.1 (7.4)	0.0 (0.0)	79.8 (7.3)
			1985 STOCK COMPOSITION - AREA 21			
21	12-Oct-85	137	8.4 (9.6)	13.8 (11.0)	4.5 (5.8)	73.3 (11.6)
21	19-Oct-85	150	3.0 (2.9)	7.4 (8.1)	11.8 (7.7)	77.8 (10.3)
21	26-Oct-85	144	12.0 (8.9)	21.9 (11.9)	1.9 (3.2)	64.2 (11.8)
			1986 STOCK COMPOSITION - AREA 21			
21	04-Oct-86	150	11.5 (8.1)	18.8 (12.3)	0.4 (1.1)	69.4 (12.4)
21	11-Oct-86	150	29.4 (10.1)	4.2 (7.2)	0.0 (0.0)	66.3 (10.3)
21	18-Oct-86	150	3.5 (6.0)	16.9 (8.5)	2.5 (4.5)	77.1 (9.6)
21	25-Oct-86	140	5.6 (6.5)	12.2 (10.9)	11.9 (9.0)	70.3 (11.5)
21	01-Nov-86	149	0.8 (2.3)	1.2 (3.2)	5.4 (4.5)	92.6 (5.4)

DATA SOURCE : 1984 FROM BEACHAM ET AL. 1987
1985 & 1986 FROM JOHNSTONE STRAIT MANAGEMENT GROUP
( ) = STANDARD DEVIATION

FILE..21TF8586
DISK..UPPER JOHNSTONE STRAIT TEST FISHING #3

TABLE 11. G.S.I. RESULTS FROM AREA 26 & 29 SAMPLING, 1983 TO 1985.
(FR=FRASER, JS,GS=JOHNSTONE/GEORGIA STRAIT, US=WASHINGTON STATE, WCVI=W.C. VAN. IS.)

AREA	WEEK ENDING	SAMPLE SIZE	% FR	% GS	% US	% WCVI
			1985 STOCK COMPOSITION - AREA 26 (NOOTKA)			
26	28-Sep-85	141	2.8 (4.0)	2.0 (3.8)	8.0 (6.1)	87.2 (7.8)
			1982 STOCK COMPOSITION - AREA 29 (FRASER)			
29	1982	500	80.4 (9.2)	17.8 (7.9)	2.8 (3.3)	NA
			1983 TO 1985 STOCK COMPOSITION - AREA 29 (ROBERTS BANK)			
29	1983	188	58.3 (11.9)	35.1 (11.3)	6.7 (4.6)	NA
29	1984	260	41.2 (14.1)	46.2 (11.6)	12.7 (7.1)	NA
29	16-Nov-85	115	85.8 (10.0)	3.6 (6.1)	10.7 (8.9)	NA

DATA SOURCE :FROM BEACHAM ET AL. 1987
( ) = STANDARD DEVIATION

FILE..29TF8385.WK1
DISK..UPPER JOHNSTONE STRAIT TEST FISHING #3

Table 12. Estimated percentage stock composition (p), standard deviation (SD), and sample size for weekly sampling of the San Juan Island (Area 7) test fishery in 1983.

Week Ending	No. of Samples	Fraser p	Fraser SD	Other Canadian p	Other Canadian SD	US p	US SD
Oct. 15	124	90	44	0	33	10	21
Oct. 29	192	86	30	0	26	14	20
Nov. 5	242	88	32	0	26	13	18
Nov. 12	163	78	36	0	26	22	20

Table 13. Estimated percentage stock composition (p), standard deviation (SD), and sample size for weekly sampling of the San Juan Island (Area 7) test fishery in 1984.

Week Ending	No. of Samples	Fraser p	Fraser SD	Other Canadian p	Other Canadian SD	US p	US SD
Oct. 20	71	2	73	51	110	48	58
Oct. 27	173	2	37	87	24	11	33
Nov. 3	190	14	37	37	63	47	30
Nov. 10	200	10	40	66	65	24	30
Nov. 17	160	12	45	65	70	22	36
Nov. 24	41	15	91	28	169	57	81

Table 14. Estimated percentage stock composition (p), standard deviation (SD), and sample size for weekly sampling of the Lummi Island (Area 7) test fishery in 1983.

Week Ending	No. of Samples	Stock Component: Fraser p	Fraser SD	Other Canadian p	Other Canadian SD	US p	US SD
Oct. 22	87	73	49	0	36	27	36
Oct. 29	232	32	30	0	22	66	24
Nov. 5	198	43	33	1	24	56	24
Nov. 19	27	78	110	1	80	21	98

Table 15. Estimated percentage stock composition (p), standard deviation (SD), and sample size for weekly sampling of the Lummi Island (Area 7) test fishery in 1984.

Week Ending	No. of Samples	Stock Component: Fraser p	Fraser SD	Other Canadian p	Other Canadian SD	US p	US SD
Oct. 20	81	10	45	16	33	73	50
Oct. 27	200	18	26	18	22	64	30
Nov. 10	200	48	29	0	21	52	36
Nov. 17	154	51	35	0	23	49	58

Table 16. Estimated percentage stock composition (p), standard deviation (SD), and sample size for weekly sampling of the Lummi Island (Area 7) test fishery in 1985.

Week Ending	No. of Samples	Stock Component: Fraser p	Fraser SD	Other Canadian p	Other Canadian SD	US p	US SD
Nov. 2	151	21.2	27.5	26.8	22.9	52.0	16.4
Nov. 9	118	10.1	21.6	0.0	0.0	89.8	35.4
Nov. 16	400	31.3	20.2	9.7	9.9	58.8	31.8
Nov. 30	200	45.2	9.6	0.0	0.0	54.7	14.1

Table 17. Estimated percentage stock composition (p), standard deviation (SD), and sample size for weekly sampling of the Area 5 commercial fishery in 1985.

Week Ending	No. of Samples	Stock Component: Fraser p	Fraser SD	Other Canadian p	Other Canadian SD	US p	US SD
Oct. 19	201	4.6	19.0	55.7	21.2	39.7	9.8
Oct. 26	200	14.4	18.7	21.9	19.9	63.7	18.7

Table 18. Comparison of stock composition estimates currently used for domestic management in Washington with GSI estimates.

Area	Current Estimate US %	GSI Estimate US %
Area 5	60%	52% (1985 data)
Area 7		
Salmon Banks	30%	47% (1983-84 data)
Lummi Island	30%	54% (1983-85 data)
Area 7A	5%	32% (1985 data)

Note: Given the limitations of the GSI data at this time, the GSI estimates are simply an average across all years. No attempt was made to weight each sample by the fraction of the run which it represented.

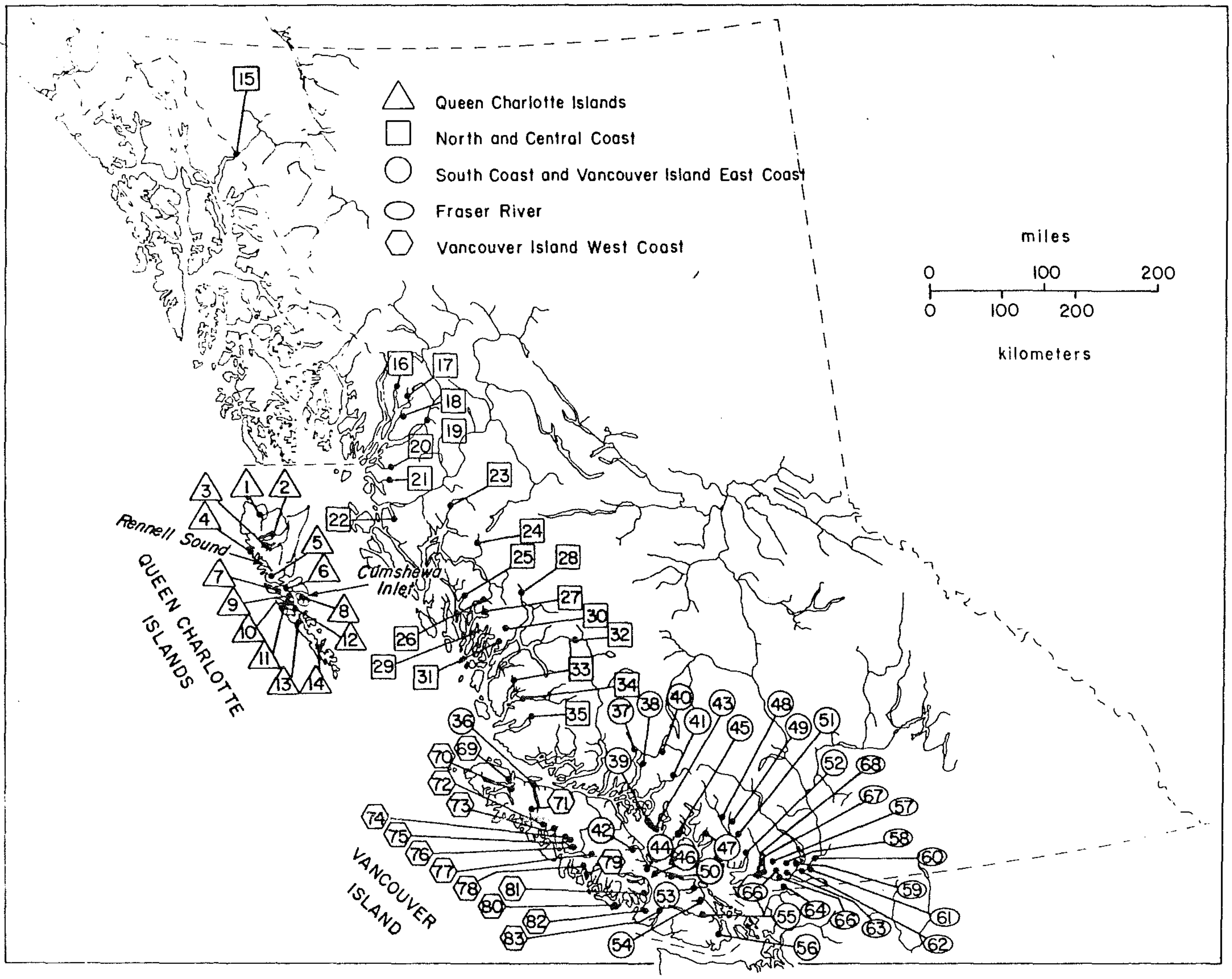

Fig. 1. Locations where chum salmon were sampled during 1981-1985.
South Coast: (36) Nimpkish R. (37) Homathko R. (38) Orford R. (39) Okeover Cr. (40) Southgate R. (41) Toba R. (42) Puntledge R. (43) Sliammon R. (44) Rosewall Cr. (45) Saltery Bay Cr. (46) Big Qualicum R. (47) Tzoonie R. (48) Squamish R. (49) Cheakamus R. (50) Little Qualicum R. (51) Mamquam R. (52) Indian R. (53) Nanaimo R. (54) Chemainus R. (55) Cowichan R. (56) Goldstream R
Fraser River: (57) Stave R. (58) Chehalis R. (59) Weaver Cr. (60) Fraser R. (61) Wahleach Slough (62) Harrison R. (63) Squakum Cr. (64) Vedder R. (65) Inch Cr. (66) Chilqua Cr. (67) Alouette R. (68) Blaney Cr.
Vancouver Island - west coast: (69) Stevens Cr. (70) Marble R. (71) Tahsish R. (72) Zeballos R. (73) Tahsis R. (74) Sucowa R. (75) Canton R. (76) Conuma R. (77) Burman R. (78) Megin R. (79) Atleo R. (80) Thornton Cr. (81) Nahmint R. (82) Sarita R. (83) Nitnat R.

