

# TANANA DRAINAGE LAKE STOCKING EVALUATIONS, 1986

By: Michael Doxey



---

STATE OF ALASKA  
Steve Cowper, Governor  
ALASKA DEPARTMENT OF FISH AND GAME  
Don W. Collinsworth, Commissioner  
DIVISION OF SPORT FISH  
Norval Netsch, Director



---

P.O. Box 3-2000, Juneau, Alaska 99802

SEPTEMBER 1987

TANANA DRAINAGE LAKE STOCKING EVALUATIONS, 1986<sup>1</sup>

By

Michael Doxey

Alaska Department of Fish and Game  
Division of Sport Fish  
Juneau, Alaska 99802

September 1987

<sup>1</sup> This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-2, Job No. T-8-1.



TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES. . . . .	ii
ABSTRACT. . . . .	1
INTRODUCTION. . . . .	1
METHODS . . . . .	4
Birch and Quartz Lake Evaluations. . . . .	4
Chena Lake Evaluation. . . . .	5
Other Stocked Lake Evaluations . . . . .	6
RESULTS . . . . .	6
1986 Fish Stocking . . . . .	6
1987 Region III Stocking Request . . . . .	6
Lake Trout and Burbot Broodstock . . . . .	6
Stocking Evaluations . . . . .	6
Birch Lake Rainbow Trout. . . . .	6
Birch Lake Coho Salmon. . . . .	21
Birch Lake Angler Effort. . . . .	21
Quartz Lake Rainbow Trout . . . . .	22
Quartz Lake Coho Salmon . . . . .	22
Chena Lake Rainbow Trout. . . . .	27
Chena Lake Coho Salmon. . . . .	27
Other Stocked Lake Evaluations. . . . .	27
DISCUSSION. . . . .	29
Recommendations. . . . .	30
LITERATURE CITED. . . . .	31

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Number and size of rainbow trout stocked in AYK lakes in 1986. . . . .	7
2. Number and size of Arctic grayling stocked in AYK lakes in 1986 . . . . .	8
3. Number and size of sheefish stocked in AYK lakes in 1986. . . . .	9
4. Number and size of Arctic char stocked in AYK lakes in 1986. . . . .	10
5. Number and size of chinook salmon stocked in AYK lakes in 1986 . . . . .	11
6. Number and size of coho salmon stocked in AYK lakes in 1986. . . . .	12
7. Requested number and size of Arctic char to be stocked in AYK lakes in 1987. . . . .	13
8. Requested number and size of Arctic grayling to be stocked in AYK lakes and rivers in 1987 . . . . .	14
9. Requested number and size of coho salmon to be stocked in AYK lakes in 1987. . . . .	16
10. Requested number and size of chinook salmon to be stocked in AYK lakes in 1987. . . . .	17
11. Requested number and size of rainbow trout to be stocked in AYK lakes and rivers in 1987 . . . . .	18
12. Requested number and size of sheefish to be stocked in AYK lakes in 1987 . . . . .	19
13. Birch Lake rainbow trout population estimate, 1986. . . . .	20
14. Quartz Lake catchable rainbow trout population estimate, (August 1986) . . . . .	23
15. Quartz Lake catchable rainbow trout population estimate (winter 1986-1987). . . . .	24
16. Recapture rates obtained from the Birch Lake winter rainbow trout fishery and the Quartz Lake rainbow trout and coho salmon fisheries . . . . .	25

LIST OF TABLES (Continued)

<u>Table</u>	<u>Page</u>
17. Quartz Lake catchable coho salmon population estimate (September 1986) . . . . .	26
18. Region III 1986 stocked lake sampling. Nets were set for 18-24 hours . . . . .	28



## ABSTRACT

This report presents the results of the Region III lake stocking and stocked lakes evaluations performed in 1986. In 1986, a combined total of 1,453,655 rainbow trout (*Salmo gairdneri* Richardson), Arctic grayling (*Thymallus arcticus* Pallas), coho and chinook salmon, (*Oncorhynchus kisutch* and *Oncorhynchus tshawytscha* Walbaum), sheefish (*Stenodus leucichthys* Guldenstadt), and Arctic char (*Salvelinus alpinus* Linnaeus) were stocked into 55 lakes and ponds in interior Alaska. The 1987 request is 1,860,350 fish to be stocked in 47 waters.

A mark-recapture population estimate of rainbow trout stocked as subcatchables in Birch Lake in 1986 indicated that 57 percent had survived to catchable size. This high survival rate is expected to reverse the declining trends in the sport fishery resulting from poor survival of rainbow trout stocked as fingerlings. A mark-recapture population estimate of rainbow trout and coho salmon was also performed in Quartz Lake. The total abundance of rainbow trout greater than 170 millimeters was estimated at only 10,479 fish, and the abundance of coho salmon was estimated at 21,503 fish.

Netting was performed in some stocked lakes and ponds to evaluate stocking success and growth of stocked fish. Most stocking attempts were successful and sport fishing potential was judged to be increased. No sheefish that were stocked into Harding Lake in 1982 and 1984 were caught during sampling.

KEY WORDS: stocked lakes, Birch Lake, Quartz Lake, population estimates, survival, growth.

## INTRODUCTION

Many lakes and ponds in interior Alaska are stocked on a continuing basis with rainbow trout (*Salmo gairdneri* Richardson), coho salmon (*Oncorhynchus kisutch* Walbaum), Arctic grayling (*Thymallus arcticus* Pallas), or chinook salmon (*Oncorhynchus tshawytscha* Walbaum). These stocked lakes are an important component of the area fisheries, supporting over one-third of the recreational angling in the Tanana River drainage. In 1985, 74,474 stocked rainbow trout and coho salmon were harvested by Tanana drainage anglers (Mills 1986).

Increasing human population in the Tanana Valley is putting a greater demand on limited sport fishing opportunities. Temporal and financial constraints cause the majority of fishermen to favor roadside fisheries over more remote angling opportunities. Native fish populations near the interior road system are receiving heavy angler utilization.

