PART V

SPORT FISHERY EVALUATION AND ALTERNATIVES

CHAPTER 14

Background Rationale for Fisheries Evaluation

A major function of the Okanagan Basin Study program was to present the anticipated effects of a series of water management and population growth alternatives on associated resources within the Basin to the year 2020 and to propose plans for their management. To do this successfully for fisheries, it was first necessary to determine the present potential of the resource on a sustained basis, the present utilization of the resource, the characteristics of the users, and the social and economic worth of the resource. These aspects have been presented and dealt with in detail in Parts II, III and IV.

With a base of factual "present" data established, it is possible to project what might happen to the sport fishery of the Okanagan Basin given growth projection alternatives, and how the assumed desire of at least maintaining, and if possible, increasing projected angler satisfaction (based on catch of sport fishes) might be achieved. Further, it is possible to examine these alternatives on an economic (cost : benefit) basis, thus providing an evaluation of the programs proposed.

As noted earlier, the Okanagan Basin fishery resource base consists of four basic components:

1. Headwater lakes sport fishery
2. Tributary streams sport fishery
3. Main valley lakes
4. Okanagan River
   (a) Sport fishery
   (b) Indian and commercial salmon fishery.

Within each of the four principal components of the fishery system, an estimate was made of the present abundance of fish species (based on field programs carried out intermittently to 1973), and referred to as the "1970 level of abundance" (or 1971 in the case of the headwater lakes). Further estimates were made of the anticipated abundance of fish species to the year 2020, according to the nature of the reproductive habitat, anticipated discharge regimes in the tributary streams and in the mainstem Okanagan River, anticipated limitations of the level of Okanagan Lake, anticipated water quality conditions in the main valley lakes, and increased stocking programs.

Angling participation and catch characteristics recorded by field surveys in 1971-72 were projected according to resident and tourist growth characteristics to the year 2020. Again, angling participation recorded in 1971-72 is referred to as the 1970 (or 1971) datum in this report.

Measures necessary to promote and enhance the fishery resource to satisfy projected angling demands to the year 2020 are analyzed and evaluated both as regards their cost-effectiveness within alternative fishery enhancement measures, and also as regards the benefits derived by anglers. The practical possibility of carrying out some of these measures is also explored.

It was necessary to make one very fundamental assumption throughout these analyses and evaluations. This was that relevant cause-and-effect phenomena, identified as well as inferred, were assumed to be inter-related on a simple linear and independent basis. This is undoubtedly a gross over-simplification in many instances, however data were not at hand for deriving more rigorous models. The more significant corollary assumptions are:

1. That recruitment from natural reproductive systems will be altered in linear proportion to
   (a) changed discharge regimes, and
   (b) changed quantity and quality of reproductive habitat.
   (in both cases relative to an artibrary index of suitability)
2. That carrying and productive capacity will be altered in linear proportion to a complex of positive and negative impacts, assumed to be independent, and as related to an arbitrary norm.
3. That catch-per-unit-fishing-effort and/or available fish harvest will be altered in linear proportion to:
   (a) changed recruitment, and
   (b) changed carrying and productive capacity
4. That distribution of fishing effort will reflect fishing quality.

14.1 FUTURE ANGLING DEMANDS

The first step in the sport fishery evaluation process was to estimate potential angling demands in all four components of the fishery resource base. These projections were based on anticipated growth of tourist and resident populations, with high and low growth estimates prepared after 1980 in keeping with the concept of providing alternative choices for future growth in the Basin. The major assumptions associated with each projection are discussed below.

14.1.1 High Growth (Projection I)

Using the assumption of maximizing economic growth in the Valley, net economic benefits could be increased by attracting non-resident anglers whose prime reason for coming to the Basin were to fish, as well as promoting a continued high rate of resident angler participation. Thus, the basic assumptions for development of high projection of angling days include an increased rate of non-resident angling participation accompanied by a continuation of the present rates of resident angler participation associated with the high rate of population growth in Projection I. As both resident and non-resident anglers could be attracted to headwater lake fishing, relative rates of headwater angling could be increased to 2000, followed by a decline to maintain a reasonably high quality of angling experience required to attract tourists to the Valley. As a result, more pressure would be placed on main valley lake fishing after the year 2000. Projections of angling days in headwater and main valley lakes (Table 14.1), indicate that total angler demands would increase almost fourfold from 158,000 in 1971 to 602,400 in 2020.

14.1.2 Low Growth (Projection III)

The basic aim for Projection III was to improve the natural environmental quality of the Valley, even if this meant sacrificing some portion of potential economic gains. Angling could contribute to this goal by maintaining high quality fishing opportunities throughout the Basin and by placing greater emphasis on resident angling. These assumptions are based on the greater recreational (social) values placed on sport fishing by residents compared with non-residents, particularly in headwater lakes.

Angling demands projected under this low growth policy are based on the reduced resident and visitor population growth rates developed under Projection III, with the following participation rates:

1) An increase of 2.5% per decade in resident participation rates. This figure includes both relatively more anglers and relatively more angler-days per resident.

2) Continuation of existing rates of tourist participation

3) Relatively greater emphasis on headwater lake angling throughout the 50 year planning period.

The results presented in Table 14.1 indicate that total angling-day demands could increase almost three-fold, totalling 406,500 by 2020. Over 74% of this fishing effort could be enjoyed by residents (compared with 60% at present, and 64% in the High Growth Projection).

The next step in sport fishery evaluation is to determine whether potential carrying capacities of the lakes and streams are sufficient to accommodate projected angling demands. Analysis of carrying capacities and evaluation of fishery management measures to meet demands are now examined for each of the four components of the fishery resource base mentioned earlier.

TABLE 14.1

PROJECTIONS OF ANGLING-DAY DEMANDS

(a) Residents and Non-Residents*

	1971	HIGH GROWTH PROJECTION 1980	2000	2020	LOW GROWTH PROJECTION 1980	2000	2020
Non-Residents	52,700	82,300	156,900	241,800	74,000	100,800	140,000
Residents	105,300	156,600	234,800	360,600	148,000	217,800	266,500
Total	158,000	238,900	391,700	602,400	222,000	318,600	406,500

(b) Main Valley and Headwater Lakes*

	1971	HIGH GROWTH PROJECTION 1980	2000	2020	LOW GROWTH PROJECTION 1980	2000	2020
Headwater	65,900	114,300	187,700	246,800	100,000	150,000	191,000
Main Valley	84,600	114,300	190,000	336,700	112,000	155,000	200,000
OK. River & Streams	7,500	10,300	14,000	18,900	10,000	13,000	15,500
Total	158,000	238,900	391,700	602,400	222,000	318,000	406,500

(c) Main Valley Lakes*

	1971	HIGH GROWTH PROJECTION 1980	2000	2020	LOW GROWTH PROJECTION 1980	2000	2020
Okanagan	70,350	95,000	158,000	281,000	93,200	128,900	166,300
Skaha	6,650	9,000	14,900	26,400	8,800	12,200	15,700
Vaseux	550	700	1,200	1,300	700	1,000	1,300
Osoyoos	1,650	2,200	3,700	6,600	2,200	3,000	3,900
Wood	2,800	3,800	6,300	11,000	3,700	5,100	6,600
Kalamalka	2,600	3,600	5,900	10,300	3,400	4,800	6,200
Total	84,600	114,300	190,000	336,700	112,000	155,000	200,000

* Descrepancies between values in this table and those in other portions of this report are due to use of preliminary projection data. Differences between these and final projection data are less than 10% and do not affect results for planning purposes.

CHAPTER 15
Headwater Lakes
Fishery Management

15.1 BACKGROUND AND RATIONALE OF EVALUATIONS

Evaluation proceeded essentially upon the cause and effect relationships explained earlier, superimposed upon the present resource capability for headwater lakes outlined in Chapter 3.

Among basic factors readily identified as influencing trout productivity in the headwater lakes, four are of particular importance. These are

1) elevation (as this influences temperature, length of growing season and drainage),
2) total dissolved solids (as an index of nutrient availability),
3) water level fluctuation (as this influences bottom fauna production, available habitat area, and over-wintering depth and oxygen parameters) and,
4) presence or absence of predator and competitor fish species.

Negative impacts of drawdown and presence of competitor/predator fishes were arbitrarily quantified according to elevation. These negative impacts were applied against the estimates of trout available to harvest on the basis of recruitment alone. This aspect was not evaluated for ameliorated situations since there is little realistic opportunity for significant improvement in terms of revised water management. In most cases, revised management would be aimed at supplying more favorable flows in streams, often a higher fisheries priority than maintenance of headwater lake levels.

All evaluations were based on increased stocking, proceeding from the premise that trout would be introduced as fry or under-yearlings. Lake productivity is therefore a critical function, since the trout must grow within the lake to reach catchable size. Introduction of older trout (up to catchable size) poses an open-ended (but expensive) management opportunity which was not evaluated.

15.2 RESOURCE CAPABILITY

If the 57 'key' lakes were stocked to absolute capacity, it was found that potential annual harvest capacity (physical capability) under 1971 water management conditions was 303,700 trout (Table 15.1). It should be noted that Swan and Hydraulic Lakes are not included in this analysis of headwater lakes. Swan Lake is large, shallow and infested with coarse fish. Hydraulic Lake is subjected to violent water level fluctuations and is shallow during the winter months. Stocking during the period 1967-71 provided an annual average of 119,400 harvestable trout, and natural reproduction increased this total so that the average annual take by

TABLE 15.1

DISTRIBUTION BY ELEVATION OF POTENTIAL INCREASES OF AVAILABLE TROUT HARVEST FROM 1971 LEVELS, AND CONSEQUENT INCREASES NECESSARY IN INTRODUCTIONS, 57 "KEY" OKANAGAN HEADWATER LAKES

ELEVATION FEET	1971 POTENTIAL HARVEST CAPACITY NO X 1000	1971 AVAILABLE HARVEST CAPACITY NO X 1000	1971 REALIZED HARVEST NO X 1000	1971 UTILIZATION OF AVAILABLE HARVEST (PERCENT)	POTENTIAL INCREASE AVAILABLE IN 1971 HARVEST NO X1000	RECENT (1967-71) INTRODUCTIONS AT 2500/lb. EQUIVALENT NO X 1000	RATIO OF INTRODUCTION TO AVAILABLE HARVEST	POTENTIAL INCREASE IN INTRODUCTIONS NO X1000
< 3501	59.6 *	49.7	33.7	68	25.2	552.5	11.12	280.2
3501-4000	32.8 **	14.4	10.3	72	28.1	160.1	11.12	312.5
4001-4500	144.3	49.6	65.8	100+	78.5	883.1	17.80	1397.3
4501-5000	28.7	3.9	12.5	100+	16.2	91.6	23.49	380.5
5001-5500	10.6	1.7	2.9	100+	7.7	41.1	24.18	186.2
> 5500	2.7	0.0	0.3	100+	2.4	0.0	1.00	60.0
TOTALS	278.7***	119.4	125.5	--	184.1	1728.4	14.48	2616.7

