APPENDIX II

REPORT TCCHINOOK (88)-2

EXPLOITATION RATE ANALYSIS
A Report of the Analytical Work Group*
of the Chinook Technical Committee
October 7, 1988

---

* Members of the Analytical Work Group completing the analysis: John Clark, Al Debrot, Gary Morishima, Howard Schaller, Jim Scott, Paul Starr

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 INTRODUCTION

1.1 TERMINOLOGY

In previous years, the term "Harvest Rate Analysis" was used by the Chinook Technical Committee to refer to the type of analyses in this report. Our basic assessment procedures have not changed, but our assessment is more correctly termed an "Exploitation Rate Analysis". Harvest rate more appropriately refers to the proportion removed by the fishery of the total fish abundance (vulnerable to a fishery) in a fishing area. Exploitation rate refers to the catch or total fishing mortality in a fishery as the proportion of the total cohort size in all areas (i.e., the total number of fish in the stock of interest at the beginning of the fishing season). The exploitation rate may be calculated within fisheries and by ages, or across all fisheries and ages. In this report, stock-specific coded-wire tag information is used to develop exploitation histories on stocks and to develop indices of changes in fishery harvest rates using stock-specific exploitation rate data.

1.2 OVERVIEW

This report is based on coded-wire tag recoveries for 10 indicator stocks with a continuous time series of recovery data which began during the base period (1979-1982). These 10 stocks are referred to as the "Exploitation Rate" indicator stocks. Analyses in this report are specific to these stocks; the extrapolation of results to similar stocks and/or generalized statements about fishery impacts will be dependent upon how representative these indicator stocks are of other stocks of interest or upon the stock composition in a fishery. At present, these indicator stocks consist of 4 fall chinook stocks from southern B.C., 5 fall chinook stocks from the Columbia River, and the Willamette spring chinook stock (lower Columbia River). The committee is also beginning to evaluate a S.E. Alaskan spring chinook stock as an exploitation rate indicator. However, complete data for exploitation rate analyses are not available for the S.E. Alaska stock until the 1983 recovery year.

The Exploitation Rate Analysis presented in this report consists of seven major parts:

(1) Data, methods, and analytical procedures employed in the analysis are presented for reference.

(2) Fishery Indices: stock and age specific exploitation rates

in a fishery are combined across the indicator stocks to develop indices of change in fishery impacts under PST chinook management regimes relative to a 1979-82 base period. Indices based upon landed catch and total mortalities are presented. The index which includes total mortalities provides a consistent means of representing changes in total mortalities associated with regulatory measures employed to implement PST regimes.

(3) Stock Indices: age specific exploitation rates by stock are combined across ocean fisheries to estimate changes in exploitation rates relative to the 1979-82 base period.

(4) Brood Year Exploitation Rate: within specific stocks, the cumulative impacts of all fisheries (or a subset such as the ocean fisheries) on all ages (i.e., across the cohort) can be measured. When the chinook rebuilding program was first established, exploitation rates for depressed stocks were expected to be reduced by 15 percentage points by 1998. The 1982 brood year (fall chinook) is the first brood year to have legal size chinook fished entirely under PST management regimes. Monitoring this index will be important in evaluating rebuilding and chinook productivities.

(5) Survival Rate Indices: monitoring the survival of stocks assists in the interpretation of exploitation rates and rebuilding progress. This interpretation depends in part upon an ability to examine changes in the relative contributions of various stocks.

(6) Stock Contribution Indices: estimates of contributions of five major indicator stocks (Columbia River Upriver Bright, Robertson Creek, Spring Creek, Oregon Lower Columbia Hatchery Tules, and Washington Lower Columbia Hatchery Tules) to the Southeast Alaska, North/Central B.C., and West Coast Vancouver Island Troll fisheries are used to illustrate relative changes in stock contributions. These contribution indices provide insight into interpretation of exploitation rates; for example, these data illustrate how substantial increases in abundance of some stocks do not automatically result in reduced exploitation rates, because of decreased abundance of other stocks.

(7) Results of the exploitation rate analysis are summarized to assist in interpretation.

1.3 CHANGES TO PRIOR PROCEDURES AND DATA

1.3.1 CALCULATION OF THE FISHERY INDEX

The fishery index employed in previous years was a simple average of the exploitation rate indices for the stocks and ages included in the analysis for each fishery. The new fishery index consists of the ratio between the sum of the stock-specific exploitation rates and the sum of the base-period average exploitation rates for those stocks. This index no longer gives equal importance to all stocks in each fishery; that is, stocks which are heavily exploited will contribute more to the value of the index than stocks which are lightly exploited. A discussion of the rationale for using the new index is presented in section 2.1.2.

1.3.2 USE OF ADULT EQUIVALENTS

Since implementation of the Pacific Salmon Treaty (PST), size limits in some fisheries have changed. Such changes create problems for exploitation rate analysis, especially where indices involve more than a single age class. In fact, the impacts of size limit increases can be to decrease exploitation rates of age 3 fish while increasing exploitation rates of age 4 fish. A multiple-age fishery exploitation rate index would not appropriately measure fishery impact in relation to a selected base period, under such circumstances. The concept of "adult equivalents", i.e. the potential contribution of fish of a given age to the spawning escapement in the absence of fishing, can be used to overcome this problem. The index is unaffected by the use of adult equivalents within an age class. Given unstable regulations, the expression of exploitation rates in terms of adult equivalents is necessary to compensate for changes in fishery impacts on fish populations over time.

1.3.3 USE OF TOTAL FISHERY MORTALITY

The conduct of chinook fisheries has changed in recent years in ways that significantly affect incidental mortalities. For example, shaker losses may be reduced by shortening of fishing seasons and catch ceilings; non-retention restrictions have been employed to provide continued access to other species once chinook catch ceilings have been reached; and size limit changes have been implemented. These changes are not reflected in CWT recovery data, yet are crucially important for assessment of total fishery impacts. The Analytical Work Group (AWG) of the Chinook Technical Committee developed procedures to theoretically estimate these incidental mortality losses and incorporate them

into the exploitation rate analysis. Details concerning the procedures employed to estimate total fishing mortality are presented in Supplement B.

1.3.4 CHANGES TO CWT DATA BASES

Due to updates of agency CWT databases, in some instances data employed for the 1988 analysis differ significantly from those employed in previous analyses. In particular, the Southeast Alaska CWT data base employed for the 1988 exploitation rate analysis had significant differences from the data available in previous years. Results reflect exploitation rate analysis performed on an accounting year (October 1 through September 30th) for S.E. Alaska. Details are provided in Supplement A.

2.0 ESTIMATION OF EXPLOITATION RATES

2.1 THEORY AND PROCEDURES

The Exploitation Rate Analysis is a time series of age and fishery specific exploitation rates created through cohort analysis for stocks with suitable CWT data. These exploitation rates by stock and fishery are then scaled to an index relative to a base period (1979-82) and combined across stocks so that a composite description of the change in that fishery is obtained (termed "fishery index" in the remainder of this report). The presumption is that this index is a direct measure of the overall effect of changes in fishery impacts on index stocks under management regimes instituted by the PST.

The PSC rebuilding program relies upon the progressive reductions over time of exploitation rates in fisheries under ceiling management. The fishery index was developed to provide a measure of the effects of the management changes for specific fisheries under PSC chinook management.

2.1.1 LANDED CATCH VS TOTAL MORTALITIES

Management strategies have changed considerably for fisheries constrained by PST catch ceilings . Regulatory changes include size limit changes and periods of chinook non-retention (CNR). Any assessment of changes in total fishery impacts from earlier time periods must incorporate estimates of the effects of these management changes.

An analysis based only on reported catches would overestimate the benefits of the management changes. A brief summary of the calculations involved in using total versus catch

mortalities follows. Supplement B describes the additions made to the cohort analysis to estimate incidental mortality losses.

The exploitation rate analysis used a 30% shaker mortality rate in the troll and sport fisheries. This rate is in the 20%-30% range previously stated by the Committee and is the most conservative value (within this range) for estimating mortality impacts. Other rates within this shaker mortality range would not affect any of the overall conclusions in these analyses.

2.1.2 ESTIMATION OF THE FISHERY INDEX

The exploitation rate analysis is designed to express changes in the impact of a fishery upon a stock or a group of stocks over time. For a given fishery, there will be several stock specific estimates of an exploitation rate for the base period and for the current year. Through simulation modeling, the AWG evaluated four methods of combining fishery indices calculated for individual stocks into a single estimator for the fishery. The ratio of the means estimator had the smallest variance and the smallest Mean Square Error of the estimators evaluated. The AWG concluded that a ratio index would provide the best relative measure of fishery impacts. For comparison, the AWG also completed the analysis using the simple average method employed in previous years. A discussion of the two combination methods employed in the 1988 exploitation rate analysis follows.

Note:

Subscript Definitions:

f = fishery;
s = stock;
y = year;
i = age.

Variable Definitions:

$EXR_{f,s,y,i}$ = Calculated exploitation rate from cohort analysis

$EXRTot_{f,by=y-i,i}$ = Fishery index (Total mortalities)

$EXRLeg_{f,by=y-i,i}$ = Fishery index (Reported catch only)

If Exploitation Rate Analysis is performed on Total Mortalities, then

$$EXR_{f,s,y,i} = EXRTot_{f,by=y-i,i}$$

else if Exploitation Rate Analysis is performed on Legal Catch only, then

$$EXR_{f,s,y,i} = EXRLeg_{f,by=y-i,i}$$

2.1.2.1 SIMPLE AVERAGE METHOD

This method calculates an unweighted mean of the ratios of each stock's exploitation rate to its base period exploitation rate.

(i) Calculation of Base Period average exploitation rate for each stock:

$$BEXR_{f,s,l} = \sum_{y=1979}^{1982} \frac{EXR_{f,s,y,l}}{n}$$

where n = number of years in the base period average.

(ii) Calculation of exploitation rate index for each stock:

$$NEXR_{f,s,l} = \frac{EXR_{f,s,y,l}}{BEXR_{f,s,l}}$$

(iii) Calculation of unweighted mean of exploitation rate indices (over all stocks present in each year):

$$SAVEXR_{f,y,l} = \frac{1}{n} \sum_{s=1}^{n} NEXR_{f,s,y,l}$$

where: n = number of stock-age combinations being considered in a fishery.

2.1.2.2 RATIO METHOD

This method calculates a weighted mean of the ratios of the current stock specific exploitation rates to the sum of average base period exploitation rates (over all stocks).

Calculation of weighted index:

$$RatioEXR_{f,y,l} = \frac{\sum_{s=1}^{n} EXR_{f,s,y,l}}{\sum_{s=1}^{n} BEXR_{f,s,l}}$$

where n = number of stock age combinations being considered in a fishery.

2.1.2.3 EXAMPLE: COMPARISON OF SIMPLE AVERAGE AND RATIO METHODS

	EXR	BEXR	NEXR
STOCK 1	.20	.25	.800
STOCK 2	.50	.55	.909
STOCK 3	.15	.18	.833

$$\text{Simple Average (SAVEXR)} = 1/3 * (.800 + .909 + .833)$$

$$= .847$$

$$\text{Ratio (RatioEXR)} = \frac{(.20 + .50 + .15)}{(.25 + .55 + .18)}$$

$$= .867$$

2.1.2.4 DISCUSSION/RECOMMENDATIONS

The Analytical Work Group recommends that the Exploitation Rate Analysis use the Ratio of Means Index on estimates of total mortality, adjusted for adult equivalents.

The Simple Average Index was the method used in the 1985 and 1986 exploitation rate analyses (TCCHINOOK 86-1; TCCHINOOK 87-4). This method was continued this year to provide continuity with previous analyses. For the 1987 analysis, exploitation rates were estimated using reported catch only and using total fishing mortality (reported catch + sublegal mortality + all CNR mortality).

The average fishery index during the base period is defined as 1 (one). Therefore, a fishery index less than one represents a decrease from the base period while a fishery index greater than one indicates an increase. The magnitude of the change will be the difference of the measured fishery index from one.

2.1.3 STOCK SPECIFIC METHODS

The following stock-specific analyses were performed:

1) Stock indices provide information on the total ocean fishery impact for individual stocks at specific ages relative to the 1979-82 base period.

2) Brood exploitation rates provide an estimate of the total cumulative ocean exploitation on a brood of a single stock over all ages.

3) Survival rate indices provide a relative measure of year to year variation in stock survival.

4) Stock contribution indices are a time series of estimated total contribution for 5 major stocks in 3 fisheries with PST ceilings.

2.1.3.1 STOCK INDEX

Two age-specific indices are depicted: (1) catch; and (2) total mortality. The first index is the ocean fishery catch (exludes terminal catch) an age divided by the total adult equivalent catch by all fisheries plus escapement at that age. The second age-specific fishery index is the total mortality associated with ocean fisheries at age divided by the total mortality in all fisheries plus escapement at the same age. For both indices, catch and total mortality are expressed in terms of adult equivalents. Values greater than one indicate that the ocean exploitation rate is higher than the base period average.

2.1.3.2 BROOD YEAR EXPLOITATION RATES

This analysis sums all ocean mortalities over all ages (adjusted for adult equivalents) and divides by the total mortalities (again adjusted for adult equivalents) and escapement summed over all ages. These brood year exploitation rates are the best indication of the cumulative effect of fishing on a stock. When the chinook rebuilding program was first established, exploitation rates of depressed stocks were expected to be reduced by 15 percentage points by 1998. Since fisheries have operated under PSC regimes for three years, data are now available to initiate a brood year exploitation rate analysis. To assess the overall effects of PST management, both the brood exploitation rate and fishery indices are needed. The former provides cumulative information over all fisheries for a stock while the later provides information for a specific fishery over several stocks.

2.1.3.3 SURVIVAL RATE INDICES

A time series of indices is calculated by summing the total fishing mortalities and escapement for an indicator stock at age 3 (for each year), divided by total hatchery release for that stock.

2.1.3.4 STOCK CONTRIBUTION INDICES

The contributions of major index stocks to the Southeast Alaska, North/Central, and West Coast of Vancouver Island troll fisheries were estimated by expanding the fishery CWT recoveries at age by the ratio of terminal (escapement + terminal catch) CWT recoveries to stock specific terminal returns at the same age. The major index stocks are Robertson Creek, Columbia River Brights, Spring Creek hatchery, Oregon Lower Columbia hatchery tules, and Washington Lower Columbia hatchery tules. Only the Robertson Creek and Columbia River Brights were compared in the Alaska and North/Central B.C. troll fisheries. The estimated contributions of each individual stock was compared to its average contribution during the 1979-82 base period.

2.1.4 ASSUMPTIONS AND INTERPRETATION OF THE ANALYSES

These analyses rely upon several fundamental assumptions:

1) The temporal and spatial distributions of stocks in and between the fisheries are relatively stable from year to year.

2) The coded wire tagged fish behave in the same manner as the untagged stocks which they are intended to represent.

3) Fishery and escapement CWT recovery data are obtained in a consistent manner from year to year. This implies that biases and relative precision of CWT recovery data are of the same magnitude from year to year and do not significantly prejudice the estimates of relative change in exploitation rates.

Given these assumptions, changes in fishery indices reflect differences in fishery harvest rates.

4) There are a number of assumptions about parameter values involved in the cohort analysis; details are included in Supplement B.

2.2 RESULTS

2.2.1 COMPARISON OF LANDED VERSUS TOTAL MORTALITY AND SIMPLE AVERAGE VERSUS RATIO FISHERY INDICES

Results of the exploitation rate analysis based on landed and total mortalities using the simple and ratio fishery indices are presented in Table 1.

Ratio and simple average fishery indices showed generally similar results and trends. The greatest difference was evident for the WCVI troll fishery indices. These differences are due to the large variation among indices for individual stocks within a year.

In all instances, where significant changes in incidental mortality resulting from regulatory restrictions have not occurred, indices based on total mortality and catch are very close. The effects of size limit changes and non-retention restrictions on total mortalities are apparent, particularly for West Coast Vancouver Island (size limit increase in 1987 differentially affects age 3 and 4 fish) and Southeast Alaskan troll fisheries (non-retention restrictions) (Figures 1 - 7).

2.2.2 FISHERY INDICES

Figures 8 through 18 depict fishery indices based on total fishing mortality over time. The heavy black line indicates the estimated fishery index; the light vertical bars are used to display the range of fishery indices observed for individual stocks. For reference, tabular results of the analysis for individual stocks and the fishery as a whole are presented below each figure. Actual estimates of exploitation rates by stock and age are in Supplement C.

A comparison of estimated and target reductions in fishery indices resulting from the PSC regimes is summarized in Table 2. With the exception of the North/Central B.C. troll fishery, these analyses indicate that total fishing mortalities on index stocks have not decreased to the extent anticipated when the chinook rebuilding program was established. The index for Washington and Oregon ocean fisheries indicates that exploitation rates have decreased substantially from base period levels.

All fishery index changes expressed in the following paragraphs refer to table 2.

2.2.2.1 SOUTHEAST ALASKA

2.2.2.1.1 INDEX STOCKS AGES 4 AND 5

Total fishery mortality rates on index stocks have not decreased from base period levels for the Alaska troll fishery for two of three years under PST regimes (Figure 8). The results show that 1987 total mortalities have increased by 19% above base period levels. The 1985-87 average fishery index is 9% above base period levels and 31% above target reduction under the initial PST regimes.

2.2.2.1.2 SOUTHEAST ALASKA SPRING STOCK

Exploitation rate analysis was conducted for the years 1982-87 on the Southeast Alaska spring index stock, which has migratory characteristics different from those of the standard index stocks. The trend in the 1985-87 exploitation rates is similar to that of the other stocks, decreasing through 1986 with an increase in 1987 (Figure 3). Exploitation rates on this stock in the 1985-87 period were less than those in the earlier 1982-84 period. However, due to lack of data from the base period (1979 - 1982), results are not directly comparable to those of the other indicator stocks and cannot be incorporated into the fishery index.

2.2.2.2 NORTH/CENTRAL B.C.

Total mortality of age 4 and 5 index stocks in the North/Central British Columbia troll fisheries have decreased from base period levels since implementation of the PST (Figure 9). The 1987 exploitation rate is estimated to be 24% below base period levels. The 1985-87 average fishery index is 22% below the base period and in the range expected under the initial PST regimes.

2.2.2.3 WEST COAST VANCOUVER ISLAND TROLL

2.2.2.3.1 AGE 3

Fishery indices for age 3 index stocks in the West Coast Vancouver Island troll fishery have varied about base period levels since implementation of the PST (Figure 10). The 1987 exploitation rate is estimated to be 13% below base period levels. The size limit change implemented in 1987 resulted in a substantial decrease in the age 3 exploitation rate from the 1986

level. The 1985-87 average fishery index is 23% above target reduction under the initial PST regimes.

2.2.2.3.2 AGE 4

Fishery indices for age 4 index stocks in the West Coast Vancouver Island troll fishery have varied about base period levels since implementation of the PST (Figure 11). The 1987 exploitation rate is estimated to be 78% above the base period. The impact of the 1987 size limit increase for this fishery was apparent in the analysis; compared to 1986, the index for age 4 fish increased by 85% whereas the index for age 3 fish decreased by 30%. The 1985-87 average fishery index is 47% above target reduction under the initial PST regimes.

2.2.2.3.3 AGES 3 & 4 COMBINED

Combined fishery indices for age 3 and 4 fish in the West Coast Vancouver Island troll fishery have generally increased over base period levels since implementation of the PST (Figure 12). Although the 1985 fishery index is estimated to be 3% below base period levels, the indices for 1986 and 1987 indicate that exploitation rates have increased above base period levels by 3% and 31%, respectively. The 1985-87 average fishery index is 34% above target reduction under the initial PST regimes.

2.2.2.4 GEORGIA STRAIT

2.2.2.4.1 SPORT AND TROLL COMBINED

Fishery indices for age 3 and 4 year old fish in the combined Strait of Georgia sport and troll fisheries have declined from base period levels, but the 1985-87 index is 32% above target reduction under initial PST regimes. The index for these combined fisheries has increased since 1985 (Figure 13). The 1985, 1986, and 1987 indices were 67%, 95%, and 92% of the base period index, respectively. The index indicates that exploitation of the stocks in these fisheries is approaching base period levels, despite a declining trend in catch levels. To evaluate the Georgia Strait sport and troll fisheries separately, we have divided the PST catch ceilings according to Canadian domestic allocation policy.

2.2.2.4.2 TROLL

Fishery indices for age 3 and 4 year old fish in the Strait of Georgia troll fishery have declined from base period levels,

but have generally increased since 1985 (Figure 14). The 1985, 1986, and 1987 fishery indices for this fishery have decreased by 82%, 62%, and 64%, respectively. The 1985-87 average fishery index is, however, 10% above target reduction under initial PST regimes.

2.2.2.4.3 SPORT

Fishery indices of age 3 and 4 index stocks combined in the Georgia Strait sport fishery have generally increased from base period levels since implementation of the PST (Figure 15). This trend appears to be increasing since 1985. The 1985 fishery index decreased by 2% from the base period while the indices for 1986 and 1987 increased over the base period by 31% and 26%, respectively. The 1985-87 average exploitation rate is 38% above target reduction under the initial PST regimes.

2.2.2.5 WASHINGTON/OREGON OCEAN FISHERIES

2.2.2.5.1 AGE 3

Fishery indices of age 3 index stocks in the combined Washington/Oregon ocean troll and sport fisheries have remained below base period levels since implementation of the PST (Figure 16). The fishery index ranged from 18% (1987) to 31% (1986) below the base period level and averaged 25% below the average base period level.

2.2.2.5.2 AGE 4

Fishery indices of age 4 index stocks in the combined Washington/Oregon ocean troll and sport fisheries have remained substantially below base period levels since implementation of the PST (Figure 17). The fishery index ranged from 80% below the base period level in 1985 to 59% below this level in 1986 and averaged 69% below the average base period level from 1985-87.

2.2.2.5.3 AGES 3 & 4 COMBINED

Fishery indices of age 3 and 4 index stocks in the combined Washington/Oregon ocean troll and sport fisheries have declined from the average base period levels since implementation of the PST (Figure 18). The 1985, 1986, and 1987 fishery indices for this fishery have decreased by 48%, 42%, and 35% respectively and averaged 42% below the average base period level.

2.2.3 STOCK SPECIFIC RESULTS

2.2.3.1 STOCK INDICES

Stock indices used in the analysis are presented in Figures 19 through 28. Ocean exploitation rates decreased for four index stocks: Quinsam, Willamette Spring, Spring Creek, and Cowlitz fall. Reductions in ocean exploitation rates for Spring Creek and Cowlitz fall stocks are due to reductions in impacts of the West Coast of Vancouver Island troll fishery and ocean fisheries off the Washington and Oregon coasts. The principal ocean exploitation of the Quinsam stock occurs in North/Central B.C and S.E. Alaska. In spite of increases in exploitation rate in the Alaska troll fishery, total ocean exploitation on this stock decreased, due to decreased impact of the North/Central B.C. troll fishery and possibly in the coastal B.C. net fisheries.

Five index stocks (Big Qualicum, Robertson Creek, Columbia River Upriver Bright, Bonneville, and Stayton Pond) exhibited small but variable reductions in ocean exploitation rates of age 3 fish, but increased in ocean exploitation rates of age 4 fish. Reductions in the three-year-old ocean exploitation index for Bonneville and Stayton Pond are due predominately to reductions in the Washington/Oregon ocean fisheries.

Capilano is the tenth indicator stock but the trend in this index is uncertain. Spawning escapements in recent years have been very poor but are thought to be related to the extermely low flow in the Capilano River and poor recent survivals of this hatchery stock.

2.2.3.2 BROOD EXPLOITATION RATES

Results of this analysis are presented graphically in Figures 29 through 38. Note that the brood year exploitation rates depicted in these figures are not indices, but rather represent actual values of estimates.

Brood year ocean exploitation rates have declined for five stocks (Quinsam, Spring Creek, Cowlitz Fall,, Bonneville Tule, and Stayton Pond Tule). The decline in the Quinsam stock is due to a decrease in North/Central B.C. troll fishery exploitation and a possible decline in B. C. net fisheries. For the four other stocks in this group, declines in ocean exploitation rates are due to reductions in impacts of fisheries off the Washington and Oregon coasts. Rates remained relatively unchanged for three stocks (Big Qualicum, Columbia River Upriver Bright, and Willamette Spring). Rates for the Capilano and Robertson Creek

stocks have increased under PST management regimes. The responses may be confounded by changes in collection of escapement data in recent years, particularly in Capilano.

2.2.3.3 SURVIVAL RATE INDICES

The results of the survival rate index analysis are presented graphically in Figures 39-48. Survival rate indices for four Columbia River stocks (Upriver Bright, Cowlitz Tule, Bonneville Tule, and Stayton Pond Tule) have increased substantially. Survival rate indices for the Upriver Bright stock have increased since 1980; the survival rate of the 1983-84 broods for the Cowlitz fall stock are far above average levels; survival rate indices for the Bonneville and Stayton Pond tule stocks indicate a dramatic increase for the 1984 brood.

Survival rate indices for Robertson Creek, Big Qualicum, Capilano, and Spring Creek stocks have declined substantially. No trend is apparent for survival rate indices for two stocks (Quinsam and Willamatte Spring).

2.2.3.4 STOCK CONTRIBUTION INDICES

The results of the stock contribution index analysis are presented in Table 3. These data should most appropriately be viewed on an individual stock basis since estimation procedures for terminal run size and the associated accuracy of the estimate may not be directly comparable between stocks. Trends for individual stocks are believed to be reliable indicators of relative contributions for that stock.

The contribution of Columbia Upriver Brights to the outside PSC fisheries with ceilings has increased dramatically since the implementation of the PST. However, the relative contribution of Robertson Creek fish to the same fisheries and time periods has decreased substantially. There is evidence that west coast of Vancouver Island troll catches have recently declined in the contribution of Robertson Creek and Spring Creek stocks concomitant with increases in the contribution of Upriver Bright and Washington and Oregon Lower Columbia hatchery tule stocks.

3.0 DISCUSION AND SUMMARY

This report is based on coded-wire tag recoveries for 10 indicator stocks with a continuous time series of recovery data which began during the base period (1979-1982). These 10 stocks are referred to as the "Exploitation Rate" indicator stocks. Analyses in this report are specific to these stocks; the extrapolation of results to similar stocks and/or generalized statements about fishery impacts will be dependent upon how representative these indicator stocks are of other stocks of interest or upon the stock composition in a fishery. At present, these indicator stocks consist of 4 fall chinook stocks from southern B.C., 5 fall chinook stocks from the Columbia River, and the Willamette spring chinook stock (lower Columbia River). The committee is also beginning to evaluate a S.E. Alaskan spring chinook stock as an exploitation rate indicator. However, complete data for exploitation rate analyses are not available until the 1983 recovery year.

3.1 FISHERY INDICES

The fishery index measures the relative change in the total mortality of the indicator stocks within a fishery. With the exception of the North/Central troll fishery, exploitation rates for index stocks in fisheries with ceilings have not declined to levels anticipated for 1985 through 1987 when fishing regimes were established under the Pacific Salmon Treaty.

Target exploitation rate reductions, for some fisheries with fixed ceilings, have not been met, partially due to unanticipated mortalities from size limit changes and increasing mortalities from non-retention fisheries. In addition, the west coast Vancouver Island troll fishery historically harvested primarily 3 year old fish; the size limit change has caused an increase in the exploitation of older age fish above that anticipated under PST fixed ceiled management.

3.1.1 S.E. ALASKA TROLL FISHERY

The average 1985-87 total mortality fishery index was 9% over the 1979-82 base period. The yearly index from 1985-87 was above the base period level for 2 of the 3 years. The average 1985-87 fishery index, based on reported catch only, was 3% below the base period.

A combination of factors may have contributed to the lack of expected reductions in the fishery index in the S.E. Alaska troll fishery: 1) changes in the structure of the fishing season,

principally large reductions in fishing times during the late spring and late summer, smaller reductions in the mid-summer season, and no reductions in the winter fishery; 2) increased catch in the CNR fishery; 3) use of principally fall stocks as indicators which do not provide a complete representation of all stocks in the fishery. The decrease in the S.E. Alaska hatchery stock exploitation rates in the 1985-87 period suggests that implementation of PST regimes in this fishery is differentially affecting stocks.

3.1.2 NORTH/CENTAL B.C. TROLL FISHERY

The reduction in the fishery index appears to be in the range expected under PST ceilings, averaging 22% below base period levels. The 1987 size limit change had little measurable impact in this fishery because very few chinook were landed in the 62cm to 67cm size category prior to the increase in the size limit.

3.1.3 WEST COAST VANCOUVER ISLAND TROLL FISHERY

The combined age 3 and 4 fishery index did not decrease below base period levels during 1985 or 1986, and increased by 31% above the base period in 1987. The 1987 size limit change had three effects: 1) a large increase in the 4 year old fishery index from 1986 to 1987; 2) a decrease in the total age 3 fishery index from 1986 to 1987; and 3) an increase in the three-year-old proportion of total mortality attributed to incidental mortality. The following combination of reasons may be responsible for the failure of this fishery to meet target reductions in exploitation rate: 1) time and area restructing of the fishery may have concentrated exploitation on fall stocks; 2) a failure of Spring Creek hatchery stock and fluctuations in abundance of other key fall hatchery stocks; 3) the effect of concentrating harvest on 4 year olds due to the change in size limit has caused an increase in the exploitation rate on 4 year olds (historically, this fishery has concentrated on 3 year old fish).

3.1.4 GEORGIA STRAIT SPORT AND TROLL FISHERIES

The average 1985-87 fishery index for the combined troll and sport fisheries has decreased 15% since the base period, but remains 32% above target reduction under the initial PST regimes. The exploitation rate for the troll fishery has been substantially reduced. However, the exploitation rate for the sport fishery has increased above base period levels. The results of this analysis indicate that, after an initial drop in

1985, the exploitation rate has returned nearly to base period levels by 1987. Catches have declined in this same period because of declining abundance of available stocks. There is evidence of reduced abundances for the Lower Georgia Strait stock complex (survival rate indices have declined in both major Georgia Strait hatcheries). The reason exploitation rates have been maintained near base period levels is because management actions necessary to compensate for reduced abundances have not been implemented.

3.1.5 WASHINGTON/OREGON TROLL AND SPORT FISHERIES

The average fishery index for Washington and Oregon (North of Cape Falcon) troll and sport fisheries has decreased substantially from the base period. The 1985-87 fishery index averaged 42% of the base period levels for age 3 and 4 fish.

3.1.6 VARIABILITY IN THE FISHERY INDEX

Large variability is often evident when the indices of several stocks are compared. This variation may be due to sampling errors, departures from assumptions, and differential harvest rates.

3.2 STOCK INDICES

These stock indices are designed to assess the combined effect of all ocean fisheries on fish of a given age from a specific stock. Ocean exploitation rates decreased for four index stocks: Quinsam, Willamette Spring, Spring Creek, and Cowlitz fall. Reductions in ocean exploitation rates for Spring Creek and Cowlitz fall stocks are due to reductions in impacts of the West Coast of Vancouver Island troll fishery and ocean fisheries off the Washington and Oregon coasts. The principal ocean exploitation of the Quinsam stock occurs in North/Central B.C and S.E. Alaska. In spite of increases in exploitation rate in the Alaska troll fishery, total ocean exploitation on this stock decreased, due to decreased impact of the North/Central B.C. troll fishery and possibly in the coastal B.C. net fisheries.

Five index stocks (Big Qualicum, Robertson Creek, Columbia River Upriver Bright, Bonneville, and Stayton Pond) exhibited small but variable reductions in ocean exploitation rates of age 3 fish, but increased in ocean exploitation rates of age 4 fish. Reductions in the three-year-old ocean exploitation index for Bonneville and Stayton Pond are due predominately to reductions in the Washington/Oregon ocean fisheries.

Capilano is the tenth indicator stock but the trend in this index is uncertain. Spawning escapements in recent years have been very poor but are thought to be related to the extermely low flow in the Capilano River and poor recent survivals of this hatchery stock.

3.3 BROOD YEAR EXPLOITATION RATES

Brood year exploitation rates are designed to monitor the cumulative impacts of ocean fisheries over the life of offspring of a single spawning year (i.e., a cohort).

Brood year ocean exploitation rates have declined for five stocks (Quinsam, Spring Creek, Cowlitz Fall,, Bonneville Tule, and Stayton Pond Tule). The decline in the Quinsam stock is due to a decrease in North/Central B.C. troll fishery exploitation and a possible decline in B. C. net fisheries. For the four other stocks in this group, declines in ocean exploitation rates are due to reductions in impacts of fisheries off the Washington and Oregon coasts. Rates remained relatively unchanged for three stocks (Big Qualicum, Columbia River Upriver Bright, and Willamette Spring). Rates for the Capilano and Robertson Creek stocks have increased under PST management regimes. The responses may be confounded by changes in collection of escapement data in recent years, particularly in Capilano.

3.4 SURVIVAL RATE INDICES

Survival rate indices (defined as three-year old catch and escapement divided by the total release size) indicate that substantial changes have occurred during recent years. For some stocks, increases in abundance can be traced directly to increases in survival rather than reductions in exploitation rates.

Survival rate indices for four Columbia River stocks (Upriver Bright, Cowlitz Tule, Bonneville Tule, and Stayton Pond Tule) have increased substantially. Survival rate indices for the Upriver Bright stock have increased since 1980; the survival rate of the 1983-84 broods for the Cowlitz fall stock are far above average levels; survival rate indices for the Bonneville and Stayton Pond tule stocks indicate a dramatic increase for the 1984 brood.

Survival rate indices for Robertson Creek, Big Qualicum, Capilano, and Spring Creek stocks have declined substantially. No trend is apparent for survival rate indices for two stocks (Quinsam and Willamatte Spring).