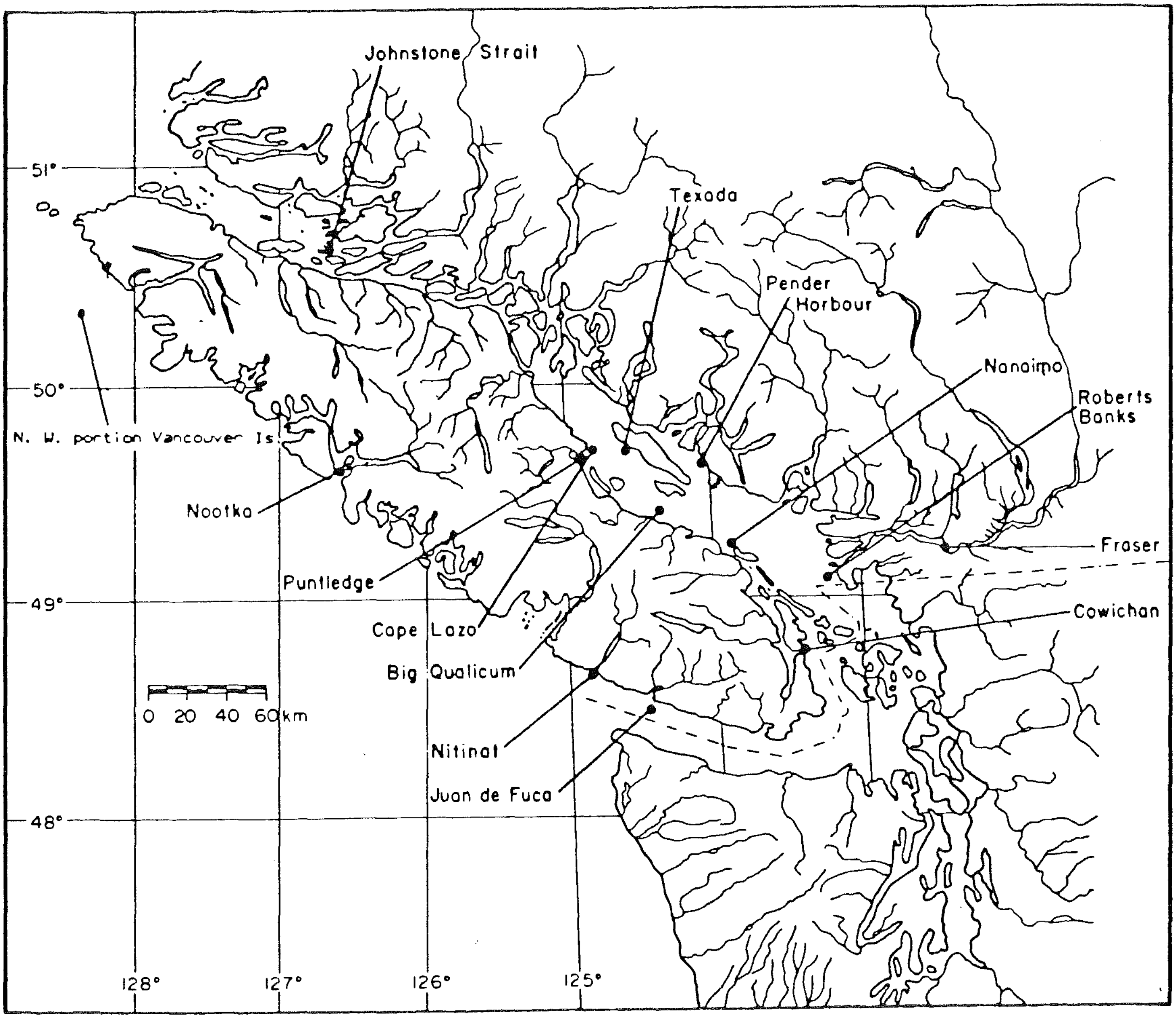

Figure 2. Location of G.S.I. sampling from 1982 to 1986.

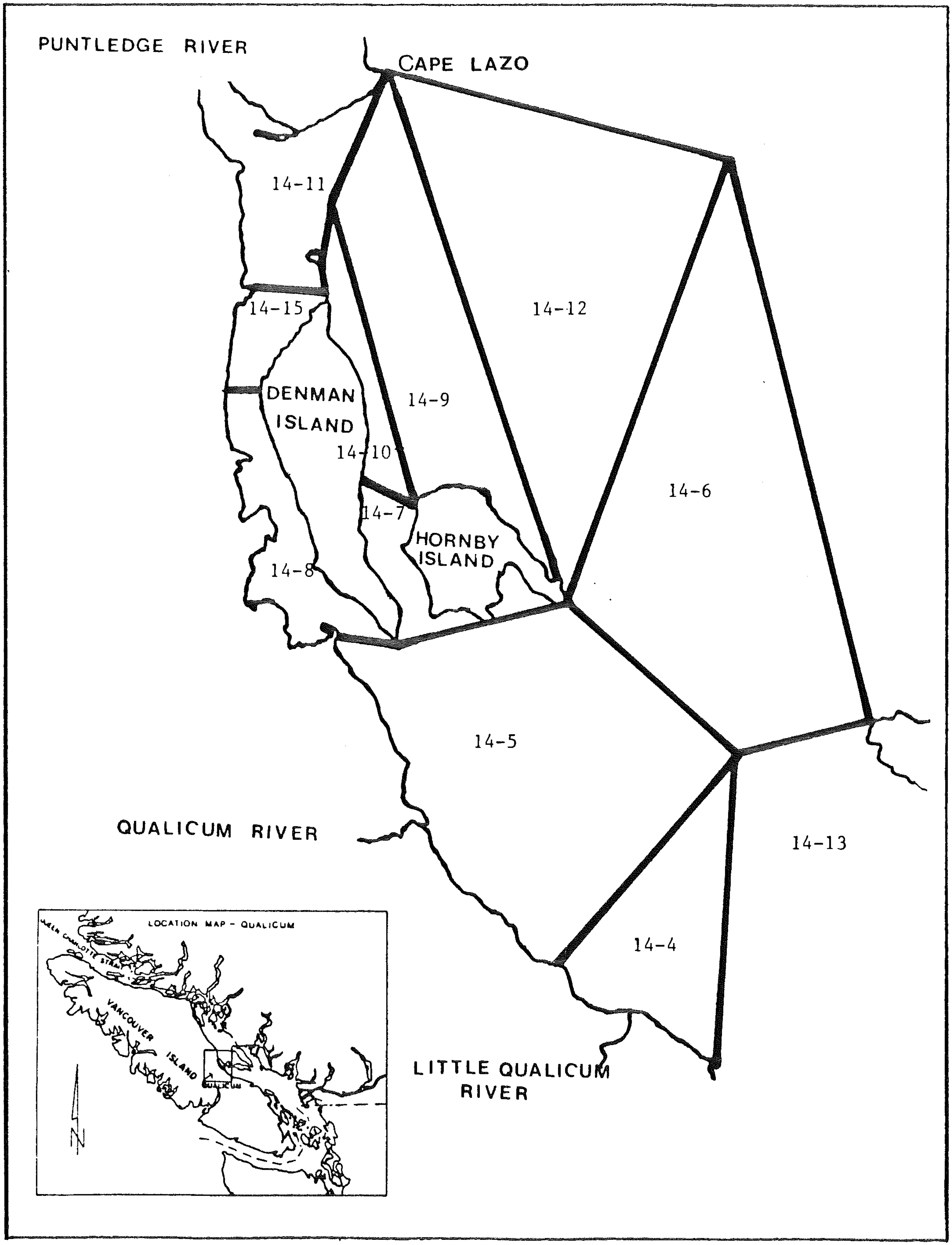

Figure 3. Sub-area statistical map of Mid Vancouver Island area. (Area 14)

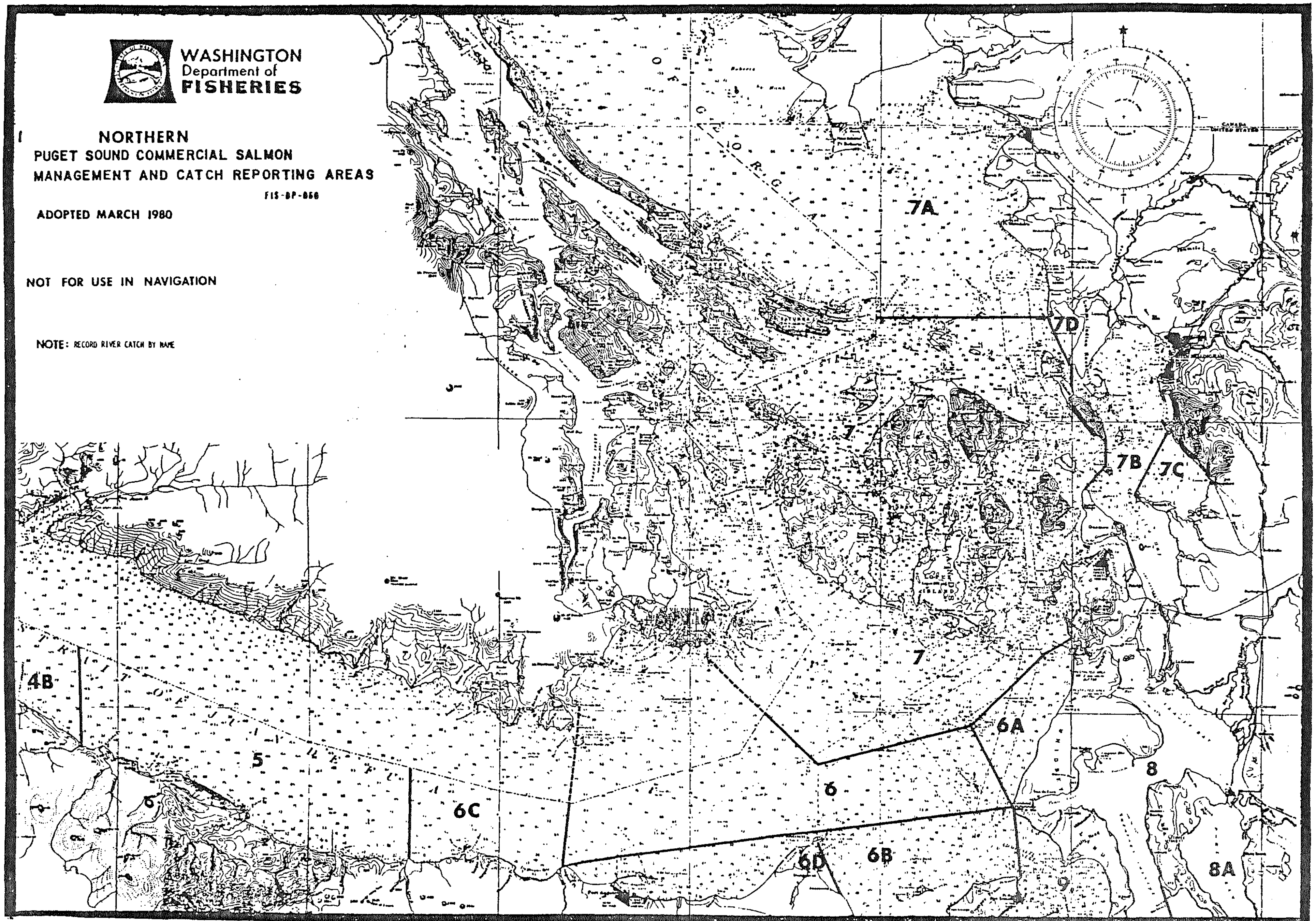

Figure 4. Washington fishery management areas.