* Excluding Swan Lake
** Excluding Hydraulic Lake
*** Excluding Swan and Hydraulic Lakes

TABLE 15.2

DISTRIBUTION BY ELEVATION OF POTENTIAL INCREASES OF AVAILABLE TROUT HARVEST FROM 1971, AND LEVELS AND CONSEQUENT INCREASES NECESSARY IN INTRODUCTIONS,80 "ADDITIONAL" OKANAGAN HEADWATER LAKES

ELEVATION	1971 POTENTIAL HARVEST CAPACITY	1971 AVAILABLE HARVEST	POTENTIAL INCREASE IN 1971 AVAILABLE HARVEST	RATIO OF INTRODUCTIONS TO AVAILABLE HARVEST	POTENTIAL INCREASE IN 1971 INTRODUCTIONS
FEET	NO X1000	NO. X1000	NO X1000		NO X1000
< 3501	67.0	8.1	58.9	11.12	655.0
3501-4000	0.1	0.0	0.1	11.12	1.1
4001-4500	24.6	4.0	20.6	17.80	366.7
4501-5000	19.5	1.3	18.2	23.49	427.5
5001-5500	39.0	4.7	34.3	24.18	829.4
> 5500	20.7	1.5	19.2	25.00	480.0
Totals	170.9	19.6	151.3		2759.7

anglers is some 125,500 trout (Chapter 3). For all the 137 headwater lakes investigated, the 1971 potential harvest capacity was estimated at 464,600 trout. Estimated potential harvest capacities, harvest available from 1967-71 stocking programs, and the introductions of juvenile trout made during that period are indicated by elevation ranges in Tables 15.1 and 15.2. These data are based solely on the physical capacity of the waters to produce, with all other management constraints, excepting present water level manipulations being removed.

On the basis of the harvests derived in 1971 from stocking programs in 1967-71, the introductions required to provide increased harvests were extrapolated linearly. Potential harvest capacities of 137 lakes and the corresponding introductions necessary are summarized for all elevations in Table 15.3. It is estimated that 'saturation' stocking of all 137 lakes excepting Swan, Ellison, Tugulnuit and Hydraulic, (thus, in fact 133) would require an annual total of about 5.4 million fry at an equivalent size of 2500/lb.

Ultimate potential harvest capacity; that is, the ability of the lakes to produce sport fish if all management constraints were removed and water levels controlled to the maximum benefit of fisheries irrespective of other needs, would be about 2.8 times as great as the 1971 potential capacity. Required introductions of juvenile trout would be increased by about the same factor.

TABLE 15.3

PRESENT POTENTIAL ANNUAL TROUT HARVEST CAPACITIES, AND CORRESPONDING INTRODUCTIONS NECESSARY FOR THEIR REALIZATION AT THE EQUIVALENT SIZE OF 2500/lb., FOR 137 OKANAGAN HEADWATER LAKES. FOR ALL ELEVATIONS COMBINED

Harvest from 57 'key' lakes, No. X 1000	303.7
Harvest from 80 'additional' lakes, No. X 1000	170.9
Total Harvest, 137 lakes, No. X 1000	474.6
Introductions to 57 'key' lakes, No. X 1000	2616.7
Introductions to 80 'additional' lakes, No. X 1000	2759.7
Total Introductions, 137 lakes, No. X 1000	5376.4

15.3 PROJECTED ANGLING DEMANDS AND FUTURE SUCCESS RATE

In order to incorporate the assumed public desire that angling success rates-measured as number of trout caught per hour-should be maintained or enhanced, a high demand projection for 1970-2020 was adopted. Future demands are unlikely to exceed these projected figures, and success rates are correspondingly unlikely to fall below those currently experienced, assuming that an intensification of current stocking programs is undertaken. Conversely, assuming that future rates of average annual stocking will not differ from those undertaken in 1967-71, average angling success rates may be expected to fall approximately as outlined in Table 15.4.

TABLE 15.4

EXPECTED ANGLER SUCCESS RATES IN HEADWATER LAKES ASSUMING NO CHANGE IN AVERAGE ANNUAL STOCKING RATES

Year	Projected Demand (Angling - Days)	Success Rate (Trout/Angler/Hr)
1971	75,300	0.57
1980	121,400	0.40
2000	217,800	0.21
2020	272,100	0.17

Projections of angling demand were expanded for Projection I with the addition of 5.8% to account for ice-fishermen (1971 creel census figures) projected success rates are based on trout available for harvesting from all 137 lakes (Tables 15.1 and 15.2), a total of 139,000 fish. A corresponding 12,000 additional angling-days were assumed to be absorbable with no decrease in average success rate. This is because the available trout harvest of lakes below 4000 feet is only about 70% utilized (Table 15.1, column 5).

15.4 FUTURE MANAGEMENT ALTERNATIVES

In order to maintain 1971 average success rates throughout the headwater lakes, the total trout harvest required and the corresponding introductions will have to be increased approximately as shown in Table 15.5. The total number of trout to be introduced by 2020 at an equivalent size of 2500/lb is 5.2 million. It has been determined (Table 15.3) that the resource capability of 137 headwater lakes to accommodate annual fry introductions is 5.4 million, if existing water management (i.e. water level fluctuations) is to continue.

It is evident that average 1971 success rates may be maintained in the headwater lakes only by encouraging current angling activity, which presently centers on 57 key lakes, to envelop most of the 137 lakes. On an individual basis, it is probable that some lakes will become over-fished, whereas others will not receive adequate attention to achieve average values. Excessive local angling pressure may be partially compensated by measures such as seasonal angling restrictions, access management and stocking of larger fish. Some recognition of this latter factor has been taken into account in the costing of future hatchery operations for the Okanagan headwater lakes (Table 15.5). A general shift is projected away from the stocking of trout at 2500/lb and 500/lb towards increasing proportions of larger fish at 50/lb and 10/lb. The stocking of catchable size trout in specific heavily utilized lakes is an open-ended

TABLE 15.5

PROJECTED HEADWATER ANGLING DEMAND UNDER PROJECTION I, 1970 - 2020, WITH CORRESPONDING TROUT HARVESTS NECESSARY TO MAINTAIN 1971 SUCCESS RATES

YEAR	ESTIMATED/ PROJECTED DEMAND	CORRESPONDING TROUT HARVEST REALIZED/REQUIRED	CORRESPONDING TROUT INTRO-DUCTIONS @ 2500/LB. EQUIV.	PROPORTION OF TOTAL ANNUAL INTRODUCTIONS (BY EQUIV. SIZE) ESTIMATED FOR FOLLOWING SIZE CLASSES, %				ANNUAL ESTIMATED COST OF INTRODUCTIONS IN 1970 DOLLARS X 1000				
	angling-days	No. x 1000	No. x 1000	fry (2500/1b)	500/1b	50/1b.	10/1b.	fry	500/1b.	50/1b.	10/1b.	TOTAL
1971	65,900	125.5	1728.4	4	82	13	1	2.3	35.8	12.5	2.4	53.0
1980	114,300	217.2	2382.9	-	80	19	1	-	56.4	29.5	3.9	89.8
2000	187,700	356.6	3629.3	-	70	26	4	-	88.6	72.4	28.1	189.1
2020	246,800	469.9	4678.3	-	55	35	10	-	87.0	121.8	87.8	296.6

TABLE 15.6

ESTIMATED BENEFITS AND COSTS OF A HEADWATER LAKES STOCKING PROGRAM TO MEET PROJECTED ANGLING DEMANDS, 1970 - 2020

YEAR	PROJECTED DEMAND		TROUT HARVEST REQUIRED		TROUT INTRODUCTIONS REQUIRED AT 2500 FRY PER POUND		TOTAL COSTS (1970 DOLLARS) INCREMENTAL		TOTAL BENEFITS			
									ECONOMIC		SOCIAL	
	HIGH ANGLING DAYS	LOW	HIGH NO. X 1000	LOW	HIGH No. x 1000	LOW	HIGH $1000	LOW	HIGH $1000	LOW	HIGH $1000	LOW
1970	65,900	65,900	125.5	125.5	1728.4	1728.4	0	0	0	0	0	0
1980	114,300	100,000	217.2	190.0	2382.9	2085.7	31.4	21.0	22.5	19.7	56.6	49.6
2000	187,700	150,000	356.6	285.0	3629.3	2900.4	1110.0	772.0	768.6	655.6	1509.5	1252.4
2020	246,800	191,000	469.9	362.9	4678.3	3619.9	2160.0	1362.0	1559.2	1256.5	2626.6	2130.5

management alternative, but was not evaluated because of the apparent lack of need to stock trout at sizes larger than about 10/lb.

Benefits and costs associated with an increased stocking program were evaluated. After 1980, the existing hatchery capacity in the Okanagan will not be able to support the Okanagan stocking requirements, as well as meet other commitments in other areas in the interior of the Province. New hatchery facilities would have to be constructed by 1985, resulting in a four-fold increase of annual costs from $53,000 at present to $216,000 by 2020 (in 1970 dollars, not discounted). For benefit calculations, net economic benefits were valued at $1.73 and $4.90 per resident and visitor angler-day respectively, with social (consumer surplus) benefits valued at $13.50 and $2.50 per resident and visitor angler-day respectively, as obtained from the sport fishermen survey.

The appropriate economic benefits associated with the stocking program involve an estimate of the number of potential angler-days that would not occur due to falling success rates in the absence of increased stocking. There are many problems associated with determining this figure. First, there is little understanding of the relationship between angler participation and success rate. Presumably this would vary among anglers, some persevering longer than others, content with other factors such as low angling densities, aesthetics and lack of power boats. In addition, the 'social value' of an angling day might decline with reduced success rates, but this relationship is completely unknown. Second, it is not known how many anglers would simply transfer their participation to the main valley lakes rather than not fish in the Basin at all. A transfer of fishing activity within the Basin would not incur any net losses to the Basin as a whole. Third, it is not certain that angling success rates would fall in a linear manner as noted in Table 15.4.

In the absence of any better data, it was assumed that 10%, 30% and 50% of potential headwater angling effort for 1980, 2000 and 2020 respectively would be foregone if existing stocking programs are continued. Annual benefits and costs (not discounted) are compared in Table 15.6. Net economic benefits alone could justify an increased stocking program because of the high potential demand for headwater fishing in whatever type of future the Okanagan Valley will experience,

15.5 DETAILED PROJECTIONS OF ANGLING DEMAND BY LAKE IN 1980

Within the general framework of angling demand projections and consequent evaluations outlined in preceding sections, detailed projections were made of the angling pressure likely to be recorded at individual lakes in 1980. Angling pressure at a lake was found to be related on the average, to the access available to the lake. Solicitation of the advice of individuals familiar with local planning conditions revealed the anticipated access for 1980, from which projections of total regional angling pressure at individual lakes was estimated. Access factors so determined, and the corresponding angling pressures, are listed for 57 'key' headwater lakes in Table 15.7.