3.5 STOCK CONTRIBUTION INDICES

The result of the analyses in this report indicate that the ocean exploitation rates on Columbia River Brights did not decrease in spite of large increases in stock abundance. This result can be caused by dramatic decreases in abundance of other stocks which historically contributed substantially to a fishery. A time series of contributions of certain major indicator stocks to some ocean fisheries was estimated to investigate changes in relative stock compositions. The contribution of Columbia Upriver Brights to the outside PSC fisheries with ceilings has increased dramatically since the implementation of the PST. However, the contribution of Robertson Creek and Spring Creek hatchery fish to the same fisheries and time periods has decreased substantially. These data suggest that increased contributions of Upriver Brights are probably compensating for decreased contributions of other stocks in these fisheries. It appears that the Upriver Bright stock is presently the largest single contributor to the outside PSC fisheries.

TABLES and FIGURES

Table 1. COMPARISON OF ALTERNATIVE FISHERY HARVEST RATE INDICES
SAvg = simple Average; Ratio = Ratio of Harvest Rates

	ALASKA TROLL AGE 4 and 5				N/C TROLL AGE 4 and 5			
	CATCH		TOTAL MORTALITY		CATCH		TOTAL MORTALITY	
YEAR	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio
1979	0.89	0.86	0.86	0.84	1.11	1.06	1.10	1.06
1980	1.00	0.96	0.97	0.94	1.21	1.20	1.21	1.20
1981	1.12	1.25	1.10	1.23	1.05	1.09	1.05	1.08
1982	0.99	0.89	1.05	0.96	0.65	0.66	0.65	0.66
1983	1.51	1.22	1.58	1.28	0.94	0.96	0.95	0.96
1984	0.96	1.01	1.03	1.09	0.64	0.58	0.64	0.58
1985	1.27	1.01	1.43	1.14	0.74	0.69	0.74	0.69
1986	0.88	0.89	0.93	0.94	0.97	0.89	0.98	0.89
1987	1.19	1.00	1.43	1.19	0.84	0.74	0.87	0.76

	WCVI TROLL AGE 3 & 4				WCVI TROLL AGE 3				WCVI TROLL AGE 4			
	CATCH		TOTAL MORTALITY		CATCH		TOTAL MORTALITY		CATCH		TOTAL MORTALITY	
year	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio
1979	1.03	0.99	1.03	0.98	1.07	1.08	1.07	1.06	0.99	0.88	1.00	0.88
1980	1.32	1.09	1.31	1.08	1.30	1.05	1.28	1.04	1.34	1.12	1.34	1.12
1981	0.74	0.82	0.75	0.84	0.76	0.89	0.79	0.90	0.71	0.76	0.71	0.77
1982	0.98	1.10	0.97	1.10	0.94	1.03	0.93	1.03	1.01	1.16	1.01	1.16
1983	1.02	1.34	1.02	1.35	1.00	1.36	1.01	1.37	1.03	1.33	1.04	1.34
1984	1.39	1.64	1.39	1.63	1.21	1.39	1.24	1.41	1.54	1.81	1.53	1.80
1985	0.84	0.94	0.85	0.96	0.87	0.88	0.89	0.93	0.81	0.98	0.82	0.99
1986	1.04	1.06	1.01	1.03	1.24	1.23	1.18	1.17	0.90	0.93	0.90	0.93
1987	0.90	1.22	1.01	1.31	0.53	0.68	0.69	0.87	1.35	1.75	1.39	1.78

	GEORGIA ST SPT & TRL AGE 3 & 4				GEORGIA ST TROLL AGE 3 & 4				GEORGIA ST SPORT AGE 3 & 4			
	CATCH		TOTAL MORTALITY		CATCH		TOTAL MORTALITY		CATCH		TOTAL MORTALITY	
year	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio
1979	0.87	0.90	0.87	0.90	1.03	1.04	1.03	1.04	0.76	0.81	0.76	0.81
1980	1.00	0.97	1.00	0.97	1.14	1.14	1.14	1.14	0.91	0.87	0.91	0.87
1981	1.46	1.43	1.46	1.43	0.89	0.87	0.89	0.87	1.79	1.77	1.79	1.77
1982	0.67	0.70	0.67	0.70	0.94	0.94	0.94	0.94	0.53	0.55	0.54	0.55
1983	0.82	0.78	0.82	0.78	0.70	0.64	0.70	0.64	0.88	0.87	0.88	0.87
1984	1.29	1.20	1.30	1.21	0.42	0.43	0.43	0.45	1.75	1.68	1.76	1.68
1985	0.64	0.66	0.65	0.67	0.13	0.16	0.15	0.18	0.97	0.98	0.97	0.98
1986	0.91	0.92	0.94	0.95	0.26	0.29	0.35	0.38	1.30	1.31	1.30	1.31
1987	0.89	0.90	0.90	0.92	0.28	0.32	0.31	0.36	1.24	1.26	1.24	1.26

	WA/OR OCEAN AGE 3 and 4				WA/OR OCEAN AGE 3				WA/OR OCEAN AGE 4			
	CATCH		TOTAL MORTALITY		CATCH		TOTAL MORTALITY		CATCH		TOTAL MORTALITY	
year	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio	SAvg	Ratio
1979	0.86	0.83	0.84	0.81	0.72	0.72	0.72	0.71	1.13	1.13	1.09	1.09
1980	0.93	0.96	0.92	0.95	1.09	1.10	1.08	1.09	0.69	0.70	0.69	0.69
1981	1.12	1.06	1.14	1.08	0.88	0.89	0.91	0.92	1.44	1.32	1.44	1.33
1982	0.99	1.04	0.99	1.04	1.19	1.19	1.17	1.18	0.79	0.83	0.80	0.84
1983	0.73	0.65	0.72	0.64	0.62	0.61	0.62	0.61	0.85	0.71	0.81	0.69
1984	0.19	0.21	0.20	0.22	0.27	0.29	0.27	0.28	0.11	0.11	0.12	0.12
1985	0.50	0.48	0.52	0.52	0.72	0.71	0.74	0.74	0.28	0.18	0.31	0.20
1986	0.62	0.61	0.58	0.58	0.77	0.75	0.72	0.69	0.46	0.42	0.44	0.42
1987	0.52	0.64	0.53	0.65	0.76	0.82	0.77	0.82	0.20	0.33	0.20	0.32

Table 2. Fishery indices (based on 10 indicator stocks) relative to the 1979-82 base period and the target reductions established under the initial PST fishery regimes. All calculations, except as noted, based on total fishing mortalities (1).

Fishery	Age	Total Mortalities 1985	1986	1987	85-87 Avg	Reported Catch 85-87 Avg	Target Reduction(2)
Southeast Alaska Troll	4 & 5	14%	-6%	19%	9%	-3%	-22%
North/Central Troll	4 & 5	-31%	-11%	-24%	-22%	-23%	-16%
WCVI Troll	3	-7%	17%	-13%	-1%	-7%	-24%
WCVI Troll	4	-1%	-7%	78%	23%	22%	-24%
WCVI Troll	3 & 4	-4%	3%	31%	10%	7%	-24%
Georgia Str. Sport & Troll	3 & 4	-33%	-5%	-8%	-15%	-17%	-47%
Georgia Strait Troll	3 & 4	-82%	-62%	-64%	-69%	-74%	-79%
Georgia Strait Sport	3 & 4	-2%	31%	26%	18%	18%	-20%
WA/OR Ocean Tr & Spt	3	-26%	-31%	-18%	-25%	-24%	(2)
WA/OR Ocean Tr & Spt	4	-80%	-59%	-68%	-69%	-69%	(2)
WA/OR Ocean Tr & Spt	3 & 4	-48%	-42%	-35%	-42%	-42%	(2)

FootNotes:

(1) Indicator stocks used are as follows:
Lower Georgia Strait: Big Qualicum (fall), Capilano (fall)
Upper Georgia Strait: Quinsam (fall)
W. Coast Vancouver Island: Robertson Creek (fall)
Columbia River: Upriver Brights (fall), Willamette (spring), Spring Cr (fall), Cowlitz (fall), Bonneville Hatchery (fall), Stayton Ponds (fall)

(2) Target reductions are initial reductions from the 1979-82 base period expected from the rebuilding program. No target reduction was established for Washington and Oregon ocean fisheries north of Cape Falcon, Oregon.

Table 3. Stock contribution indices of Columbia River Upriver Bright, Robertson Creek Hatchery, Spring Creek Hatchery, Oregon Lower Columbia Tule Hatchery and Washington Lower Columbia Tule Hatchery stocks to the S.E. Alaska, North Central, and West Coast Troll Fisheries (1979-1987). Contribution indices are in 1000 fish units; the index is calculated for each stock relative to 1979-82 Average (Base Period).

			ROBERTSON CREEK			
		COL RIV BRIGHT	<--TERM RUN a/->		<--RELEASE b/-->	
	YEAR	CONTRB	INDEX	CONTRB	INDEX	CONTRB	INDEX
SOUTHEAST	1979	36	132%	62	78%	13	45%
ALASKA	1980	29	106%	76	96%	34	118%
TROLL	1981	34	125%	80	101%	31	108%
	1982	10	37%	100	126%	37	129%
	1983	27	99%	93	117%	44	153%
	1984	61	224%	69	87%	34	118%
	1985	52	191%	28	35%	12	42%
	1986	49	180%	9	11%	6	21%
	1987	104	382%	8	10%	6	21%
BASE AVG		27	100%	80	100%	29	100%

			ROBERTSON CREEK			
		COL RIV BRIGHT	<--TERM RUN a/->		<--RELEASE b/-->	
	YEAR	CONTRB	INDEX	CONTRB	INDEX	CONTRB	INDEX
NTH/CNTRL	1979	21	138%	76	120%	20	87%
B.C. TRLL	1980	22	144%	40	63%	21	91%
	1981	11	72%	54	85%	20	87%
	1982	7	46%	84	132%	31	135%
	1983	24	157%	49	77%	26	113%
	1984	39	256%	46	72%	21	91%
	1985	32	210%	35	55%	16	70%
	1986	38	249%	6	9%	5	22%
	1987	97	636%	0 /c	0%	0 /c	0%
BASE AVG		15	100%	64	100%	23	100%

			ROBERTSON CREEK						OREGON		WASHINGTON	
		COL RIV BRIGHT	<--TERM RUN a/->		<--RELEASE b/-->		SPR CR HATCH		LWR RIV HAT		LWR RIV HAT	
	YEAR	CONTRB	INDEX	CONTRB	INDEX	CONTRB	INDEX	CONTRB	INDEX	CONTRB	INDEX	CONTRB	INDEX
WEST COAST	1979	22	187%	24	123%	9	113%	89	125%	NA	NA	NA	NA
VANCOUVER	1980	10	85%	18	92%	10	125%	79	111%	NA	NA	NA	NA
ISLAND	1981	8	68%	13	67%	5	63%	59	83%	20	49%	13	100%
TROLL	1982	7	60%	23	118%	8	100%	57	80%	62	151%	13	100%
	1983	7	60%	13	67%	6	75%	25	35%	43	105%	24	185%
	1984	24	204%	18	92%	10	125%	33	46%	66	161%	25	192%
	1985	30	255%	4	21%	2	25%	10	14%	37	90%	14	108%
	1986	59	502%	3	15%	1	13%	6	8%	22	54%	26	200%
	1987	48	409%	0 /c	0%	0 /c	0%	2	3%	143	349%	32	246%
BASE AVG		12	100%	20	100%	8	100%	71	100%	41	100%	13	100%

a/ "Term Run" Robertson Creek estimate based on expansion of fishery tag recoveries using mark rates calculated from the terminal gillnet fishery and hatchery rack escapement.

b/ "Release" Robertson Creek estimate based on expansion of fishery tag recoveries using mark rates at release.

c/ No CWT recoveries.

FISHERY INDEX

ALASKA TROLL (AGE 4 AND 5)

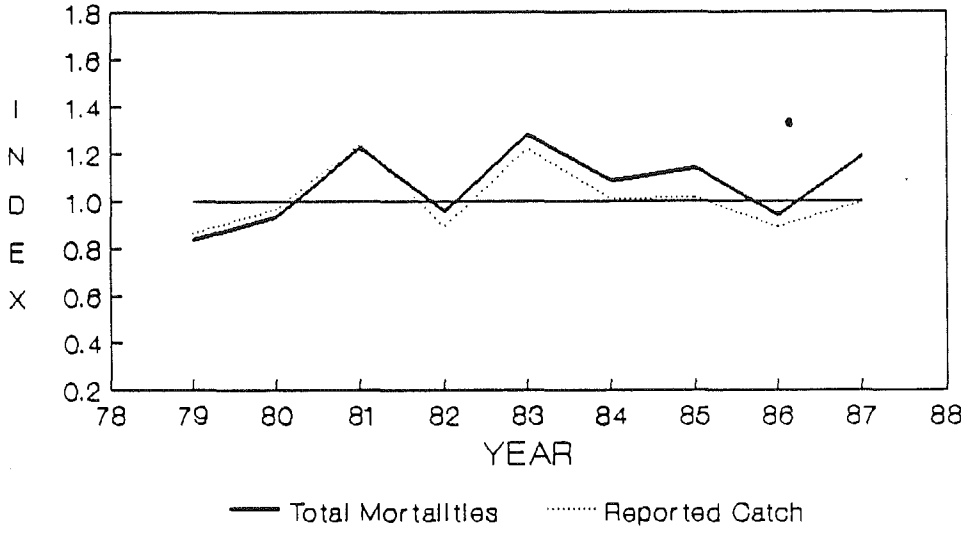


Fig. 1

FISHERY INDEX

NORTH/CENTRAL TROLL (AGE 4 AND 5)

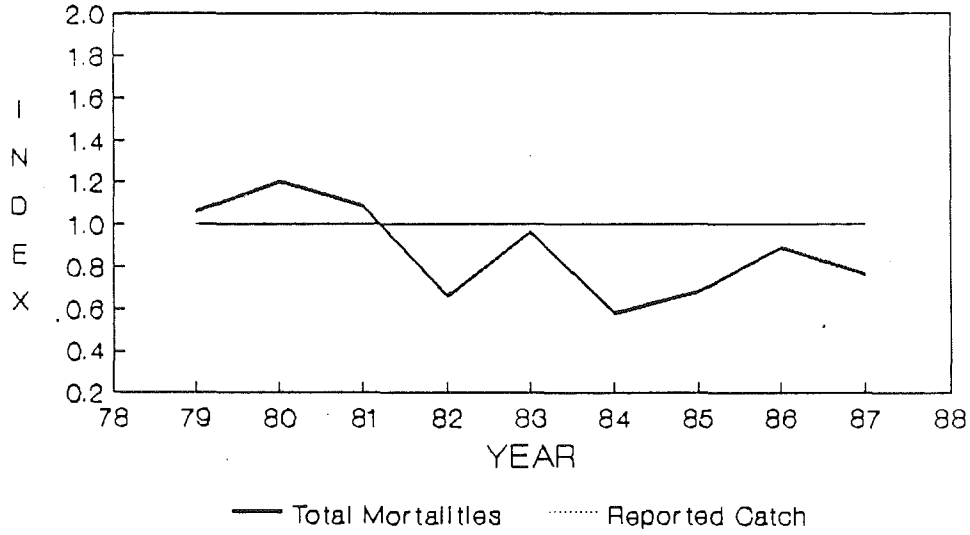


Fig. 2

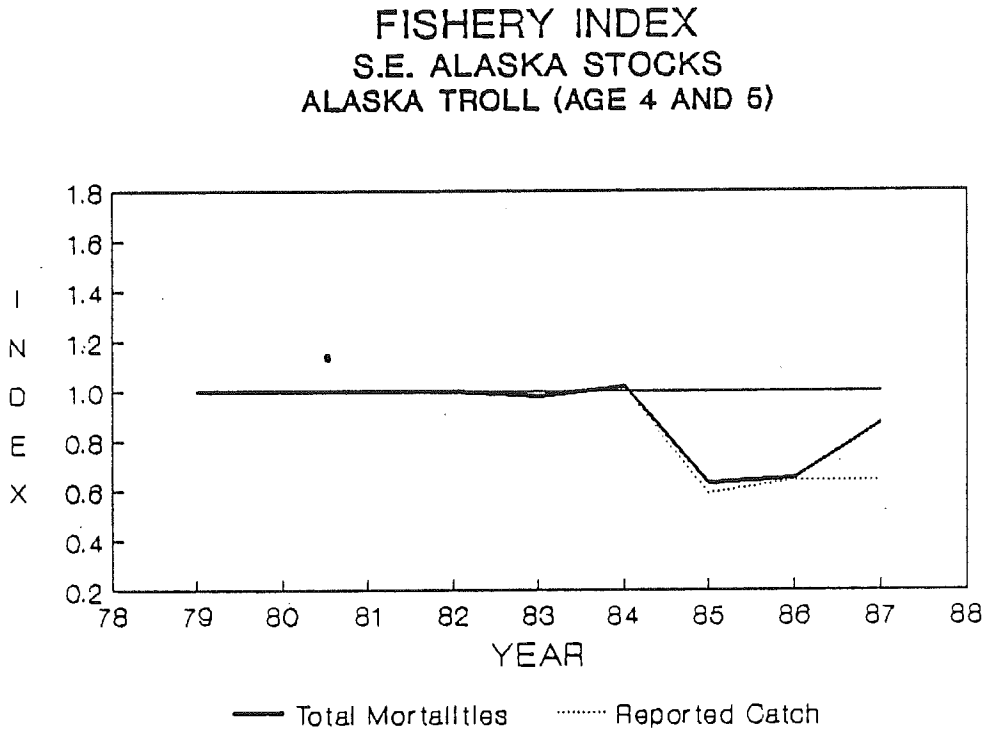


Fig. 3

Year	S.E. ALASKA STK Age 4	S.E. ALASKA STK Age 5	Reptd Catch Total	S.E. ALASKA STK Age 4	S.E. ALASKA STK Age 5	Total Mortality
79	NA	NA	NA	NA	NA	NA
80	NA	NA	NA	NA	NA	NA
81	NA	NA	NA	NA	NA	NA
82	0.99	NA	0.99	1.00	NA	1.00
83	1.38	0.86	1.00	1.35	0.85	0.98
84	0.63	1.14	1.01	0.64	1.15	1.02
85	0.71	0.55	0.59	0.75	0.58	0.63
86	1.32	0.38	0.64	1.34	0.39	0.65
87	0.59	0.66	0.64	1.08	0.79	0.87

FISHERY INDEX

WCVI TROLL (AGE 3)

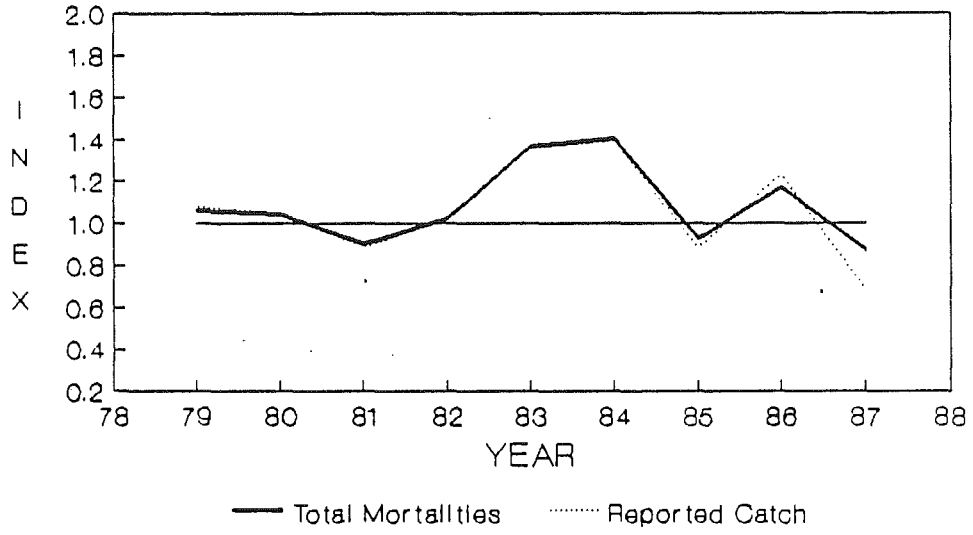


Fig. 4

FISHERY INDEX

WCVI TROLL (AGE 4)

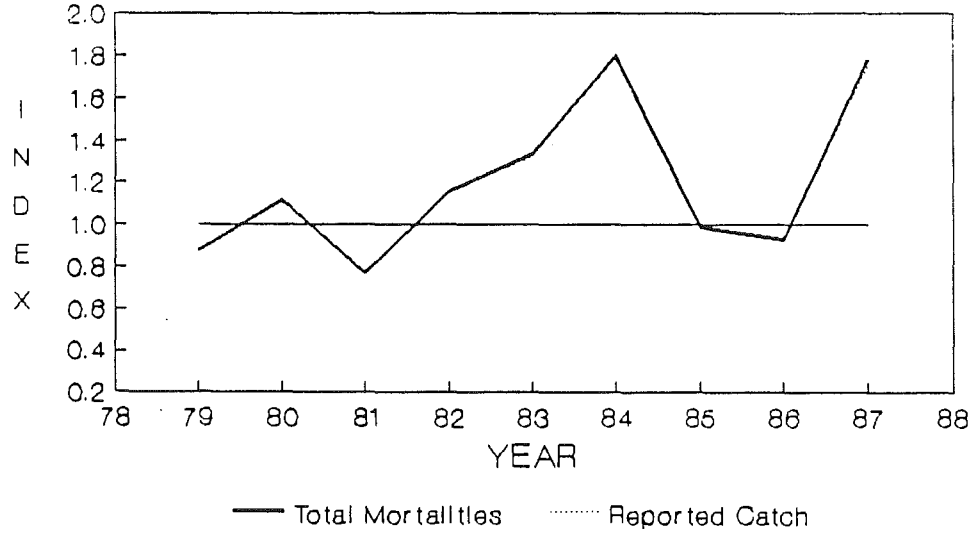


Fig. 5

FISHERY INDEX

WCVI TROLL (AGE 3 AND 4)

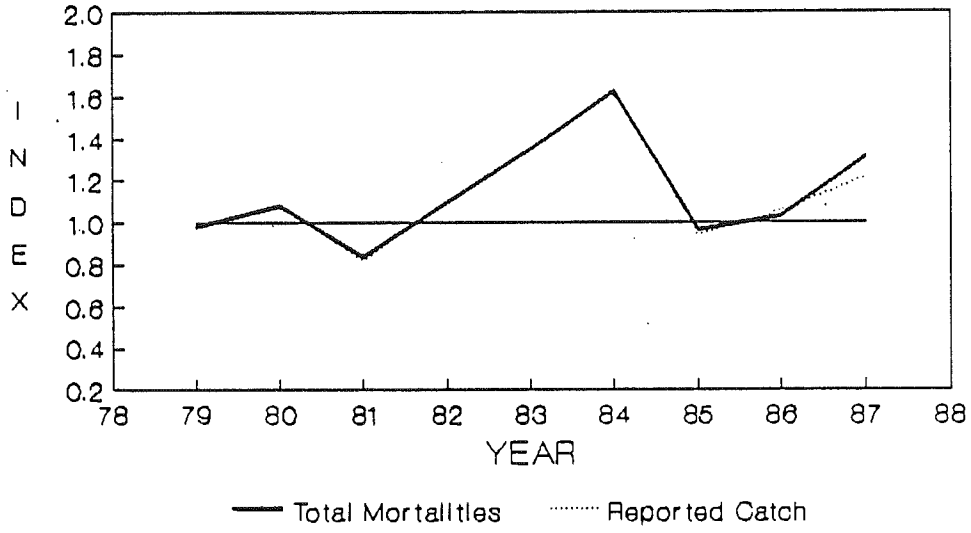


Fig. 6

FISHERY INDEX

GEORGIA ST SPORT AND TROLL (AGE 3 AND 4)

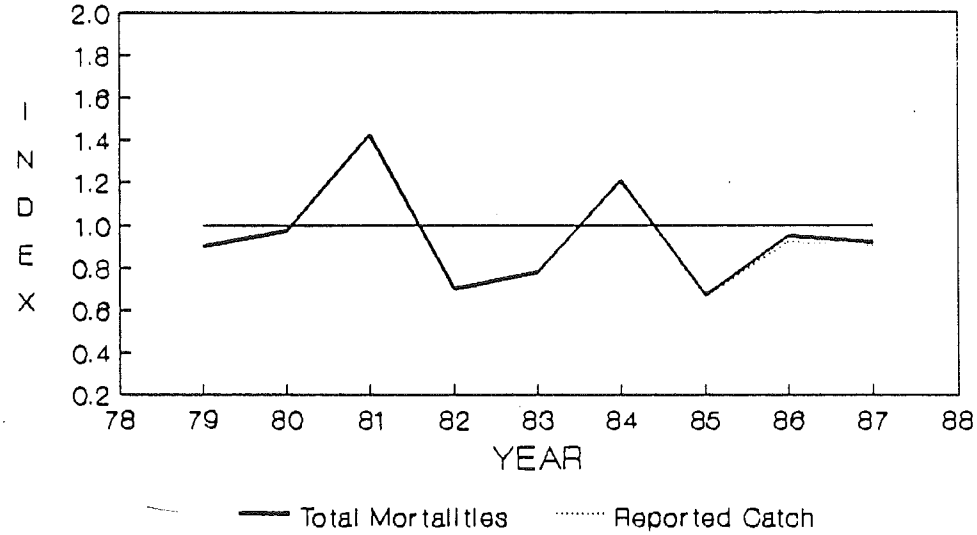


Fig. 7

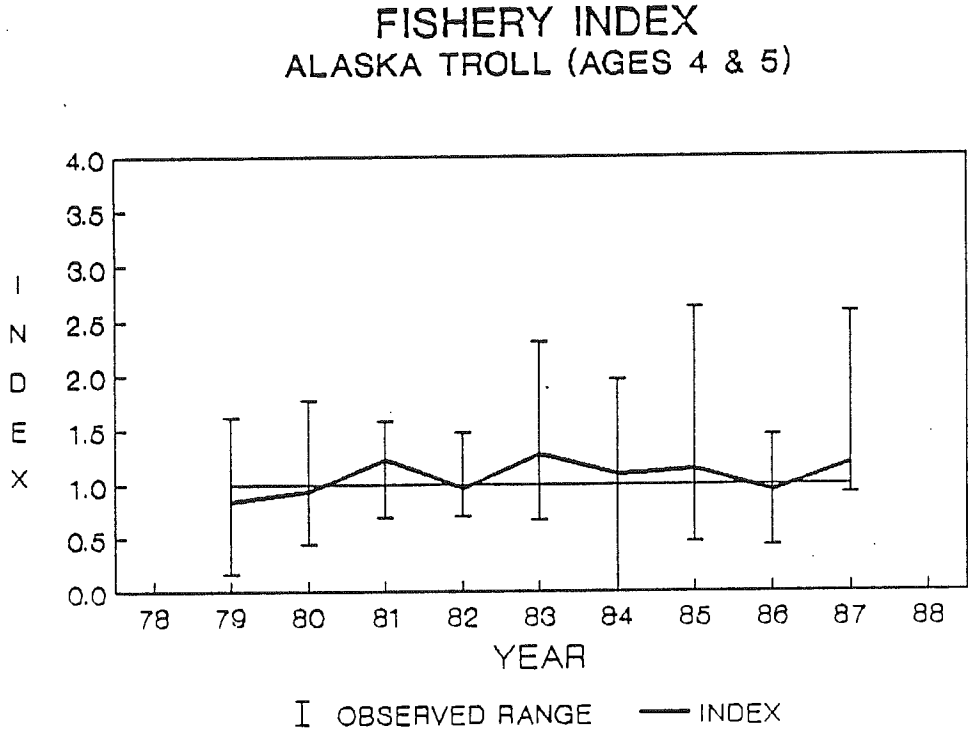


Fig. 8

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4	Fishery
79	1.6162	0.1744	0.8825	0.9123	0.9405	NA	0.6130	0.8350
80	0.4402	1.1377	0.5996	0.9703	1.1460	0.6971	1.7753	0.9350
81	0.6866	1.2074	1.0554	1.2005	1.0637	1.5931	0.9107	1.2286
82	1.2570	1.4805	1.4625	0.9169	0.8498	0.7098	0.7010	0.9575
83	2.2874	2.3122	2.1635	1.0495	1.3378	0.6576	1.2696	1.2811
84	0.0000	1.2084	1.9599	1.0336	1.3273	0.9246	0.7593	1.0881
85	0.9023	1.7847	2.2440	0.4606	1.0686	0.9193	2.6302	1.1428
86	0.9107	1.0902	1.4535	1.1919	0.7512	0.6604	0.4275	0.9391
87	2.5782	1.0380	1.3891	NA	0.9744	0.9058	1.7222	1.1917

Stock Identifiers

BQR = BIG QUALICUM
QUI = QUINSAM
RBT = ROBERTSON CREEK
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

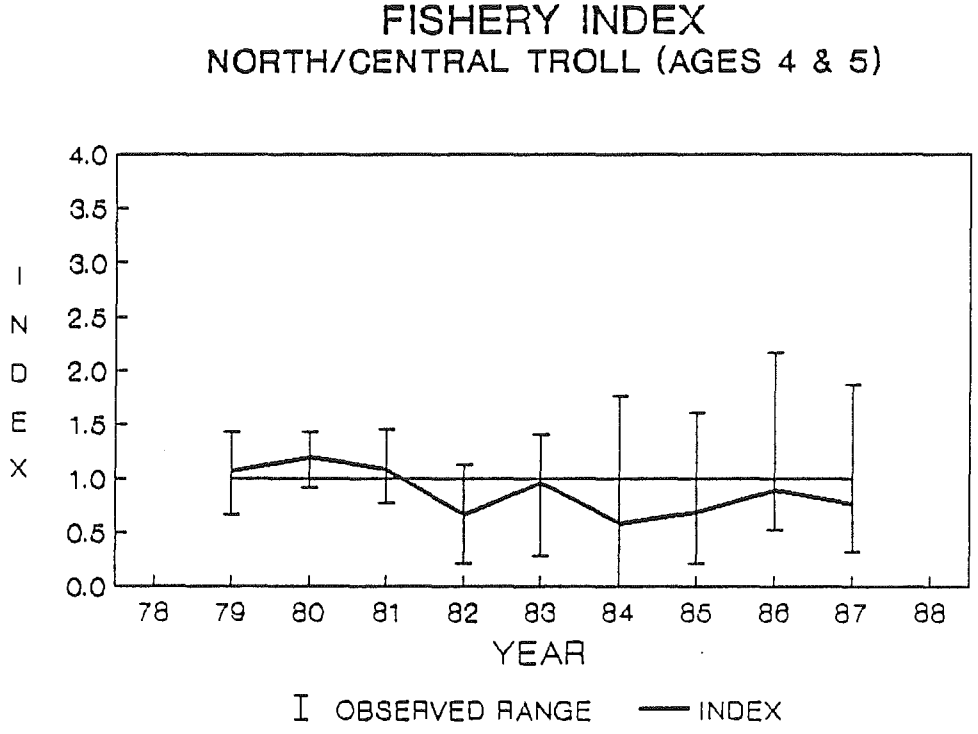


Fig. 9

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4	Fishery
79	1.0893	1.1862	0.6622	1.0431	1.2138	NA	1.4316	1.0599
80	0.9108	1.0978	1.4270	0.9465	1.3381	1.3272	1.4161	1.2026
81	0.8768	1.1776	1.1924	0.9455	0.7728	1.4548	0.9437	1.0846
82	1.1231	0.5384	0.7184	1.0650	0.6753	0.2180	0.2086	0.6606
83	1.1922	0.9995	1.4050	0.7982	1.1370	0.7955	0.2936	0.9644
84	0.0000	0.4217	0.4560	0.9874	1.7560	0.5639	0.2891	0.5823
85	0.6718	0.2942	0.2123	1.6097	1.3987	0.6648	0.3382	0.6861
86	2.1698	0.5689	0.5160	1.0291	1.0836	0.7098	0.7487	0.8916
87	0.8022	0.3627	0.7632	NA	1.8748	1.0982	0.3243	0.7622

Stock Identifiers

BQR = BIG QUALICUM
QUI = QUINSAM
RBT = ROBERTSON CREEK
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

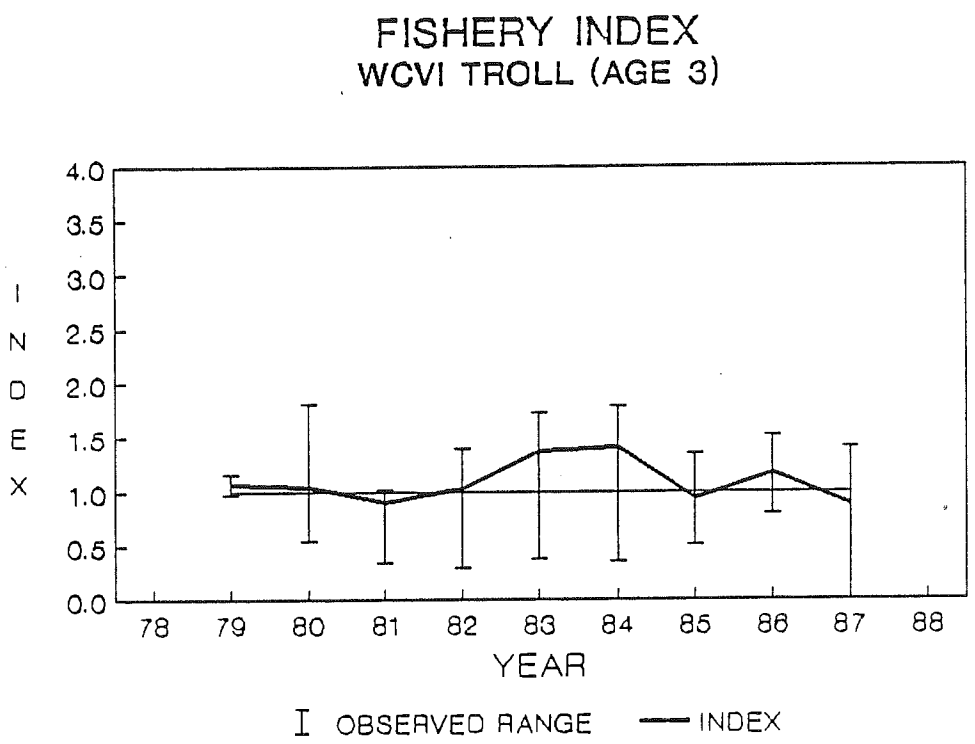


Fig. 10

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	RBT Age 3	SPR Age 3	BON Age 3	CWF Age 3	URB Age 3	STP Age 3	Fishery
79	1.0195	0.9695	1.1552	NA	1.1409	NA	1.0635
80	1.4870	1.1882	0.5413	1.8078	1.3919	NA	1.0422
81	0.6862	0.9008	0.9011	0.8876	0.3403	1.0158	0.9034
82	0.8073	0.9416	1.4024	0.3046	1.1269	0.9842	1.0264
83	0.4139	1.4814	1.7347	0.6588	0.3802	1.3684	1.3657
84	1.6246	1.3569	1.4284	0.3577	0.8654	1.7902	1.4050
85	1.0601	0.6592	1.3524	0.5116	0.8728	0.8922	0.9258
86	NA	1.0955	1.5739	0.7888	1.5101	0.9327	1.1720
87	0.0000	0.5063	1.0170	0.1638	1.0374	1.4082	0.8731