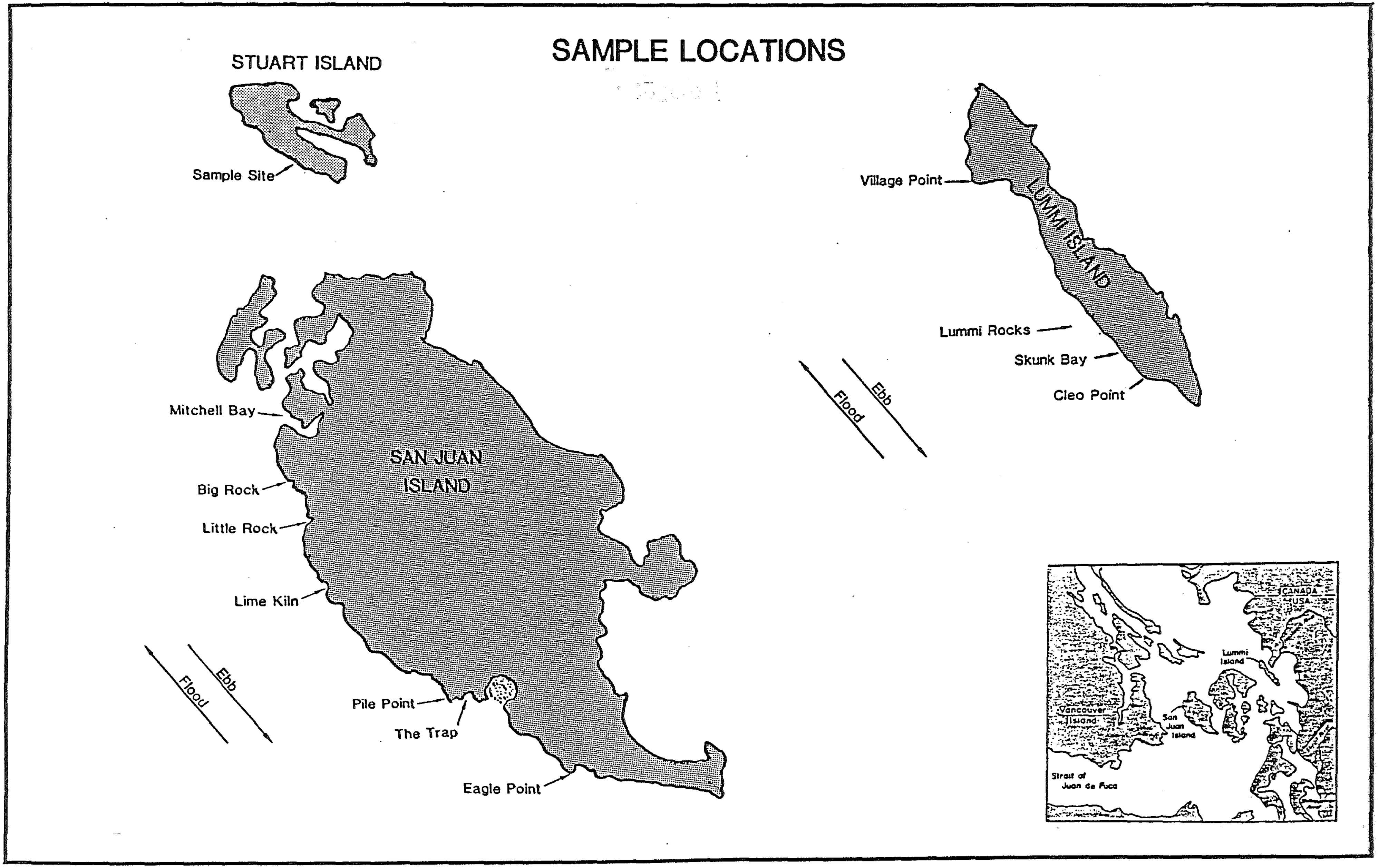

Figure 5. Detail map for the Area 7 test fishery.

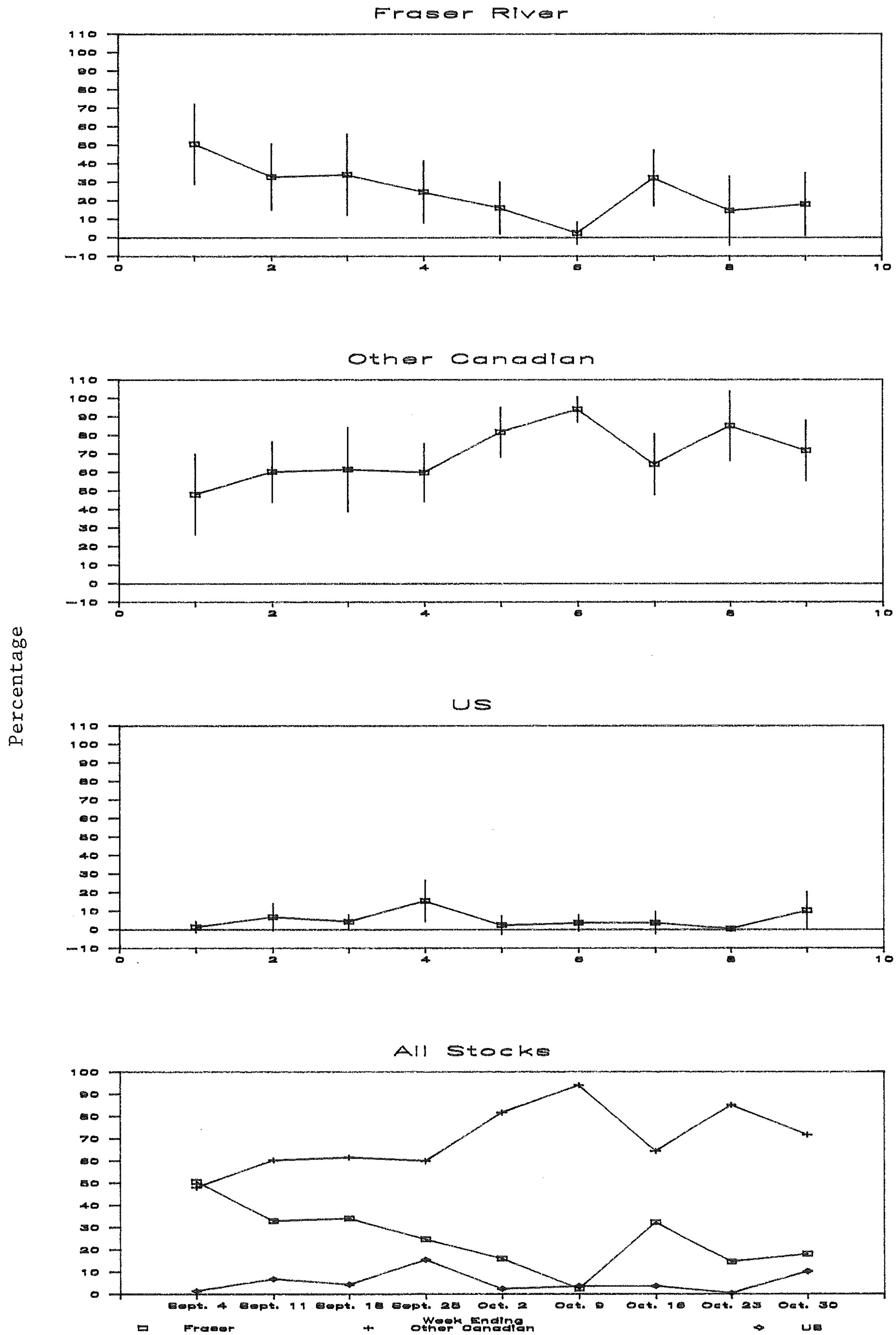

Figure 6. Estimated stock composition and standard deviation (vertical lines) for the Upper Johnston Strait test fishery in 1982.

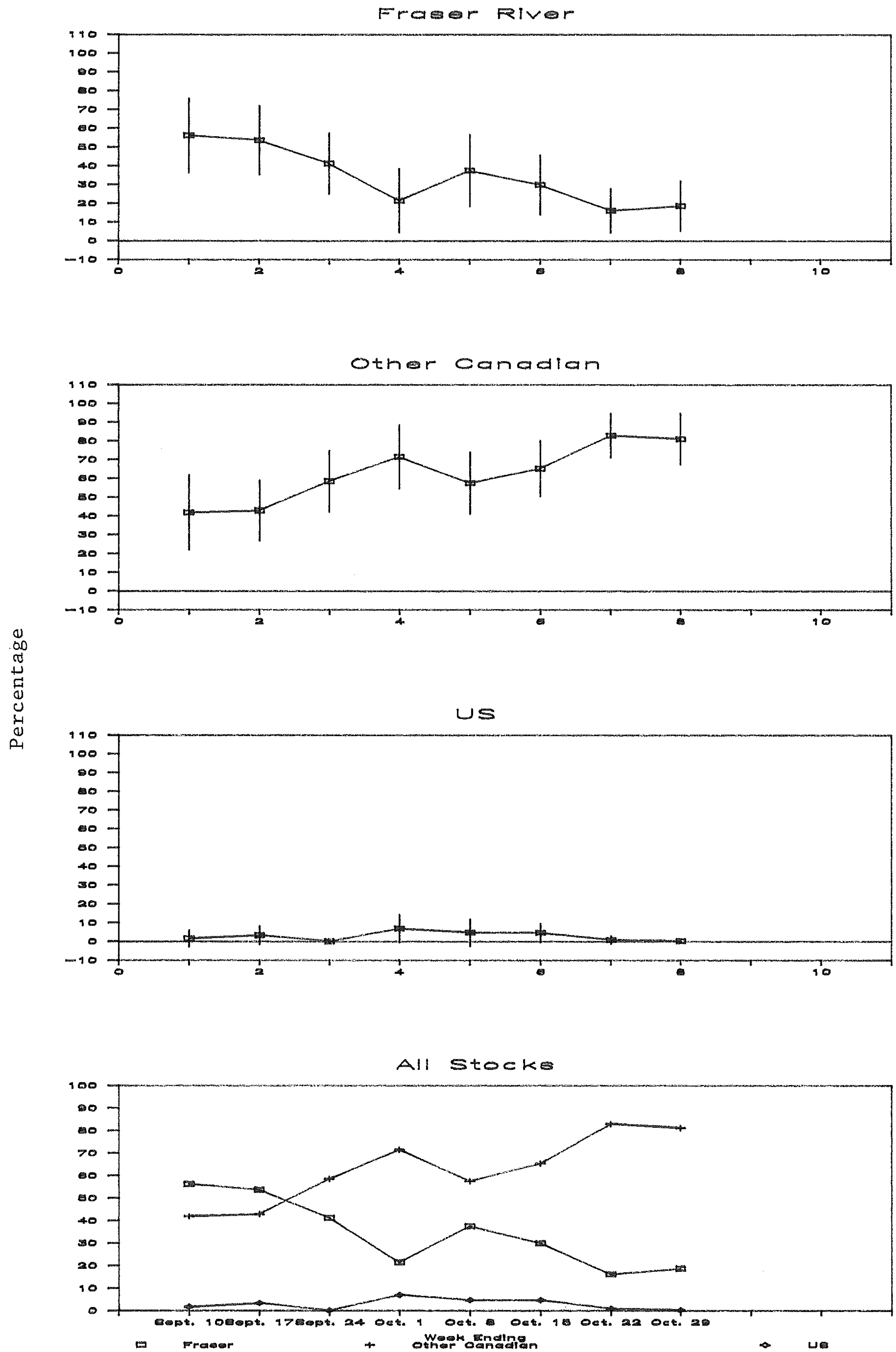

Figure 7. Estimated stock composition standard deviation (vertical lines) for the Upper Johnstone Strait test fishery in 1983.