15.5.1 Access Factors

Access factors for 1971 (i.e. the time in hours taken to reach a lake from paved roadway, multiplied by the factors: 1-car; 2-pick-up; 3-four-wheel drive;

and 4-hike) were determined for the 57 key lakes.

Angling pressures in 1971 were according to the following five groupings:

Hours per Acre
0 - 14
14 - 43
44 - 100
101 - 213
214 - 440

The mean values of pressures for the lakes within each group were determined and plotted against the corresponding mean values of access factor within each group on a semi-logarithmic scale (Figure 15.1).

15.5.2 Projected Demand

Demand for headwater lakes angling is projected to rise by 1980 from a 1971 level of 71,200 angling-days (excluding ice-fishing) to a range of 88,000 (low projection), or 127,300 (high projection).

These demand figures were further broken down into semi-arbitrarily bounded regional districts given below: individual lakes are denoted by region in Table 15.7 and regional districts are defined in Figure 3.1.

TABLE 15.8
1980 PROJECTED DEMAND-ANGLING-DAYS
(BY REGION)

REGION	LOW	HIGH
Vernon	58,300	55,300
Kelowna	40,300	58,200
Penticton	6,800	10,000
Osoyoos	2,600	3,800

According to the relationship determined between access and angling pressure (Figure 15.1), and with reference to the projected regional angling pressures above, total angling demand within each region was estimated for the 1980 level of development (Table 15.8). For these calculations it was assumed that the access-pressure relationship determined for the Okanagan Valley as a whole would hold good also for each of the four individual regions.

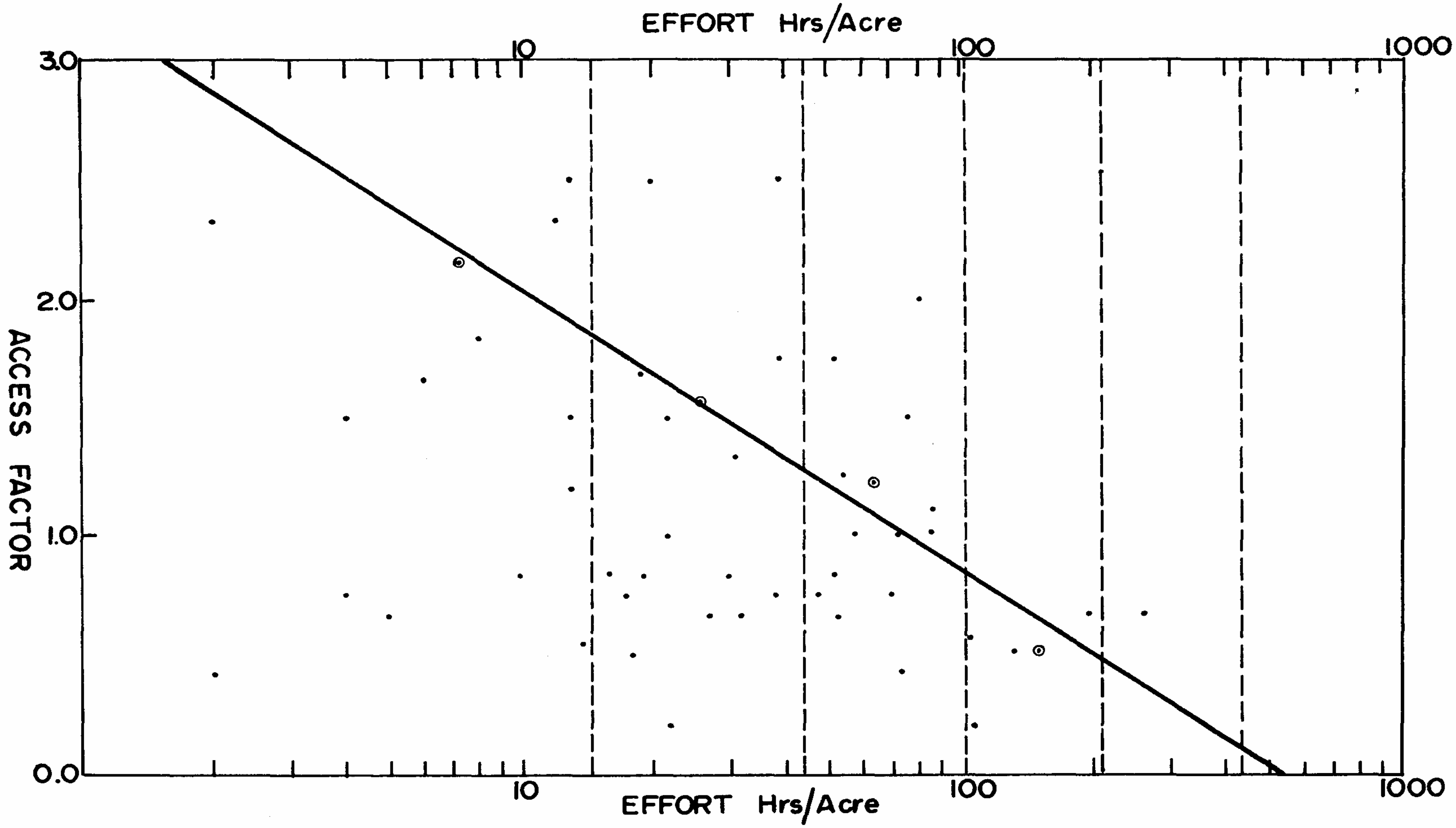
TABLE 15.7

ESTIMATED 1971 AND 1980 ACCESS FACTORS AND ANGLING PRESSURES AT 57 "KEY" HEADWATER LAKES, FOR HIGH AND LOW PROJECTIONS OF ANGLING DEMAND

LAKE	REGION	ACCESS FACTOR 1971	ACCESS FACTOR 1980	ANGLING PRESSURE 1971 hours/acre	ESTIMATED ANGLING PRESSURE IN 1980 RELATIVE TO 1971: High Angling Demand	ESTIMATED ANGLING PRESSURE IN 1980 RELATIVE TO 1971: Low Angling Demand
Agur	P	0.50	0.50	73	1.00	1.00
Alex	K	3.00	3.00	6	1.87	1.27
Allendale	P	2.00	0.67	81	1.84	1.84
Bardolph	V	1.00	1.00	12	1.00	1.00
Bear	V	1.50	1.50	13	1.00	1.00
Becker	V	1.50	1.50	13	1.00	1.00
Bouleau	V	1.50	1.50	21	3.05	2.86
Browne	K	1.50	1.50	76	1.62	1.11
Burnell	O	0.30	0.30	3	6.85	4.67
Chute	P	1.00	1.00	58	1.00	1.00
Darke	P	0.50	0.50	65	1.00	1.00
Dee Chain	K	1.00	1.00	55	1.69	1.16
Deep	V	0.20	0.20	55	1.54	1.07
Deer (Tsuh)	P	2.50	2.50	41	1.00	1.00
Echo	K	3.00	3.00	13	1.91	1.31
Eneas	P	3.00	3.00	17	1.19	1.19
Esperon	K	1.20	1.20	13	1.24	1.00
Fish Hawk	K	5.00	5.00	2	1.23	1.00
Garnet Valley	P	0.42	0.42	12	1.00	1.00
Geen	K	5.33	4.58	8	3.09	2.12
Glen	K	0.42	0.42	2	3.08	2.08
Haynes	K	0.75	0.75	4	1.23	1.00
Headwater #1	K	0.75	0.75	17	1.82	1.25
#2	K	0.83	0.83	16	1.00	1.00
#3	K	0.83	0.83	30	1.86	1.25
#4	K	0.83	0.83	10	1.23	1.00
Hereron	K	4.00	4.00	4	3.69	2.54
High	V	3.00	0.58	18	6.54	4.51

TABLE 15.7
(Continued)

LAKE	REGION	ACCESS FACTOR 1971	ACCESS FACTOR 1980	ANGLING PRESSURE 1971 hours/acre	ESTIMATED ANGLING PRESSURE IN 1980 RELATIVE TO 1971: High Angling Demand	ESTIMATED ANGLING PRESSURE IN 1980 RELATIVE TO 1971: Low Angling Demand
Hydraulic	K	0.75	0.75	1	1.23	1.00
Ideal	K	3.75	3.75	2	1.23	1.00
Jackpine	K	2.50	0.67	38	3.58	2.45
James	K	2.00	2.00	1	2.48	1.69
Kaiser Bill	V	1.75	0.50	39	2.46	1.69
King Edward	V	1.67	0.42	3	9.54	6.57
Lady King	V	0.50	0.50	133	1.38	1.00
Lambly	K	0.75	0.67	46	2.96	2.03
Lone Pine	P	0.83	0.83	19	1.00	1.00
Lost	K	1.74	1.74	8	1.23	1.00
McCall	K	0.50	0.50	18	1.24	1.00
Madden	O	0.60	0.60	160	2.00	1.37
Munro	P	3.00	3.00	15	1.54	1.54
Oyama	V	3.50	0.33	12	6.46	4.45
Peachland	K	1.33	1.33	31	2.40	1.64
Pinaus	V	0.50	0.50	195	1.64	1.13
Pinaus (Little)	V	0.67	0.67	14	1.30	1.00
Postill	K	0.67	0.58	33	3.86	2.65
Ripley	O	0.67	0.67	223	2.00	1.37
Rose Valley	K	0.20	0.20	26	2.38	1.63
Round	K	2.50	1.00	13	1.69	1.16
Silver	K	1.33	1.33	31	1.23	1.00
South	K	2.33	1.58	11	3.06	2.10
Square	V	0.75	0.75	104	1.46	1.00
Streak	V	3.50	0.67	35	1.87	1.29
Swalwell	K	0.58	0.58	53	1.86	1.26
Swan	V	0.20	0.20	1	1.00	1.00
Whitehead	K	0.75	0.75	37	1.24	1.00
Wilma	K	1.70	1.70	19	1.24	1.00



NOTE: All access factors in excess of 3.00 are not recorded, but were used in the calculation of mean values; individual lakes are represented by uncircled points; circled points represent group mean values.

OKANAGAN HEADWATER ALKES -- ANGLING PRESSURE AS A FUNTION OF ACCESS FACTOR.

Figure 15.1

15.5.3 Conclusions and Discussion

Of 57 lakes, it was estimated that 11 and 25 would not receive increased angling pressure by 1980 under high and low demand, respectively. The greatest increases likely will be at Burnell, High, King Edward and Oyama Lakes (6 times and 4 times increased from present angling pressures for high and low demand projections, respectively).

It should be noted that the results of these detailed projections are based on unvalidated assumptions, the most relevant of which are given below. It cannot be expected that the projections given in Table 15.8 will occur precisely but only that they indicate trends of future angling pressure among headwater lakes.

