Fraser River Pink Salmon Catch and Exploitation Patterns: 1989-1995

Bruce White

November, 1998

Pacific Salmon Commission
Technical Report No. 10

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ABSTRACT

Pacific Salmon Commission (PSC) staff used genetic stock identification (GSI) to identify the proportion of Fraser River pink salmon caught in mixed-stock fisheries in odd-numbered years from 1989 to 1995. The GSI-based estimates of catch were used by the Fraser River Panel in the development of in-season regulations designed to achieve escapement goals and the allocation of catches of Fraser River pink salmon catch between user groups in Canada and the United States. The estimated total catches of Fraser River pink salmon ranged from 5,702,000 (1995) to 9,295,000 (1989). The contribution of Fraser River pink salmon to northern British Columbia mixed-stock fisheries was generally quite low (typically < 10%) but was much higher in fisheries that occurred in southern British Columbia and Washington. From late August to mid September Fraser River pink salmon often comprised over 80% of the pink salmon fishery catches in Johnstone Strait net fisheries, and greater than 90% of the catch in more terminal fisheries occurring off the San Juan Islands and Point Roberts. Examination of the peak catches of Fraser pink salmon in major southern fisheries indicated that they took approximately two weeks to migrate between the troll fisheries off the northwest coast of Vancouver Island, south-eastward to fisheries around the San Juan Islands. Information collected through the Commission's pink salmon GSI program between 1989 and 1995 was used in the allocation of Fraser River pink salmon between user groups and in the development of run size estimates that were used in management decisions. The information gained from the program can also be used in planning future fisheries that harvest Fraser River pink salmon.

INTRODUCTION

The largest odd-numbered year run of pink salmon (*Oncorhynchus gorbuscha*) in British Columbia originates from the Fraser River and several tributaries (i.e., the Chilliwack-Vedder River, Harrison River, Seton Creek, and Thompson River). In even-numbered years, Fraser River pink salmon populations are negligible and do not support directed fisheries. Fraser River pink salmon have been harvested in Canadian and United States fisheries for over a century (Roos 1991). Most of the catch is taken in purse seine, gillnet and troll mixed-stock fisheries in southern British Columbia and northern Washington State.

Under the 1985 Pacific Salmon Treaty, the Fraser River Panel of the Pacific Salmon Commission (PSC or Commission) is required to develop in-season fisheries regulations to meet Canada's escapement goals for Fraser River pink salmon, achieve agreed international catch allocations, and to the extent practicable, to meet each country's domestic allocation objectives. To assist in achieving these goals, a technique was required that would enable rapid, in-season estimation of the contribution of Fraser River pink salmon to mixed-stock fisheries. Before 1987 the PSC (and the International Pacific Salmon Fisheries Commission, IPSFC prior to 1985) used run reconstruction methods including data from migrational studies on pink salmon (e.g. Vernon et al. 1964; Hourston et al. 1965) to estimate catches of Fraser River pink salmon on a post-season basis. The development of genetic stock identification (GSI) techniques for aiding management of Pacific salmon stocks (e.g. Milner et al. 1985) prompted researchers to investigate its potential for improving management of pink salmon mixed-stock fisheries.

Beacham et al. (1985) found that sufficient genetic differences existed between pink salmon from the Fraser River, Puget Sound, and Canadian non-Fraser stocks to allow reasonably accurate estimation of their contribution to mixed-stock fisheries. Based on these findings, the PSC initiated pilot pink salmon GSI programs in 1985 and 1987. The methodology employed in the Commission's GSI program included: the collection and laboratory analysis of samples for development of GSI baselines for individual stocks; collection of random samples in-season from all major commercial fisheries; in-season electrophoretic analyses of tissue samples; and the in-season statistical analysis of genetic data. The use of the resulting stock contribution estimates for fisheries management applications are described in White (1996).

This report examines the results of the in-season pink salmon GSI sampling and analysis programs conducted by the Commission from 1989 to 1995 that were used to:

1. estimate the proportion of Fraser River pink salmon in mixed stock fisheries;
2. estimate the catches of Fraser River pink salmon; and
3. examine the catch patterns of Fraser River in southern fisheries.

METHODS

White (1996) described the planning and implementation of the Commission's in-season pink salmon GSI programs from 1989 to 1995, including the selection of fisheries for sampling and contracting laboratories to perform the electrophoretic analyses. The PSC's pink salmon GSI baselines include stock-specific genetic data for pink salmon stocks spawning from Washington State to northern British Columbia. Approximately 40 pink salmon stocks assigned into four stock-groups are represented in the Commission's baselines with genetic data compiled at 15 loci (genetic traits). The Commission uses a three stock-group baseline for analyzing stock contributions from fisheries occurring south of Cape Caution. The south coast baseline incorporates pink salmon from the: (1) Fraser River, (2) Puget Sound, and (3) Canada South Coast stock groups (Figure 1). The Canada North Coast stock group was included in the baseline for GSI analyses of fisheries occurring north of Cape Caution.
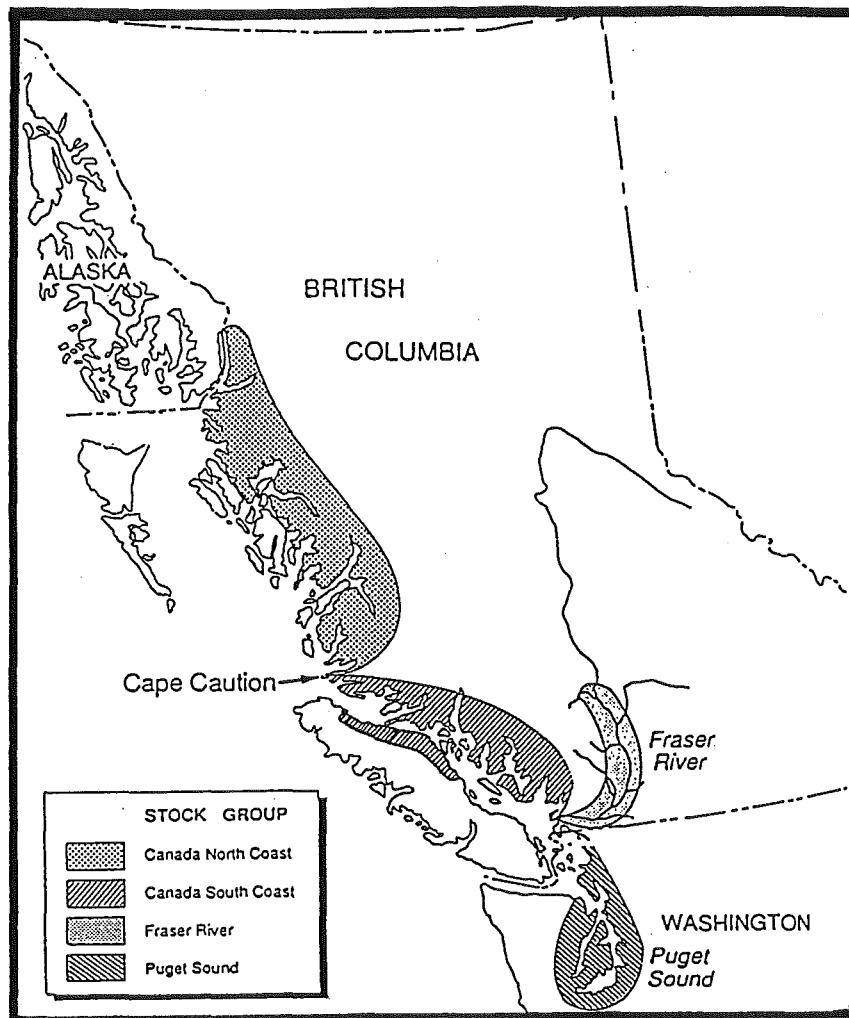

Figure 1. Pink salmon stock groups represented in the Pacific Salmon Commission's GSI baselines (after White and Shaklee 1991).

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In-Season Sampling Programs from 1989 to 1995

Commission staff designated mixed-stock fisheries where large catches of Fraser River pink salmon were anticipated (>100,000 pink salmon per week from a fishery) as the highest priority for sampling efforts. GSI analyses have shown that substantial catches of Fraser pink salmon have occurred in recent years in mixed-stock fisheries from the northern portion of the Queen Charlotte Islands (Area 101 troll) south to the San Juan Islands (Washington Area 7). Sampling activities have focused on Canadian purse seine and troll fisheries and on Washington State purse seine fisheries because these fisheries harvest the majority of the Fraser pink catch. The collection of GSI samples from purse seine and troll fisheries north of Cape Caution has been concentrated from mid-July to late August and in southern fisheries from early August to mid-September.

In this report, "fisheries" are defined by a specific statistical area, fishing gear, and week-ending (W/E) date. For example, a collection of tissue samples taken from a Canadian Area 20 purse seine fishery from W/E period ending August 15, includes fish caught from Sunday, August 9 to Saturday, August 15. Additionally, all mixed-stock fisheries specified in this report are in Canadian waters unless otherwise indicated (e.g. Washington Areas 7 and 7A purse seine fisheries). In some cases, the references to Canadian areas include sub-area designations, e.g., Area 12-1 to 7 refers to Area 12 sub-areas 1 to 7.

Statistical examinations using simulation analyses have indicated that sampling 150 fish per fishery usually yields satisfactory accuracy in stock-group estimates (generally within 10% of the true proportion of the Fraser River stock group in a mixture sample) for most fisheries management applications. Samples obtained however, have varied from slightly less than 100 fish (when fish are difficult to obtain for sampling) to frequently 300 fish or more, for fisheries where large catches of Fraser pink salmon are expected.

To obtain representative collections of tissue samples from pink salmon harvested in specific fisheries, fish were usually sampled from tender vessels or several different vessels that had participated solely in that fishery. Samplers also attempted to ensure that random samples were obtained to minimize bias, which can be introduced into GSI analyses if fish are selected based on specific physical characteristics.

Tissue samples were removed from pink salmon by extracting a small portion (approximately 1 cm^3) of muscle tissue from the nape area of the fish (White 1996). The tissue samples were inserted into individual, labelled test tubes and frozen using dry ice prior to shipping to a laboratory for electrophoretic analysis. Length, weight and sex measurements for each sampled fish were also recorded.

North Coast Fisheries Sampling Programs

Several Canadian fisheries occurring north of Cape Caution (Figure 2) were sampled by Commission port-samplers from 1989 to 1995 (Appendix Tables 1-4). The pink salmon tissue samples collected in northern areas were taken primarily at processing plants in Prince Rupert and some from Port Edward (located approximately 10 km southeast of Prince Rupert). The sampling

effort was concentrated on the Areas 101 and 142 troll fisheries because GSI analyses showed that the majority of Fraser River pink salmon harvested in northern areas were caught there. Sampling of Area 101 and 142 troll fisheries ranged from mid-July until the end of August with most of the sampling concentrated during the first half of August. The GSI sampling program directed at fisheries occurring north of Cape Caution was reduced in 1993 and 1995 because of budget constraints, however sampling continued in the northern troll fisheries where the largest catches of Fraser pink salmon were anticipated.
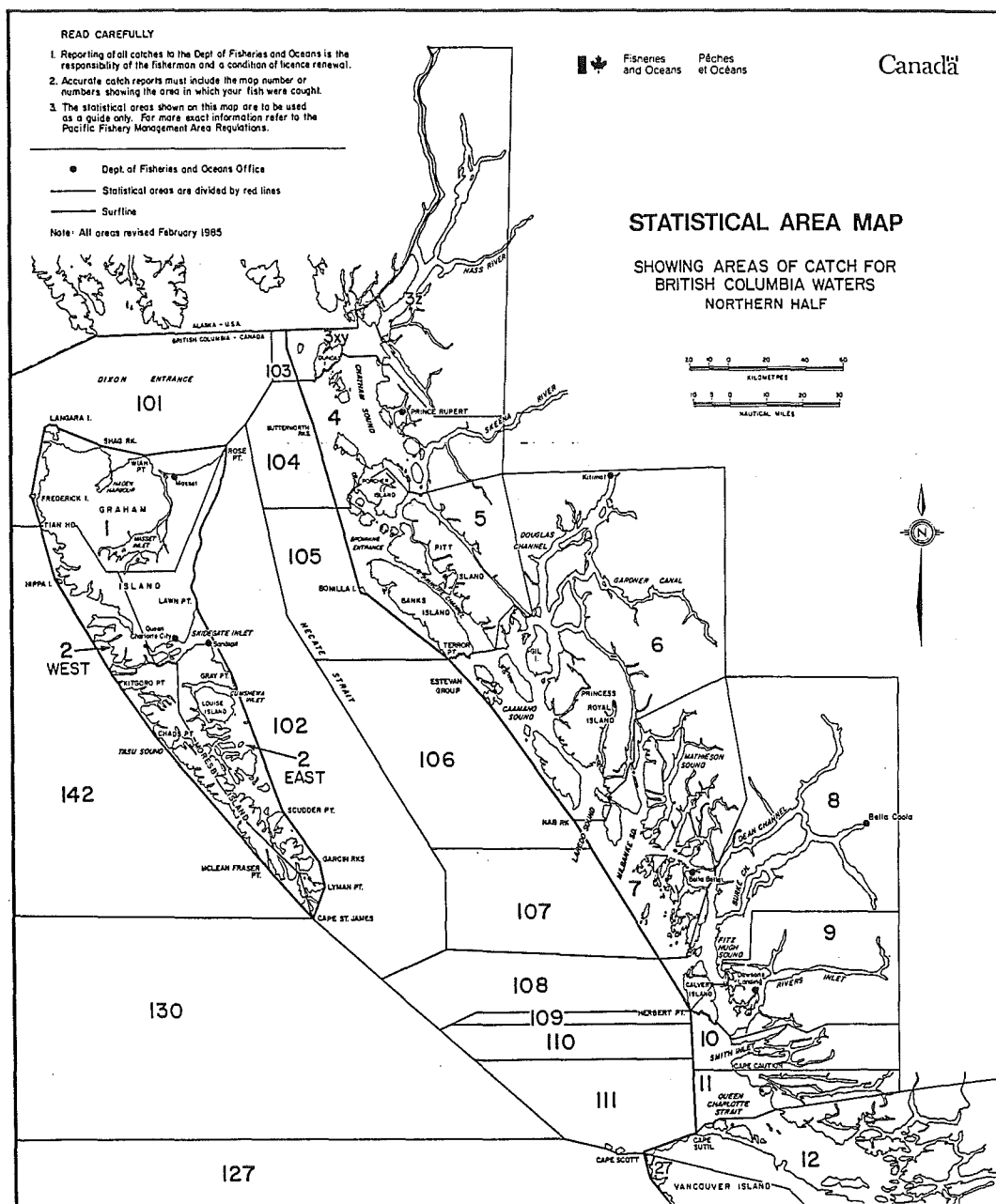

Figure 2. Canadian statistical fishing areas located north of Cape Caution (Canada Department of Fisheries and Oceans: 1985).

Pink salmon caught in Areas 4 and 6 net fisheries (primarily purse seine) were also sampled in some of the years (Appendix Tables 1 and 2). Because the GSI analyses in 1989 and 1991 indicated typically low proportions of Fraser pink salmon in the Areas 4 and 6 net fisheries, subsequent sampling efforts were confined to the Areas 1 and 2W purse seine fisheries.

South Coast Fisheries Sampling Programs

Historically, large catches of Fraser River, Johnstone Strait, and Puget Sound pink salmon stocks have occurred in southern British Columbia and northern Washington waters. Therefore, most of the GSI sampling effort has been directed at southern fisheries. The largest catches of Fraser pink salmon usually occur in purse seine fisheries off the east coast of Vancouver Island in Queen Charlotte Strait and Johnstone Strait (Areas 12 and 13). Fraser pink salmon are also harvested off the west coast of Vancouver Island (Areas 121-127 troll, Area 20 purse seine) and in Washington State waters off San Juan Island (Washington Area 7, purse seine) and near Point Roberts (Washington Area 7A, purse seine).

East Coast Vancouver Island Fisheries — Port samplers from the Canadian Department of Fisheries and Oceans (CDFO) obtained collections of pink salmon muscle tissue samples during August and September from purse seine fisheries in Queen Charlotte Strait and Johnstone Strait and the Area 11 troll fishery (Appendix Tables 5-8). Pink salmon caught by purse seine vessels in Queen Charlotte Strait north of Malcolm Island (Areas 12-8 to 12) and by trollers in Area 11 were sampled at processing plants in Port Hardy while purse seine catches from upper Johnstone Strait (Areas 12-1 to 7) were usually sampled at Alert Bay or Port Hardy, and periodically from vessels on the fishing grounds. The catches of pink salmon from purse seine vessels in the lower portion of Johnstone Strait (Area 13) were sampled at fish processors in Quathiaski Cove. Commission port-samplers collected tissue samples from purse seine catches taken off Texada Island (Area 16) that were delivered to fish processors in Vancouver or Steveston.

The number of pink salmon sampled from purse seine fisheries in Areas 12 and 13 was often increased from 150 to 300 fish per week to improve the accuracy of the stock composition estimates (Appendix Tables 5-8). Sampling efforts were most intense during late August and early September when the catches and the contribution of Fraser River pink salmon to these fisheries usually peaked.