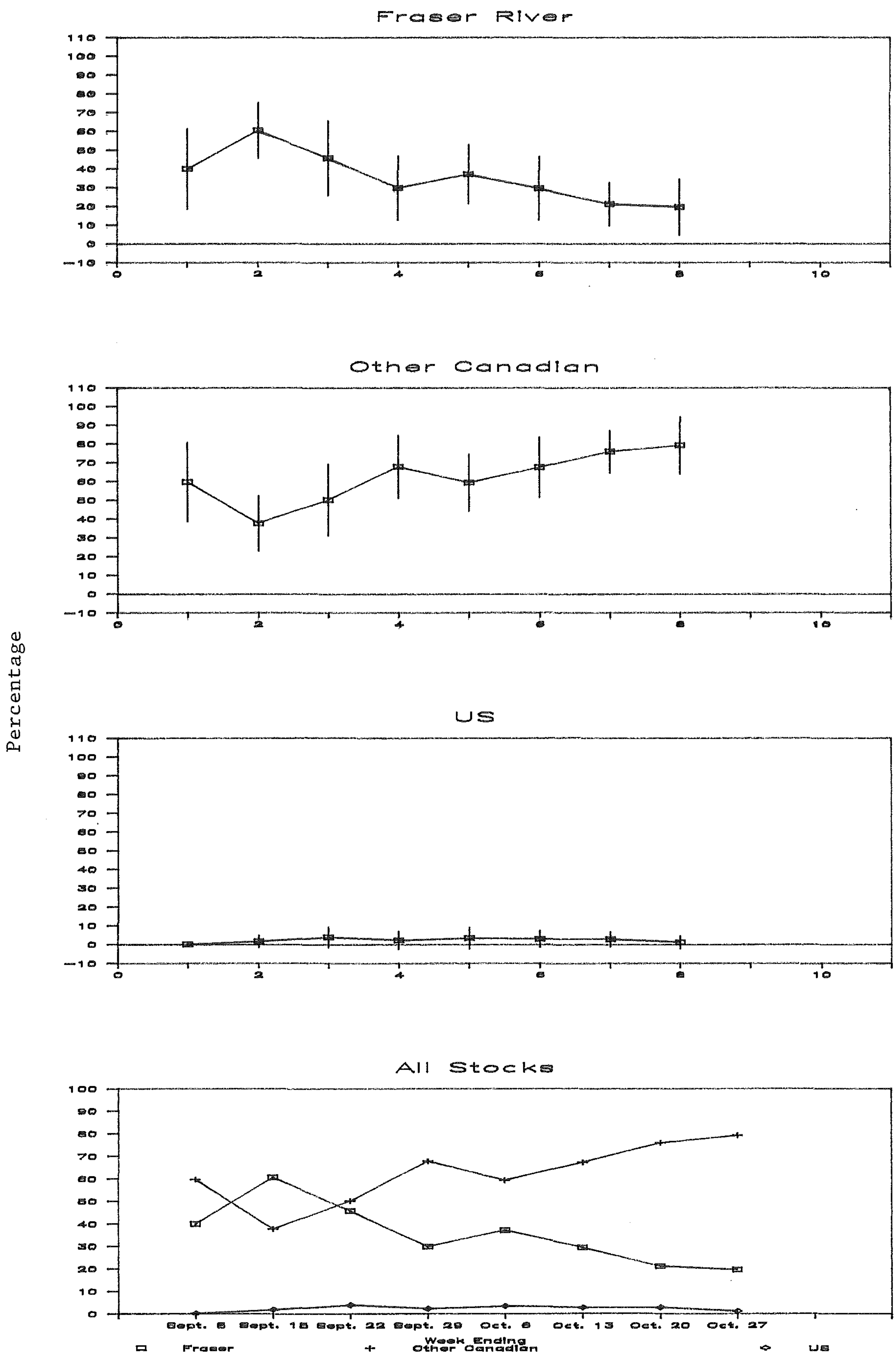

Figure 8. Estimated stock composition and standard deviation (vertical lines) for the Upper Johnstone Strait test fishery in 1984.

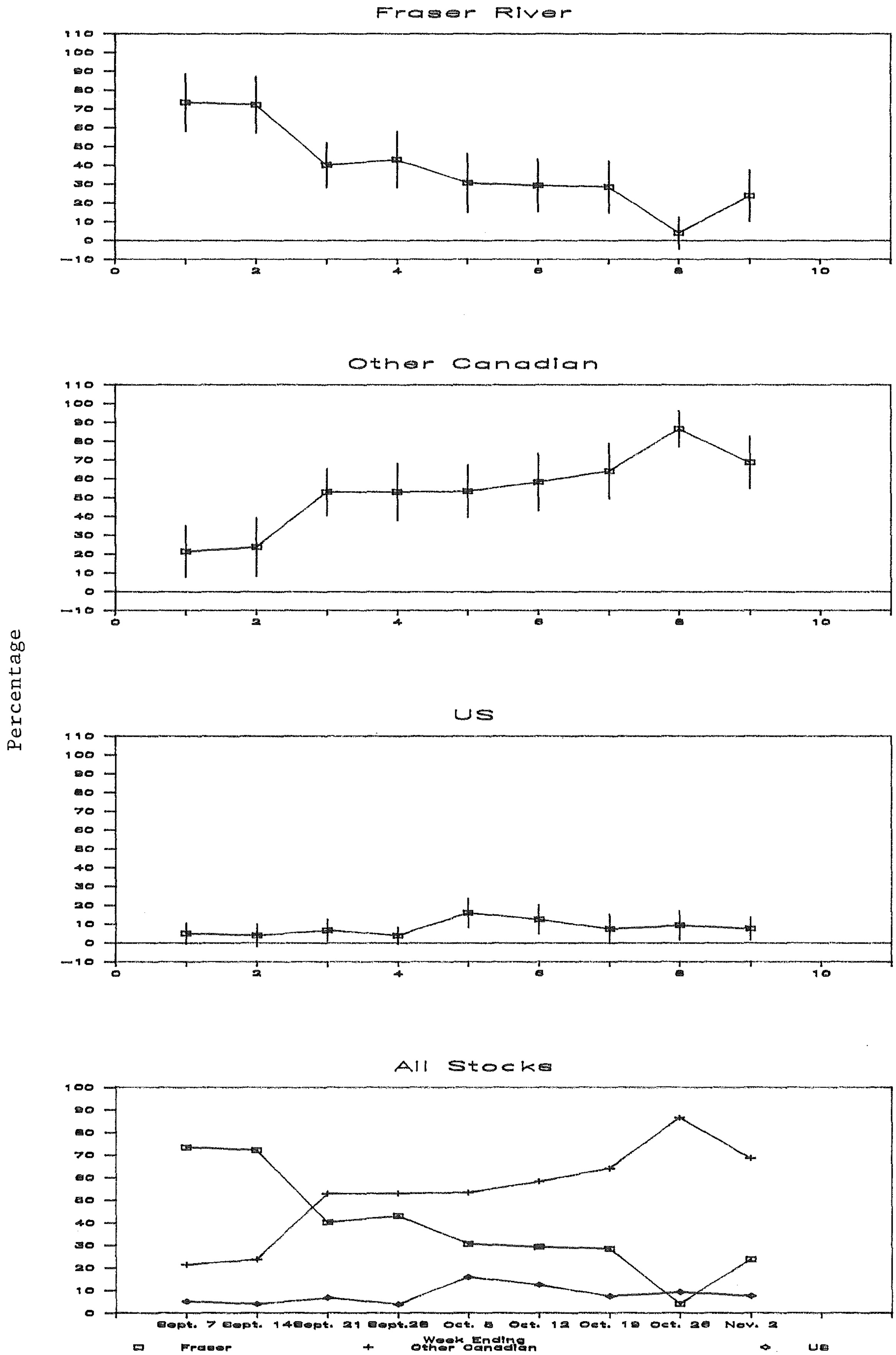

Figure 9. Estimated stock composition and standard deviation (vertical lines) for the Upper Johnstone Strait test fishery in 1985.

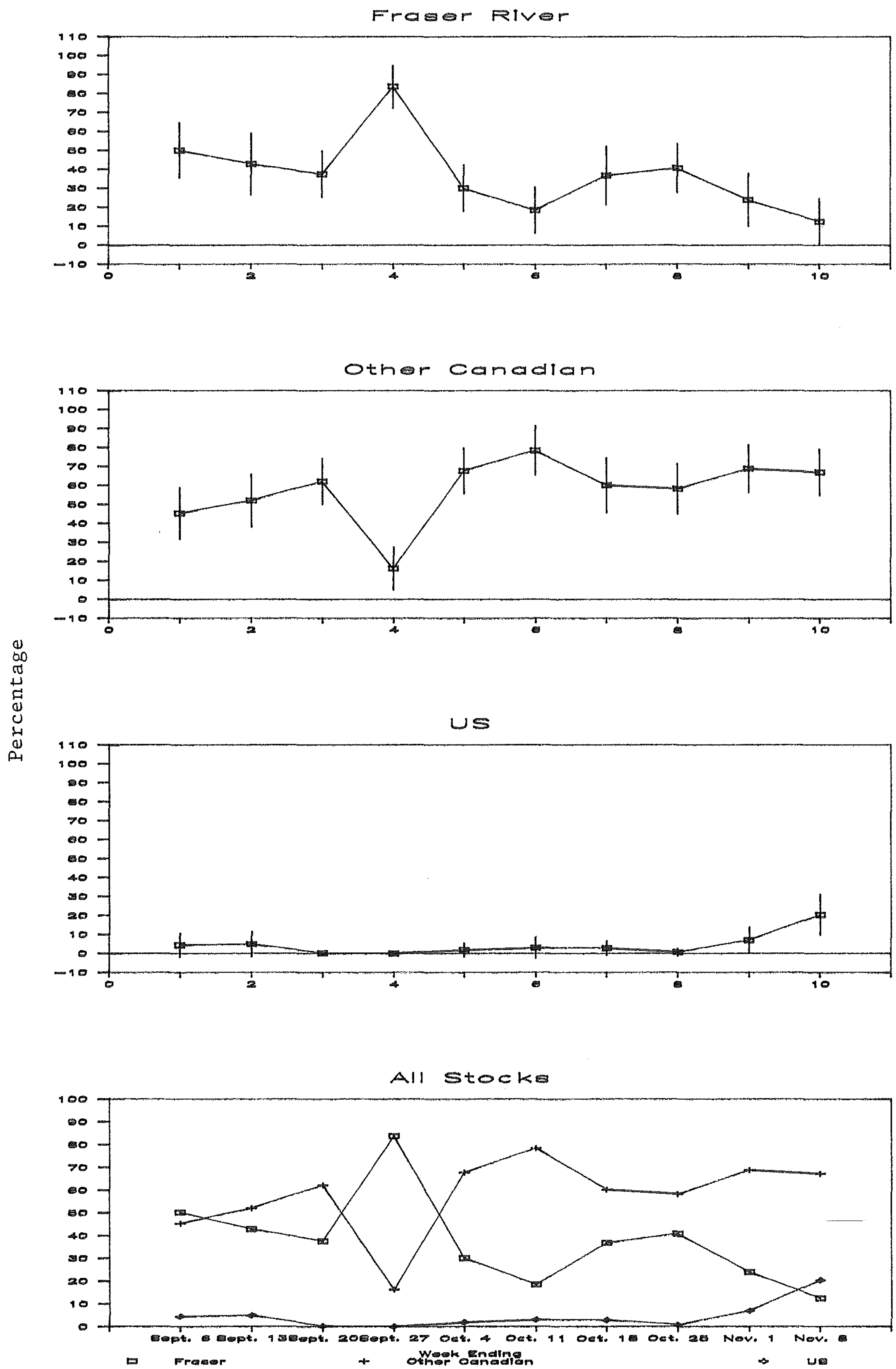

Figure 10. Estimated stock composition and standard deviation (vertical lines) for the Upper Johnstone Strait (Double Bay) test fishery in 1986.