Assumptions:

1. That changes in lake access determine the corresponding changes in lake angling pressure, according to the relationship depicted in Figure 15.1. This relationship was shown to be valid for average values only.
2. That although the relationship in 1. above was derived for 57 lakes throughout the Okanagan Valley, the relationship is equally valid within each regional grouping of lakes.
3. That angling within each region may be considered a discrete entity, and that anglers tend to remain within particular regions over time. By and large, this is probably true, although differential growth rates among angling demand in regions adjacent to the Okanagan could exert unstabilizing influences.

CHAPTER 16
Tributary Streams Fishery Management

16.1 RATIONALE

The basic capacities of the Okanagan tributaries to produce in-channel trout were estimated by reference to the literature. These estimates were adjusted downward according to the available seasonal discharge requirement. This allowed evaluation of the effects of discharge regimes for different projections.

16.2 PRESENT PRODUCTIVITY AND UTILIZATION

Table 16.1 indicates a potential increased annual harvest of about 16% (6,198 trout) is possible with minimal optimum discharges in streams. As is indicated however, modified discharges in one or two selected streams would not make a significantly increased harvest possible. Generally, all streams would require altered flows to significantly affect the stream fishery harvest potential.

16.3 HARVEST CAPACITIES AND CHARACTERISTICS OF STREAM FISHERIES

Two categories of trout harvest capacity estimates were derived for the Okanagan tributary streams; both tended to reflect an annual sustainable harvest equilibrium:

1. Primary potential harvest capacity: The estimated number of trout (38,410 total) which could be harvested annually, given a 'minimal optimum' discharge regime consistent with the overall average annual discharge volume, and given present physical stream habitat characteristics.
2. Present potential harvest capacity: The primary potential harvest capacity adjusted (downward) to take account of disparities between the present discharge regime and the estimated 'minimal optimum' discharge requirement (32,223 trout in total).

No formal projections have been made for future angling demands in tributary streams. There is a potential demand for stream fishing which will likely increase, however anglers were generally aware of the restricted capacity of Okanagan streams (small fish, fluctuating water quantity, etc.) and admitted that extreme interest in stream fishing would motivate anglers to fish outside the region where better stream fishing opportunities exist.

TABLE 16.1

PRIMARY POTENTIAL AND PRESENT AVAILABLE TROUT HARVEST CAPACITIES OF OKANAGAN TRIBUTARY STREAMS.

Creek and reach	Primary potential annual trout harvest capacity for "minimal optimum" discharge No. of trout	Present available annual harvest capacity for "present" discharge, No. of trout	Potential Increase with Optimum Discharge No. of trout
B-X, Upper	147	32	115
B-X, Lower	135	82	53
Coldstream	307	206	101
Deep	110	76	34
Equesis	736	729	7
Ellis	546	475	71
Inkaneep	129	74	55
Kelowna	208	183	25
Lambly	2533	1570	963
Mission (a)	1913	1779	134
(b)	6169	5552	617
(c)	5690	4893	797
Peachland	938	816	122
Penticton	1778	1405	373
Powers	889	711	178
Shingle (a)	454	259	195
(b)	386	301	85
Shorts	2545	1909	636
Shuttleworth	196	139	57
Trepanier	1637	1326	311
Trout (a)	711	611	100
b,c)	6132	5457	675
Vaseux	1165	1165	0
Vernon (a)	368	320	48
(b)	1202	829	373
Whiteman (a)	662	629	33
(b)	724	695	29
Total	38410	32223	6187

16.4 FUTURE FISHERY MANAGEMENT ALTERNATIVES

It is apparent that storage reservoirs on tributary systems expand opportunities to meet resident stream fishery flow requirements. However, these opportunities have not to date received much priority in Okanagan reservoir operations. It is probable that present operations tend to benefit stream trout in summer only in stream reaches situated between reservoirs and diversion points. Unfortunately, gains of this nature achieved in summer tend to be compensated by proportionate losses induced in winter. No specific assessment was made of the absolute water demands implicit in meeting the minimal optimum discharge requirements for stream fisheries as estimated. In many cases the actual demands would probably be quite small as deficiencies tend to be short-term. In general, the resident Okanagan stream fisheries do not appear particularly sensitive to reduced flows, except where such flows virtually cease.

Only a 16% overall enhancement in stream-trout productive capacity is predicted from a minimal optimization of discharge regimes for this purpose. Water which might be diverted for the particular benefit of resident stream trout may bend to yield greater fishery benefits if applied to the maintenance of requisite levels for trout in the headwater reservoirs, or if applied to propagation of salmonids from the main valley lakes in the lower stream reaches, or if used to maximize shore spawning for main valley lake fishes. It then becomes the function of fishery managers and water managers to weigh these alternatives in particular cases, and select the most beneficial.

Some recognition was given to the particular disbenefits of stream channelization and other cultural modifications indirectly, in the adoption of the relatively conservative estimate of 12 lb/acre as the primary potential harvest capacity baseline for present physical habitat and minimal optimum discharge. It is expected that stream bank preservation measures would significantly enhance resident stream trout productive capacities in these most accessible lower stream reaches.

CHAPTER 17
Main Valley Lakes
Fishery Management

17.1 BACKGROUND AND RATIONALE

All six of the Okanagan main valley lakes harbor extensive indigenous fish stocks. These have in some cases been augmented by introductions, both purposeful and inadvertent. There is no stocking program in effect at present.

Kokanee and rainbow trout occur in all these lakes, and are the mainstay of the fishery. Lake whitefish (introduced) occur in the four lower lakes. All lakes harbor a complement of coarse, forage, and miscellaneous sport fish species. Sockeye salmon rear in Osoyoos Lake.

All evaluations pertaining to enhanced recruitment of kokanee and rainbow trout in the main valley lakes, either by enhanced natural reproductive systems or by creation of artificial reproductive facilities, were conducted with reference to the lake carrying capacity. This was estimated for kokanee partially in terms of Zooplankton standing crop as detailed in Chapter 5. It was estimated for rainbow trout with reference to the stocking formula as utilized for headwater lakes in conjunction with adjustments pertaining to phosphorus concentration (relative to the present concentration in Okanagan Lake), and to predation-competition. Spawning and rearing area in tributary streams is a factor presently limiting rainbow trout and kokanee production. The lakes have a far greater capacity to accept and grow sport fishes than the streams are capable of producing.

Angling demands for each of the main valley lakes are presented in Chapter 14, for high and low growth projections. In order to ensure the satisfactory accommodation of a possible high future demand rate, the anticipated demands applicable to Projection I (high growth) were adopted for evaluation purposes;

these data are presented for each lake in Table 17.1. Future demands for fish were based on anticipated catch-per-angler-hour

(a) equal to 1970 success rates, and

(b) improved by 30% over 1970 rates.

17.2 ESTIMATES OF ANNUAL FISH HARVEST CAPACITIES AND PROJECTIONS OF ANGLING DEMAND

Estimates of fish harvest capacities under 1970 conditions of lake water quality and discharge management are fully detailed in Chapter 5. These estimates are reproduced under "kokanee" and "Rainbow Trout" in Tables 17.2 and 17.3 respectively, and as "species groups" in Table 5.3. These form the basis for the evaluation process.

TABLE 17.1

PROJECTIONS OF ANGLING-DAY DEMANDS IN OKANAGAN MAIN VALLEY LAKES, FOR PROJECTION I - 1970-2020

LAKE	1970	1980	2000	2020
Wood	2,800	3,500	5,400	10,500
Kalamalka	2,500	3,500	5,000	8,000
Okanagan	68,400	99,500	154,600	292,800
Skaha	6,500	10,500	15,000	24,500
Vaseux	-	-	-	-
Osoyoos	1,500	2,400	4,000	7,200

TABLE 17.2

ESTIMATED PRESENT AND POTENTIAL ANNUAL SUSTAINABLE KOKANEE HARVEST CAPACITIES. OKANAGAN MAIN VALLEY LAKES, 1970 LEVEL OF BASIN DEVELOPMENT

DISCHARGE REGIMES	REPRODUCTIVE HABITAT	NUMBER OF KOKANEE HARVESTABLE ANNUALLY, X 1000						
		WOOD	KALAMALKA	OKANAGAN	SKAHA	VASEUX	OSOYOOS	TOTAL
Present	Present	7.12	25.74	1128.7	95.78	0.52	25.46	1283.32
Modified[1]	Present	8.62	37.32	1207.7	132.18	0.78	40.23	1426.83
Modified	Enhanced[2]	13.17	37.32	2347.7	209.76	0.78	40.23	2648.96
		POUNDS OF KOKANEE HARVESTABLE ANNUALLY, PER ACRE						
Present	Present	0.49	0.75	3.65	10.12	0.23	1.79	
Modified	Present	0.60	1.09	3.90	13.97	0.34	2.83	
Modified	Enhanced	0.91	1.09	7.59	22.17	0.34	2.83	

[1]Modified - this involves adjusting discharge schedules from headwater reservoirs to meet minimum flows for fisheries where possible.

[2]Enhanced - this assumes modifications to stream beds to improve spawning gravels and general spawning environment.

TABLE 17.3

ESTIMATED PRESENT AND POTENTIAL ANNUAL SUSTAINABLE RAINBOW TROUT HARVEST CAPACITIES, OKANAGAN MAIN VALLEY LAKES, 1970 LEVEL OF BASIN DEVELOPMENT

DISCHARGE REGIMES	REPRODUCTIVE HABITAT	NUMBER OF RAINBOW TROUT HARVESTABLE ANNUALLY, X 1000						
		WOOD	KALAMALKA	OKANAGAN	SKAHA	VASEUX	OSOYOOS	TOTAL
Present	Present	0.15	2.79	17.86	1.45	0.05	0.23	22.53
Modified	Present	0.35	6.50	31.97	1.52	0.05	0.24	40.63
Modified	Enhanced	1.40	6.50	197.00	2.35	0.05	0.24	207.54
		POUNDS OF RAINBOW TROUT HARVESTABLE ANNUALLY, PER ACRE						
Present	Present	0.09	0.60	0.26	0.20	0.05	0.10	
Modified	Present	0.21	1.40	0.46	0.21	0.05	0.11	
Modified	Enhanced	0.84	1.40	2.86	0.33	0.05	0.11	

17.3 MANAGEMENT ALTERNATIVES: WOOD, KALAMALKA, VASEUX AND OSOYOOS LAKES

As a result of a lack of detailed information concerning the fish populations of the main valley lakes, and also due to time constraints, detailed evaluations were restricted to Okanagan and Skaha Lakes and are presented in Table 17.4. Observations and available data pertinent to Wood, Kalamalka, Vaseux and Osoyoos Lakes are fully detailed in Parts II, III and IV. General remarks and suggestions concerning their future management are as follows:

Wood Lake

According to water quality evaluations detailed in Technical Supplement VI, Wood Lake water quality may slowly improve as regional treatment of septic tank effluents is developed, and nutrient loadings are reduced to about one-third of present levels. Under these circumstances, Wood Lake might return to its 1930 condition when it harbored an important kokanee and trout fishery.