West Coast Vancouver Island Fisheries — Pink salmon caught in the major troll and purse seine fisheries off the west coast of Vancouver Island were sampled by port samplers from the PSC (Appendix Tables 9-12). Sampling of pink salmon catches from the northern portion of the west coast Vancouver Island troll fishery (Areas 125 -127, Figure 3) took place primarily at processing plants in Winter Harbour. Troll fisheries occurring off the southern portion of Vancouver Island (121, 123, and 124) were sampled at fish processing plants in Ucluelet and Tofino. Samples from the west coast Vancouver Island troll fisheries were collected from approximately mid July to early September. During periods when most Fraser pink salmon migrated through these waters (usually from early August to early September) up to 300 pink salmon were sampled per fishery.
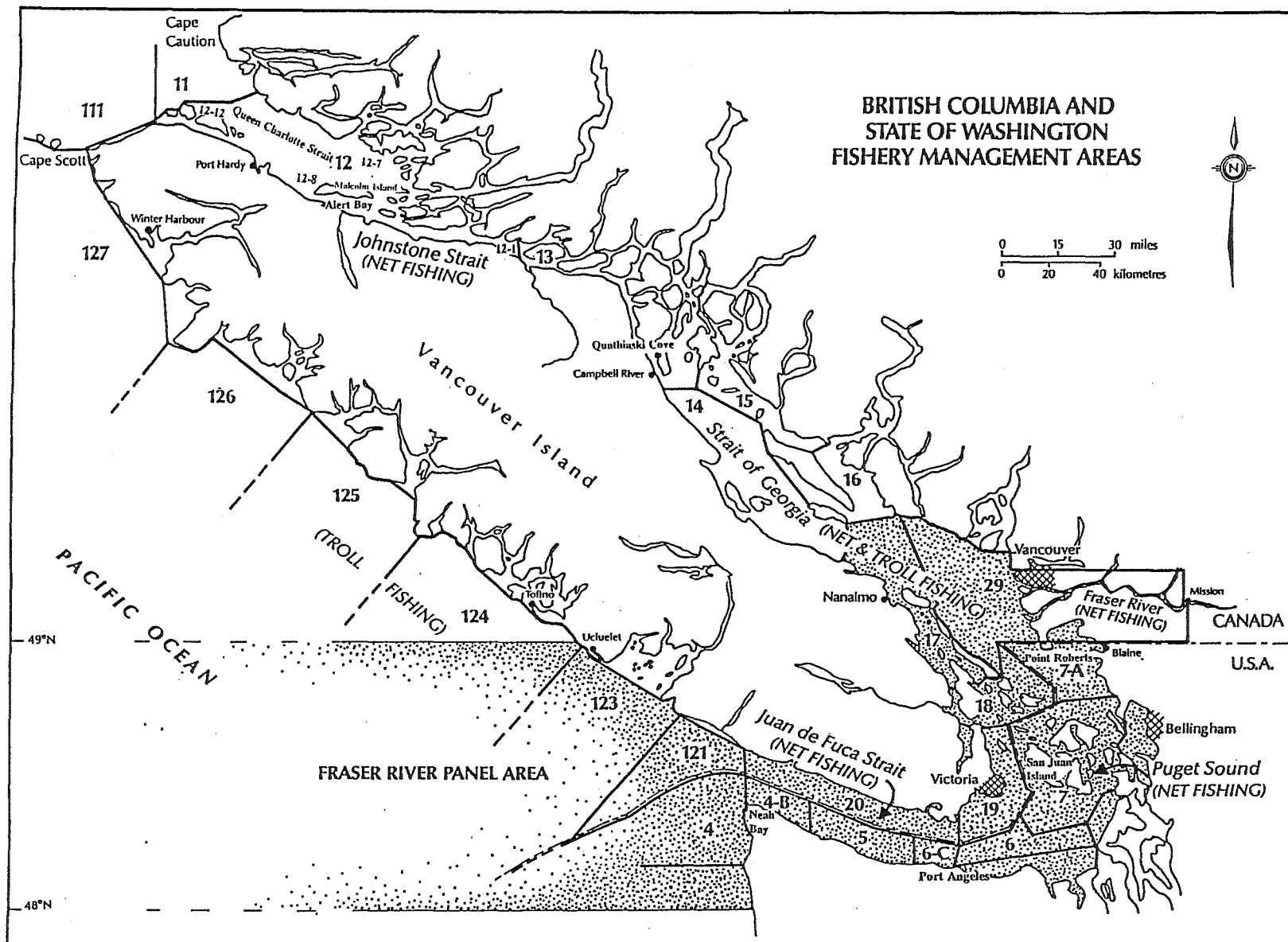
Figure 3. Statistical fishing areas south of Cape Caution including the Fraser River Panel Area of management jurisdiction (modified from PSC 1994).

Catches from the Area 20 purse seine fishery in Juan de Fuca Strait were generally off-loaded and sampled at processors in Steveston. Sampling of Area 20 pink catches by purse seine vessels during 1989 extended from the middle of July to the middle of September (Appendix Tables 9-12). From 1991 to 1995 the number of fisheries decreased so fewer samples were collected. Because of the large catches of Fraser pink salmon that are often taken in Area 20 purse seine fisheries, sample sizes were often 300 fish per week.

Washington State Fisheries — Catches of Fraser River pink salmon in Washington State waters occur primarily in the San Juan Islands (Washington Area 7) and Point Roberts (Washington Area 7A) net fisheries and in troll fisheries off the northwest coast of Washington (Areas 3, 4) and in gillnet fisheries in Areas 4B, 5, 6C on the south side of Juan de Fuca Strait. Sample sizes of 150 to 300 pink salmon were taken by PSC samplers from catches in Washington Areas 7 and 7A Treaty Indian and Non-Indian purse seine fisheries off-loaded at fish processing plants in Bellingham and Blaine from early August to mid-September (Appendix Tables 13-16). The Washington troll fishery samples were collected by Washington Department of Fish and Wildlife (WDFW) staff at a fish processor in Neah Bay during the latter half of August.

In-Season Electrophoretic Analyses

Standard starch-gel electrophoretic techniques were used to obtain genetic data for analysis of mixed-stock fishery samples. Methodologies describing starch-gel electrophoresis are provided in several publications (e.g. Aebersold et al. 1987; Shaklee and Keenan 1986). The Genetics Unit of WDFW has performed most of the in-season electrophoretic analyses of pink salmon tissue samples collected through the Commission's pink salmon GSI program. The PSC contracted more than one laboratory to perform the in-season electrophoretic analyses during some years to analyze the large number of tissue collections more rapidly, which helped satisfy fishery management requirements for in-season stock contribution estimates of Fraser pink salmon. The laboratories contracted by the PSC to analyze pink salmon tissue samples were required to standardize electrophoretic methods and scoring loci prior to conducting in-season analyses (White and Shaklee 1991). In addition, the laboratories were required to double-score (i.e., by two technicians independently) all loci and compare and agree upon their scores to increase the accuracy of their analyses. After the laboratories had completed their analysis of collections, the genetic data were immediately transmitted to the PSC. The loci that the Commission included in the in-season electrophoretic analyses (1989 to 1995) as well as the screening conditions and the relative mobility of the alleles are listed in Tables 1 and 2.

Table 1. Enzyme and locus nomenclature and electrophoretic screening conditions for pink salmon GSI using muscle tissue.

LOCUS[a]	SYNONYMY[b]	ENZYME NAME (NUMBER)	SUBUNIT STRUCTURE[c]	BUFFER(S)
ADA-2	Ada (Ada-2)	adenosine deaminase (3.5.4.4)	M	CAME6.1; CAME6.8; TC-4
mAH-4		Mitochondrial aconitate hydratase (4.2.1.3)	M	CAME6.8
ALAT		alanine aminotransferase (2.6.1.2)	D	TRIS-GLY; CAME6.8
CK-A1	Ck-1	creatine kinase (2.7.3.2)	D[d]	TRIS-GLY
GPI-A	Pgi-3 (Phi-3)	glucose-6-phosphate isomerase (5.3.1.9)	D	TRIS-GLY
GPI-B1,2	Pgi-1,2	glucose-6-phosphate isomerase (5.3.1.9)	D	TRIS-GLY
G3PDH-1	Agp	glycerol-3-phosphate dehydrogenase (1.1.1.8)	D	TRIS-GLY CAME6.8
FDHG		Formaldehyde dehydrogenase (glutathione) (1.2.1.1)	D	TRIS-GLY;CAME6.8
LDH-A1	Ldh-1	lactate dehydrogenase (1.1.1.27)	T	TRIS-GLY
sMDH-B1,2	Mdh-3,4	cytosolic malate dehydrogenase (1.1.1.37)	D	CAME6.3; TC-4; CAME6.8
mMEP-1	Me (MDHp-1)	Mitochondrial NADP+-dependent malate dehydrogenase (1.1.1.40)	T	CAME6.8
PEPD-2	Pp (PDPEP-2)	proline dipeptidase (3.4.13.9)	D	CAME6.8; TRIS-GLY
PEP-LT	Ll-1	peptidase (leucyl-tyrosine substrate) (3.4.-.-)	M	TC-4; TRIS-GLY
PGDH	6-Pg	Phosphogluconate dehydrogenase (1.1.1.44)	D	CAME6.8; TC-4
PGM-2	Pgm	Phosphoglucomutase (5.4.2.2)	M	TRIS-GLY; CAME6.8

a = nomenclature according to AFS standard (Shaklee et al. 1990).
b = locus symbols used in previous publications (e.g., Beacham et al. 1985).
c = M = monomer; D = dimer; T = tetramer.
d = although this enzyme is a dimer, the isozyme expressed in muscle tissue (CK-A1,2) exhibits monomeric patterns of variation in salmonids and other teleost fishes.

Table 2. Alleles and relative electrophoretic mobilities[a] for recognized alleles at 14 systems in pink salmon.

LOCUS	ALLELES							
ADA-2	100	110	90	105	114			
MAH-4	100	116	76	81				
ALAT	100	111	108	87	77	106		
CK-A1	100	66	110	74				
FDHG	100	138	58					
GPI-A	100	108	91	87	120			
GPI-B1,2	100	200	-64	25				
G3PDH-1	-100	-170	60	-10	20	200		
LDH-A1	-100	-250						
SMDH-B1,2	100	124	66	72	69	85	130	47
MMEP-1	100	123	115					
PEPD-2	100	120	80	110	130			
PEP-LT	100	108	90	80				
PGDH	100	108	96	86	90			
PGM-2	100	155	135	25	250			

[a] Some alleles at specific loci are pooled with the allele of closest mobility prior to MLE analysis to minimize potential laboratory scoring errors. Negative numbers associated with some alleles indicate cathodal mobility.

Statistical Analysis of In-Season Electrophoretic Data

The genetic data provided by the laboratories from in-season collections of pink salmon tissues were analyzed by the PSC using a maximum likelihood estimation (MLE) model. MLE models estimate the most likely composition of stocks contributing to a fishery mixture sample. The algorithms underlying these models are described in several publications (e.g. Fournier et al. 1984, Millar 1987, Pella and Milner 1987). A "Fournier-based" MLE model was used to analyze the in-season electrophoretic data collected from 1989 to 1995.

Three computer files are required by the MLE model to generate stock composition estimates: (1) start-up file, (2) fishery or mixture file, and (3) baseline file. In the start-up file, analysts specify the type of analysis to be run, e.g. number of stocks and loci in the baseline file, iteration and convergence parameters and bootstrapping options. The raw genetic data are in the mixture file and contain allele scores at each locus for the fish in a mixture sample.

The third computer file required by the MLE model is the baseline file. It contains the genetic profile of the samples collected on the spawning grounds of stocks that potentially contributed to a fishery mixture sample. Much of the baseline data used in the Commission's GSI program is documented in Shaklee et al. (1991). Two separate baselines (Table 3) were used to analyze the in-season pink salmon collections. The "North Coast Baseline", includes stocks from all four major stock-groups (Figure 1): (1) Fraser River, (2) Puget Sound, (3) Canada south coast, and (4) Canada north coast, and is used for GSI analysis of fisheries occurring north of Cape Caution.

The "South Coast Baseline" includes three stock groups (Fraser River, Puget Sound, and Canada South Coast) and is used for determining the stock composition of samples from mixed-stock fisheries south of Cape Caution. This baseline excludes data from pink salmon stocks spawning in central and northern British Columbia, because it is unlikely that they contribute to fisheries conducted south of Cape Caution. The removal of the northern pink salmon stocks from this baseline improves the accuracy of southern pink salmon stock composition estimates because it reduces the complexity of the mixture problem that the MLE model solves to produce estimates (i.e., the MLE model would sometimes mis-assign a small proportion of the mixture sample to the Canada north coast stock-group despite their absence from the mixture sample). A thorough description of how Commission analysts create baselines used in the GSI program is given in White (1996).

The GSI method has several assumptions; some of the main ones include: (1) the baseline samples accurately characterize the genetic profile of each stock; (2) the stocks contributing to the mixture sample are included in the baseline; (3) the mixture sample accurately reflects the genotypes in the contributing stocks; and (4) the laboratory and statistical analyses of the samples and data are performed accurately.

Table 3. Pink salmon stocks often included in the Commission's GSI baselines.

STOCK GROUP	STOCK
FRASER RIVER	Fraser mainstem Thompson River Bridge River Seton Creek Harrison River Vedder River Coquihalla River
PUGET SOUND	Nooksack River Skagit River Snohomish River Stillaguamish River Hamma Hamma River Duckabush River Dosewallips River Dungeness River
CANADA SOUTH COAST	Wakeman River Kakweiken River Glendale Creek Adam River Quinsam River Keogh River Phillips River Puntledge River
CANADA NORTH COAST	Johnston Creek Kilbella River Koeye River Kwatna River Bella Coola River Atnarko River Salloompt River Kainet Creek Mussel River Kemano River Quaal River Kitimat River Kumealon Creek Skeena River Andesite River Lakelse River Morice River Babine River Kispiox River Kitwanga River Khutzeymateen River Kwinamass River Ishkheenickh River Iknouk River Stagoo River

As a result of the assumptions in the GSI technique, there are several potential sources of bias in the estimation of stock contributions to mixed-stock fishery samples. Some of these include non-random field sampling (Shaklee and Phelps 1990), mistakes during electrophoretic analyses (White and Shaklee 1991) and inherent biases in the MLE models (Wood et al. 1987) that are used to analyze the genetic data from mixture samples. The MLE models have a tendency to overestimate the contribution of stocks that are minor contributors to mixture samples and underestimate the presence of stocks that are dominant contributors. Simulation analyses were conducted to estimate the amount of bias in the MLE analyses on pink salmon mixture samples. Genetic data were drawn from the south coast baseline to create simulated fisheries with known or "true" proportions of pink salmon from Fraser River stocks. The sample size of the simulated fisheries was 250 fish, which approximated the sample sizes collected from the major south coast fisheries. The simulated fisheries were created with "true" proportions of Fraser pink salmon ranging from 20%-100%, with concentration on the Fraser contribution interval from 60% -100% because most of the in-season analyses of major south coast fisheries indicate Fraser pink proportions in this range. The simulated fisheries were bootstrapped 100 times and the mean estimates of Fraser contributions and associated standard errors were calculated (Table 4).

Table 4. Estimates of bias from MLE analysis of simulated fisheries of Fraser River pink salmon.

True % Fraser Pink Salmon (T)	Estimated % Fraser Pink Salmon (E) & (standard error)	Bias (T-E)
20	34.9 (9.6)	14.9
40	48.2 (2.7)	8.2
50	59.4 (4.9)	9.4
60	65.2 (8.0)	5.2
65	69.1 (6.1)	4.1
70	72.4 (8.4)	2.4
75	73.4 (5.0)	-1.6
80	79.5 (7.3)	-0.5
85	83.9 (4.8)	-1.1
90	87.8 (3.4)	-2.2
95	91.0 (2.5)	-4.0
100	95.0 (2.6)	-5.0

Table 4 shows that Fraser River pink salmon are typically over-estimated in the mixture samples when they are present in relatively low to moderate proportions. Fraser pink salmon are slightly under-estimated when they constitute a high proportion of the mixture samples, e.g. from true contributions of 75% to 90% (which is a normal range of Fraser pink contributions in major southern fisheries) the estimates were usually under-estimated by about 2% (Table 4). Because the estimated bias in southern mixed-stock fisheries was small, it was not considered necessary to apply a statistical bias-correction methodology to the MLE estimates. Therefore, the stock composition estimates reported in this paper are the "raw" MLE estimates of contributions by stock group for the fisheries examined.

Application of GSI Estimates to Pink Salmon Catches

The Fraser River Panel requires regular updates of Fraser River pink salmon catches by country and by user group within each country during the in-season period. To produce these updates, estimates of pink salmon catches in fisheries and corresponding stock composition estimates are needed. The catch data are compiled from government and industry sources (e.g. fish processors) and the stock composition estimates are generated by the GSI program.

The estimates of pink salmon catches by statistical area and week-ending date and the estimated proportion of Fraser pink salmon by fishery were tabulated on a computer spreadsheet. Catch summary tables were produced weekly during the in-season management period that itemized the catches of Fraser pink salmon by country, area, and user-group. These tables were provided to fishery managers to help in the development of fishery regulations aimed at achieving escapement goals and international and domestic catch allocation objectives.

Examination of Fraser River Pink Salmon Catch Patterns

The pink salmon catch data combined with the GSI stock composition estimates allow the probable marine movements of Fraser River pink salmon returning through coastal fisheries between July and September to be determined. The timing and routes of major migrations of adult Fraser pink salmon, and their interannual variability, were determined from the GSI data collected between 1989 and 1995 in fisheries from the north and west coast of the Queen Charlotte Islands, the east and west coast of Vancouver Island and from Washington State fisheries off the San Juan Islands and at Point Roberts.

The comparison of Fraser pink proportions and catches in fisheries across years required adjusting the differing W/E periods occurring between 1989 to 1995 to a common series of dates referred to here as "Mean Mid-Week Catch-Dates". Fraser River pink salmon stock proportions and catches were examined using mean mid-week catch dates for the odd years from 1989 to 1995.

The catch patterns of Fraser pink salmon in northern and southern fisheries based on the catch and GSI estimates were examined using two main types of graphs. Line-graphs were prepared for the major fisheries that showed the proportion of Fraser pink salmon contributing to these fisheries over the fishing seasons. Bar-graphs were used to show the estimated catches of Fraser pink salmon that occurred in the major fisheries over the main commercial catch periods.

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RESULTS

Contribution of Fraser River Pink Salmon to Fisheries

The stock composition estimates from the mixed-stock fisheries analyses (Appendix Tables 1-16) and the associated catches allowed the estimation of Fraser River pink salmon contributions to northern and southern fisheries.

Northern British Columbia Fisheries

Proportion of Fraser River Pink Salmon in Catches — The examination of contributions of Fraser pink salmon to northern fisheries is focused on the Areas 101 and 142 troll fisheries because this is where the largest contributions of Fraser pink salmon to northern fisheries has occurred during the study period and because numerous GSI estimates are available. GSI samples analyzed from purse seine fisheries occurring in Areas 1, 2W, 4 and 6 between 1989-1995 (see Appendix Tables 1-3) are too intermittent to provide sufficient information for reliable migrational analysis.

Most of the GSI samples collected from the Area 101 troll fishery were collected in 1989 and 1991 from mid-July to late August. Fraser pink salmon comprised about 5% of the catch of pink salmon during July (Figure 4). Their contributions to this fishery increased during the first half of August to about 25% and continued to climb over the remainder of August until they reached about 50%. There was lower inter-annual variability in the estimated proportion of Fraser pink salmon at equivalent catch dates in July than in August.

Figure 4. Estimated proportions of Fraser River pink salmon in the Area 101 troll fishery during the 1989-1995 fishing seasons.

The number of days of troll fishing in Area 142 decreased from 1989 to 1995, and consequently few GSI samples were collected after 1989. The samples collected over the latter half of July indicated that Fraser pink salmon comprised about 15% of the catch (Figure 5). Although the estimated Fraser proportions for corresponding catch periods were quite variable across years, they suggest an increasing trend from about 40% in early August to about 70% by late August.