To provide more year round fishing opportunities and to shift pressure away from heavily utilized wild stocks, the Alaska Department of Fish and Game (ADF&G) is expanding its lake stocking program for rainbow trout, coho salmon, grayling, sheefish, (*Stenodus leucichthys* Guldenstadt), Arctic char, (*Salvelinus alpinus* Linnaeus), and chinook salmon. The

Division of Sport Fish stocking program is conducted in an approximate 50,000 square mile area bordered by the Kantishna River on the west, the Tok area to the east, the Delta River drainage south to Donnelly Dome, and the Steese Highway area north to the town of Central. Most of the stocked lakes within the area are near communities or along road systems, but a number of remote lakes accessible only by dog team, ATV, snow machine, or airplane are also stocked. While most enhancement activities are presently conducted in Tanana drainage waters, this is a region-wide project, and may be expanded beyond the Tanana drainage in future years should the need arise.

The Department's stocking program in the interior began in the early 1960's, when barren lakes along the road system were stocked with trout or salmon and lakes with indigenous fish populations that provided little or no sport fishing opportunity were chemically treated with rotenone to eliminate predator/competitor species and stocked with more desirable species. Since 1968, 15 of the 50 regularly stocked lakes (including 37 hectare Quartz Lake and 20 hectare Birch Lake) have been chemically treated. These actions have accelerated growth rates of stocked fish and increased returns to the creel for target species.

In addition to the summer sport fisheries, important winter sport fisheries occur at stocked lakes. The native fish stocks along the road system have only a limited capacity to support winter sport fishing, but almost half of the yearly sport fishing effort on the larger, more accessible stocked lakes takes place in winter. Harvest and effort statistics for those fisheries are estimated annually through a postal survey of licensed fishermen and/or through on-site creel censuses.

In the late 1970's the Department, which had previously imported rainbow trout eggs from outside Alaska, discontinued imports to reduce the chance of introducing diseases. The Department was faced with the task of establishing hatchery brood stocks from wild rainbow trout populations. This resulted in a number of years of inadequate hatchery production. Many interior lakes went 5 or more years without stocking. In 1971, 1,300,000 rainbow trout were stocked in interior waters. This level dropped to 227,000 by 1975 and by 1978 only 105,000 rainbow trout were stocked. Some waters that had previously received rainbow trout were stocked with coho salmon to provide some harvest opportunity.

As suitable rainbow trout brood stocks were developed and new hatcheries put into production, numbers of stocked fish increased. By 1985, average annual harvest and effort levels for stocked waters had risen by over 40% and 20%, respectively, since 1977. This is largely in response to increased numbers of fish being available for stocking.

In 1987, an anticipated 1,096,500 rainbow trout, 318,000 coho salmon, and 204,700 grayling will be stocked in the interior.

With increasing success of the hatcheries, refinement of stocking parameters (optimum numbers, size, timing, and strain) has been possible. For example, experimental stocking of 20 g subcatchable rainbow trout into Birch Lake was begun in 1980 and 1981. This resulted in higher fish

survival and higher harvests than were obtained from fish stocked as fingerlings (Doxey 1985).

Since the inception of the stocking program, research has been directed toward determining the feasibility of stocking additional waters and evaluating the success of existing stocking programs. New waters considered for stocking have been generally evaluated on the criteria of their capacity to overwinter fish, the presence of indigenous predatory/competing/forage species, public access status, accessibility, size, and presence or absence of an outlet. Chena Lake, a 260 acre lake created during the construction of the Chena Flood Control Project, is a good example of a new fishery that was developed through the lake stocking project. During the summer of 1985, 21,500 trout and salmon were harvested in 11,300 man-days of effort at Chena Lake.

Success of the stocking program is evaluated annually. The level of evaluation varies according to the size and accessibility of the lake and the importance and intensity of the sport fishery. Minimal evaluations answer the question of whether the stocked fish survived and whether they are providing any sport fishing. More comprehensive evaluations provide limnological data, growth rates, and fishery statistics such as catch per unit effort (CPUE), population estimates, analysis of growth rates and comparisons of performance between different species, stocking sizes, and broodstocks.

The goals of the project are to create, maintain, or improve a variety of sport fishing opportunities in the region through a lake stocking program; to experimentally test different stocking parameters (species, sizes, etc.); and to provide information to the staff and public on sport fishing opportunities made available by the stocking program.

Specific project objectives include:

1. To report on the 1986 stocking program, including lakes, species, and numbers of fish stocked;
2. To formulate and include in this report the 1987 Regional lake stocking request;
3. To conduct evaluations of stocking programs in Region III waters as follows:
  - A. Birch Lake
    1. To estimate the survival to catchable size of the subcatchable rainbow trout stocked in 1986;
    2. To monitor growth to catchable size of rainbow trout and coho salmon; and
    3. To utilize creel census results to monitor angler use, catch trends, and the contribution of various stocking classes to the creel.

B. Chena Lake

1. To monitor growth rate to catchable size of stocked coho salmon of stocked cohos and rainbow trout;
2. To utilize creel census results to monitor the harvest and determine the contribution of various stocking classes to the creel.

C. Quartz Lake

1. To estimate abundance of the catchable rainbow trout and coho salmon available to anglers;
2. To monitor growth of rainbow trout stocked in 1985 and coho salmon stocked in 1986; and
3. To utilize creel census data to monitor angler use trends.

D. To conduct evaluations at varying intensities of the survival, growth, and sport fishing potential of rainbow trout, coho salmon, chinook salmon, sheefish, or Arctic char in other stocked lakes and ponds as time permits.

E. To give direction to the Division of Fisheries Rehabilitation, Enhancement and Development (FRED) in beginning the process of developing lake trout (*Salvelinus namaycush* Walbaum) and burbot (*Lota lota* Linnaeus) broodstock sources.

## METHODS

### Birch And Quartz Lake Evaluations

In both Birch and Quartz Lake, relatively intensive population sampling was performed in 1986. Rainbow trout and coho salmon were captured with fyke nets set perpendicular to the shoreline. All fyke nets used in this project were 6.1 m in length by 1.2 m diameter with 9.53 mm knotless nylon webbing and 1.2 m x 30.5 m center leads. One to four nets were set approximately once a month to obtain rainbow trout and coho for growth samples.