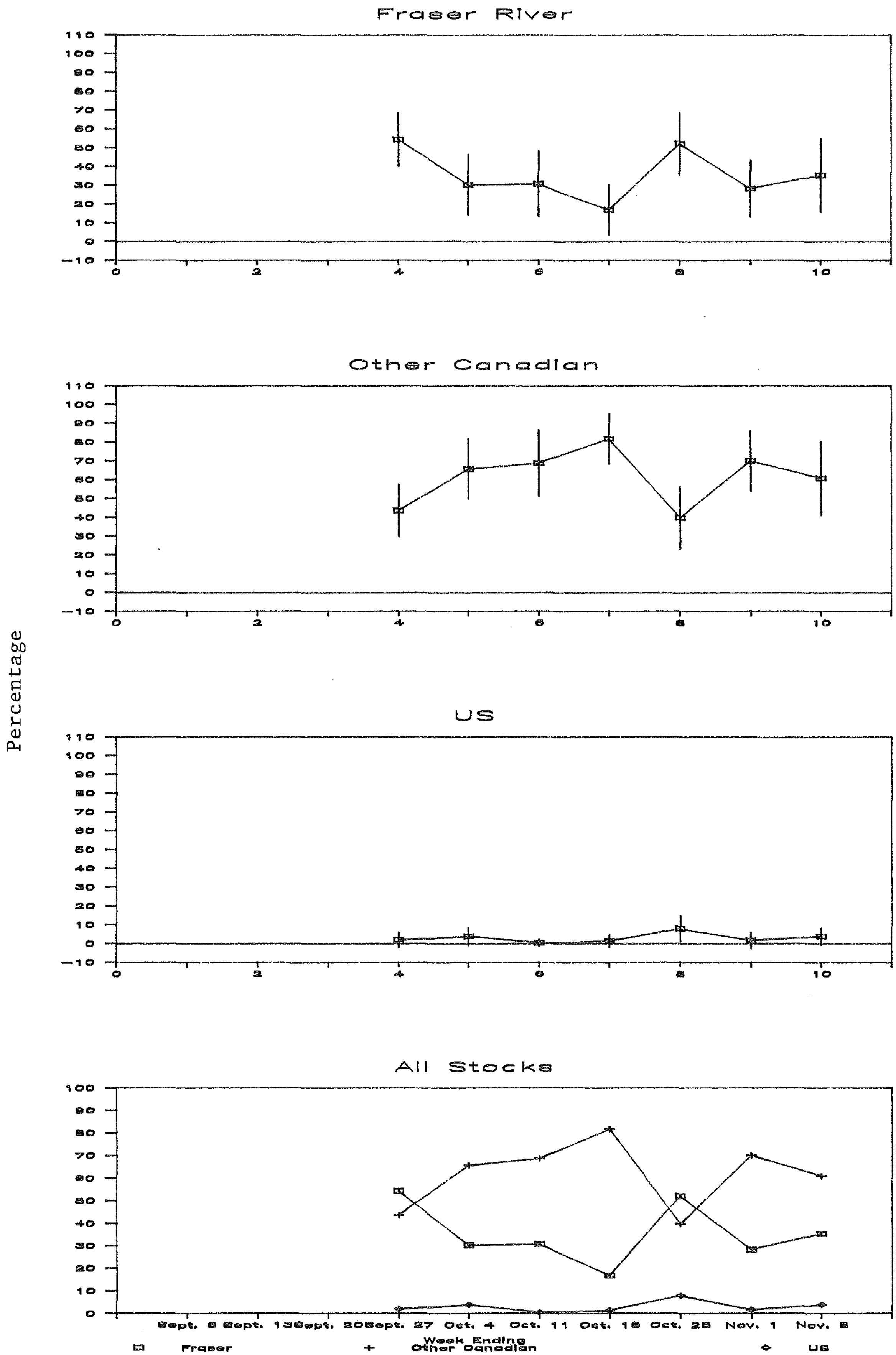

Figure 11. Estimated stock composition and standard deviation (vertical lines) for the Upper Johnstone Strait (mid-Strait) test fishery in 1986.

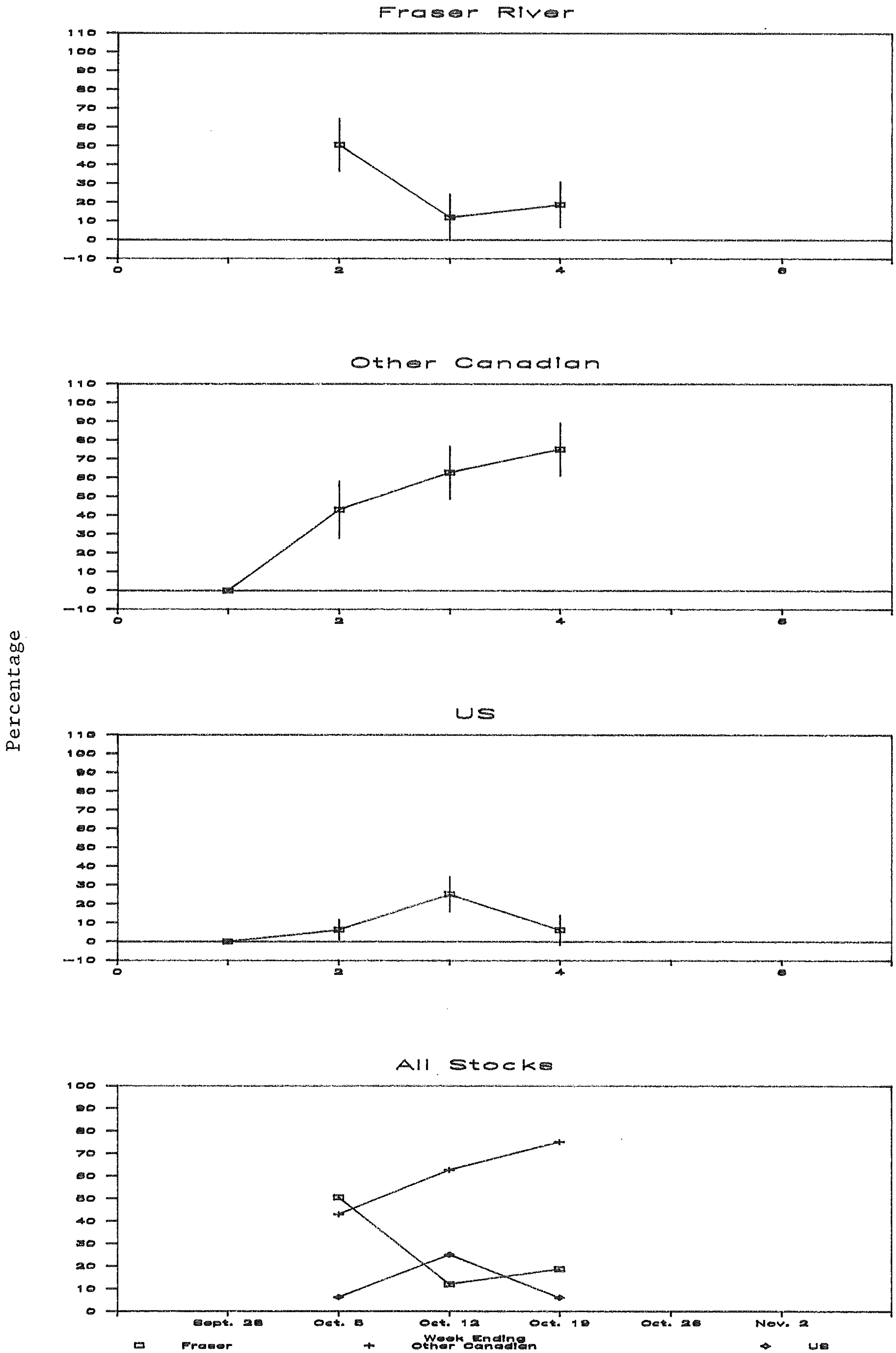

Figure 12. Estimated stock composition and standard deviation (vertical lines) for the Area 20 test fishery in 1985.

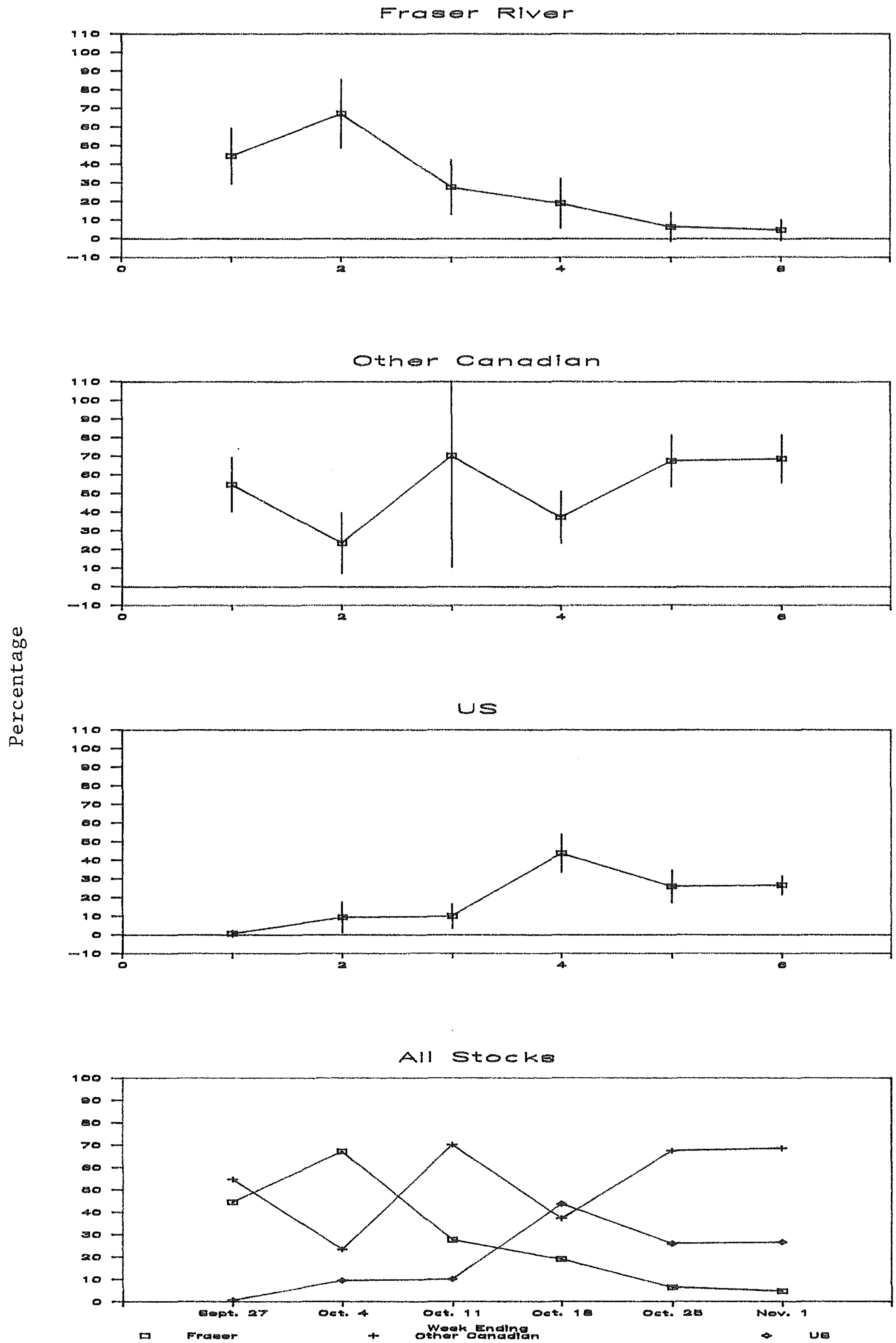

Figure 13. Estimated stock composition and standard deviation (vertical lines) for the Area 20 test fishery in 1986.