The re-establishment of Wood Lake as a productive sport fishery is dependent upon such a chain of variables that it is pointless to make any firm projections of sport fishery potential at this time. It is simply worth noting that there is considerable potential, should water quality conditions improve.

Kalamalka Lake

Lake trout, which were introduced in 1967-by 1971 contributed the largest proportion by weight of all angled species. This species is likely to have considerable impact on the population dynamics of Kalamalka Lake within the coming years; it is not possible to predict such changes without improved data. Provision of additional reproductive habitat would be expected to enhance the kokanee population of this lake.

Vaseux Lake

This lake is highly eutrophic and completely dependent on Okanagan River water quality. It is not presently a significant producer of desirable sport fish, a condition which is expected to continue over the next fifty years.

Osoyoos Lake

Due to relatively high average temperatures, low summer oxygen concentrations and an abundance of predatory species, this lake is far from ideal as rainbow trout habitat. Enhancement of kokanee stock would likely result from the improvement of reproductive conditions (vis: Okanagan River discharge regime). Recommendations concerning the bass fishery are not possible with presently available data. The management of this lake for warm water species is however, a possibility which warrants serious consideration.

17.4 OKANAGAN AND SKAHA LAKES: EVALUATION

17.4.1 General Estimates of Supply of and Demand for Kokanee and Rainbow Trout

Estimates of annual sustainable harvest capacities of kokanee and rainbow trout are presented in Chapter 3, according to the models there developed. These models include the effects upon salmonids of anticipated water quality changes under management options which included:

1) a continuation of 1970 waste treatment, and

2) tertiary waste treatment at all major centers in the Valley.

These options are designated synonymous with 'high' and 'low' nutrient estimates. Also considered are the options of:

1) continuing discharge management in all tributaries and the mainstem Okanagan River according to historic practices,

2) modifying such practices so as to benefit fishery interests without significant losses to other users, and adding necessary storage,

3) enhancing reproductive habitat to its realistic potential at the same time as modifying discharge management.

The corresponding estimates of annual harvest capacities of kokanee and rainbow trout are summarized for all management conditions in Tables 17.4 and 17.5, and are depicted graphically in Figures 17.1, 17.2, 17.3 and 17.4.

The numbers of kokanee and rainbow trout required for harvesting at a continued 1970 success rate and at a success rate arbitrarily improved by 30% were determined according to the ratio between the number of fish estimated to be available and the projected number of angler-days at any date. The projected demand for these species is shown graphically in Figures 17.1, 17.2, 17.3 and 17.4 and is detailed in Tables 17.6, 17.7, 17.8 and 17.9. The numbers of fish available for harvesting were estimated under the option of "no fishery enhancement"; the corresponding success rates measured as number of fish caught per hour were determined, and are also given in Tables 17.6, 17.7, 17.8 and 17.9.

17.4.2 Specific Enhancement Measures for Kokanee and Rainbow Trout

(a) Seasonal Discharge Management

Stream spawning kokanee and rainbow trout stocks could be improved by taking sport fish values into account in the management of tributary discharge regimes. River-spawners in Skaha Lake are also amenable to enhancement as a result of modified sequences of management operations in the Okanagan River.

The possible increments in stream spawning escapements of kokanee and rainbow trout as a result of modified systems of discharge management are estimated. The actual deficiencies of discharge with respect to adequate fishery discharge in acre-feet per year, under both historic and modified operations, were determined for the six streams analyzed individually. These are given in Appendix V together with maximum monthly deficiencies.

The costs of making up fisheries deficiencies from the minimum were examined for both additional storage upstream and pumping from Okanagan Lake when necessary

TABLE 17.4

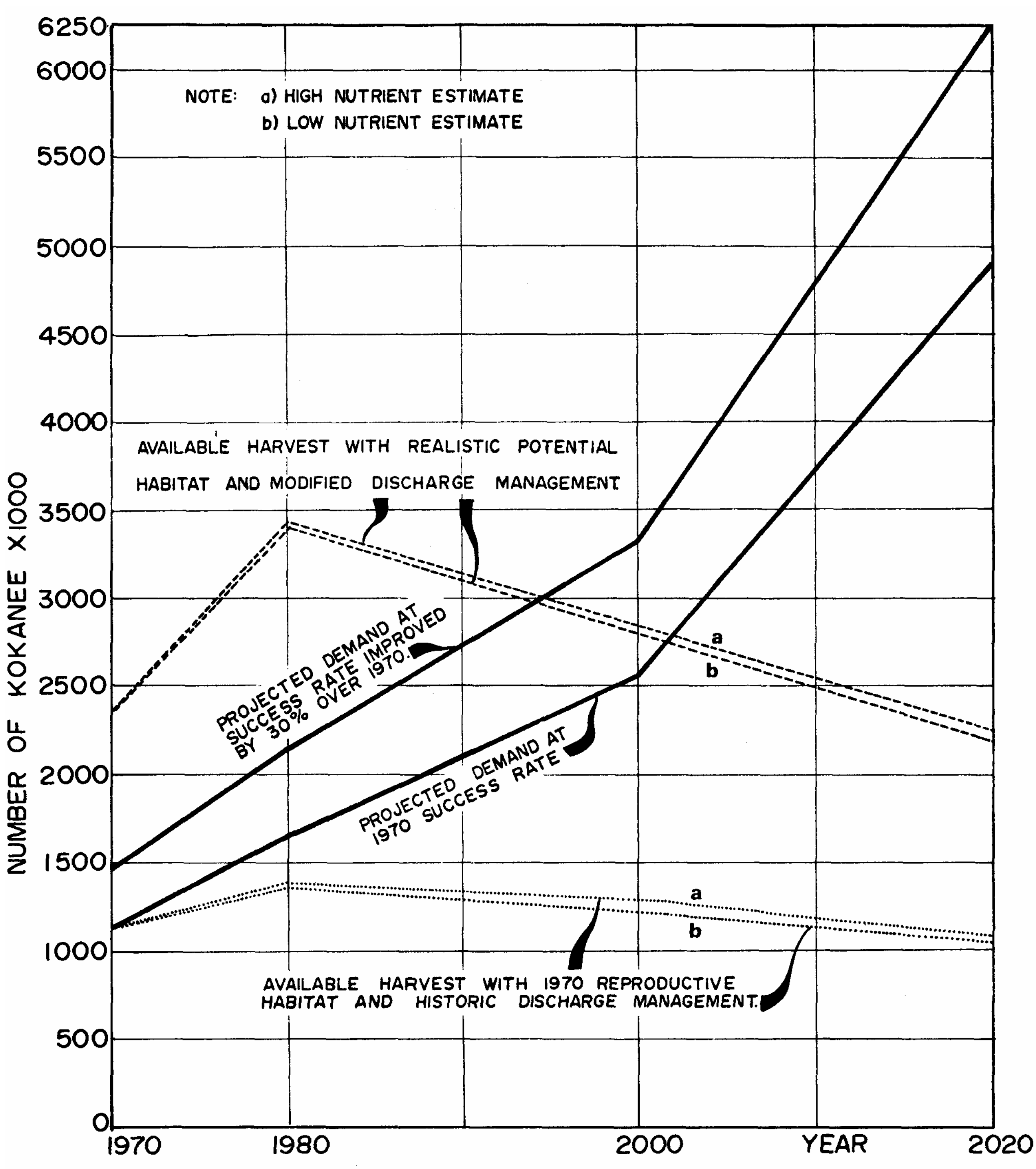
ESTIMATED "MOST PROBABLE" ANNUAL SUSTAINABLE KOKANEE HARVEST CAPACITIES, OKANAGAN AND SKAHA LAKES, FOR 1970, 1980, 2000 and 2020 LEVELS OF BASIN DEVELOPMENT

LAKE	YEAR	NUTRIENT ESTIMATE	KOKANEE HARVESTABLE ANNUALLY					
			NUMBER X 1000			POUNDS PER ACRE		
			1970-71 REPRO-DUCTIVE HABITAT HISTORIC DISCHARGES	MODIFIED DISCHARGES	REALISTIC POTENTIAL HABITAT MODIFIED DISCHARGES	1970-71 REPRO-DUCTIVE HABITAT HISTORIC DISCHARGES	MODIFIED DISCHARGES	REALISTIC POTENTIAL HABITAT MODIFIED DISCHARGES
Okan-agan	1970	---	1128.7	1207.7	2347.7	3.65	3.90	7.59
	1980	high	1376.1	1535.0	3423.1	4.46	4.97	11.09
	1980	low	1365.1	1522.7	3395.8	4.39	4.89	10.92
	2000	high	1280.0	1362.8	3024.8	4.20	4.47	9.92
	2000	low	1212.4	1342.6	2795.1	3.91	4.33	9.02
	2020	high	1082.6	1187.6	2239.4	3.59	3.94	7.43
	2020	low	1054.1	1156.4	2180.6	3.40	3.73	7.04
Skaha	1971	---	95.78	132.18	209.76	10.12	13.97	22.17
	1980	high	78.12	107.74	171.53	6.86	9.46	15.06
	1980	low	66.18	91.26	145.25	6.03	7.04	11.21
	2000	high	43.96	60.68	96.75	2.46	3.39	5.41
	2000	low	76.45	105.35	167.47	6.58	9.06	14.41
	2020	high	20.31	27.95	44.44	0.64	0.88	1.40
	2020	low	82.18	113.24	180.37	7.43	10.24	16.32