Figure 5. Estimated proportions of Fraser River pink salmon in the Area 142 troll fishery during the 1989-1995 fishing seasons.

Catches Estimates of Fraser River Pink Salmon — Most of the Fraser pink salmon harvested in the Areas 101 and 142 troll fisheries between 1989 and 1995 were caught during August (Figure 6). The average peak-catch date was August 23, which corresponded to the time when the proportion of Fraser pink salmon in the Areas 101 and 142 troll fisheries was highest (Figures 4 and 5).
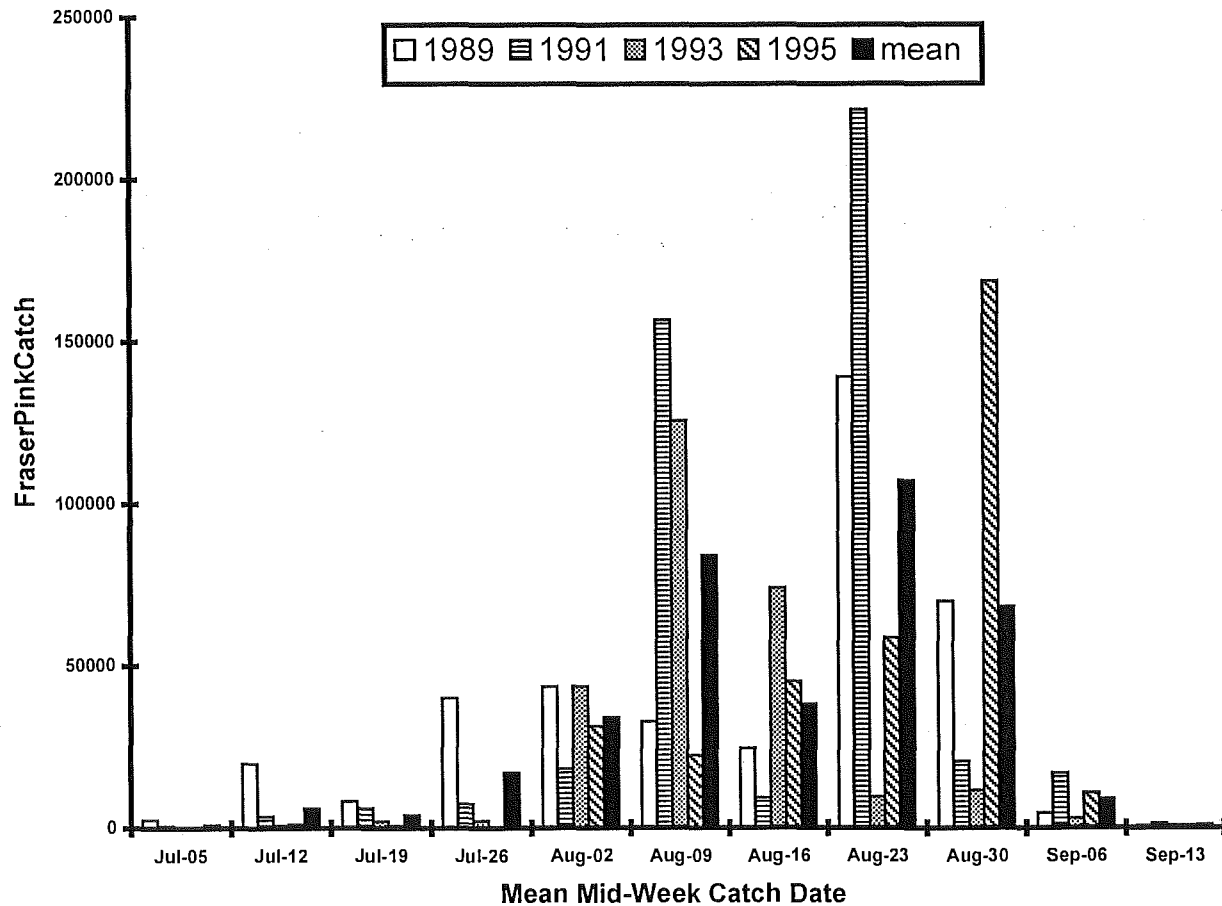
Figure 6. Estimated catches of Fraser River pink salmon in the Area 101 and 142 troll fisheries during the 1989-1995 fishing seasons.

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Southern British Columbia Fisheries

The contribution of Fraser River pink salmon to major British Columbia fisheries south of Cape Caution are described below.

Proportion of Fraser River Pink Salmon in Catches — Samples collected from purse seine fisheries conducted in the Queen Charlotte Strait (Area 12-8 to 12, Figure 7) indicated Fraser pink salmon comprised approximately 40% of the catch in early August. The proportion of Fraser pink salmon in these fisheries increased rapidly through August until they peaked at about 87% near the end of August.
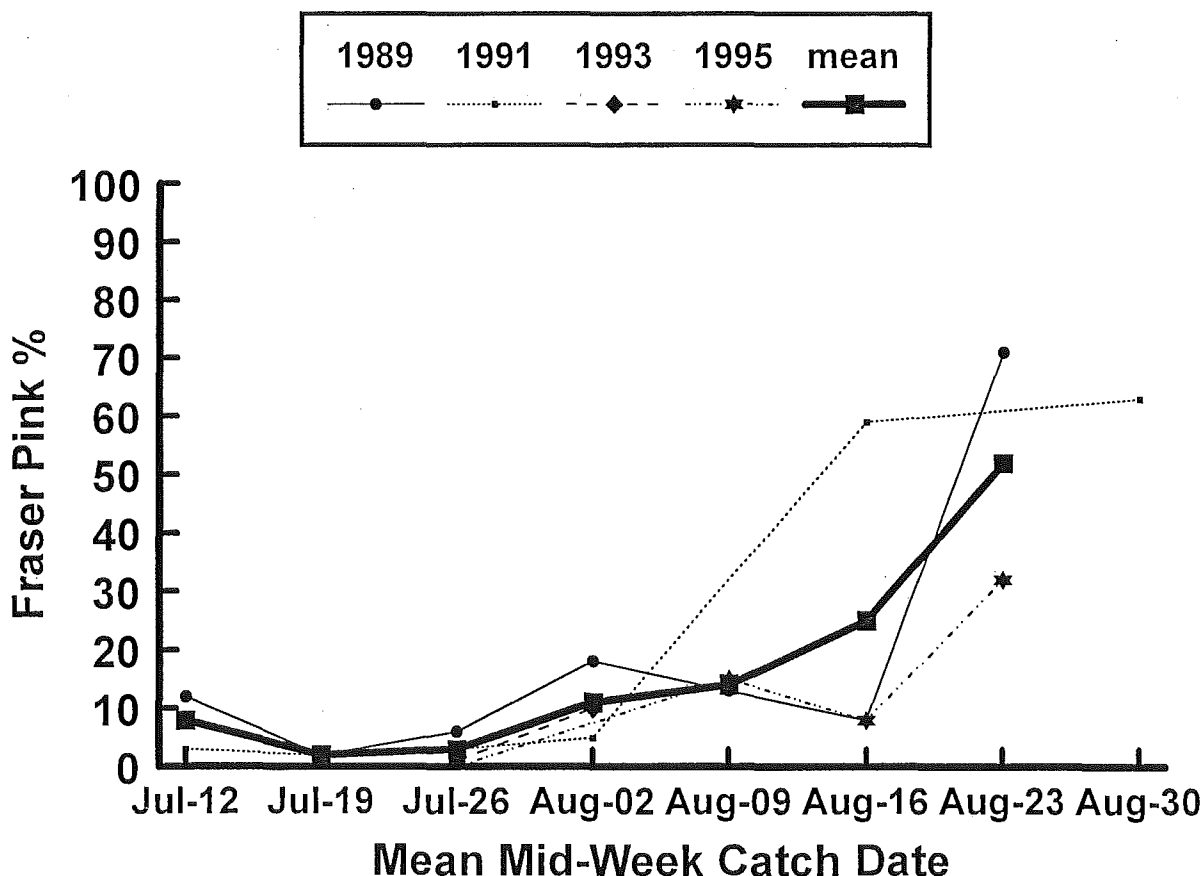

Figure 7. Estimated proportions of Fraser River pink salmon in the Area 12-8 to 12 purse seine fishery during the 1989-1995 fishing seasons.

The upper Johnstone Strait purse seine fisheries (Areas 12-1 to 7, Figure 8) occurring in late July and early August generally showed Fraser contributions ranging from 20% to 40%. The proportion of Fraser pink salmon in these fisheries increased until the end of August when they constituted about 80% of the catch. The trend in Fraser proportions was similar across years, however the inter-annual variability was quite high for similar catch dates, e.g. for catch date August 30, estimates ranged from 76% in 1993 to 93% in 1991.
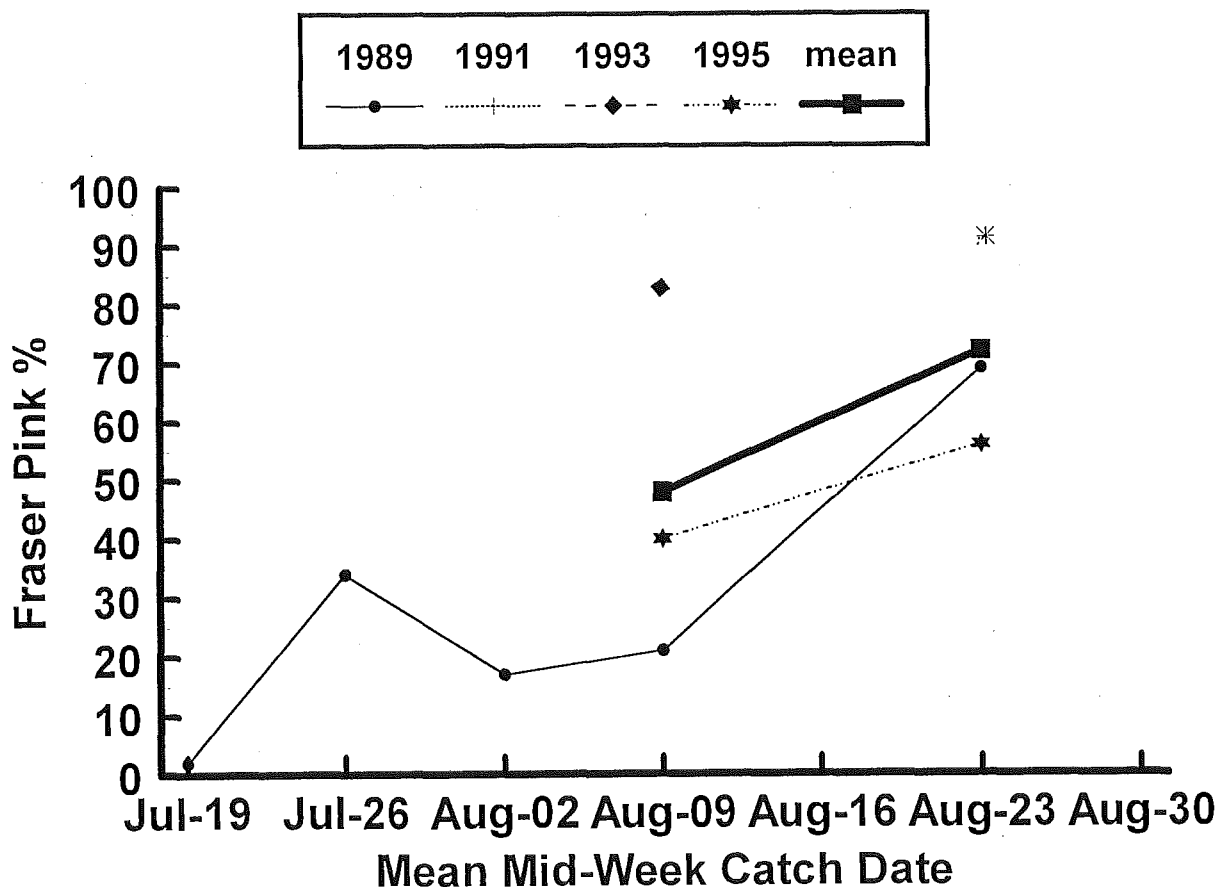

Figure 8. Estimated proportions of Fraser River pink salmon in the Area 12-1 to 7 purse seine fishery during the 1989-1995 fishing seasons.

From early to mid-August Fraser pink contributions rose steadily from approximately 25% to 60% in purse seine catches in southern Johnstone Strait (Area 13, Figure 9) fisheries. The proportion of Fraser pink salmon in the catches continued to increase until they typically levelled off at close to 90% by the end of August. The inter-annual variability in the proportion of Fraser pink salmon in the Area 13 fisheries was quite high; in particular, from mean catch dates between August 9 and August 23. For example, during 1989 and 1993, on August 16, the estimates were 42% and 83%, respectively. However, the 1991 estimate of 59% was approximately the same as the average (61%) of the three estimates recorded for that mean catch date.

Figure 9. Estimated proportions of Fraser River pink salmon in the Area 13 purse seine fishery during the 1989-1995 fishing seasons.

The GSI samples collected from Areas 12 and 13 purse seine fisheries between August 2 and August 30 show that the mean proportion of Fraser pink salmon increased steadily from about 25% to 86% (Figure 10). During the first half of September, Fraser pink salmon continued to contribute over 80% of the pink salmon harvested in those fisheries.
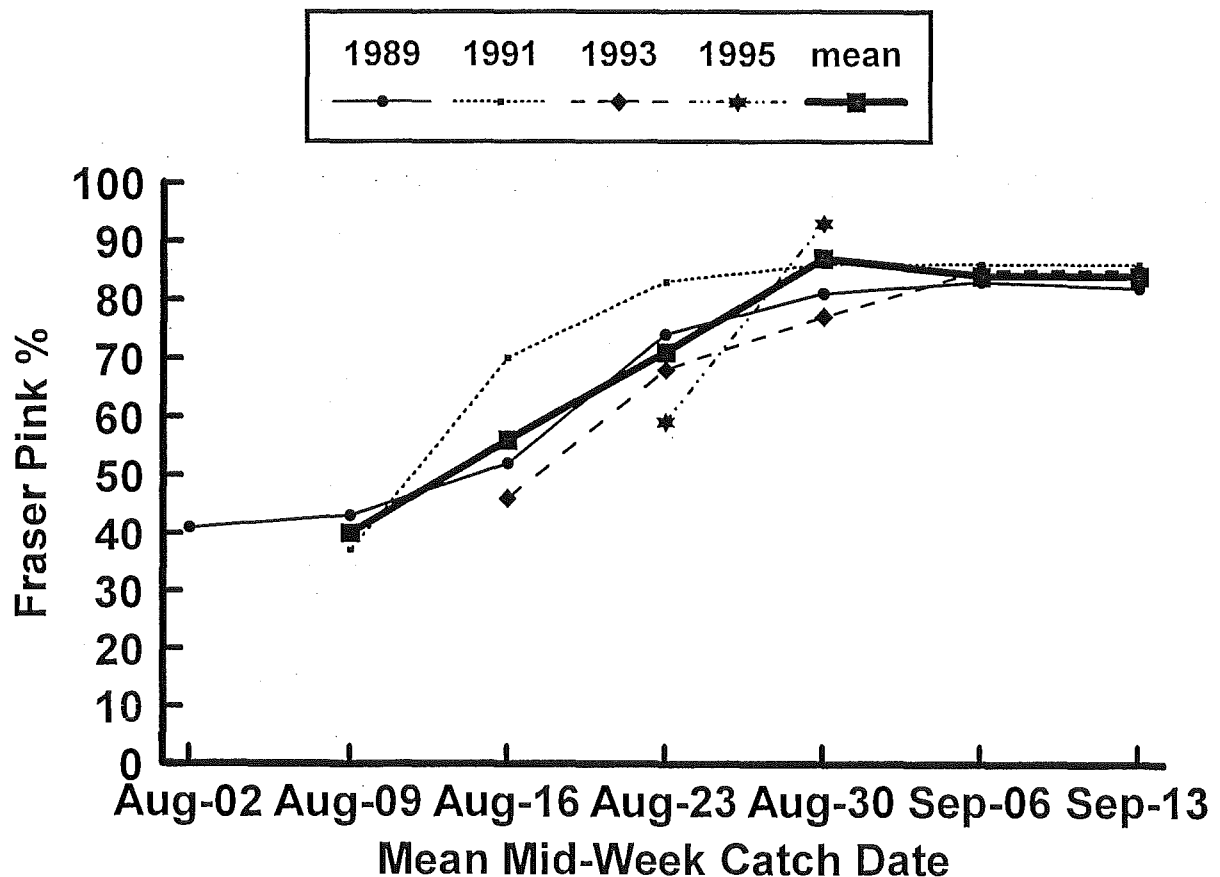

Figure 10. Mean estimated proportions of Fraser River pink salmon in the Areas 12 and 13 purse seine fishery during the 1989-1995 fishing seasons.