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
RBT = ROBERTSON CREEK
SPR = SPRING CREEK
STP = STAYTON POND TULE
URB = COLUMBIA RIVER UPRIVER BRIGHT

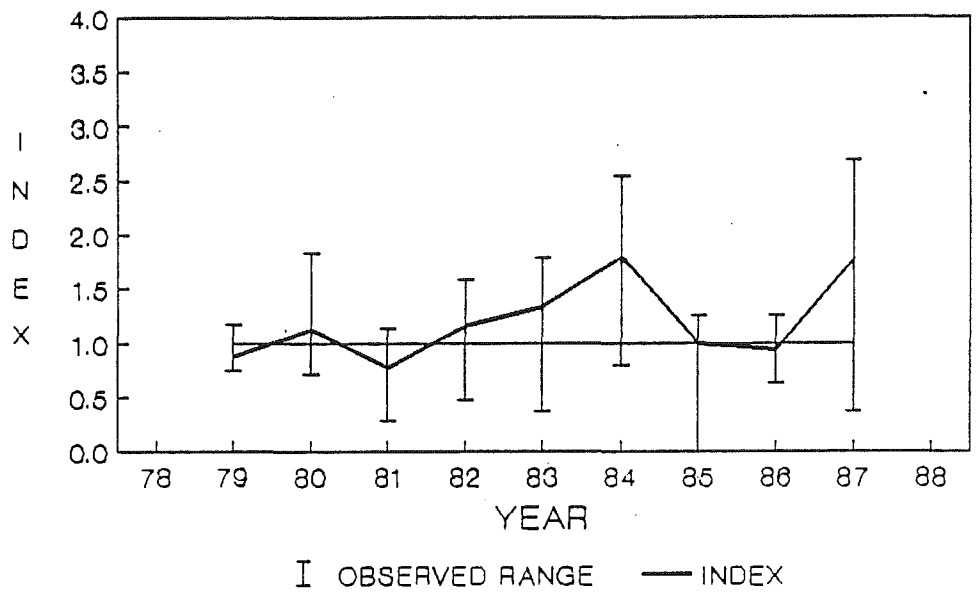


Fig. 11

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	RBT Age 4	SPR Age 4	BON Age 4	CWF Age 4	URB Age 4	WSH Age 4	STP Age 4	Fishery
79	1.0916	0.7430	NA	NA	1.1740	0.9775	NA	0.8779
80	1.6359	1.2910	0.7079	NA	1.2186	1.8346	NA	1.1165
81	0.4888	0.8244	0.7017	0.8376	1.1382	0.2827	NA	0.7680
82	0.7837	1.1416	1.5904	1.1624	0.4692	0.9052	1.0000	1.1587
83	0.7827	1.3045	1.4944	1.3648	0.3734	0.1779	1.7870	1.3378
84	1.2217	1.6421	2.5434	1.3248	1.1473	0.7922	2.0311	1.7988
85	0.0000	1.2585	1.2401	0.8816	0.9252	0.6291	0.8123	0.9921
86	0.6334	0.8656	0.8967	1.2556	1.1238	0.7157	0.7831	0.9257
87	NA	NA	2.6900	0.8280	0.9899	0.3721	2.0670	1.7848

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
RBT = ROBERTSON CREEK
SPR = SPRING CREEK
STP = STAYTON POND TULE
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

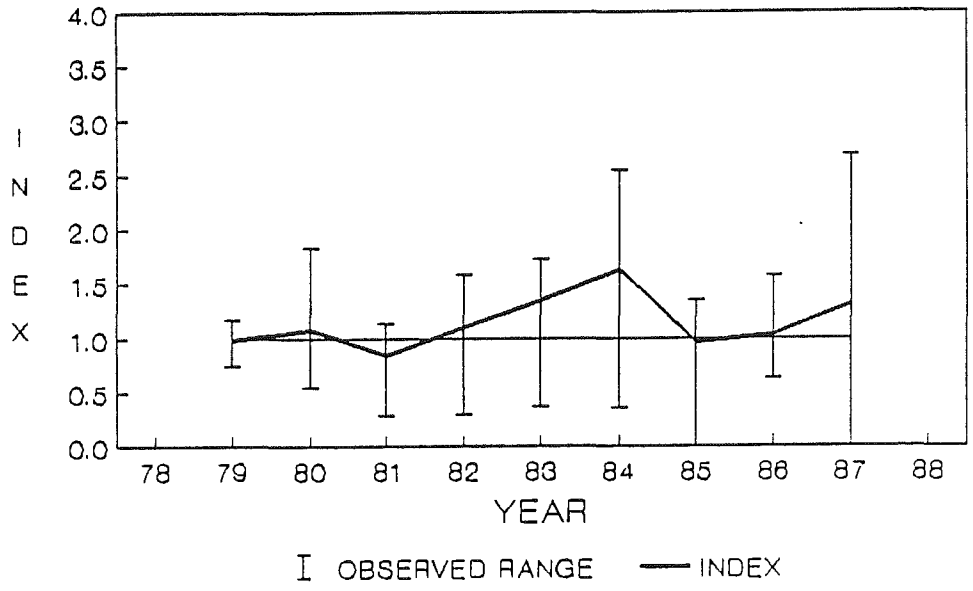


Fig. 12

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BON Age 3	BON Age 4	CWF Age 3	CWF Age 4	RBT Age 3	RBT Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	URB Age 4	WSH Age 4	Fishery
79	1.1552	NA	NA	NA	1.0195	1.0916	0.9695	0.7430	NA	NA	1.1740	0.9775	0.9780
80	0.5413	0.7079	1.8078	NA	1.4870	1.6359	1.1882	1.2910	NA	NA	1.2186	1.8346	1.0731
81	0.9011	0.7017	0.8876	0.8376	0.6862	0.4888	0.9008	0.8244	1.0158	NA	1.1382	0.2827	0.8445
82	1.4024	1.5904	0.3046	1.1624	0.8073	0.7837	0.9416	1.1416	0.9842	1.0000	0.4692	0.9052	1.1002
83	1.7347	1.4944	0.6588	1.3648	0.4139	0.7827	1.4814	1.3045	1.3684	1.7870	0.3734	0.1779	1.3661
84	1.4284	2.5434	0.3577	1.3248	1.6246	1.2217	1.3569	1.6421	1.7902	2.0311	1.1473	0.7922	1.6384
85	1.3524	1.2401	0.5116	0.8816	1.0601	0.0000	0.6592	1.2585	0.8922	0.8123	0.9252	0.6291	0.9645
86	1.5739	0.8967	0.7888	1.2556	4.6619	NA	1.0955	0.8656	0.9327	0.7831	1.1238	0.7157	1.0981
87	1.0170	2.6900	0.1638	0.8280	0.0000	NA	0.5063	NA	1.4082	2.0670	0.9899	0.3721	1.3158

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
RBT = ROBERTSON CREEK
SPR = SPRING CREEK
STP = STAYTON POND TULE
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

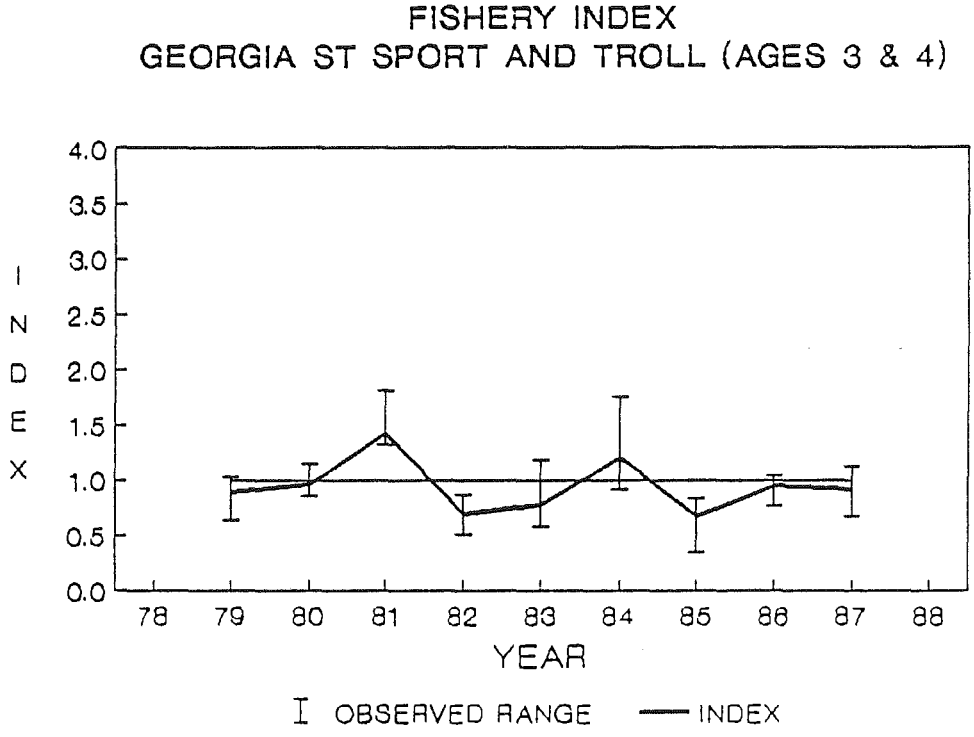


Fig. 13

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4	Fishery
79	0.8985	0.6383	0.9254	1.0313	0.8993
80	1.1497	1.0480	0.8630	0.9383	0.9739
81	1.3582	1.8058	1.3385	1.3184	1.4258
82	0.5935	0.5078	0.8731	0.7121	0.7011
83	1.1851	0.7619	0.7654	0.5826	0.7803
84	1.5441	1.7533	0.9237	0.9678	1.2081
85	0.7218	0.3499	0.6730	0.8395	0.6729
86	1.0376	0.7726	0.9522	1.0101	0.9514
87	0.6827	0.9794	1.1315	0.8061	0.9177

Stock Identifiers

BQR = BIG QUALICUM
CAP = CAPILANO

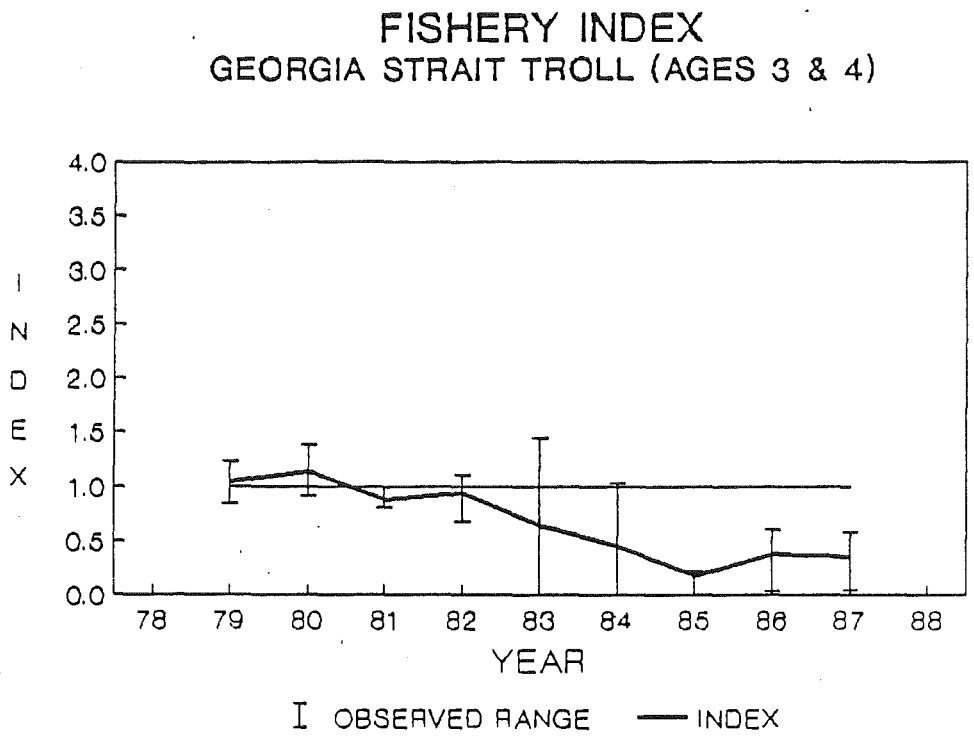


Fig. 14

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4	Fishery
79	1.2285	0.8600	1.1795	0.8444	1.0447
80	1.2026	1.0651	0.9068	1.3904	1.1408
81	0.8911	0.9905	0.8127	0.8822	0.8737
82	0.6778	1.0844	1.1010	0.8830	0.9408
83	1.4447	0.6253	0.7148	0.0000	0.6360
84	1.0259	0.0000	0.4296	0.2516	0.4464
85	0.1547	0.0000	0.2348	0.2022	0.1776
86	0.5961	0.0436	0.3831	0.3573	0.3772
87	0.3475	0.0516	0.5800	0.2537	0.3614

Stock Identifiers

BQR = BIG QUALICUM
CAP = CAPILANO

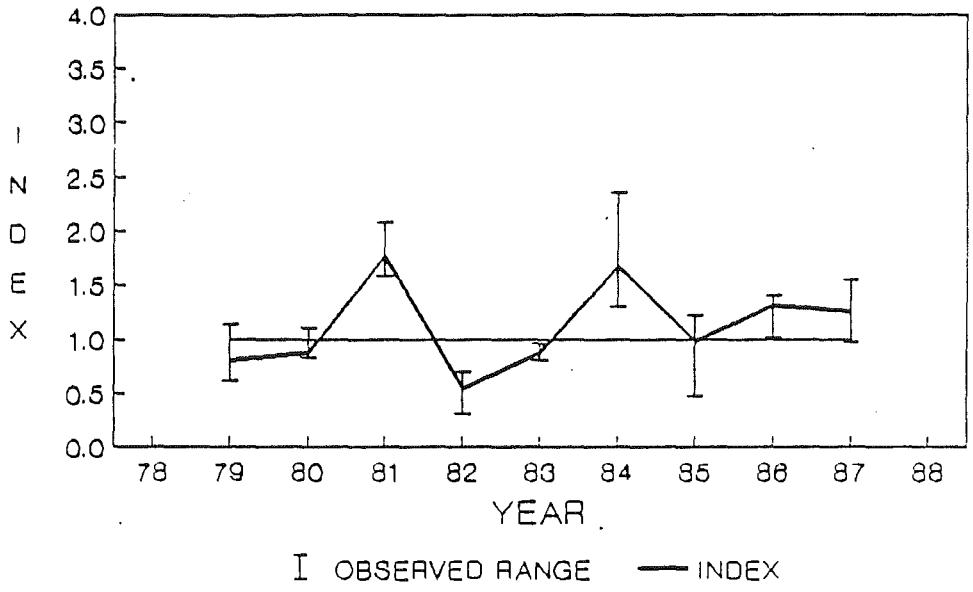


Fig. 15

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4	Fishery
79	0.6176	0.5633	0.7309	1.1414	0.8090
80	1.1048	1.0422	0.8295	0.6719	0.8702
81	1.7559	2.0818	1.7409	1.5754	1.7686
82	0.5216	0.3127	0.6987	0.6113	0.5522
83	0.9641	0.8081	0.8041	0.9259	0.8699
84	1.9853	2.3468	1.3018	1.3898	1.6812
85	1.2047	0.4684	1.0083	1.2150	0.9805
86	1.4135	1.0194	1.3878	1.3948	1.3080
87	0.9682	1.2935	1.5536	1.1316	1.2631

Stock Identifiers

BQR = BIG QUALICUM
CAP = CAPILANO

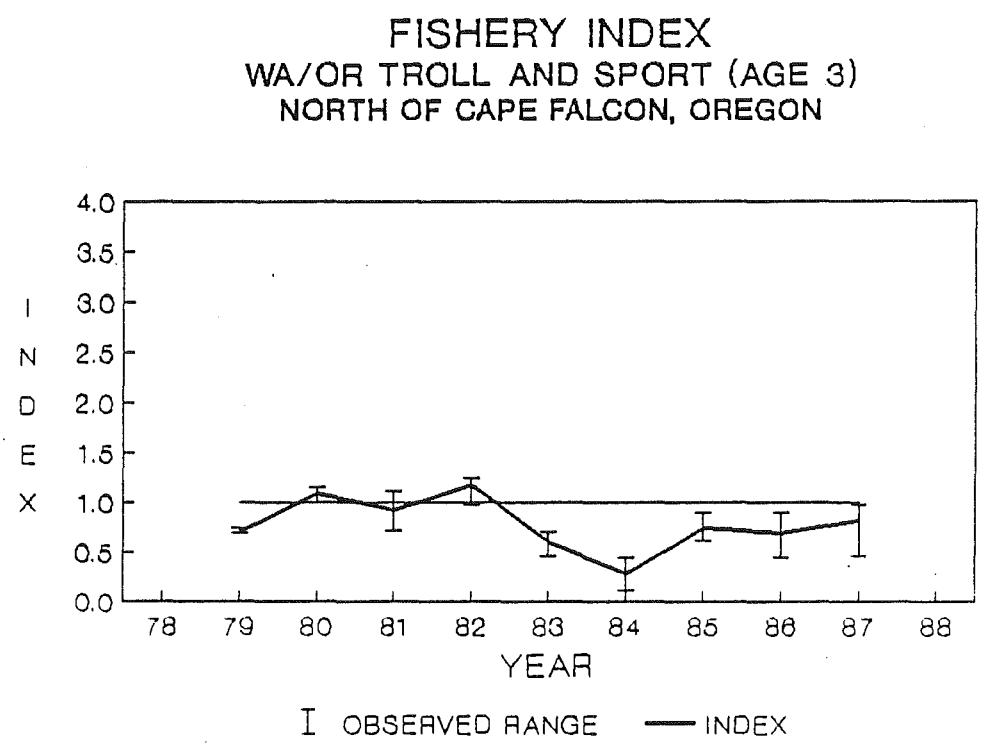


Fig. 16

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	CWF Age 3	SPR Age 3	STP Age 3	BON Age 3	Fishery
79	NA	0.6889	NA	0.7432	0.7110
80	1.0017	1.0855	NA	1.1556	1.0893
81	0.7624	1.0265	0.7188	1.1233	0.9186
82	1.2358	1.1990	1.2812	0.9778	1.1784
83	0.5934	0.4581	0.7044	0.7073	0.6064
84	0.1191	0.3001	0.2139	0.4529	0.2814
85	0.6162	0.6407	0.7864	0.9005	0.7374
86	0.9217	0.4486	0.9016	0.6096	0.6894
87	0.4602	0.9739	0.8935	0.7575	0.8211

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
SPR = SPRING CREEK
STP = STAYTON POND TULE

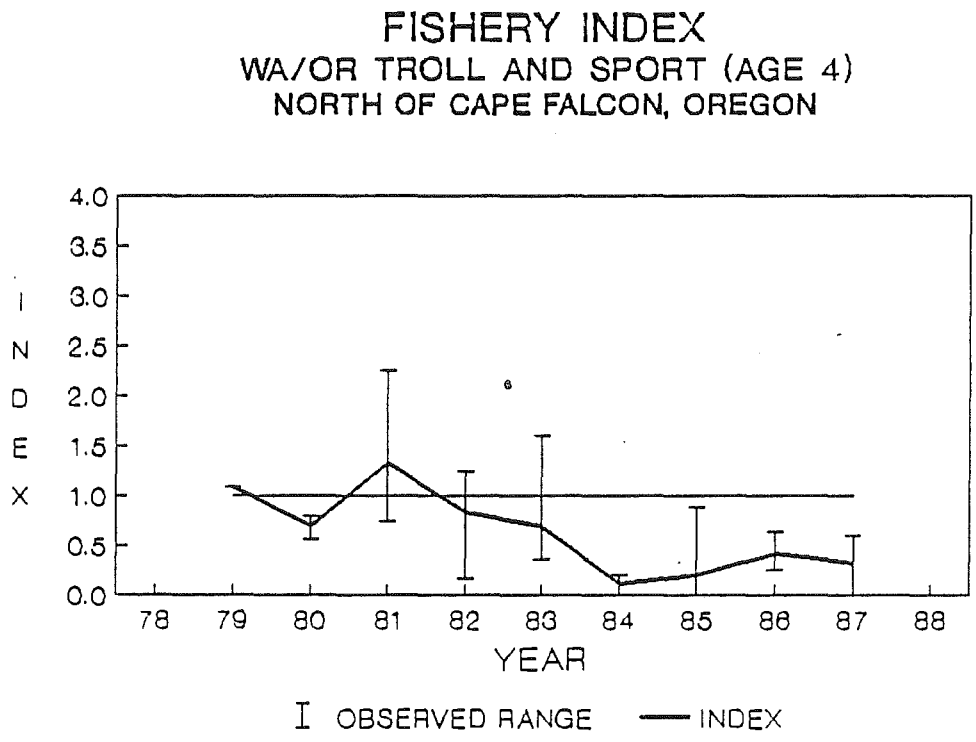


Fig. 17

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	CWF Age 4	SPR Age 4	STP Age 4	BON Age 4	Fishery
79	NA	1.0896	NA	NA	1.0896
80	NA	0.8005	NA	0.5698	0.6920
81	0.7537	1.3212	NA	2.2595	1.3299
82	1.2463	0.7887	1.0000	0.1707	0.8367
83	0.8319	0.3591	1.6101	0.4583	0.6889
84	0.1980	0.0000	0.1434	0.1388	0.1242
85	0.1911	0.1575	0.8925	0.0000	0.2046
86	0.2554	0.4302	0.4422	0.6416	0.4150
87	0.6007	NA	0.0000	0.0000	0.3194

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
SPR = SPRING CREEK
STP = STAYTON POND TULE

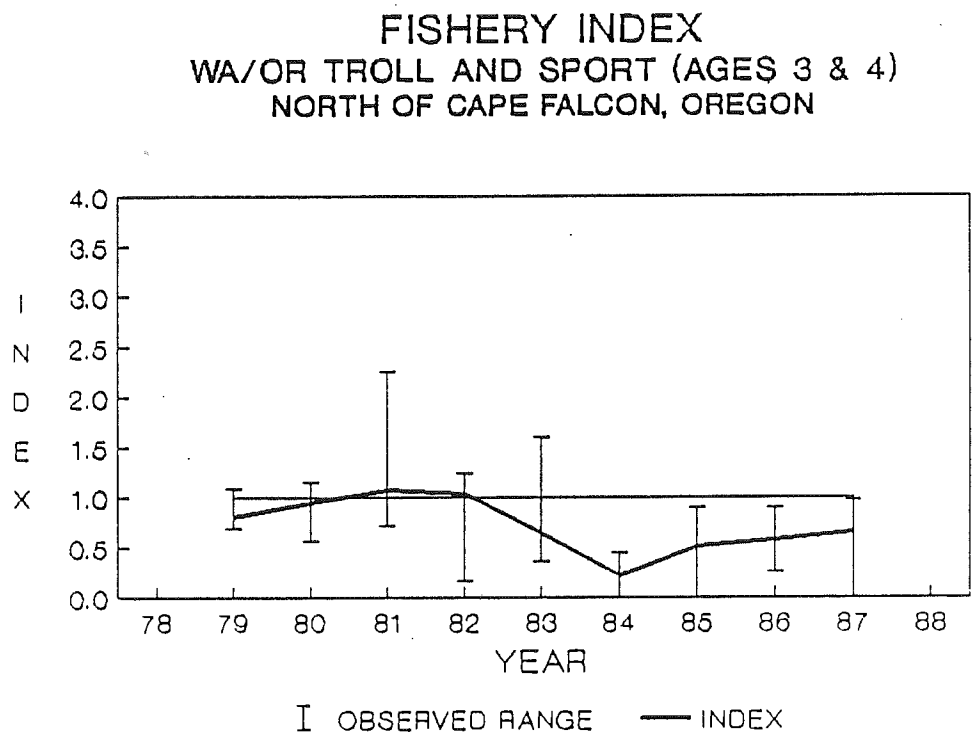


Fig. 18

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	CWF Age 3	CWF Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	BON Age 3	BON Age 4	Fishery
79	NA	NA	0.6889	1.0896	NA	NA	0.7432	NA	0.8089
80	1.0017	NA	1.0855	0.8005	NA	NA	1.1556	0.5698	0.9546
81	0.7624	0.7537	1.0265	1.3212	0.7188	NA	1.1233	2.2595	1.0792
82	1.2358	1.2463	1.1990	0.7887	1.2812	1.0000	0.9778	0.1707	1.0365
83	0.5934	0.8319	0.4581	0.3591	0.7044	1.6101	0.7073	0.4583	0.6407
84	0.1191	0.1980	0.3001	0.0000	0.2139	0.1434	0.4529	0.1388	0.2162
85	0.6162	0.1911	0.6407	0.1575	0.7864	0.8925	0.9005	0.0000	0.5162
86	0.9217	0.2554	0.4486	0.4302	0.9016	0.4422	0.6096	0.6416	0.5755
87	0.4602	0.6007	0.9739	NA	0.8935	0.0000	0.7575	0.0000	0.6502

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
SPR = SPRING CREEK
STP = STAYTON POND TULE

