AN ABSTRACT OF THE THESIS OF

RONALD HERBERT HICKS for the M. S. in STATISTICS
(Name) (Degree) (Major)

Date thesis is presented August 7, 1964

Title AN EVALUATION OF THE PUNCH CARD METHOD OF ESTIMATING SALMON-STEELHEAD SPORT CATCH

Abstract approved Redacted for Privacy
(Major professor)

A primary objective of the management practices of the Oregon State Game Commission is to maximize and sustain the annual harvest of salmon and steelhead by sportsmen fishing in Oregon. Assessment of these practices is dependent upon an accurate determination of total annual sports harvest throughout the state.

Present total harvest figures are derived under a report card system which requires each salmon-steelhead angler fishing in Oregon to purchase and subsequently return to the Game Commission a punch card giving dates, rivers, and numbers of salmon and steelhead caught during the year. Unfortunately, only about 30 percent of the salmon-steelhead anglers return their cards. Lacking information on the harvest characteristics of anglers not returning punch cards, estimates of total annual catch, total catch by river, month, and type of angler have been made by simple expansion of punch card reported

catch. Inherent in this method of estimation are the assumptions that the average catch per angler by month, by river, by type of angler, and for the year are the same for anglers returning and for anglers not returning punch cards. This paper reports on an evaluation of these assumptions and on the method for estimating total catch.

Evaluation of the assumptions is based on comparisons of catch rate estimates from sample data (not punch cards) collected from both anglers returning and anglers not returning punch cards. Sample data was collected by means of double return postcard questionnaires in a sample survey during 1961. Stratified sampling was employed with allocations approximately proportional to the angler-fishing months in each stratum. Variances for the catch rate estimates made for both groups of anglers were estimated using replicated subsampling.

Nearly all comparisons indicate that the catch rates for anglers not returning punch cards were significantly lower than the catch rates for anglers returning punch cards. On the basis of the observed differences in catch rates, a procedure using ratios of the 1961 catch rate estimates is suggested for future estimates of total catch.

AN EVALUATION OF THE PUNCH CARD METHOD OF ESTIMATING SALMON-STEELHEAD SPORT CATCH

by

RONALD HERBERT HICKS

A THESIS

submitted to

OREGON STATE UNIVERSITY

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

August 1964

APPROVED:

Redacted for Privacy

Professor of Statistics

In Charge of Major

Redacted for Privacy

Head of Department of Statistics

Redacted for Privacy

Dean of Graduate School

Date thesis is presented August 7, 1964

Typed by Marion F. Palmateer

ACKNOWLEDGMENTS

The author wishes to express his appreciation for the valuable guidance and contributions of his advisor, Dr. Lyle D. Calvin; for the assistance of Bonita Peura and Larry Janssen in performing calculations; and for the research grant from the Oregon State Game Commission which made this study possible.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX TABLES

AN EVALUATION OF THE PUNCH CARD METHOD OF ESTIMATING SALMON-STEELHEAD SPORT CATCH

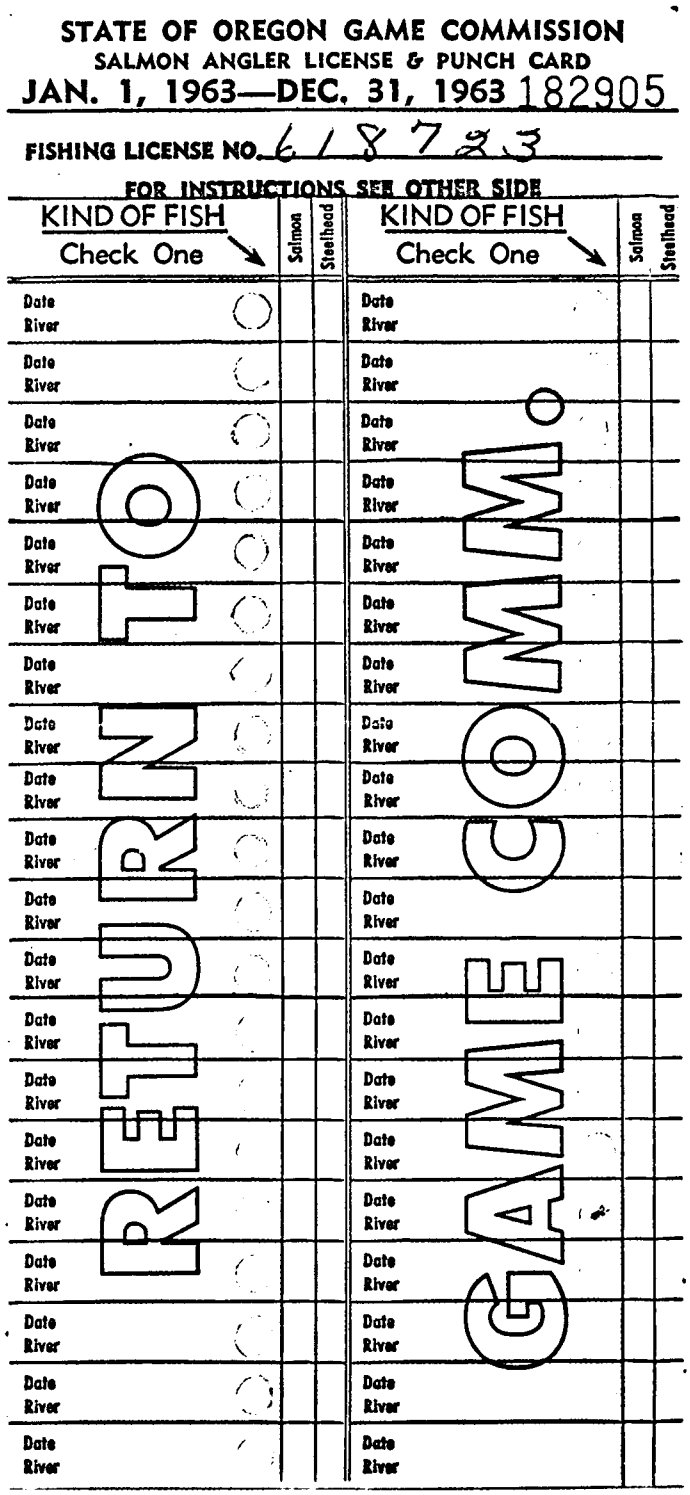
CHAPTER 1

INTRODUCTION

A primary objective of the management practices of the Oregon State Game Commission is to maximize and sustain the annual catch of salmon and steelhead by sportsmen fishing in Oregon. In 1960, this annual catch amounted to an estimated 146, 000 salmon and 80, 000 steelhead harvested by 172, 000 anglers fishing on the ocean and on some 75 rivers throughout the state. Although both species of fish are caught throughout the year, the major harvest of steelhead occurs during November, December, and January, while salmon are caught at an increasing rate from April through September.

Presently, estimates of annual harvest are based on catch information derived under a "report card" system which requires each angler fishing for salmon or steelhead in Oregon to obtain a punch card in addition to an Oregon fishing license. This punch card, shown in Figure 1 for 1963, permits fishing for both species of fish during the time for which the fishing license is valid. Upon catching a salmon or a steelhead, the angler is required to immediately remove a punch from the card and to record in the space provided the date, river, and

Figure 1. State of Oregon Salmon-Steelhead Punch Card Side 1



STATE OF OREGON GAME COMMISSION
SALMON ANGLER LICENSE & PUNCH CARD
JAN. 1, 1963—DEC. 31, 1963 182905

FISHING LICENSE NO. 618723

FOR INSTRUCTIONS SEE OTHER SIDE

KIND OF FISH Check One	Salmon	Steelhead	KIND OF FISH Check One	Salmon	Steelhead
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		
Date River	○		Date River		

RETURN TO GAME COMM.

Figure 2. State of Oregon Salmon-Steelhead Punch Card Side 2

NON-TRANSFERABLE

FEE $1.00

CHECK ONE

FISHED BUT DID NOT CATCH SALMON OR STEELHEAD _____

DID NOT FISH FOR SALMON OR STEELHEAD _____

Catch shall not exceed two per day or four in any seven consecutive days. See synopsis for exceptions.

1. All Anglers fishing for salmon or steelhead 20 inches and over in length during 1963 season must have in their possession a Salmon-Steelhead Punch Card.

2. Upon catching a fish as specified above, the licensee shall immediately completely remove a punch from his card and in addition shall record in space provided on face of the card, the date, river and type of fish.

3. This license must be returned to Game Commission, Portland, Oregon before July 1, 1964.

The Annual Bag Limit for Salmon and Steelhead, 20 inches and over in length, is 20 Salmon and 20 Steelhead.

The purpose of this license and punch card is to furnish the Game Commission with a measure of the catch, including the ocean take, and to determine the rivers which receive the greatest fishing load. Management practices aimed at the continued use of the resource and its preservation will result from the conscientious use of this card by each angler.

Steelhead **are distinguishable from salmon by the number** of rays in the anal fin just back of the vent. The steelhead has 12 or less and the salmon has more than 12.

Eastman Tag & Label Co. Portland, Ore.

type of fish caught. It is stated on the punch card that each angler must submit his card at the end of the year to the Oregon State Game Commission in Portland, Oregon, to facilitate the management practices of the commission. Unfortunately, response is not complete, and only about 30 percent of the annual salmon-steelhead fishing population comply by submitting their cards.

Since 1953, annual estimates of salmon-steelhead sport catch in Oregon have been derived by means of the "report card" system described above. Similar systems have been employed in the State of Washington since 1947 and in Idaho since 1962. Although subsequent estimates have been made principally from sample surveys conducted by mail, Michigan game kill estimates were also derived from a "report card" system prior to 1952. Response in these several states has been similar to the response noted in Oregon, and the accuracy of computed harvest estimates from these report card systems have all suffered from the effects of nonresponse. That is, the harvest characteristics of those sportsmen who do not respond have not always been the same as the harvest characteristics of those who do respond. Since assessment of the management practices of the Oregon State Game Commission is dependent upon an accurate determination of annual harvest, there is considerable interest in the effects of nonresponse on the annual estimate of salmon-steelhead sport catch in Oregon.

Estimates of total catch and estimates of catch by river and fishing month are computed annually from salmon-steelhead punch

cards returned to the Game Commission. The tables in Appendix A show some of these estimates for 1961. To make these estimates and to obtain measures of their precision, certain assumptions have been made about punch card data and about the catch characteristics of anglers not returning cards. The five primary assumptions are the following:

(1) The average catch per angler not returning a punch card is the same as the average catch per angler returning a card.

(2) For salmon and steelhead rivers in Oregon, the average catch on a given river per angler not returning a punch card is the same as the average catch on that river per angler returning a card.

(3) For each fishing month during the year, the average catch per angler not returning a punch card is the same as the average catch per angler returning a card.

(4) Anglers accurately report on their punch cards the month and river of catch.

(5) Anglers report their total catch.

Assumption (1) is made in estimating the average catch per angler for the year and in estimating the total number of fish caught. In the past, this average catch per angler has been computed by dividing the total catch reported on punch cards by the number of anglers returning cards. This figure has then been reported as an estimate of the catch per angler for the entire salmon-steelhead fishing population. An estimate of the total catch of the population has been made by multiplying this figure by the number of anglers who obtained punch cards

during the year. Estimates of total catch by month and river have been made in like fashion by dividing the appropriate reported catch by the proportion of punch cards purchased that are returned. This procedure requires assumptions (2) and (3) above. Of course, the accuracy of all estimates will have been impared if assumptions (4) and (5) are not valid. Since it is becoming increasingly important to have catch estimates calculated more precisely and without bias, it is important that the validity of these assumptions be established or that the extent of the bias be evaluated.

This thesis concerns an investigation of these assumptions and of the present procedures for estimating salmon-steelhead sport catch in Oregon. During 1961, data for this investigation were obtained by means of a sample survey of some 13,000 Oregon anglers. The survey was conducted principally by means of double return postcard questionnaires which requested one month's fishing information from each sampled angler. By comparing catch rates derived from questionnaire data for anglers returning and for anglers not returning punch cards and by comparing catch rates derived from punch card data with catch rates derived from survey questionnaire data, it was possible to study the assumptions above and to develop new estimating procedures which will yield better estimates of salmon-steelhead sport catch in the future.

CHAPTER 2

SAMPLING PROCEDURE

One purpose of the survey during 1961 was to provide data for estimating the catch rates of two subpopulations, anglers returning punch cards and anglers not returning punch cards, which comprise the total annual salmon-steelhead fishing population. At this point, it is convenient to be concerned only with this total population of salmon-steelhead anglers and to distinguish them as sportsmen under classifications (1) and (2) in the following breakdown of licensed Oregon sportsmen.

(1) Anglers who obtain punch cards at the same time they purchase their fishing licenses.

(2) Anglers who obtain punch cards at some time after the time of the license purchase.

(3) Sportsmen who do not fish for salmon or steelhead.

The sportsmen classified above purchase licenses annually from agents (primarily merchants) throughout the State of Oregon. At the end of each month, carbon copies of licenses sold during the month are collected at the game commission offices in Portland. It was the 1961 collection of license carbon copies which constituted the survey sampling frame. The sampling unit chosen was an angler month. It was felt that this sampling unit and the resulting employment of survey

questionnaires requesting only one month's fishing information would reduce angler memory bias since questionnaires could generally be issued within a month after the close of the month for which information was requested.

At the end of each month during 1961 and from those license carbon copies collected during the month, a sample was taken by selecting every kth license in the order of counting. As a kth license was counted, it was examined to determine whether a punch card had been purchased with the license as evidenced by the presence of a punch card number in the "fish" space on the license. If the license did not have a punch card number recorded, it was not admitted to the sample, and the next license in order was examined until one with a punch card number was found. Such a license was called a "valid license" and was admitted to the sample. Counting for succeeding licenses began at the last kth license counted and not from the valid one, and if no valid license was found in the interval between kth licenses, counting continued as though the k licenses in the interval were missing. Thus, anglers who had not obtained punch cards at the same time they purchased their licenses were not admitted to the sample. Principally, these anglers were not admitted because their punch card purchase records were not available in most cases until after the close of the year. To sample these anglers would have required considerable money and effort in comparison to the relatively

simple procedure described above. In addition, such sampled anglers would have been required to exhibit quite facile memories to report accurately their fishing activities after elapsed times as long as 12 months. Under the assumption that the catch characteristics of anglers not purchasing license and punch card simultaneously are the same as those of the sampled anglers, there is a basis for extending inference over the entire salmon-steelhead fishing population.

During the sampling, the order in which licenses were counted and selected was the order in which they were encountered, and no effort had been made, prior to sampling, to put them in any particular order. With respect to the number of fish caught by each angler, it was assumed that the license carbon copies were in random order. The sampling rates varied from month to month, and the respective k values are indicated below.

Table 1. Sampling Rates

Month	k	Month	k	Month	k
January	10	May	40	September	40
February	10	June	40	October	100
March	10	July	40	November	100
April	20	August	40	December	400

Determination of these k values was made in part from the license and punch card purchase records for 1960 by estimating the number of salmon-steelhead anglers eligible to fish during each month of 1961. The k values were then chosen to allocate over fishing months a total sample of 20,000 anglers subject to the following three conditions: (1) The sample would be allocated among fishing months in proportion to the number of anglers eligible to fish for salmon and steelhead during each month. This allocation corresponds to that which would result from a simple random sampling of the primary sampling unit, an angler-fishing month. (2) That portion of the allocated sample corresponding to anglers who purchased licenses in a given month would all be selected at the end of that month. This condition made it possible to proceed continuously and with a minimum of effort through the collection of license carbon copies as it grew each month. (3) The final sampling rates would allow for the fact that the frame did not consist entirely of "valid" licenses. Unfortunately, the estimated number of anglers eligible to fish for salmon and steelhead during each month of 1961 included anglers who had not purchased punch cards at the same time they had obtained their licenses. That is, sample size was apportioned on the basis of 1960 purchases, for which no figures were available on the number of anglers purchasing tags independently of licenses. Since these anglers were not admitted to the monthly samples, the proportionality specified in (1) above was

disturbed, and the final sample size was 15,875.

For each sampled angler, the following information was recorded on an IBM card:

Initials and last name of angler (Mrs. after name when appropriate and ascertained)

Street address, city, and state

Type of license held by angler (OSGC Code)

Month of license purchase

Punch card number

These cards[1] were used initially to produce listings to facilitate tallying survey questionnaire returns and to address gummed labels which were affixed to questionnaires for mailing. Later, by means of identification numbers punched in these cards and stamped on survey questionnaires, cards were collated with survey returns so that a purchase month, a questionnaire month or fishing month, and a license type could be associated with each item of survey data. The types of licenses purchased by anglers fishing in Oregon are listed in Table 2 on the following page.

To illustrate the remaining features of the sampling process, consider the sample taken after the end of June of salmon-steelhead anglers who purchased licenses during June. This sample was

[1] Sampling of license carbon copies and punching of the above mentioned IBM cards were carried out by the Game Commission in Portland.