GSI samples collected in 1989 from the northern portion of the west coast Vancouver Island troll fisheries (Areas 125-127) on mean catch dates July 12 and July 26 showed the component of Fraser pink salmon to be about 65% of the mixtures (Figure 11). In early August, Fraser pink salmon averaged about 70% contribution to these fisheries. From mid to late August the contribution of Fraser pink salmon fluctuated slightly (79%-85%). A sample collected in 1991 on mean catch date September 6 indicated that Fraser pink salmon comprised 84% of the mixture. The inter-annual variability of Fraser contributions to this fishery at similar times was fairly low, with most estimates for similar catch dates within 10% of the average for each catch date. The highest variability between years was observed on about August 2 when Fraser contributions were 55% in 1989 and 87% in 1991.
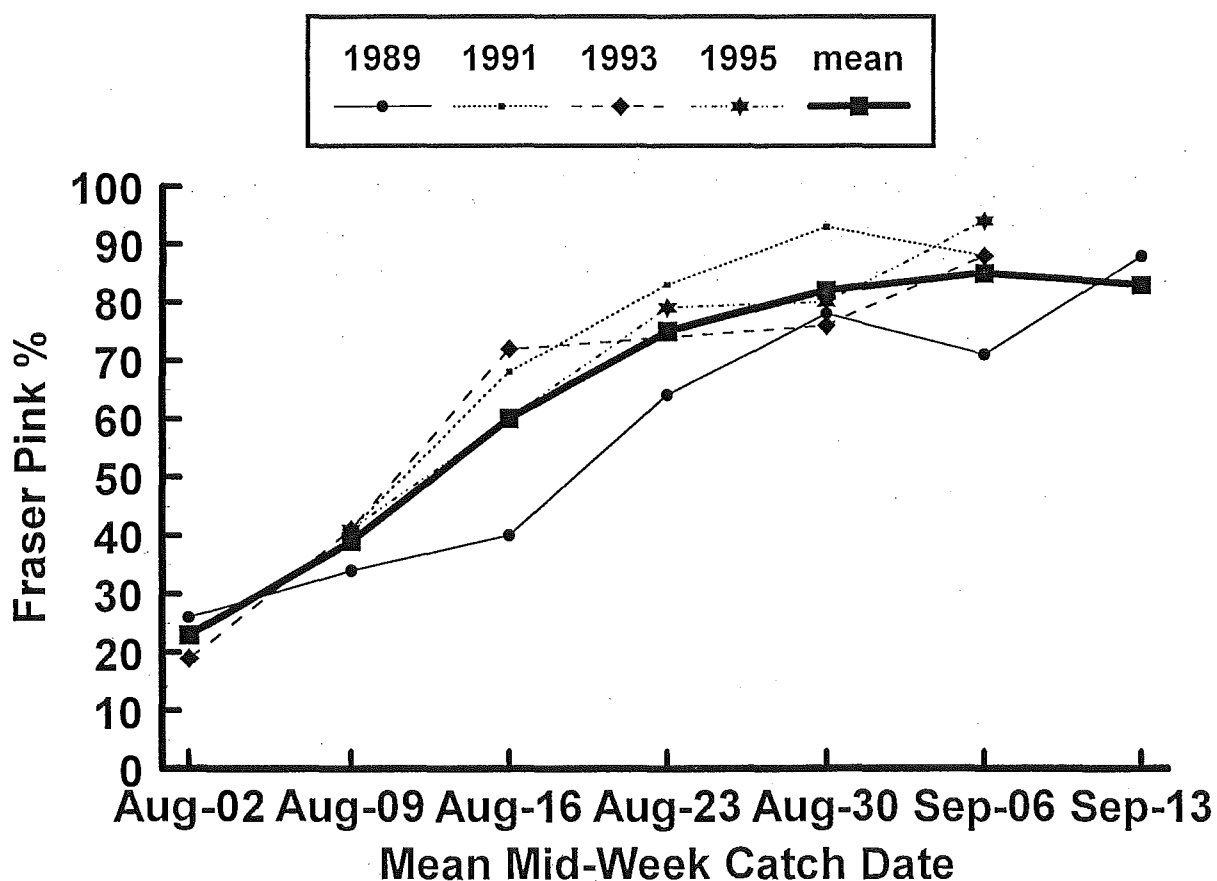

Figure 11. Estimated proportions of Fraser River pink salmon in the Area 125-127 troll fishery during the 1989-1995 fishing seasons.

The earliest sample taken from the southern portion of the west coast Vancouver Island troll fisheries (Areas 121-124) was taken in 1989 on about July 12 when Fraser pink salmon comprised approximately 46% of the fishery mixture sample (Figure 12). From July 19 to mid-August Fraser pink salmon constituted about 70% of the harvests. Between August 16 and August 23 the proportion of Fraser pink salmon in the mixtures increased to about 90%. From late August to mid-September the Fraser contribution varied between approximately 75% to 85%. The inter-annual variability was quite high throughout the season, with estimates for similar catch dates often varying by about 15%.
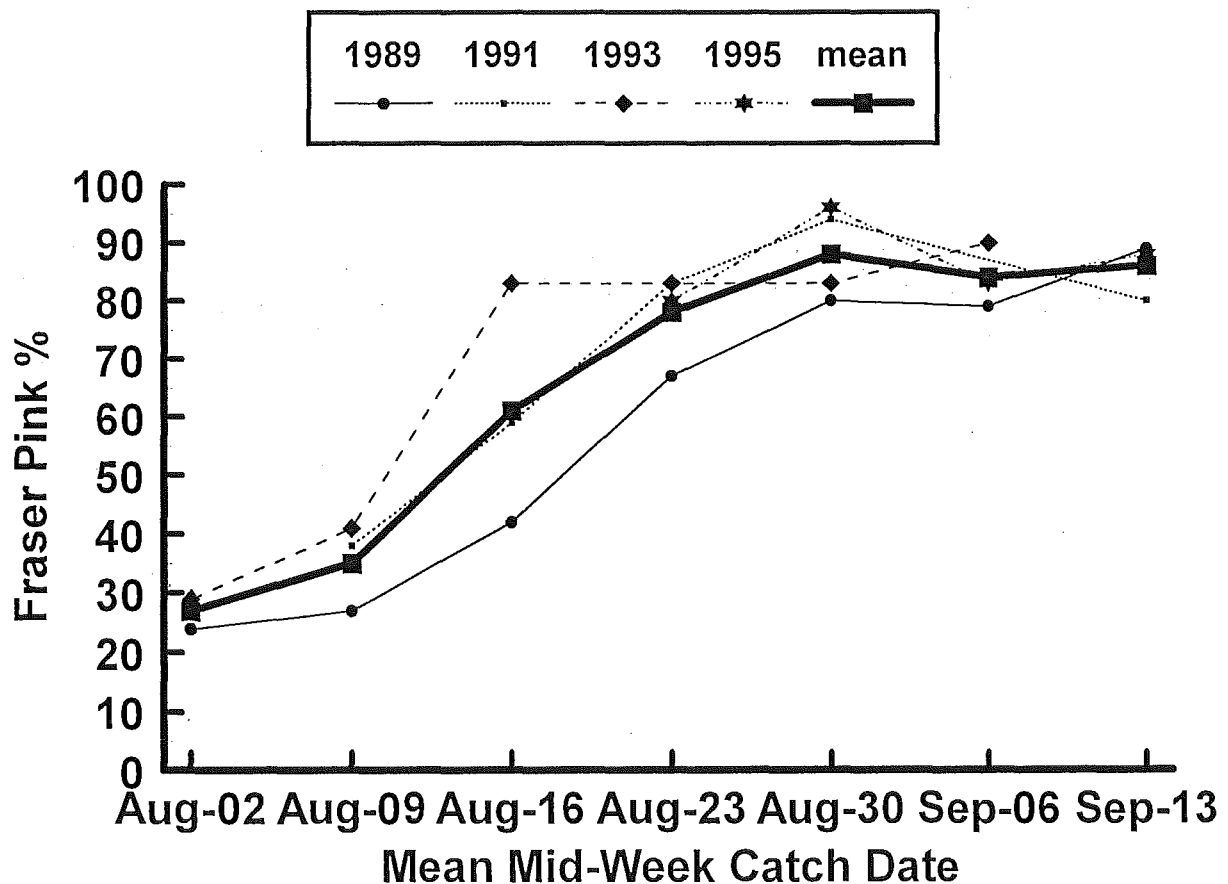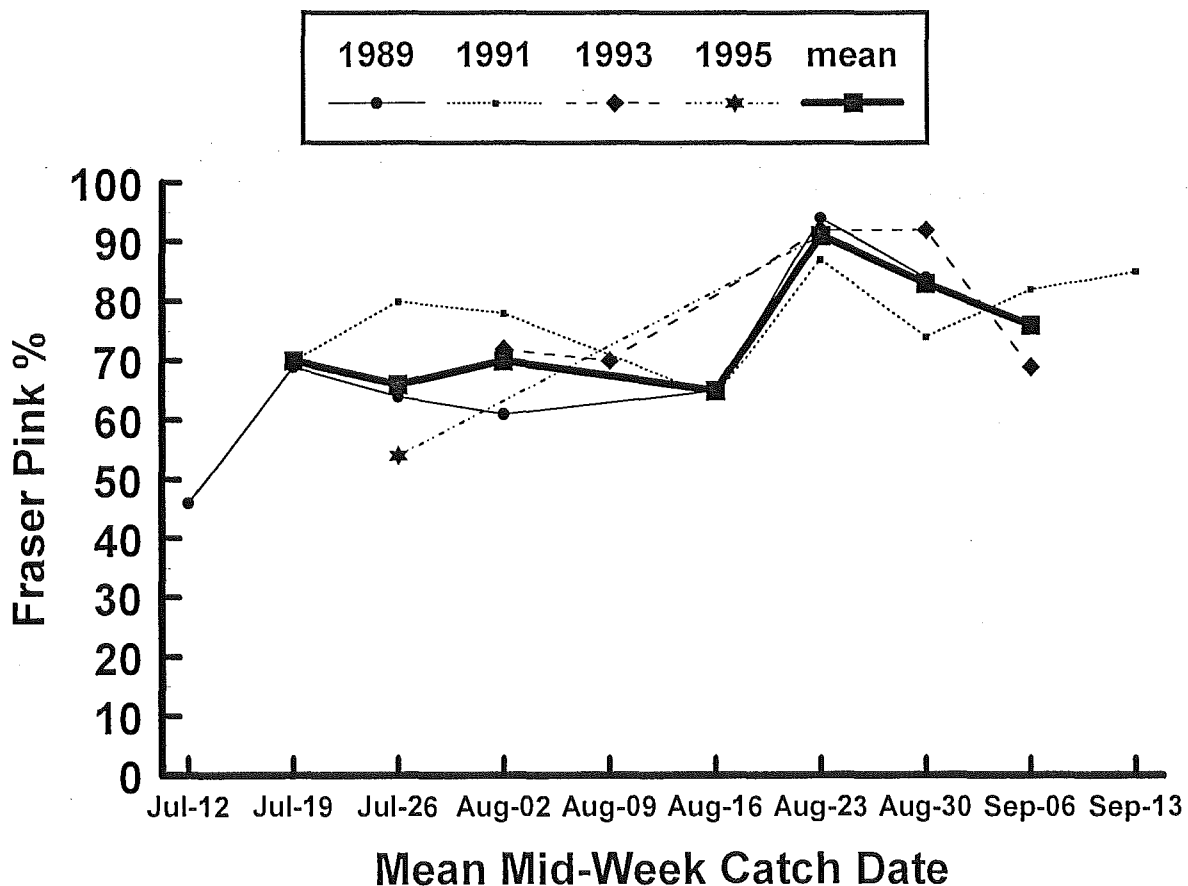

Figure 12. Estimated proportions of Fraser River pink salmon in the Area 121-124 troll fishery during the 1989-1995 fishing seasons.

Purse seine fisheries have not occurred regularly in Area 20 since 1989, therefore stock composition estimates for the years between 1991 to 1995 are incomplete (Figure 13). However, in general the trend in Fraser pink contributions to the Area 20 purse seine fishery was similar to the adjacent Area 121-124 troll fishery; i.e., Fraser pink salmon increased from about 40% in mid-July to over 80% by the end of August.
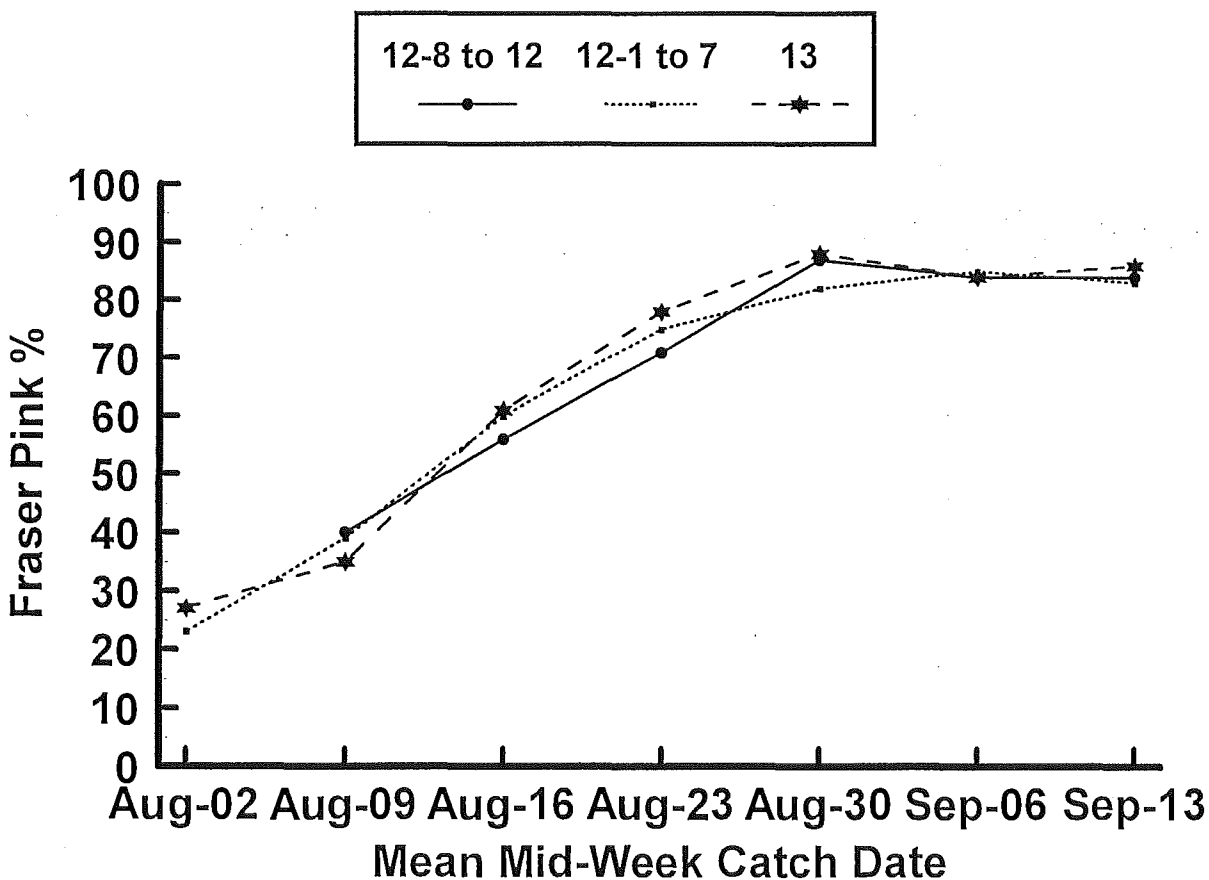

Figure 13. Estimated proportions of Fraser River pink salmon in the Area 20 purse seine fishery during the 1989-1995 fishing seasons

Catches Estimates of Fraser River Pink Salmon — Most Fraser River pink salmon were harvested in the Queen Charlotte Strait and Johnstone Strait (Areas 12 and 13) net fisheries between mid-August and mid-September (Figures 14 and 15). The mean peak-catch date for Fraser pink salmon in these fisheries was August 30, which was also when the proportion of Fraser pink salmon contributing to these fisheries was highest (Figure 10). Closures to these fisheries in early September (1991 and 1993) affect catch estimates of these weeks relative to August 30.

Figure 14. Estimated catches of Fraser River pink salmon in the Area 11 and 12 net fisheries during the 1989-1995 fishing seasons.
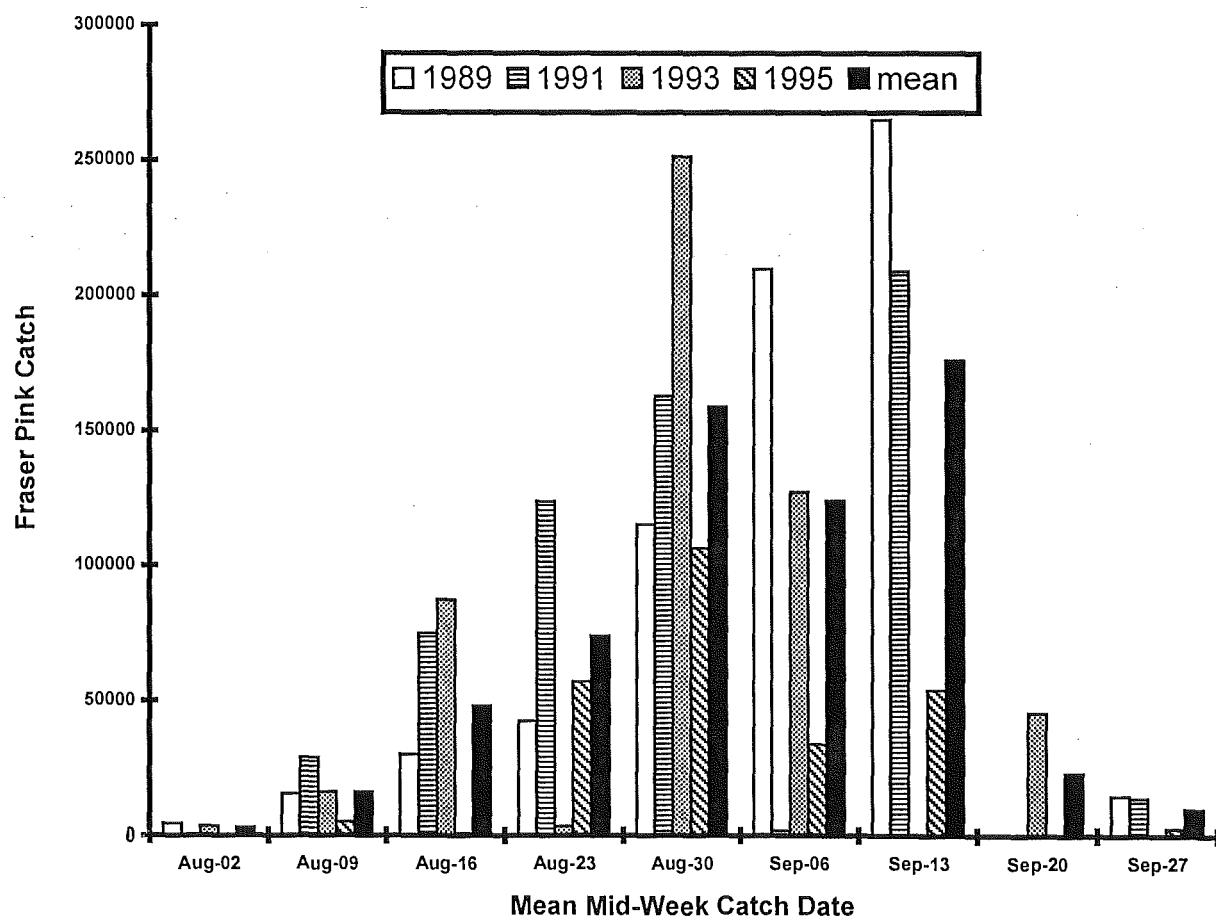
Figure 15. Estimated catches of Fraser River pink salmon in the Area 13 net fisheries during the 1989-1995 fishing seasons.