TABLE 17.5

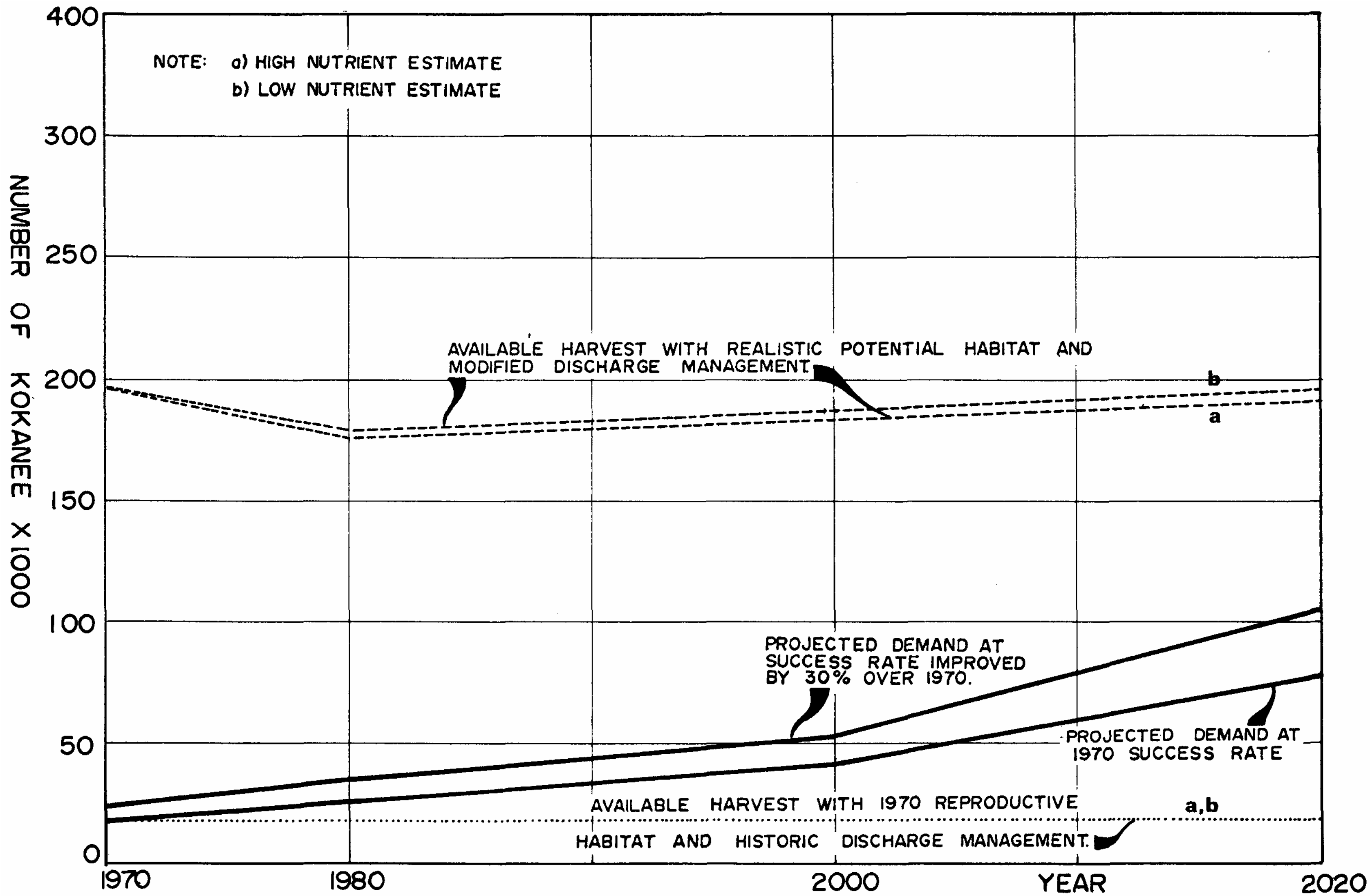
ESTIMATED "MOST PROBABLE" ANNUAL SUSTAINABLE RAINBOW TROUT HARVEST CAPACITIES, OKANAGAN AND SKAHA LAKES, FOR 1970, 1980, 2000 and 2020 LEVELS OF BASIN DEVELOPMENT

LAKE	YEAR	NUTRIENT ESTIMATE	RAINBOW TROUT HARVESTABLE ANNUALLY					
			NUMBER X 1000			POUNDS PER ACRE		
			1970 REPRO-DUCTIVE HABITAT HISTORIC DISCHARGES	MODIFIED DISCHARGES	REALISTIC POTENTIAL HABITAT MODIFIED DISCHARGES	1970 REPRO-DUCTIVE HABITAT HISTORIC DISCHARGES	MODIFIED DISCHARGES	REALISTIC POTENTIAL HABITAT MODIFIED DISCHARGES
Okan-agan	1970	---	17.86	31.97	197.00	0.26	0.46	2.86
	1980	high	17.81	28.84	177.67	0.26	0.42	2.59
	1980	low	17.95	29.08	179.10	0.26	0.42	2.61
	2000	high	17.61	29.93	184.39	0.26	0.44	2.68
	2000	low	17.90	30.42	187.35	0.26	0.44	2.73
	2020	high	17.50	31.15	191.87	0.25	0.45	2.79
	2020	low	17.82	31.72	195.39	0.26	0.46	2.84
Skaha	1970	---	1.45	1.52	2.35	0.20	0.21	0.33
	1980	high	1.24	1.31	2.01	0.17	0.18	0.28
	1980	low	1.98	2.08	3.21	0.27	0.29	0.44
	2000	high	0.85	0.90	1.38	0.12	0.12	0.19
	2000	low	1.81	1.90	2.92	0.25	0.26	0.40
	2020	high	0.39	0.41	0.63	0.05	0.06	0.09
	2020	low	1.73	1.82	2.80	0.24	0.25	0.39

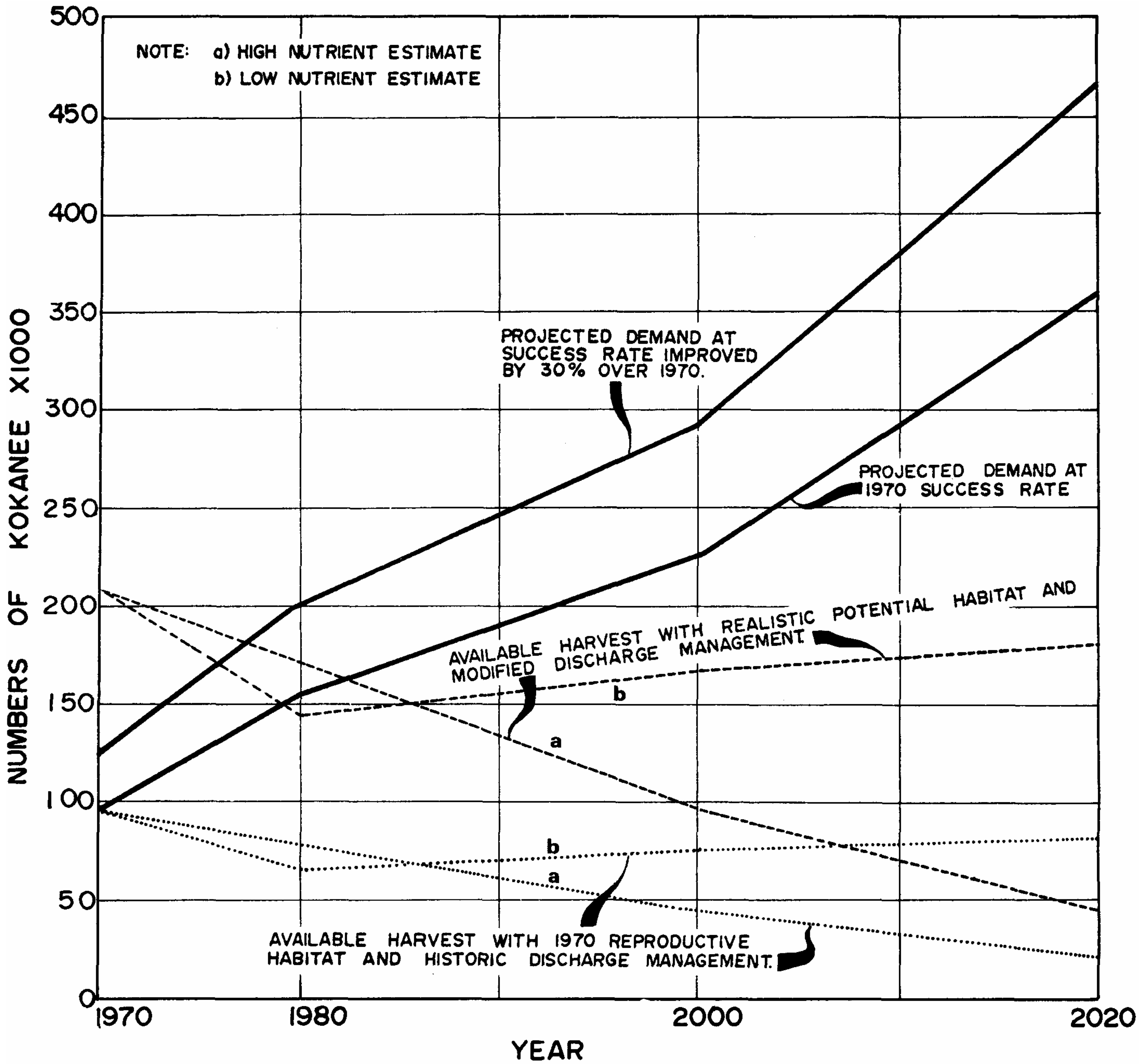


COMPARISONS BETWEEN AVAILABLE HARVEST OF, AND DEMAND FOR, KOKANEE IN OKANAGAN LAKE, 1970-2020, UNDER SPECIFIED CONDITIONS OF MANAGEMENT.

Figure 17.1

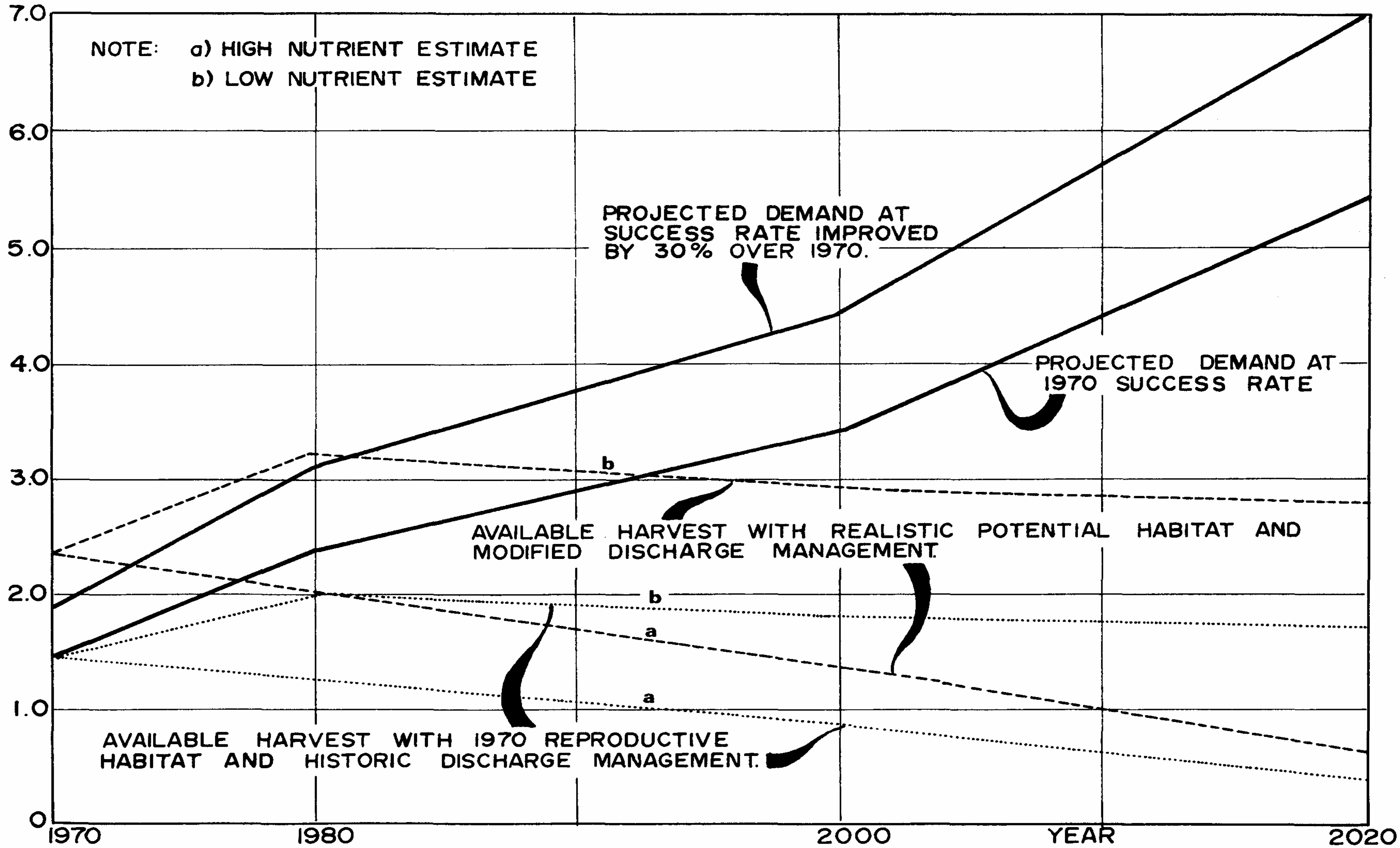


COMPARISONS BETWEEN AVAILABLE HARVEST OF, AND DEMAND FOR, RAINBOW TROUT IN OKANAGAN LAKE, 1970 - 2020 UNDER SPECIFIED CONDITIONS OF MANAGEMENT. Figure 17.2