Table 2. Angling Licenses Issued by the Oregon State Game Commission (OSGC)

OSGC Code	Type of License	Period of License
01	Resident Combination	purchase date to end of year
*02	Life Free Veteran Comb.	purchase date to end of year
04	Resident Angler	purchase date to end of year
05	Juvenile Angler	purchase date to end of year
06	Non-Resident Angler	purchase date to end of year
07	Five-Day Vacation Angler	five days indicated on license
46	Daily Angler	one day indicated on license
12	Pioneer Combination	purchase date to end of year
13	Pioneer Angler	purchase date to end of year
35	Veteran Combination	purchase date to end of year
36	Veteran Angler	purchase date to end of year
38	Old Age Combination	purchase date to end of year
39	Old Age Angler	purchase date to end of year

*Because of the very small number of type 02 licenses issued in 1961, this classification of anglers is not included in this study.

randomly divided into seven subsamples of equal size, one for June and six for the remaining fishing months during the year. To members of the first subsample, questionnaires requesting information about fishing activity during June were mailed as soon as possible after the sample was drawn. Questionnaires were mailed shortly after the close of July to members of the second subsample requesting information about fishing success during July, and the rest of the subsamples were dealt with in like fashion during the remaining months of the year. Each of the 12 monthly samples was processed in this

manner. That is, each sample was evenly divided into a number of subsamples depending upon the number of fishing months left in the year, and questionnaires were mailed to the members of these subsamples for a month's information at the appropriate time of the year. Early in July for instance, questionnaires concerning fishing success during June were mailed to members of subsamples from each of the monthly samples of anglers purchasing licenses from January through June.

There was an exception to the subsampling process for two groups of anglers, the Five Day Vacation Anglers (OSGC code 07) and the Daily Anglers (OSGC code 46). These anglers are eligible to fish during the purchase month for a limited period only, for five days in the first case and for a single day in the latter case. Therefore, sampled anglers of these two types were not included in the subsampling process but immediately received questionnaires concerning their fishing success during the month of license purchase. Consequently, the effective sampling rate was greater for these two groups of anglers than for other anglers.

Additional attempts were made to elicit information from sampled anglers not returning initial questionnaires. Anglers not responding to the initial questionnaire within a 14 day period were mailed a first reminder questionnaire. After an additional 14 day period, second reminder questionnaires were mailed to each of those anglers who had

not responded to either the initial or first reminder questionnaires. During the months of July through October, additional attempts were made to contact anglers not responding to any of the postcard questionnaires. The first attempt was made by telephone[2], and those anglers who were contacted gave their reports over the telephone. The second attempt employed personal interviews[3] conducted with those anglers in Oregon who could be located.

Examples of the double return postcard questionnaires are shown in Figures 3 through 7. One-half of the double postcard consisted of the questionnaire proper on one side with the other side containing a return address under a postal permit. The other half was a postcard with a short introductory note on one side and metered first class postage together with the name and address of the angler on the other side. For mailing, the double postcard was folded at a perforation so that the questionnaire and the introductory note faced each other, and the free ends were closed with a small piece of tape. Upon receipt of this double postcard, an angler had only to separate the two cards, fill in the questionnaire, and mail the completed questionnaire postcard. Printing on the initial, first reminder, and second reminder double postcards was done in black, green, and orange respectively.

---

[2]Telephone interviews were conducted by the firm of Clark, Bardsley, and Haslacher, Portland, Oregon.

[3]Personal interviews were conducted by agents of the Game Commission.

Figure 3. Double Return Postcard Questionnaire Side 1

Salmon-Steelhead Survey

Did you fish for salmon or steelhead during February 1961? Yes ☐ No ☐

If yes, please fill in the information below for days fished.

Feb.	Check (✓) days fished	If you were fishing . . .		Check (✓) if you caught fish	If you caught fish, how many . . .	
		. . . on a river, which river?	. . . on the ocean, near which river?		Salmon	Steelhead
Wed. 1						
Thu. 2						
Fri. 3						
Sat. 4						
Sun. 5						
Mon. 6						
Tue. 7						
Wed. 8						
Thu. 9						
Fri. 10						
Sat. 11						
Sun. 12						
Mon. 13						
Tue. 14						
Wed. 15						
Thu. 16						
Fri. 17						
Sat. 18						
Sun. 19						
Mon. 20						
Tue. 21						
Wed. 22						
Thu. 23						
Fri. 24						
Sat. 25						
Sun. 26						
Mon. 27						
Tue. 28						

Please detach and mail TODAY. THANK YOU.

Figure 4. Double Return Postcard Questionnaire Side 2

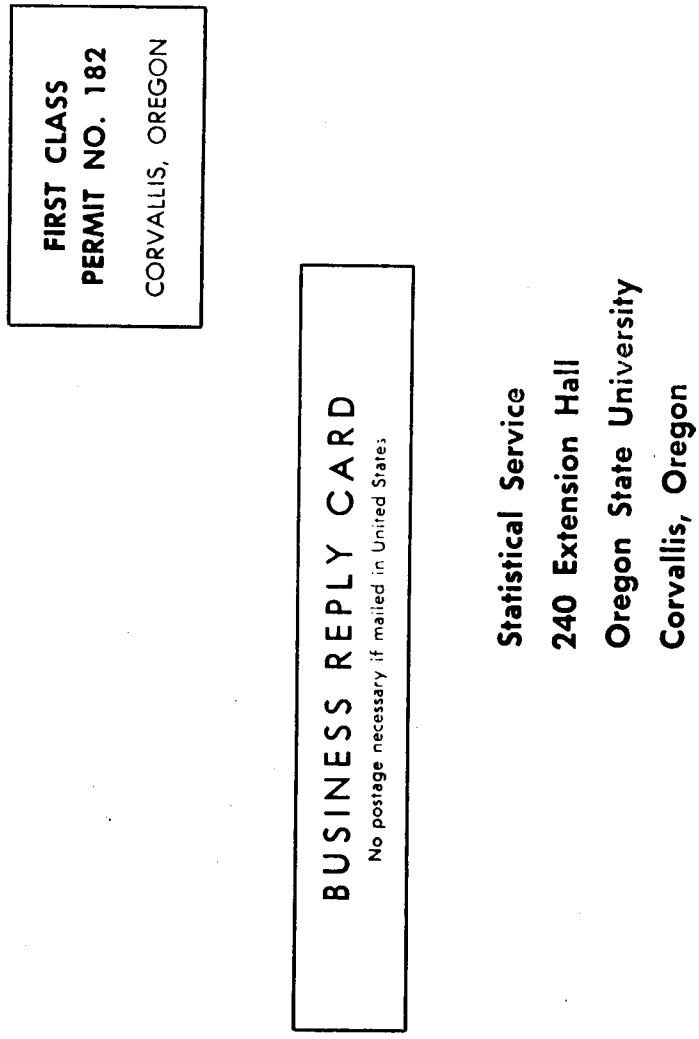


Figure 5. Double Return Postcard Questionnaire Side 3

Mr. Oregon Angler:

You have been selected as a representative angler to help us obtain an accurate appraisal of the 1961 salmon-steelhead catch. Your experiences added to those of many others will give us very important information necessary for the best use and preservation of fish in future years.

Please note that this survey covers only one month. If you did not fish for salmon or steelhead during the month, answer only the first question before returning the card.

Please fill out the attached card and mail today. No stamp is required. Many thanks.

STATISTICAL SERVICE
Oregon State University
in cooperation with
Oregon State Game Commission

Figure 6. Double Return Postcard Questionnaire Side 4

Figure 7. Texts of Reminder Questionnaires

FIRST REMINDER

A few days ago we asked you to help us by supplying certain information about your recent fishing experiences. The information you mail us, added to that of many others, is important for the best management of salmon and steelhead runs in future years.

Since we haven't heard from you, we would appreciate it if you would fill out the attached card and mail it today. This information is needed even though you may not have fished for salmon or steelhead during the past month. Many thanks.

STATISTICAL SERVICE
Oregon State University
in cooperation with
Oregon State Game Commission

SECOND REMINDER

Some time ago we asked you to help by supplying certain information regarding your recent angling for salmon or steelhead. The information that you can give is very important to us, so we are sending another card in case the others have been lost or mislaid.

Fishing information is requested for only one month. If you did not fish for salmon or steelhead during the month, please check only the first question on the card and send it in. If you did fish for salmon or steelhead during the month, please fill in the card carefully and mail it to us right away. Thank you.

STATISTICAL SERVICE
Oregon State University
in cooperation with
Oregon State Game Commission

The reminder questionnaires were identical in form to the initial questionnaire except for the introductory notes which were worded appropriately.

Operationally, a gummed label printed with the name and address of a sample angler was affixed to each double return postcard. Each postcard was stamped with an identification number identical to one punched in the associated IBM card and then mailed. Upon receipt of a returned questionnaire, the date was tallied, and by comparison with the identification number, the associated IBM card was set aside, so that 14 days after issuing the initial questionnaire, the remaining cards could be used to address labels for the first reminder questionnaires. This process continued with the issuing of questionnaires at each stage of mailing facilitated by the use of IBM punch cards and mechanized addressing.

Subsequently, the IBM cards were collated by means of the identification number, with data cards punched from returned questionnaires, so that a fishing month (questionnaire month), a license type, and a month of license purchase could be associated with each item of questionnaire information. Chapter 4 relates the use of fishing month, angler type, and purchase month as bases for stratification in the methods of analysis.

CHAPTER 3

SAMPLING RESPONSE

During 1961, 201,016 salmon-steelhead punch cards were purchased in Oregon. Of these, only 141,603 (about 70 percent) were obtained at the time of license purchase. Sampling from these 141,603 under the procedure discussed in Chapter 2 resulted in a total survey sample of 15,875 anglers.

To complete the mail portion of the survey, 29,232 postcard questionnaires were used; 15,875 were initial questionnaires, 8,525 were first reminders, and 4,832 were second reminder questionnaires. For the questionnaire months of July through October, 579 telephone interviews and 355 personal interviews were completed. Including the completed telephone and personal interviews, response was obtained from 13,655 anglers (86 percent of the 15,875 sampled). Data reported on 22 questionnaires were too ambiguous to be used, and clerical errors prior to mailing invalidated 201 other questionnaire returns. Returns from the remaining 13,332 anglers were used for the analyses in the following chapters.

In Table 3, cumulative percentage returns are given for the year by questionnaire month (month for which questionnaire requested fishing information). The two reminder mailings, although separately

less efficient than the initial mailing, were quite effective in raising the initial response. These two reminder mailings together were about 60 percent effective and, combined with a 47 percent return on the initial mailings, effected response from 80 percent of the sampled anglers. The relatively costly telephone and personal interviewing procedures yielded between 30 and 40 percent return. By employing these interviewing procedures for the questionnaire months of July through October, an overall response of 86 percent was achieved.

Table 4 indicates effective sampling rates by purchase month for several angler types. The average effective sampling rate was about 1.3 percent. The rates for Daily and Five-Day Vacation anglers (OSGC codes 46 and 07) were somewhat greater than the average while the rates for Pioneer, Veteran, and Old Age anglers (OSGC codes 12-39) were smaller than average. As mentioned in Chapter 2, it was expected that the rates for Daily and Five-Day Vacation anglers would be greater than average because these anglers were not subjected to the subsampling process performed for all other angler types. However, the relatively small effective sampling rates for Pioneer, Veteran, and Old Age anglers were unexpected. It was determined subsequent to completion of sampling that a portion of the 1961 Pioneer and Veteran anglers purchasing licenses and punch cards during January had not been sampled. From Table 5 in Chater 5 it was determined that 81.9 percent of the total 1961 Pioneer and Veteran angler-fishing months

Table 3. Questionnaire Cumulative Percentage Returns

Questionnaire Month	No. of Initial Questionnaires mailed	Response at mailing date of first reminder %	Response after second reminder %	Response after telephone interviews %	Response after personal interviews%	Total Response	No. of questionnaires used for computations
January	406	57.1	86.0			349	328
February	519	56.3	85.7			445	436
March	685	52.4	83.5			572	560
April	991	41.4	80.8			801	791
May	1,112	48.4	80.9			899	883
June	1,251	44.4	81.5			1,020	1,001
July	1,535	46.3	80.9	88.7	94.0	1,443	1,396
August	1,825	42.5	79.5	87.6	91.9	1,677	1,649
September	1,865	43.0	77.5	85.8	89.7	1,673	1,636
October	2,235	45.5	79.1	86.1	89.8	2,007	1,939
November	1,718	49.5	80.2			1,378	1,357
December	1,733	48.6	80.3	____	____	1,391	1,356
Totals	15,875					13,655	13,332
Composite Response		46.6%	80.4%		86.0%		

Table 4. Effective Sampling Rates

Month	Angler Type (OSGC Code) 01 A	01 B	01 C	04 A	04 B	04 C
January	14, 203	158	1.06	14, 529	139	.95
February	16, 673	201	1.21	17, 942	180	1.00
March	19, 750	229	1.16	24, 102	260	1.08
April	23, 622	312	1.32	35, 842	381	1.06
May	25, 357	246	1.36	40, 112	430	1.07
June	26, 357	350	1.33	43, 120	461	1.07
July	28, 038	421	1.50	47, 690	675	1.41
August	29, 261	452	1.54	51, 566	651	1.26
September	29. 904	488	1.63	53, 299	762	1.43
October	29. 983	611	2.04	54, 058	996	1.84
November	29, 987	464	1.55	54, 354	709	1.30
December	30, 279	446	1.47	54, 731	726	1.33
Totals		4, 478			6, 370	

Month	Angler Type (OSGC Code) 05 A	05 B	05 C	06 A	06 B	06 C
January	1, 436	9	.63	189	3	1.59
February	1, 793	20	1.12	265	3	1.13
March	2, 517	20	.79	371	10	2.69
April	3, 811	43	1.13	628	10	1.59
May	4, 182	53	1.27	788	8	1.01
June	4, 507	58	1.29	989	11	1.11
July	4, 985	80	1.60	1, 233	14	1.13
August	5, 411	92	1.70	1, 567	13	.83
September	5, 545	89	1.60	1, 862	11	.59
October	5, 597	107	1.91	1, 948	38	1.95
November	5, 634	67	1.19	1, 957	21	1.07
December	5, 668	105	1.85	1, 963	15	.76
Totals		743			157	

Table 4. Continued

Month	Angler Type (OSGC Code) 07 & 46 A	B	C	12 - 39 A	B	C	A Totals
Jan.	517	9	1.74	8,983	19	.21	39,920
Feb.	248	2	.81	10,358	32	.31	47,279
March	306	2	.65	10,790	41	.38	57,836
April	726	9	1.24	11,201	45	.40	75,830
May	723	2	.27	11,300	46	.41	82,462
June	2,067	70	3.38	11,343	51	.45	88,383
July	8,097	137	1.69	11,396	69	.61	101,439
Aug.	13,852	374	2.70	11,439	67	.58	113,096
Sept.	6,879	221	3.21	11,459	65	.57	108,948
Oct.	2,218	118	5.32	11,465	69	.60	105,269
Nov.	757	31	4.09	11,467	65	.57	104,156
Dec.	1,079	1	.09	11,493	63	.55	105,213
Totals		976			632		

A Number of anglers purchasing license and punch card simultaneously who were eligible to fish during month indicated

B Number of anglers who returned questionnaires for month indicated

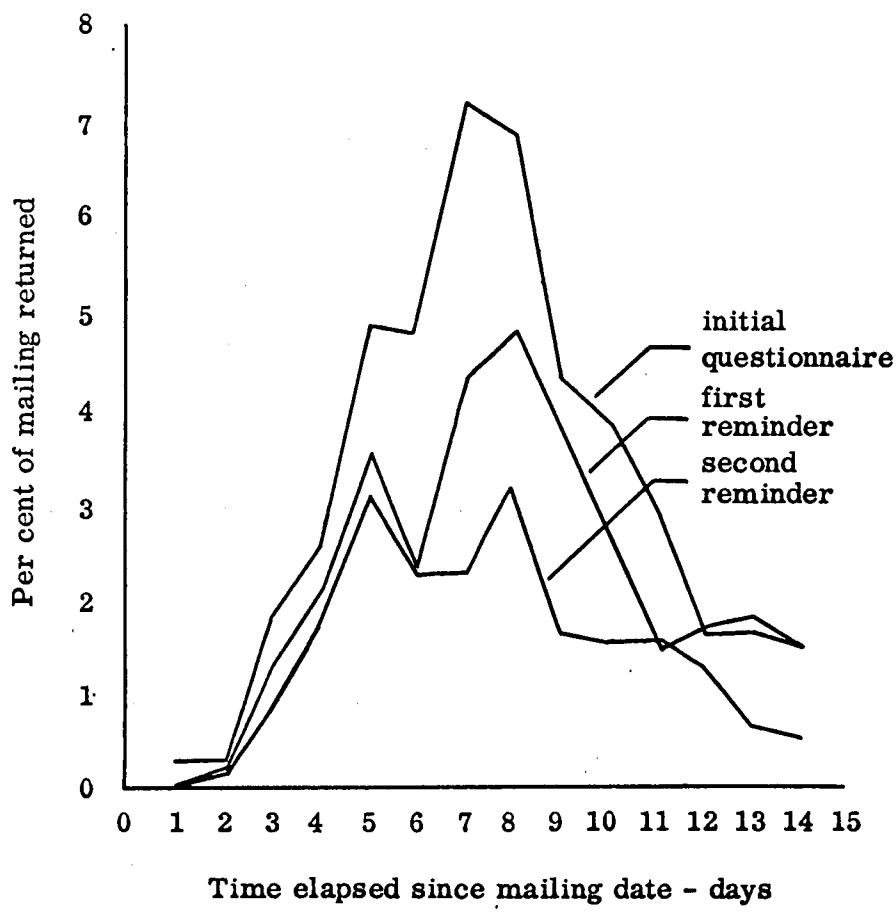
C Effective sampling rate (B/A) - percent

arose from purchases during January, so that the omission of anglers from the sample taken at the end of January resulted in lower effective sampling rates over the entire year. The general variability of sampling rates over purchase months reflects errors in estimation of numbers of anglers eligible to fish as well as the effects of rounding a computed sampling rate of, say, one in every 12.9 to a rate such as one in every ten.