Most of the catch of Fraser River pink salmon in the west coast Vancouver Island troll fisheries occurred from August 9 to September 13 (Figures 16 and 17). The largest catches of Fraser pink salmon were observed on about August 23 in Areas 125-127 (Figure 16) and one week later, on August 30 in the more southern Areas 121-124 (Figure 17).

Figure 16. Estimated catches of Fraser River pink salmon in the Area 125-127 troll fishery during the 1989-1995 fishing seasons.
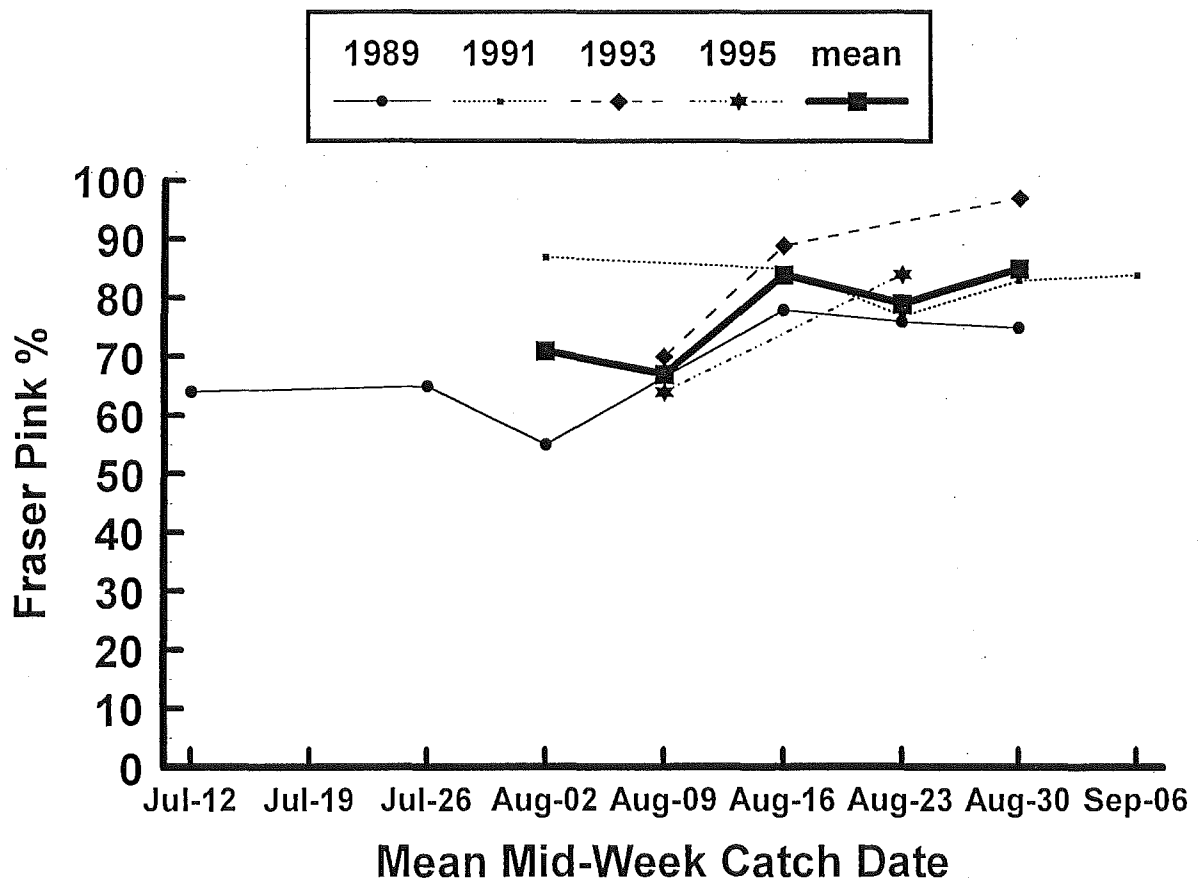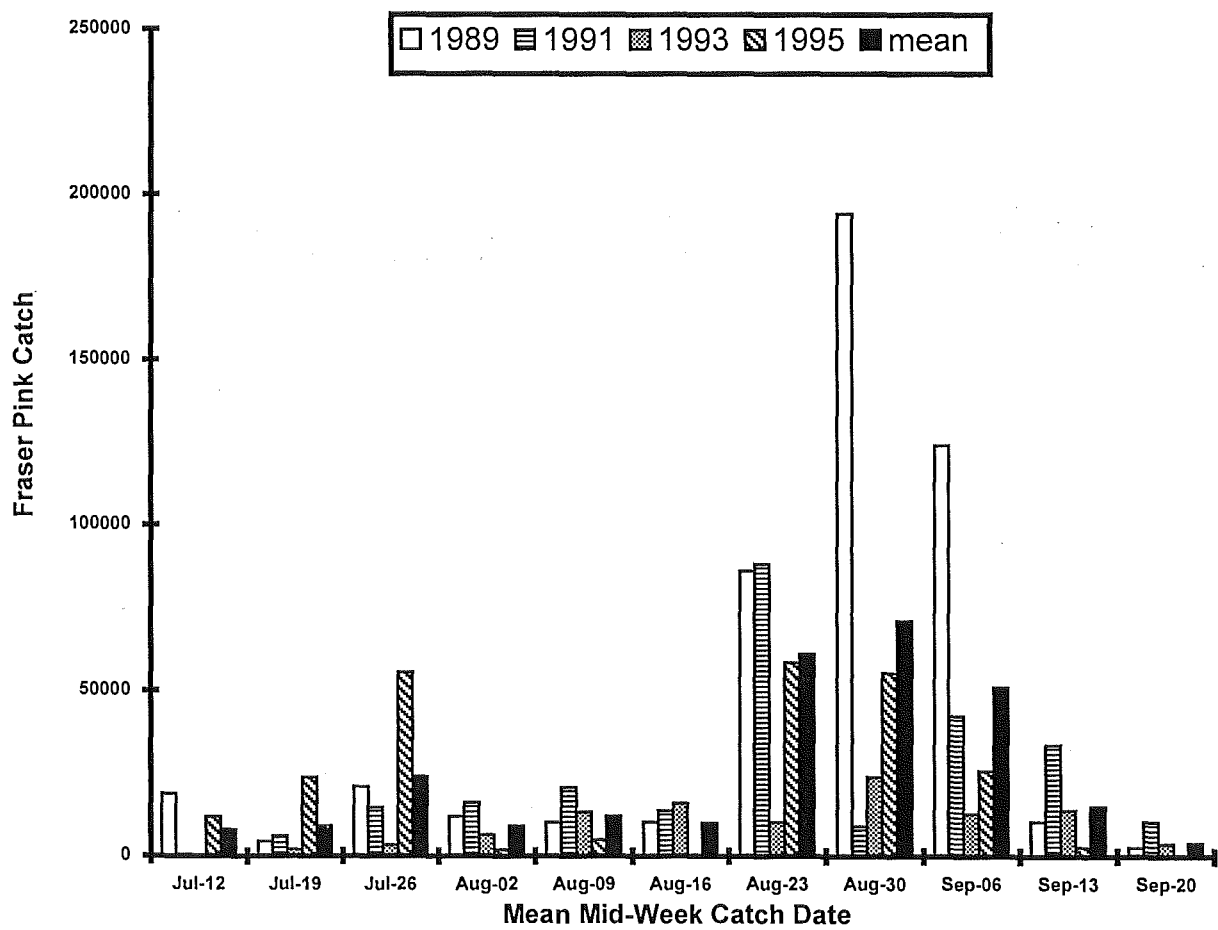
Figure 17. Estimated catches of Fraser River pink salmon in the Area 121-124 troll fishery during the 1989-1995 fishing seasons.

The harvest of Fraser pink salmon in the Area 20 purse seine fishery occurred primarily from about August 23 to September 6 (Figure 18). The peak catches were seen on August 30 with approximately 700,000 Fraser pink salmon taken per week during two of the years examined (Figure 18).

Figure 18. Estimated catches of Fraser River pink salmon in the Area 20 purse seine fishery during the 1989-1995 fishing seasons.

Proportion of Fraser River Pink Salmon in Catches — The earliest samples from the San Juan Islands (Washington Area 7) purse seine fisheries were taken in 1989 and 1991 in W/E August 2 (Figure 19). On average, Fraser pink salmon constituted almost 30% of the fishery mixtures at that date. From early August the proportion of Fraser pink salmon in this fishery increased rapidly to an average of 89% by August 16. This high proportion of Fraser pink salmon in the San Juan Islands purse seine fishery was sustained for the remainder of the season each year. The latest sample taken from this fishery was on September 20 in 1993 and it showed that Fraser pink salmon comprised 94% of the mixture. The highest inter-annual variability in Fraser proportions occurred around the middle of August as the contributions of Fraser pink salmon were increasing rapidly. After Fraser pink proportions reached approximately 90% in late August to early September, the inter-annual variability in the estimates decreased.

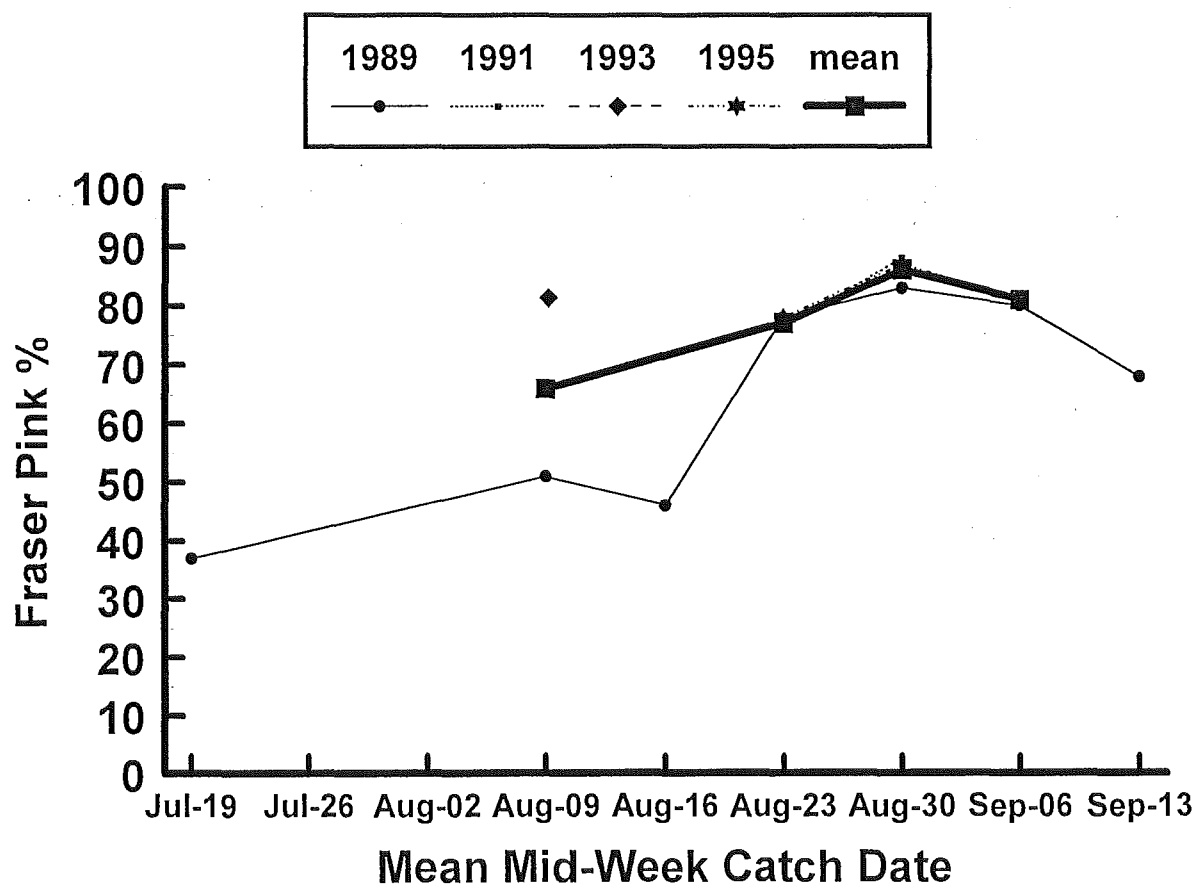**Figure 19.** Estimated proportions of Fraser River pink salmon in the Washington Area 7 purse seine fishery during the 1989-1995 fishing seasons.

In 1989, the contribution of Fraser pink salmon to the Point Roberts (Washington Area 7A) purse seine fishery almost doubled from 32% on August 2 to 61% by August 9 (Figure 20). The average proportion of Fraser pink salmon climbed gradually during middle and late August and reached an average of 89% by September 6 and sustained this high contribution the following week. The inter-annual variability in Fraser percentages comprising the fisheries was quite low throughout the season, i.e., individual estimates varied less than 10% from the mean estimates of Fraser pink salmon for equivalent catch dates.
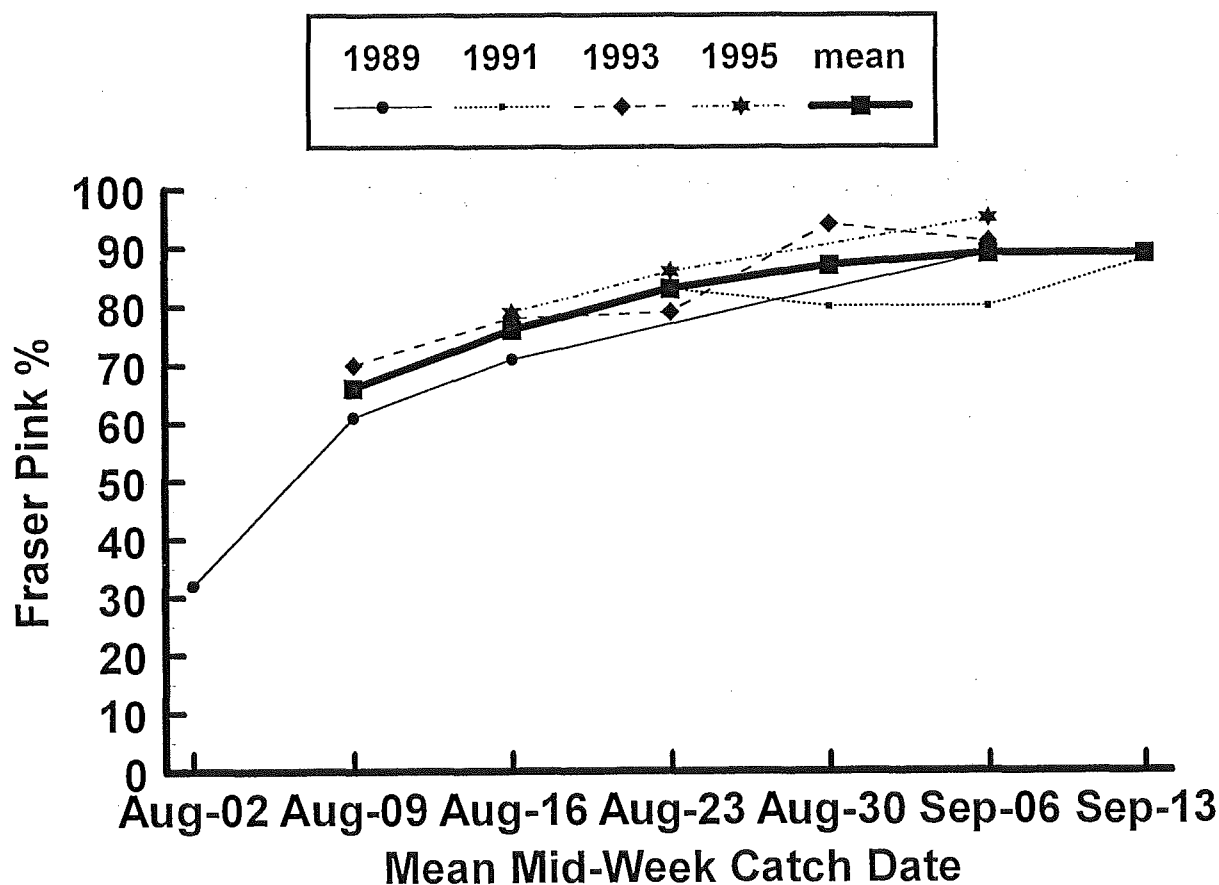
Figure 20. Estimated proportions of Fraser River pink salmon in the Washington Area 7A purse seine fishery during the 1989-1995 fishing seasons.