COMPARISONS BETWEEN AVAILABLE HARVEST OF, AND DEMAND FOR, KOKANEE IN SKAHA LAKE, 1970-2020, UNDER SPECIFIED CONDITIONS OF MANAGEMENT.

Figure 17.3



COMPARISONS BETWEEN AVAILABLE HARVEST OF, AND DEMAND FOR, RAINBOW TROUT IN SKAHA LAKE, 1970-2020, UNDER SPECIFIED CONDITIONS OF MANAGEMENT.

Figure 17.4

TABLE. 17.6

COMPARISON BETWEEN PRODUCTION OF, AND DEMAND FOR, KOKANEE IN OKANAGAN LAKE FROM 1970 TO 2020 UNDER ALTERNATIVE CONDITIONS OF ANGLING SUCCESS RATE, DISCHARGE MANAGEMENT, AND STATUS OF REPRODUCTIVE HABITAT

						BEST ESTIMATE OF KOKANEE HARVEST AVAILABLE X 1000				
MANAGEMENT OPTION	YEAR	NUTRIENT ESTIMATE	PROJECTED ANGLING DEMAND DAYS	NO. OF KOKANEE REQUIRED/ ANGLING-DAY	TOTAL HARVEST-ABLE KOKANEE REQUIRED X 1000	1970 RE-PRODUCTIVE HABITAT, 1970 DISCHARGE MANAGEMENT	1970 RE-PRODUCTIVE HABITAT, MODIFIED DISCHARGE MANAGEMENT	REALISTIC POTENTIAL HABITAT, MODIFIED DISCHARGE MANAGEMENT	NO. OF KOKANEE AVAILABLE PER ANGLING DAY	CORRESPONDING CATCH PER UNIT EFFORT NO/HR (SEE MANAGE-MENT OPTION)
No fishery enhancement; success rate declines	1970	---	6,500	---	---	95.78	---	---	14.74	0.048
	1980	high	10,500	---	---	78.12	---	---	7.44	0.024
		low	10,500	---	---	66.18	---	---	6.30	0.021
	2000	high	15,200	---	---	43.96	---	---	2.89	0.009
		low	15,200	---	---	76.45	---	---	5.03	0.016
	2020	high	24,300	---	---	20.31	---	---	0.84	0.003
		low	24,300	---	---	82.18	---	---	3.38	0.011
Fishery enhancement to maintain 1970 success rate	1970	---	6,500	14.74	95.78	95.78	132.18	209.76	14.74	0.048
	1980	high	10,500	14.74	154.77	78.16	107.74	171.53	---	0.048
		low	10,500	14.74	154.77	66.18	91.26	145.25	---	0.048
	2000	high	15,200	14.74	224.05	44.06	60.68	96.75	---	0.048
		low	15,200	14.74	224.05	76.45	105.35	167.47	---	0.048
	2020	high	24,300	14.74	358.18	20.31	27.95	44.44	---	0.048
		low	24,300	14.74	358.18	82.18	113.24	180.37	---	0.048
Fishery enhancement to increase 1970 success rate by 30%	1970	---	6,500	19.16	124.54	95.78	132.18	209.76	---	0.062
	1980	high	10,500	19.16	201.18	78.16	107.74	171.53	---	0.062
		low	10,500	19.16	201.18	66.18	91.26	145.25	19.16	0.062
	2000	high	15,200	19.16	291.23	43.96	60.68	96.75	---	0.062
		low	15,200	19.16	291.23	76.45	105.35	167.47	---	0.062
	2020	high	24,300	19.16	465.59	20.31	27.95	44.44	---	0.062
		low	24,300	19.16	465.59	82.18	113.24	180.37	---	0.062

TABLE 17.7

COMPARISON BETWEEN PRODUCTION OF, AND DEMAND FOR, KOKANEE IN SKAHA LAKE FROM 1970 TO 2020, UNDER ALTERNATIVE CONDITIONS OF ANGLING SUCCESS RATE, LAKE WATER QUALITY, DISCHARGE MANAGEMENT, AND STATUS OF REPRODUCTIVE HABITAT

						BEST ESTIMATE OF KOKANEE HARVEST AVAILABLE X 1000				
MANAGEMENT OPTION	YEAR	NUTRIENT ESTIMATE	PROJECTED ANGLING DEMAND DAYS	NO. OF KOKANEE REQUIRED/ ANGLING-DAY	TOTAL HARVEST-ABLE KOKANEE REQUIRED X 1000	1970 RE-PRODUCTIVE HABITAT, 1970 DISCHARGE MANAGEMENT	1970 RE-PRODUCTIVE HABITAT, MODIFIED DISCHARGE MANAGEMENT	REALISTIC POTENTIAL HABITAT, MODIFIED DISCHARGE MANAGEMENT	NO. OF KOKANEE AVAILABLE PER ANGLING DAY	CORRESPONDING CATCH PER UNIT EFFORT NO/HR (SEE MANAGE-MENT OPTION)
No fishery enhancement; success rate declines	1970	---	68,400	---	---	1128.7	---	---	16.50	1.264
	1980	high	99,500	---	---	1376.1	---	---	13.83	1.059
		low	99,500	---	---	1365.1	---	---	13.72	1.051
	2000	high	154,600	---	---	1280.0	---	---	8.28	0.634
		low	154,600	---	---	1212.4	---	---	7.84	0.601
	2020	high	292,800	---	---	1082.6	---	---	3.70	0.283
		low	292,800	---	---	1054.1	---	---	3.60	0.276
Fishery enhancement to maintain 1970 success rate	1970	---	68,400	16.50	1128.7	1128.7	1207.7	2347.7	---	1.264
	1980	high	99,500	16.50	1641.8	1376.1	1535.0	3423.1	---	1.264
		low	99,500	16.50	1641.8	1365.1	1522.7	3395.8	---	1.264
	2000	high	154,600	16.50	2550.9	1280.0	1362.8	3024.8	---	1.264
		low	154,600	16.50	2550.9	1212.4	1342.6	2795.1	Estimates	1.264
	2020	high	292,800	16.50	4831.2	1082.6	1187.6	2239.4	---	1.264
		low	292,800	16.50	4831.2	1054.1	1156.4	2180.6	shown	1.264
Fishery enhancement to increase 1970 success rate by 30%	1970	---	68,400	21.45	1467.2	1128.7	1207.7	2347.7	---	1.643
	1980	high	99,500	21.45	2134.3	1376.1	1535.0	3423.1	under	1.643
		low	99,500	21.45	2134.3	1365.1	1522.7	3395.8	---	1.643
	2000	high	154,600	21.45	3316.2	1280.0	1362.8	3024.8	management	1.643
		low	154,600	21.45	3316.2	1212.4	1342.6	2795.1	---	1.643
	2020	high	292,800	21.45	6280.6	1082.6	1187.6	2239.4	options	1.643
		low	292,800	21.45	6280.6	1054.1	1156.4	2180.6	---	1.643

TABLE 17.8

COMPARISON BETWEEN PRODUCTION OF, AND DEMAND FOR, RAINBOW TROUT IN OKANAGAN LAKE FROM 1970 TO 2020, UNDER ALTERNATIVE CONDITIONS OF ANGLING SUCCESS RATE, LAKE WATER QUALITY, DISCHARGE MANAGEMENT, AND STATUS OF REPRODUCTIVE HABITAT

MANAGEMENT OPTION	YEAR	NUTRIENT ESTIMATE	PROJECTED ANGLING DEMAND DAYS	NO. OF RAINBOW REQUIRED/ ANGLING-DAY	TOTAL HARVEST-ABLE RAINBOW REQUIRED X 1000	BEST ESTIMATE OF RAINBOW TROUT HARVEST AVAILABLE X 1000: 1970 RE-PRODUCTIVE HABITAT, 1970 DISCHARGE MANAGEMENT	1970 RE-PRODUCTIVE HABITAT, MODIFIED DISCHARGE MANAGEMENT	REALISTIC POTENTIAL HABITAT, MODIFIED DISCHARGE MANAGEMENT	NUMBER OF RAINBOW AVAILABLE PER ANGLING DAY	CORRESPONDING CATCH PER· UNIT EFFORT NO/HR (SEE MANAGE-MENT OPTION)
No fishery enhancement; success rate declines	1970	---	68,400	---	---	17.86	---	---	0.261	0.019
	1980	high	99,500	---	---	17.81	---	---	0.179	0.013
		low	99,500	---	---	17.95	---	---	0.180	0.013
	2000	high	154,600	---	---	17.61	---	---	0.114	0.008
		low	154,600	---	---	17.90	---	---	0.116	0.008
	2020	high	292,800	---	---	17.50	---	---	0.060	0.004
		low	292,800	---	---	17.82	---	---	0.061	0.004
Fishery enhancement to maintain 1970 success rate	1970	---	68,400	0.261	17.86	17.86	31.97	197.00	0.261	0.019
	1980	high	99,500	0.261	25.97	17.81	28.84	177.67	---	0.019
		low	99,500	0.261	25.97	17.95	29.08	179.10	---	0.019
	2000	high	154,600	0.261	40.35	17.61	29.93	184.39	---	0.019
		low	154,600	0.261	40.35	17.90	30.42	187.35	---	0.019
	2020	high	292,800	0.261	76.42	17.50	31.15	191.87	---	0.019
		low	292,800	0.261	76.42	17.82	31.72	195.39	---	0.019
Fishery enhancement to increase 1970 success rate by 30%	1970	---	68,400	0.339	23.19	17.86	31.97	197.00	0.339	0.025
	1980	high	99,500	0.339	33.73	17.81	28.84	177.67	---	0.025
		low	99,500	0.339	33.73	17.95	29.08	179.10	---	0.025
	2000	high	154,600	0.339	52.41	17.61	29.93	184.39	---	0.025
		low	154,600	0.339	52.41	17.90	30.42	187.35	---	0.025
	2020	high	292,800	0.339	99.26	17.50	31.15	191.87	---	0.025
		low	292,800	0.339	99.26	17.82	31.72	195.39	---	0.025

TABLE 17.9

COMPARISON BETWEEN PRODUCTION OF, AND DEMAND FOR, RAINBOW TROUT IN SKAHA LAKE FROM 1970 TO 2020 UNDER ALTERNATIVE CONDITIONS OF ANGLING SUCCESS RATE, LAKE WATER QUALITY, DISCHARGE MANAGEMENT, AND STATUS OF REPRODUCTIVE HABITAT.