Examination of average daily questionnaire return rates as shown in Figure 8 indicates a peak return rate at about seven or eight days after the mailing date. The general pattern of return rates is the same for all three mailings, and it appears that an interval between mailings somewhat shorter than 14 days might well have been used (6, p. 398). These response rates were calculated by associating each questionnaire returned with a particular mailing. They do not reflect, for instance, initial questionnaires returned due to receipt of a second reminder. In addition, it should be noted that mailing of questionnaires was not limited to one particular day of the week, but mailings were uniformly distributed over a six day work week. Returned questionnaires were also tallied on the day received over a six day week, Sunday being the only day on which questionnaires were neither mailed nor received.

Some 668 anglers returned more than one questionnaire. Of these, 583 were anglers who returned two questionnaires with identical

Figure 8. **Daily Questionnaire Return Rates**



reports. However, approximately 90 percent of these 583 were from anglers who reported that they did not fish during the questionnaire month, a fact that seems easily remembered. Seventy-five anglers returned two questionnaires with reports which did not match. About 20 percent of these 75 were from anglers who caught no fish during the questionnaire month; however, each in this 20 percent reported on the second questionnaire returned that he had not fished whereas dates and rivers of fishing trips had been reported on the first questionnaire returned. Another 30 percent of these 75 had the same catch totals reported on both questionnaires returned, but the two questionnaires differed in reported dates and rivers. The remaining 50 percent of these 75 consisted of mismatches in total catch as well as dates, rivers, and numbers of fishing trips during the questionnaire month. Only ten anglers responded after three mailings by returning all three questionnaires. In all cases of multiple returns, the questionnaire used for analysis was the one corresponding to the earliest mailing.

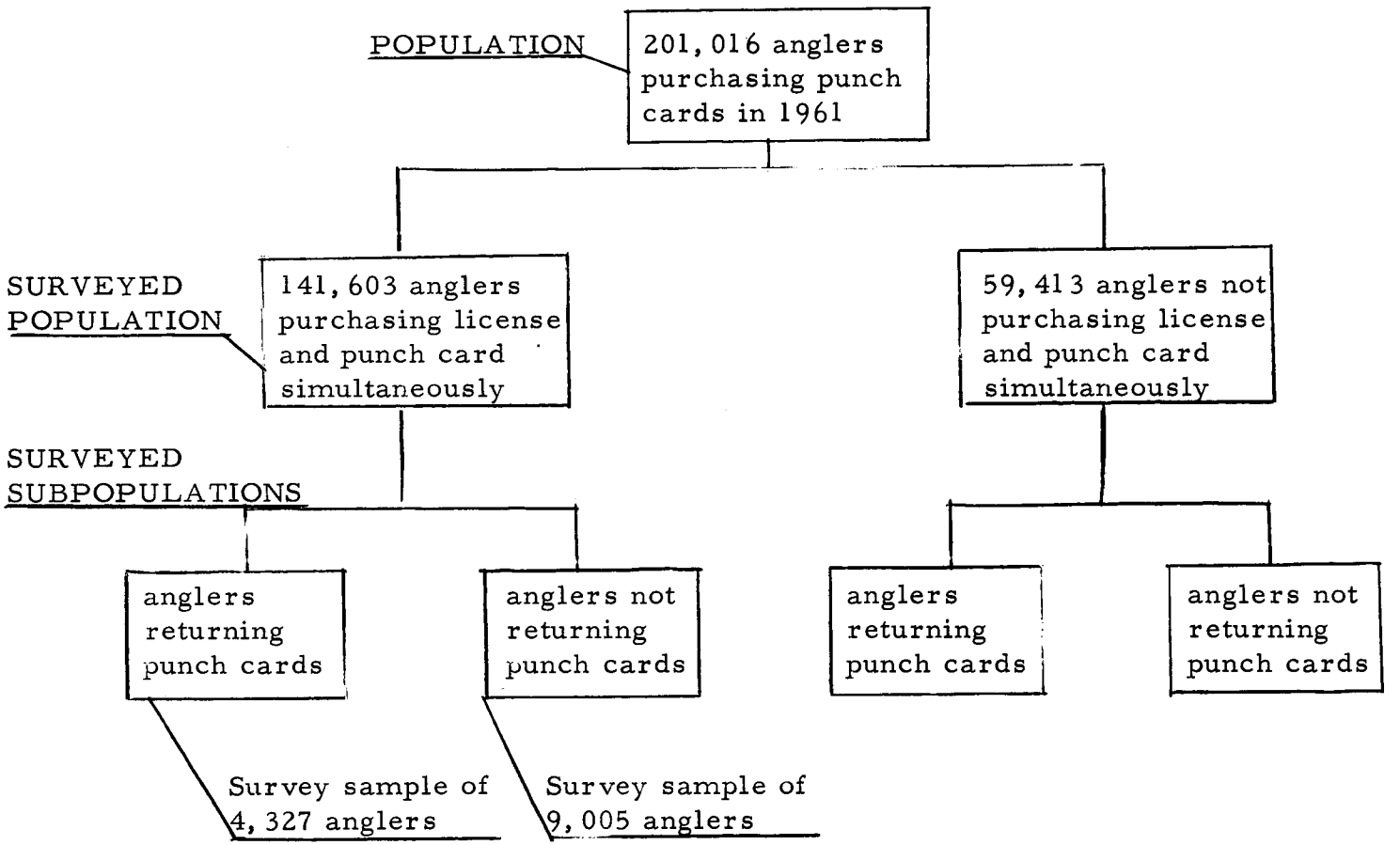
CHAPTER 4

METHODS OF ANALYSIS

It should be mentioned again that only anglers who obtained salmon-steelhead punch cards concurrent with the license purchase were admitted to the survey sample. In 1961, 141, 603 of the total 201, 016 salmon-steelhead anglers fell into this category. In the following, the 201, 016 will be termed "the population" whereas the 141, 603 will be called "the surveyed population." In Chapter 2 it was stated that the population will be considered to consist of two subpopulations, anglers returning punch cards at the end of the year and anglers not returning punch cards at the end of the year. Similarly, the surveyed population will be considered to consist of two "surveyed subpopulations", anglers returning punch cards and anglers not returning punch cards. This breakdown of the 1961 salmon-steelhead fishing population is diagrammed in Figure 9.

From the punch cards returned to the Game Commission after the close of 1961, the survey questionnaires were divided into two groups, one group of 4, 327 questionnaire returns constituting a sample from the surveyed subpopulation of anglers who returned punch cards, and the other group of 9, 005 questionnaire returns constituting a sample from the surveyed subpopulation of anglers who did not return

Figure 9. Breakdown of 1961 Salmon-Steelhead Fishing Population



punch cards. The first assumption that average catch rates are the same for anglers returning and for anglers not returning punch cards was studied by comparing estimates of the average annual catch per angler for these two groups of anglers as determined from the questionnaire returns. The second and third assumptions regarding equality of catch rates by river and month were studied by further dividing questionnaires into subgroups on the basis of rivers and fishing months and by comparing catch rate estimates from these subgroups. Of course, for the assumptions that anglers accurately report total catch, it was necessary to consider only anglers returning punch cards. These last two assumptions were investigated by studying the discrepancies in reported catch between punch card and survey questionnaire returns. Inherent in these methods of study is the assumption that the receipt of a survey questionnaire in no way influenced the recipient as to whether or not the punch card would be returned to the Game Commission at the end of the year.

Estimates of Catch Rates

Monthly catches of both surveyed subpopulations (and therefore the surveyed population) of salmon-steelhead anglers were stratified according to the following classifications:

i - Month of License Purchase ($i = 1, 2, \ldots, 12$)

j - Type of Angler (according to the OSGC code for type of license purchased, see Table 2 on page 12)

k - Fishing Month (k = 1, 2, . . . , 12)

In the following, i and j define a stratum, and k a substratum within ij. It is convenient to present the ideas in this chapter in terms of the full range of these three indices, but, as will be discussed in Chapter 5, some strata were restricted for computation of catch rate estimates.

Considering first the anglers who returned punch cards, an average catch per angler for the year could be computed for this surveyed subpopulation according to the following equation:

$$C_1 = \frac{\sum_i \sum_j \sum_k Y_{1ijk}}{\sum_i \sum_j N_{1ij}} \qquad (4.1)$$

where

N_{1ij} is the number of anglers who returned punch cards and who purchased licenses of type j during month i,

Y_{1ijk} is the total number of fish caught during month k by the N_{1ij} anglers.

Similarly for the surveyed subpopulation of anglers who did not return punch cards, an average catch per angler for the year could be computed according to the following equation:

$$C_0 = \frac{\sum_i \sum_j \sum_k Y_{0ijk}}{\sum_i \sum_j N_{0ij}} \qquad (4.2)$$

where

N_{0ij} is the number of anglers who did not return punch cards and who purchased licenses of type j during month i,

Y_{0ijk} is the total number of fish caught during month k by the N_{0ij} anglers.

The stratum sizes N_{1ij} and N_{0ij} can be expressed in terms of their sum N_{ij} as follows:

$$N_{1ij} = P_{ij} N_{ij}, \qquad (4.3)$$

$$N_{0ij} = Q_{ij} N_{ij}, \qquad (4.4)$$

where

N_{ij} is the number of anglers who purchased licenses of type j during month i,

and where P_{ij} and Q_{ij} are proportions.

Then

$$C_1 = \frac{\sum_i \sum_j \sum_k Y_{1ijk}}{\sum_i \sum_j P_{ij} N_{ij}}, \qquad (4.5)$$

$$C_0 = \frac{\sum_i \sum_j \sum_k Y_{0ijk}}{\sum_i \sum_j Q_{ij} N_{ij}}. \qquad (4.6)$$

Finally, (4. 1) and (4. 2) may be written as:

$$C_1 = \frac{\sum_i \sum_j P_{ij} N_{ij} \sum_k \left(\frac{Y_{1ijk}}{P_{ij} N_{ij}} \right)}{\sum_i \sum_j P_{ij} N_{ij}}, \tag{4.7}$$

$$C_0 = \frac{\sum_i \sum_j Q_{ij} N_{ij} \sum_k \left(\frac{Y_{0ijk}}{Q_{ij} N_{ij}} \right)}{\sum_i \sum_j Q_{ij} N_{ij}}. \tag{4.8}$$

In equations (4. 7) and (4. 8), $\frac{Y_{1ijk}}{P_{ij} N_{ij}}$ and $\frac{Y_{0ijk}}{Q_{ij} N_{ij}}$ define catch rates in stratum ij for fishing month k, and C_1 and C_0 are weighted means of strata average annual catches per angler.

The quantities in the numerators and denominators of the equations above are not known for the surveyed population, but from the questionnaire data, estimates of $\frac{Y_{1ijk}}{P_{ij} N_{ij}}$, $\frac{Y_{0ijk}}{Q_{ij} N_{ij}}$, $P_{ij} N_{ij}$, and $Q_{ij} N_{ij}$ can be obtained, and C_1 and C_0 may be estimated according to the following equations:

$$c_1^q = \frac{\sum_{ij} p_{ij} N_{ij} \sum_k \left(\frac{y^q_{1ijk}}{n_{1ijk}} \right)}{\sum_{ij} p_{ij} N_{ij}}, \tag{4.9}$$

$$c_0^q = \frac{\sum_{ij} q_{ij} N_{ij} \sum_k \left(\frac{y^q_{0ijk}}{n_{0ijk}} \right)}{\sum_{ij} q_{ij} N_{ij}}, \tag{4.10}$$

where

$$n_{ijk} = n_{1ijk} + n_{0ijk}, \tag{4.11}$$

$$p_{ij} = \frac{\sum_k n_{1ijk}}{\sum_k n_{ijk}}, \tag{4.12}$$

$$q_{ij} = \frac{\sum_k n_{0ijk}}{\sum_k n_{ijk}}, \tag{4.13}$$

and where

n_{ijk} is the number of anglers purchasing licenses of type j in month i who returned questionnaires for month k,

n_{1ijk} is that portion of the n_{ijk} who returned punch cards,

n_{0ijk} is that portion of the n_{ijk} who did not return punch cards,

y^q_{1ijk} is the total number of fish reported on the survey questionnaires (q) by the n_{1ijk} anglers,

y^q_{0ijk} is the total number of fish reported on the survey questionnaires (q) by the n_{0ijk} anglers.

Referring to equations (4.7) and (4.8), the strata sizes N_{0ijk} and N_{1ijk} are expressed in terms of P_{ij}, Q_{ij}, and N_{ij} because the N_{0ij} and the N_{1ij} could not be determined from the frame. However, N_{0ij} and N_{1ij} can be estimated, as in equations (4.9) and (4.10), from the observed proportions p_{ij} and q_{ij}. Since it is assumed that the sampling procedure of Chapter 2 constitutes simple random

sampling within each stratum (and substratum), the $p_{ij}N_{ij}$ and the $q_{ij}N_{ij}$ are considered unbiased estimates of N_{1ij} and N_{0ij} respectively. Equations (4. 9) and (4. 10) exhibit the gneral form of all catch rate estimating equations in this chapter.

Equations (4. 9) and (4. 10) were used directly to provide catch rate estimates for studying the first assumption. In addition annual catch rates by type of angler were estimated using the following equations:

$$c_{1j}^{q} = \frac{\sum_{i} p_{ij}N_{ij} \sum_{k} \left(\frac{y_{1ijk}^{q}}{n_{1ijk}} \right)}{\sum_{i} p_{ij}N_{ij}}, \tag{4.14}$$

$$c_{0j}^{q} = \frac{\sum_{i} q_{ij}N_{ij} \sum_{k} \left(\frac{y_{0ijk}^{q}}{n_{0ijk}} \right)}{\sum_{i} q_{ij}N_{ij}}. \tag{4.15}$$

Equations (4. 14) and (4. 15) estimate the average annual catch by anglers of type j per angler of type j in the respective surveyed subpopulations.

For assumption 2 where catch rates were considered for various Oregon rivers, the following equations were employed:

$$c_{1r}^{q} = \frac{\sum_{ij} p_{ij}N_{ij} \sum_{k} \left(\frac{y_{1rijk}^{q}}{n_{1ijk}} \right)}{\sum_{ij} p_{ij}N_{ij}}, \tag{4.16}$$

$$c^q_{0r} = \frac{\sum_{ij} q_{ij} N_{ij} \sum_k \left(\frac{y^q_{0rijk}}{n_{0ijk}} \right)}{\sum_{ij} q_{ij} N_{ij}}, \qquad (4.17)$$

where

y^q_{1rijk} is the total number of fish reported caught on river r by the n_{1ijk} sampled anglers,

y^q_{0rijk} is the total number of fish reported caught on river r by the n_{0ijk} sampled anglers.

A c^q_{1r} is an estimate of average annual catch on river r per angler returning a punch card, and c^q_{0r} estimates the average annual catch on river r per angler not returning a punch card. In other words, the annual catch from river r by anglers not returning punch cards could be estimated as c^q_{0r} multiplied by the number of anglers not returning cards.

Clearly $$\sum_r c^q_{1r} = c^q_1, \qquad (4.18)$$

and $$\sum_r c^q_{0r} = c^q_0. \qquad (4.19)$$

By type of angler, estimates of annual catch rates on a given river r were computed according to the following equations:

$$c^q_{1rj} = \frac{\sum_i p_{ij} N_{ij} \sum_k \left(\frac{y^q_{1rijk}}{n_{1ijk}} \right)}{\sum_i p_{ij} N_{ij}}, \qquad (4.20)$$

$$c^{q}_{0rj} = \frac{\Sigma q_{ij} N_{ij} \Sigma_{k} \left(\frac{y^{q}_{0rijk}}{n_{0ijk}} \right)}{\Sigma q_{ij} N_{ij}} . \qquad (4.21)$$

For the third assumption where catch rates were considered by fishing month, the following estimating equations were employed:

$$\underset{-}{c}^{q}_{1k} = \frac{\Sigma \Sigma p_{ij} N_{ij} \left(\frac{y^{q}_{1ijk}}{n_{1ijk}} \right)}{\Sigma \Sigma p_{ij} N_{ij} \delta_{ij}} , \qquad (4.22)$$

$$\underset{-}{c}^{q}_{0k} = \frac{\Sigma \Sigma q_{ij} N_{ij} \left(\frac{y^{q}_{0ijk}}{n_{0ijk}} \right)}{\Sigma \Sigma q_{ij} N_{ij} \delta_{ij}} , \qquad (4.23)$$

where

$$\delta_{ij} = \left\{ \begin{matrix} 0 \text{ for } (i \neq k) \text{ and } (j = 07 \text{ or } 46) \\ 1 \text{ Otherwise} \end{matrix} \right\} . \qquad (4.24)$$

The $\underset{-}{c}^{q}_{1k}$ and the $\underset{-}{c}^{q}_{0k}$ are estimates of catch during month k per angler eligible to fish during that month, for anglers returning and anglers not returning punch cards respectively. The δ_{ij} in the denominators of equations (4.22) and (4.23) are employed because the Daily anglers (OSGC code 46) and the Five-Day Vacation anglers (OSGC code 07) are not eligible to fish during a month other than the month of license and punch card purchase. Here,

$$\Sigma_{k} \underset{-}{c}^{q}_{ik} \neq c^{q}_{1} , \qquad (4.25)$$

and

$$\sum_k c^q_{0k} \neq c^q_0 . \tag{4.26}$$

Certain estimates of total catch will require catch rates based in each subpopulation upon catch per angler rather than catch per angler eligible to fish in month k. Equations (4.27) and (4.28) provide for estimates of catch during month k per angler in the respective subpopulations.

$$c^q_{1k} = \frac{\sum_i \sum_j p_{ij} N_{ij} \left(\frac{y^q_{1ijk}}{n_{1ijk}} \right)}{\sum_i \sum_j p_{ij} N_{ij}}, \tag{4.27}$$

$$c^q_{0k} = \frac{\sum_i \sum_j q_{ij} N_{ij} \left(\frac{y^q_{0ijk}}{n_{0ijk}} \right)}{\sum_i \sum_j q_{ij} N_{ij}}, \tag{4.28}$$

Here,

$$\sum_k c^q_{1k} = c^q_1 , \tag{4.29}$$

and

$$\sum_k c^q_{0k} = c^q_0 . \tag{4.30}$$

The fourth and fifth assumptions that anglers accurately report by punch card their total catch can be studied by comparing catch rates determined from punch card returns with catch rates estimated from survey questionnaires. The reported 1961 catch per angler returning

a punch card is known for the entire population from a Game Commission tally, and this rate can be compared with the rate estimate computed from survey questionnaires according to equation (4. 9). It is somewhat more difficult to make such comparisons in finer detail by type of angler. Since angler type is not noted on punch cards, the reported 1961 annual catch rates for anglers returning punch cards are not known by type of angler. However, these catch rates were estimated according to the following equation:

$$c_{lj}^{pc} = \frac{\sum_i p_{ij} N_{ij} \left(\frac{y_{lij}^{pc}}{\sum n_{lijk}} \right)}{\sum_i p_{ij} N_{ij}}, \qquad (4.31)$$

where

$$y_{lij}^{pc} = \sum_k \sum_{\ell=1}^{n_{lijk}} \left(y_{lijk\ell}^{pc} \right) \qquad (4.32)$$

and

$y_{lijk\ell}^{pc}$ is the catch of angler ℓ for month k as reported by punch card (pc) where angler ℓ is in stratum ij and has returned both a punch card and a survey questionnaire.