A mark-recapture population estimate of rainbow trout was performed in Birch Lake during 1986. All rainbow trout caught in fyke nets during a 10 day period in late August and early September were marked with a partial caudal finclip. Mixing of marked and unmarked fish was assessed by differential finclipping (top versus bottom caudal) on opposite sides of the lake. Recapture sampling took place in Birch Lake in late September and early October. During both marking and recapture sampling, fish were measured to the nearest millimeter fork length. Separate population estimates were performed on three stocking cohorts: those fish 169 mm or less in length which represented fish stocked as subcatchables that would not grow to catchable size (180 mm) by the winter; those 170 to

230 mm which represented fish stocked as subcatchables that would be of catchable size by the winter; and those over 230 mm representing "carry-over" fish from previous stockings.

In Quartz Lake, mark-recapture population abundance estimates were performed for rainbow trout as well as coho salmon. Fish were marked with a partial caudal finclip during a 10 day sampling effort in early August. Eight to 12 fyke nets were used to capture fish for marking. During both marking and recapture sampling, all fish were measured to the nearest millimeter fork length. Separate population estimates were performed on two stocking cohorts of each species: those rainbow trout or coho salmon from 170 to 230 mm which represented the component of the survivors of the 1985 fingerling stocking that were near or over catchable size (180 mm); and those fish over 230 mm representing "carry-over" fish from previous stockings. Recapture sampling took place in early September. During recapture sampling, all unmarked fish were marked with a caudal finclip adding them to the population of marked fish. This allowed an additional recapture event to be performed during winter creel sampling. All harvested rainbow trout during winter creel census periods were measured and examined for clips. Sampling methods and designs for the creel census are outlined in the AYK Creel Census Report (Clark and Ridder 1987).

All population estimates were calculated using Chapman's modification of the Petersen mark-recapture formula (Seber 1982):

$$N^* = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1$$

where:  $N^*$  = the estimated population size,

$n_1$  = the number of fish marked during the first sampling event,

$n_2$  = the number of fish examined during the second sampling event, and

$m_2$  = the number of marked fish caught during the second sampling event.

The sampling variance of this estimate was calculated as:

$$v^* = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2(m_2 + 2)}$$

Data were recorded on mark-sense forms and processed with IBM and Kaypro personal computers after initial processing by the Research and Technical Services (RTS) Section of the Division of Sport Fish.

#### Chena Lake Evaluation

Length estimates of Chena Lake rainbow trout and coho salmon were obtained by measuring fish captured by fyke nets and anglers. Fyke nets were set

parallel to the shoreline because the steep bottom gradient prevented perpendicular sets. Harvest and effort estimates were obtained from the Regional creel census program (Clark and Ridder 1987).

#### Other Stocked Lake Evaluations

Length and relative abundance estimates for stocked fish in other lakes were obtained by overnight sampling with fyke and gill nets and spot check creel census interviews. Gill nets were monofilament experimental sinking nets with overall dimensions of 38.1 m x 1.8 m consisting of five, 7.6 m long panels of 12.7 mm through 63.5 mm bar mesh.

### RESULTS

#### 1986 Fish Stocking

A total of 694,205 rainbow trout, 321,112 Arctic grayling, 89,560 sheefish, 12,778 Arctic char, 36,000 chinook salmon, and 300,000 coho salmon were stocked in Tanana drainage lakes in 1986 (Tables 1-6). No major logistic problems or fish mortalities occurred during stocking.

#### 1987 Region III Stocking Request

Planned stocking for Tanana drainage lakes in 1987 includes: 5,150 Arctic char in seven lakes (Table 7); 204,700 Arctic grayling in 26 ponds or rivers (Table 8); 318,000 coho salmon in 12 Lakes (Table 9); 36,000 chinook salmon in three lakes (Table 10); 1,096,500 rainbow trout in 41 lakes (Table 11); and 200,000 sheefish in four lakes (Table 12).

#### Lake Trout And Burbot Broodstock

Discussions were initiated with FRED Division personnel concerning the biological, technical, and logistical aspects of developing broodstock sources for lake trout and burbot. Planning began for a lake trout egg take from one of several lakes in the Paxson area to be performed in 1987. Eggs will be incubated in the Clear Hatchery. After discussing the potential for a burbot egg take and determining that the brood source would be from the Tanana drainage, further discussion and implementation were postponed.

#### Stocking Evaluations

Sampling to evaluate survival and or growth of stocked fish was performed on 18 AYK lakes in 1986. Population estimates of rainbow trout and coho salmon were performed on the two most important stocked lakes (Birch and Quartz Lakes). Relative abundance and growth of stocked fish were evaluated in all other sampled lakes.

#### Birch Lake Rainbow Trout:

The total estimated number of rainbow trout in Birch Lake during August 1986 was 58,269 with a 95% confidence interval of  $\pm 4,713$  fish (Table 13). The majority (96.4%) were fish stocked as subcatchables in 1986. Of

Table 1. Number and size of rainbow trout stocked in AYK lakes in 1986.

Lake	Number Stocked	Size <sup>1</sup>
Four Mile	20,000	Fingerling
31 Mile Pit	500	Fingerling
45.5 Mi. CHSR Pit	1,000	Fingerling
Bathing Beauty Pond	500	Fingerling
Chet	1,000	Fingerling
Grayling	500	Fingerling
Hidden	4,000	Fingerling
Hidden	500	Fingerling
Jan	8,800	Fingerling
JRP #1	500	Fingerling
Koole	30,000	Fingerling
Lisa	1,000	Fingerling
Manchu	10,000	Fingerling
Nickle	1,000	Fingerling
North Twin	4,000	Fingerling
Rapids	2,000	Fingerling
Robertson #2	3,000	Fingerling
Sansing	450	Subcatchable
South Twin	4,000	Fingerling
Spencer	1,500	Fingerling
Quartz	300,000	Fingerling
Birch	83,368	Subcatchable
Chena	29,102	Catchable
Harding	187,485	Fingerling
<b>Total</b>	<b>694,205</b>	

<sup>1</sup> Fish sizes were as follows: Fingerling - 2 g  
Subcatchable - 20 g  
Catchable - 65 g

Table 2. Number and size of Arctic grayling stocked in AYK lakes in 1986.