Catches Estimates of Fraser River Pink Salmon — The largest catches of Fraser pink salmon in the Washington Area 7 and 7A net fisheries occurred between mid-August and mid-September (Figure 21 and 22). The peak mean catch date of Fraser pink salmon from net fisheries occurring in both of these areas was about September 6.
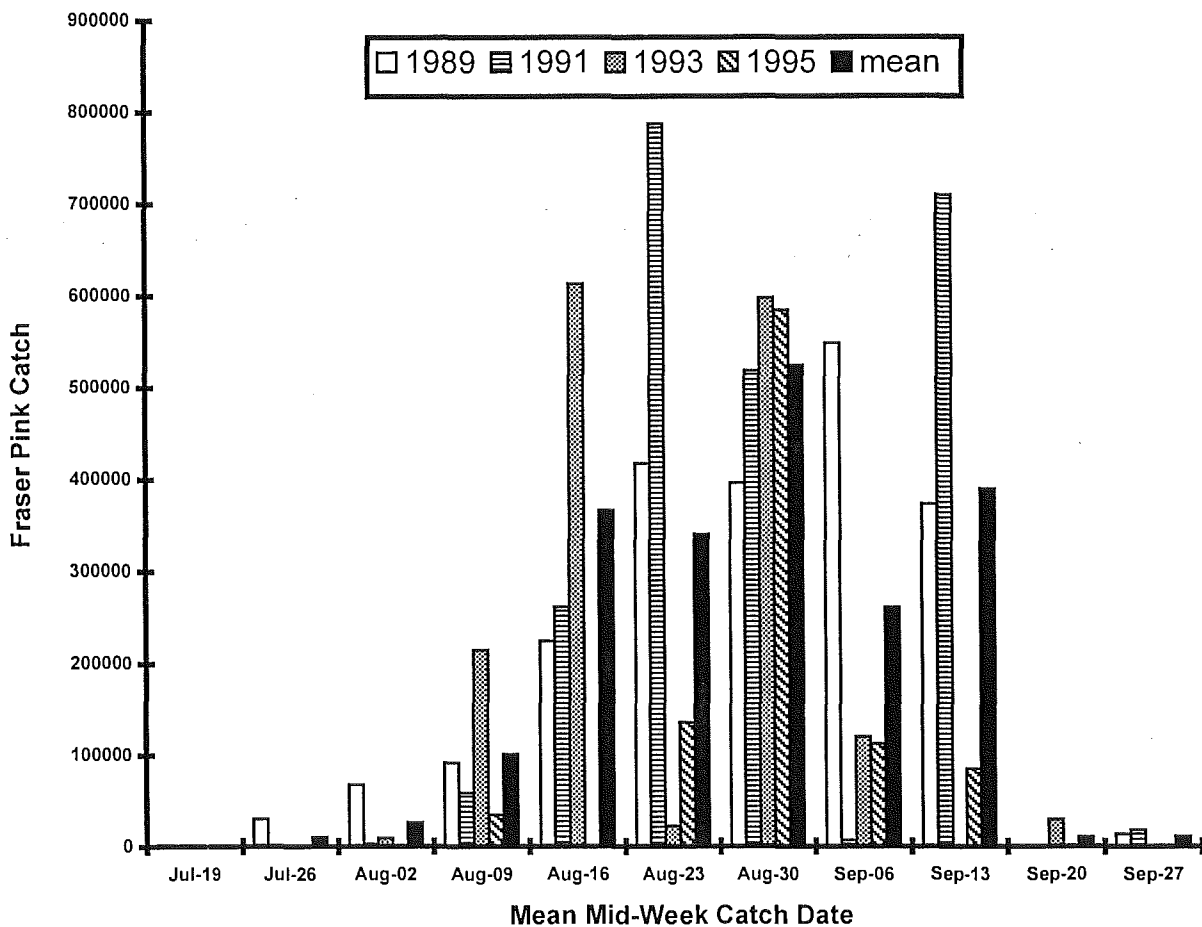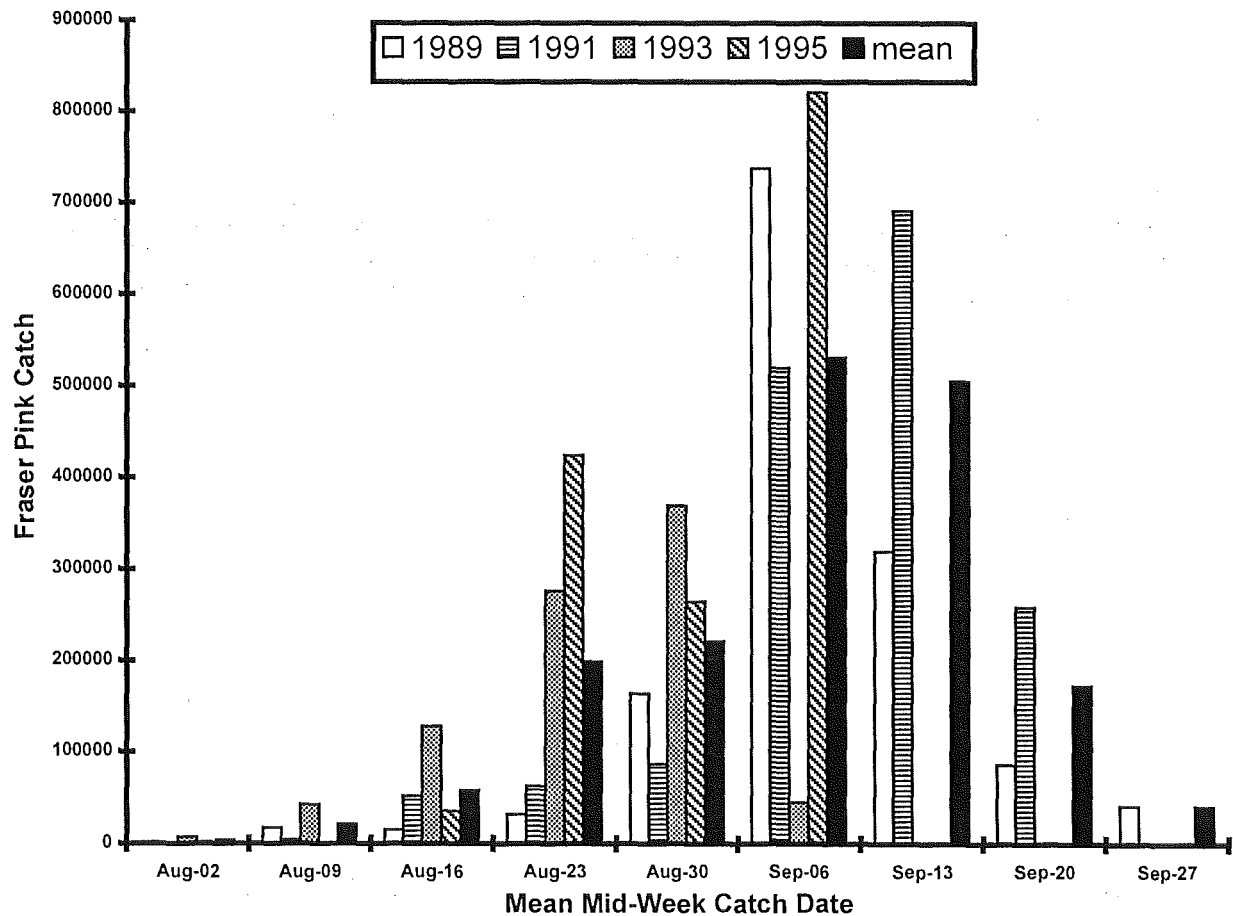

Figure 21. Estimated catches of Fraser River pink salmon in the Washington Area 7 net fishery during the 1989-1995 fishing seasons.
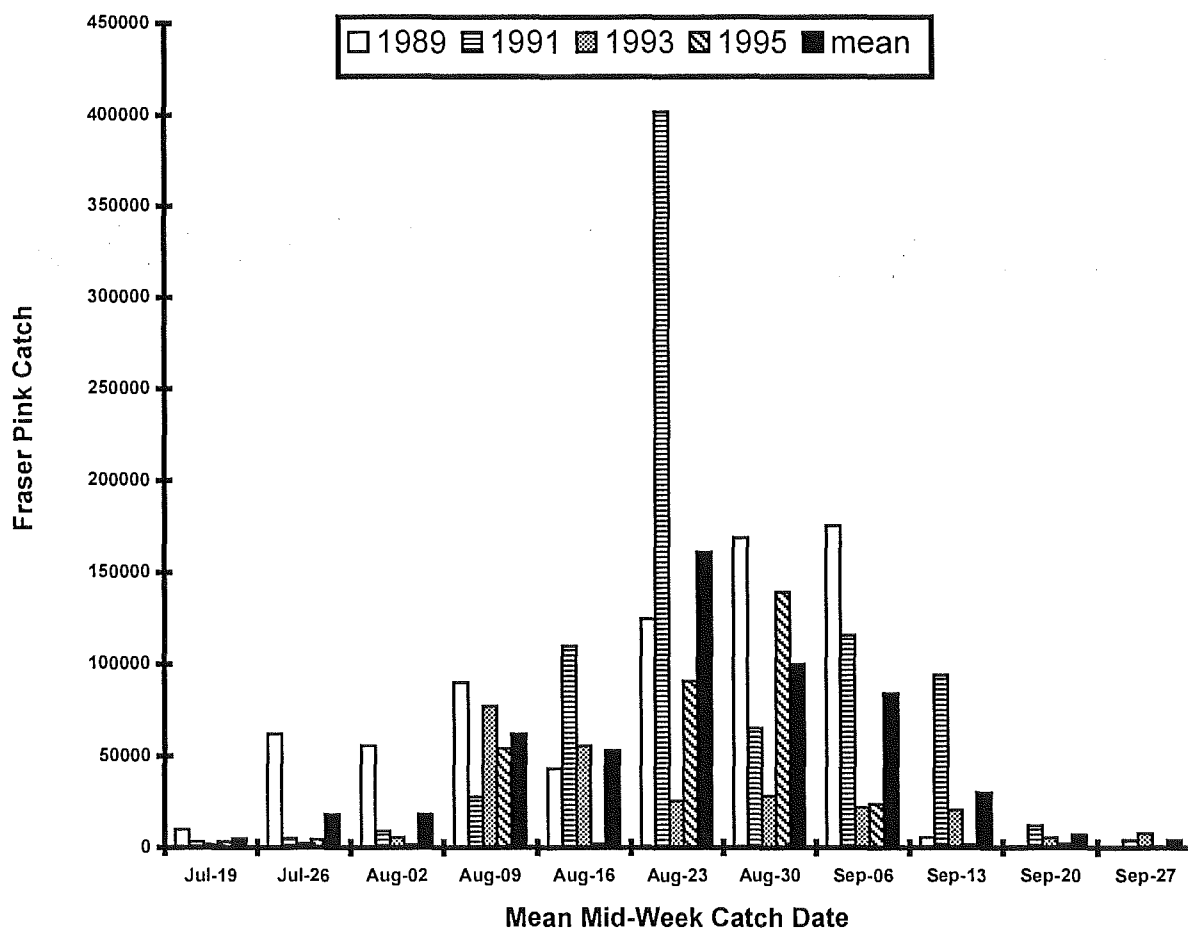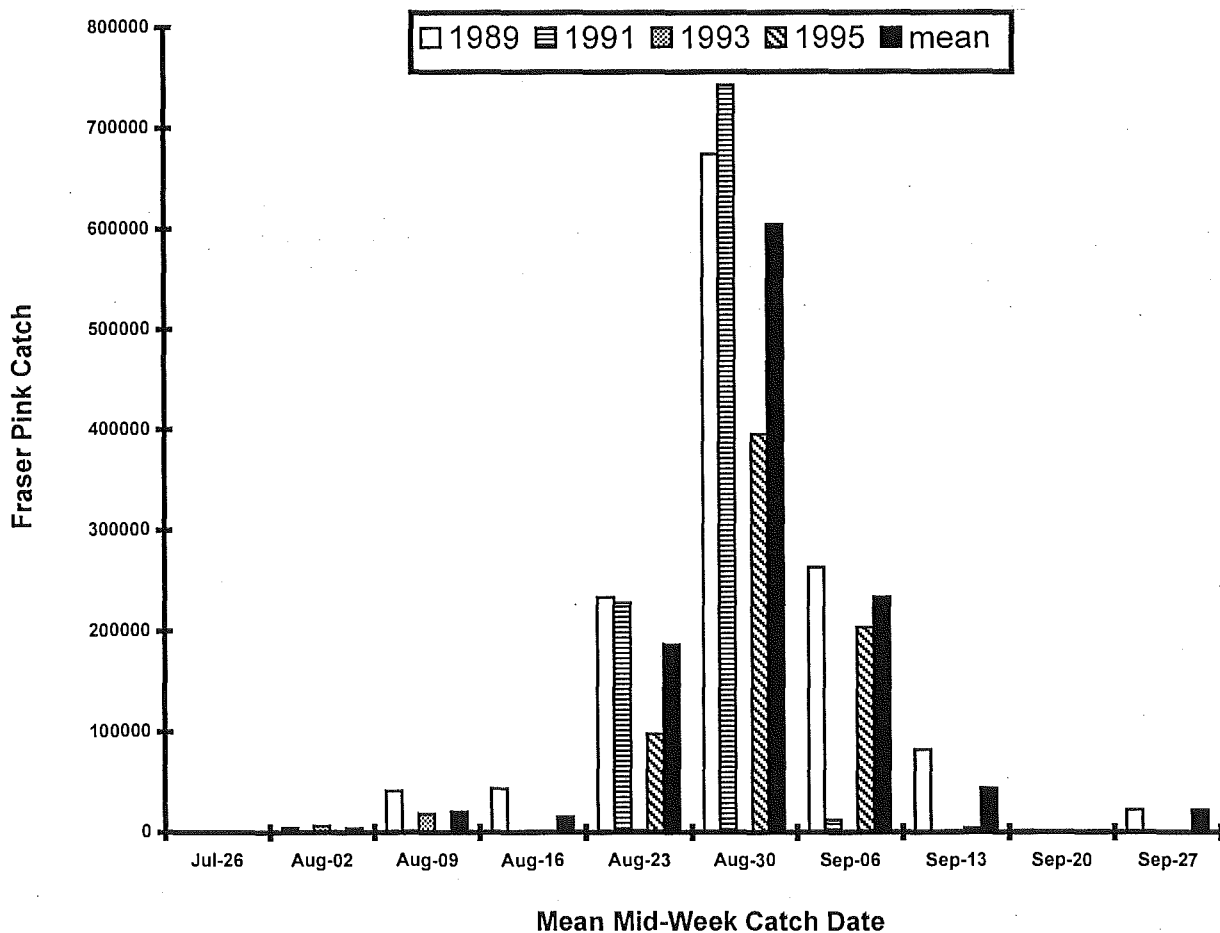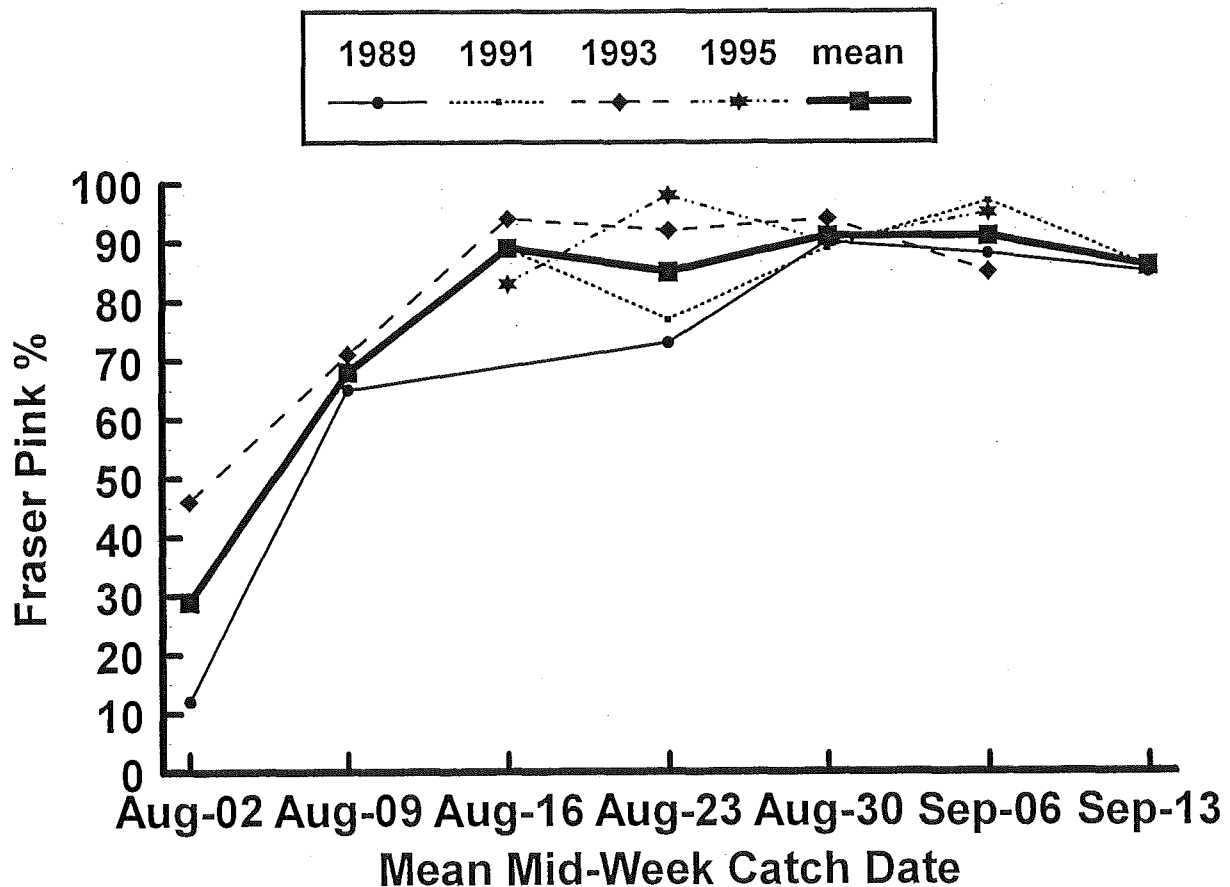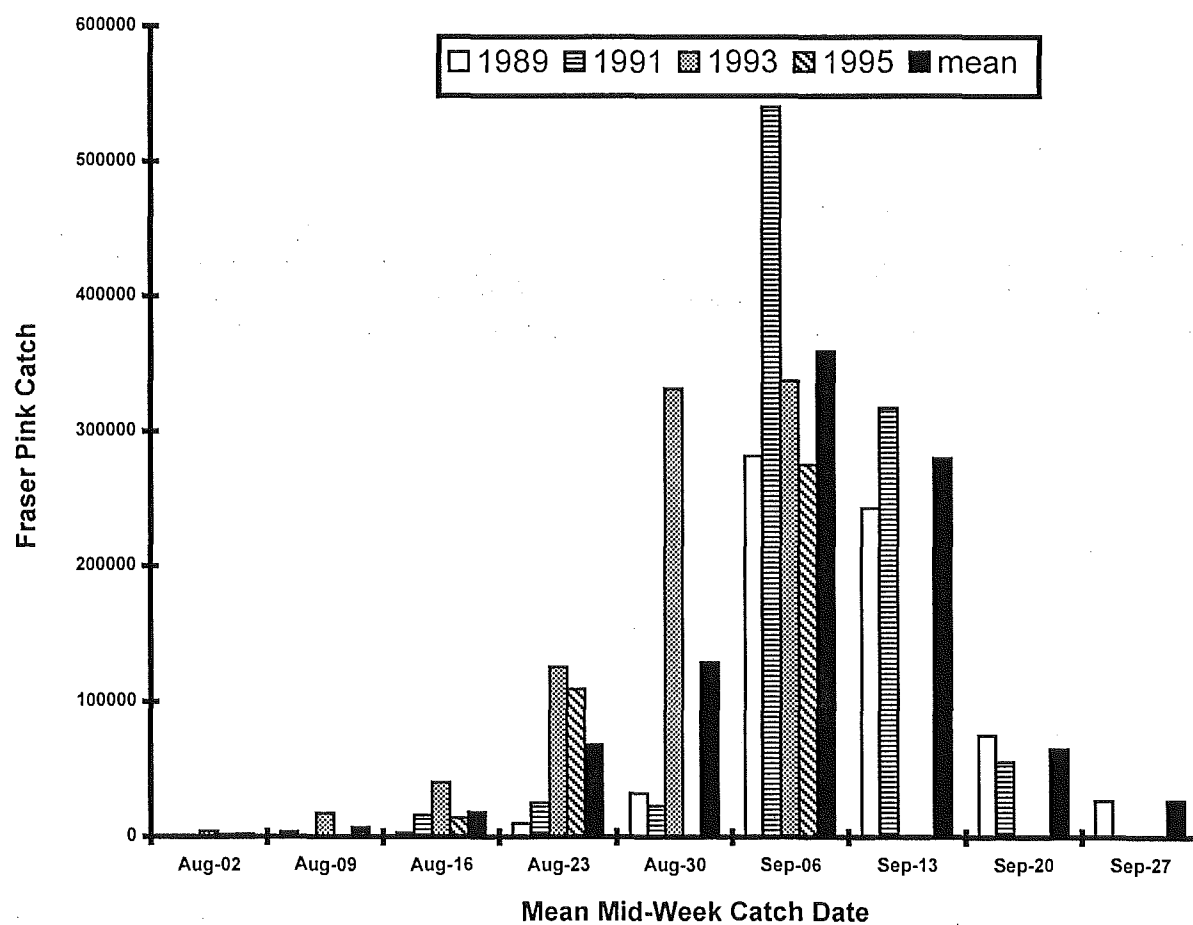
Figure 22. Estimated catches of Fraser River pink salmon in the Washington Area 7A purse seine fishery during the 1989-1995 fishing seasons.