That is, since an angler type could be associated with each punch card returned by a surveyed angler, catch rates by type of angler as reported by punch card could be estimated. These estimates c_{lj}^{pc} can be compared with similar estimates c_{lj}^{q} derived using equation (4. 14).

Assumptions 4 and 5 might be studied in somewhat greater detail

by computing two-way tables relating monthly catch reported by survey questionnaire to monthly catch reported by punch card. Such tables could illustrate similarity or dissimilarity of dates and rivers of reported catch as well as other aspects of differences in catch reports between punch card and questionnaire. But it is very doubtful that the validity of assumptions 4 and 5 can be assessed with such procedures or even with the comparisons suggested in the previous paragraph. For instance, if catch rates determined from questionnaires were not significantly different from those determined from punch cards, it might be concluded that anglers accurately report their entire catch on punch cards. On the other hand, it might be concluded only that most anglers referred to their punch cards while filling out the questionnaire. If a significant difference is detected, it does not necessarily follow that this difference is due to inaccuracies in punch card reports. It may be that many anglers did not refer to their punch cards while filling out the questionnaire. Under such circumstances, a fish caught and recorded on punch card during the last part of March, for instance, might easily be included by a sample angler in his questionnaire report of total catch for April. Similarly, a fish caught early in April might not be included in the questionnaire report of total catch for April. Essentially, it is difficult to support the thesis that survey questionnaire data are more accurate than punch card data. Therefore, the question of the validity of assumptions 4 and 5 cannot

be directly answered from this survey. The comparison of questionnaire and punch card estimates of catch rates does, however, play an important role in the determination of new procedures presented in Chapter 5 for estimating total annual catch.

Variance Estimates

Replicated subsampling was employed for estimating the variances of catch rate estimates. For instance, to estimate the variance associated with c_l^q, the entire sample of 13, 332 was randomly divided into ten subsamples by means of simple random sampling within strata. Each subsample contained members of both surveyed subpopulations. Using, for example, the questionnaire reports of anglers returning punch cards, an estimate of C_l was derived from each subsample as follows:

$$c_{lm}^q = \frac{\sum_{ij} p_{ijm} N_{ij} \sum \frac{y_{lijkm}^q}{n_{lijkm}}}{\sum_{ij} p_{ijm} N_{ij}} \qquad (4.34)$$

where

n_{lijkm} is the number of returned questionnaires in subsample m conveying fishing information for month k, these questionnaires being submitted by anglers who also returned punch cards,

n_{0ijkm} is similarly defined regarding anglers not returning punch cards,

$$p_{ijm} = \frac{\sum_k n_{1ijkm}}{\sum_k (n_{1ijkm} + n_{0ijkm})}, \tag{4.35}$$

and y^q_{1ijkm} is the total number of fish reported on survey questionnaires by the n_{1ijkm} anglers. From the ten resulting estimates, the variance of c^q_1 was estimated as follows:

$$\text{var}(c^q_1) \tilde{=} \text{var}(\bar{c}^q_1) = \frac{\sum_{m=1}^{10} (c^q_{1m} - \bar{c}^q_1)^2}{90} \tag{4.36}$$

where

$$\bar{c}^q_1 = \frac{\sum_{m=1}^{10} c^q_{1m}}{10} \quad . \tag{4.37}$$

These procedures also were used for estimating the variance of catch rate estimates for anglers not returning punch cards and for estimating the variance of catch rates by river and by month.

In explanation of these procedures, note first that the stratum weights of equations (4.9) and (4.10) are random variables, so that $\text{var}(c^q_1)$ and $\text{var}(c^q_0)$ should contain terms arising from the variability of these weights. Thus, rather than use the weights $P_{ij}N_{ij}/\Sigma_{ij}p_{ij}N_{ij}$ and $q_{ij}N_{ij}/\Sigma_{ij}q_{ij}N_{ij}$ over all subsamples, weight estimates $p_{ijm}N_{ij}/\Sigma_{ij}p_{ijm}N_{ij}$ and $q_{ijm}N_{ij}/\Sigma_{ij}q_{ijm}N_{ij}$ were derived and used within each subsample. Second, through subsampling, additional

estimates of the catch rates discussed in this chapter are derived. C_1, for instance, is estimated by $\bar{c}_1^q$ as well as by c_1^q, and there arises the need for a choice between the estimate $\bar{c}_1^q$, the mean of the subsample estimates, and what might be called the overall estimate c_1^q. To resolve this choice, note that c_1^q and c_0^q, although consistent estimates, are biased estimates of C_0 and C_1. The biases arise because c_1^q and c_0^q are ratio estimates, the numerator and denominator for equations (4. 9) and (4. 10) being random variables. Because the subsample estimates involve small sample sizes, the subsample estimates are expected to be more biased than the overall estimate. Consequently, the overall estimate was chosen in all instances.

CHAPTER 5

RESULTS

In 1961, 201,016 salmon-steelhead punch cards were issued to anglers in Oregon. The four previous chapters have been devoted to describing sampling procedures and results and procedures for estimating catch rates for anglers who purchased license and punch card simultaneously. This "surveyed population" of anglers purchasing license and punch card simultaneously consisted of 141,603 anglers. The distribution of these 141,603 over 144 strata formed by 12 purchase months (i) and 12 angler types (j) is shown in Table 5.

Breaking down the population of 201,016 in another way yields two subpopulations, anglers returning and anglers not returning punch cards. In 1961, 56,642 anglers returned punch cards while the remaining 144,374 anglers did not return punch cards. Again, only portions of these two subpopulations have received the attention of the previous chapters. These two portions, called "the surveyed subpopulations", consist only of anglers who purchased license and punch card concurrently. Together, the two surveyed subpopulations are the surveyed population of 141,603. The effective sample sizes, resulting from the sampling procedure described in Chapter 2, are shown for the two surveyed subpopulations in Tables 6 and 7.

Table 5. Stratum Sizes N_{ij} for 1961 Salmon-Steelhead Fishing Population of Anglers Purchasing License and Punch Card Simultaneously

Type of Angler	OSGC Code	Purchase Month Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
Resident Comb.	01	14203	2470	3077	3872	1735	1000	1681	1223	643	79	4	292	30279
Resident	04	14592	3350	6160	11740	4270	3008	4570	3876	1733	759	296	377	54731
Juvenile	05	1436	357	724	1294	371	325	478	426	134	52	37	34	5668
Non-Resident	06	189	76	106	257	160	201	244	334	295	86	9	6	1963
Five-Day Vac.	07	58	19	25	62	128	171	274	670	598	505	89	64	2663
Pioneer Comb.	12	4882	588	163	148	35	12	13	12	6	0	1	22	5882
Pioneer	13	574	122	86	67	8	11	20	14	11	4	1	1	919
Veteran Comb.	35	1959	344	59	79	22	4	8	7	1	0	0	2	2485
Veteran	36	208	60	29	42	15	5	5	4	1	1	0	0	380
Old Age Comb.	38	988	174	38	35	5	4	1	1	1	0	0	0	1247
Old Age	39	372	87	47	40	14	7	6	5	0	1	0	1	580
Daily	46	459	229	281	664	595	1896	7823	13182	6281	1713	668	1015	34806
Totals		39920	7876	10805	18300	7358	6644	15123	19754	9704	3200	1105	1814	141603

Table 6. Stratum Sample Sizes n_{0ij} for Surveyed Subpopulation of Anglers Not Returning Punch Cards

Type of Angler	OSGC Code	Purchase Month Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
Resident Comb.	01	1121	249	295	533	178	94	143	120	111	26	2	0	2872
Resident	04	1066	323	543	932	397	255	312	273	209	115	19	1	4445
Juvenile	05	115	44	89	127	48	27	42	31	28	10	3	0	564
Non-Resident	06	26	11	9	14	12	14	9	10	7	2	0	0	114
Five-Day Vac.	07	-	-	-	-	-	11	3	5	10	16	1	0	46
Pioneer Comb.	12	27	11	7	9	3	4	1	1	1	0	0	0	64
Pioneer	13	14	3	9	7	0	2	2	0	6	1	0	0	44
Veteran Comb.	35	12	10	5	9	8	1	3	1	1	0	0	0	50
Veteran	36	6	1	2	2	0	0	1	0	0	1	0	0	13
Old Age Comb.	38	16	4	3	7	4	0	0	0	0	0	1	0	35
Old Age	39	7	6	7	4	1	1	1	1	1	0	0	0	29
Daily	46	-	-	-	-	-	45	109	297	170	85	23	0	729
Totals		2410	662	969	1644	651	454	626	739	544	256	49	1	9005

Table 7. Stratum Sample Sizes n_{1ij} for Surveyed Subpopulation of Anglers Returning Punch Cards

Type of Angler	OSGC Code	Purchase Month Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
Resident Comb.	01	791	147	177	260	78	41	47	33	22	10	0	0	1606
Resident	04	650	168	233	380	136	83	85	85	61	34	10	0	1925
Juvenile	05	46	12	26	34	12	12	14	10	5	4	3	1	179
Non-Resident	06	9	4	2	4	3	7	4	2	5	3	0	0	43
Five-Day Vac.	07	-	-	-	-	-	3	2	7	4	1	1	0	18
Pioneer Comb.	12	64	21	15	11	5	0	2	2	0	0	0	0	120
Pioneer	13	61	9	6	10	0	1	3	1	0	1	0	0	92
Veteran Comb.	35	31	12	9	9	4	0	1	1	0	0	0	0	67
Veteran	36	16	4	2	5	1	0	1	1	1	0	0	0	31
Old Age Comb.	38	16	7	8	5	0	0	0	0	0	0	0	0	36
Old Age	39	22	3	12	6	5	1	2	0	0	0	0	0	51
Daily	46	-	-	-	-	-	11	23	65	37	16	6	1	159
Totals		1706	387	490	724	244	159	184	207	135	69	20	2	4327

From consideration of Tables 6 and 7, it is obvious that the sample size would be zero in many of the 804 substrata which would result from construction of a substratum per fishing month k within each of 144 strata. Consequently, to provide adequate sample sizes for substrata, construction of strata was limited in number to somewhat fewer than 144. For computation of many of the estimates presented in this chapter, only two classifications by type of angler were established, one classification for Daily and Five-Day Vacation anglers (OSGC codes 46 and 07) and another for anglers of the remaining ten types. Preliminary computations indicated that, for estimating annual catch rates, stratification by purchase month was about as effective as stratification by type of angler, and the combination of strata over angler types more easily solved the problem of small substrata sample sizes. Angler types 07 and 46 were chosen for one classification because the sampling rate for these anglers within a given purchase month was necessarily different from the sampling rate for the remaining ten angler types. The estimated annual catch rates for the 07 and 46 anglers were also considerably different from the catch rates of the other types, providing another reason for maintaining a separate stratum for these types. The strata for the other ten types could be combined within each purchase month because their effective sampling rates were nearly equal. Second, because of the small sample sizes achieved in the strata formed by purchase months October, November, and

December, these strata were combined to form one purchase month. Consequently, all catch rate estimates presented in this chapter other than estimates by type of angler were computed using the formulas of Chapter 4 and data from 20 strata formed by ten purchase months (January, February, ..., October through December) and two type of angler classifications (types 07 and 46, all other types). For estimates by type of angler, strata were formed by ten purchase month classifcations and one type of angler classification. Further, each variance estimate given in this chapter was computed using ten subsamples according to equation (4. 36). Some catch rate estimates do not have accompanying variance estimates because of small sample sizes.

Tables 6 and 7 indicate that there are no usable questionnaire catch reports from anglers of types 07 or 46 for the first five months of 1961. The 24 reports which were received for this period were invalidated by clerical errors. However, to each of these fishing months an 18 percent response rate was assigned together with a catch rate equal to the estimated catch rate for all other angler types. Such a procedure did not significantly effect the determination of overall catch rates since the stratum sizes for the 07 and 46 type anglers were relatively small during the first five months of 1961.

Tables 6 and 7 are summarized in Table 8 wherein punch card response rates are given by purchase month for six classifications of

Table 8. Sample Sizes n_{1ij} and n_{0ij} and Punch Card Response Rates p of Surveyed Anglers

Purchase Month		Type of Angler (OSGC code) 01	04	05	06	12-39	07 & 46	Totals
January	n_1	791	650	46	9	210	0	1706
	n_0	1121	1066	115	26	82	0	2410
	p%	41.4	37.9	28.6	25.7	71.9	18.0*	41.1
February	n_1	147	168	12	4	56	0	387
	n_0	249	323	44	11	35	0	662
	p%	37.1	34.2	21.4	26.7	61.5	18.0*	36.9
March	n_1	177	233	26	2	52	0	490
	n_0	295	543	89	9	33	0	969
	p%	37.5	30.0	22.6	18.2	61.2	18.0*	33.6
April	n_1	260	380	34	4	46	0	724
	n_0	533	932	127	14	38	0	1644
	p%	32.8	29	21.1	22.2	54.8	18.0*	30.6
May	n_1	78	136	12	3	15	0	244
	n_0	178	397	48	12	16	0	651
	p%	30.5	25.5	20.0	20.0	48.4	18.0*	27.3
June	n_1	41	83	12	7	2	14	159
	n_0	94	255	27	14	8	56	454
	p%	30.4	24.6	30.8	33.3	20.0	20.0	25.9
July	n_1	47	85	14	4	9	25	184
	n_0	143	312	42	9	8	112	626
	p%	24.7	21.4	25	30.8	52.9	18.2	22.7
August	n_1	33	85	10	2	5	72	207
	n_0	120	273	31	10	3	302	739
	p%	21.6	23.7	24.4	16.7	62.5	19.3	21.9
September	n_1	22	61	5	5	1	41	135
	n_0	111	209	28	7	9	180	544
	p%	16.5	22.6	15.2	41.7	10	18.6	19.9
October - December	n_1	10	44	8	3	1	25	91
	n_0	28	135	13	2	3	125	306
	p%	26.3	24.6	38.1	60.	33.3	16.7	22.9
Total number returned		1606	1925	179	43	397	177	4327
Total number not returned		2872	4445	564	114	235	775	9005
Totals		4478	6370	743	157	632	952	13332

*Assigned response rate

Table 9. Estimated Stratum Sizes for Surveyed Subpopulations

Purchase Month		Type of Angler (OSGC code) 01	04	05	06	12-39	07&46	Totals	Number Eligible to Fish
January	R	5875.8	5527.3	410.3	48.6	6460.4	93.1	18,416	18,416
	NR	8327.2	9064.7	1025.7	140.4	2522.6	423.9	21,504	21,504
February	R	916.9	1146.2	76.5	20.3	846.2	44.6	3,051	21,373
	NR	1553.1	2203.8	280.5	55.7	528.8	203.4	4,825	25,906
March	R	1153.9	1849.6	163.7	19.3	264.3	55.1	3,506	24,834
	NR	1923.1	4310.4	560.3	86.7	167.7	250.9	7,299	33,002
April	R	1269.0	3400.3	273.3	57.1	225.1	130.7	5,355	30,134
	NR	2603.0	8339.7	1020.7	199.9	185.9	595.3	12,945	45,696
May	R	528.6	1090.0	74.2	32.0	47.9	130.1	1,903	31,906
	NR	1206.4	3180.0	296.8	128.0	51.1	592.9	5,455	50,556
June	R	303.7	738.7	100.0	67.0	8.6	413.4	1,631	33,407
	NR	696.3	2269.3	225.0	134.0	34.4	1653.6	5,013	54,976
July	R	415.8	978.4	119.5	75.1	28.1	1477.6	3,095	36,089
	NR	1265.2	3591.6	358.5	168.9	24.9	6619.4	12,028	65,350
August	R	263.8	920.3	103.9	55.7	26.9	2666.7	4,037	38,649
	NR	959.2	2955.7	322.1	278.3	16.1	11185.3	15,717	74,448
September	R	106.4	392.0	20.3	122.9	2.0	1276.2	1,919	37,900
	NR	536.6	1341.0	113.7	172.1	18.0	5602.8	7,785	71,048
October - December	R	98.7	352.0	46.9	60.6	11.3	675.7	1,245	
	NR	276.3	1080.0	76.1	40.4	22.7	3378.3	4,874	
Total	R	10,933	16,394	1389	558	7,921	6,963	44,158	
	NR	19,346	38,337	4279	1405	3,572	30,506	97,445	
		30,279	54,731	5668	1963	11,493	37,469	141,603	
% Response overall		36.1075	29.9538	24.5060	28.4259	68.9202	18.5834	31.1851	
% Non-Response overall		63.8925	70.0462	75.4940	71.5741	31.0793	81.4166	68.8149	

R - Estimated number returning punch cards

NR - Estimated number not returning punch cards

angler types. From the proportions p_{ij} and q_{ij} in Table 8 and the strata sizes N_{ij} given in Table 5 for the surveyed population, the estimated strata sizes $p_{ij}N_{ij}$ and $q_{ij}N_{ij}$ given in Table 9 were computed for the two surveyed subpopulations.