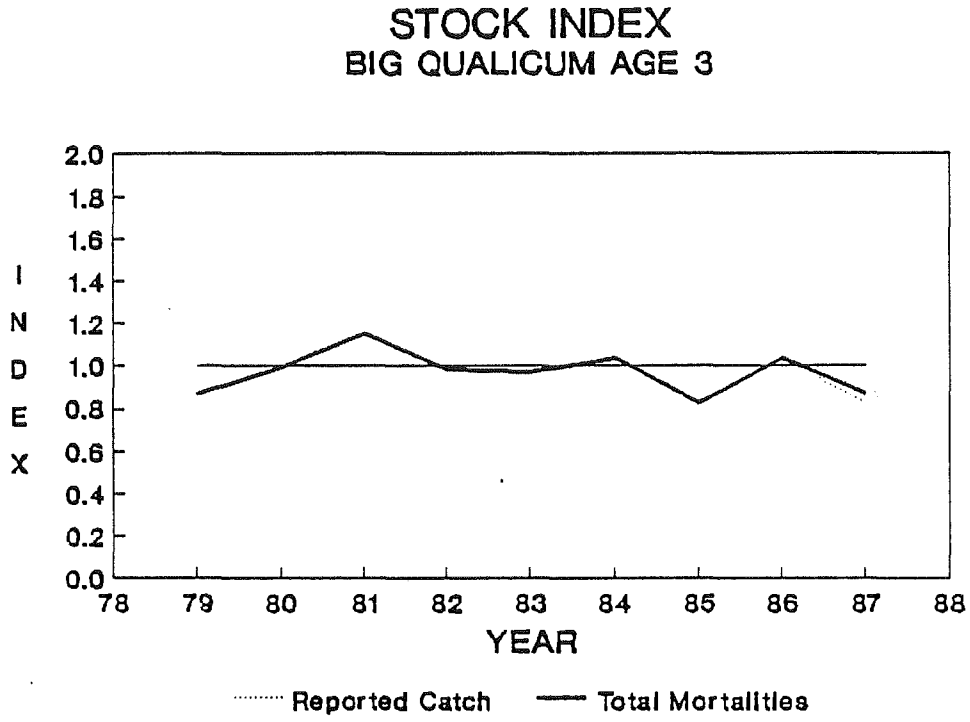


Fig. 19a

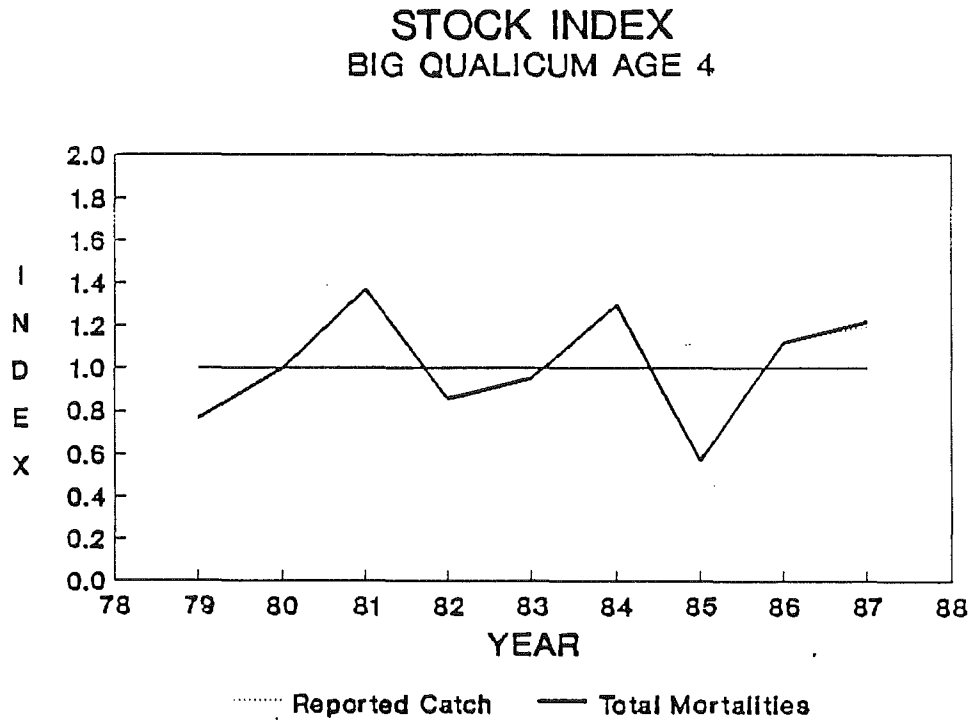


Fig. 19b

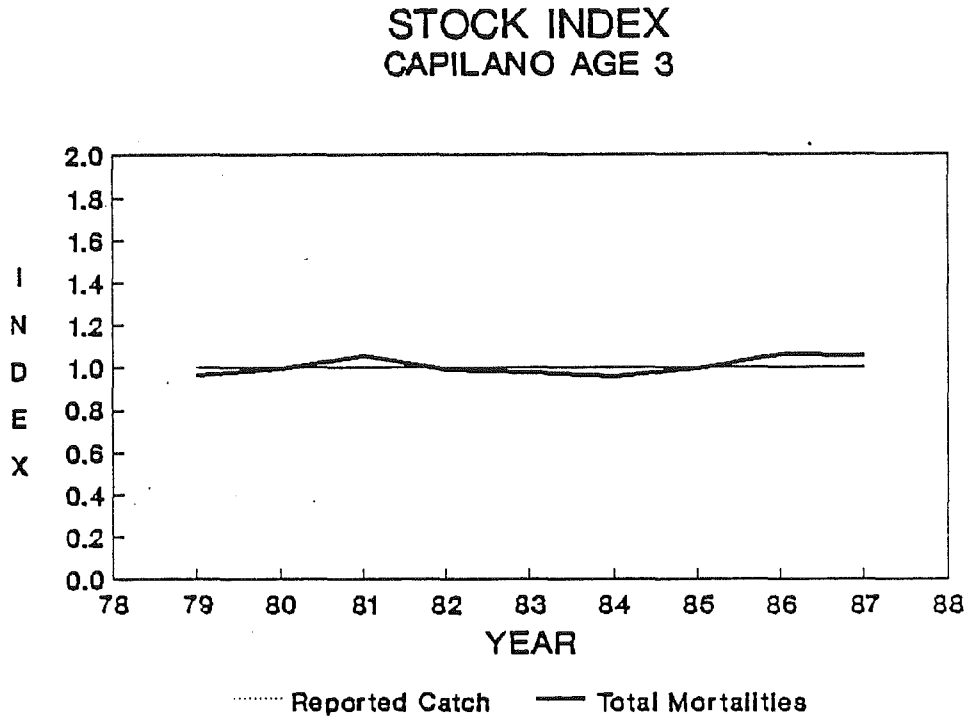


Fig. 20a

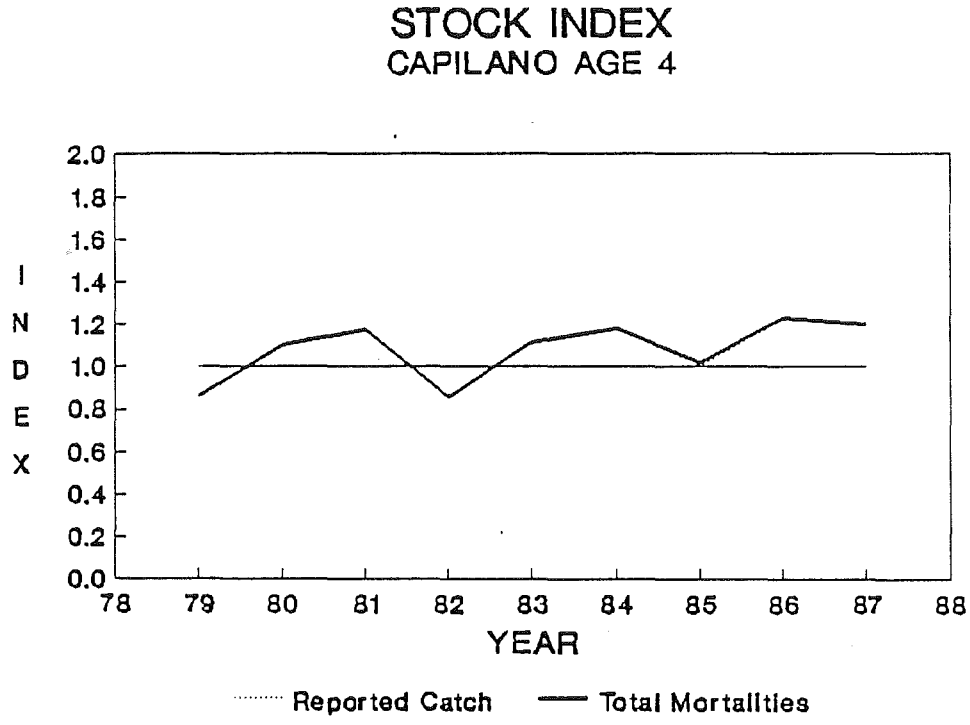


Fig. 20b

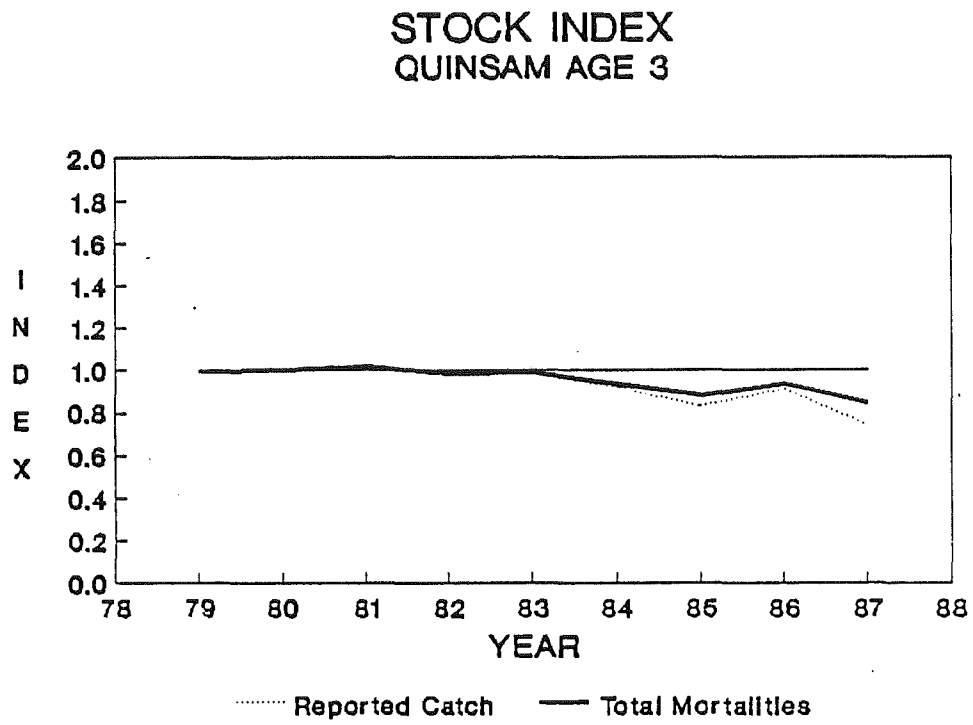


Fig. 21a

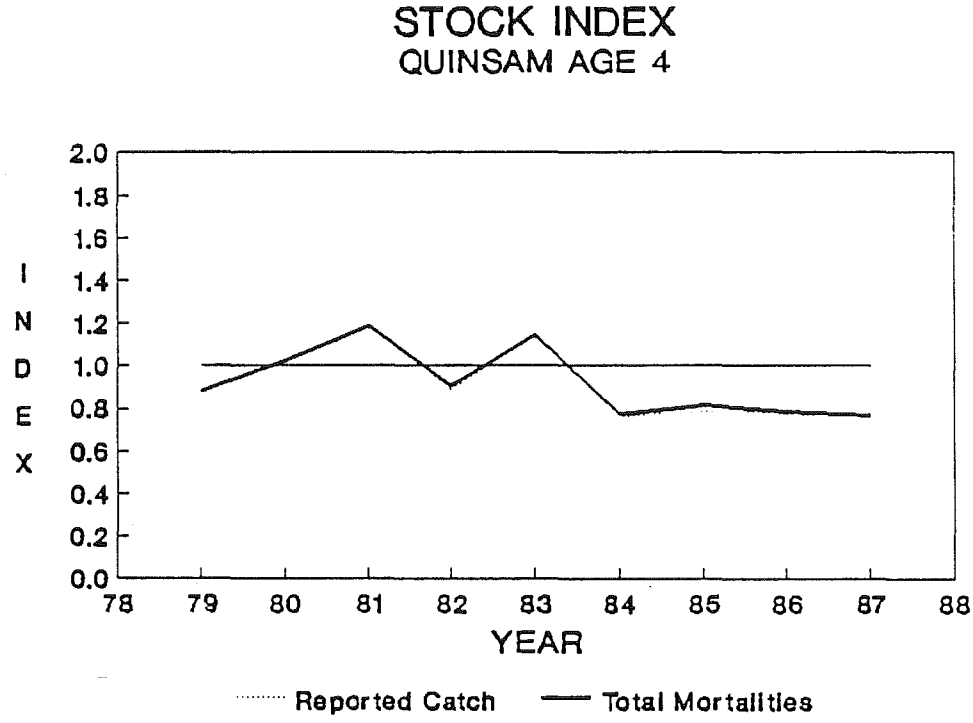


Fig. 21b

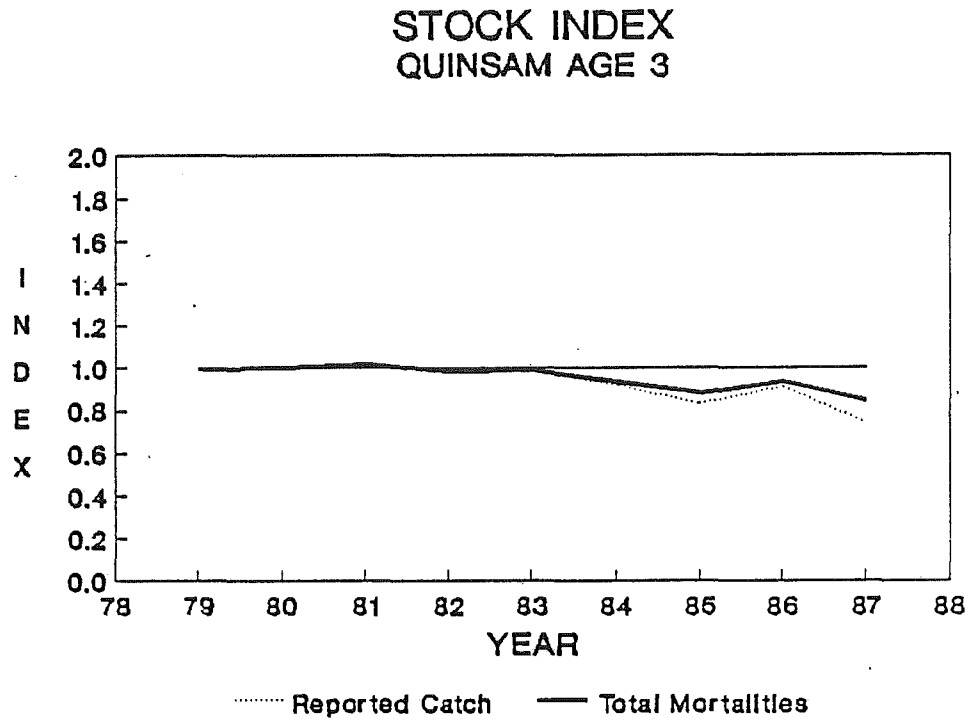


Fig. 21a

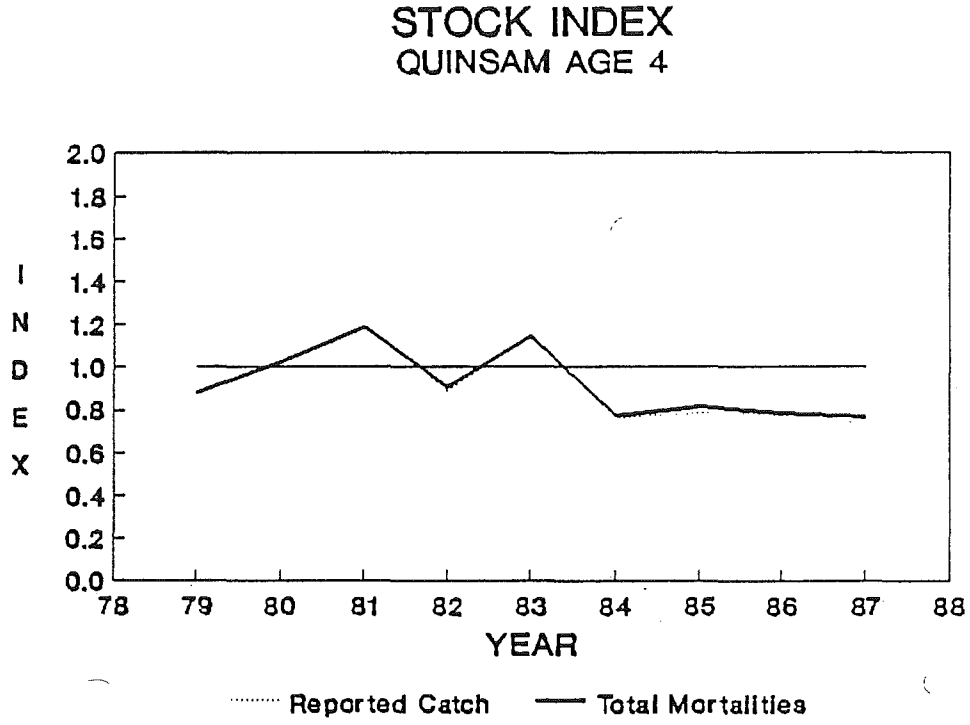


Fig. 21b

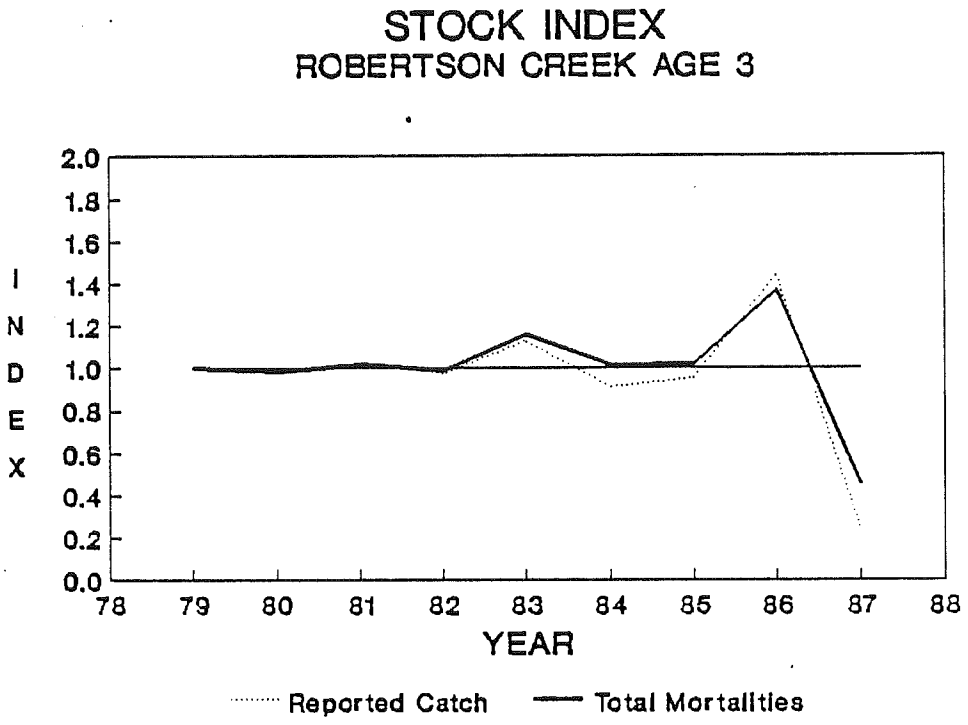


Fig. 22a

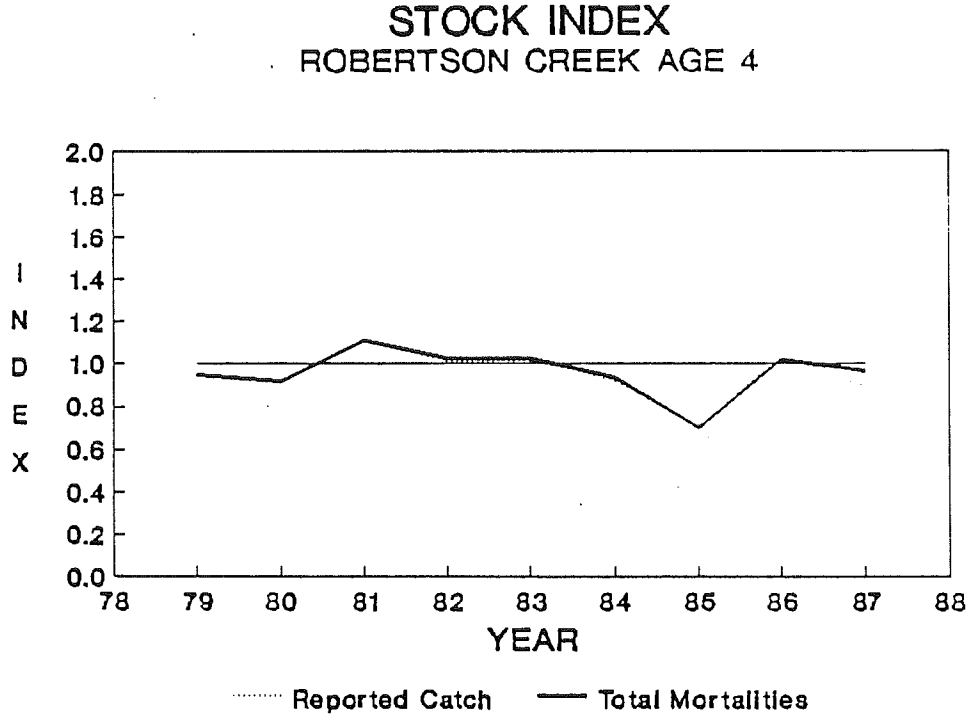


Fig. 22b

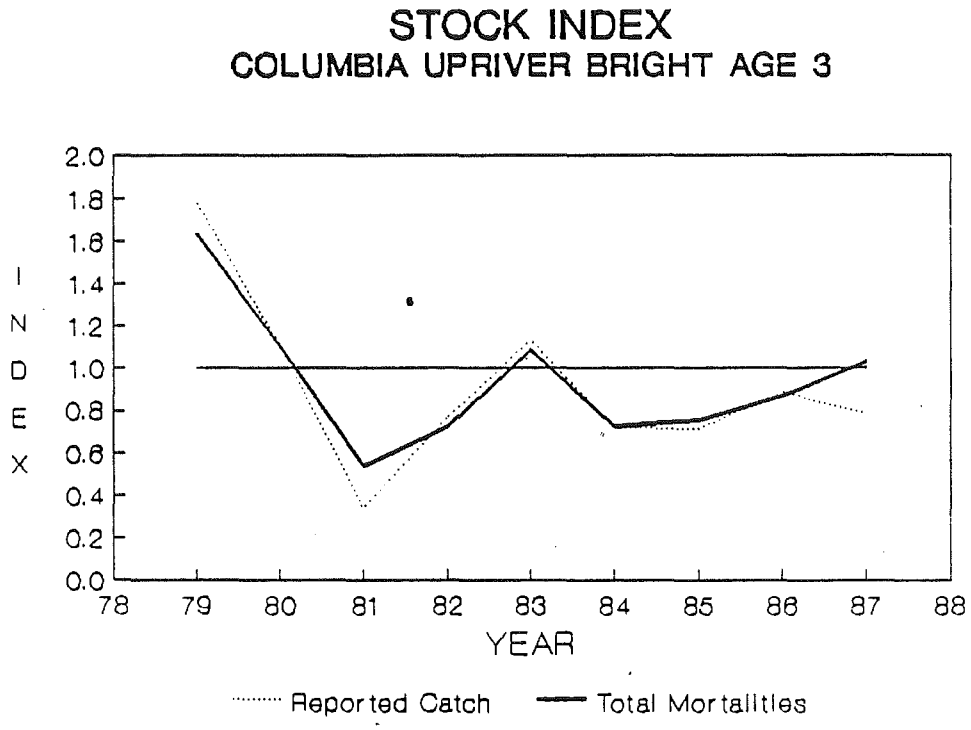


Fig. 23a

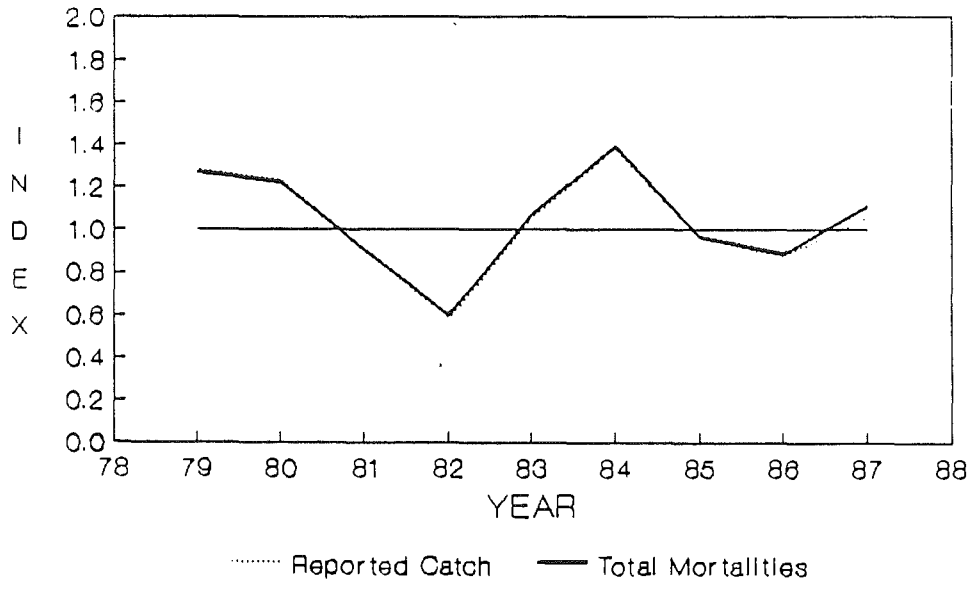


Fig. 23b

STOCK INDEX
WILLAMETTE SPRING AGE 4

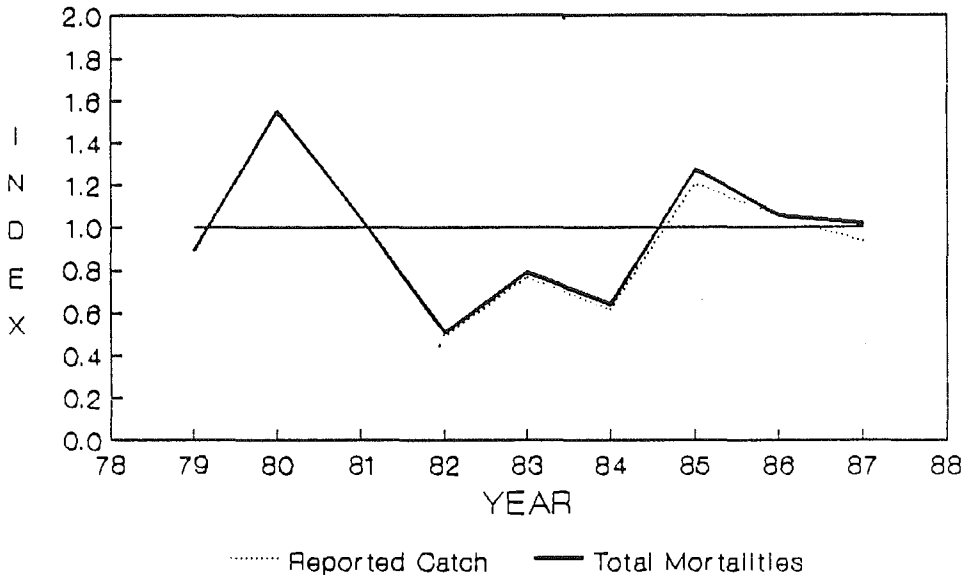


Fig. 24a

STOCK INDEX
WILLAMETTE SPRING AGE 5

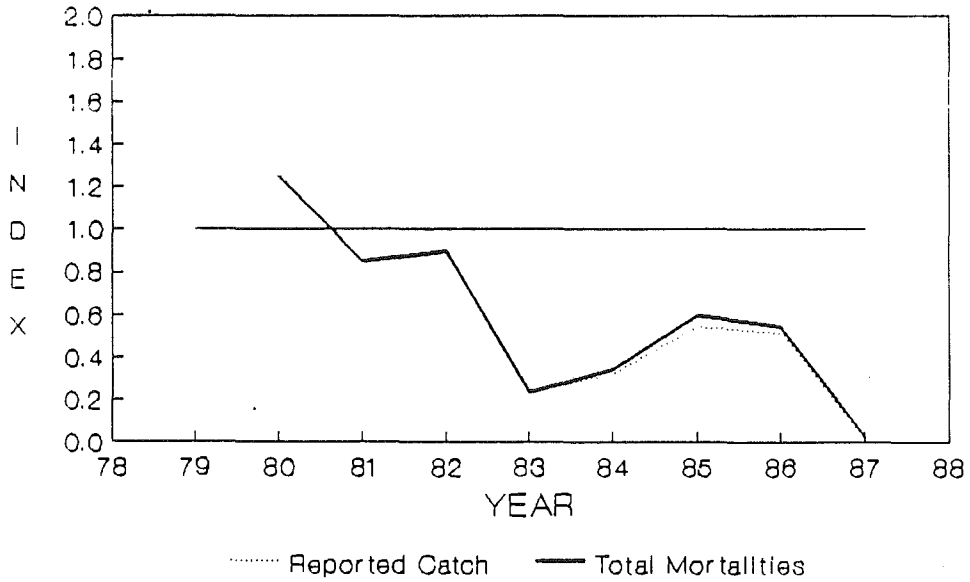


Fig. 24b

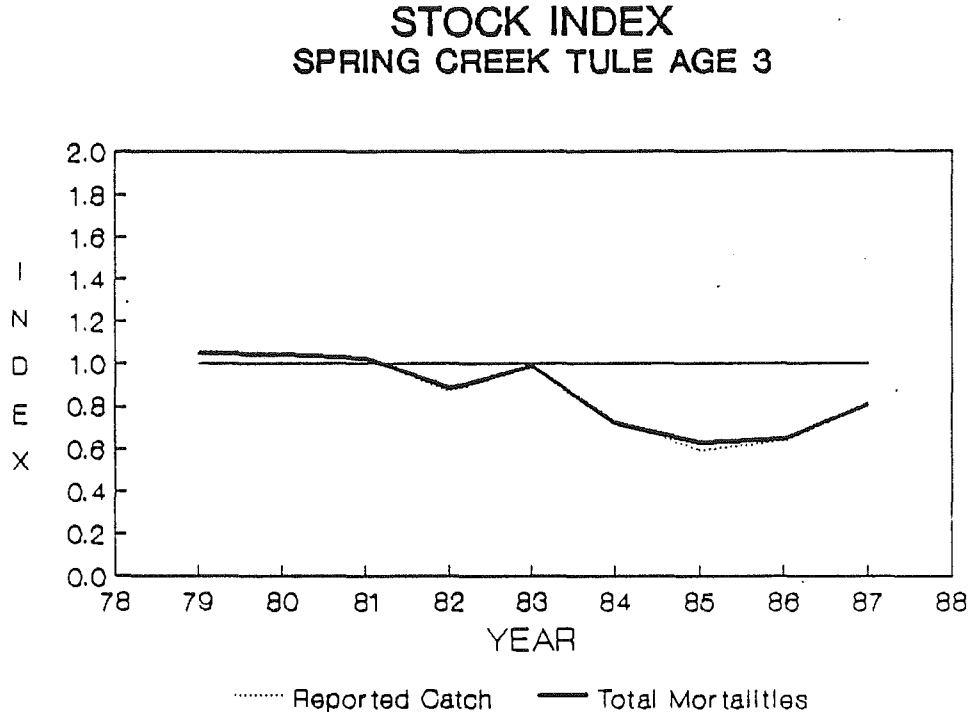


Fig. 25a

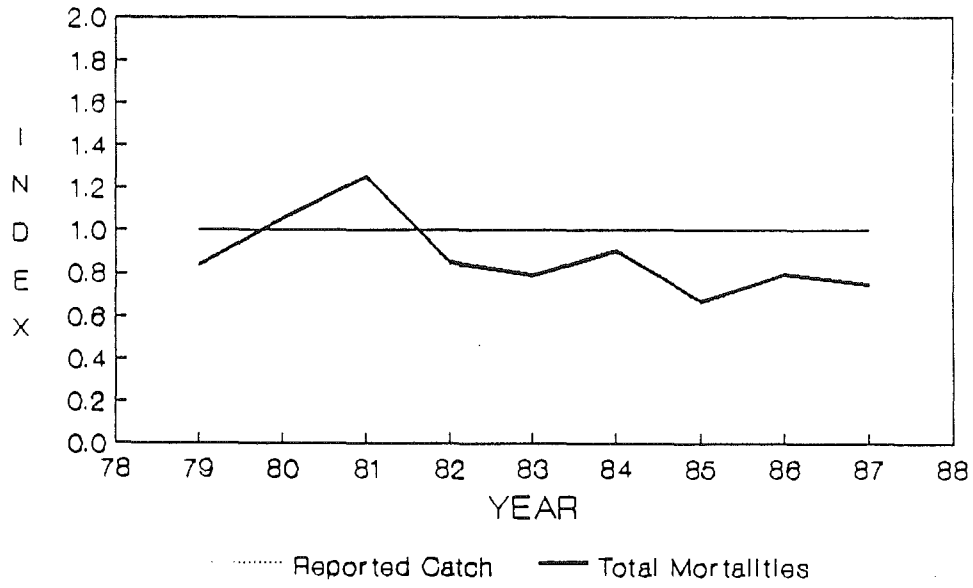


Fig. 25b

STOCK INDEX
COWLITZ TULE AGE 3

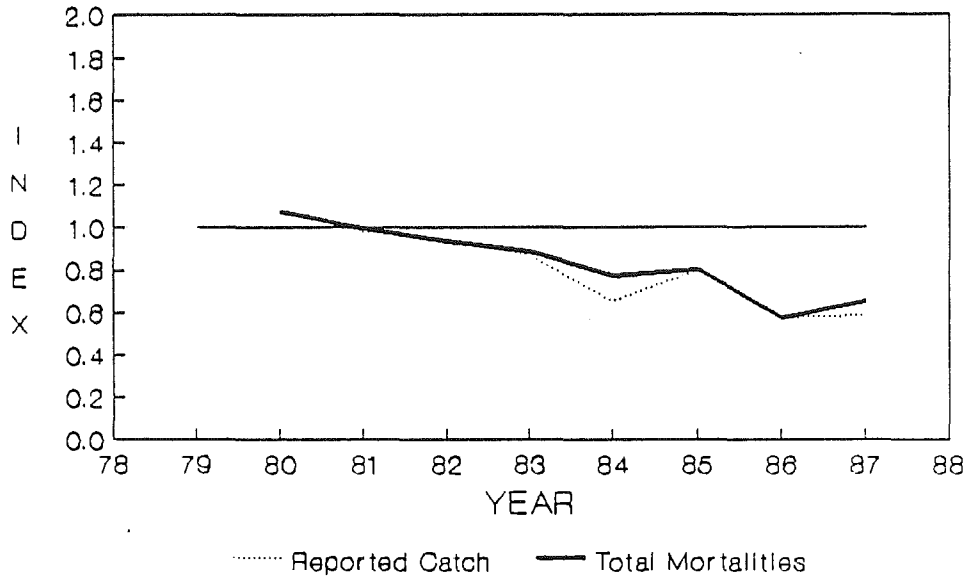


Fig. 26a

STOCK INDEX
COWLITZ TULE AGE 4

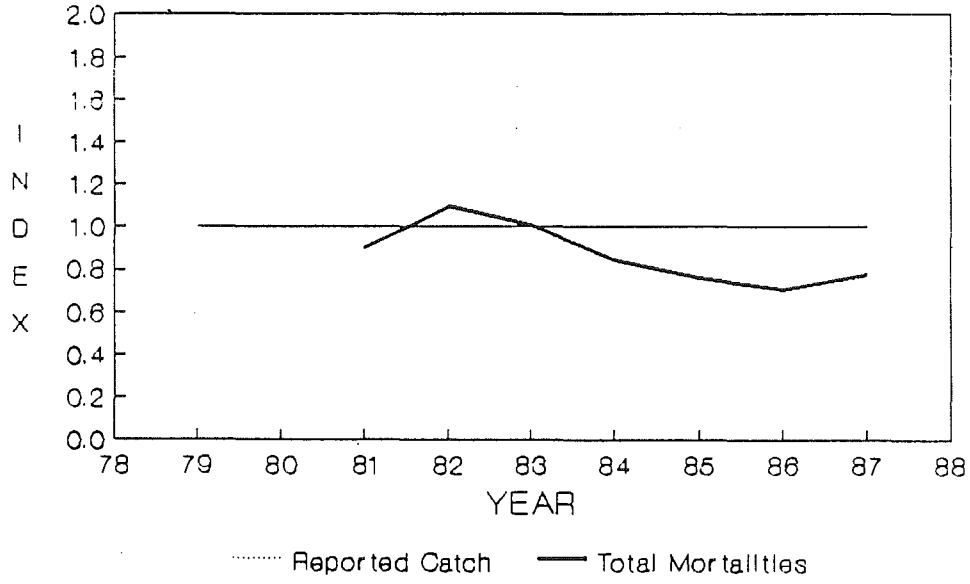


Fig. 26b

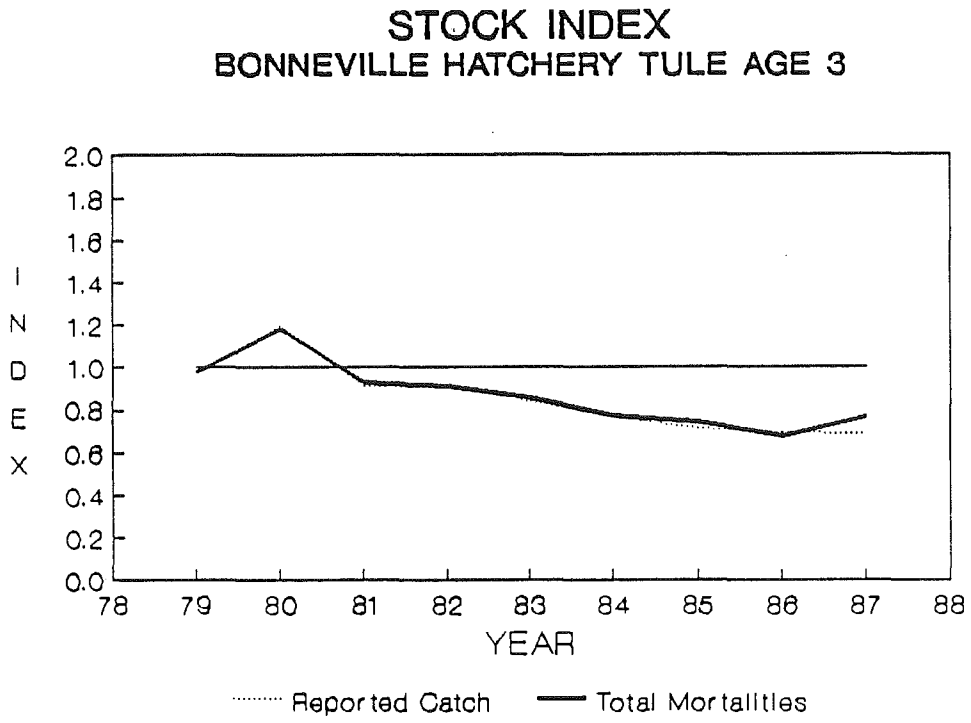


Fig. 27a

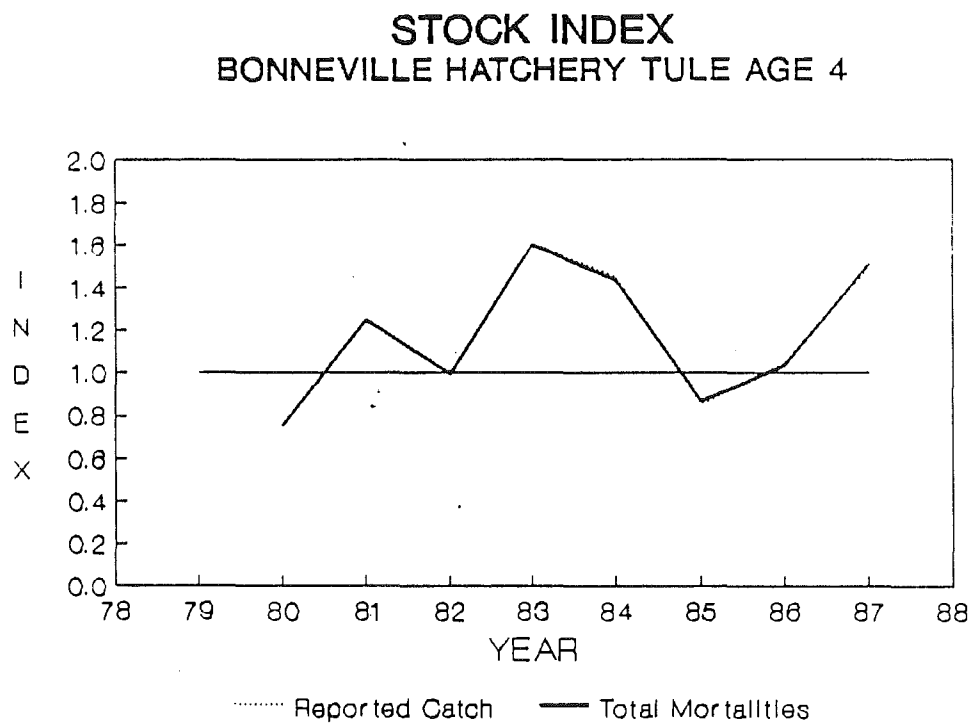


Fig. 27b

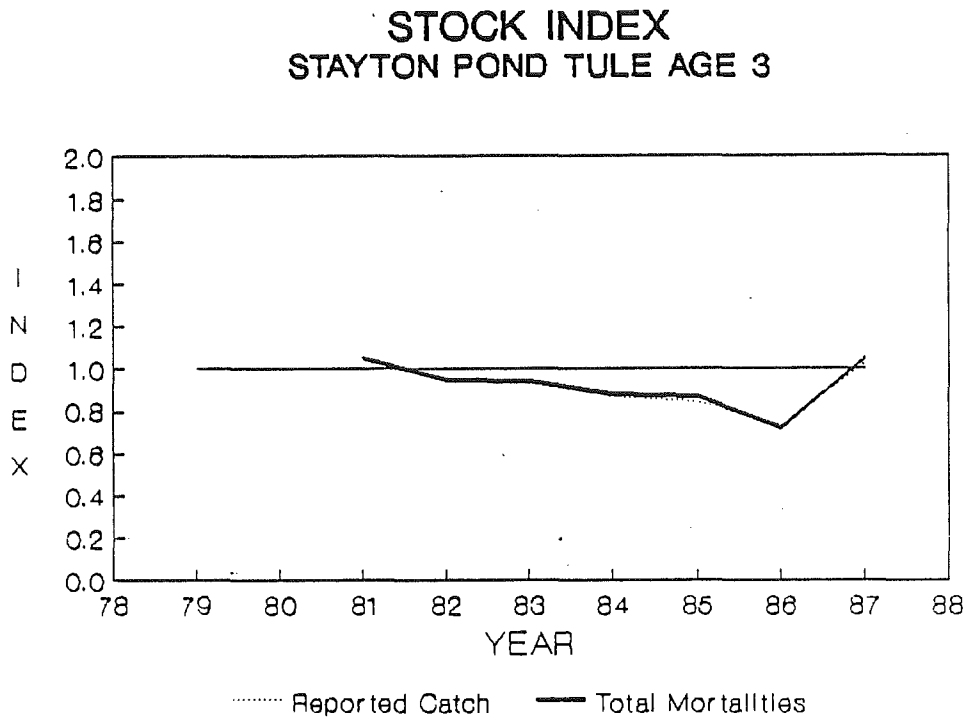


Fig. 28a

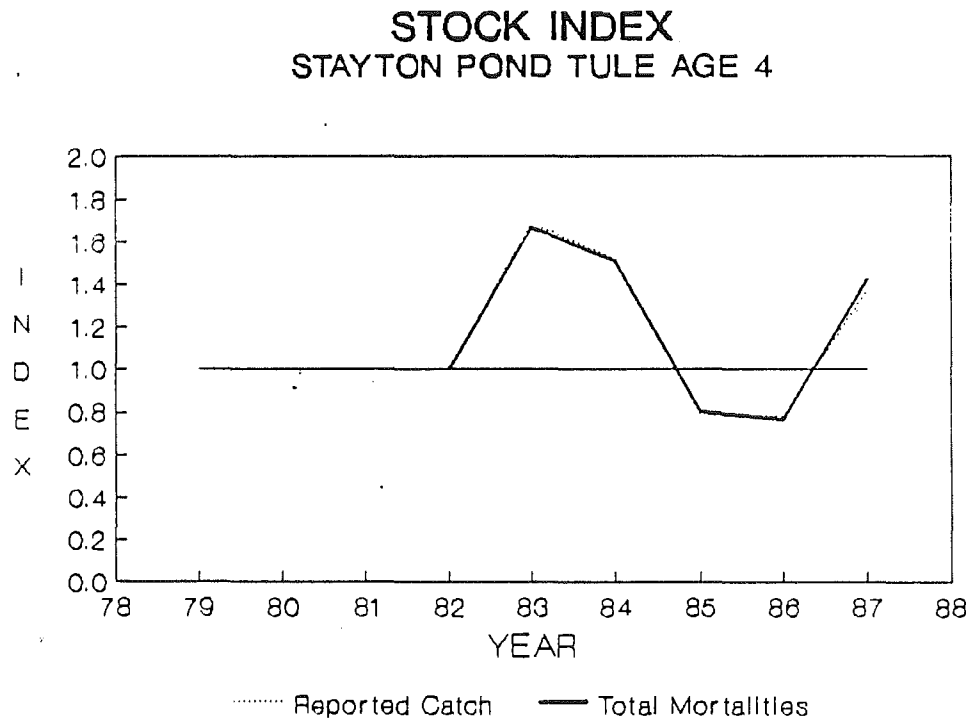


Fig. 28b

BROOD YEAR EXPLOITATION RATE
BIG QUALICUM

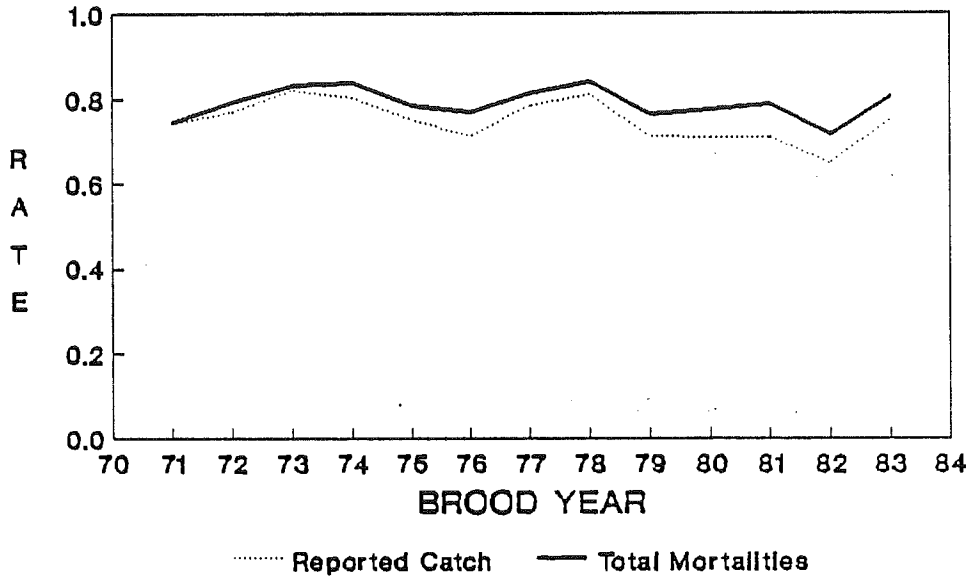
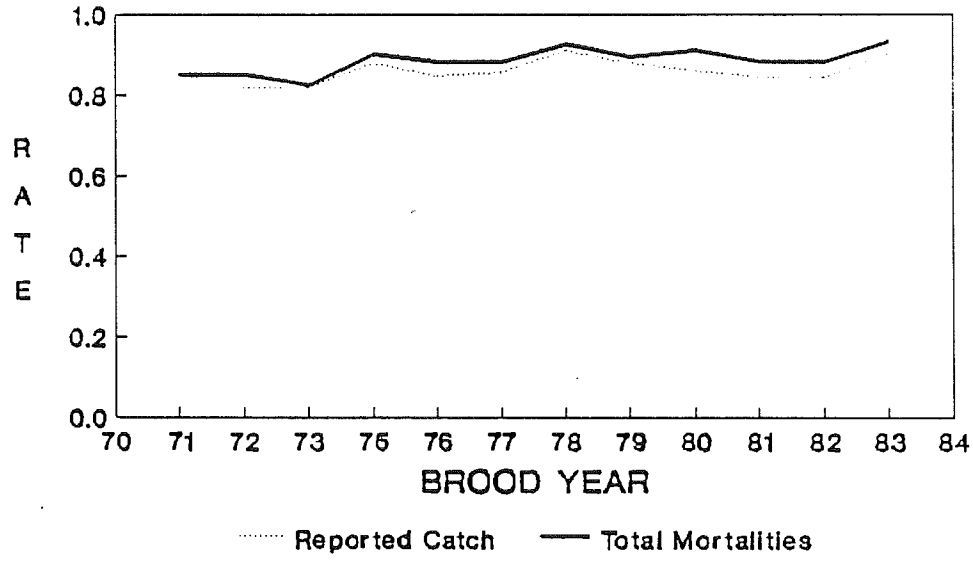


Fig. 29

BROOD YEAR EXPLOITATION RATE
CAPILANO



1974 brood year lost due to chlorine leak.

Fig. 30

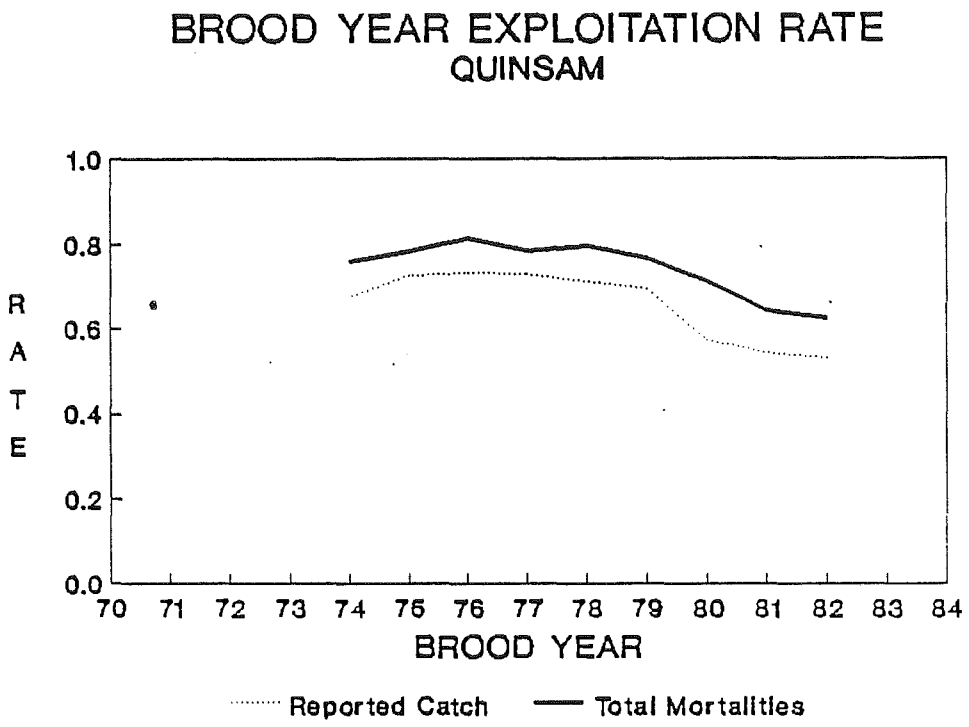

BROOD YEAR EXPLOITATION RATE
QUINSAM
1.0
0.8
0.6
0.4
0.2
0.0
R
A
T
E
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84
BROOD YEAR
Reported Catch
Total Mortalities

Fig. 31

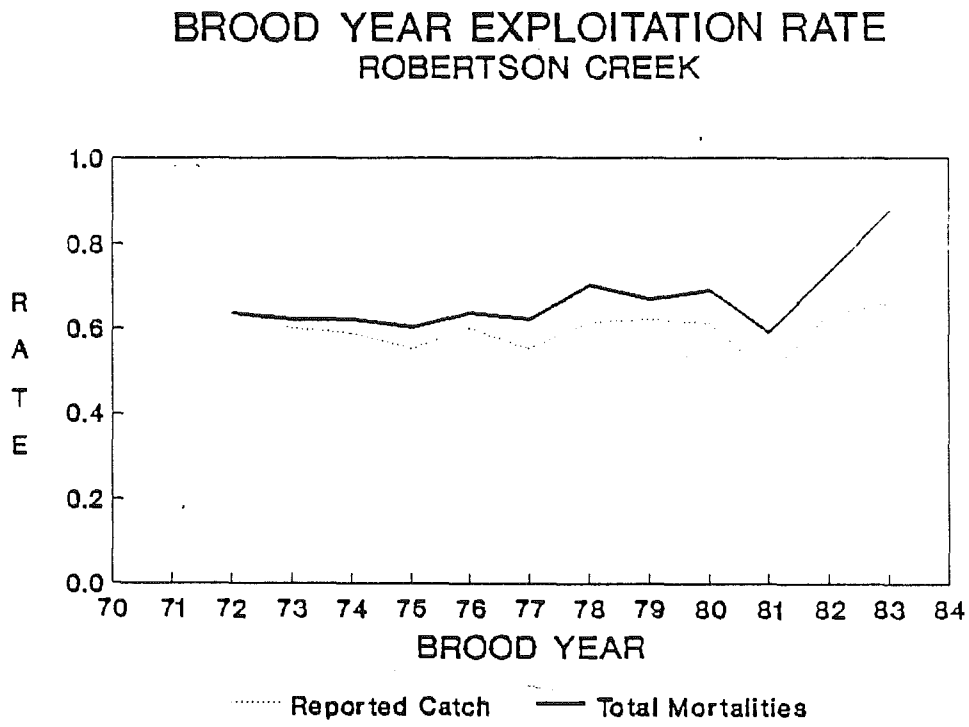

BROOD YEAR EXPLOITATION RATE