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Total Catches of Fraser River Pink Salmon from 1989 to 1995

The estimated catches of Fraser River pink salmon by country, Fraser River Panel Area and Non-Panel Area, and area and gear groupings (e.g. Areas 11-16 net and troll) from 1989 to 1995 are shown in Table 5. The total Canadian catch of Fraser pink salmon ranged from 3,584,000 to 7,077,000 and averaged 5,319,000 fish. In United States fisheries the estimated total catch of Fraser pink salmon varied from 1,779,000 to 2,751,000 with a mean catch of 2,184,000. The total average run (catch plus escapement) of Fraser pink salmon over the four cycle years was 17,076,000 and ranged from a high of 22,180,000 in 1991 to a low of 12,877,000 in 1995.

Catch tables similar to but more detailed than Table 5 are updated regularly during the in-season management period to help track catches by country and domestic user groups. These catch data, in addition to other information, assisted in the development of management actions taken by the Fraser River Panel between 1989 to 1995 to help achieve the catch and escapement goals for Fraser pink salmon. These management actions are described in annual reports of the Fraser River Panel to the Pacific Salmon Commission (PSC 1990, 1994, 1996, 1998).

Catch Patterns of Fraser River Pink Salmon in Southern Fisheries

Higher catches of Fraser River pink salmon (often two-fold or more) in fisheries south of Cape Caution have occurred in the weekly net fisheries (mainly purse seine) than in the troll fisheries, even though commercial openings for trollers have typically been for the entire week, whereas the purse seine openings for pink salmon have generally been limited to one or two days per week (Figure 23). The largest mean catches of Fraser pink salmon (often approximately 500,000 fish per fishery per week) have occurred in the Areas 11 and 12, and 20 net fisheries in Canada and the Areas 7 and 7A net fisheries in Washington waters.

In years where a high proportion of Fraser River pink salmon migrate through Johnstone Strait, catches of these fish in the major inside fisheries are usually much higher proportionally than those from the West Coast of Vancouver Island fisheries. This is because of their greater availability to the commercial fishing fleets.

The time required for Fraser River pink salmon to migrate from each of the major southern mixed-stock fisheries to the mouth of the Fraser River varies. It is estimated that Fraser pink salmon take approximately 14 days to migrate from Areas 125-127 to Washington Area 7A, (PSC unpublished data). Peak catches derived from the GSI data in Areas 125-127 typically occur on August 23, then in Areas 11,12, 121-124, 20 on August 30, and finally they peak in Washington Areas 7 and 7A on September 6 (Figure 23). In total there is approximately a two week difference in the peak catch dates in these major southern fisheries, which is consistent with the expected migration times. The highest mean catch in Area 13 occurred on September 13, which was later than expected. This late peak catch date in Area 13 was because of unusually high catches during this time in one of the years (1989).

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Table 5. Estimates of Fraser River pink salmon catches during the 1989 to 1995 fishing seasons, by country and area.

	1989	1991	1993	1995
CANADA				
COMMERCIAL CATCH				
Fraser River Panel Area				
Areas 121-124* Troll	499,507	256,751	106,591	244,417
Area 20 Net	1,389,528	984,471	26,277	700,546
Areas 17-18 ,29 Troll and Net	310,986	196,781	254,513	70,004
Total	2,200,021	1,438,003	387,381	1,014,967
Non-Panel Areas				
Areas 1-10 Troll and Net	403,633	563,526	348,256	362,775
Areas 11-16 Troll and Net	3,512,499	3,263,656	3,027,507	1,553,678
Areas 124*-127 Troll	805,382	848,547	252,268	327,204
Total	4,721,514	4,675,729	3,628,031	2,243,657
Commercial Total	6,921,535	6,113,732	4,015,412	3,258,624
FIRST NATIONS CATCH				
Marine Areas				
Areas 12-16, 18, 20, 29 and 123-126	0	0	0	7,039
Fraser River	72,443	103,692	17,022	154,493
First Nations Total	72,443	103,692	17,022	161,532
NON-COMMERCIAL CATCH				
Recreational Fishery	83,416	197,300	146,564	164,081
Charters	0	20,815	0	0
Non-Commercial Total	83,416	218,115	146,564	164,081
CANADIAN TOTAL	7,077,394	6,435,539	4,178,998	3,584,237
UNITED STATES				
COMMERCIAL CATCH				
Fraser River Panel Area				
Areas 4B, 5 and 6C Net	37,859	23,343	8,613	28,450
Areas 6, 7, 7A Net	2,093,458	2,653,286	1,725,194	1,948,797
Washington Troll	28,015	41,033	4,863	19,942
Total	2,159,332	2,717,662	1,738,670	1,997,189
Non-Panel Areas				
WA, OR, CA Troll	7	2,168	194	59
Alaska Troll and Net	0	0	0	0
Total	7	2,168	194	59
Commercial Total	2,159,339	2,719,830	1,738,864	1,997,248
NON-COMMERCIAL CATCH				
Recreational Fishery	19,241	31,205	40,464	31,603
Non-Commercial Total	19,241	31,205	40,464	31,603
UNITED STATES TOTAL	2,178,580	2,751,035	1,779,328	2,028,851
TEST FISHING				
COMMISSION				
Areas 123-127,16,20,29 Test Fishing	31,532	33,269	27,813	43,142
Areas 7 and 7A Test Fishing	4,080	2,315	36	33
Commission Total	35,612	35,584	27,849	43,175
CANADA				
Area 12 and 13 Test Fishing	3,486	8,647	2,178	46,014
TEST FISHING TOTAL	39,098	44,231	30,027	89,189
TOTAL CATCH	9,295,072	9,230,805	5,988,353	5,702,277
SPAWNING ESCAPEMENT	7,189,186	12,949,318	10,774,681	7,174,584
TOTAL RUN	16,484,258	22,180,123	16,763,034	12,876,861

* Troll catches in Area 124 are divided between Panel and non-Panel Areas.

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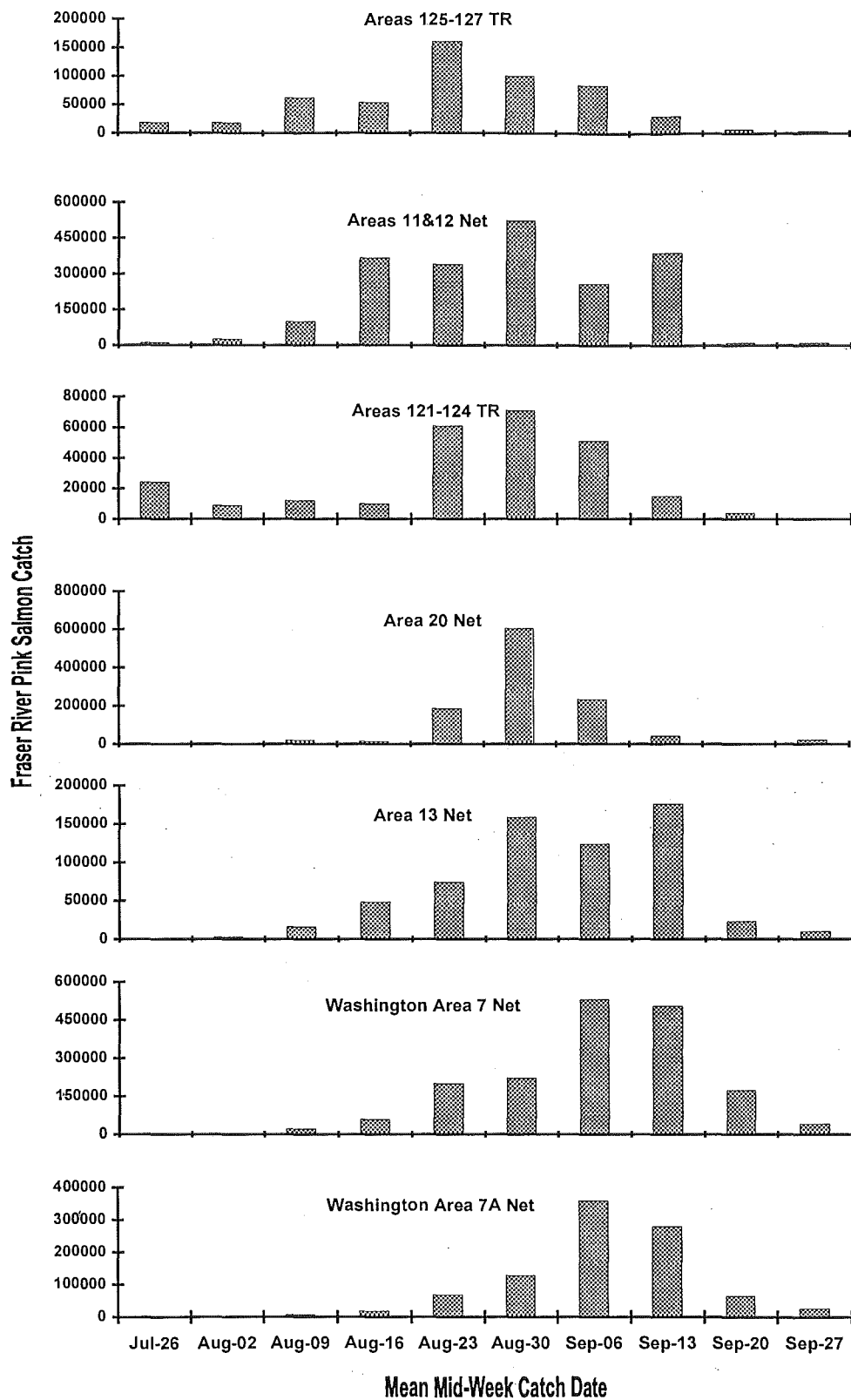
Figure 23. Mean catches (1989-1995) of Fraser River pink salmon through major southern Canadian and United States fishing areas.

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DISCUSSION

The Fraser River Panel used the Commission's pink salmon GSI data to help achieve its mandate for managing Fraser River pink salmon in the period 1989 to 1995. The capability of the Commission's pink salmon GSI program to provide reliable information to the Fraser River Panel depends on several factors, including: obtaining satisfactory collections of tissue samples from pink salmon caught in mixed-stock fisheries where Fraser pink salmon could make significant contributions; receiving accurate data from the electrophoretic analysis of the collections of pink salmon tissue samples; and generating accurate estimates of the proportion of Fraser River pink salmon in the samples using various statistical methodologies. Reliable estimates of the proportions of Fraser River pink salmon provided the means to estimate the catch of Fraser pink salmon by week, fishery, user group, and country. This information also produced catch patterns and timing of adult Fraser River pink salmon through the major southern fisheries.

The main goals of the in-season sampling program have been to obtain sufficient numbers of random, representative and high quality tissue samples from the wide geographic and temporal range of fisheries where Fraser pink salmon may occur. Consequently, collections of tissue samples were obtained from mixed-stock fisheries occurring in waters spanning north of the Queen Charlotte Islands to the southern tip of the San Juan Islands, encompassing nearly all of the major fisheries where Fraser pink salmon were likely harvested. The collections were obtained from fisheries conducted between early July to late September in each of the return years examined, but the sampling was concentrated from mid-August to early September to coincide with the peak of the southern British Columbia and Puget Sound pink salmon migration.

The paramount goal of the in-season electrophoretic analyses was to ensure that the laboratories obtained accurate data for the specified loci so that accurate stock composition estimates could be generated. Replicate testing (White and Shaklee 1991) where identical tissues samples were examined by different laboratories, confirmed that the lab analyses were accurate (generally less than a 2% error rate in identifying and correctly scoring variant alleles for the loci examined). It was also important that the in-season electrophoretic analyses be conducted rapidly so that the contribution of Fraser pink salmon could be estimated and reported to the Fraser River Panel in a timely manner during the in-season management period. The contract laboratories generally met the objective of analyzing and reporting results for "high priority" collections within three days.

The in-season statistical analyses of the genetic data from the electrophoretic laboratories were performed promptly so that reliable information could be provided to fisheries managers planning regulations for the harvest of Fraser pink salmon. The simulation tests, where samples of known mixture composition were analyzed with the maximum likelihood model, indicated that the contribution of Fraser River pink salmon was usually estimated within 5% of their true contribution when Fraser pink salmon dominated the fishery mixtures (> 70% contribution of Fraser pink salmon). During the in-season period, initial stock composition estimates for mixed-stock fisheries were conducted and available for in-season management applications within two hours of the receipt of genetic data from the laboratories.

In-season estimates of total pink salmon catches in fisheries were obtained from several sources by Commission staff. The estimates of the proportion of Fraser pink salmon in specific fisheries were multiplied by the total catch of pink salmon to estimate the catch of Fraser pink salmon in those fisheries. The in-season Fraser pink salmon contribution estimates and catch estimates were usually within 10% of the final post-season estimates. Although in-season racial estimates and total catch estimates (for pink salmon from all contributing stocks) vary from the more accurate post-season estimates, they are sufficiently accurate for in-season fisheries management needs.

Data gathered between 1989 and 1995 has provided important information on Fraser River pink salmon catch patterns and timing through coastal fisheries. The data showed that Fraser pink salmon migrated south-eastward through the major southern mixed-stock fisheries and were caught in a fairly consistent pattern from early August to mid-September. The GSI program also has given a clearer understanding of the inter-annual variability in Fraser pink salmon catch patterns because it spans several years in which highly variable marine conditions have occurred. As this database on Fraser pink salmon catch patterns expands it should have increasing utility for fisheries management applications.

The Commission's pink salmon GSI program has been successful in helping to meet the fisheries management mandates for Fraser pink salmon stipulated in the Pacific Salmon Treaty. It provides rapid and reliable in-season estimates of Fraser pink contributions to fisheries. The success in applying GSI methodologies achieved by the PSC for Fraser River pink salmon is not isolated. Several other fisheries management agencies have also had positive results applying GSI techniques on other species of Pacific salmon, e.g., the WDFW has used GSI methodologies to aid in the management of chum salmon (*Oncorhynchus keta*) and the Canadian Department of Fisheries and Oceans has used these techniques to estimate stock contributions of chinook salmon (*Oncorhynchus tshawytscha*) and other species of salmon in mixed-stock fisheries.

As the Commission's pink salmon GSI program accumulates further information, it will provide clearer understanding of the long-term variation in Fraser River pink salmon catch patterns and timing through fisheries in southern British Columbia and in Washington. Examination of the relationships between Fraser pink salmon catch patterns and variable marine conditions such as temperatures, salinity, and currents may also yield more powerful predictive pre-season and in-season models to forecast Fraser pink salmon migratory routes and timing so that appropriate fisheries can be planned to meet the conservation needs of the stocks and to achieve international and domestic allocation goals for the catch.

ACKNOWLEDGEMENTS

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APPENDIX

Table 1. Northern British Columbia fisheries sampled by the PSC for pink salmon GSI in 1989.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		NON-FRASER[5] %
101	(BC) [TR]	July 15	150	12	(8)	88
101	(BC) [TR]	July 22	150	2	(2)	98
101	(BC) [TR]	July 29	150	6	(5)	94
101	(BC) [TR]	August 5	300	18	(7)	82
101	(BC) [TR]	August 12	300	13	(5)	87
101	(BC) [TR]	August 19	150	8	(6)	92
101	(BC) [TR]	August 26	200	71	(9)	29
1	(BC) [PS]	August 12	150	19	(7)	81
142	(BC) [TR]	July 22	100	2	(4)	98
142	(BC) [TR]	July 29	600	34	(6)	66
142	(BC) [TR]	August 5	300	17	(7)	83
142	(BC) [TR]	August 12	142	21	(7)	79
142	(BC) [TR]	August 26	150	69	(11)	31
2W	(BC) [PS]	July 22	100	2	(4)	98
2W	(BC) [PS]	July 29	150	3	(4)	97
2W	(BC) [PS]	August 12	93	17	(9)	83
4	(BC) [GN]	July 29	150	0	(1)	100
4	(BC) [PS]	August 12	150	1	(1)	99

[1] Location abbreviations: BC - British Columbia, WA - Washington.
[2] Gear abbreviations: PS - Purse Seine, GN - Gillnet, TR - Troll.
[3] Week-ending dates are designated as ending on Saturdays and include samples collected from fish caught the previous Sunday through to and including Saturday for a catch period of 1 week, e.g. week-ending July 29 includes fish samples from catches taken from July 23 to and including July 29.
[4] Fisheries where less than approximately 75 fish were collected for a week-ending period are not listed here because of insufficient sample size for reliable estimates of stock composition.
[5] Stock composition estimate abbreviations: Fraser River - Fraser River watershed; Non-Fraser - not of Fraser River origin (assumes that Alaskan pink salmon would be included within this group); Puget Sound - Washington State including Puget Sound; Cdn. S. Coast - Canadian non-Fraser pink salmon spawning south of Cape Caution. In brackets are estimates of the standard error of the stock composition estimates.

Table 2. Northern British Columbia fisheries sampled by the PSC for pink salmon GSI in 1991.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		NON-FRASER[5] %
101	(BC) TR	July 13	150	3	(3)	97
101	(BC) TR	July 20	250	2	(2)	98
101	(BC) TR	July 27	270	3	(2)	97
101	(BC) TR	August 3	150	5	(4)	95
101	(BC) TR	August 17	120	59	(12)	41
101	(BC) TR	August 31	100	63	(14)	37
1	(BC) PS	August 3	120	1	(2)	99
142	(BC) TR	August 24	300	91	(4)	9
2W	(BC) PS	August 3	120	1	(2)	99
2W	(BC) PS	August 10	150	31	(8)	69
4	(BC) GN	July 27	150	0	(1)	100
4	(BC) GN	August 3	150	0	(0)	100
4	(BC) GN	August 10	150	0	(0)	100
4	(BC) PS	August 17	150	1	(2)	99
6	(BC) PS	July 20	150	3	(3)	97
6	(BC) PS	July 27	150	0	(1)	100
6	(BC) PS	August 3	150	0	(1)	100
6	(BC) PS	August 10	150	0	(1)	100
6	(BC) PS	August 17	150	1	(2)	99

[1-5] Refer to footnotes at bottom of Table 1.