Estimates of Catch Rates

Estimates of annual catch rates, determined using equations (4.9) and (4.10), and associated variances by species of fish for the two surveyed subpopulations are given in the following table. The catch rate ratios R (also given in following tables) will be referred to subsequently in connection with revised estimating procedures.

Table 10. Estimated 1961 Annual Catch Rates

	Salmon			Steelhead		
	Anglers not returning punch cards	Anglers returning punch cards	R	Anglers not returning punch cards	Anglers returning punch cards	R
Catch Rate	.1.1251	1.7811	.6317	.7225	.9340	.7735
Variance	.00223	.01510	.00367	.00166	.01121	.02055

For both species of fish, the differences in the catch rates of anglers returning and anglers not returning punch cards are highly significant ($Pr < .01$). Thus, in the surveyed population it appears that the first assumption regarding equality of catch rates for anglers returning and

anglers not returning punch cards was not generally applicable for either species of fish during 1961.

To further illustrate catch rate differences, estimates by type of angler determined using equations (4. 14) and (4. 15) are given in Table 11. Considering first the salmon catch rates, the catch rates of anglers returning punch cards is significantly different at the one percent level from the catch rate of anglers not returning punch cards for all classifications of anglers in the table except Juvenile (05) anglers. For steelhead, the only non-significant difference occurred for resident (01) anglers, the other five differences being highly significant ($Pr < .01$).

In Table 12 estimates are given of annual catch from the ocean, from the Columbia River, and from all other Oregon rivers combined per angler in the respective surveyed subpopulations. The estimates were computed according to the formulas of equations(4. 16) and (4. 17). Only the catch rates for steelhead taken in the ocean are not significantly different for the two surveyed subpopulations at the one percent level. The catch rate differences for salmon taken from the ocean and salmon and steelhead taken from the Columbia River are all significant at the one percent level. Thus, assumption 2 does not appear to be warranted generally.

Table 13 further illustrates catch rate differences by river for two classifications of anglers. The computations were performed

Table 11. Estimated 1961 Annual Catch Rates by Type of Angler

Type of Angler j	Salmon			Steelhead		
	Anglers not returning punch cards	Anglers returning punch cards	R	Anglers not returning punch cards	Anglers returning punch cards	R
01						
Catch Rate	1.5671	2.3186	.6759	1.0403	1.0359	1.0042
Variance	.00830	.01082	.00620	.00210	.00114	.03523
04						
Catch Rate	1.1163	1.8947	.5892	.6703	.9490	.7063
Variance	.00651	.00441	.00797	.00966	.00055	.02466
05						
Catch Rate	.9784	1.0156	.9633	.7812	.0985	7.9338
Variance	.00544	.02136	.02217	.16920	.03315	.31258
06 & 12-39						
Catch Rate	1.6045	1.1187	1.4342	2.2609	.5721	3.9517
Variance	.07973	.10202	.06228	.08237	.01985	.27310
07 & 46						
Catch Rate	.6159	.8471	.7270	.1790	.3096	.5781
Variance	.00403	.01868	.03384	.00013	.00165	.08049
All except 07 & 46						
Catch Rate	1.3560	1.9524	.6945	.9096	1.0485	.8675
Variance	.00384	.02052	.00367	.00324	.01565	.02465

Table 12. 1961 Annual Catch Rate Estimates for Several Oregon Rivers

River r	Salmon			Steelhead		
	Anglers not returning punch cards	Anglers returning punch cards	R	Anglers not returning punch cards	Anglers returning punch cards	R
Ocean						
Catch Rate	.7254	1.0537	.6885	.0180	.0158	1.1372
Variance	.00208	.00098	.00203	.003927	.00431	.17133
Columbia						
Catch Rate	.0933	.2036	.4584	.0647	.1520	.4256
Variance	.00237	.00020	.00851	.00682	.00017	.20295
All other Rivers Combined						
Catch Rate	.3063	.5237	.6849	.6397	.7661	.8350

Table 13. 1961 Annual Catch Rate Estimates by Type of Angler for the Ocean and the Columbia River

Type of Angler j	River r	Salmon Catch Rate			Steelhead Catch Rate		
		Anglers not returning punch cards	Anglers returning punch cards	R	Anglers not returning punch cards	Anglers returning punch cards	R
07 & 46	Ocean	.5012	.7100	.7059	.0311	.0691	.4497
	Columbia	.0142	.0443	.3208	.0397	.0307	1.2932
All others	Ocean	.8149	1.0796	.7549	.0101	.0045	2.2750
	Columbia	.1277	.2257	.5657	.0689	.1586	.4345

according to equations (4. 20) and (4. 21), and no attempt was made to obtain variance estimates by subsampling because of limited sample sizes.

In Table 14, ratios of catch rates are given without variance estimates for 13 major salmon and steelhead rivers. These ratios, like those in Tables 12 and 13, are ratios of annual catches per angler in the respective surveyed subpopulations and will be used subsequently in connection with revised estimating procedures.

Table 14. Ratios of Estimated Annual Catch Rates for Various Oregon Rivers

OSGC code	River r	R_r Salmon	R_r Steelhead
01	Alsea	1. 4068	1. 1808
10	Columbia	. 4584	. 4256
11	Coos	. 2153	5. 4783
13	Deschutes	. 1592	4. 3741
35	Nehalem	. 4815	1. 1890
37	Nestucca	. 6544	. 6963
38	Pacific Ocean	. 6884	1. 1372
43	Rogue River	4. 9949	3. 0963
49	Siletz	. 1102	. 2983
51	Siuslaw	. 7426	. 4930
62	Umpqua	2. 2841	. 7404
67	Willamette	1. 3180	5. 7649
68	Wilson	. 5501	. 7680

Regarding the third assumption that the catch rate of anglers returning punch cards is the same as the catch rate of anglers not returning punch cards for each month of the year, Tables 15 and 16 contain, respectively, estimates of monthly catch rates in terms of the total

Table 15. Estimated Catch During Month Indicated Per Angler in the Respective Subpopulations

Fishing Month k	Salmon Catch Rate			Steelhead Catch Rate		
	Anglers not returning punch cards	Anglers returning punch cards	R	Anglers not returning punch cards	Anglers returning punch cards	R
January	.0037	.0086	.4278	.1139	.1858	.6130
February	.0021	.0000	---	.0591	.0391	1.4606
March	.0252	.0152	1.6596	.0942	.0459	2.0504
April	.0674	.2090	.3225	.0154	.0209	.7353
May	.0587	.0733	.8014	.0092	.0050	1.8517
June	.0390	.0643	.6070	.0062	.0162	.3816
July	.2203	.2576	.8556	.0388	.0486	.7981
August	.4245	.6100	.6959	.0572	.0589	.9716
September	.1655	.2772	.5969	.0591	.0550	1.0744
October	.0673	.1198	.5620	.0481	.0437	1.1014
November	.0398	.1009	.3944	.0550	.1287	.4270
December	.0152	.0386	.3944	.1309	.2785	.4702

Table 16. Estimated Catch During Month Indicated Per Angler Eligible to Fish that Month

Fishing Month k	Salmon Catch Rate: Anglers not returning punch cards	Salmon Catch Rate: Anglers returning punch cards	Salmon Catch Rate: R	Steelhead Catch Rate: Anglers not returning punch cards	Steelhead Catch Rate: Anglers returning punch cards	Steelhead Catch Rate: R
January	.0155	.0222	.6995	.4870	.4593	1.0605
February	.0015	.0000	---	.2041	.0825	2.4731
March	.0713	.0282	2.5265	.2695	.0894	3.0149
April	.1406	.3146	.4468	.0324	.0302	1.0724
May	.1112	.1033	1.0773	.0144	.0068	2.6178
June	.0681	.0862	.7904	.0109	.0210	.5207
July	.3257	.3179	1.0246	.0581	.0577	1.0069
August	.5529	.7001	.7898	.0753	.0655	1.1506
September	.2254	.3263	.6909	.0814	.0628	1.2976
October	.0926	.1413	.6555	.0668	.0495	1.3501
November	.0547	.1190	.4599	.0764	.1460	.5232
December	.0209	.0455	.4598	.1821	.3159	.5766

number of anglers in the surveyed subpopulations (equation (4. 27) and (4. 28)) and in terms of the number of anglers in the surveyed subpopulations eligible to fish each month (equations (4. 22) and (4. 23)).

Variances were not obtained for the estimates in these tables, and no significance tests were made. Tables 15 and 16 do suggest that the general tendency, illustrated in previous tables, for the catch rate of anglers returning punch cards to be greater than the catch rate of anglers not returning punch cards does not hold for every fishing month.

The following Tables 17 and 18 provide monthly catch rate estimates in finer detail by two classifications of anglers, the 07 and 46 types and all other types. Of course, the tables are identical from January through May. Recall that there were no usable questionnaire returns for the 07 and 46 type anglers for January through May and that catch rates for these anglers were assigned each month equal to the estimated catch rate for all other types. The catch rates for June through December in Table 17 were calculated according to equations (4. 22) and (4. 23) using only questionnaires returned by 07 and 46 type anglers. The catch rates in Table 18 were calculated according to (4. 22) and (4. 23) using the questionnaires for all other angler types.

Comparing catch rates in Tables 17 and 18 for June through December, it appears that the salmon and steelhead catch rates for 07 and 46 type of anglers are greater than the catch rates for all other angler types particularly for anlgers returning punch cards.

Table 17. For Daily and Five-Day Vacation Anglers, Estimated Catch During Month Indicated Per Angler Eligible to Fish That Month

Fishing Month k	Salmon Catch Rate			Steelhead Catch Rate		
	Anglers not returning punch cards	Anglers returning punch cards	R	Anglers not returning punch cards	Anglers returning punch cards	R
January	.0155	.0222	.6995	.4870	.4593	1.0605
February	.0015	.0000	---	.2041	.0825	2.4731
March	.0713	.0282	2.5265	.2695	.0894	3.0149
April	.1406	.3146	.4468	.0324	.0302	1.0724
May	.1112	.1033	1.0773	.0177	.0068	2.6178
June	.5536	.3571	1.5500	.0536	.0000	---
July	.7411	1.0000	.7411	.0714	.1200	.5952
August	.8079	1.3194	.6123	.0861	.2083	.4132
September	.3611	.3902	.9253	.1722	.2927	.5884
October	.4257	.2941	1.4475	.3861	.4706	.8205
November	.0870	.0000	---	.3913	.0000	---
December	---	.0000	---	---	---	---

Table 18. For All Anglers Combined Except Daily and Five-Day Vacation Anglers, Estimated Catch During Month Indicated Per Angler Eligible to Fish That Month

Fishing Month k	Salmon Catch Rate			Steelhead Catch Rate		
	Anglers not returning punch cards	Anglers returning punch cards	R	Anglers not returning punch cards	Anglers returning punch cards	R
January	.0155	.0222	.6995	.4870	.4593	1.0605
February	.0015	.0000	---	.2041	.0825	2.4731
March	.0713	.0282	2.5265	.2695	.0894	3.0149
April	.1406	.3146	.4468	.0324	.0302	1.0724
May	.1112	.1033	1.0773	.0177	.0068	2.6178
June	.0536	.0826	.6490	.0097	.0213	.4539
July	.2803	.2645	1.0598	.0566	.0603	.9376
August	.5091	.6517	.6611	.0735	.0543	1.3609
September	.2141	.3239	.6611	.0739	.0543	1.3606
October	.0763	.1384	.5513	.0512	.0414	1.2349
November	.0531	.1213	.4382	.0609	.1488	.4095
December	.0220	.0464	.4734	.1910	.3027	.6311

This result is not at all unexpected since many anglers not of type 07 or 46 eligible to fish in a given month may not fish at all during that month, whereas, an angler of type 07 or 46 generally purchases a license in a given month for the purpose of fishing during that month.

For studying assumptions 4 and 5 that anglers accurately report their total catch, Table 19 shows reported and estimated catch rates derived from returned punch cards and survey questionnaires respectively for anglers returning punch cards. The catch rates from punch cards were determined from the Game Commission tally of punch card returns by dividing total reported catch by the number of anglers returning punch cards (See Table A-1 in Appendix A), and the catch rates from questionnaires were computed according to equation (4. 7). For both species of fish the catch rates are significantly different at the one percent level.

Table 19. Estimated and Reported 1961 Annual Catch Rates per Angler Returning a Punch Card

		Salmon	Steelhead
Questionnaire	Catch Rate	1. 7811	. 9340
	Variance	. 01510	. 01121
Punch Card	Catch Rate	1. 1025	. 4099

It can be argued that the differences between catch rates in Table 19 might well be expected in that the punch card derived catch rates apply to all anglers returning punch cards, whereas, the

questionnaire derived catch rates apply only to the surveyed subpopulation. However, this argument can apparently be set aside after comparing the entries in the last row of Table 19 with the corresponding entries in the last row of Table 20. The last row of Table 20 contains estimates of catch rates for the surveyed subpopulation calculated from punch card data as weighted sums of catch rates by type of angler. The catch rates by type of angler were computed according to equation (4. 31). Although no variance estimates were made, the c_1^{pc} in the last row of Table 20 are very nearly equal to the corresponding punch card catch rates in Table 19, so that it appears that a significant difference exists between catch rates derived from questionnaires and catch rates derived from punch cards for the surveyed subpopulation of anglers returning punch cards.

Table 20. Annual Catch Rates by Type of Angler Estimated from Punch Card and from Questionnaire Data

	Salmon		Steelhead	
Angler Type (OSGC Code)	From questionnaire	From punch cards	From questionnaire	From punch cards
A 07 & 46	.8471	.9945	.3097	.1653
B all others combined	1.9524	1.0197	1.0485	.4469
C weighted mean of A and B	1.7811	1.0157	.9340	.4022

It would probably be an easy task to collect many suggested reasons for the difference between c_1^{pc} and c_1^{q} illustrated in Table 19, but three possible reasons seem salient. First, it might be suggested that anglers are not reporting by punch card their entire catch, and that for the one month's catch reported by questionnaire, the surveyed anglers did indicate true catch. Second, whereas many surveyed anglers probably referred to their punch cards while completing questionnaires, those not referring quite possibly completed questionnaires not in agreement with punch card, the tendency being to overreport with respect to the report given by punch card. Third, it might be suggested that the difference is due to the effects of the survey nonresponse as would seem to be indicated from the trend in the table below. That is, the catch rate of survey nonrespondents may be small enough to eliminate the difference between c_1^{pc} and c_1^{q} .

Table 21. 1961 Annual Catch Rates as Estimated by Type of Questionnaire Returned

	Salmon Catch Rate			Steelhead Catch Rate		
Type of Questionnaire	Anglers not returning punch cards	Anglers returning punch cards	R	Anglers not returning punch cards	Anglers returning punch cards	R
Initial	1.9415	2.2358	.8683	.9021	1.0443	.8638
First Reminder	1.1959	1.6988	.7039	.6301	.9349	.6740
Second Reminder	1.3071	1.0776	1.2129	.3626	.0968	3.7456

For the third reason to account fully for the difference between c_1^{pc} and c_1^{q}, it would be necessary for the survey nonrespondents (approximately 16 percent of the total sample) to have achieved an average catch rate less than zero. So, although the first and third reasons may contribute somewhat to the difference between c_1^{pc} and c_1^{q}, it is the opinion of the author that the second reason accounts for most of this difference. The influence of the data in Table 19 on the determination of revised estimating procedures will be apparent in the following section.

Estimates of Total Catch

In Appendix A, Tables 1-A through 6-A contain catch summaries prepared by the Oregon State Game Commission from punch cards returned by 28.181 percent of the 1961 Oregon salmon-steelhead fishing population. Tables 1-A and 6-A contain estimates of total catch as well as summaries of reported catch. These estimates were obtained by simple expansions. That is, reported catch was divided by .28181, the return rate for punch cards in 1961. In the light of the results presented in the previous section, it appears that the estimates in these tables are somewhat biased, the catch rate for anglers returning punch cards being not equal, generally, to the catch rate for anglers not returning punch cards. It is the purpose of this section to propose

an alternate estimating scheme which can be used in the future to provide estimates less biased than those in the tables mentioned above. In the following, the inferences of the last section are considered to apply to the entire salmon-steelhead fishing population.