ROBERTSON CREEK
1.0
0.8
0.6
0.4
0.2
0.0
R
A
T
E
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84
BROOD YEAR
Reported Catch
Total Mortalities

Fig. 32

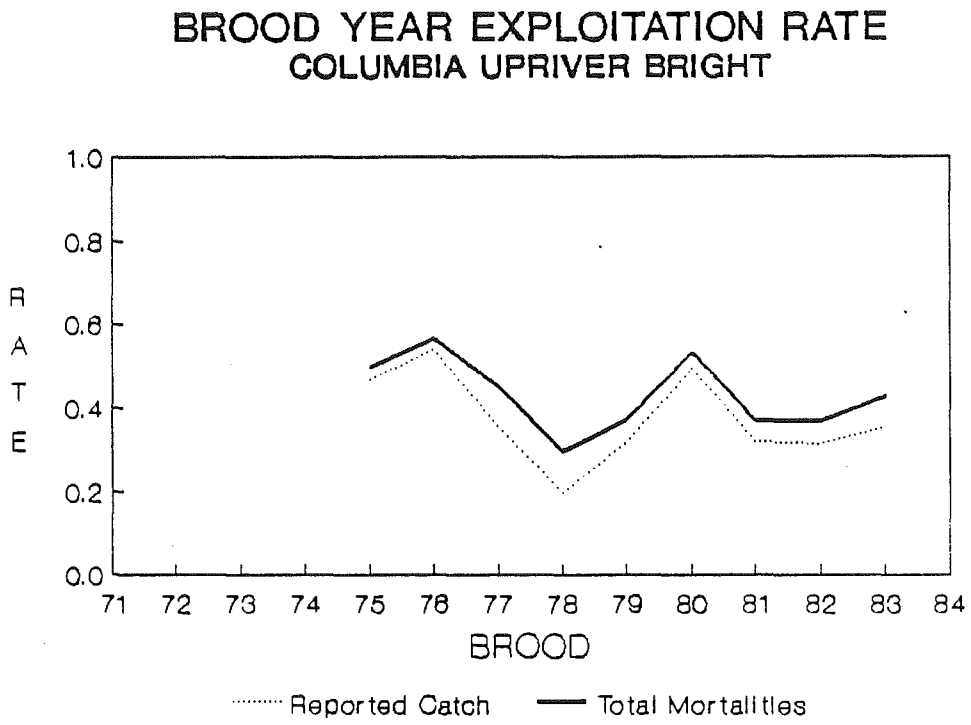

BROOD YEAR EXPLOITATION RATE
COLUMBIA UPRIVER BRIGHT
RATE
1.0
0.8
0.6
0.4
0.2
0.0
71 72 73 74 75 76 77 78 79 80 81 82 83 84
BROOD
Reported Catch
Total Mortalities

Fig. 33

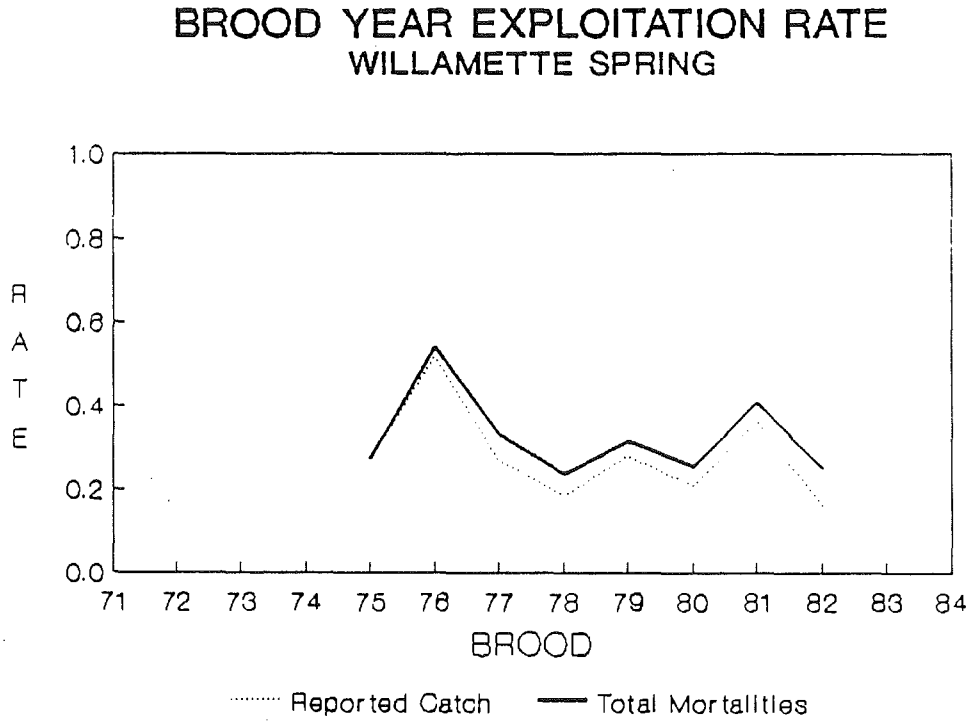

BROOD YEAR EXPLOITATION RATE
WILLAMETTE SPRING
RATE
1.0
0.8
0.6
0.4
0.2
0.0
71 72 73 74 75 76 77 78 79 80 81 82 83 84
BROOD
Reported Catch
Total Mortalities

Fig. 34

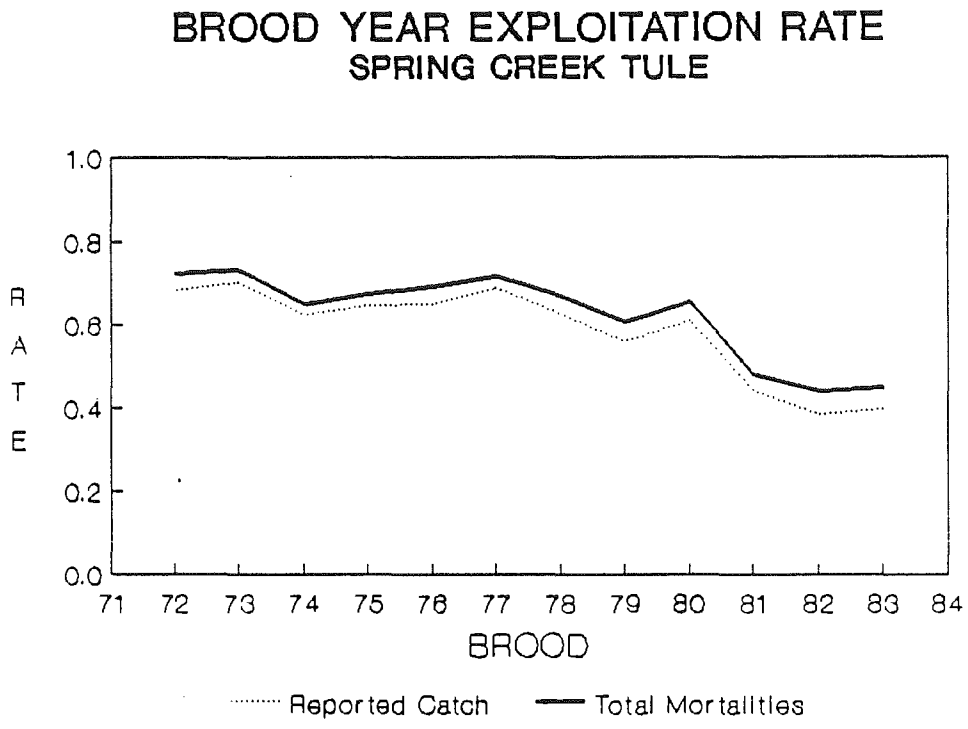

BROOD YEAR EXPLOITATION RATE
SPRING CREEK TULE
1.0
0.8
0.6
0.4
0.2
0.0
RATE
71 72 73 74 75 76 77 78 79 80 81 82 83 84
BROOD
Reported Catch
Total Mortalities

Fig. 35

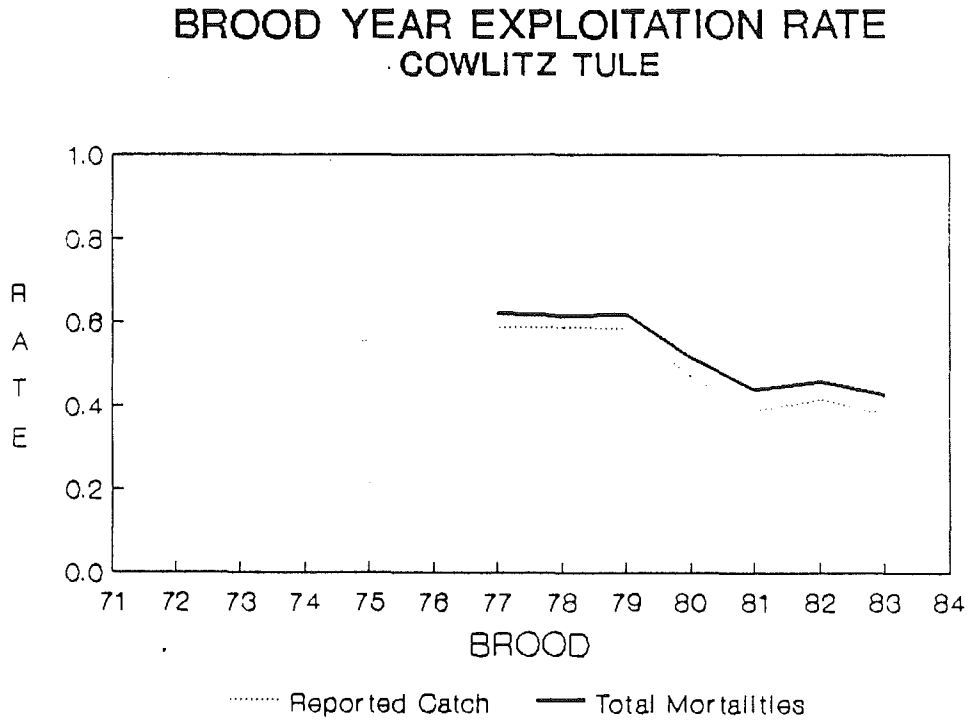

BROOD YEAR EXPLOITATION RATE
COWLITZ TULE
1.0
0.8
0.6
0.4
0.2
0.0
RATE
71 72 73 74 75 76 77 78 79 80 81 82 83 84
BROOD
Reported Catch
Total Mortalities

Fig. 36

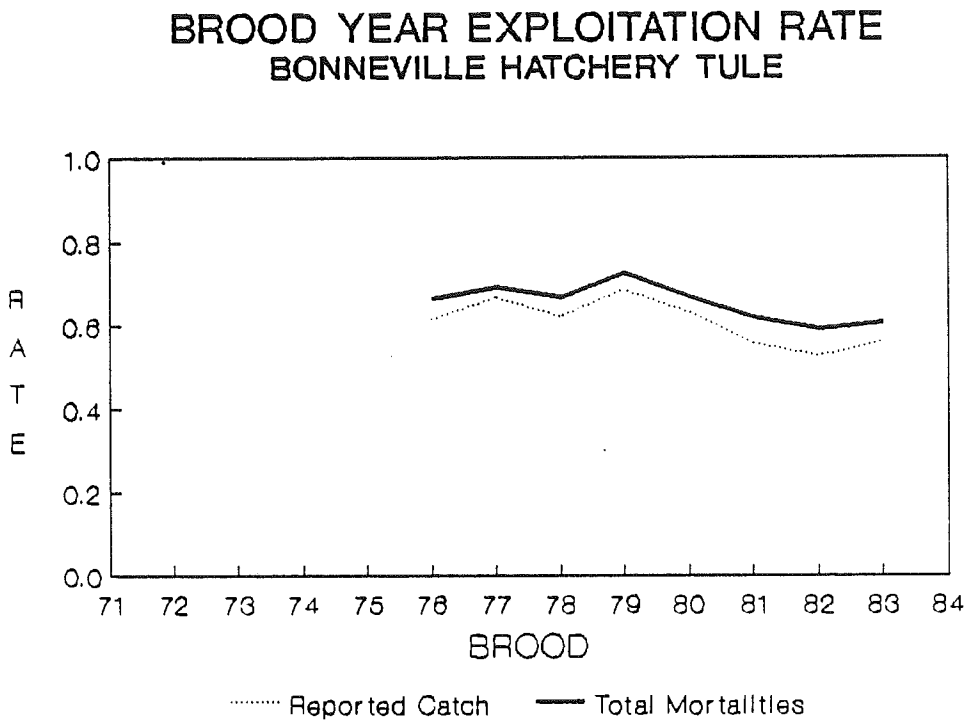

BROOD YEAR EXPLOITATION RATE
BONNEVILLE HATCHERY TULE
1.0
0.8
0.6
0.4
0.2
0.0
RATE
71 72 73 74 75 76 77 78 79 80 81 82 83 84
BROOD
Reported Catch
Total Mortalities

Fig. 37

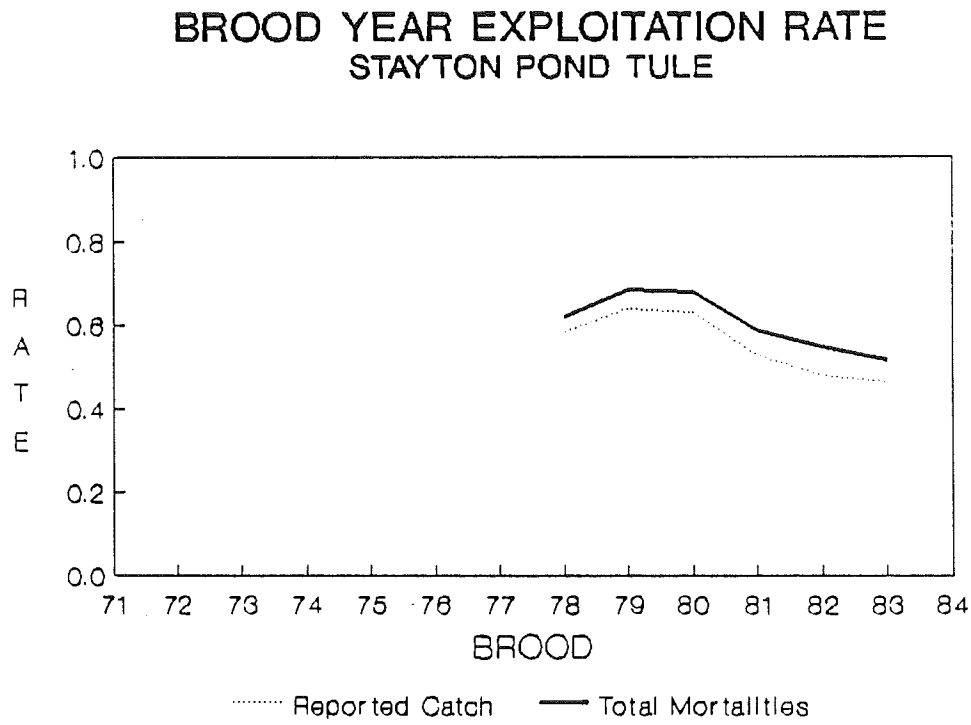

BROOD YEAR EXPLOITATION RATE
STAYTON POND TULE
1.0
0.8
0.6
0.4
0.2
0.0
RATE
71 72 73 74 75 76 77 78 79 80 81 82 83 84
BROOD
Reported Catch
Total Mortalities

Fig. 38

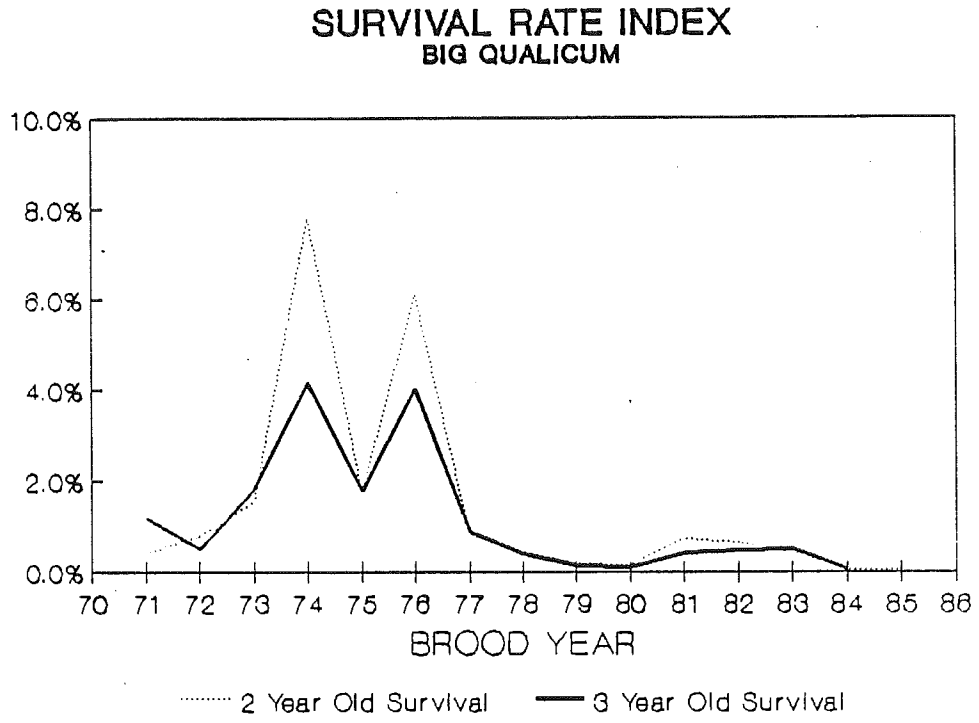

SURVIVAL RATE INDEX
BIG QUALICUM
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
BROOD YEAR
2 Year Old Survival
3 Year Old Survival

Fig. 39

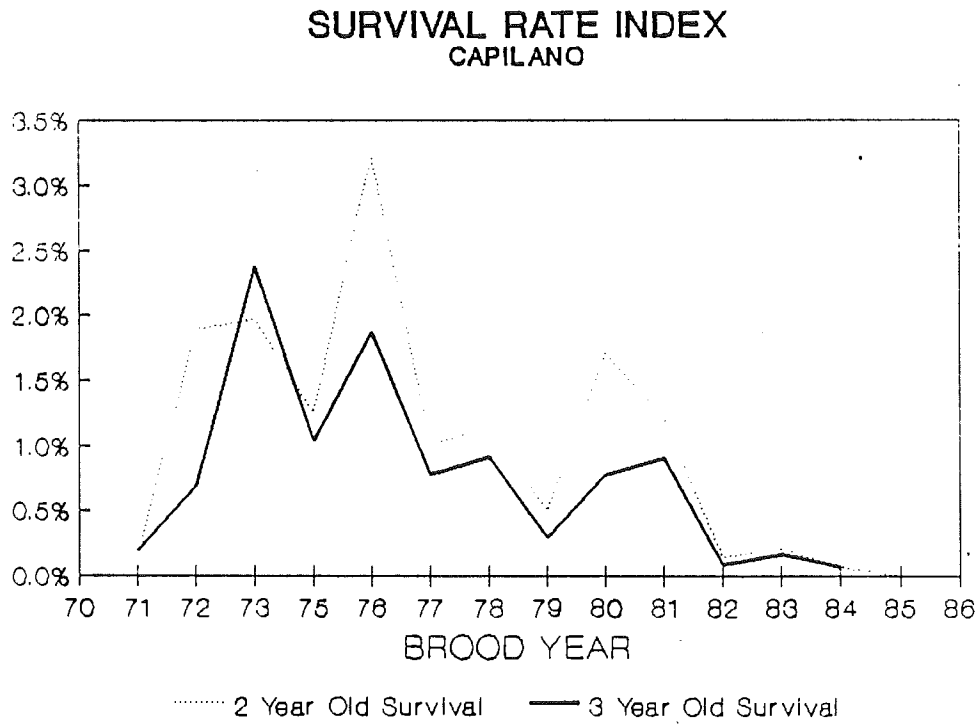

SURVIVAL RATE INDEX
CAPILANO
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
70 71 72 73 75 76 77 78 79 80 81 82 83 84 85 86
BROOD YEAR
2 Year Old Survival
3 Year Old Survival