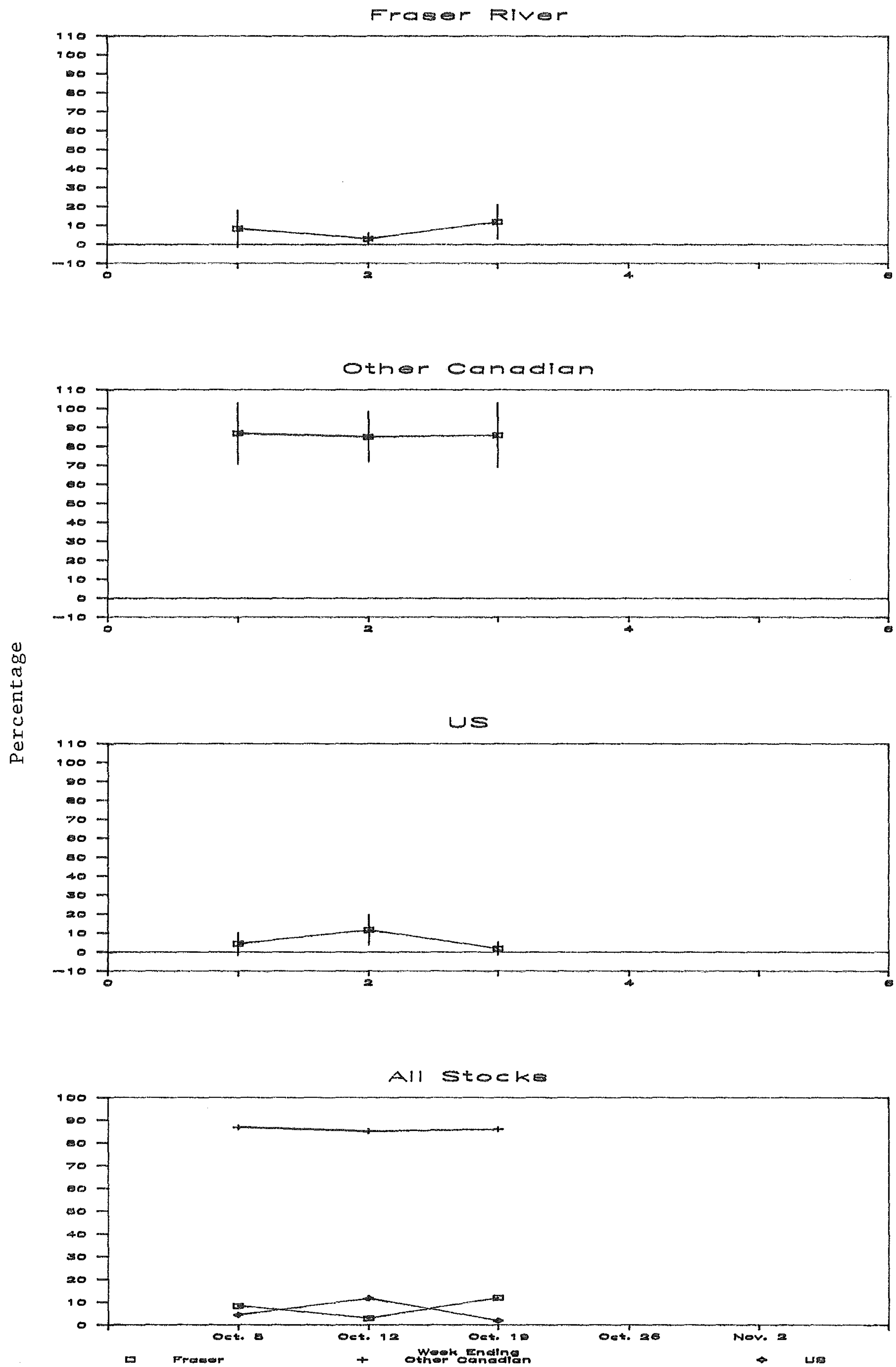

Figure 14. Estimated stock composition and standard deviation (vertical lines) for the Nitinat (Area 21) test fishery in 1985.

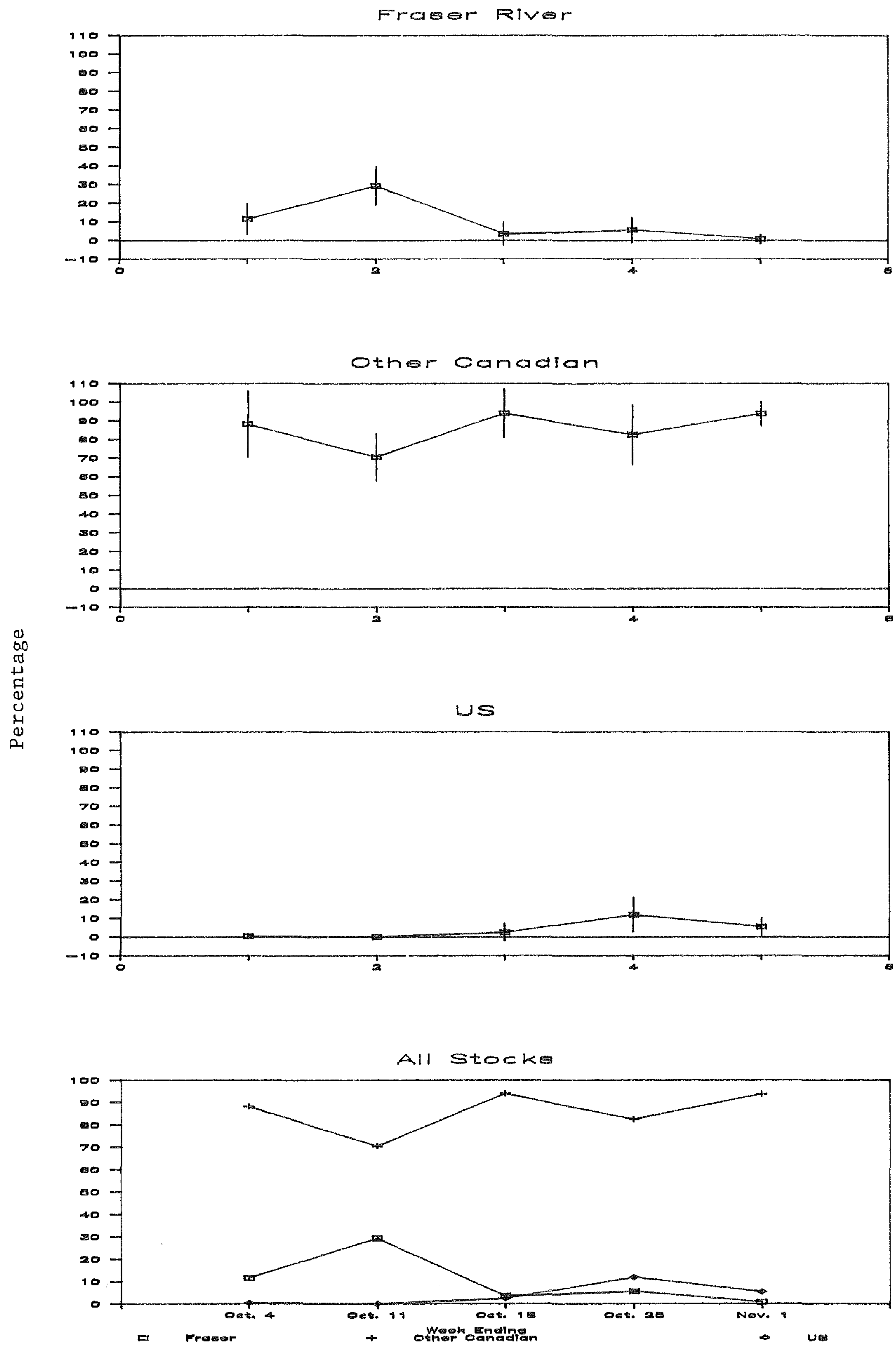

Figure 15. Estimated stock composition and standard deviation (vertical lines) for the Nitinat (Area 21) test fishery in 1986.

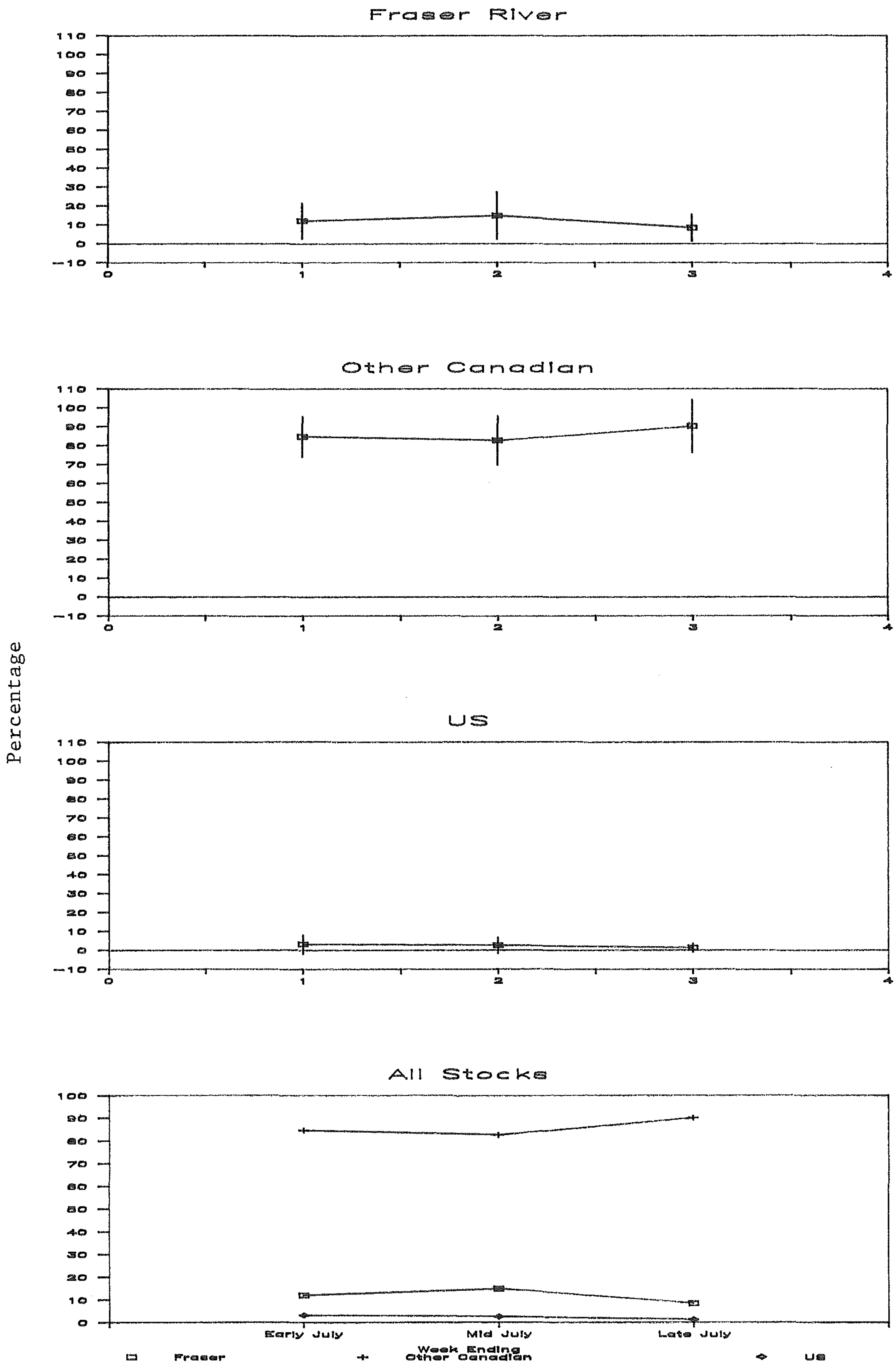

Figure 16. Estimated stock composition and standard deviation (vertical lines) for the NWCVI (Areas 126-7) troll fishery in 1986.