In comparing various methods for estimating total catch (annually, monthly, by river, etc.) in future years, the following major points were considered.

(1) In 1961, the catch rates (annually, monthly, etc.) of anglers returning punch cards were not generally the same as the catch rates of anglers not returning punch cards.

(2) The annual catch rate for anglers returning punch cards as determined for 1961 from punch cards returned to the Game Commission was significantly different from the annual catch rate for anglers returning punch cards as computed for 1961 from survey questionnaires.

Of course, the first point has been illustrated in the preceding section and is the basis for attempting to improve on estimates presently made by simple expansion. In consideration of the second point, the formulas for future estimates of total catch presented in this section employ ratios such as c_0^q / c_1^q of catch rates for anglers returning and anglers not returning punch cards. It was suggested in the last section that most of the observed difference between c_1^{pc} and c_1^q arose because surveyed anglers returning punch cards tended to overreport

when completing a survey questionnaire from memory. It seems logical that anglers not returning punch cards would have been subject to the same tendency to overreport. Further, by assuming that the percent difference between C_0 and c_0^q is the same as the percent difference between C_1 and c_1^q, then C_0/C_1 will be equal to c_0^q/c_1^q. It is felt that such an assumption, although not supportable by any of the survey results previously presented, is quite reasonable and it is proposed that formulas of the form given in (5. 1) be employed for future estimates of total catch.

$$H\Big|_x = H^{pc}\Big|_x \left[1 + R\left(\frac{N_0}{N_1}\Big|_x\right)\right] \tag{5.1}$$

$$= H^{pc}\Big|_x + \left(H^{pc}\Big|_x\right)\left(\frac{c_0^q}{c_1^q}\right)\left(\frac{N_0}{N_1}\Big|_x\right)$$

$$= H^{pc}\Big|_x + \left(C_1\Big|_x\right)\left(\frac{c_0^q}{c_1^q}\right)\left(N_0\Big|_x\right)$$

where

$H\Big|_x$ = total catch estimate for year x ,

$H^{pc}\Big|_x$ = catch reported by punch card for year x ,

$N_0\Big|_x$ = number of anglers not returning punch cards for year x,

$N_1\big|_x$ = number of anglers returning punch cards for year x ,

and where the variance of $H\big|_x$ is estimated according to (5. 2)

$$\text{Var}\,(H\big|_x) = \left(\frac{H^{pc}N_0}{N_1}\bigg|_x\right)^2 \text{Var}\,(R) \qquad (5.2)$$

The catch rate ratios R of Table 10 may be used according to equation (5. 1) to estimate directly 1961 total salmon and steelhead catches. Differences which might occur between the value $H\big|_{1961}$ from equation (5. 1) and true total catch for 1961 will be due to inaccuracies in $H^{pc}\big|_{1961}$ and/or R since $N_0\big|_{1961}$ and $N_1\big|_{1961}$ are known. It has already been stated that this survey cannot conclusively establish the accuracy of $H^{pc}\big|_{1961}$, and, with respect to that component of estimated total catch attributable to anglers returning punch cards, an estimate from equation (5. 1) will be as biased by any inaccuracy in $H^{pc}\big|_x$ as an estimate obtained by simple expansion. However, the bias in a total catch estimate which may arise from inaccuracies in $H^{pc}\big|_x$ is expected to be much smaller in 1961 and in future years than the bias which can result by generally assuming identical catch rates for anglers returning and anglers not returning punch cards. The second term in brackets in equation (5. 1) is intended to account for the difference in catch rates to reduce this potentially large bias.

Using the appropriate catch summary data with the catch rate ratios R given in the tables of the previous section, estimates of total annual catch by type of angler, total catch by month, and total catch by river can be made for 1961 and for future years using the following equations similar in form to equation (5. 1). For total annual catch by type of angler (j),

$$H_j\Big|_x = H_j^{pc}\Big|_x \left[1 + R_j\left(\frac{N_{0j}}{N_{1j}}\Big|_x\right)\right] , \tag{5. 3}$$

$$\text{var}(H_j\Big|_x) = \left(\frac{H_j^{pc}\, N_{0j}}{N_{ij}}\Big|_x\right)^2 \text{var}\,(R_j) \tag{5. 4}$$

where $N_{0j}\Big|_x$ and $N_{1j}\Big|_x$ are, for the respective subpopulations during year x, the total number of angler of type j.

For total annual catch estimates by river (r),

$$H_r\Big|_x = H_r^{pc}\Big|_x \left[1 + R_r\left(\frac{N_0}{N_1}\Big|_x\right)\right] , \tag{5. 5}$$

$$\text{var}\,(H_r\Big|_x) = \left(\frac{H_r^{pc}\, N_0}{N_1}\Big|_x\right)^2 \text{var}\,(R_r) \tag{5. 6}$$

For total catch estimates by month (k),

$$H_k\Big|_x = H_k^{pc}\Big|_x \left[1 + R_k\left(\frac{N_0}{N_1}\Big|_x\right)\right] , \tag{5. 7}$$

or

$$H_k\Big|_x = H_k^{pc}\Big|_x \left[1 + \underline{R}_k \left(\frac{\underline{N}_{0k}}{\underline{N}_{1k}}\Big|_x\right)\right], \qquad (5.8)$$

where $\underline{N}_{0k}$ and $\underline{N}_{1k}$ are, for the respective subpopulations, the number of anglers eligible to fish during month k.

To illustrate the use of equations (5.1) through (5.8), the indicated operations have been carried out in Appendix B using the Oregon State Game Commission 1961 catch summary data of Appendix A and the catch rate ratios in the preceding tables of this chapter. The results are summarized in Table 22.

Not all of the estimates in Table 22 are based on actual reported catch. The reported catch figures required for estimating total catch according to equation (5.1), total catch by river according to equation (5.5), and total catch by month according to equation (5.7), were readily available in the 1961 catch summary, but reported catch by type of angler (required for equation (5.3)) and the ratios $\frac{\underline{N}_{0k}}{\underline{N}_{1k}}\Big|_{1961}$ of numbers of anglers in each subpopulation eligible to fish each month of 1961 (required for equation (5.8)) were not available. Consequently, the results from equations (5.3) and (5.8) have been based on estimates of reported catch by type of angler and estimates of numbers of anglers eligible to fish. Using the c_{1j}^{pc} from Table 20, estimates of reported catch by type of angler were made in Appendix B for the surveyed subpopulation and subsequently for the entire subpopulation of anglers returning punch cards. The reported catch

Table 22. Total Catch Estimates from Equation (5. 1) through (5. 8)

Equation	Item	Salmon Catch	Steelhead Catch
5. 1	H_{1961}	162, 997	68, 991
5. 2	s 1/	9, 637	8, 483
5. 3	$H_{07 - 46}$	40, 353	5, 310
5. 3	H_{others}	118, 809 2/	55, 615 2/
5. 3	Total	159, 162	60, 925
5. 4	s 1/	9, 904	6, 414
5. 5	H_{ocean}	65, 743	234
5. 5	$H_{Columbia}$	20, 205	7, 268
5. 5	$H_{all\ others}$	72, 894	61, 537
	Total	158, 842	69, 039

5. 7 & 5. 8	H_k	5. 7	5. 8	5. 7	5. 8
	Jan	527	458	7, 647	6, 679
	Feb	425	310	7, 712	6, 528
	Mar	3, 949	3, 290 3/	8, 798	7, 074 3/
	Apr	9, 389	8, 644	2, 029	1, 854
	May	6, 201	5, 517	1, 281	1, 153
	Jun	7, 461	6, 739	367	345
	Jul	39, 187	35, 178	3, 987	3, 710
	Aug	60, 317	54, 830	5, 225	4, 834
	Sep	22, 910	20, 854	7, 171	6, 583
	Oct	10, 263	9, 278	6, 031	5, 496
	Nov	5, 193	4, 735	4, 354	4, 050
	Dec	2, 446	2, 235	16, 856	15, 662
5. 7	Total	168, 268		71, 458	
5. 8	Total		152, 068		63, 968

1/ Standard error of total catch estimate

2/ Based on estimates of reported catch and estimates of N_{0j}/N_{1j}

3/ Based on estimates of numbers of anglers eligible to fish each month of 1961

estimates for the entire subpopulation were computed by allocating to each classification of anglers a percentage of total reported catch the same as the percentage observed in the estimation of reported catch by type of angler for the surveyed subpopulation. The results from equation (5. 8) are based on estimates of the ratios $\frac{N_{0k}}{N_{1k}}$. It was assumed that the ratios of numbers of anglers in each subpopulation eligible to fish each month of 1961 were the same for both the surveyed population and the entire population, and these ratios were estimated as shown in Table 9.

Estimates of total catch by month, river, and type of angler are of interest to the Oregon State Game Commission, but of prime importance is an estimate of total annual catch. Table 22 contains for 1961 several estimates of total annual catch. Total annual catch is estimated (1) directly for the entire state from equation (5. 1), (2) by summing separate total catch estimates made by type of angler according to equation (5. 3), (3) by summing separate total catch estimates made by river according to equation (5. 5), and (4) and (5) by summing separate total catch estimates made by months according to equations (5. 7) and (5. 8). The questions now arise as to which of the five procedures just described yields the "best" estimate of 1961 total annual catch, and which of these five procedures will yield the "best" estimate of some future total annual catch. In answering these questions, the "best" estimate will be considered to be that estimate with which is associated

the least mean square error.

Procedure 1 above yields combined ratio estimates (1, p. 131) of total salmon and total steelhead catch. Procedure 2 yields total catch estimates computed as sums of separate stratum ratio estimates. Procedures 3, 4, and 5 yield total catch estimates as sums of combined ratio estimates of total catch, each combined ratio estimate being applicable to a particular domain of study of the entire salmon-steelhead fishing population. Comparing procedures 1 and 2, it might be expected that the estimates from procedure 2 would be more precise than the estimates from procedure 1, but they also may have greater bias. It has been shown (1 p. 130) that the absolute value of the bias in a separate stratum ratio estimate of a total may be as large as the standard error of that estimate times the coefficient of variation of the denominator of the stratum ratio. From Table 11, the coefficients of variation of the c_{1j}^{q} are about 16 percent for j equal to 07 and 46 and about eight percent for all other angler types combined. Thus any resulting bias in the procedure 2 estimates of total salmon and steelhead catches would be expected, on the basis of this consideration alone, to be considerably less than the sum of the separate stratum biases, about 0.2 standard errors for the total salmon catch estimate and about 0.1 standard errors for the total steelhead catch estimate. The same type of bias can arise in procedures 3, 4 and 5.

There is another factor to be considered however, in comparing

the estimates in Table 22. Recall that exact stratum sizes were not known but were estimated as $p_{ij}N_{ij}$ and $q_{ij}N_{ij}$. Because stratum sizes were estimated this way, the catch rate estimates in Tables 10 through 21 are not unbiased. The total catch estimates from procedures 1 through 5 are all subject to bias from inexact stratum weighting, and procedures 2 through 5 may produce further biasing through summing separate ratio estimates. It has been shown that for instance by employing estimates of stratum sizes $q_{ij}N_{ij}$, the average value of the bias component of the error mean square of an estimate such as c_0^q is roughly:

$$(\text{bias})^2 = \frac{\sum_{ij} (\bar{Y}_{0ij} - C_0)\ \text{VAR}\ (q_{ij}N_{ij})}{(\sum_{ij} q_{ij}N_{ij})^2} \qquad (5.9)$$

where

C_0 is the expected value of c_0^q

$\bar{Y}_{0ij}$ is the expected value of $\bar{y}_{0ij}$

and $\bar{y}_{0ij} = \sum_k \frac{y^q_{0ijk}}{N_{0ijk}}$ is the average annual catch rate for stratum ij.

Estimates of VAR $(q_{ij}N_{ij})$ are available from subsamples and the $\bar{Y}_{0ij}$ and C_0 are estimated by the $\bar{y}_{0ij}$ and c_0^q. Substituting these estimates in equation (5.9), it turns out that the estimated average bias in c_0^q is about ± .003 for both salmon and steelhead. Interestingly, it turns out that the estimated average bias in c_1^q is also about ±.003 for both salmon and steelhead. The following table shows the change in the

combined ratio estimates of total salmon and total steelhead catch computed according to equation (5. 1) when c_0^q and c_1^q of Table 10 are adjusted by the amount . 003.

Table 23. Combined Ratio Estimates of Total Catch According to Equation (5. 1) with Adjusted Catch Rate Ratios

	Salmon	Steelhead
$\frac{c_0^q + .003}{c_1^q - .003}$	163, 426	69, 363
$\frac{c_0^q}{c_1^q}$	162, 997	68, 991
$\frac{c_0^q - .003}{c_1^q + .003}$	162, 552	68, 653

The bias adjustments effect very little change in the combined ratio estimates of total catch. The adjusted estimates fall within 0. 5 standard errors of the unadjusted estimate for both salmon and steelhead. Of course these adjustments are based on estimates of the average value of bias and not on the maximum values of bias. That is, the combined ratio estimates of total salmon and total steelhead catch may contain biases, due to inexact weighting, larger than 0. 5 standard errors.

What is important here is that the total catch estimates from all

5 procedures are subject to bias from inexact stratum weighting and that procedures 2 through 5 may produce even further biasing.

It is beyond the scope of this study to delve into the nature of the interplay between inexact stratum weighting and summing separate ratio estimates. The study of such interplay is hampered here because of the use of estimated reported catch by type of angler with procedure 2 and because of the use of estimated numbers of anglers eligible to fish month by month with procedure 5. Further, such study is complicated by a factor which, in fact, may account for most of the difference between the procedure 1 estimate of total catch and any of the other 4 estimates of total catch. This factor is the obvious one that the catch rate ratios R in estimating equations (5. 1) through (5. 8) were not estimated from a survey sample of the entire 1961 salmon-steelhead fishing population. They were estimated from sample data collected only from anglers who purchased license and punch card simultaneously. That is, if the catch summary data required for equations (5. 1) through (5. 8) could be known for the surveyed population, the 5 estimates of total catch from these equations might exhibit considerably less spread than do those in Table 22.

The factors considered above concern the accuracy of the estimates in Table 22. Estimates of precision are given in that table only for the catch estimates from procedures 1 and 2. But from five subsamples taken for each of the fishing months January through June,

rough estimates of the precision of the catch rates c^q_{0k} and c^q_{1k} and subsequently of the total catch estimates from procedure 4 were made. These rough estimates indicated no increase over the precision resulting from procedures 1 and 2.

Thus, the choice of the best of the 5 estimates of 1961 total catch in Table 22 is a very hypothetical matter. The author is inclined to suggest the choice of the procedure 1 estimates of 1961 total salmon and steelhead catches.

For estimating total catch in future years, it will again be desirable to use the estimating procedure which yields estimates with the least expected MSE. But to the complications just presented in connection with choosing a "best" estimate of 1961 total catch the complication of a changing salmon-steelhead fishing population from year to year must be added. Consider some assumptions which will be made in employing each of the 5 procedures to estimate total catch for some future year x. For estimating total catch by month according to equation (5. 8), it will be necessary to assume that $\frac{C_{0k}}{C_{1k}} = \frac{c^q_{0k}}{c^q_{1k}}$ x . Having made this assumption, the factor $\frac{N_{0k}}{N_{1k}}$ will adjust for monthly punch card response rates in year x different from those observed in 1961, and an estimate of total catch may be made by summing the separate monthly total catch estimates. Of course, if this procedure is to be employed, it will be necessary to record date of punch card purchase on each punch card so that the summary data compiled at

the end of the year can include the $\underline{N}_{0k}$ and $\underline{N}_{1k}$. For equation (5. 7), it will be necessary to assume that $\left.\frac{C_{0k}}{C_{1k}}\right|_x = \frac{c^q_{0k}}{c^q_{1k}}$. Then, $\left.\frac{N_0}{N_1}\right|_x$ will adjust for annual punch card response rates in year x different from those observed in 1961, and an estimate of total catch may be made by summing the separate monthly total catch estimates. To employ summations of separate total catches computed according to equation (5. 5) and (5. 3), it is necessary to assume respectively that $\left.\frac{C_{0r}}{C_{1r}}\right|_x = \frac{c^q_{0r}}{c^q_{1r}}$ and $\left.\frac{C_{0j}}{C_{1j}}\right|_x = \frac{c^q_{0j}}{c^q_{1j}}$, the $\left.\frac{N_{0j}}{N_{1j}}\right|_x$ permitting response rates by type of angler in year x different from the 1961 rates. If (5. 3) is to be employed, angler type (j) will have to be recorded on punch cards sold so that the annual summary data can be broken down to yield N_{0j} and N_{1j}. To make one overall estimate according to (5. 1), it will be necessary to assume that $\left.\frac{C_0}{C_1}\right|_x = \frac{c^q_0}{c^q_1}$, the $\left.\frac{N_0}{N_1}\right|_x$ accounting for annual response rates in year x different from the 1961 rates.

Essentially then, the question as to which of the five estimating procedures to use in making future estimates of total annual catch can be resolved by ascertaining which of the assumptions just stated will be most consistently correct in the future. The author feels that the assumption that $\left.\frac{C_{0j}}{C_{1j}}\right|_x = \frac{c^q_{0j}}{c^q_{1j}}$ is the most reasonable

assumption among the five stated above, and recommends procedure 2 for future estimates of total annual catch. But to firmly establish a preference for one of the five estimating procedures, it will be necessary to study thoroughly the sensitivity of estimates from each of the five procedures to changes in stratum sizes or rather punch card return rates and reported catch. Then with some indication of how return rates and reported catch do in fact change from year to year or with some indication of how they may change in the future, a preference can be established for one of the five estimating procedures given above or for some other procedure.