Fig. 40

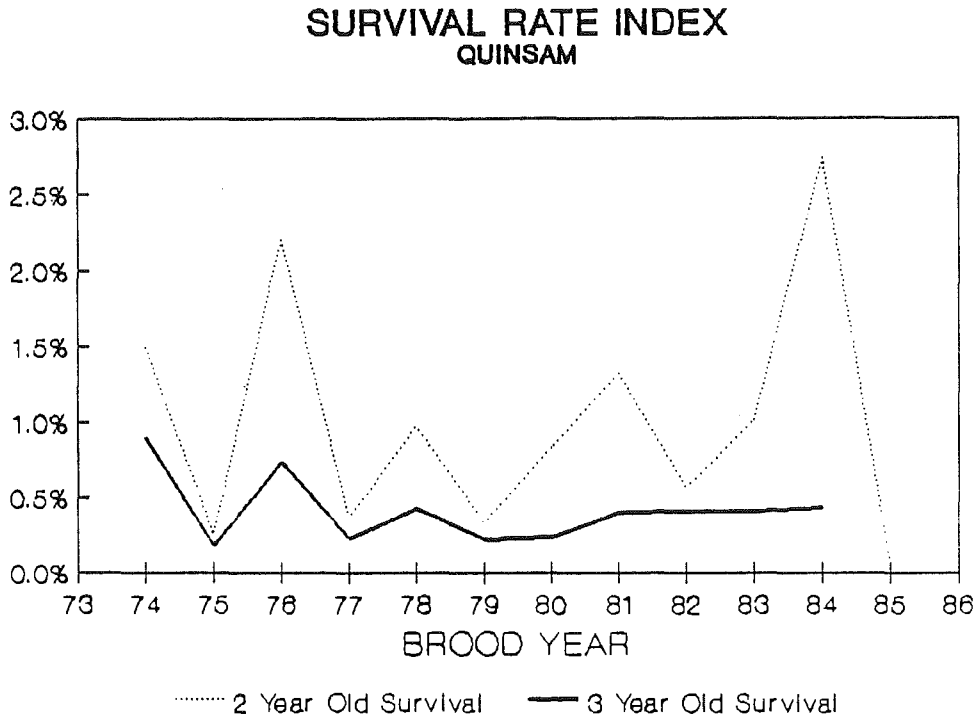

SURVIVAL RATE INDEX
QUINSAM
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
73 74 75 76 77 78 79 80 81 82 83 84 85 86
BROOD YEAR
2 Year Old Survival
3 Year Old Survival

Fig. 41

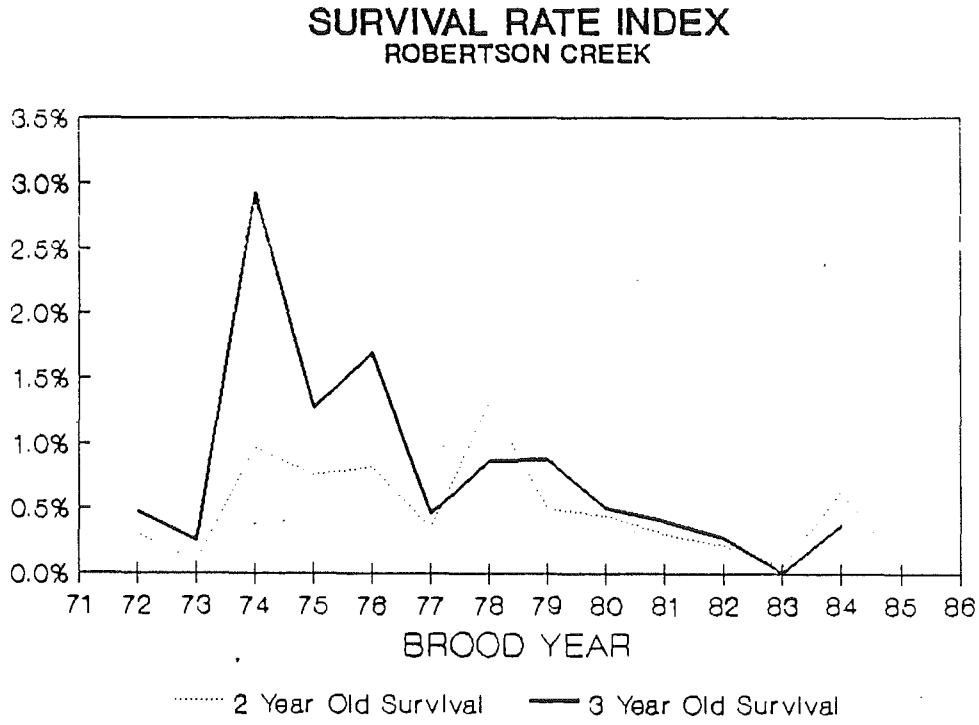

SURVIVAL RATE INDEX
ROBERTSON CREEK
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
BROOD YEAR
2 Year Old Survival
3 Year Old Survival

Fig. 42

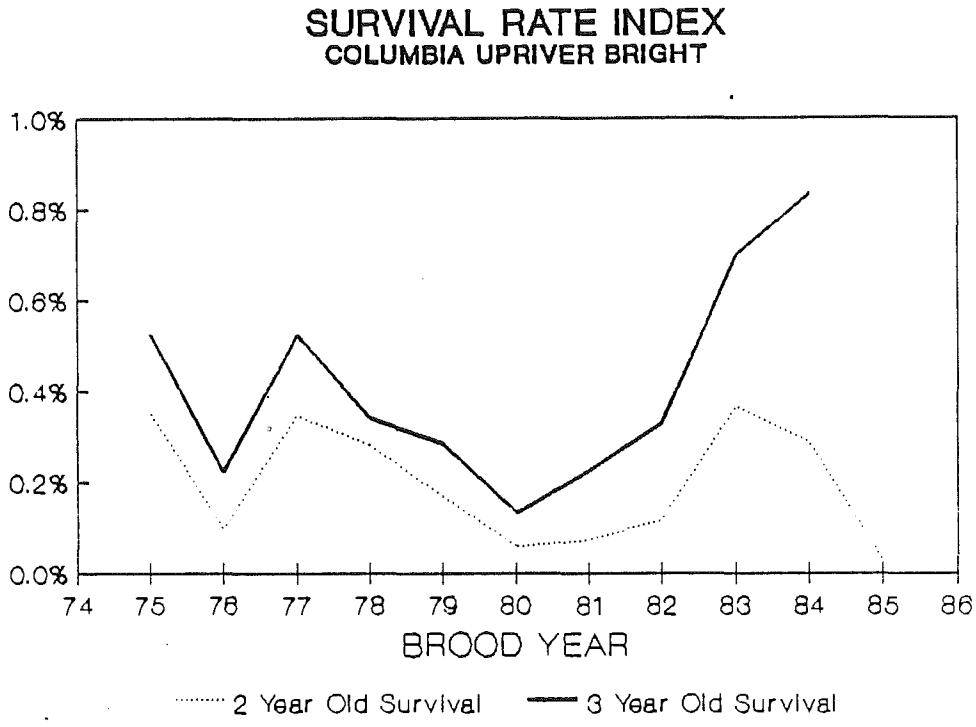

SURVIVAL RATE INDEX
COLUMBIA UPRIVER BRIGHT
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
74 75 76 77 78 79 80 81 82 83 84 85 86
BROOD YEAR
2 Year Old Survival
3 Year Old Survival

Fig. 43

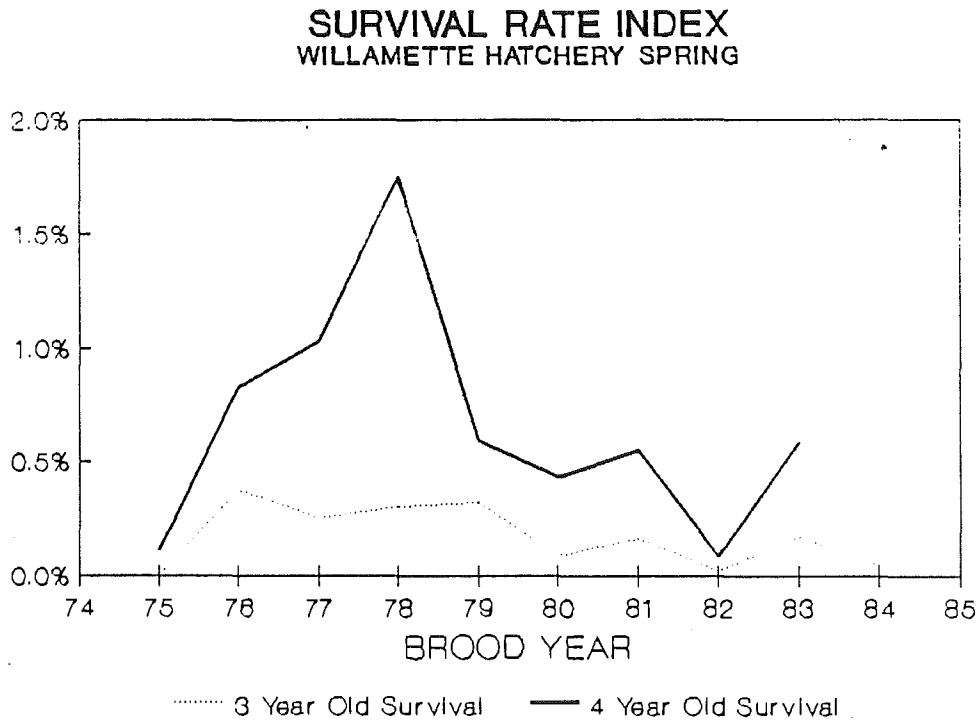

SURVIVAL RATE INDEX
WILLAMETTE HATCHERY SPRING
2.0%
1.5%
1.0%
0.5%
0.0%
74 75 76 77 78 79 80 81 82 83 84 85
BROOD YEAR
3 Year Old Survival
4 Year Old Survival

Fig. 44

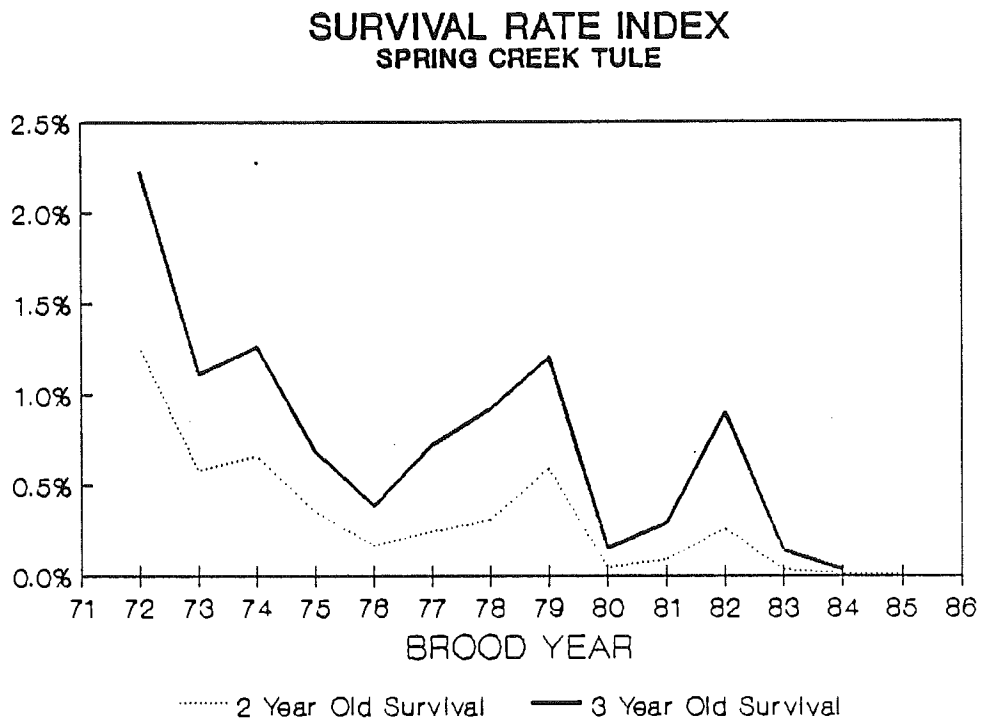

SURVIVAL RATE INDEX
SPRING CREEK TULE
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
BROOD YEAR
2 Year Old Survival
3 Year Old Survival

Fig. 45

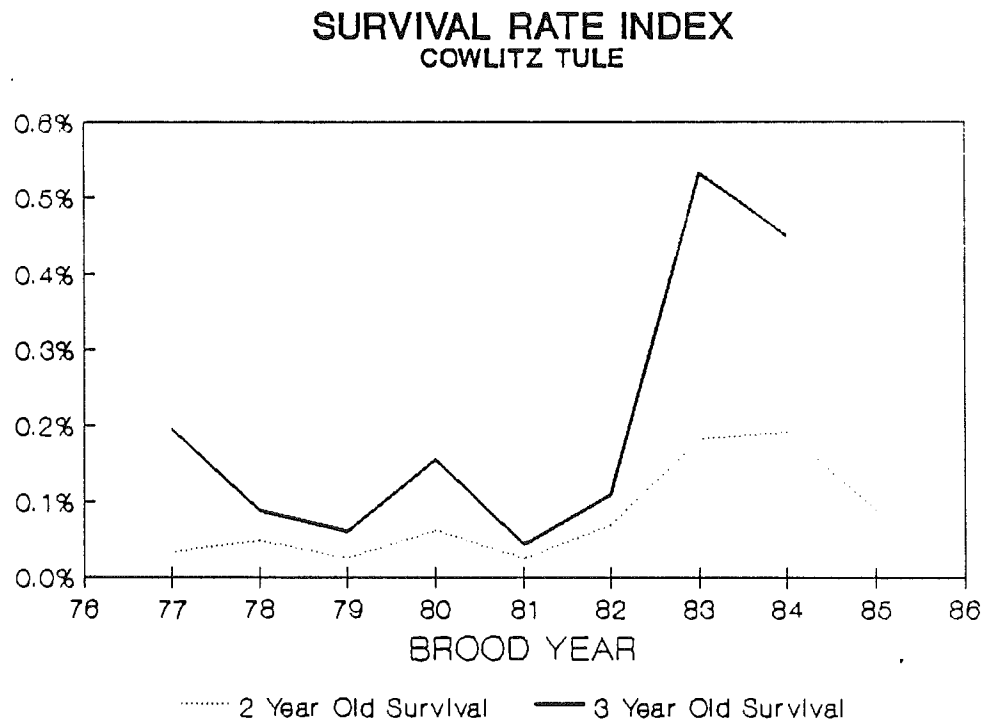

SURVIVAL RATE INDEX
COWLITZ TULE
0.6%
0.5%
0.4%
0.3%
0.2%
0.1%
0.0%
76 77 78 79 80 81 82 83 84 85 86
BROOD YEAR
2 Year Old Survival
3 Year Old Survival

Fig. 46

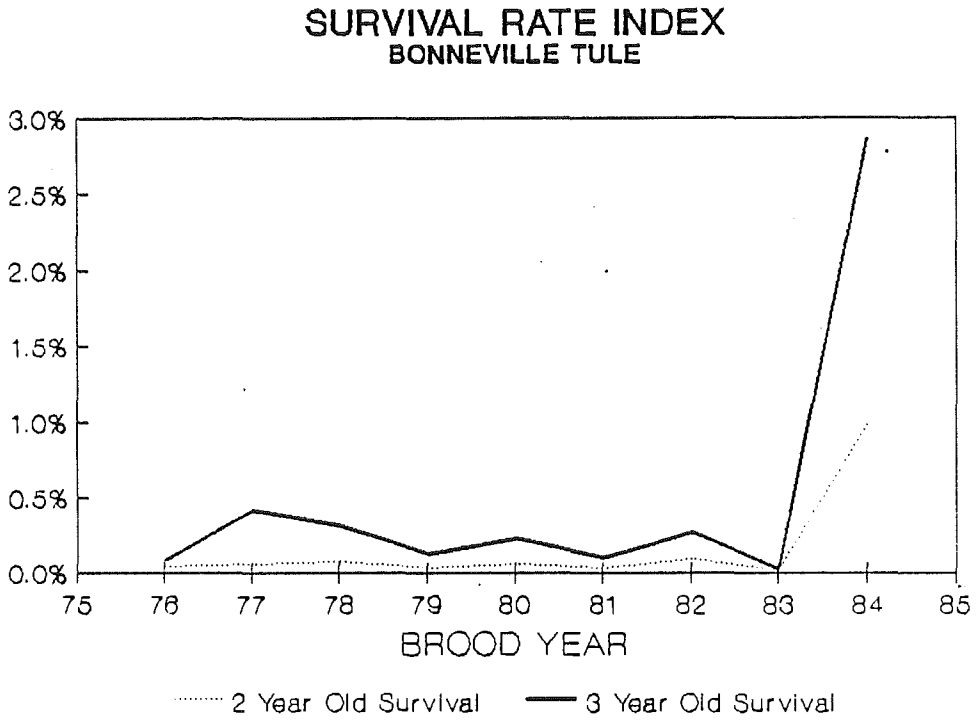

SURVIVAL RATE INDEX
BONNEVILLE TULE
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
75
76
77
78
79
80
81
82
83
84
85
BROOD YEAR
2 Year Old Survival
3 Year Old Survival

Fig. 47

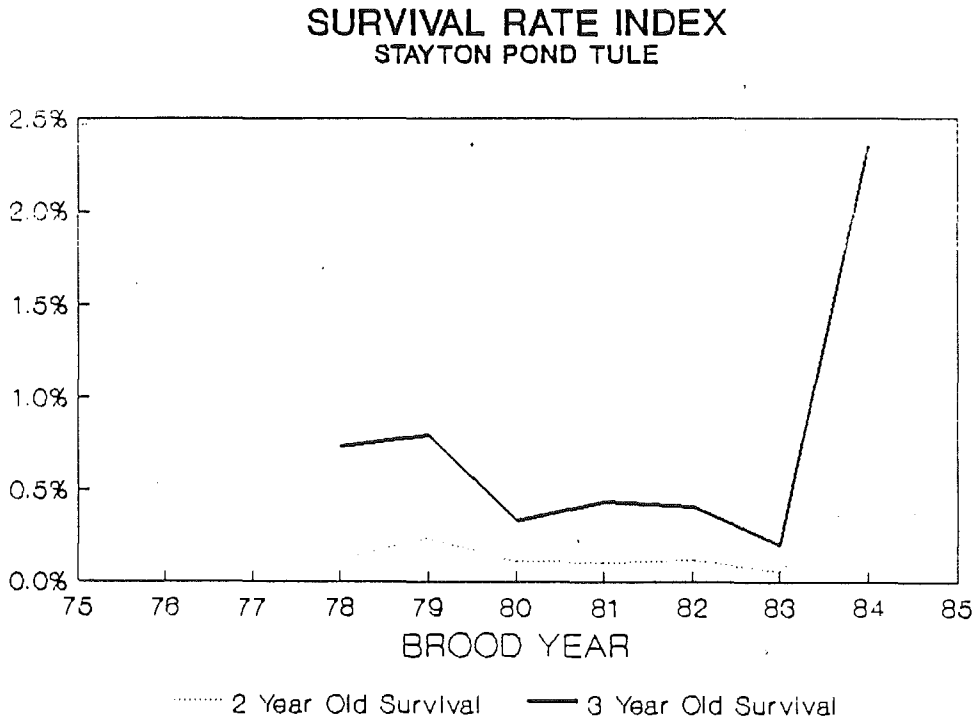

SURVIVAL RATE INDEX
STAYTON POND TULE
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
75
76
77
78
79
80
81
82
83
84
85
BROOD YEAR
2 Year Old Survival
3 Year Old Survival

Fig. 48

APPENDIX II, Supplement A
1988 DATA EMPLOYED FOR ANALYSIS

This appendix contains a description of changes to stocks and data used for exploitation rate analysis.

1.0 ALASKAN CWT DATA

The CWT data employed for the 1988 exploitation rate analysis differs from that available in previous years. The most significant change resulted from updated estimates of recoveries by Alaskan fisheries. In preparing the 1988 exploitation rate analysis, CWT tag sampling and recovery data for Southeast Alaska fisheries were updated from the Alaska CWT database. Alaskan CWT data have been reviewed and revised by ADFG over the past year. Changes in the estimated number of tags harvested occurred in all years and fisheries. For example, CWTs recovered in 1979 and 1981 have recently been reread and recovery information associated with these tags checked, resulting in changes to the database. Also, some of the estimated CWT recoveries in the WDF database (particularly in the Alaska sport fishery) did not correspond to actual recoveries and are suspected of being "imputed". Further, the stratification of the catch and recovery data was changed. Estimation of total number of CWTs harvested was based on week and quadrant grouping of data for the troll fishery and week and district grouping of data for the net fisheries. This level of stratification was maintained for the gillnet, seine, and fishtrap data, but was replaced by quadrant and period grouping in the troll data. This grouping of troll fishery recoveries reduces the unsampled catches and increases the number of recoveries which are expandable.

Sources for CWT data employed in previous analyses are summarized as follows: (1) CWT recovery estimates for Alaskan fisheries prior to 1982 were obtained from the CWT data base maintained by the Washington Department of Fisheries; (2) Alaskan recoveries for 1982-1986 were hand entered from printouts received from the Alaska Department of Fish and Game; and (3) 1987 recovery data were obtained from a printout from ADFG. The data employed in the 1988 exploitation rate analysis were current as of June 1, 1988.

For some stocks, estimated Alaskan recoveries differed substantially from data that were available in 1987. The use of calendar year rather than accounting year to perform the analysis accounts for some differences, but other factors such as expansion factors and recovery strata also contribute. To illustrate the effects of this revised data set upon the exploitation rate analysis, results for the 1986 recovery year are compared in the following table. The first two columns compare the estimates of 1986 Alaskan troll observed recoveries available in the 1987 and 1988 data sets. The second two sets of

columns represent corresponding estimates of expanded recoveries for unsampled catch. The last two columns compare the resulting estimates of exploitation rates based only on landed catch. When the stocks listed in the table are averaged, the total fishery exploitation rate index compared to the base period changed from a 19% decrease using the 1987 data to 14% increase using the 1988 data. A large part of this increase is due to CWTs recovered in the October 1 - December 31, 1986, winter fishery, notably resulting in increased estimates of Big Qualicum and Quinsam tags.

Comparison of Estimated 1986 Alaska Troll Recoveries Available in 1987 and 1988 and Impacts on Estimated Exploitation Rates.

STOCK	data set	OBSERVED RECOVERIES '87	OBSERVED RECOVERIES '88	EXPANDED & WEIGHTED RECOVERIES '87	EXPANDED & WEIGHTED RECOVERIES '88	EXPLOITATION RATE INDEX '87	EXPLOITATION RATE INDEX '88
Big Qualicum		5	8	12	22	.77	1.59
Quinsam		23	27	57	78	.60	1.13
Robertson Creek		18	18	76	64	1.18	1.14
Col Riv Upriver Bright		124	125	282	283	.69	.72
Fishery Exploitation Rate Index						- 19%	+ 14%

Upon examination of the data, several problem areas were encountered. Decision rules were formulated to adjust CWT recovery data in response to anomalous conditions:

(1) Exclude all "select" recoveries, except for sport prior to 1983 (sport recoveries prior to 1983 are expanded by 4).

(2) Exclude all random commercial fishery recoveries with no expansion and no quadrant or district (except trap).

(3) Exclude all random commercial recoveries with no gear type.

(4) If expansion factor (catch/sample ratio) <1, then set catch/sample ratio =1. The most likely cause of this problem probably relates to sampling and reporting when changes in statistical weeks occur (e.g. the catch may be sampled on Saturday, but reported on Sunday). This situation creates problems for expansion of CWT recoveries not only for the strata in question, but also for the strata in which the catch was actually reported (the catch/sample ratio would be high). Other potential causes for catch/sample ratios include the inability to assign a recovery to a particular strata (a catch/sample ratio = 0), or misreporting of species.

Four general alternatives were considered to address this problem: (a) restratify the CWT data so that catch/sample ratios are >=1; (b) utilize the catch/sample ratios regardless of their values; (c) disregard any CWT recovery with an expansion of less than 1; and (d) establish a minimum catch/sample ratio. The time available to complete the exploitation rate analysis did not permit alternative (a) to be pursued. Alternative (b) would be simplest and may compensate for inappropriately high catch/sample ratios in other strata if the same codes are recovered. Alternative (c) would essentially consider the CWT recovery of no information value. The last alternative, utilizing a minimum catch/sample ratio of one (logically, the catch must be at least as large as the sample), was employed for consistency with Canadian CWT analysis procedures. It is recognized that this adjustment may introduce some bias into the analysis, however, the number of cases with catch/sample ratios <1 was relatively minor.

(5) All trap recoveries placed in net category; if there is no expansion for a trap recovery, use an expansion factor = 4.

(6) The expansion factor for random sport fishery recoveries is = 4.

(7) A few recoveries were encountered with very high catch sample ratios. These situations generally occurred with extremely small sample sizes which would not be representative. A maximum catch/sample ratio of 50 was employed for the analysis.

(8) Expansion of Alaska CWT Data to Account for Unsampled Catches

The Alaska CWT commercial catch sampling program is stratified into quadrant and period (grouped weeks) strata for the troll fishery and district and week strata for the net and trap fisheries. Catches in some of these strata were not sampled and expansion of CWT recoveries over these unsampled catches is not contained in the database. Of particular concern were the winter troll catches from 1979 to 1982 and many of the early net catches. This absence of CWT estimates in the unsampled catches would tend to result in underestimation of the total number of tags in the annual net and troll catches. Recoveries were therefore adjusted as follows.

Troll

Troll CWT recoveries were adjusted by the ratio of the total accounting year troll catch to the total accounting year

troll catch which was landed in a sampled catch stratum. Troll catches were multiplied by the following constants:

Year	Constant
1979	1.1094
1980	1.0264
1981	1.0324
1982	1.0200
1983	1.0505
1984	1.0229
1985	1.0000
1986	1.0001
1987	1.0075

Net

The net fisheries vary in character from 'interceptive' (District 104 seine fishery for example) to 'terminal' (District 115 gillnet fishery). Therefore, estimates of CWT recoveries in unsampled catches were assumed to be more accurate if the ratios total catch: sampled catch of individual districts or groups of adjacent districts were used instead of total gear catch. Purse seine catch and sample data were combined each year into a southern inside area (Districts 101 and 102), an outside area (Districts 103, 104, and 113), a central area (Districts 105, 106, 109, 112, and 114), and individual inside districts 107, 108, and 110. Gillnet data were combined each year for districts 106 and 108. Annual catches and samples from the remaining gillnet districts of 101, 111, and 115 were treated separately. Purse seine recoveries in districts 107, 108, and 110 were not adjusted. Other recoveries were multiplied by the following constants:

	Purse Seine Constants		
Year	101&102	103,104,113	105,106,109, 112,&114
1979	1.1706	1.1070	1.7070
1980	2.5071	1.2765	1.8482
1981	1.0370	1.1507	2.6486
1982	1.0026	1.0025	1.0272
1983	1.0021	1.0000	1.1766
1984	1.0043	1.0005	1.0071
1985	1.0173	1.0021	1.0000
1986	1.0874	1.0000	1.1815
1987	1.4921	1.0018	1.0403

Year	Gillnet and Fishtrap Constants 101	106&108	111	115	Trap
1979	1.9475	1.4386	1.0082	1.5989	N/D
1980	1.3053	1.3531	1.0040	6.1111	N/D
1981	1.0000	1.2453	1.0330	2.4904	N/D
1982	1.0224	1.1477	1.0670	1.4195	34.5625**
1983	1.0063	1.1585	1.0242	1.0485	1.0430
1984	1.0000	1.0000	1.0006	1.0199	1.0055
1985	1.0016	1.0088	1.0000	1.0591	1.1339
1986	1.0000	1.0157	1.2632	1.2532	N/D
1987	1.0000	1.0233	1.1683	1.0340	N/D

** No CWTs were recovered in the 1982 trap fishery.

(9) Adjustments for accounting year

The accounting period for reporting total annual catches in the Alaska fisheries is October 1 of the previous year through September 30. The management of fisheries and monitoring of total chinook salmon catch is based on this accounting period. Therefore, Alaska CWT recoveries are grouped by accounting year instead of calendar year.

2.0 CANADIAN STOCKS

Canadian stocks CWT Data Update:

Some changes occurred in the CWT input data for Canadian stocks. These changes are the direct result of updates made to various data bases from which the data are derived. The following is a summary of the changes which were made to the input CWT data prior to analysis:

1) Recoveries prior to 1982

All tag codes for the 1988 analysis were updated with the most recent data available. However, some of the 1987 analysis tag codes still contained the original WDF data (i.e., had never been updated). In some cases, the changes to the input data due to these updates are considerable (particularly in Alaska - see previous for a more complete discussion). Some of the Canadian recovery data also changed, but less drastically.

2) Escapement Data:

Some minor discrepancies have surfaced between the escapement data in some of the input data for Canadian codes (derived directly from hatchery records) and the data in the Canadian data base. Most of these discrepancies are 1 or 2 recoveries in magnitude and are probably due to differences in rounding protocol. A few other discrepancies remain, but have not been investigated. The original data (based on hatchery records) were used in the 1988 analysis.

3.0 COLUMBIA RIVER STOCKS

Two stocks were added to the exploitation rate analysis from the Columbia River.

Willamette River spring chinook: This stock was not included in previous analyses because of time constraints to compile the data base.

Stayton Pond tule fall chinook: This stock was added because the coded wire tagging program was dropped from Bonneville Hatchery in 1985. Stayton Pond, located on the Willamette River, is a holding pond and release site for Bonneville Hatchery tule fall chinook. Stayton Pond fish have a similar distribution to Bonneville fish, but exhibit a higher survival rate than Bonneville Hatchery tule chinook.

A number of discrepancies in CWT escapement recoveries were observed between the PMFC recovery data base and agency recovery data. The agency escapement data was considered to be the correct source. All Columbia River CWT escapement recovery data were acquired directly from the recovery agency. For some stocks, the escapement data have changed from the previous analysis.

All of the Columbia River stocks ocean recoveries, from Canada and Alaska, were updated directly from the data bases maintained by the respective recovery agencies.

APPENDIX II, Supplement B
COHORT ANALYSIS: DESCRIPTION OF METHODS AND THEORY

1.0 Background:

The following is a summary of the methods currently being used for the cohort analysis (virtual population analysis) of CWT data used in the exploitation rate analysis. In addition, the new methods to calculate incidental mortalities are documented.

These methods supersede all previous documented procedures (similar to the Georgia Strait model - Argue et al., 1982)(Starr et al., 1986; AWG memo, Nov. 02, 1987). A forward variant of this procedure is in use in the current version of the PSC Chinook Model.

The notation employed in the equations presented in this Appendix is defined in section 4.

2.0 Cohort Analysis:

The cohort size at any age is calculated by summing all catches at age (including incidental mortalities), the escapement at age, and the cohort from the next older age. (Equation 1 below).

Once the basic cohort is reconstructed, various parameters can be estimated. These include:

a) Maturation rate at age;

b) Adult equivalent factor at age;

c) Fishery specific exploitation rate at age;

d) Total exploitation rates, both at age and for the entire cohort.

These procedures estimate parameters correctly only for complete cohorts. However, often we need to estimate the same parameters for incomplete cohorts. In these cases, average maturity rates and average adult equivalents can be used to estimate the size of the remaining cohort (see Equations 9 - 10 below). Using average maturity rates will correct for biases which would otherwise occur if the exploitation rate parameters were calculated on the incomplete cohort.

2.1 Exploitation Rate Analysis:

The "Exploitation Rate Analysis" as used by the PSC Chinook Technical Team is based on cohort analysis for stocks with suitable available data. A time series of age specific fishery exploitation rates is generated and converted to a relative index by stock. These indices are then combined to produce a composite index for a fishery. The relative change indicated by the age-specific fishery exploitation rate index represents the overall effect of the management regimes instituted through the 1985 PSC Salmon Treaty.

The PSC rebuilding program relies upon the progressive reduction of exploitation rates in fisheries under ceiling management over time. Measurement of this reduction is best done through the analysis of complete cohorts returning under the new management regime. However, this type of information takes a great deal of time to accumulate because data for complete cohorts must be available. The age-specific fishery exploitation rate analysis was developed to provide an early indication of the effects of the management changes under the PSC chinook management.

A detailed description of the methods used in calculating and combining the indices is presented later in this Appendix. The various assumptions which underlie the estimate have already been discussed (2.1.2.4)

2.2 Calculation of incidental mortalities associated with Size Limit Restrictions:

The basis for the current approach in calculating incidental mortality resulting from size limit restrictions lies in estimating the proportion of the underlying population which is above the size limit for each age (called PV_{fl} below). However, this proportion is difficult to estimate for each individual stock, especially by fishery. Therefore, fishery specific PV factors were used for all stocks. This use of the same PV factors for all stocks has the effect of assuming that fish of a given age have the same size distribution for all stocks. This is probably not correct due to potential differences in abundance of age-classes of individual stocks, but sufficient data to estimate stock-specific differences are not available.

The premise for the modification of the cohort analysis procedure is to perform the cohort analyses on all brood years simultaneously. Total shakers can be then estimated by using total legal catches. These legal catches can be totaled within a brood (but across calendar years = brood year method) or can be

totaled within a calendar year (but across brood years = calendar year method). Shakers are then assigned to the appropriate age classes based on the relative abundance of the non-vulnerable populations at age. This procedure is performed iteratively until the cohort size stabilizes. The number of shakers is estimated initially by using the cohort abundances resulting from only the legal catch. These shakers are then added into the cohort and the cohort populations are recalculated. The number of shakers are then recalculated and the process is repeated until the cohort size stabilizes.