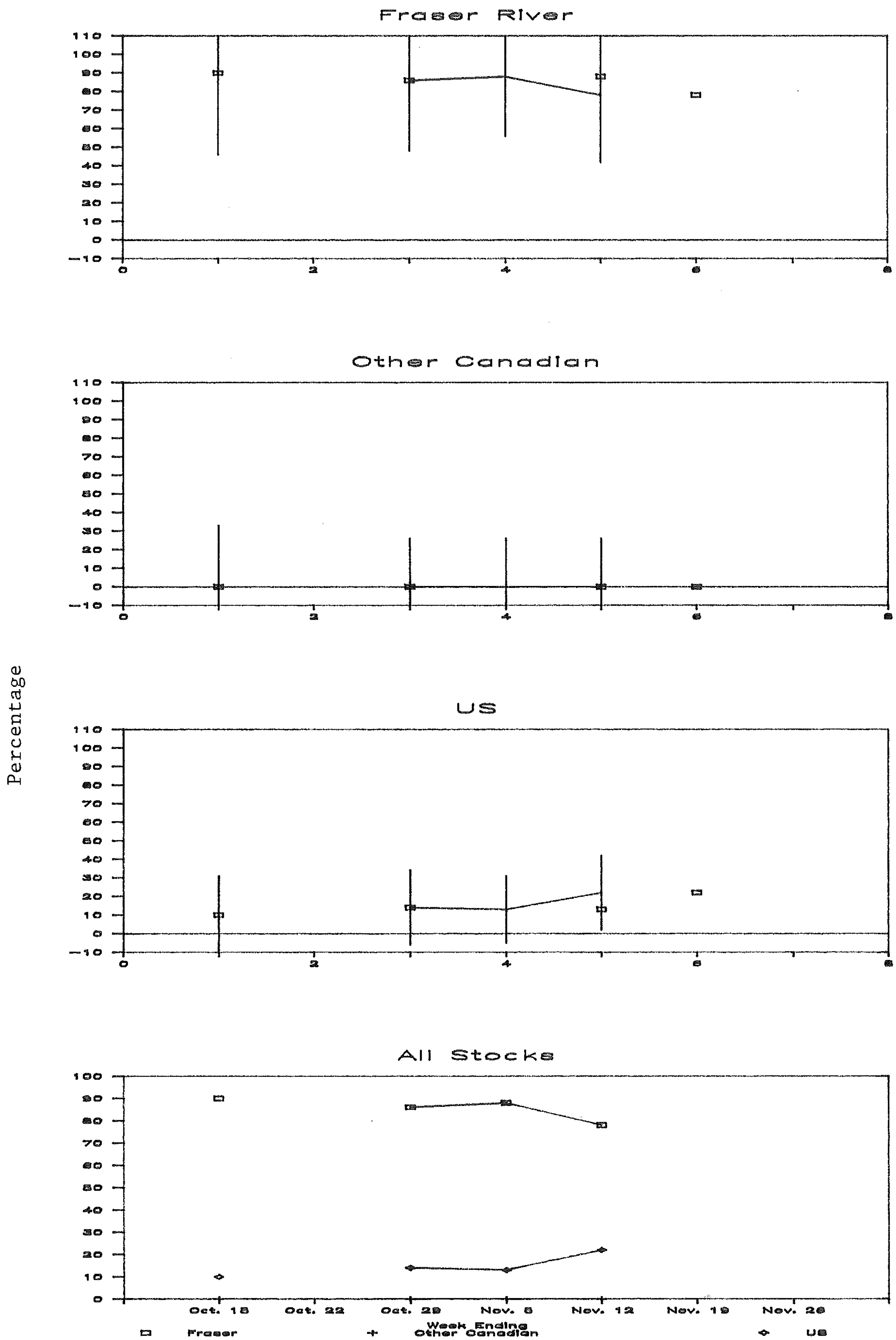

Figure 17. Estimated stock composition and standard deviation (vertical lines) for the San Juan Island (Area 7) test fishery in 1983.

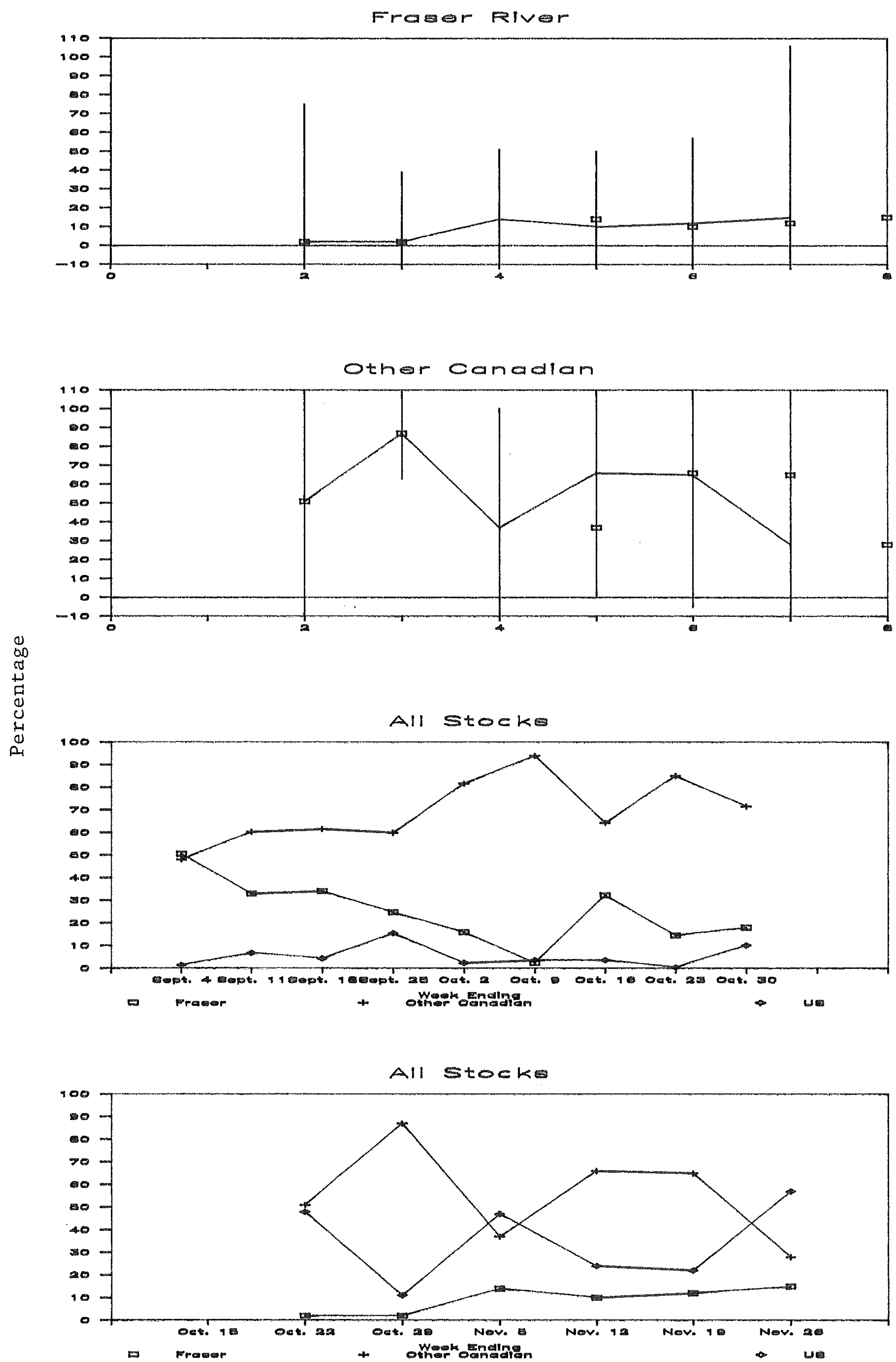

Figure 18. Estimated stock composition and standard deviation (vertical lines) for the San Juan Island (Area 7) test fishery in 1985.

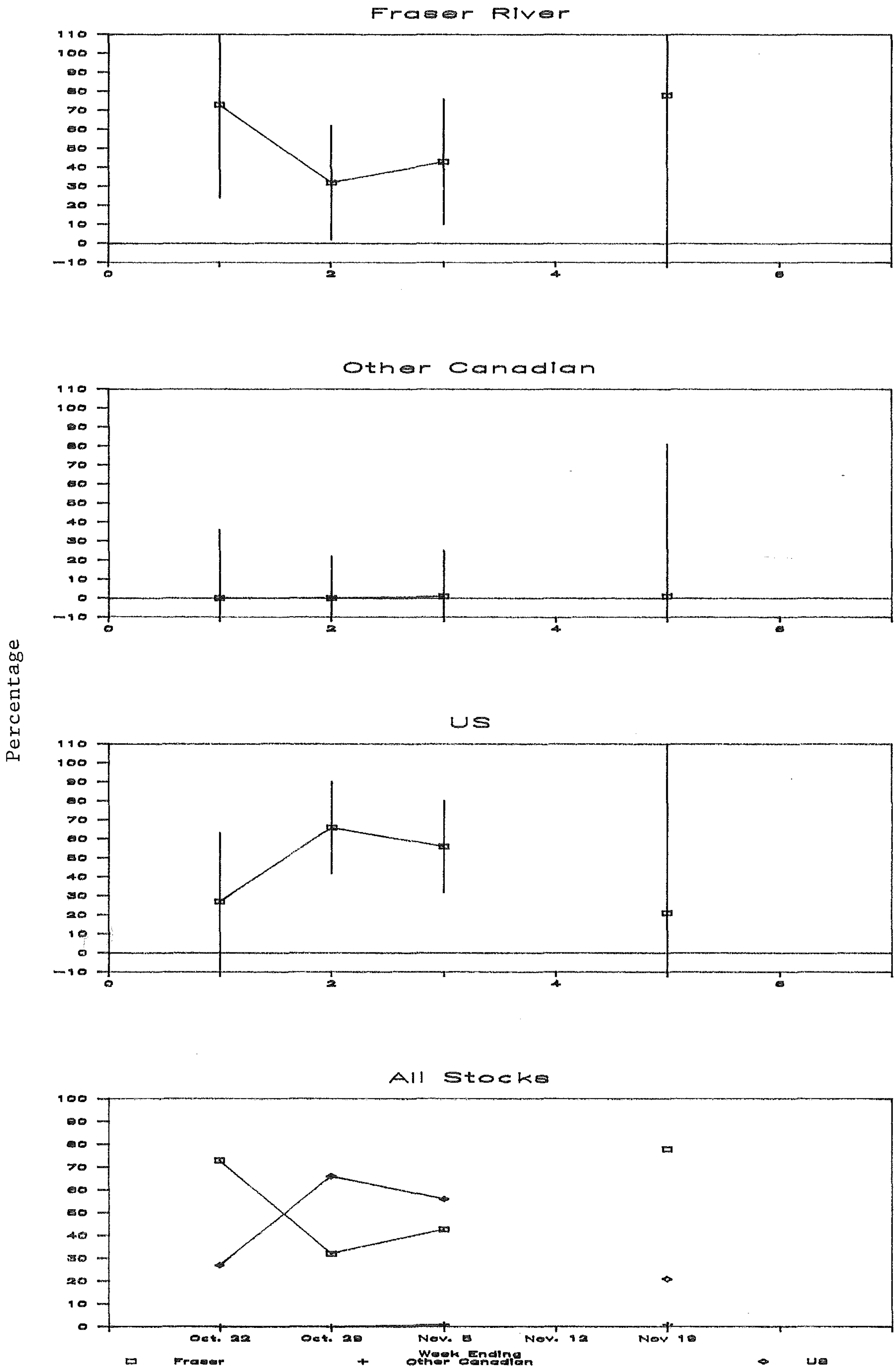

Figure 19. Estimated stock composition and standard deviation (vertical lines) for the Lummi Island (Area 7) test fishery in 1983.