Lake	Number Stocked	Size <sup>1</sup>
Harding	79,412	Fingerling (4 g)
West Pond	25,000	Fry
Left O.P. Pond	25,000	Fry
Sheefish	10,000	Fry
Sheefish	500	Fingerling (4 g)
Sheefish	500	Fingerling (8 g)
Delta Unnamed	10,000	Fry
Delta Unnamed	500	Fingerling (4 g)
Delta Unnamed	500	Fingerling (8 g)
Bathing Beauty Pond	10,000	Fry
Grayling	10,000	Fry
Hidden	10,000	Fry
Johnson Road #2	10,000	Fry
Walden Pond	1,500	Fingerling (4 g)
Engineer Hill	25,000	Fry
Steese Hwy Pits:		
29.5	10,000	Fry
30.6	10,000	Fry
31.6	4,000	Fry
31.6	200	Fingerling (4 g)
31.6	200	Fingerling (8 g)
33.5	10,000	Fry
34.6	8,000	Fry
34.6	400	Fingerlings (4 g)
34.6	400	Fingerlings (8 g)
35.8	10,000	Fry
36.6	10,000	Fry
Chena Hot Springs Rd Pits:		
32.9	10,000	Fry
42.8	10,000	Fry
45.5	10,000	Fry
47.9	10,000	Fry
Totals:		
Fry	237,000	
Fingerlings (4 g)	82,512	
Fingerlings (8 g)	1,600	

<sup>1</sup> Multiple sizes were stocked into some ponds in conjunction with an experiment being conducted by another project.

Table 3. Number and size of sheefish stocked in AYK lakes in 1986.

Lake	Number Stocked	Size <sup>1</sup>
Harding	88,460	Fingerling
Silver Fox Pit	200	Fingerling
Weigh Station Pond #1	200	Fingerling
Weigh Station Pond #2	400	Fingerling
Earthmover Pit	300	Fingerling
Total	89,560	

<sup>1</sup> Sheefish fingerlings were 8 g.

Table 4. Number and size of Arctic char stocked in AYK lakes in 1986.

Lake	Number Stocked	Size <sup>1</sup>
Trap	12,778	Fingerling

<sup>1</sup> Arctic char fingerlings were 4 g.

Table 5. Number and size of chinook salmon stocked in  
AYK lakes in 1986.

Lake	Number Stocked	Size <sup>1</sup>
Bolio	20,000	Fingerling
Donnelly	6,000	Fingerling
Little Harding	10,000	Fingerling
Total	36,000	

<sup>1</sup> Chinook fingerlings were 9 g.

Table 6. Number and size of coho salmon stocked in AYK lakes in 1986.

Lake	Number Stocked	Size <sup>1</sup>
28 Mile Pit	500	Fingerling
31 Mile Pit	500	Fingerling
Birch	40,000	Fingerling
Chena	30,000	Fingerling
Dune	15,000	Fingerling
Geskakmina	20,000	Fingerling
JRP #1	500	Fingerling
Lost	10,000	Fingerling
Manchu	10,000	Fingerling
Moose	5,000	Fingerling
Quartz	168,500	Fingerling
Total	300,000	

<sup>1</sup> Coho fingerlings were 4 g.

Table 7. Requested number and size of Arctic char to be stocked in AYK lakes in 1987.

Lake	Number Stocked	Size
Brodie	1,000	Fingerling
Rangeview	900	Fingerling
Old Beaver	650	Fingerling
Dick's Pond	1,000	Fingerling
Ken's Pond	500	Fingerling
Backdown	600	Fingerling
Last	500	Fingerling
Total	5,150	

Table 8. Requested number and size of Arctic grayling<sup>1</sup> to be stocked in AYK lakes and rivers in 1987.

Waterbody	Number	Size
West Pond <sup>2</sup>	25,000	Fry
	(Goodpaster Stock)	
Left O.P. <sup>2</sup>	25,000	Fry
	(Goodpaster Stock)	
Sheefish Lake	10,000	Fry
Delta Unnamed	500	Fingerling (4 g)
Bathing Beauty Pond	1,000	Fingerling (4 g)
Grayling Lake	1,000	Fingerling (4 g)
Hidden Lake	1,000	Fingerling (4 g)
Johnson Road #1	10,000	Fry
Johnson Road #2	1,000	Fingerling (4 g)
Walden Pond	15,000	Fry
Goodpaster River	10,000	Fingerling (8 g)
	(Goodpaster Stock)	
Delta Clearwater River	5,000	Fingerling (4 g)
	(Goodpaster Stock)	
Delta Clearwater River	5,000	Fingerling (8 g)
	(Goodpaster Stock)	
Engineer Hill Lake	25,000	Fry
Bolio Lake	20,000	Fry
Steese Hwy Pits:		
29.5 Mi	1,000	Fingerling (4 g)
30.6 Mi	1,000	Fingerling (4 g)
31.6 Mi	400	Fingerling (4 g)
33.0 Mi	10,000	Fry
33.5 Mi	10,000	Fry
34.6 Mi	8,000	Fry
35.8 Mi	1,000	Fingerling (4 g)
36.6 Mi	1,000	Fingerling (4 g)
Chena HSR Pits:		
32.9 Mi	1,000	Fingerling (4 g)
42.8 Mi	1,000	Fingerling (4 g)
45.5 Mi	10,000	Fry
47.9 Mi	800	Fingerling (4 g)

-(continued)-

Table 8. Requested number and size of Arctic grayling<sup>1</sup> to be stocked in AYK lakes and rivers in 1987 (continued).

Waterbody	Number	Size
<u>Totals by Brood Source:</u>		
Goodpaster Stock	50,000	Fry
Any Stock	123,000	Fry
Combined	173,000	Fry
Goodpaster Stock	5,000	Fingerling (4g)
Any Stock	11,700	Fingerling (4g)
Combined	16,700	Fingerling (4g)
Goodpaster Stock	15,000	Fingerling (8g)
Total	204,700	

<sup>1</sup> All grayling surplus to the needs of this and other stocking programs will be stocked into Harding Lake.