2.3 Estimation of Proportion Vulnerable:

The calculation of incidental mortalities associated with size limit restrictions depends critically upon the estimation of the proportion of each stock that is vulnerable (PV) in a particular fishery by age. Available data are not sufficient to permit estimation of stock-specific PV's. Therefore, age-size distributions for large fishing areas were calculated from available data. Coded Wire Tag recoveries turned out to be the best source of this type of age-length data. This is because these data belong to a large (and easily available) data set that can be identified accurately as to age and catch location. A description of the procedure used to estimate the proportion vulnerable by age follows:

a) Due to the absence of sufficient, direct observational data on the size distribution of fish encountered by a particular fishery, age-length data from CWT tag recoveries were examined from troll and seine fisheries from Canada and some U.S. fisheries. Seine data were preferred because they are potentially the least size-selective of the fisheries. Troll CWT data were also examined. Canadian sport recoveries were not useful since most returns are from voluntary sources without sampling and consistent measuring procedures. Year-to-year variability seemed to be less than area-to-area variability; data across years were combined as well as some minor areas to produce specific age-size distributions. Seine data from Canadian fisheries appeared to be lacking representative fish in the larger size classes while the troll data lacked fish in the smaller size classes (due to size limits). The two data sets were pooled to give large combined data sets for each region (e.g., West Coast Vancouver Island). Only the Alaska seine data were used to estimated the size distribution of chinook salmon encountered by the Alaska troll fishery.

b) The estimated PV's were then adjusted using the PSC Chinook Model to estimate the encounter rates (non-retained/retained) for particular fisheries. These were then compared to field data collected in those fisheries (where available). The PV's were adjusted iteratively until they corresponded as closely as possible to the observed data.

c) The estimated PV's from the PSC model (by fishery) were then sorted by calendar year (and age) and became input data into the cohort analysis procedure. Size limit changes are represented by changes in the proportion vulnerable at age in the appropriate year

2.4 Other Input Parameters:

a) Natural Mortality:

Direct estimates of natural (non-catch) mortality for chinook salmon are lacking. The numbers used in the cohort analysis were chosen to conform to the numbers used in the Georgia Strait virtual population analysis (Argue et al, 1982 - spreadsheet version). Specifically, the Argue paper used a natural mortality of 1.5% per month for ages 3 to 5 and 3% per month for age 2. These values calculate to:

Age 3-5 = $\{1 - (1 - .015)^{12}\}$ = 17% per year

Age 2 = $\{1 - (1 - .03)^{12}\}$ = 31% per year

In 1982, when these cohort analysis procedures were begun (undocumented), it was decided to use stepped values of mortality by age. The values chosen were:

Age 2 = 40%; Age 3 = 30%; Age 4 = 20%; Age 5+= 10%

The mean of the values used for ages 3-5 is 20% (similar to the 17% used in the Argue paper). The 40% continues the stepped progression. However, the values chosen for these parameters do not affect the conclusions of the analyses as long as they are applied uniformly to all cohorts.

b) Shaker Mortality Rates:

There has been much discussion on appropriate values to use for these parameters. For the purposes of this analysis the following values were chosen:

Troll = 30%; Net = 90%; Sport = 30%

The same values were used for both legal and sub-legal shakers. These values are in the range of accepted values agreed to by the full Chinook Technical Committee in 1986.

c) CNR Selectivity Factors:

CNR catches were estimated by two different methods (see Computations-Section (d) below for equations). When sampling information on the legal and sub-legal encounters in a CNR fishery is not available, a ratio of legal and CNR season lengths is used to estimate the CNR catch. This ratio is then adjusted by a "selectivity factor" to compensate for changes in chinook mortality resulting from the fishery targeting on other species. A selectivity factor of 0.34 was used for catch of legal fish. This value is the average selectivity factor calculated from 3 years of observer data in the nonretention Alaska troll fishery. In the absence of sufficient data to estimate this parameter for sub-legal encounters, we assumed a factor of 1.00.

2.5 Cohort Analysis Computations:

2.5.1 Cohort analysis on individual stock, all brood years combined:

(i) Calculation of Cohort Size:

$$(1)\quad Cohrt_{by,l} = \frac{\left[Cohrt_{by,l+1} + Escape_{by,l} + \sum_{f} \left(Catch_{f,by,l} + Shak_{f,by,l} + RL_{f,by,l} + RS_{f,by,l} \right) \right]}{SurvRte_{l}}$$

(summed across all fisheries)

Therefore, the cohort size at any age will include all

mortalities which occur in that year plus the number of fish alive at the end of the fishing year. When i = MaxAge, then the cohort size at age i+1 = 0. The cohort size at age is increased by the mortalities due to non-fishing causes ("natural" mortality) after all fishing mortalities have been included.

The sequence of calculations are as follows:

1) TOTAL ALL LEGAL CATCHES

2) CALCULATE INITIAL COHORT ABUNDANCES W/O INCIDENTAL MORTALITIES

DO

3) CALCULATE SHAKER MORTALITIES

4) CALCULATE CNR MORTALITIES

5) CALCULATE NEW COHORT ABUNDANCES

6) COMPARE NEW AGE 2 COHORT SIZE WITH OLD AGE 2 COHORT SIZE (ALL BROOD YEARS)

LOOP UNTIL ALL CHANGES IN AGE 2 COHORT SIZES ARE < 0.05%

7) CALCULATE FINAL EXPLOITATION RATES AND PRINT OUTPUT

In most equations below, the cohort size is first reduced by the non-catch mortalities:

(2) $CH_{by,i} = (Cohrt_{by,i})(SurvRte_i)$

(ii) Calculation of Maturity Rate:

If f < > terminal fishery then

(3) $TotOcnCat_{by,i} = \sum_f \left[Catch_{f,by,i} + Shak_{f,by,i} + RL_{f,by,i} + RS_{f,by,i}\right]$

(summed across all non-terminal fisheries)

If f = terminal fishery then

(4) $TotMatCat_{by,i} = \sum_f \left[Catch_{f,by,i} + Shak_{f,by,i} + RL_{f,by,i} + RS_{f,by,i}\right]$

(summed across all terminal fisheries)

$$(5)\quad MatRun_{by,l} = TotMatCat_{by,l} + Escape_{by,l}$$

$$(6)\quad MatRte_{by,l} = \frac{MatRun_{by,l}}{(Cohrt_{by,l})(SurvRte_{l}) - TotOcnCat_{by,l}}$$

(iii) Calculation of Adult Equivalents:

$$(7)\quad AdltEqv_{by,l} = MatRte_{by,l} + \left[(1 - MatRte_{by,l})(SurvRte_{l+1})(AdltEqv_{by,l+1})\right]$$

by definition:

$$(8)\quad AdltEqv_{by,maxage} = 1$$

(iv) Calculation of Average Maturity Rate and Average Adult Equivalents:

$$(9)\quad AvgMatRte_{l} = \frac{\sum_{by} MatRte_{by,l}}{NumComplBY}$$

$$(10)\quad AvgAdltEqv_{l} = \frac{\sum_{by} AdltEqv_{by,l}}{NumComplBY}$$

(summed across all complete brood years)

(v) Calculation of Estimated Cohort (for Incomplete Brood Years only):

We can express the maturity rate in equation (6) as follows:

$$(11)\quad MatRte_{by,l} = \frac{MatRun_{by,l}}{MatRun_{by,l} + Cohrt_{by,l+1}}$$

If we solve the above equation for $Cohrt_{by,l+1}$ and use average maturity rates in place of the actual maturity rate, we obtain:

$$(12)\quad ACohrt_{by,lage+1} = (1 - AvgMatRte_{lage})\left(\frac{MatRun_{by,lage}}{AvgMatRte_{lage}}\right)$$

This estimated cohort can then be incorporated into the equation (i) as Cohrti+1 to correct for the bias introduced in any calculations using cohort size in incomplete brood years (e.g., shaker weights, exploitation rates, etc...).

For any age i, the estimated cohort can be reduced by the non-catch mortality rate:

(13) $ACH_{by,i} = (ACohrt_{by,i})(SurvRte_i)$

(vi) Calculation of Age Specific Ocean Exploitation Rate:

If by = Complete BY (all ages present to MaxAge) then

(14) $OcnEXR_{by,i} = \frac{TotOcnCat_{by,i}}{CH_{by,i}}$

elseif by = Incomplete BY then

(15) $OcnEXR_{by,i} = \frac{TotOcnCat_{by,i}}{ACH_{by,i}}$

2.5.2 Calculation of Incidental Mortalities (Legal Catch):

Shaker calculations can be done by one of two methods:

a) by brood year (i.e., use the accumulated catches for a total brood year, summed across all calendar years the brood year is in the ocean, to estimate the shakers for that brood year); or,

b) by calendar year (i.e., use the accumulated catches in a calendar year, summed over the brood years present, to estimate the shakers in that calendar year).

(i) Total Population for all Calculations:

If f < > Terminal Fishery then

if by = Complete BY (all ages present to MaxAge) then

(16) $ShakPop_{f,by,i} = CH_{by,i}$

elseif by = Incomplete BY then

(17) $ShakPop_{f,by,i} = ACH_{by,i}$

elseif f = Terminal Fishery then

if by = Complete BY (all ages present to MaxAge) then

(18) $ShakPop_{f,by,l} = MatRun_{by,l}$

elseif by = Incomplete BY then

(19) $ShakPop_{f,by,l} = (ACH_{by,l})(1 - OcnEXR_{by,l})(AvgMatRte_{l})$

(ii) Calculation of Population of Non-Vulnerable Fish:

(20) $NNV_{f,by,l} = (ShakPop_{f,by,l})(1 - PV_{f,yr,l})$

If calendar year method used then

(21) $NNV_{f,yr,.} = \sum_{l} NNV_{f,by=yr-l,l}$

elseif brood year method used then

(22) $NNV_{f,by,.} = \sum_{l} NNV_{f,by,l}$

(summed across all ages)

(iii) Calculation of Population of Vulnerable Fish:

(23) $NV_{f,by,l} = (ShakPop_{f,by,l})(PV_{f,yr,l})$

If calendar year method used then

(24) $NV_{f,yr,.} = \sum_{l} NV_{f,by=yr-l,l}$

elseif brood year method used then

(25) $NV_{f,by,.} = \sum_{l} NV_{f,by,l}$

(summed across all ages)

(iv) Estimated Encounter Rate:

$$(26)\quad ER_{f,xx} = \frac{NNV_{f,xx,..}}{NV_{f,xx,..}}$$

where xx = by or xx = yr, depending on estimation method chosen

(v) Estimated Shaker Loss for all ages:

$$(27)\quad Shak_{f,xx,..} = SMS_f(Catch_{f,xx,..})(ER_{f,xx})$$

where xx = by or xx = yr, depending on estimation method chosen.

(vi) Shaker Loss in Age i for fishery f:

If calendar year method used then

$$(28)\quad Shak_{f,by=yr-i,i} = Shak_{f,yr,..}\left(\frac{NNV_{f,by=yr-i,i}}{NNV_{f,yr,..}}\right)$$

However, we know from Equations 20 - 22 that $Shak_{f,yr,..}$ also contains the term $NNV_{f,yr,..}$. Therefore, this term can be canceled out and the above equation simplifies to:

$$(29)\quad Shak_{f,by=yr-i,i} = (Catch_{f,yr,..})(SMS_f)\left(\frac{NNV_{f,by=yr-i,i}}{NV_{f,yr,..}}\right)$$

Therefore, it is not necessary to actually calculate the encounter rates and the total number non-vulnerable.

elseif brood year method used then

$$(30)\quad Shak_{f,by,i} = (Catch_{f,by,..})(SMS_f)\left(\frac{NNV_{f,by,i}}{NV_{f,by,..}}\right)$$

(by similar reasoning as for the calendar year method equation).

2.5.3 Calculation of CNR mortalities in Exploitation Rate Analysis:

Mortalities caused by the CNR fisheries can be estimated by two methods, depending on the type of data available:

a) The preferred method uses an independent estimate (usually from sampling) of the encounters of legal and sub-legal fish during the fishing year in question; or,

b) In the absence of sampling information, the alternate method calculates a relative ratio of the legal to CNR season length to estimate the CNR mortalities.

(i) Calculation of Legal CNR Catch, fishery f (LCNR known):

$$(31)\quad RL_{f,by=yr-i,i} = (Catch_{f,by=yr-i,i})(SML_f)\left(\frac{LCNR_{f,yr}}{L_{f,yr}}\right)$$

(ii) Calculation of Sub-Legal CNR Catch, fishery f (SLCNR known):

$$(32)\quad RE_{f,yr,..} = \left(\frac{LCNR_{f,yr}}{L_{f,yr}}\right)\sum_{i} Catch_{f,by=yr-i,i}$$

(summed across all ages)

The term $(LCNR_{f,yr} / L_{f,yr})$ is a constant and is therefore removed from the summation term.

$$(33)\quad RS_{f,yr,..} = \left(\frac{RE_{f,yr,..}}{LCNR_{f,yr}}\right)(SLCNR_{f,yr})(SMS_f)$$

But we know that $RE_{f,yr,..}$ also contains the value $LCNR_{f,yr}$. This value cancels out and the equation simplifies to:

$$(34)\quad RS_{f,yr,..} = (SLCNR_{f,yr})(SMS_f)\left(\frac{\sum_{i} Catch_{f,by=yr-i,i}}{L_{f,yr}}\right)$$

(summed across all ages)

$$(35)\quad RS_{f,by=yr-i,i} = RS_{f,yr,.}\left(\frac{Shak_{f,by=yr-i,i}}{Shak_{f,yr,.}}\right)$$

(This means that the legal encounters do not have to be summed across all ages before calculating the sub-legals.)

(iii) Calculation of Legal CNR Catch, fishery f (LCNR unknown):

$$(36)\quad RL_{f,by=yr-i,i} = Catch_{f,by=yr-i,i}\left(\frac{SeaCNR_{f,yr}}{SeaL_{f,yr}}\right)\ SML_f\ \ SelLCNR_f$$

(iv) Calculation of Sub-Legal CNR Catch, fishery f (SLCNR unknown):

$$(37)\quad RS_{f,by=yr-i,i} = Shak_{f,by=yr-i,i}\left(\frac{SeaCNR_{f,yr}}{SeaL_{f,yr}}\right)\ SelSLCNR_f$$

2.5.4 Calculation of Age Specific Fishery Exploitation Rates:

(i) Determination of Total Population for all Calculations:

If f < > Terminal Fishery then

if by = Complete BY (all ages present to MaxAge) then

$$(38)\quad EXRPop_{f,by,i} = CH_{by,i}$$

elseif by = Incomplete BY then

$$(39)\quad EXRPop_{f,by,i} = ACH_{by,i}$$

elseif f = Terminal Fishery then

$$(40)\quad EXRPop_{f,by,i} = MatRun_{by,i}$$

(ii) Calculation of Fishery Exploitation Rates:

for legal catch exploitation rate:

$$(41)\quad EXRLeg_{f,by,l} = Catch_{f,by,l}\left(\frac{AdltEqv_{by,l}}{EXRPop_{f,by,l}}\right)$$

for total mortality exploitation rate:

$$(42)\quad TotCat_{f,by,l} = Catch_{f,by,l} + Shak_{f,by,l} + RL_{f,by,l} + RS_{f,by,l}$$

$$(43)\quad EXRTot_{f,by,l} = TotCat_{f,by,l}\left(\frac{AdltEqv_{by,l}}{EXRPop_{f,by,l}}\right)$$

3.0 ANALYSIS OF EXPLOITATION RATE DATA

3.1. CALCULATION OF EXPLOITATION RATE INDICES

The exploitation rate analysis is designed to express changes over time concerning the impact of a fishery upon a stock or a group of stocks. For a given fishery, there will be several stock specific estimates of a exploitation rate for the base period and for the current year. Scott (1988) in a memo to the AWG addressed the topic of combining the stock specific data so that the best estimate of the change in the fishery exploitation rate would be calculated. Through simulation modeling, he evaluated four methods of combining exploitation rate indices calculated for individual stocks into a single estimator for the fishery being evaluated. A discussion of each of the four combination methods follows.

Note: In the following discussion, the variable $EXRA_{f,s,yr,l}$ is used to identify the fishery and age specific exploitation rate by stock which is the output of the cohort analysis.

If Exploitation Rate Analysis is performed on Total Mortalities, then

$$(44)\quad EXRA_{f,s,yr,l} = EXRTot_{f,by=yr-1,l}$$

Elseif Exploitation Rate Analysis is performed on Legal Catch only, then

$$(45) \quad EXRA_{f,s,yr,l} = EXRLeg_{f,by=yr-l,l}$$

The above assignments relate the previous discussion concerning the cohort analysis of a single stock over all brood years of available data and the following discussion of linking the calculated exploitation rates of all stocks available for each fishery.

3.1.1 Simple Average Method

This method calculates an unweighted mean of the ratios of each stock specific exploitation rate to the base period exploitation rate.

(i) Calculation of Base Period average exploitation rate for each stock:

$$(46) \quad BEXR_{f,s,l} = \sum_{yr=1979}^{1982} \frac{EXRA_{f,s,yr,l}}{n}$$

where n = number of years in the base period average.

(ii) Calculation of exploitation rate index for each stock:

$$(47) \quad NEXR_{f,s,yr,l} = \frac{EXRA_{f,s,yr,l}}{BEXR_{f,s,l}}$$

(iii) Calculation of unweighted mean of exploitation rate indices (over all stocks present in each year):

$$(48) \quad SAVEXR_{f,yr,l} = \frac{1}{n} \sum_{s=1}^{n} NEXR_{f,s,yr,l}$$

where: n = number of stock-age combinations being considered in a fishery.

3.1.2 Ratio of Means Method

This method calculates a weighted mean of the ratios of the current stock specific exploitation rates to the sum of average base period exploitation rates (over all stocks).

(i) Calculation of weighted index:

$$(49)\quad RatioEXR_{f,yr,l} = \frac{\sum_{s=1}^{n} EXRA_{f,s,yr,l}}{\sum_{s=1}^{n} [BEXR_{f,s,l}]}$$

where n = number of stock age combinations being considered in a fishery.

3.1.3 Variance Method

This method calculates a exploitation rate index which is weighted by the variance between tag codes within a stock.

A variance $Var(NEXR_{f,s,y,l})$ was computed for all stocks with more than one tag group per brood year. If only one tag group was present, then average variance for the stock, age and fishery was used.

Calculation of the variance index:

$$(50)\quad IVAR_{f,yr,l} = \frac{\sum_{s} \frac{NEXR_{f,s,yr,l}}{Var(NEXR_{f,s,yr,l})}}{\sum_{s} \frac{1}{Var(NEXR_{f,s,yr,l})}}$$

3.1.4 Weight by Exploitation Rate Method

This method calculates the exploitation rate index weighted by the square of the exploitation rate.

(i) Calculation of the index:

$$(51)\quad EXRwEXR_{f,yr,l} = \frac{\sum_{s} \frac{EXRA_{f,s,yr,l}^{2}}{BEXRs_{,f,l}}}{\sum_{s} EXRA_{f,s,yr,l}}$$

3.2 Selection of Methods:

The simple average index was the method used in the 1986 and 1987 Exploitation Rate Analysis. This method was continued this year to provide continuity with previous analyses. The Ratio of the Means Index yielded the smallest variance and Mean Square Error of the four estimators evaluated (Scott, 1988). For this reason, the ratio method was also chosen for this year's analysis. The other two methods yielded results which were either equal to or inferior to the two methods chosen.

For the 1988 analysis, exploitation rates were estimated using legal catch only and using total fishing mortality (legal catch + sub legal mortality + all CNR mortality).

The average exploitation rate index during the base period will be 1 (one). Therefore, a fishery exploitation rate index less than one represents a decrease from the base period while a fishery exploitation rate index greater than one indicates an increase. The magnitude of the change will simply be the difference of the measured exploitation rate index from one.

3.3 ASSESSING CHANGE IN THE EXPLOITATION RATE INDICES

Age specific exploitation rate indices were calculated for each fishery of interest over all the stocks present. Then the percent change of the exploitation rate index from the base period was calculated:

$$(52) \quad EXRC_{f,yr,l} = 100 \times \left(SAVEXR_{f,yr,l} - 1\right)$$

or

$$(53) \quad EXRC_{f,yr,l} = 100 \times \left(RatioEXR_{f,yr,l} - 1\right)$$

In addition, the percent change in a fishery exploitation rate index was averaged for 1985, 1986, and 1987 seasons to estimate short term trends.

The objective of these analyses was to compare the observed exploitation rate changes to the expected reductions for each fishery of interest. Given the fact that size limit changes have been implemented and CNR fisheries have increased from the base period, the appropriate exploitation rate measurement for comparison to expected reductions is the one calculated using total mortality (legal catch + sublegal mortality + CNR mortality.

This analysis is only applicable to the initial years of the rebuilding program (first cycle). Assuming that the abundance in a fishery remains constant, the expected reduction in a fishery exploitation rate is directly proportional to the reduction in catch from the base period to the PSC ceiling. Therefore, the following relationship between the reduction in a catch ceiling and the expected fishery exploitation rate is made:

$$(54)\quad EEXR_f = \left(\frac{PSC_f}{BPC_f}\right) BEXR_f$$

The expected percent reduction in the exploitation rate, for a fishery of interest, is calculated as follows:

$$(55)\quad EPR_f = 100 \times \left(\frac{1 - PSC_f}{BPC_f}\right)$$

Inferences about changes in abundance could be made if observed exploitation rate reductions greatly deviate from expected reductions, and the other assumptions about cohort analysis are met (Starr et al, 1986).

4.0 Notation: Variable List for Exploitation Rate Documentation

Dimensions:
- by = brood year
- f = Fishery
- i = Age
- s = Stock
- yr = Year

$ACH_{by,i}$ = Estimated Cohort size, brood year by at age i (discounted by natural mortality and for incomplete brood years only).

$ACohrt_{by,i}$ = Estimated Cohort size, brood year by at age i (for incomplete brood years only).

$AdltEqv_{by,i}$ = Adult Equivalent factor for brood year by at age i.

AvgAdltEqvi	= Average adult equivalent factor at age i.
$AvgMatRte_i$	= Average maturity rate at age i.
BPC_f	= Average catch in a fishery for the base period 1979-1982.
$BEXR_{f,s,i}$	= Average Base period exploitation rate.
$Catch_{f,by,i}$	= Legal Catch for fishery f, brood year by, age i.
$Catch_{f,xx,.}$	= Total legal catch for fishery f, where xx = calendar year yr, added across all brood years present or xx = brood year by, added across calendar years.
$Cohrt_{by,i}$	= Cohort size, brood year by at age i.
$CH_{by,i}$	= Cohort size, brood year by at age i (discounted by natural mortality).
$EEXR_f$	= The fishery exploitation rate expected under catch ceiling management.
EPR_f	= Expected percent change in the relative fisher exploitation rate from the base period average.
$ER_{f,xx}$	= Encounter Rate for Fishery f, where xx = calendar year yr or xx = brood year by.
$Escape_{by,i}$	= Escapement in brood year by at age i.
$EXRA_{f,s,yr,i}$	= Calculated exploitation rate from cohort analysis.
$EXRC_{f,yr}$	= Calculated percent change in exploitation rate for year y in fishery f.
$EXRLeg_{f,by,i}$	= Age Specific Fishery Exploitation Rate, fishery f, brood year by at age i for legal catch only.
$EXRTot_{f,by,i}$	= Age Specific Fishery Exploitation Rate, fishery f, brood year by at age i for total mortalities.

$EXRPop_{f,by,i}$	= Population from which the age specific fishery exploitation rate is calculated.
$EXRwEXR_{f,yr,i}$$	= Exploitation rate weight index.
iage	= Oldest age class in the incomplete brood year.
$IVar_{f,yr,i}$	= Variance method index.
$L_{f,yr}$	= Actual(total pieces) Legal Catch, pre-CNR (Chinook Non-Retention Fishery), calendar year yr.
$LCNR_{f,yr}$	= Estimated encounter of legal-sized fish during CNR (includes selectivity). Externally provided by agency.
$MatRte_{by,i}$	= Maturity Rate in brood year by at age i.
$MatRun_{by,i}$	= Mature Run Size, brood year by at age i.
MaxAge	= Maximum age encountered for the stock being analyzed in any brood year.
$NEXR_{f,s,yr,i}$	= Simple Average exploitation rate index of stock s in fishery f at age i.
$NNV_{f,by,i}$	= Population not vulnerable to fishery f, brood year by at age i.
$NNV_{f,xx,.}$	= Total population not vulnerable to fishery f, where xx = calendar year yr, added across all brood years present or xx = brood year by, added across calendar years.
NumComplBY	= Number of brood years with all age classes present (to MaxAge).
$NV_{f,by,i}$	= Population vulnerable to fishery f, brood year by at age i.

$NV_{f,xx,.}$ = Total population vulnerable to fishery f, where xx = calendar year yr, added across all brood years present or xx = brood year by, added across calendar years.

$OcnEXR_{by,i}$ = Age Specific exploitation rate for brood year by at age i.

PSC_{f} = Pacific Salmon Commission catch ceiling.

$PV_{f,yr,i}$ = Proportion vulnerable to fishery f, calendar year yr at age i.

$RatioEXR_{f,yr,i}$ = Exploitation rate index calculated by Ratio method

$RE_{f,yr,.}$ = Total Legal Encounters, CNR fishery f in calendar year yr totaled for all ages (summed across brood years).

$RL_{f,by,i}$ = Legal Mortality, CNR fishery f, brood year by at age i.

$R\text{-}L_{f,yr,.}$ = Total Legal Mortalities, CNR fishery f in calendar year yr totaled for all ages (summed across brood years).

$RS_{f,by,i}$ = Sub-legal Mortality, CNR fishery f, brood year by, at age i.

$RS_{f,yr,.}$ = Total Sub-legal Mortality, CNR fishery f in calendar year yr totaled for all ages (summed across brood years).

$SAVEXR_{f,yr,i}$ = Simple Average exploitation rate index.

$SeaCNR_{f,yr}$ = Length in time of CNR fishery f, calendar year yr.

$SeaL_{f,yr}$ = Length in time of Legal fishery f, calendar year yr.

$SelLCNR_{f}$ = Legal Selectivity of CNR fishery f relative to Legal Fishery f.

$SelSLCNR_{f}$ = Sub-Legal Selectivity of CNR fishery f relative to Legal Fishery f.

$Shak_{f,by,i}$ = Shaker mortality for fishery f, brood year by at age i.

$Shak_{f,xx..}$ = Total shaker mortality for all ages in fishery f, where xx = calendar year yr, added across all brood years present or xx = brood year by, added across calendar years.

$ShakPop_{f,by,i}$ = Population size for shaker calculations in fishery f, brood year by at age i (varies according to terminal status of fishery and complete status of brood year).

$SLCNR_{f,yr}$ = Estimated encounter of sublegal-sized fish during CNR (includes selectivity). Externally provided by agency.

SML_{f} = Shaker Mortality Rate for fishery f (legal only).

SMS_{f} = Shaker Mortality Rate for fishery f (sub-legal only).

$SurvRte_{i}$ = Survival Rate at age i (1 - Natural Mortality Ratei).

$TotCat_{f,by,i}$ = Total Mortalities in fishery f, for brood year by at age i.

$TotMatCat_{by,i}$ = Total Mature (terminal) catch in brood year by at age i.

$TotOcnCat_{by,i}$ = Total Ocean (non-terminal) catch in brood year by at age i.

APPENDIX II Supplement C

EXPLOITATION RATE ANALYSIS DATA

CONTENTS

ALASKA TROLL FISHERY

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4
79	0.0769	0.0171	0.0962	0.2860	0.1391	NA	0.0486
80	0.0210	0.1113	0.0654	0.3042	0.1694	0.2010	0.1408
81	0.0327	0.1181	0.1150	0.3763	0.1573	0.4595	0.0722
82	0.0598	0.1448	0.1594	0.2874	0.1256	0.2047	0.0556
83	0.1089	0.2262	0.2358	0.3290	0.1978	0.1897	0.1007
84	0.0000	0.1182	0.2136	0.3240	0.1963	0.2667	0.0602
85	0.0429	0.1746	0.2446	0.1444	0.1580	0.2651	0.2086
86	0.0433	0.1066	0.1584	0.3736	0.1111	0.1905	0.0339
87	0.1227	0.1015	0.1514	NA	0.1441	0.2612	0.1366
Base	0.0476	0.0978	0.1090	0.3135	0.1479	0.2884	0.0793

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4	Fishery
79	1.6162	0.1744	0.8825	0.9123	0.9405	NA	0.6130	0.8350
80	0.4402	1.1377	0.5996	0.9703	1.1460	0.6971	1.7753	0.9350
81	0.6866	1.2074	1.0554	1.2005	1.0637	1.5931	0.9107	1.2286
82	1.2570	1.4805	1.4625	0.9169	0.8498	0.7098	0.7010	0.9575
83	2.2874	2.3122	2.1635	1.0495	1.3378	0.6576	1.2696	1.2811
84	0.0000	1.2084	1.9599	1.0336	1.3273	0.9246	0.7593	1.0881
85	0.9023	1.7847	2.2440	0.4606	1.0686	0.9193	2.6302	1.1428
86	0.9107	1.0902	1.4535	1.1919	0.7512	0.6604	0.4275	0.9391
87	2.5782	1.0380	1.3891	NA	0.9744	0.9058	1.7222	1.1917

Stock Identifiers

BQR = BIG QUALICUM
QUI = QUINSAM
RBT = ROBERTSON CREEK
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

ALASKA TROLL FISHERY

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4
79	0.0769	0.0171	0.0962	0.2847	0.1382	NA	0.0486
80	0.0210	0.1107	0.0654	0.3023	0.1675	0.2002	0.1401
81	0.0310	0.1155	0.1121	0.3675	0.1526	0.4505	0.0703
82	0.0541	0.1299	0.1449	0.2569	0.1128	0.1811	0.0496
83	0.1008	0.2075	0.2177	0.3005	0.1821	0.1724	0.0922
84	0.0000	0.1058	0.1909	0.2877	0.1759	0.2389	0.0537
85	0.0368	0.1484	0.2110	0.1203	0.1355	0.2277	0.1778
86	0.0402	0.0956	0.1440	0.3407	0.1004	0.1722	0.0339
87	0.0971	0.0817	0.1230	NA	0.1156	0.2104	0.1101
Base	0.0458	0.0933	0.1046	0.3028	0.1428	0.2773	0.0771

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4	Fishery
79	1.6809	0.1829	0.9192	0.9402	0.9679	NA	0.6301	0.8633
80	0.4578	1.1869	0.6246	0.9981	1.1731	0.7222	1.8157	0.9649
81	0.6784	1.2377	1.0712	1.2135	1.0687	1.6246	0.9113	1.2450
82	1.1829	1.3925	1.3850	0.8482	0.7902	0.6532	0.6428	0.8904
83	2.2028	2.2237	2.0803	0.9924	1.2755	0.6218	1.1958	1.2199
84	0.0000	1.1341	1.8244	0.9499	1.2320	0.8616	0.6956	1.0087
85	0.8044	1.5905	2.0167	0.3973	0.9493	0.8211	2.3053	1.0133
86	0.8795	1.0242	1.3764	1.1249	0.7033	0.6209	0.4394	0.8881
87	2.1211	0.8754	1.1757	NA	0.8097	0.7590	1.4276	0.9960

Stock Identifiers

BQR = BIG QUALICUM
QUI = QUINSAM
RBT = ROBERTSON CREEK
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

NORTHERN/CENTRAL B.C. TROLL

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4
79	0.0995	0.1877	0.1122	0.1559	0.0737	NA	0.1458
80	0.0832	0.1737	0.2418	0.1415	0.0813	0.1438	0.1442
81	0.0801	0.1864	0.2021	0.1413	0.0469	0.1577	0.0961
82	0.1026	0.0852	0.1217	0.1592	0.0410	0.0236	0.0213
83	0.1089	0.1582	0.2381	0.1193	0.0691	0.0862	0.0299
84	0.0000	0.0667	0.0773	0.1476	0.1067	0.0611	0.0295
85	0.0613	0.0466	0.0360	0.2406	0.0850	0.0720	0.0345
86	0.1981	0.0900	0.0874	0.1538	0.0658	0.0769	0.0763
87	0.0733	0.0574	0.1293	NA	0.1139	0.1190	0.0330
Base	0.0913	0.1582	0.1695	0.1495	0.0608	0.1084	0.1019

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4	Fishery
79	1.0893	1.1862	0.6622	1.0431	1.2138	NA	1.4316	1.0599
80	0.9108	1.0978	1.4270	0.9465	1.3381	1.3272	1.4161	1.2026
81	0.8768	1.1776	1.1924	0.9455	0.7728	1.4548	0.9437	1.0846
82	1.1231	0.5384	0.7184	1.0650	0.6753	0.2180	0.2086	0.6606
83	1.1922	0.9995	1.4050	0.7982	1.1370	0.7955	0.2936	0.9644
84	0.0000	0.4217	0.4560	0.9874	1.7560	0.5639	0.2891	0.5823
85	0.6718	0.2942	0.2123	1.6097	1.3987	0.6648	0.3382	0.6861
86	2.1698	0.5689	0.5160	1.0291	1.0836	0.7098	0.7487	0.8916
87	0.8022	0.3627	0.7632	NA	1.8748	1.0982	0.3243	0.7622

Stock Identifiers

BQR = BIG QUALICUM
QUI = QUINSAM
RBT = ROBERTSON CREEK
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

NORTHERN/CENTRAL B.C. TROLL

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4
79	0.0995	0.1877	0.1122	0.1547	0.0732	NA	0.1458
80	0.0832	0.1721	0.2418	0.1404	0.0803	0.1438	0.1433
81	0.0801	0.1850	0.2021	0.1413	0.0469	0.1577	0.0956
82	0.1026	0.0841	0.1217	0.1579	0.0410	0.0236	0.0207
83	0.1048	0.1582	0.2381	0.1183	0.0691	0.0862	0.0295
84	0.0000	0.0658	0.0773	0.1461	0.1067	0.0611	0.0295
85	0.0613	0.0466	0.0360	0.2380	0.0850	0.0720	0.0345
86	0.1950	0.0900	0.0874	0.1538	0.0655	0.0769	0.0763
87	0.0696	0.0552	0.1293	NA	0.1093	0.1161	0.0308
Base	0.0913	0.1572	0.1695	0.1486	0.0604	0.1084	0.1014