The catch rate ratios estimated in this study for 1961 will probably be more sensitive to changes in population makeup or changes in punch card response rates than to changes in, for instance, the reported catch rate for anglers returning punch cards. Thus, it would seem advisable to begin including in the annual catch summary more detailed breakdowns of the salmon-steelhead fishing population by type of angler and possibly by purchase month. Then, large changes in punch card return rates or in population makeup should be regarded as harbingers of possible changes in the catch rate ratios given in the tables of this chapter. In fact, it would seem advisable to periodically reevaluate these catch rate ratios to learn how they change with time.

CHAPTER 6

SUMMARY

The problem of making accurate annual estimates of total salmon and steelhead catches in Oregon from punch card catch reports of an average 30 percent of the annual salmon-steelhead fishing population has been examined in this study by investigating the following five assumptions:

(1) The average catch per angler not returning a punch card is the same as the average catch per angler returning a card.

(2) For salmon and steelhead rivers in Oregon, the average catch on a given river per angler not returning a punch card is the same as the average catch on that river per angler returning a card.

(3) For each fishing month during the year, the average catch per angler not returning a punch card is the same as the average catch per angler returning a card.

(4) Anglers accurately report on their punch cards the month and river of catch.

(5) Anglers report their total catch.

Punch cards are purchased by Oregon salmon-steelhead anglers for reporting to the Oregon State Game Commission at the end of the year, dates, rivers, and numbers of salmon and steelhead caught during the year. But on the average, only about 30 percent of the annual salmon-steelhead fishing population return punch cards to the Game

Commission. Consequently, the five assumptions above have been made annually in estimating total catch and total catch by month, river and type of angler through simple expansion of reported catches.

The approach to investigating these assumptions was to derive for the 1961 salmon-steelhead fishing population estimates of catch rates for anglers not returning punch cards to the Oregon State Game Commission and to compare these rates with the catch rates for anglers who did return punch cards. The procedure is outlined below.

(1) A sample survey of 13, 332 Oregon salmon-steelhead anglers purchasing fishing licenses and salmon-steelhead punch cards at the same time was taken during 1961. Salmon-steelhead anglers who purchased punch cards at some time after the license purchase were not sampled. The primary sampling unit was an angler-month, and each sampled angler was mailed a post card questionnaire requesting one month's fishing information as to numbers and dates of fishing trips and numbers and species (salmon or steelhead) of fish caught. Questionnaires concerning a particular month's fishing activity were mailed to sampled anglers soon after the close of that month, and generally anglers who completed questionnaires from memory were not required to recall fishing activities from more than one or two months in the past. Each sampled angler supplied only one month's fishing information.

(2) Anglers not returning initial postcard questionnaires were

mailed as many as two reminder questionnaires at about 14 day intervals. For the questionnaire months of July through October 1961 (big harvest months for salmon), attempts were made to contact by telephone those anglers who had not responded to either the initial or the two reminder questionnaires, and further attempts were made to contact personally those sampled anglers who could not be reached by telephone. Over the entire year, approximately 47 percent of the sampled anglers responded within about 14 days by returning the initial postcard questionnaire, and after two reminder questionnaires, an average response rate of 80 percent had been achieved. Telephone and personal interviews resulted in from 90 to 94 percent total response for the months of July through October, and for the entire year, the overall response rate was 86 percent. That is, out of 15, 875 initial questionnaires mailed to sampled anglers, response was effected from 13, 332 or 86 percent. One hundred forty-one thousand, six hundred and three anglers purchased license and punch card at the same time throughout 1961, and the 13, 332 resulted from an average sampling rate each month of about 1. 3 percent of the salmon-steelhead anglers eligible to fish during the month.

(3) The 141, 603 anglers who purchased license and punch card at the same time throughout 1961 were termed the surveyed population. This surveyed population was considered to consist of two surveyed subpopulations, anglers who returned punch cards and anglers who

did not return punch cards at the end of the year. By collating sampled anglers with 1961 punch cards returned to the Game Commission, the 13, 332 sample anglers were divided into two groups, each group constituting a sample from the respective surveyed subpopulation. The monthly catches of anglers in both surveyed subpopulations were stratified according to type of fishing license (j) held by each angler and month of license and punch card purchase (i). Fishing months (k; $k \geq i$) formed substrata within each stratum (ij). Estimates of overall annual catch rates were then computed by forming weighted averages of appropriate strata mean annual catch rates, each stratum mean annual catch rate being computed by summing substrata average monthly catches. Annual catch rates by type of angler (j) were estimated by weighting and summing only over ten strata formed by ten purchase months (i) for a particular angler type. For annual catch rate estimates by river, substrata averages were broken down and summed by river, and for catch rate estimates by fishing month (k), each stratum average annual catch rate was replaced by the substratum mean for the month of interest. Exact stratum weights were not known for the surveyed subpopulations, but unbiased estimates were determined from a knowledge of stratum sizes for the surveyed population and from punch card response rates by strata for the survey sample. Variance estimates were derived through replicated subsampling. Tables 24 and 25 summarize the survey estimates of 1961 catch rates.

Table 24. Summary of Annual Catch Rate Estimates

	Salmon			Steelhead		
	A Anglers not returning punch cards	B Anglers returning punch cards	$R = \frac{A}{B}$	A Anglers not returning punch cards	B Anglers returning punch cards	$R = \frac{A}{B}$
Overall Catch Rate	1.1251	1.7811	.6317	.7225	.9340	.7735
Variance	.0022	.0151	.0037	.0017	.0112	.0206
Catch Rate For:						
Daily & Five Day Vacation Anglers	.6159	.8471	.7270	.1790	.3096	.5781
Variance	.0040	.0187	.0338	.0001	.0016	.0805
All other anglers	1.3560	1.9524	.6945	.9096	1.0485	.8675
Variance	.0038	.0205	.0037	.0032	.0156	.0246
Catch Rate For:						
Ocean	.7254	1.0537	.6885	.0180	.0158	1.137
Columbia	.0933	.2036	.4584	.0647	.1520	.4256
All Other Rivers Combined	.3063	.5237	.6849	.6397	.7661	.8350

Table 25. Survey Estimates of Catch in Month Indicated Per Angler Eligible to Fish That Month

Month	Salmon Catch Rate			Steelhead Catch Rate		
	A Anglers not returning punch cards	B Anglers returning punch cards	$R = \frac{A}{B}$	A Anglers not returning punch cards	B Anglers returning punch cards	$R = \frac{A}{B}$
January	.0155	.0222	.6995	.4870	.4593	1.0605
February	.0015	.0000	---	.2041	.0825	2.4731
March	.0713	.0282	2.5265	.2695	.0894	3.0149
April	.1406	.3146	.4468	.0324	.0302	1.0724
May	.1112	.1033	1.0773	.0177	.0068	2.6178
June	.0681	.0862	.7904	.0109	.0210	.5207
July	.3257	.3179	1.0246	.0581	.0577	1.0069
August	.5529	.7001	.7393	.0753	.0655	1.1506
September	.2254	.3263	.6909	.0814	.0628	1.2976
October	.0926	.1413	.6555	.0668	.0495	1.3501
November	.0547	.1190	.4599	.0764	.1460	.5232
December	.0209	.0455	.4598	.1821	.3159	.5766

No variance estimates were made for catch rates by months because of limited sample sizes, but for the other three groups of catch rate estimates in Table 24, the difference between the catch rate for anglers returning punch cards and the catch rate for anglers not returning punch cards is significantly different from zero at the one percent level in all instances except for steelhead caught in the ocean. The monthly catch rates in Table 25 indicate that the general tendency for the catch rate for anglers returning punch cards to be greater than the catch rate for anglers not returning punch cards does not hold for every fishing month. It was concluded that the first three assumptions were not generally valid in 1961 for anglers purchasing license and punch card at the same time.

No firm conclusions were drawn concerning the fourth and fifth assumptions that anglers report accurately their total catch because it was felt that questionnaire reports, even though limited to only one month's fishing information, could not be considered to be as accurate as punch card reports. In fact, for anglers returning punch cards, there is quite a discrepency between the 1961 annual catch rates of 1.1025 salmon per angler and .4099 steelhead per angler determined by dividing total punch card reported catches by the number of anglers returning punch cards and the 1961 annual catch rates of 1.7811 salmon per angler and .9340 steelhead per angler determined from questionnaire reports. At first though it was

suspected that these discrepencies might have arisen because the punch card derived catch rates apply to all anglers returning punch cards whereas the questionnaire derived catch rates were computed from a sample of only anglers purchasing license and punch card simultaneously. However, this is apparently not the case in that catch rates computed by using punch card reports of anglers in the survey sample who purchased license and punch card simultaneously were almost identical to those stated above for all anglers returning punch cards. The author felt that the major portion of the differences between catch rates determined from punch cards and catch rates determined from survey questionnaires could be attributed to a tendency for anglers to overreport when completing survey questionnaires from memory. Further, there was no reason to suspect that anglers not returning punch cards would not be subject to the same tendency to overreport when completing questionnaires from memory, and no modification was made to the conclusion that the first three assumptions were not valid in 1961.

For future estimates of total catches, it was proposed that estimating equations of the following form be employed.

$$H_x = H^{pc}_x \left[1 + R\left(\frac{N_0}{N_1} \Big|_x \right) \right]$$

$$\text{var}(H_x) = \left(\frac{H^{pc} N_0}{N_1} \right)^2 \left(\text{var}(R) \right) \qquad (6.1)$$

where, for some future year x,

$H|_x$ is the total catch estimate for year x,

$H^{pc}|_x$ is catch reported by punch card for year x,

$N_0|_x$ is the number of salmon-steelhead anglers not returning punch cards,

$N_1|_x$ is the number of salmon-steelhead anglers returning punch cards,

R is the catch per angler not returning a punch card divided by the catch per angler returning a punch card as computed in this survey.

var $(H|_x)$ is an estimate of the variance of $H|_x$

var (R) is the estimate of the variance of R as determined from the survey.

Differences which might occur between the estimate $H|_x$ from the equation above and true total catch will be due to inaccuracies in $H^{pc}|_x$ and/or R since $N_0|_x$ and $N_1|_x$ will be known. This survey cannot conclusively establish the accuracy of $H^{pc}|_x$, and with respect to that component of estimated total catch attributable to anglers returning punch cards, an estimate from the equation above will be as biased by any inaccuracies in $H^{pc}|_x$ as an estimate obtained by simple expansion. However, the bias which may arise from inaccuracies in $H^{pc}|_x$ is expected to be much smaller in future years than tne bias which can result by generally assuming identical catch rates for anglers returning and anglers not returning punch cards. The second term in brackets in equation (6. 1) is intended to account for the

difference in catch rates to reduce this potentially large bias. The specific estimating equations and catch rate ratios for estimating total catch by type of angler, by river, and by month are given in the tables in Chapter 5.

It was recommended that future estimates of total annual catch be made by summing separate total catch estimates made by type of angler. This procedure was selected over three alternates which yield estimates of total annual catch (1) by summing separate estimates made by river, (2) by summing separate estimates made by month, and (3) by computing one overall estimate according to equation (6. 1). However, the preference for summing over types of angler is not a strong one. It was desired to choose that procedure which yields consistently the most nearly correct estimate of total annual catch. But this choice centers around the accuracy of estimates from the four procedures in the face of a changing population since all four procedures yield estimates with about the same precision. No detailed study was made of the accuracy of each procedure under changes in population makeup so that a firm preference for one of the procedures must await further study. Presently, any one of the four procedures should yield estimates more nearly correct than those obtained by simple expansion of reported catches.

Because of the sensitivity of catch rate ratios to changes in population makeup and punch card return rates, it was suggested that the

catch summary issued annually by the Oregon State Game Commission be expanded to include more detailed breakdowns of the salmon-steelhead fishing population by type of angler and by purchase month.

BIBLIOGRAPHY

1. Cochran, William G. Sampling techniques. New York, Wiley, 1953. 330 p.

2. Deming, William Edwards. Sample design in business research. New York, Wiley, 1960. 517 p.

3. Deming, William Edwards. Some theory of sampling. New York, Wiley, 1950. 602 p.

4. Eberhardt, Lee and R. M. Murray. Estimating the kill of game animals by licensed hunters. 1960. 13 p. (Michigan Department of Conservation. Game Division, Lansing. Report No. 2302)

5. Hansen, Morris H., William N. Hurwitz and William G. Madow. Sample survey methods and theory. Vol. 1. New York, Wiley, 1953. 638 p.

6. Parten, Mildred B. Surveys, polls and samples. New York, Harper and Brother, 1950. 624 p.

7. Sukhatme, Pandurang V. Sampling theory of surveys with applications. Ames Iowa, U. S. A., The Iowa State College Press, 1954. 491 p.

APPENDICES

APPENDIX A

Table A-1. 1961 Salmon and Steelhead Catch Summary *

	Salmon	Steelhead	Total
No. anglers receiving punch cards			201, 016
Percent cards returned			28. 181
Est. No. anglers not fishing			63, 628
Est. No. anglers fishing - no catch			47, 193
Est. No. anglers catching both salmon and steelhead			12, 218
Est. No. anglers catching fish	74, 301	28, 105	90, 188
Est. No. fish caught	221, 620 ± 3055	82, 396 ± 2151	304, 017 ± 3920
Est. No. fish per angler	1. 1025 ± . 0152	.4099 ± .0107	1. 5124 ± .0195
Est. No. fish per angler catching	2. 98	2. 93	

*All estimates were made by simple expansion. Catches and catch rates are given as estimate ± standard error.

Table A -2. 1961 Punch Card Tallies

Number adult cards issued	186, 352
Number of Junvenile cards issued	14, 664
Total Number cards issued	201, 016
From returned punch cards:	
Number who fished but did not catch	13, 298
Number who did not fish	17, 929
Number who fished and did catch	25, 415
Total Number cards returned	56, 642
Number not returning cards	144, 374

Table A -3. 1961 Salmon Catch Frequency from Punch Cards Returned

No. of Fish	Anglers	Total Fish	No. of Fish	Anglers	Total Fish
1	6771	6771	14	60	840
2	6188	12376	15	41	615
3	2326	6978	16	44	704
4	1952	7808	17	20	340
5	1000	5000	18	20	360
6	782	4692	19	10	190
7	481	3367	20	17	340
8	343	2744	21	3	63
9	293	2637	22	1	22
10	211	2110	23	1	23
11	159	1749	25	1	25
12	125	1500	30	1	30
13	87	1131	33	1	33
Totals	Anglers	20,938	No. of Fish	62,448	

Table A-4. 1961 Steelhead Catch Frequency from Punch Cards Returned

No. of Fish	Anglers	Total Fish	No. of Fish	Anglers	No. of Fish
1	3326	3326	18	10	180
2	1692	3384	19	10	190
3	884	2652	20	5	100
4	604	2416	21	3	63
5	364	1820	22	4	88
6	269	1614	23	1	23
7	194	1358	24	1	24
8	157	1256	25	2	50
9	95	855	26	1	26
10	93	930	27	1	27
11	47	517	28	3	84
12	44	528	29	1	29
13	32	416	30	1	30
14	29	406	32	1	32
15	18	270	38	1	38
16	18	288	39	2	78
17	7	119			
Totals	Anglers	7920	No. of Fish	23, 217	

Table A-5. 1961 Total Fish Catch Frequency from Punch Cards Returned

No. of Fish	Anglers	Total Fish	No. of Fish	Anglers	No. of Fish
1	7816	7816	20	36	720
2	6790	13580	21	21	441
3	2871	8613	22	15	330
4	2407	9628	23	13	299
5	1366	6830	24	8	192
6	1006	6036	25	7	175
7	720	5040	26	9	234
8	554	4432	27	3	81
9	395	3555	28	2	56
10	350	3500	29	2	58
11	242	2662	30	2	60
12	214	2568	31	1	31
13	144	1872	32	2	64
14	118	1652	33	1	33
15	82	1230	34	1	34
16	80	1280	35	1	35
17	56	952	38	1	38
18	44	792	39	3	117
19	31	589	40	1	40
Totals	Anglers	25, 415	No. of Fish	85, 665	

Table A-6. 1961 Salmon and Steelhead Catch by Month

Month	Salmon		Steelhead	
	Reported Catch	Estimated* Catch	Reported Catch	Estimated* Catch
January	252	894	2, 984	10, 589
February	140	497	1, 633	5, 795
March	755	2, 679	1, 413	5, 014
April	5, 153	18, 285	706	2, 505
May	2, 038	7, 232	224	795
June	2, 929	10, 394	186	660
July	12, 320	43, 717	1, 314	4, 663
August	21, 746	77, 165	1, 503	5, 333
September	9, 086	32, 242	1, 918	6, 806
October	4, 219	14, 971	1, 584	5, 621
November	2, 590	9, 191	2, 085	7, 399
December	1, 220	4, 329	7, 667	27, 206
Totals	62, 448	221, 596	23, 217	82, 386

* Estimates were obtained by dividing reported catch by . 28181, the 1961 punch card return rate.