<sup>2</sup> Grayling will rear in these ponds until fall, and survivors (approx. 20%) will be stocked into the Delta Clearwater River.

Table 9. Requested number and size of coho salmon to be stocked in AYK lakes in 1987.

Lake	Number	Size <sup>1</sup>
28 Mi. Pit	500	Fingerling
31 Mi. Pit	500	Fingerling
Birch	40,000	Fingerling
Chena	30,000	Fingerling
Dune	20,000	Fingerling
Geskakmina	20,000	Fingerling
JRP #1	500	Fingerling
Lost	10,000	Fingerling
Manchu	5,000	Fingerling
Moose	8,000	Fingerling
Quartz	168,500	Fingerling
Eight Mi.	15,000	Fingerling
Total	318,000	

<sup>1</sup> 4 gram.

Table 10. Requested number and size of chinook salmon to be stocked in AYK lakes in 1987.

Lake	Number	Size
Bolio	20,000	Fingerling
Donnelly	6,000	Fingerling
Little Harding	10,000	Fingerling
Total	36,000	

Table 11. Requested number and size of rainbow trout to be stocked in AYK lakes and rivers in 1987.

Waterbody	Number	Size
South Johnson	1,400	Fingerling
31 Mi Pit	500	Fingerling
45.5 Mi CHSR Pit	1,000	Fingerling
Backdown	500	Fingerling
Bathing Beauty Pond	10,000	Fingerling
Bluff Cabin	10,000	Fingerling
Chet	1,000	Fingerling
Craig	4,000	Fingerling
Donna	11,600	Fingerling
Dune	10,000	Fingerling
Forrest	7,000	Fingerling
Rockhound	1,500	Fingerling
No Mercy	1,500	Fingerling
Doc	1,500	Fingerling
Geskakmina	14,000	Fingerling
Grayling	500	Fingerling
Jan	8,800	Fingerling
JRP #1	500	Fingerling
Ken's Pond	600	Fingerling
Koole	30,000	Fingerling
Les'	750	Fingerling
Lisa	10,000	Fingerling
L. Harding	1,000	Fingerling
Little Donna	9,400	Fingerling
Lost	1,000	Fingerling
Manchu	10,000	Fingerling
Mark	4,000	Fingerling
Monte Lake	20,000	Fingerling
Nickle	1,000	Fingerling
North Twin	4,000	Fingerling
Rainbow	25,000	Fingerling
Sansing	450	Fingerling
South Twin	4,000	Fingerling
Spencer	5,000	Fingerling
Weazel	2,000	Fingerling
Quartz	300,000	Fingerling
	10,000	Subcatchable
Birch	34,500	Subcatchable
Piledriver Slough	12,500	Catchable
	12,500	Subcatchable
	35,000	Fingerling
Chena Lake	17,500	Catchable
Harding	451,000	Fingerling
Roys Lake	10,000	Fingerling
Totals:	Fingerling 1,009,500	
	Subcatchable 57,000	
	Catchable 30,000	

Table 12. Requested number and size of sheefish to be stocked in AYK lakes in 1987.

Lake	Number	Size
Harding	199,200	Fingerling
Silver Fox Pit	200	Fingerling
Weigh Station #1	200	Fingerling
Weight Station #2	400	Fingerling
Total	200,000	

Table 13. Birch Lake rainbow trout population estimates, August 1986.

Length Cohort	Number Marked	Number Examined	Recaptures	Population Estimate	Standard Error	95% Confidence Interval
< 169 mm	909	715	76	8,461	866.0	± 1,697.3
170-230 mm	3,222	5,671	382	47,730	2,207.9	± 4,327.5
> 230 mm	193	224	20	2,078	398.5	± 781.0
Totals:						
0-230 mm				56,191	2,371.7	± 4,648.5
All Rainbow Trout				58,269	2,404.3	± 4,712.5

these, an estimated 47,730 (95% CI  $\pm$  4,328 fish) were fish that would reach catchable size (180 mm) by winter (Table 13). A total of 83,368 subcatchable rainbow trout were stocked in the spring of 1986, so the estimated summer survival was 67.4% and the estimated survival to catchable size by winter 1986 was 57.3%. An estimated 2,078 rainbow trout (95% CI  $\pm$  781) larger than 230 mm were present in the lake. These represent fish that had survived from previous stockings.

Sampled rainbow trout ranged in length from 120 to 372 mm in fall 1986. Mean length of 592 rainbow trout sampled on 16 September 1986 was 172 mm (SE = 9.999).

The on-site creel census estimated that 2,535 rainbow trout were harvested in Birch Lake from breakup in late May through August 1986. The overall CPUE of 173 anglers interviewed from May through August was 0.16 fish/hr (SE = 0.11) (Clark and Ridder 1987). This is a continuation of the downward trend in Birch Lake rainbow trout harvests (Doxey 1985) that resulted from poor survival of fish stocked as fingerlings. Mean length of 97 rainbow trout harvested by anglers during the summer of 1986 was 255 mm (SE = 38.9). Harvested rainbow trout ranged in length from 200 to 580 mm. These were fish from the 1984 fingerling stocking and "carry overs" from previous years.

The rainbow trout catch rate increased during the winter fishery as fish stocked as subcatchables in 1986 grew to a catchable size. Rainbow trout CPUE in November 1986 was 1.48 fish/hr. Almost 80% of the rainbow trout harvested in the winter fishery were stocked as subcatchables.

#### Birch Lake Coho Salmon:

A sample of 130 coho salmon was obtained from fyke nets on 16 September. Of these, fish stocked as fingerlings in the spring of 1986 had a length range of 103-181 mm with a mean length of 140 mm (n = 64, SE = 4.22). Cohos stocked in 1985 and before had a length range of 195 to 320 mm with a mean length of 225 mm (n=66, SE = 8.28).

An estimated 466 coho salmon (SE = 270) were harvested by anglers during the summer of 1986 (Clark and Ridder 1987). The CPUE was 0.03 fish/hr (SE = 0.06). Seventeen coho salmon were sampled during the 1986 summer creel census. Length range of these fish was 190-330 mm, and mean length was 224 mm (SE = 53.26). During November 1986, coho CPUE increased to 1.21 fish/hr.