Table 3. Northern British Columbia fisheries sampled by the PSC for pink salmon GSI in 1993.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		NON-FRASER[5] %
101	(BC) TR	July 31	150	1	(2)	99
101	(BC) TR	August 7	150	10	(6)	90
1	(BC) PS	August 14	150	34	(12)	66
142	(BC) TR	August 14	180	82	(6)	18
2W	(BC) PS	August 7	150	12	(6)	88
2W	(BC) PS	August 14	100	84	(13)	16

[1-5] Refer to footnotes at bottom of Table 1.

Table 4. Northern British Columbia fisheries sampled by the PSC for pink salmon GSI in 1995.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		NON-FRASER[5] %
101	(BC) TR	July 29	150	0	(1)	100
101	(BC) TR	August 12	150	15	(6)	85
101	(BC) TR	August 19	300	8	(4)	92
101	(BC) TR	August 26	150	32	(10)	68
142	(BC) TR	August 12	150	40	(11)	60
142	(BC) TR	August 26	150	56	(9)	44

[1-5] Refer to footnotes at bottom of Table 1.

Table 5. East Coast Vancouver Island fisheries sampled by the PSC for pink salmon GSI in 1989.

STATISTICAL AREA (LOCATION[1])[GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
11	(BC) [TR]	August 5	150	58	(13)	22	(13)	20	(9)
11	(BC) [TR]	August 12	150	66	(12)	22	(13)	12	(6)
12-12	(BC) [PS]	August 5	150	41	(15)	28	(14)	31	(10)
12-9	(BC) [PS]	August 12	150	43	(16)	17	(14)	40	(11)
12-11	(BC) [PS]	August 19	300	52	(9)	22	(12)	26	(6)
12-11	(BC) [PS]	August 26	150	74	(12)	5	(8)	21	(9)
12-12	(BC) [PS]	September 2	150	81	(12)	8	(10)	11	(8)
12-11	(BC) [PS]	September 9	150	83	(12)	16	(12)	1	(3)
12-12	(BC) [PS]	September 16	150	82	(11)	11	(10)	7	(6)
12-3	(BC) [PS]	July 29	150	36	(13)	19	(11)	45	(11)
12-3	(BC) [PS]	August 5	150	26	(10)	21	(10)	53	(10)
12-3	(BC) [PS]	August 12	140	34	(15)	29	(14)	37	(11)
12-3	(BC) [PS]	August 19	149	40	(12)	34	(15)	26	(10)
12-3	(BC) [PS]	August 26	300	64	(8)	15	(9)	21	(6)
12-3	(BC) [PS]	September 2	150	78	(9)	9	(8)	13	(7)
12-3	(BC) [PS]	September 9	150	71	(17)	20	(16)	9	(6)
12-3	(BC) [PS]	September 16	150	88	(10)	5	(9)	7	(5)
13	(BC) [PS]	August 5	98	24	(15)	34	(18)	42	(16)
13	(BC) [PS]	August 12	150	27	(11)	8	(7)	65	(10)
13	(BC) [PS]	August 19	295	42	(11)	16	(10)	42	(9)
13	(BC) [PS]	August 26	150	67	(14)	21	(14)	12	(9)
13	(BC) [PS]	September 2	148	80	(11)	13	(12)	7	(6)
13	(BC) [PS]	September 9	150	79	(11)	14	(11)	7	(6)
13	(BC) [PS]	September 16	150	89	(8)	5	(7)	6	(4)
16	(BC) [PS]	September 2	148	72	(11)	14	(9)	14	(8)

[1-5] Refer to footnotes at bottom of Table 1.

Table 6. East coast Vancouver Island fisheries sampled by the PSC for pink salmon GSI in 1991.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
12-11	(BC) [PS]	August 10	150	37	(10)	10	(8)	53	(9)
12-9	(BC) [PS]	August 17	250	70	(8)	6	(6)	24	(7)
12-9	(BC) [PS]	August 24	250	83	(8)	11	(8)	6	(4)
12-9	(BC) [PS]	August 31	300	86	(7)	9	(6)	5	(3)
12-9	(BC) [PS]	September 14	150	86	(8)	9	(8)	5	(4)
12-3	(BC) [PS]	August 10	150	41	(14)	19	(14)	40	(9)
12-3	(BC) [PS]	August 17	250	68	(12)	17	(12)	15	(7)
12-3	(BC) [PS]	August 24	285	83	(7)	13	(7)	4	(3)
12-3	(BC) [PS]	August 31	300	93	(5)	4	(5)	3	(3)
12-3	(BC) [GN]	September 7	126	88	(5)	8	(8)	4	(4)
13	(BC) [PS]	August 10	150	38	(14)	12	(9)	50	(11)
13	(BC) [PS]	August 17	300	59	(8)	10	(8)	31	(7)
13	(BC) [PS]	August 24	300	83	(7)	6	(5)	11	(5)
13	(BC) [PS]	August 31	275	94	(5)	4	(5)	2	(2)
13	(BC) [PS]	September 14	150	80	(10)	18	(11)	2	(3)
13	(BC) [PS]	September 28	115	91	(9)	5	(8)	4	(5)

[1-5] Refer to footnotes at bottom of Table 1.

Table 7. East coast Vancouver Island fisheries sampled by the PSC for pink salmon GSI in 1993.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]	WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
12 - 8-12 (BC) [PS]	August 14	300	46	(9)	17	(10)	37	(7)
12 - 8-12 (BC) [PS]	August 21	300	68	(10)	16	(10)	16	(5)
12-9 (BC) [PS]	September 4	74	85	(13)	3	(5)	12	(12)
12-9 (BC) [PS]	September 11	150	85	(10)	12	(10)	3	(4)
12-4 (BC) [PS]	August 7	122	19	(11)	16	(11)	65	(11)
12-4 (BC) [PS]	August 14	150	41	(13)	6	(8)	53	(10)
12-4 (BC) [PS]	August 21	282	72	(10)	18	(11)	10	(6)
12-4 (BC) [PS]	September 4	278	76	(9)	15	(10)	9	(5)
12-4 (BC) [PS]	September 11	135	88	(8)	4	(6)	8	(5)
13 (BC) [PS]	August 7	150	29	(11)	14	(10)	57	(11)
13 (BC) [PS]	August 14	150	41	(12)	25	(13)	34	(10)
13 (BC) [PS]	August 21	300	83	(7)	12	(7)	5	(4)
13 (BC) [GN]	August 28	150	83	(8)	4	(4)	13	(8)
13 (BC) [PS]	September 4	300	83	(8)	12	(8)	5	(4)
13 (BC) [PS]	September 11	300	90	(5)	4	(5)	6	(3)
16 (BC) [PS]	September 4	150	89	(7)	6	(6)	5	(5)
16 (BC) [PS]	September 11	75	93	(7)	1	(3)	6	(6)

[1-5] Refer to footnotes at bottom of Table 1.

Table 8. East coast Vancouver Island fisheries sampled by the PSC for pink salmon GSI in 1995.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
12-8	(BC) [PS]	August 26	150	59	(14)	25	(15)	16	(9)
12-8	(BC) [PS]	September 2	150	93	(7)	3	(6)	4	(4)
12-3	(BC) [PS]	August 12	150	41	(11)	26	(10)	33	(9)
12-3	(BC) [PS]	August 26	250	79	(10)	15	(10)	6	(4)
12 - 3-5	(BC) [PS]	September 2	300	80	(12)	13	(12)	7	(4)
12-3	(BC) [PS]	September 9	150	94	(8)	3	(7)	3	(4)
12 - 3-5	(BC) [PS]	September 16	150	78	(13)	18	(13)	4	(4)
13	(BC) [PS]	August 26	150	80	(10)	4	(5)	16	(9)
13	(BC) [PS]	September 2	150	96	(3)	2	(2)	2	(3)
13	(BC) [PS]	September 9	150	83	(12)	5	(9)	12	(9)
13	(BC) [GN]	September 16	150	88	(8)	7	(7)	5	(6)

[1-5] Refer to footnotes at bottom of Table 1.

Table 9. West coast Vancouver Island fisheries sampled by the PSC for pink salmon GSI in 1989.

STATISTICAL AREA (LOCATION[1])[GEAR[2]]	WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
125,127 (BC) [TR]	July 15	230	64	(12)	24	(12)	12	(7)
126,127 (BC) [TR]	July 29	150	65	(10)	25	(9)	10	(7)
127 (BC) [TR]	August 5	90	55	(14)	31	(16)	14	(11)
127 (BC) [TR]	August 19	300	78	(11)	11	(11)	11	(6)
127 (BC) [TR]	August 26	300	76	(10)	18	(10)	6	(4)
125,127 (BC) [TR]	September 2	225	75	(15)	22	(14)	3	(3)
123 (BC) [TR]	July 15	149	46	(13)	41	(15)	13	(8)
123 (BC) [TR]	July 22	150	69	(13)	20	(13)	11	(7)
123 (BC) [TR]	July 29	139	64	(14)	21	(16)	15	(8)
123 (BC) [TR]	August 5	150	61	(14)	27	(13)	12	(7)
123 (BC) [TR]	August 19	74	65 ·	(19)	25	(18)	10	(7)
123 (BC) [TR]	August 26	150	94	(7)	5	(7)	1	(3)
124 (BC) [TR]	September 2	135	84	(11)	5	(8)	11	(9)
20 (BC) [PS]	July 22	150	37	(13)	50	(16)	13	(9)
20 (BC) [PS]	August 12	150	51	(15)	38	(17)	11	(7)
20 (BC) [PS]	August 19	150	46	(16)	43	(17)	11	(7)
20 (BC) [PS]	August 26	300	78	(9)	11	(10)	11	(6)
20 (BC) [PS]	September 2	300	83	(11)	10	(11)	7	(5)
20 (BC) [PS]	September 9	300	80	(9)	13	(10)	7	(5)
20 (BC) [PS]	September 16	300	68	(13)	23	(14)	9	(5)

[1-5] Refer to footnotes at bottom of Table 1.

Table 10. West coast Vancouver Island fisheries sampled by the PSC for pink salmon GSI in 1991.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]	WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
125,126 (BC) [TR]	August 3	100	87	(11)	10	(10)	3	(4)
127 (BC) [TR]	August 17	150	85	(8)	9	(7)	6	(5)
127 (BC) [TR]	August 24	150	77	(8)	13	(7)	10	(5)
127 (BC) [TR]	August 31	250	83	(10)	12	(9)	5	(4)
125,127 (BC) [TR]	September 7	150	84	(10)	9	(9)	7	(5)
123,124 (BC) [TR]	July 20	150	70	(14)	17	(13)	13	(7)
123,124 (BC) [TR]	July 27	150	80	(11)	11	(10)	9	(6)
123 (BC) [TR]	August 3	150	78	(14)	16	(14)	6	(5)
123,124 (BC) [TR]	August 17	250	64	(11)	20	(10)	16	(5)
124 (BC) [TR]	August 24	250	87	(7)	8	(7)	5	(4)
123,124 (BC) [TR]	August 31	260	74	(12)	24	(12)	2	(2)
123,124 (BC) [TR]	September 7	241	82	(10)	12	(10)	6	(4)
123,124 (BC) [TR]	September 14	150	85	(10)	2	(6)	13	(8)
20 (BC) [PS]	August 24	300	76	(10)	19	(10)	5	(4)
20 (BC) [PS]	August 31	300	88	(7)	8	(6)	4	(3)

[1-5] Refer to footnotes at bottom of Table 1.

Table 11. West coast Vancouver Island fisheries sampled by the PSC for pink salmon GSI in 1993.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
126,127	(BC) [TR]	August 14	150	70	(9)	9	(8)	21	(9)
127	(BC) [TR]	August 21	198	89	(8)	2	(6)	9	(6)
127	(BC) [TR]	September 4	174	97	(5)	2	(5)	1	(1)
123,124	(BC) [TR]	August 7	300	72	(8)	16	(9)	12	(4)
124	(BC) [TR]	August 14	150	70	(14)	25	(14)	5	(5)
123,124	(BC) [TR]	August 28	100	92	(7)	5	(7)	3	(4)
123	(BC) [TR]	September 4	120	92	(7)	3	(5)	5	(4)
123	(BC) [TR]	September 11	150	69	(19)	29	(20)	2	(4)
20	(BC) [PS]	August 14	150	81	(9)	6	(6)	13	(7)

[1-5] Refer to footnotes at bottom of Table 1.

Table 12. West coast Vancouver Island fisheries sampled by the PSC for pink salmon GSI in 1995.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
127	(BC) [TR]	August 12	150	64	(10)	10	(10)	26	(8)
127	(BC) [TR]	August 26	150	84	(8)	7	(7)	9	(5)
123,124	(BC) [TR]	July 29	150	54	(15)	40	(16)	6	(6)
123	(BC) [TR]	August 26	120	91	(12)	8	(12)	1	(2)
20	(BC) [PS]	August 26	300	78	(11)	17	(12)	5	(4)
20	(BC) [PS]	September 2	300	87	(8)	10	(8)	3	(3)
20	(BC) [PS]	September 9	300	81	(10)	15	(11)	4	(3)

[1-5] Refer to footnotes at bottom of Table 1.

Table 13. Washington State fisheries sampled by the PSC for pink salmon GSI in 1989.

STATISTICAL AREA (LOCATION[1])[GEAR[2]]	WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
7A (WA) [PS]	August 5	150	32	(11)	17	(9)	51	(10)
7A (WA) [PS]	August 12	150	61	(15)	28	(14)	11	(9)
7A (WA) [PS]	August 19	150	71	(11)	11	(10)	18	(8)
7A (WA) [PS]	September 9	300	89	(6)	3	(4)	8	(5)
7A (WA) [PS]	September 16	300	89	(8)	7	(8)	4	(4)
7A (WA) [PS]	September 23	250	89	(7)	5	(6)	6	(4)
7 (WA) [PS]	August 5	150	12	(10)	61	(12)	27	(11)
7 (WA) [PS]	August 12	150	65	(12)	14	(12)	21	(10)
7 (WA) [PS]	August 26	150	73	(12)	12	(12)	15	(8)
7 (WA) [PS]	September 2	150	90	(10)	8	(10)	2	(3)
7 (WA) [PS]	September 9	300	88	(11)	8	(10)	4	(5)
7 (WA) [PS]	September 16	300	85	(12)	13	(12)	2	(2)
4 (WA) [TR]	August 12	150	63	(16)	26	(17)	11	(7)
4 (WA) [TR]	August 19	150	52	(17)	38	(17)	10	(9)

[1-5] Refer to footnotes at bottom of Table 1.

Table 14. Washington State fisheries sampled by the PSC for pink salmon GSI in 1991.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]		WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
7A	(WA) [PS]	August 24	150	83	(12)	11	(11)	6	(5)
7A	(WA) [PS]	August 31	150	80	(12)	12	(11)	8	(6)
7A	(WA) [PS]	September 7	300	80	(9)	15	(9)	5	(4)
7A	(WA) [PS]	September 14	300	88	(7)	6	(6)	6	(4)
7A	(WA) [PS]	September 21	100	88	(6)	4	(4)	8	(6)
7	(WA) [PS]	August 17	150	89	(11)	6	(9)	5	(6)
7	(WA) [PS]	August 24	150	77	(13)	18	(14)	5	(5)
7	(WA) [PS]	August 31	300	89	(8)	8	(8)	3	(3)
7	(WA) [PS]	September 7	300	97	(4)	2	(3)	1	(2)
7	(WA) [PS]	September 14	350	86	(6)	7	(6)	7	(3)
7	(WA) [PS]	September 21	450	94	(4)	3	(3)	3	(2)
3, 4	(WA) [TR]	August 17	300	85	(6)	9	(6)	6	(4)
4	(WA) [TR]	August 24	150	88	(10)	10	(10)	2	(3)

[1-5] Refer to footnotes at bottom of Table 1.

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Table 15. Washington State fisheries sampled by the PSC for pink salmon GSI in 1993.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]	WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
7A (WA) [PS]	August 14	150	70	(12)	10	(11)	20	(9)
7A (WA) [PS]	August 21	150	78	(11)	14	(10)	8	(6)
7A (WA) [PS]	August 28	150	79	(8)	7	(7)	14	(6)
7A (WA) [PS]	September 4	300	94	(5)	3	(4)	3	(2)
7A (WA) [PS]	September 11	300	91	(7)	3	(6)	6	(4)
7 (WA) [PS]	August 7	150	46	(15)	27	(15)	27	(9)
7 (WA) [PS]	August 14	150	71	(13)	20	(13)	9	(7)
7 (WA) [PS]	August 21	189	94	(5)	3	(4)	3	(5)
7 (WA) [PS]	August 28	300	92	(6)	5	(7)	3	(2)
7 (WA) [PS]	September 4	300	94	(5)	3	(4)	3	(3)
7 (WA) [PS]	September 11	150	85	(9)	10	(8)	5	(5)

[1-5] Refer to footnotes at bottom of Table 1.

Table 16. United States fisheries sampled by the PSC for pink salmon GSI in 1995.

STATISTICAL AREA (LOCATION[1]) [GEAR[2]]	WEEK-ENDING DATE[3]	SAMPLE SIZE[4]	FRASER RIVER[5] %		PUGET SOUND[5] %		CDN. S COAST[5] %	
7A (WA) [PS]	August 19	150	79	(9)	5	(7)	16	(8)
7A (WA) [PS]	August 26	150	86	(9)	3	(6)	11	(7)
7A (WA) [PS]	September 9	150	95	(5)	1	(3)	4	(5)
7 (WA) [PS]	August 19	150	83	(10)	6	(8)	11	(7)
7 (WA) [PS]	August 26	300	98	(2)	1	(1)	1	(1)
7 (WA) [PS]	September 2	300	90	(8)	9	(8)	1	(2)
7 (WA) [PS]	September 9	300	95	(5)	2	(4)	3	(3)
4 (WA) [TR]	August 19	150	51	(17)	37	(18)	12	(9)
4 (WA) [TR]	August 26	150	74	(17)	22	(18)	4	(5)

[1-5] Refer to footnotes at bottom of Table 1.