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 4	QUI Age 4	QUI Age 5	RBT Age 4	URB Age 4	URB Age 5	WSH Age 4	Fishery
79	1.0893	1.1938	0.6622	1.0409	1.2120	NA	1.4385	1.0614
80	0.9108	1.0944	1.4270	0.9451	1.3305	1.3272	1.4137	1.2011
81	0.8768	1.1768	1.1924	0.9512	0.7778	1.4548	0.9435	1.0861
82	1.1231	0.5350	0.7184	1.0628	0.6797	0.2180	0.2043	0.6594
83	1.1481	1.0058	1.4050	0.7963	1.1443	0.7955	0.2909	0.9611
84	0.0000	0.4183	0.4560	0.9832	1.7673	0.5639	0.2905	0.5813
85	0.6718	0.2961	0.2123	1.6015	1.4077	0.6648	0.3398	0.6852
86	2.1359	0.5725	0.5160	1.0354	1.0845	0.7098	0.7523	0.8904
87	0.7621	0.3510	0.7632	NA	1.8114	1.0714	0.3042	0.7417

Stock Identifiers

BQR = BIG QUALICUM
QUI = QUINSAM
RBT = ROBERTSON CREEK
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

WCVI TROLL AGE 3

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	RBT Age 3	SPR Age 3	BON Age 3	CWF Age 3	URB Age 3	STP Age 3
79	0.0285	0.1981	0.2311	NA	0.0309	NA
80	0.0416	0.2428	0.1083	0.1144	0.0376	NA
81	0.0192	0.1840	0.1802	0.0562	0.0092	0.2107
82	0.0226	0.1924	0.2805	0.0193	0.0305	0.2041
83	0.0116	0.3027	0.3470	0.0417	0.0103	0.2838
84	0.0455	0.2772	0.2857	0.0226	0.0234	0.3713
85	0.0297	0.1347	0.2705	0.0324	0.0236	0.1851
86	NA	0.2238	0.3148	0.0499	0.0408	0.1935
87	0.0000	0.1034	0.2034	0.0104	0.0281	0.2921
Base	0.0280	0.2043	0.2000	0.0633	0.0270	0.2074

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	RBT Age 3	SPR Age 3	BON Age 3	CWF Age 3	URB Age 3	STP Age 3	Fishery
79	1.0195	0.9695	1.1552	NA	1.1409	NA	1.0635
80	1.4870	1.1882	0.5413	1.8078	1.3919	NA	1.0422
81	0.6862	0.9008	0.9011	0.8876	0.3403	1.0158	0.9034
82	0.8073	0.9416	1.4024	0.3046	1.1269	0.9842	1.0264
83	0.4139	1.4814	1.7347	0.6588	0.3802	1.3684	1.3657
84	1.6246	1.3569	1.4284	0.3577	0.8654	1.7902	1.4050
85	1.0601	0.6592	1.3524	0.5116	0.8728	0.8922	0.9258
86	NA	1.0955	1.5739	0.7888	1.5101	0.9327	1.1720
87	0.0000	0.5063	1.0170	0.1638	1.0374	1.4082	0.8731

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
RBT = ROBERTSON CREEK
SPR = SPRING CREEK
STP = STAYTON POND TULE
URB = COLUMBIA RIVER UPRIVER BRIGHT

WCVI TROLL AGE 3

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	RBT Age 3	SPR Age 3	BON Age 3	CWF Age 3	URB Age 3	STP Age 3
79	0.0248	0.1857	0.2151	NA	0.0271	NA
80	0.0379	0.2262	0.0984	0.1050	0.0333	NA
81	0.0175	0.1668	0.1597	0.0472	0.0061	0.1942
82	0.0200	0.1676	0.2640	0.0169	0.0288	0.1874
83	0.0091	0.2819	0.3108	0.0350	0.0097	0.2635
84	0.0403	0.2637	0.2571	0.0113	0.0210	0.3363
85	0.0275	0.1154	0.2340	0.0286	0.0204	0.1639
86	NA	0.2022	0.3148	0.0460	0.0374	0.1905
87	0.0000	0.0862	0.1313	0.0036	0.0189	0.2163
Base	0.0251	0.1866	0.1843	0.0564	0.0238	0.1908

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	RBT Age 3	SPR Age 3	BON Age 3	CWF Age 3	URB Age 3	STP Age 3	Fishery
79	0.9902	0.9952	1.1672	NA	1.1363	NA	1.0784
80	1.5115	1.2124	0.5340	1.8634	1.3965	NA	1.0518
81	0.6997	0.8940	0.8663	0.8373	0.2574	1.0180	0.8870
82	0.7986	0.8984	1.4324	0.2993	1.2098	0.9820	1.0267
83	0.3629	1.5108	1.6864	0.6210	0.4087	1.3808	1.3645
84	1.6060	1.4135	1.3951	0.2009	0.8806	1.7625	1.3940
85	1.0987	0.6187	1.2698	0.5070	0.8578	0.8589	0.8845
86	NA	1.0835	1.7080	0.8171	1.5710	0.9982	1.2322
87	0.0000	0.4620	0.7126	0.0644	0.7916	1.1338	0.6843

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
RBT = ROBERTSON CREEK
SPR = SPRING CREEK
STP = STAYTON POND TULE
URB = COLUMBIA RIVER UPRIVER BRIGHT

WCVI TROLL AGE 4

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	RBT Age 4	SPR Age 4	BON Age 4	CWF Age 4	URB Age 4	WSH Age 4	STP Age 4
79	0.0473	0.1597	NA	NA	0.0642	0.0347	NA
80	0.0710	0.2775	0.1579	NA	0.0666	0.0652	NA
81	0.0212	0.1772	0.1565	0.1418	0.0622	0.0100	NA
82	0.0340	0.2454	0.3547	0.1969	0.0256	0.0322	0.1906
83	0.0339	0.2804	0.3333	0.2311	0.0204	0.0063	0.3406
84	0.0530	0.3529	0.5673	0.2244	0.0627	0.0281	0.3871
85	0.0000	0.2705	0.2766	0.1493	0.0506	0.0223	0.1548
86	0.0275	0.1860	0.2000	0.2126	0.0614	0.0254	0.1493
87	NA	NA	0.6000	0.1402	0.0541	0.0132	0.3939
Base	0.0434	0.2149	0.2230	0.1693	0.0547	0.0355	0.1906

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	RBT Age 4	SPR Age 4	BON Age 4	CWF Age 4	URB Age 4	WSH Age 4	STP Age 4	Fishery
79	1.0916	0.7430	NA	NA	1.1740	0.9775	NA	0.8779
80	1.6359	1.2910	0.7079	NA	1.2186	1.8346	NA	1.1165
81	0.4888	0.8244	0.7017	0.8376	1.1382	0.2827	NA	0.7680
82	0.7837	1.1416	1.5904	1.1624	0.4692	0.9052	1.0000	1.1587
83	0.7827	1.3045	1.4944	1.3648	0.3734	0.1779	1.7870	1.3378
84	1.2217	1.6421	2.5434	1.3248	1.1473	0.7922	2.0311	1.7988
85	0.0000	1.2585	1.2401	0.8816	0.9252	0.6291	0.8123	0.9921
86	0.6334	0.8656	0.8967	1.2556	1.1238	0.7157	0.7831	0.9257
87	NA	NA	2.6900	0.8280	0.9899	0.3721	2.0670	1.7848

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
RBT = ROBERTSON CREEK
SPR = SPRING CREEK
STP = STAYTON POND TULE
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	RBT Age 4	SPR Age 4	BON Age 4	CWF Age 4	URB Age 4	WSH Age 4	STP Age 4
79	0.0461	0.1567	NA	NA	0.0631	0.0347	NA
80	0.0699	0.2734	0.1579	NA	0.0656	0.0645	NA
81	0.0212	0.1723	0.1522	0.1383	0.0622	0.0100	NA
82	0.0331	0.2395	0.3514	0.1969	0.0256	0.0316	0.1860
83	0.0334	0.2757	0.3175	0.2264	0.0188	0.0063	0.3370
84	0.0515	0.3529	0.5673	0.2216	0.0627	0.0275	0.3790
85	0.0000	0.2705	0.2553	0.1465	0.0499	0.0223	0.1506
86	0.0275	0.1809	0.2000	0.2126	0.0603	0.0254	0.1493
87	NA	NA	0.6000	0.1353	0.0495	0.0132	0.3636
Base	0.0426	0.2105	0.2205	0.1676	0.0542	0.0352	0.1860

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	RBT Age 4	SPR Age 4	BON Age 4	CWF Age 4	URB Age 4	WSH Age 4	STP Age 4	Fishery
79	1.0823	0.7446	NA	NA	1.1660	0.9861	NA	0.8781
80	1.6416	1.2988	0.7162	NA	1.2118	1.8310	NA	1.1214
81	0.4979	0.8188	0.6902	0.8253	1.1487	0.2852	NA	0.7615
82	0.7781	1.1379	1.5936	1.1747	0.4735	0.8977	1.0000	1.1611
83	0.7856	1.3099	1.4399	1.3511	0.3479	0.1794	1.8117	1.3259
84	1.2089	1.6769	2.5731	1.3225	1.1579	0.7806	2.0379	1.8141
85	0.0000	1.2852	1.1581	0.8741	0.9207	0.6346	0.8099	0.9767
86	0.6452	0.8594	0.9071	1.2688	1.1138	0.7220	0.8025	0.9340
87	NA	NA	2.7214	0.8074	0.9149	0.3753	1.9551	1.7511

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
RBT = ROBERTSON CREEK
SPR = SPRING CREEK
STP = STAYTON POND TULE
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

WCVI TROLL AGES 3 AND 4

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	BON Age 3	BON Age 4	CWF Age 3	CWF Age 4	RBT Age 3	RBT Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	URB Age 4	WSH Age 4
79	0.2311	NA	NA	NA	0.0285	0.0473	0.1981	0.1597	NA	NA	0.0642	0.0347
80	0.1083	0.1579	0.1144	NA	0.0416	0.0710	0.2428	0.2775	NA	NA	0.0666	0.0652
81	0.1802	0.1565	0.0562	0.1418	0.0192	0.0212	0.1840	0.1772	0.2107	NA	0.0622	0.0100
82	0.2805	0.3547	0.0193	0.1969	0.0226	0.0340	0.1924	0.2454	0.2041	0.1906	0.0256	0.0322
83	0.3470	0.3333	0.0417	0.2311	0.0116	0.0339	0.3027	0.2804	0.2838	0.3406	0.0204	0.0063
84	0.2857	0.5673	0.0226	0.2244	0.0455	0.0530	0.2772	0.3529	0.3713	0.3871	0.0627	0.0281
85	0.2705	0.2766	0.0324	0.1493	0.0297	0.0000	0.1347	0.2705	0.1851	0.1548	0.0506	0.0223
86	0.3148	0.2000	0.0499	0.2126	0.1304	NA	0.2238	0.1860	0.1935	0.1493	0.0614	0.0254
87	0.2034	0.6000	0.0104	0.1402	0.0000	NA	0.1034	NA	0.2921	0.3939	0.0541	0.0132
Base	0.2000	0.2230	0.0633	0.1693	0.0280	0.0434	0.2043	0.2149	0.2074	0.1906	0.0547	0.0355

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BON Age 3	BON Age 4	CWF Age 3	CWF Age 4	RBT Age 3	RBT Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	URB Age 4	WSH Age 4	Fishery
79	1.1552	NA	NA	NA	1.0195	1.0916	0.9695	0.7430	NA	NA	1.1740	0.9775	0.9780
80	0.5413	0.7079	1.8078	NA	1.4870	1.6359	1.1882	1.2910	NA	NA	1.2186	1.8346	1.0731
81	0.9011	0.7017	0.8876	0.8376	0.6862	0.4888	0.9008	0.8244	1.0158	NA	1.1382	0.2827	0.8445
82	1.4024	1.5904	0.3046	1.1624	0.8073	0.7837	0.9416	1.1416	0.9842	1.0000	0.4692	0.9052	1.1002
83	1.7347	1.4944	0.6588	1.3648	0.4139	0.7827	1.4814	1.3045	1.3684	1.7870	0.3734	0.1779	1.3661
84	1.4284	2.5434	0.3577	1.3248	1.6246	1.2217	1.3569	1.6421	1.7902	2.0311	1.1473	0.7922	1.6384
85	1.3524	1.2401	0.5116	0.8816	1.0601	0.0000	0.6592	1.2585	0.8922	0.8123	0.9252	0.6291	0.9645
86	1.5739	0.8967	0.7888	1.2556	4.6619	NA	1.0955	0.8656	0.9327	0.7831	1.1238	0.7157	1.0981
87	1.0170	2.6900	0.1638	0.8280	0.0000	NA	0.5063	NA	1.4082	2.0670	0.9899	0.3721	1.3158

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
RBT = ROBERTSON CREEK
SPR = SPRING CREEK
STP = STAYTON POND TULE
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

WCVI TROLL AGES 3 AND 4

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	BON Age 3	BON Age 4	CWF Age 3	CWF Age 4	RBT Age 3	RBT Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	WSH Age 4
79	0.2151	NA	NA	NA	0.0248	0.0461	0.1857	0.1567	NA	NA	0.0347
80	0.0984	0.1579	0.1050	NA	0.0379	0.0699	0.2262	0.2734	NA	NA	0.0645
81	0.1597	0.1522	0.0472	0.1383	0.0175	0.0212	0.1668	0.1723	0.1942	NA	0.0100
82	0.2640	0.3514	0.0169	0.1969	0.0200	0.0331	0.1676	0.2395	0.1874	0.1860	0.0316
83	0.3108	0.3175	0.0350	0.2264	0.0091	0.0334	0.2819	0.2757	0.2635	0.3370	0.0063
84	0.2571	0.5673	0.0113	0.2216	0.0403	0.0515	0.2637	0.3529	0.3363	0.3790	0.0275
85	0.2340	0.2553	0.0286	0.1465	0.0275	0.0000	0.1154	0.2705	0.1639	0.1506	0.0223
86	0.3148	0.2000	0.0460	0.2126	NA	0.0275	0.2022	0.1809	0.1905	0.1493	0.0254
87	0.1313	0.6000	0.0036	0.1353	0.0000	NA	0.0862	NA	0.2163	0.3636	0.0132
Base	0.1843	0.2205	0.0564	0.1676	0.0251	0.0426	0.1866	0.2105	0.1908	0.1860	0.0352

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	BON Age 3	BON Age 4	CWF Age 3	CWF Age 4	RBT Age 3	RBT Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	WSH Age 4	Fishery
79	1.1672	NA	NA	NA	0.9902	1.0823	0.9952	0.7446	NA	NA	0.9861	0.9692
80	0.5340	0.7162	1.8634	NA	1.5115	1.6416	1.2124	1.2988	NA	NA	1.8310	1.0750
81	0.8663	0.6902	0.8373	0.8253	0.6997	0.4979	0.8940	0.8188	1.0180	NA	0.2852	0.8182
82	1.4324	1.5936	0.2993	1.1747	0.7986	0.7781	0.8984	1.1379	0.9820	1.0000	0.8977	1.1255
83	1.6864	1.4399	0.6210	1.3511	0.3629	0.7856	1.5108	1.3099	1.3808	1.8117	0.1794	1.3927
84	1.3951	2.5731	0.2009	1.3225	1.6060	1.2089	1.4135	1.6769	1.7625	2.0379	0.7806	1.6664
85	1.2698	1.1581	0.5070	0.8741	1.0987	0.0000	0.6187	1.2852	0.8589	0.8099	0.6346	0.9397
86	1.7080	0.9071	0.8171	1.2688	NA	0.6452	1.0835	0.8594	0.9982	0.8025	0.7220	1.0465
87	0.7126	2.7214	0.0644	0.8074	0.0000	NA	0.4620	NA	1.1338	1.9551	0.3753	1.2374

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
RBT = ROBERTSON CREEK
SPR = SPRING CREEK
STP = STAYTON POND TULE
URB = COLUMBIA RIVER UPRIVER BRIGHT
WSH = WILLAMETTE SPRING

STRAIT OF GEORGIA TROLL AND SPORT COMBINED

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4
79	0.2317	0.1790	0.4132	0.4828
80	0.2964	0.2940	0.3854	0.4392
81	0.3502	0.5065	0.5977	0.6172
82	0.1530	0.1425	0.3899	0.3333
83	0.3056	0.2137	0.3418	0.2727
84	0.3981	0.4918	0.4125	0.4531
85	0.1861	0.0982	0.3005	0.3930
86	0.2675	0.2167	0.4252	0.4729
87	0.1760	0.2747	0.5053	0.3774
Base	0.2578	0.2805	0.4465	0.4681

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4	Fishery
79	0.8985	0.6383	0.9254	1.0313	0.8993
80	1.1497	1.0480	0.8630	0.9383	0.9739
81	1.3582	1.8058	1.3385	1.3184	1.4258
82	0.5935	0.5078	0.8731	0.7121	0.7011
83	1.1851	0.7619	0.7654	0.5826	0.7803
84	1.5441	1.7533	0.9237	0.9678	1.2081
85	0.7218	0.3499	0.6730	0.8395	0.6729
86	1.0376	0.7726	0.9522	1.0101	0.9514
87	0.6827	0.9794	1.1315	0.8061	0.9177

Stock Identifiers

BQR = BIG QUALICUM
CAP = CAPILANO

STRAIT OF GEORGIA TROLL AND SPORT COMBINED

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4
79	0.2310	0.1790	0.4123	0.4828
80	0.2960	0.2940	0.3846	0.4392
81	0.3502	0.5065	0.5973	0.6172
82	0.1515	0.1425	0.3890	0.3333
83	0.3056	0.2137	0.3405	0.2727
84	0.3934	0.4918	0.4085	0.4520
85	0.1835	0.0982	0.2929	0.3895
86	0.2477	0.2136	0.4054	0.4651
87	0.1760	0.2729	0.4842	0.3774
Base	0.2572	0.2805	0.4458	0.4681

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4	Fishery
79	0.8983	0.6383	0.9249	1.0313	0.8991
80	1.1509	1.0480	0.8628	0.9383	0.9740
81	1.3618	1.8058	1.3398	1.3184	1.4269
82	0.5890	0.5078	0.8725	0.7121	0.7001
83	1.1882	0.7619	0.7637	0.5826	0.7801
84	1.5297	1.7533	0.9162	0.9655	1.2025
85	0.7135	0.3499	0.6570	0.8320	0.6641
86	0.9631	0.7616	0.9094	0.9936	0.9175
87	0.6845	0.9729	1.0861	0.8061	0.9028

Stock Identifiers

BQR = BIG QUALICUM
CAP = CAPILANO

STRAIT OF GEORGIA SPORT

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4
79	0.0860	0.1180	0.1849	0.3362
80	0.1538	0.2184	0.2098	0.1979
81	0.2445	0.4363	0.4404	0.4641
82	0.0726	0.0655	0.1767	0.1801
83	0.1343	0.1694	0.2034	0.2727
84	0.2765	0.4918	0.3293	0.4094
85	0.1678	0.0982	0.2551	0.3579
86	0.1968	0.2136	0.3511	0.4109
87	0.1348	0.2711	0.3930	0.3333
Base	0.1393	0.2096	0.2530	0.2946

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4	Fishery
79	0.6176	0.5633	0.7309	1.1414	0.8090
80	1.1048	1.0422	0.8295	0.6719	0.8702
81	1.7559	2.0818	1.7409	1.5754	1.7686
82	0.5216	0.3127	0.6987	0.6113	0.5522
83	0.9641	0.8081	0.8041	0.9259	0.8699
84	1.9853	2.3468	1.3018	1.3898	1.6812
85	1.2047	0.4684	1.0083	1.2150	0.9805
86	1.4135	1.0194	1.3878	1.3948	1.3080
87	0.9682	1.2935	1.5536	1.1316	1.2631

Stock Identifiers

BQR = BIG QUALICUM
CAP = CAPILANO

STRAIT OF GEORGIA SPORT

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4
79	0.0860	0.1180	0.1849	0.3362
80	0.1538	0.2184	0.2098	0.1979
81	0.2445	0.4363	0.4404	0.4641
82	0.0711	0.0655	0.1758	0.1801
83	0.1343	0.1694	0.2027	0.2727
84	0.2749	0.4918	0.3286	0.4094
85	0.1678	0.0982	0.2525	0.3579
86	0.1963	0.2136	0.3498	0.4109
87	0.1348	0.2711	0.3930	0.3333
Base	0.1389	0.2096	0.2527	0.2946

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4	Fishery
79	0.6194	0.5633	0.7315	1.1414	0.8095
80	1.1078	1.0422	0.8303	0.6719	0.8708
81	1.7608	2.0818	1.7425	1.5754	1.7698
82	0.5120	0.3127	0.6958	0.6113	0.5499
83	0.9668	0.8081	0.8022	0.9259	0.8698
84	1.9794	2.3468	1.3003	1.3898	1.6799
85	1.2080	0.4684	0.9992	1.2150	0.9783
86	1.4133	1.0194	1.3841	1.3948	1.3068
87	0.9709	1.2935	1.5549	1.1316	1.2640

Stock Identifiers

BQR = BIG QUALICUM
CAP = CAPILANO

STRAIT OF GEORGIA TROLL

TOTAL MORTALITY EXLOITATION RATES BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4
79	0.1457	0.0610	0.2283	0.1466
80	0.1426	0.0756	0.1755	0.2413
81	0.1057	0.0703	0.1573	0.1531
82	0.0804	0.0769	0.2131	0.1533
83	0.1713	0.0444	0.1384	0.0000
84	0.1216	0.0000	0.0832	0.0437
85	0.0183	0.0000	0.0455	0.0351
86	0.0707	0.0031	0.0742	0.0620
87	0.0412	0.0037	0.1123	0.0440
Base	0.1186	0.0709	0.1936	0.1736

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4	Fishery
79	1.2285	0.8600	1.1795	0.8444	1.0447
80	1.2026	1.0651	0.9068	1.3904	1.1408
81	0.8911	0.9905	0.8127	0.8822	0.8737
82	0.6778	1.0844	1.1010	0.8830	0.9408
83	1.4447	0.6253	0.7148	0.0000	0.6360
84	1.0259	0.0000	0.4296	0.2516	0.4464
85	0.1547	0.0000	0.2348	0.2022	0.1776
86	0.5961	0.0436	0.3831	0.3573	0.3772
87	0.3475	0.0516	0.5800	0.2537	0.3614

Stock Identifiers

BQR = BIG QUALICUM
CAP = CAPILANO

STRAIT OF GEORGIA TROLL

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4
79	0.1450	0.0610	0.2275	0.1466
80	0.1421	0.0756	0.1748	0.2413
81	0.1057	0.0703	0.1570	0.1531
82	0.0804	0.0769	0.2131	0.1533
83	0.1713	0.0444	0.1377	0.0000
84	0.1185	0.0000	0.0798	0.0426
85	0.0157	0.0000	0.0404	0.0316
86	0.0514	0.0000	0.0556	0.0543
87	0.0412	0.0018	0.0912	0.0440
Base	0.1183	0.0709	0.1931	0.1736

REPORTED CATCH EXPLOITATION RATE

Year	BQR Age 3	BQR Age 4	CAP Age 3	CAP Age 4	Fishery
79	1.2258	0.8600	1.1780	0.8444	1.0434
80	1.2015	1.0651	0.9053	1.3904	1.1402
81	0.8932	0.9905	0.8128	0.8822	0.8743
82	0.6795	1.0844	1.1038	0.8830	0.9421
83	1.4481	0.6253	0.7133	0.0000	0.6357
84	1.0017	0.0000	0.4133	0.2453	0.4333
85	0.1330	0.0000	0.2092	0.1819	0.1578
86	0.4345	0.0000	0.2881	0.3126	0.2902
87	0.3483	0.0258	0.4725	0.2537	0.3207

Stock Identifiers

BQR = BIG QUALICUM
CAP = CAPILANO

WASHINGTON/NORTHERN OREGON OCEAN TROLL AND SPORT AGE 3

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	CWF Age 3	SPR Age 3	STP Age 3	BON Age 3
79	NA	0.1829	NA	0.1355
80	0.1270	0.2883	NA	0.2106
81	0.0966	0.2726	0.1661	0.2047
82	0.1566	0.3184	0.2961	0.1782
83	0.0752	0.1217	0.1628	0.1289
84	0.0151	0.0797	0.0494	0.0825
85	0.0781	0.1702	0.1817	0.1641
86	0.1168	0.1191	0.2083	0.1111
87	0.0583	0.2586	0.2065	0.1381
Base	0.1267	0.2656	0.2311	0.1823

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	CWF Age 3	SPR Age 3	STP Age 3	BON Age 3	Fishery
79	NA	0.6889	NA	0.7432	0.7110
80	1.0017	1.0855	NA	1.1556	1.0893
81	0.7624	1.0265	0.7188	1.1233	0.9186
82	1.2358	1.1990	1.2812	0.9778	1.1784
83	0.5934	0.4581	0.7044	0.7073	0.6064
84	0.1191	0.3001	0.2139	0.4529	0.2814
85	0.6162	0.6407	0.7864	0.9005	0.7374
86	0.9217	0.4486	0.9016	0.6096	0.6894
87	0.4602	0.9739	0.8935	0.7575	0.8211

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
SPR = SPRING CREEK
STP = STAYTON POND TULE

WASHINGTON/NORTHERN OREGON OCEAN TROLL AND SPORT AGE 3

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	CWF Age 3	SPR Age 3	STP Age 3	BON Age 3
79	NA	0.1699	NA	0.1195
80	0.1144	0.2645	NA	0.1890
81	0.0854	0.2410	0.1512	0.1700
82	0.1446	0.2771	0.2707	0.1716
83	0.0692	0.1113	0.1495	0.1108
84	0.0113	0.0763	0.0446	0.0762
85	0.0762	0.1407	0.1605	0.1398
86	0.1100	0.1119	0.2083	0.1111
87	0.0526	0.2500	0.1795	0.1124
Base	0.1148	0.2381	0.2110	0.1625

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	CWF Age 3	SPR Age 3	STP Age 3	BON Age 3	Fishery
79	NA	0.7134	NA	0.7354	0.7223
80	0.9967	1.1109	NA	1.1628	1.1018
81	0.7439	1.0121	0.7167	1.0458	0.8915
82	1.2594	1.1636	1.2833	1.0560	1.1894
83	0.6032	0.4673	0.7088	0.6820	0.6070
84	0.0986	0.3205	0.2115	0.4688	0.2869
85	0.6637	0.5907	0.7609	0.8603	0.7120
86	0.9585	0.4700	0.9875	0.6837	0.7453
87	0.4584	1.0498	0.8510	0.6915	0.8185

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
SPR = SPRING CREEK
STP = STAYTON POND TULE

WASHINGTON/NORTHERN OREGON TROLL AND SPORT AGE 4

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	CWF Age 4	SPR Age 4	STP Age 4	BON Age 4
79	NA	0.1701	NA	NA
80	NA	0.1250	NA	0.0789
81	0.1667	0.2063	NA	0.3130
82	0.2756	0.1232	0.0563	0.0236
83	0.1840	0.0561	0.0906	0.0635
84	0.0438	0.0000	0.0081	0.0192
85	0.0423	0.0246	0.0502	0.0000
86	0.0565	0.0672	0.0249	0.0889
87	0.1328	NA	0.0000	0.0000
Base	0.2211	0.1562	0.0563	0.1385

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	CWF Age 4	SPR Age 4	STP Age 4	BON Age 4	Fishery
79	NA	1.0896	NA	NA	1.0896
80	NA	0.8005	NA	0.5698	0.6920
81	0.7537	1.3212	NA	2.2595	1.3299
82	1.2463	0.7887	1.0000	0.1707	0.8367
83	0.8319	0.3591	1.6101	0.4583	0.6889
84	0.1980	0.0000	0.1434	0.1388	0.1242
85	0.1911	0.1575	0.8925	0.0000	0.2046
86	0.2554	0.4302	0.4422	0.6416	0.4150
87	0.6007	NA	0.0000	0.0000	0.3194

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
SPR = SPRING CREEK
STP = STAYTON POND TULE

WASHINGTON/NORTHERN OREGON TROLL AND SPORT AGE 4

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	CWF Age 4	SPR Age 4	STP Age 4	BON Age 4
79	NA	0.1657	NA	NA
80	NA	0.1168	NA	0.0789
81	0.1596	0.1942	NA	0.3000
82	0.2717	0.1114	0.0517	0.0203
83	0.1840	0.0561	0.0870	0.0635
84	0.0438	0.0000	0.0081	0.0096
85	0.0423	0.0164	0.0418	0.0000
86	0.0532	0.0646	0.0249	0.0889
87	0.1304	NA	0.0000	0.0000
Base	0.2156	0.1470	0.0517	0.1331

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	CWF Age 4	SPR Age 4	STP Age 4	BON Age 4	Fishery
79	NA	1.1269	NA	NA	1.1269
80	NA	0.7942	NA	0.5933	0.6987
81	0.7401	1.3208	NA	2.2544	1.3188
82	1.2599	0.7580	1.0000	0.1523	0.8313
83	0.8532	0.3814	1.6831	0.4771	0.7134
84	0.2030	0.0000	0.1561	0.0723	0.1123
85	0.1960	0.1115	0.8099	0.0000	0.1836
86	0.2465	0.4394	0.4815	0.6680	0.4230
87	0.6047	NA	0.0000	0.0000	0.3257

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
SPR = SPRING CREEK
STP = STAYTON POND TULE

WASHINGTON/NORTHERN OREGON TROLL AND SPORT AGES 3 AND 4.

TOTAL MORTALITY EXPLOITATION RATES BY STOCK

Year	CWF Age 3	CWF Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	BON Age 3	BON Age 4
79	NA	NA	0.1829	0.1701	NA	NA	0.1355	NA
80	0.1270	NA	0.2883	0.1250	NA	NA	0.2106	0.0789
81	0.0966	0.1667	0.2726	0.2063	0.1661	NA	0.2047	0.3130
82	0.1566	0.2756	0.3184	0.1232	0.2961	0.0563	0.1782	0.0236
83	0.0752	0.1840	0.1217	0.0561	0.1628	0.0906	0.1289	0.0635
84	0.0151	0.0438	0.0797	0.0000	0.0494	0.0081	0.0825	0.0192
85	0.0781	0.0423	0.1702	0.0246	0.1817	0.0502	0.1641	0.0000
86	0.1168	0.0565	0.1191	0.0672	0.2083	0.0249	0.1111	0.0889
87	0.0583	0.1328	0.2586	NA	0.2065	0.0000	0.1381	0.0000
Base	0.1267	0.2211	0.2656	0.1562	0.2311	0.0563	0.1823	0.1385

TOTAL MORTALITY EXPLOITATION RATE INDEX BY STOCK

Year	CWF Age 3	CWF Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	BON Age 3	BON Age 4	Fishery
79	NA	NA	0.6889	1.0896	NA	NA	0.7432	NA	0.8089
80	1.0017	NA	1.0855	0.8005	NA	NA	1.1556	0.5698	0.9546
81	0.7624	0.7537	1.0265	1.3212	0.7188	NA	1.1233	2.2595	1.0792
82	1.2358	1.2463	1.1990	0.7887	1.2812	1.0000	0.9778	0.1707	1.0365
83	0.5934	0.8319	0.4581	0.3591	0.7044	1.6101	0.7073	0.4583	0.6407
84	0.1191	0.1980	0.3001	0.0000	0.2139	0.1434	0.4529	0.1388	0.2162
85	0.6162	0.1911	0.6407	0.1575	0.7864	0.8925	0.9005	0.0000	0.5162
86	0.9217	0.2554	0.4486	0.4302	0.9016	0.4422	0.6096	0.6416	0.5755
87	0.4602	0.6007	0.9739	NA	0.8935	0.0000	0.7575	0.0000	0.6502

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
SPR = SPRING CREEK
STP = STAYTON POND TULE

WASHINGTON/NORTHERN OREGON TROLL AND SPORT AGES 3 AND 4

REPORTED CATCH EXPLOITATION RATES BY STOCK

Year	CWF Age 3	CWF Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	BON Age 3	BON Age 4
79	NA	NA	0.1699	0.1657	NA	NA	0.1195	NA
80	0.1144	NA	0.2645	0.1168	NA	NA	0.1890	0.0789
81	0.0854	0.1596	0.2410	0.1942	0.1512	NA	0.1700	0.3000
82	0.1446	0.2717	0.2771	0.1114	0.2707	0.0517	0.1716	0.0203
83	0.0692	0.1840	0.1113	0.0561	0.1495	0.0870	0.1108	0.0635
84	0.0113	0.0438	0.0763	0.0000	0.0446	0.0081	0.0762	0.0096
85	0.0762	0.0423	0.1407	0.0164	0.1605	0.0418	0.1398	0.0000
86	0.1100	0.0532	0.1119	0.0646	0.2083	0.0249	0.1111	0.0889
87	0.0526	0.1304	0.2500	NA	0.1795	0.0000	0.1124	0.0000
Base	0.1148	0.2156	0.2381	0.1470	0.2110	0.0517	0.1625	0.1331

REPORTED CATCH EXPLOITATION RATE INDEX BY STOCK

Year	CWF Age 3	CWF Age 4	SPR Age 3	SPR Age 4	STP Age 3	STP Age 4	BON Age 3	BON Age 4	Fishery
79	NA	NA	0.7134	1.1269	NA	NA	0.7354	NA	0.8309
80	0.9967	NA	1.1109	0.7942	NA	NA	1.1628	0.5933	0.9599
81	0.7439	0.7401	1.0121	1.3208	0.7167	NA	1.0458	2.2544	1.0648
82	1.2594	1.2599	1.1636	0.7580	1.2833	1.0000	1.0560	0.1523	1.0355
83	0.6032	0.8532	0.4673	0.3814	0.7088	1.6831	0.6820	0.4771	0.6527
84	0.0986	0.2030	0.3205	0.0000	0.2115	0.1561	0.4688	0.0723	0.2119
85	0.6637	0.1960	0.5907	0.1115	0.7609	0.8099	0.8603	0.0000	0.4849
86	0.9585	0.2465	0.4700	0.4394	0.9875	0.4815	0.6837	0.6680	0.6068
87	0.4584	0.6047	1.0498	NA	0.8510	0.0000	0.6915	0.0000	0.6434

Stock Identifiers

BON = BONNEVILLE TULE
CWF = COWLITZ FALL TULE
SPR = SPRING CREEK
STP = STAYTON POND TULE