#### Birch Lake Angler Effort:

The preliminary statewide creel census estimate of angler effort for 1986 is 9,969 days fished, compared to 14,444 in 1985, 13,170 in 1984, and a high of 17,036 in 1980 (Mills 1981-1987). This decline is attributable to the downward trend in trout availability described earlier in this report. Because of higher survival of subcatchable rainbows stocked in 1986, a reverse in the downward trend of angler use and rainbow trout harvest in Birch Lake is expected.

#### Quartz Lake Rainbow Trout:

The estimated number of catchable size rainbow trout in Quartz Lake in August 1986 was 10,497 with a 95% confidence interval of  $\pm 5,191$  fish (Table 14). The majority of these fish (87%) were larger than 230 mm. During the winter ice fishery creel sampling, 396 rainbow trout were examined for finclips. The total estimated abundance from this sampling was 30,373 rainbow trout with a 95% confidence interval of  $\pm 14,424$  fish (Table 15). The much larger population estimate obtained from the winter fishery is probably attributable to a failure of the creel clerks to recognize finclips during the ice fishery probably due to regeneration of fins and/or the fish being covered by frost. This bias in the population estimate is further confirmed by a consistent decline in the proportion of finclipped fish recovered through the course of the winter for all fisheries (Table 16).

The preliminary estimated sport harvest for Quartz Lake in 1986 is 14,778 rainbow trout (Mills 1987 in press). The estimated summer harvest (May through August 1986) was 8,088 rainbow trout with a 95% confidence interval of  $\pm 3,463$  (Clark and Ridder 1987). The estimated CPUE was 0.29 fish/hr (SE = 0.08).

In August 1986, a sample of 110 trout from the 1985 fingerling stocking had a length range of 94-230 mm. Mean length of this cohort was 158 mm (SE = 5.51). A fyke net sample of Quartz Lake rainbow trout ranged in length from 100 to 486 mm in fall 1986. Mean length was 257 mm (n=504, SE = 16.47). Fingerlings stocked in fall 1986 are not included in this sample. Mean length of trout taken by anglers during the summer of 1986 was 289 mm (n=250, range 178-460 mm, SE = 10-35). Mean length of trout taken by anglers in November 1986 was 341 mm (n=50, range = 250-417, SE = 22.45).

#### Quartz Lake Coho Salmon:

The estimated number of catchable size coho salmon in Quartz Lake in August 1986 was 21,503 with a 95% confidence interval of  $\pm 8,584$  fish (Table 17). The majority of these (99.4%) were fish stocked as fingerlings in 1985. Only 769 coho salmon (95% CI  $\pm 559$ ) were larger than 230 mm.

A late August sample of 177 coho salmon from the spring 1986 fingerling stocking cohort average 139 mm (SE = 1.07). Mean length of 381 coho salmon harvested by anglers in summer 1986 was 215 mm (SE = 1.48). These fish ranged from 108 to 346 mm in length. Mean length of 236 coho salmon harvested at the beginning of the 1986 ice fishing season (November) was 213 mm (SE = 1.48). These fish ranged in length from 160 to 290 mm in length.

Mills' (1987 in press) preliminary creel census results estimate 18,486 days fished at Quartz Lake. Angler use has risen slowly since 1983, when Mills estimated 14,612 man-days expended at Quartz Lake (Mills 1984). Regional creel census program results (Clark and Ridder 1978) estimated

Table 14. Quartz Lake catchable rainbow trout population estimate (August 1986).

Length Cohort	Number Marked	Number Examined	Recaptures	Population Estimate	Standard Error	95% Confidence Interval
170-230 mm	126	131	11	1,396	351.5	± 689.0
>230 mm	640	141	9	9,101	2,652.2	± 5,145.6
Total				10,497	2,648.7	± 5,191.5

Table 15. Quartz Lake catchable rainbow trout population estimate (winter 1986-1987).

Length Cohort	Number Marked	Number Examined	Recaptures	Population Estimate	Standard Error	95% Confidence Interval
170-230 mm	246	51	2	4,280	2,065.3	± 4,048.1
> 230 mm	904	345	11	26,093	7,063.3	±13,844.0
Total				30,373	7,359.1	±14,423.7

Table 16. Recapture rates obtained from the Birch Lake winter rainbow trout fishery and the Quartz Lake rainbow trout and coho salmon fisheries.

Time Period	Percent Recaptures Sampled		
	Birch Lake Rainbow Trout	Quartz Lake Rainbow Trout	Coho Salmon
Nov.-Dec.	6.98% (n=199)	3.21% (n=187)	4.55% (n=308)
Jan.-Feb.	1.57% (n=194)	0.96% (n=209)	0.26% (n=387)

Table 17. Quartz Lake catchable coho salmon population estimate (September 1986).

Length Cohort	Number Marked	Number Examined	Recaptures	Population Estimate	Standard Error	95% Confidence Interval
170-230 mm	1,991	227	20	21,626	4,370.3	± 8,565.8
> 230 mm	106	35	4	769	285.0	± 558.5
Total				21,503	4,379.5	± 8,583.8

that 7,096 coho salmon harvested from late May through August, (SE = 2,827) with a CPUE of 0.29 fish/hr (SE = 0.08). Coho CPUE in November 1985 was 1.56 fish/hr.

#### Chena Lake Rainbow Trout:

The estimated mean length of rainbow trout harvested by anglers from late May through August was 199 mm (range 103-365 mm, n=181, SE = 2.15). A sample of rainbow trout collected with fyke nets on 27 June had a mean length of 173 mm (range 113-218 mm, n=181, SE = 2.15).

Prior to the first stocking of catchable rainbow trout, average length of harvested fish was 188 mm (n=42, SE = 10.56). Average size of fish harvested varies throughout the year and is highly correlated with the size of trout stocked.

An estimated 6,743 rainbow trout (SE = 1,998) were harvested by sport fishermen from late May through the end of August (Clark and Ridder 1987). Thus, about 25% of the stocked catchable rainbow trout were harvested during the summer fishery. The overall CPUE was 0.93 fish/hr (SE = 0.40). Rainbow trout harvest CPUE in November was 0.96 fish/hr.