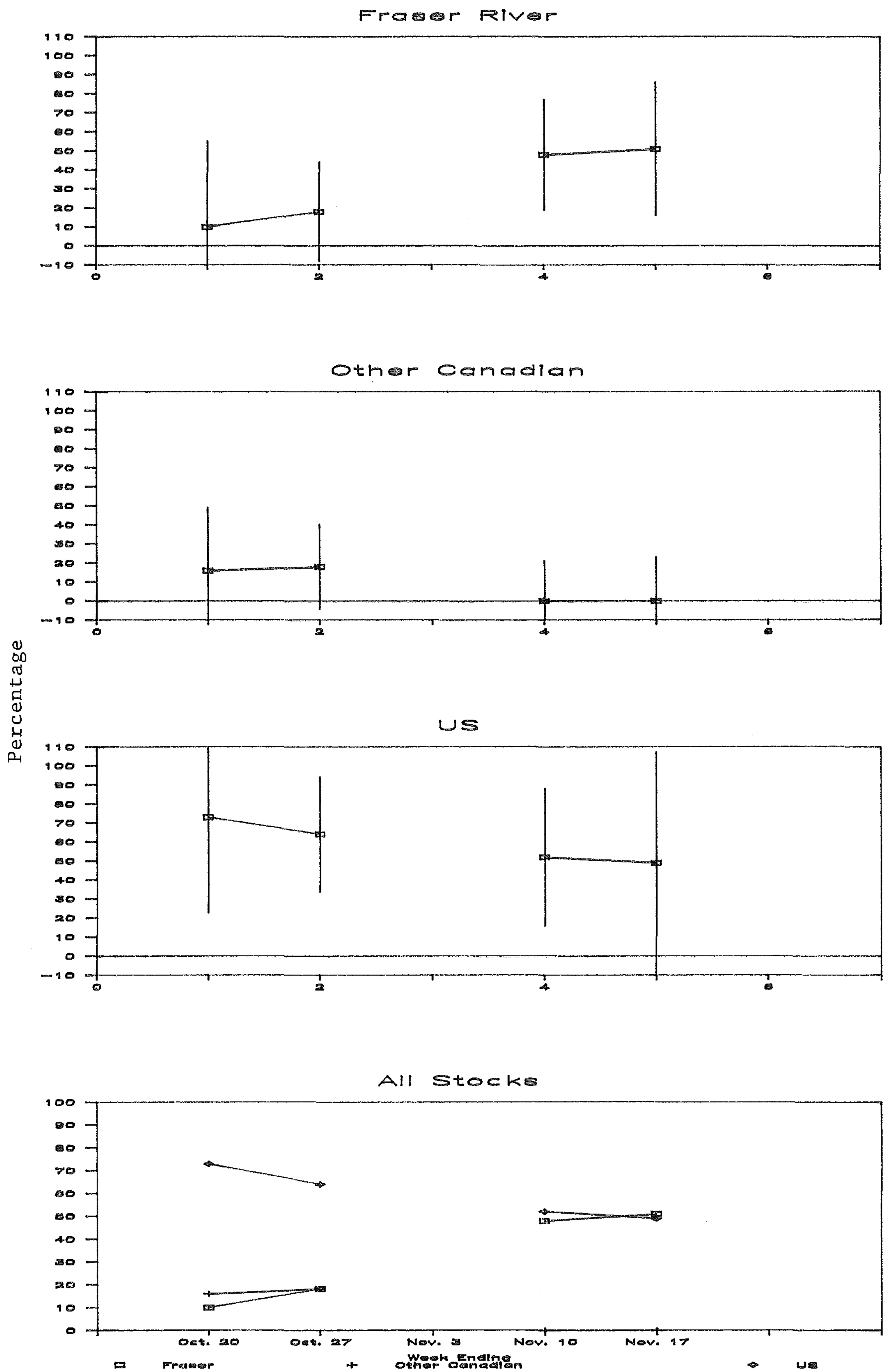

Figure 20. Estimated stock composition and standard deviation (vertical lines) for the LUmmi Island (Area 7) test fishery in 1984.

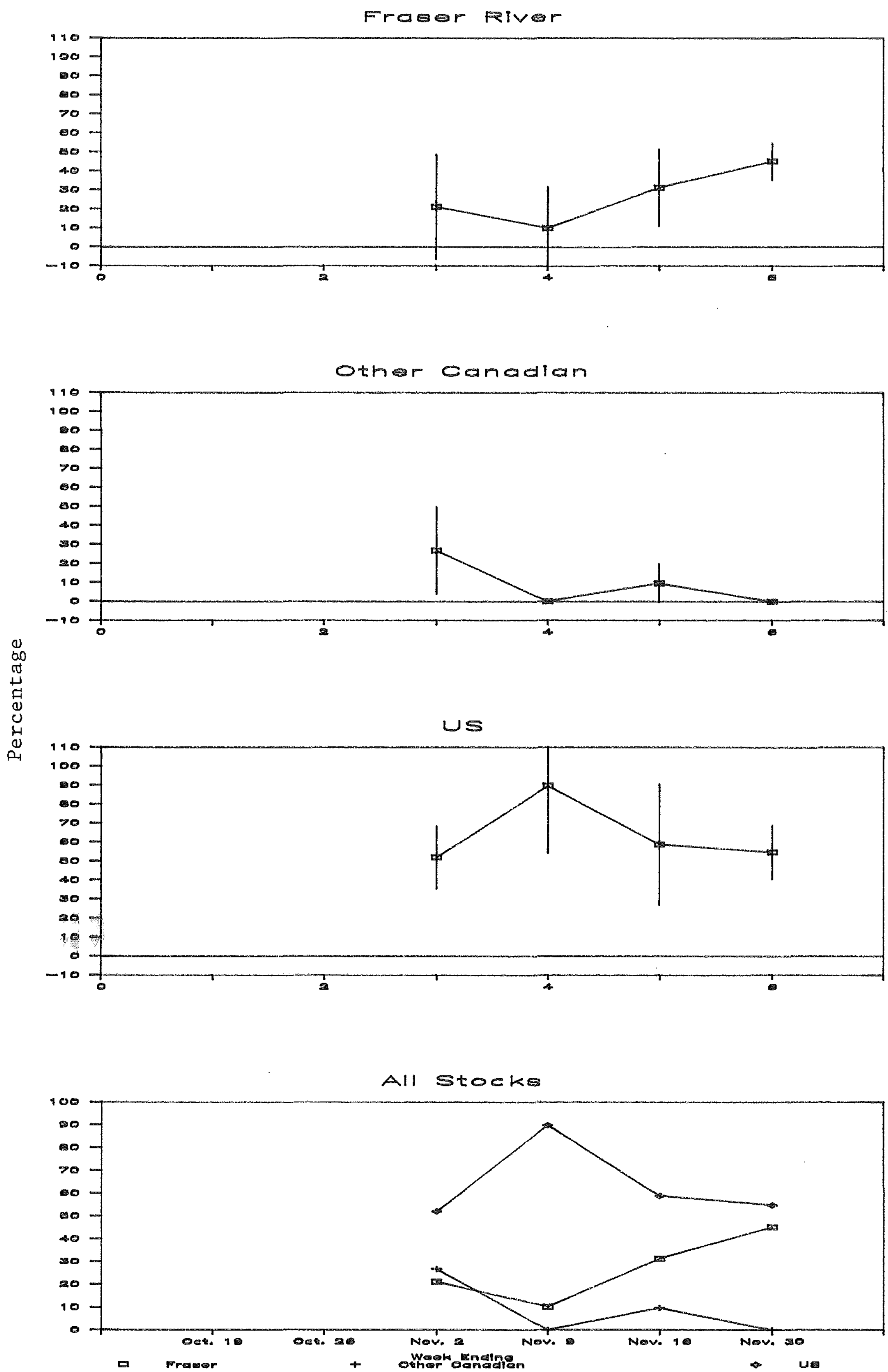

Figure 21. Estimated stock composition and standard deviation (vertical lines) for the Lummi Island (Area 7) test fishery in 1985.

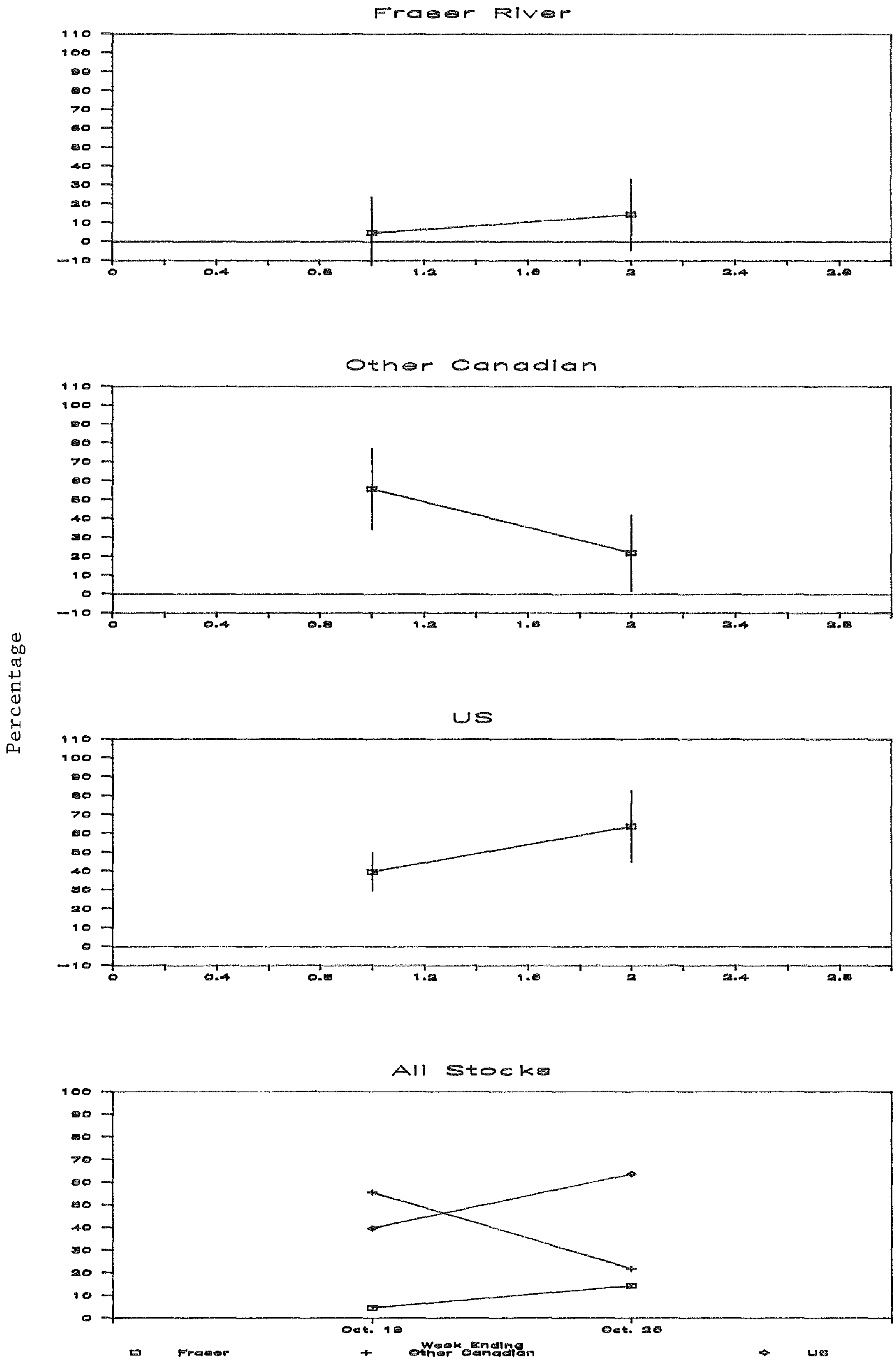

Figure 22. Estimated stock composition and standard deviation (vertical lines) for the Area 5 commercial fishery in 1985.