Table A-7. Summary of Estimates Made From Punch Cards, 1954 - 1961

	1954	1955	1956	1957	1958	1959	1960	1961
No. receiving cards	170, 849	165, 422	166, 386	135, 230	215, 410	285, 700	172, 322	201, 016
% cards returned	31. 02	27. 51	34. 48	51. 41	32. 08	23. 46	30. 75	28. 178
No. anglers not fishing	78, 126	83, 737	70, 240	61, 593	104, 172	120, 794	59, 235	63, 628
No. anglers fishing no-catch	40, 242	37, 915	31, 903	23, 475	43, 236	62, 254	45, 528	47, 193
No. anglers catching both species		7, 780	11, 756	8, 563	11, 221	14, 285	9, 239	12, 219
No. anglers catching Salmon	36, 493	30, 520	49, 160	39, 893	49, 781	78, 969	51, 977	74, 301
Steelhead	25, 103	21, 009	26, 839	18, 832	29, 425	37, 726	24, 836	28, 105
Salmon or Steelhead		43, 754	64, 243	50, 162	67, 983	102, 664	67, 639	90, 195
No. fish caught:*								
Salmon	98, 896 ±1927	81, 761 ±1945	155, 757 ±2346	130, 285 ±2367	127, 975 ±2133	221, 360 ±3486	145, 758 ±2332	221, 620 ±3055
Steelhead	74, 555 ±1855	59, 700 ±1779	83, 844 ±1913	57, 762 ±1108	90, 709 ±2197	121, 233 ±3114	79, 841 ±2085	82, 396 ±2151

Table A-7. Continued

	1954	1955	1956	1957	1958	1959	1960	1961
Total	173, 451 ±2674	140, 748 ±2812	239, 601 ±3228	188, 047 ±2015	218, 684 ±3317	342, 554 ±4934	225, 652 ±3309	304, 017 ±3920
No. fish/angler *								
Salmon	. 575 ±011	. 492 ±0117	. 936 ±0141	. 9634 ±0114	. 5941 ±0099	. 7748 ±0122	. 8461 ±0140	1. 1025 ±0152
Steelhead	. 422 ±011	. 359 ±0107	. 504 ±0115	. 4271 ±0082	. 4211 ±0102	. 4243 ±0109	. 4631 ±0126	. 4099 ±0107
Total	. 997 ±. 0156	. 851 ±. 0170	1. 440 ±. 0194	1. 3906 ±. 0194	1. 0152 ±. 0154	1. 199 ±. 0173	1. 309 ±. 0190	1. 5124 ±. 0195
No fish/angler catching fish:								
Salmon	2. 71	2. 66	3. 17	3. 27	2. 57	2. 80	2. 80	2. 98
Steelhead	2. 77	2. 83	3. 12	3. 07	3. 08	3. 21	3. 22	2. 93
Total	3. 28	3. 22	3. 73	3. 75	3. 22	3. 34	3. 33	3. 37

*Estimate ± standard error

APPENDIX B

Estimation of Total Catch for 1961 Salmon-Steelhead Fishing Population According to Equations (5. 1) through (5. 8)

Total Annual Catch-Equations (5. 1) and (5. 2)

From Tables A-2 to A-4 of Appendix A:

$$N_0\Big|_{1961} = 144,374 \qquad H^{pc}\Big|_{1961} = 62,448 \text{ salmon}$$

$$N_1\Big|_{1961} = 56,642 \qquad H^{pc}\Big|_{1961} = 23,217 \text{ steelhead}$$

$$\frac{N_0}{N_1}\Big|_{1961} = 2.548886$$

Using the catch ratios R and variance estimates from Table 10 of Chapter 5 according to equations (5. 1) and (5. 2),

$$\text{H salmon}\Big|_{1961} = 62,448\,[1 + .631695\,(2.548886)]$$

$$= 162,997$$

$$s^2 = .003665\,[62,448\,(2.548886)]^2$$

$$= 92,869,328$$

$$s = 9637 \qquad cv = 5.9\%$$

$$\text{H steelhead}\Big|_{1961} = 23,217\,[1 + .773506\,(2.548886)]$$

$$= 68,991$$

$$s^2 = .020548\,[23,217\,(2.548886)]^2$$

$$= 71,956,829$$

$$s = 8,483 \qquad cv = 12.3\%$$

For 90 percent confidence intervals, $t_{05,9}$ is 1.833 . Thus,

$$H\ salmon\Big|_{1961} = 162,997 \pm 17,667$$

$$H\ steelhead\Big|_{1961} = 68,991 \pm 15,551$$

Total Annual Catch by Type of Angler - Equation (5.3) and (5.4)

The entire 1961 punch card reported catch is not known by type of angler, but for two classifications of anglers, estimates of entire reported catch are derived below. These estimates are made by assuming a catch distribution by type of angler over the entire 1961 subpopulation of anglers returning punch cards the same as the distribution over the sampled portion of the subpopulation (anglers purchasing license and punch card simultaneously).

Table B-1. Estimation of Reported Catch by Type of Angler

	c_1^{pc}	Est. No. of anglers in surveyed subpopulation returning punch cards	Est. of Reported catch for surveyed subpopulation		Est. of Reported catch for entire subpopulation
	from T. 20	from T. 9	(Col (2) · (Col. (3))		(Col. (4)) · $H^{pc}\Big\|_{1961}$
(1)	(2)	(3)	(4)	(5)	(6)
Salmon					
07 & 46	.99452	6,963	6,925 =	15.440%	9,642
All others	1.01966	37,195	37,926 =	84.560%	52,806
Totals		44,158	44,851 =	100.000%	62,448
Steelhead					
07 & 46	.16532	6,963	1,151 =	6.473%	1,503
All others	.44689	37,195	16,622 =	93.527%	21,714
Totals		44,158	17,773 =	100.000%	23,217

Table B-2 below summarizes from Table 9 of Chapter 5 strata sizes for the surveyed subpopulation.

Table B-2. Strata Sizes for Surveyed Subpopulation

Type of Angler	Not Returning Punch Cards	Returning Punch Cards	Totals
07 & 46	30, 506	6, 963	37, 469
All others	66, 939	37, 195	104, 134
Totals	97, 445	44, 158	141, 603

Assuming that the percent punch card response is the same for all anglers of a given type whether or not license and punch card are purchased coincidentally, the numbers in Table B-2 are used with equations (5. 3) and (5. 4) to yield the following estimates.

For Salmon

$$H_{07\ \&\ 46\,|1961} = 9642\left[\,1 + .72701\,\frac{(30,506)}{6,963}\,\right]$$

$$= 40,353$$

$$s^2 = .03384\left[\,9642\,\frac{(30,506)}{6,963}\,\right]^2$$

$$= 64,955,587$$

$$s = 8,060 \qquad cv = 20\%$$

$$H_{\text{all other}\,|1961} = 52,806\left[1 + .69452\,\frac{(66,939)}{37,195}\,\right]^2$$

$$= 118,809$$

$$s^2 = .0036680\,[52,806\,\frac{(66,939)}{37,195}]^2$$

$$= 33,127,218$$

$$s = 5,756 \qquad cv = 4.84\%$$

Total Catch $= 159,162$

$$s^2 = 98,082,805$$

$$s = 9,904 \qquad cv = 6.22\%$$

For Steelhead

$$H_{07\ \&\ 46\,|\,1961} = 1,503\,[1 + .57812\,\frac{(30,506)}{6,963}]$$

$$= 5,310$$

$$s^2 = .08049\,[1503\,\frac{(30,506)}{6,963}]^2$$

$$= 3,490,100$$

$$s = 1,868 \qquad cv = 38.7\%$$

$$H_{\text{all others}\,|\,1961} = 21,714\,[1 + .86751\,\frac{(66,939)}{37,195}]$$

$$= 55,615$$

$$s^2 = .024653\,[21,714\,\frac{(66,939)}{37,195}]^2$$

$$= 37,647,835$$

$$s = 6,136 \qquad cv = 11\%$$

Total Catch $= 60,925$

$$s^2 = 41,137,935$$

$$s = 6,414 \qquad cv = 10.5\%$$

Total Annual Catch By River - Equations (5.5) and (5.6)

Using the catch rate ratios R_r and variances from Table 12, with the H^{pc} from the OSGC 1961 punch card catch summary (Aug., 1962).

For Salmon

$$H_{ocean}\big|_{1961} = 23,865\,[1 + .688456\,(2.548886)\,]$$

$$= 65,743$$

$$s^2 = .0020033\,[23,865\,(2.548886)\,]^2$$

$$= 7,412,600$$

$$H_{Columbia}\big|_{1961} = 9,318\,[1 + .459398\,(2.548886)]$$

$$= 20,205$$

$$s^2 = .00851395\,[9,318\,(2.548886)\,]^2$$

$$= 4,802,610$$

$$H_{\substack{\text{all other}\\ \text{rivers}}}\Big|_{1961} = (62,448 - 23,865 - 9,318)[1 + .584891\,(2.548886)\,]$$

$$= 72,894$$

$$\text{Total Catch} = 158,842$$

For Steelhead

$$H_{ocean}\big|_{1961} = 60\,[1 + 1.137201\,(2.548886)\,]$$

$$= 234$$

$$s^2 = .1713\,[60\,(2.548886)\,]^2$$

$$= 4,006$$

$$H_{\text{Columbia}}\Big|_{1961} = 3,486\,[1 + .425603(2.548886)]$$

$$= 7,268$$

$$s^2 = .20295\,[3486(2.548886)]^2$$

$$= 16,023,031$$

$$H_{\substack{\text{all other}\\ \text{rivers}}}\Big|_{1961} = (23,217 - 60 - 3486)[1 + .835000(2.548886)]$$

$$= 61,537$$

$$\text{Total Catch} = 69,039$$

Table B-3 contains estimates of total catch on the 13 rivers for which catch rate ratios R_r are listed in Table 14 of Chapter 5. The estimates were computed according to equation (5.5) from reported catches as given in the Oregon State Game Commission 1961 punch card catch summary (August 1962).

Sample Calculation:

Alsea River Salmon Catch

Reported catch, $H_1^{pc}\Big|_{1961} = 1558$ (OSGC Summary)

$R_{\text{Alsea}} = 1.4068$ Table 14

$$\frac{N_0}{N_1}\Big|_{1961} = 2.548886$$

$$H_{\text{Alsea}}\Big|_{1961} = 1558\,[1 + 1.4068(2.548886)]$$

$$= 7,145$$

Table B-3. Estimates of 1961 Total Catch by River - Equation (5.5)

OSGC River Code	River	Punch Card Reported Catch (1961)		Estimated Total Catch (1961)	
		Salmon	Steelhead	Salmon	Steelhead
01	Alsea	1558	1008	7145	4042
10	Columbia	9318	3486	20, 205	7268
11	Coos	2065	217	3198	3247
13	Deschutes	388	1094	545	13, 291
35	Nehalem	1647	1075	3668	4333
37	Nestucca	1076	1246	2871	6633
38	Ocean	23, 865	60	65, 746	234
43	Rogue	3037	2779	41, 702	24, 711
49	Siletz	1033	860	1323	1514
51	Siuslaw	1632	465	4721	1049
62	Umpqua	3473	1170	23, 692	3378
67	Willamette	2853	321	12, 437	5038
68	Wilson	380	983	913	2907
Totals				188, 166	77, 645

Total Catch by Month - Equation (5.7)

Estimates in Table B-4 have been computed using the catch summary data of Table A-6 Appendix A, and the catch rate ratios of Table 15, Chapter 5, according to equation (5.7).

Total Catch by Month - Equation (5.8)

To estimate total monthly catch according to equation (5.8), the number of anglers eligible to fish during each month (k) of a given year must be known for the two subpopulations. To determine these numbers, $\underline{N}_{0k}$ and $\underline{N}_{1k}$, account must be taken of the fact that One

Table B-4. Estimates of 1961 Total Monthly Catch - Equation (5. 7)

Month	Salmon		Steelhead	
Jan	252[1 + B(. 42779)]	= 527	2984[1 + B(. 61303)]	= 7, 647
Feb	140[1 + B(0. 8)]	= 425*	1633[1 + B(1. 4606)]	= 7, 712
Mar	755[1 + B(1. 6596)]	= 3, 949	1413[1 + B(2. 0504)]	= 8, 798
Apr	5153[1 + B(. 3225)]	= 9, 389	706[1 + B(. 7353)]	= 2, 029
May	2038[1 + B(. 8014)]	= 6, 201	224[1 + B(1, 8517)]	= 1, 281
Jun	2929[1 + B(. 6070)]	= 7, 461	186[1 + B(. 3816)]	= 367
Jul	12, 320[1 + B(. 85558)]	= 39, 187	1314[1 + B(. 7981]	= 3, 987
Aug	21, 746[1 + B(. 69587)]	= 60, 317	1503[1 + B(. 97156)]	= 5, 225
Sep	9086[1 + B(. 5969)]	= 22, 910	1918[1 + B(1. 07445)]	= 7, 171
Oct	4219[1 + B(. 56203)]	= 10, 263	1584[1 + B(1. 1014)]	= 6, 031
Nov	2590[1 + B(. 39436)]	= 5, 193	2086[1 + B(. 4270)]	= 4, 354
Dec	1220[1 + B(. 39442)]	= 2, 446	7667[1 + B(. 4702)]	= 16, 856
	62, 448	168, 268	23, 217	71, 458

B = 2. 548886

*Survey sample provided no estimate of R_K for February. The value 0. 8 has been assumed.

Day (07) and Five-Day Vacation (46) anglers may fish only during one month of the year. Thus, it is necessary to know for each month of a given year the total number of punch cards issued and the number of punch cards returned for two major groups of anglers, the 07 and 46

group of anglers and the group consisting of all other anglers. $\underline{N}_{0k}$ and $\underline{N}_{1k}$ cannot be determined exactly for 1961 since Oregon salmon-steelhead punch cards do not carry indications of purchase month or type of angler purchasing each card. However, in Table 9, estimates of $\underline{N}_{0k}$ and $\underline{N}_{1k}$ are given for the surveyed subpopulations for January through September determined from the estimated subpopulation strata sizes in that table. The two tables below provide for estimates of $\underline{N}_{0k}$ and $\underline{N}_{1k}$ for the remaining months October, November, and December derived from computing estimates of the two surveyed subpopulations for these months. That is, the strata for purchase months October, November, and December are not now considered to be collapsed into one stratum as in Tables 8 and 9, but punch card response rates are assigned where necessary to permit maintaining separate strata.

The $\underline{N}_{0k}$ and $\underline{N}_{1k}$ from Tables 9 and B-6, the catch rate ratios of Table 16, and the catch summary data of Table A-6 were used according to equation (5. 8) to compute the 1961 monthly total catch estimates shown in Table B-7 below. It has been assumed that the ratios $\underline{N}_{0k}/\underline{N}_{1k}$ are the same for both the surveyed population and the entire population.

Table B-5. Extension of Table 8

Purchase Month		Type of Angler (OSGC code) 01	04	05	06	12-39	07 & 46
Oct	n_1	10	34	4	3	1	17
	n_0	26	115	10	2	2	101
	p%	27.8	22.8	28.6	60.0	33.3	14.4
Nov	n_1	0	10	3	0	0	7
	n_0	2	19	3	0	1	24
	p%	36.1*	34.5	50.0	28.4*	68.9*	22.6
Dec	n_1	0	0	1	0	0	1
	n_0	0	1	0	0	0	0
	p%	36.1*	30.0*	24.5*	28.4*	68.9*	18.6*

*Assigned response rate (same as overall response rate in Table 9).

Table B-6. Extension of Table 9

Purchase Month		Type of Angler (OSGC code) 01	04	05	06	12-39	07&46	Total	No. Eligible to Fish
Oct	R	22	173	15	52	2	319	584	37,208
	NR	57	586	37	34	4	1899	2617	68,061
Nov	R	1	102	18	3	1	171	296	37,185
	NR	3	194	19	6	1	586	809	66,971
Dec	R	105	113	8	2	18	201	447	37,461
	NR	187	264	26	4	8	878	1367	67,752

Table B-7. Estimates of 1961 Total Monthly Catch - Equation (5.8)

Month	Salmon		Steelhead	
Jan	252[1 + .6995(1.1677)]	= 458	2984[1 + 1.0605(1.1677)]	= 6,679
Feb	140[1 + 1.0(1.2121)]	= 310*	1633[1 + 2.4731(1.2121)]	= 6,528
Mar	755[1 + 2.5265(1.3289)]	= 3,290	1413[1 + 3.0149(1.3289)]	= 7,074
Apr	5153[1 + .4468(1.5164)]	= 8,644	706[1 + 1.0724(1.5164)]	= 1,854
May	2038[1 + 1.0773(1.5845)]	= 5,517	224[1 + 2.6178(1.5845)]	= 1,153
Jun	2929[1 + .7904(1.6456)]	= 6,739	186[1 + .5207(1.6456)]	= 345
Jul	12,320[1 + 1.0246(1.8103)]	= 35,178	1314[1 + 1.0069(1.8108)]	= 3,710
Aug	21,746[1 + .7898(1.9263)]	= 54,830	1503[1 + 1.1506(1.9263)]	= 4,834
Sep	9086[1 + .6909(1.8746)]	= 20,854	1918[1 + 1.2976(1.8746)]	= 6,583
Oct	4219[1 + .6555(1.8292)]	= 9,278	1584[1 + 1.3501(1.8292)]	= 5,496
Nov	2590[1 + .4599(1.8010)]	= 4,735	2085[1 + .5232(1.8010)]	= 4,050
Dec	1220[1 + .4598(1.8086)]	= 2,235	7667[1 + .5766(1.8086)]	= 15,662
		152,068		63,968

*Survey sample provided no estimate of $\underline{R}_k$ for Feb. The value 1.0 has been assumed.