#### Chena Lake Coho Salmon:

During fyke net sampling in late June, four coho salmon ranging in length from 97 to 198 mm were sampled. Coho salmon harvested during the summer 1986 averaged 172 mm (range 123-208 mm, n=51, SE = 4.65).

Coho salmon harvested during November averaged 175 mm (range 158-221 mm, n=16, SE = 14.69). Summer harvest of coho salmon was estimated to be 1,043 fish (SE = 420). Harvest CPUE of coho salmon was 0.14 fish/hr (SE = 0.09). Coho salmon CPUE during November was 1.47 fish/hr.

#### Other Stocked Lake Evaluations:

Sampling for presence and growth of stocked fish was performed in 15 additional area lakes or ponds (Table 18).

Harding Lake was sampled with gill nets and fyke nets in July and October to assess the survival of sheefish fingerlings stocked in 1982, 1984, and 1986. This sampling was also directed at documenting presence and growth of grayling and rainbow trout fingerlings stocked in late summer of 1986. During July sampling, a total of 9 net nights with experimental gillnets at depths ranging from 6 to 33 m produced small numbers of least ciscos (*Coregonus sardinella* Valenciennes), northern pike (*Esox lucius* Linnaeus), burbot, and lake trout. In October, a total of 12 net nights with gill nets produced the same species. Most pike, burbot, and lake trout were released. A fyke net was fished in 0.6 m water for 4 nights in October, producing pike, burbot, least ciscos, and recently stocked rainbow trout and grayling. Northern pike and burbot often feed on smaller fish caught in the same fyke net. Catches of rainbow trout and grayling may have been greater had the predators been sacrificed and their stomach contents examined. Ten rainbow trout and one grayling were sacrificed for stomach

Table 18. Region III 1986 stocked lake sampling. Nets were set for 18-24 hours.

Lake	Date	Sampling Method	Species	Number Sampled	Mean Length (mm)	Length Range (mm)	Variance
Donna	7/17/86	Gill Net	RT (85 Fing.)	20	114	105-141	80.96
Donna	7/17/86	Gill Net	RT (85 Fing.)	29	268	236-307	215.30
Jan	7/17/86	Fyke Net	RT (85 Fing.)	2,748	173	119-225	527.69
Little Harding	7/26/86	Fyke Net	KS (85 Fing.)	42	176	156-194	71.02
Little Harding	7/26/86	Fyke Net	KS (86 Fing.)	49	124	115-133	17.53
Little Harding	3/10/87	Angling	KS (85 Fing.)	39	184	171-205	64.25
Little Harding	3/10/87	Angling	KS (86 Fing.)	4	152	151-155	2.19
Little Donna	7/16/86	Gill Net/ Angling	RT (83 Fing.)	22	344	300-392	567.60
Little Donna	7/16/86	Gill Net	RT (85 Fing.)	39	136	111-183	299.22
Manchu	7/08/86	Gill Net	SS (85 Fing.)	1	255	-	-
Manchu	7/08/86	Gill Net	SS (86 Fing.)	4	110	106-114	-
Lost	7/01/86	Gill Net	SS (85 Fing.)	19	170	155-179	39.53
Lost	7/01/86	Gill Net	SS (86 Fing.)	9	104	97-110	.13
Lost	11/7/86	Angling	SS	6	210	180-256	48.75
Silver Fox	6/12/85	Gill Net	SF (85 Fing.)	1	234	-	-
Silver Fox	6/12/85	Gill Net	SF (84 Fing.)	5	415	350-468	1,977.76
Spencer	12/6/86	Angling	RT	4	327	317-339	61.25
Weigh Sta. #1	8/05/86	Gill Net	LNS	29	180	150-250	-
Weigh Sta. #2	8/05/86	Gill Net	SF	1	420	-	-
Weigh Sta. #2	8/05/86	Gill Net	LC	2	-	-	-
Earthmovers Pit	8/05/86	Gill Net	SF	40	-	250-450	-
Earthmovers Pit	8/05/86	Gill Net	NP	2	450	-	-
South Twin	7/30/86	Angling/ Gill Net	KS	4	304	296-307	22.68
North Twin	7/30/86	Gill Net/ Angling	KS	1	270	-	-
North Twin	7/30/86	Gill Net/ Angling	RT	4	330	294-346	546.25
North Twin	7/30/86	Gill Net	GR	1	278	-	-
North Twin	7/30/86	Gill Net	SSC	1	-	-	-
Moose	7/30/86	Gill Net	NP	7	304	268-453	-
Four Mile	7/29/86	Gill Net	RT	11	278	240-312	553.06

RT = Rainbow Trout  
 KS = King (chinook) Salmon  
 SS = Silver (coho) Salmon  
 SF = Sheefish  
 LNS = Longnose Sucker  
 NP = Northern Pike  
 GR = Arctic Grayling  
 SSC = Slimy Sculpin  
 LC = Lake Chub

content examination. The 94 mm grayling had eaten cisco eggs, crustaceans, and aquatic insects. The rainbow trout ( $\bar{x}$  length 75 mm, length range 68-82 mm, SE = 1.49) had eaten water boatmen, crustaceans, chironomid larvae, caddis larvae, least cisco eggs, and unidentified insect and insect larvae fragments.

No sheefish were caught in nets in 1986. Approximately 100 sheefish were placed in a holding pen for 2 weeks after they were stocked, to assess mortality. The only mortalities were the result of pike striking at sheefish through the side of the holding pen. At the end of the experiment, five sheefish were autopsied and stomach contents examined. All had been eating water boatmen. Mean length of the sheefish stocked in 1986 was about 110 mm.

Angler reports indicated that rainbow trout fishing was excellent in Bluff Cabin, Rainbow, and Koole Lakes. Rainbow trout and coho salmon were being caught in Geskakmina Lake, and excellent fishing for rainbow trout, grayling, and coho salmon was reported at Dune Lake. Sport fishing guides and air taxi operators took clients to Dune and Koole Lakes. Angler reports also indicate the presence of sheefish weighing up to 3,000 g in Four Mile Lake near Tok.

#### DISCUSSION

The survival to catchable size of up to 57% of the subcatchable trout stocked into Birch Lake is expected to reverse the decline of that sport fishery (summarized in Doxey 1985). The increasing catches of rainbow trout in November 1986 substantiate that expectation. The survival rate in 1986 was comparable to the more than 50% survival rates estimated for similar size Swanson broodstock fish stocked in 1980 and 1981 (Doxey 1981, 1982). The fishery decline began as a result of a changeover to fingerling trout stockings (Doxey 1984). The estimated 1984 recruitment into the catchable stock from the 125,000 fingerlings stocked in 1983 was 2,727 fish (95% confidence interval from 2,239 to 3,398) (Doxey 1984). This represents a survival of only 2.2%. The estimated recruitment to the fishery of the 1986 stocking of subcatchables is 56,191 fish. Angler use on Birch Lake is expected to increase as subsequent stockings of subcatchable rainbow trout result in increased catch rates.

Growth of young-of-the-year coho salmon slowed in Birch Lake during the summer of 1986 as compared to years during which rainbow trout numbers were down (Doxey 1984). The 1986 stocking cohort of coho salmon is expected to reach catchable size by mid-summer 1987.

The first ever abundance estimates of rainbow trout and coho salmon were performed at Quartz Lake in 1986. Creel census estimates of 12,000 to 14,000 rainbow trout harvested annually represent about a 4-5% return to the creel from recent rainbow trout fingerling stockings. It appears that stocking subcatchable rainbow trout could improve fishing quality in Quartz Lake. Average size of rainbow trout harvested ( $\approx$  300 mm) with sample length ranges up to 460 mm represent reasonably good growth for a heavily utilized roadside fishery.

Fish growth in Chena Lake is slow. As a result of this and the lake's high recreational potential (due to good access, campgrounds, and proximity to Fairbanks area) the fishery has been maintained by stocking large rainbow trout (catchables) and coho fingerlings. Fishing could be further improved if salmon were available for stocking at a larger size than the 2-4 g fish currently requested by Sport Fish Division.

Most of the rainbow trout and salmon lakes sampled in 1986 demonstrated good results from stocking efforts (Table 18). Of particular interest are the rainbow trout and coho salmon stocked into Jan, Spencer, and Manchu Lakes. These represent first time stockings into essentially barren systems. Growth of the fish was excellent in Manchu and Jan Lakes, and moderate in Spencer Lake. Jan Lake had been stocked some years ago, and its ability to overwinter fish was known. Manchu and Spencer Lakes had acceptable winter dissolved oxygen levels prior to initial stocking, and overwintering capability was proved by the overwinter survival of the fish from the initial stockings.

Chinook salmon were stocked for the first time in interior lakes in 1985. These fish demonstrated the capability of attaining a large size in North and South Twin Lakes on Fort Greely. Low overall stocking densities in those lakes contributed to the fast growth.

Moose Lake (immediately behind base housing on Eielson AFB) has been stocked with coho salmon. Growth of stocked cohos had been excellent, and the lake was used extensively by young anglers living in the housing complex near the lake. However, northern pike were caught during test netting in 1986. This represents a serious threat to the angling potential of this lake. The military is working to improve the dike separating Moose Lake from nearby French Creek.

Sheefish grew to large sizes in Weigh Station Pond #2 and Silver Fox Pit, both of which have high lake chub densities. Grayling and trout previously stocked in such ponds grew slowly and had poor survival rates. Survival of stocked sheefish was not documented in Lost or Harding Lakes in 1986.

#### Recommendations

Based on this and previous research, the following stocking programs and experiments are suggested:

1. Chena Lake should be stocked with the largest trout and salmon available;
2. Subcatchable rainbow trout should be experimentally stocked into Quartz Lake along with fingerlings, and an evaluation of their performance begun;
3. Recreational potential of Manchu Lake should be increased by stocking more coho salmon and rainbow trout;

4. Coho salmon should be stocked at higher densities in Moose Lake to attempt to compensate for pike predation and to continue to provide some level of recreation;
5. Arctic char survival should be assessed at Trap Lake, and the experimental stocking of Arctic char in other lakes should be expanded;
6. Population estimates of rainbow trout should continue at Quartz and Birch Lakes;
7. Population estimates to assess survival of stocked chinook salmon should be attempted;
8. Creel census of large stocked lakes should continue. Estimation of CPUE and size of fish harvested should be emphasized and harvest estimates should be obtained whenever possible; and
9. The concept of multi-species stockings to create mixed rainbow trout, grayling, and landlocked salmon fisheries should be pursued.

#### LITERATURE CITED

- Clark, R. and W. Ridder. 1987. Tanana drainage creel census and harvest surveys, 1986. Alaska Department of Fish and Game, Fishery Data Series (unpublished).
- Doxey, M. 1980. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1979-1980, Project F-9-12, 21(G-III-K): p. 26-47.
- \_\_\_\_\_. 1981. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1980-1981, Project F-9-13, 22(G-III-K): p. 38-59.
- \_\_\_\_\_. 1982. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1981-1982, Project F-9-14, 23(G-III-K): p. 30-49.
- \_\_\_\_\_. 1983. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1982-1983, Project F-9-15, 24(G-III-K): p. 39-66.

- \_\_\_\_\_. 1984. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1983-1984, Project F-9-16, 25(G-III-K): p. 26-51.
- \_\_\_\_\_. 1985. Population studies of game fish and evaluation of Alaska waters, Salcha District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1984-1985, Project F-9-17, 26(G-III-K): p. 67-96.
- Mills, M. J. 1983. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1982-1983, Project F-9-15, 24(SW-I-A): 1-118.
- \_\_\_\_\_. 1984. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1983-1984, Project F-9-16, 25(SW-I-A): 1-122.
- \_\_\_\_\_. 1985. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1984-1985, Project F-9-17, 26(SW-I-A): 1-115.
- \_\_\_\_\_. 1986. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1985-1986, Project F-9-18, 27(SW-I-A): in press.
- Seber, G. A. F. 1982. The estimation of animal abundance and related parameters, second edition. Lubrecht and Cramer LTD. 654 pp.