MANAGEMENT OPTION	YEAR	NUTRIENT ESTIMATE	PROJECTED ANGLING DEMAND DAYS	NO. OF RAINBOW REQUIRED ANGLING-DAY	TOTAL HARVEST-ABLE RAINBOW REQUIRED X 1000	BEST ESTIMATE OF RAINBOW TROUT HARVEST AVAILABLE X 1000: 1970 RE-PRODUCTIVE HABITAT, 1970 DISCHARGE MANAGEMENT	1970 RE-PRODUCTIVE HABITAT, MODIFIED DISCHARGE MANAGEMENT	REALISTIC POTENTIAL HABITAT, MODIFIED DISCHARGE MANAGEMENT	NUMBER OF RAINBOW AVAILABLE PER ANGLING DAY	CORRESPONDING CATCH PER UNIT EFFORT NO/HR (SEE MANAGE-MENT OPTION)
No fishery enhancement; success rate declines	1970	---	6,500	---	---	1.45	---	---	0.223	0.022
	1980	high	10,500	---	---	1.24	---	---	0.018	0.012
		low	10,500	---	---	1.98	---	---	0.189	0.019
	2000	high	15,200	---	---	0.85	---	---	0.056	0.006
		low	15,200	---	---	1.81	---	---	0.119	0.012
	2020	high	24,300	---	---	0.39	---	---	0.016	0.002
		low	24,300	---	---	1.73	---	---	0.071	0.007
Fishery enhancement to maintain 1970 success rate	1970	---	6,500	0,223	1.45	1.45	1.52	2.35	0.223	0.022
	1980	high	10,500	0.223	2.34	1.24	1.31	2.01	---	0.022
		low	10,500	0.223	2.34	1.98	2.08	3.21	---	0.022
	2000	high	15,200	0.223	3.39	0.85	0.90	1.38	---	0.022
		low	15,200	0.223	3.39	1.81	1.90	2.92	---	0.022
	2020	high	24,300	0.223	5.42	0.39	0.41	0.63	---	0.022
		low	24,300	0.223	5.42	1.73	1.82	2.80	---	0.022
Fishery enhancement to increase 1970 success rate by 30%	1970	---	6,500	0.290	1.89	1.45	1.52	2.35	0.290	0.029
	1980	high	10,500	0.290	3.05	1.24	1.31	2.01	---	0.029
		low	10,500	0.290	3.05	1.98	2.08	3.21	---	0.029
	2000	high	15,200	0.290	4.41	0.85	0.90	1.38	---	0.029
		low	15,200	0.290	4.41	1.81	1.90	2.92	---	0.029
	2020	high	24,300	0.290	7.05	0.39	0.41	0.63	---	0.029
		low	24,300	0.290	7.05	1.73	1.82	2.80	---	0.029

(Table 17.10). Preliminary examination indicates that storage is in all cases less expensive than pumping. Much of the deficiency can be made up assuming a modified operation of existing storage. Additional costs for this type of operation would include alteration of some discharge regulating facilities and operational costs during winter months etc., when access is a problem.

More intensive examination of ways of supplying water for fisheries requirements might include the feasibility of pumping on a shared basis (fisheries and agriculture) to cut capital costs and make more efficient use of equipment (which would only be needed for relatively short periods if used for fisheries alone), and the use of pumping linked with spawning channels, or other intensive fisheries management structures to make most efficient use of what could be expensive water. A channel or similar device would require less water and minimize losses into the substrate.

(b) Enhancement of Natural Reproductive Habitat

Estimates were made of the increased harvest which might be anticipated due to enhancement of natural reproductive habitat in 13 streams tributary to Okanagan and Skaha Lakes, known to support reproduction of salmonids. Increased harvest from each tributary was assumed to be given by the product of enhanced spawning area, the improvement factor based on modified discharges (defined in Table 17.11), and the natural productivity factor determined separately for Okanagan and Skaha Lakes in Appendix M. These estimates of increased harvest are given in Table 17.11.

Approximate costs of enhancement of salmonid reproductive habitat to its realistic potential are given in Table 17.12. The corresponding harvest anticipated to be made available by such measures is also given in that table for 1970, 1980 and 2020 levels of Basin development.

It was assumed that prior to enhancement measures being undertaken, discharge regimes in the corresponding tributaries would be adjusted from historic to modified modes of operation, in order that minimal additional storage requirements might be necessary at the 1980 level of Basin development. Of the six tributaries examined only in Mission Creek was additional storage considered necessary specifically to satisfy fishery requirements.

Assuming modified flows at 2020 levels of development, Peachland and lower Vernon Creeks have adequate fishery flows at both high and low levels of agricultural development, the latter due to the pumping of 560 acre-feet per month into Mood Lake from Okanagan Lake, and assuming that this flow is not committed to non-consumptive uses. Equesis, Trout and Powers Creeks will have significant deficiencies in dry years (frequency: one in ten), and without specific fisheries storage. Mission Creek will always have fisheries deficiencies.

TABLE 17.10

PUMPING FROM OKANAGAN LAKE VERSUS UPLAND STORAGE, VIEWED AS POSSIBLE SUPPLY OF SUPPLEMENTAL MATER REQUIRED TO MEET "FISHERIES DEFICIENCIES" UNDER "AVERAGE YEAR FLOW CONDITIONS" AND "1980" LEVEL OF DEVELOPMENT

DESCRIPTION		TROUT CK. (Historic Operation)	PEACHLAND CK. (Historic Operation)	POWERS CK. (Historic Operation)	EQUESIS CK. (Historic Operation)	MISSION CK. (Historic Operation)
PUMPING FROM OKANAGAN LAKE						
Max. Pumping rate -	Ac.ft. per month	600	270	240	221	1,836
Max. Pumping rate -	c.f.s.	10.0	4.5	4.0	3.7	31.0
Length of forcemain	feet	17,000	18,500	18,000	38,000	54,000
Diameter of forcemain	inches	18	14	14	12	32
Static Lift	feet	380	980	880	880	980
Friction Head	feet	107	92	72	285	140
Miscellaneous Losses	feet	13	8	8	15	10
Total Head Losses, T.D.H.	feet	500	1,080	960	1,180	1,130
Annual Pumping Rate -	Ac.ft. per year	967	621	613	686	11,196
Equivalent time & max. rate	hours per year	1,160	1,660	1,800	2,200	4,400
Pump Stn. Horse Power	H.P.	740	720	570	648	5,200
Annual Power Consumption	K.W.H.	640,000	890,000	765,000	1,060,000	17×10^6
Capital Cost						
Forcemain		$340,000	$240,000	$234,000	$ 380,000	$1,780,000
Intake and Water Conditioning		20,000	20,000	20,000	20,000	20,000
Pump Stn. 740 H.P. @ $250		185,000	180,000	142,000	162,000	1,300,000
Sub Total		545,000	440,000	396,000	562,000	3,100,000
Engineering & Contingencies + 25%		135,000	110,000	99,000	140,000	775,000
Total Capital Cost		$680,000	$550,000	$495,000	$ 702,000	$3,875,000
Annual Costs						
Operation & Maingenance-Forcemain & Intake, 2% p.a.		$ 7,200	$ 5,200	$ 5,100	$ 8,000	$ 36,000
-Pump Stn. 5% p.a.		9,250	9,000	7,100	8,100	65,000
Power - K.W.H. @ $0.006		3,840	5,340	4,600	6,400	102,000
Amortization of Capital Costs (25 yrs. @ 7%)		58,310	47,160	42,400	60,500	332,000
Total Annual Cost (Pumping)		$ 78,600	$ 66,700	$ 59,200	$ 83,000	$ 535,000
UPLAND STORAGE						
Capital Cost						
Storage Required - ac.ft.		1,210	776	776	858	14,000
Capital Cost @ $250/ac.ft.		$302,000	$194,000	$192,000	$ 214,500	$3,050,000
Annual Cost						
Operation & Maintenance - 2% of Cap. Cost		$ 6,000	$ 3,900	$ 3,800	$ 4,300	$ 70,000
Amortization of Capital Cost (25 yrs. @ 7%)		26,000	16,600	16,400	18,400	300,000
Total Annual Cost (Storage)		$ 32,000	$ 20,500	$ 20,200	$ 22,700	$ 370,000

TABLE 17.11

INCREMENTS IN KOKANEE AND RAINBOW TROUT HARVESTS MADE AVAILABLE BY ENHANCEMENT OF SPAWNING AREA AND BY MODIFICATION OF STREAM DISCHARGES. (BASED ON MAXIMUM ANNUAL SUSTAINABLE HARVEST)

STREAM	ENHANCED SPAWNING HABITAT AREA[a] SQ. YDS. X 1000	IMPROVEMENT FACTOR BASED ON MODIFIED DISCHARGES						ADDITIONAL HARVEST MADE AVAILABLE NUMBER x 1000[b]					
		KOKANEE			RAINBOW TROUT			KOKANEE			RAINBOW TROUT		
		1970	1980	2020	1970	1980	2020	1970	1980	2020	1970	1980	2020
Trout Creek	61.6	1.41	1.31	0.92	2.81	3.06	0.24	94.7	88.0	61.8	16.44	17.91	1.40
Peachland Cr.	1.8	2.53	2.53	1.91	4.00	4.00	3.19	5.0	5.0	3.7	0.68	0.68	0.55
Trepanier Cr.	147.6	1.49	1.58	1.16	2.33	2.41	2.26	238.7	254.2	186.6	32.67	33.79	31.69
Powers Creek	5.5	1.03	1.31	0.92	2.74	3.54	6.57	6.2	7.9	5.5	1.43	1.85	3.43
Lambly Creek	4.0	1.49	1.58	1.16	2.33	2.41	2.26	6.5	6.9	5.1	0.89	0.92	0.86
Whiteman Creek	14.8	1.49	1.58	1.16	2.33	2.41	2.26	24.0	25.5	18.7	3.28	3.39	3.18
Equesis Creek	52.0	1.53	1.15	1.14	1.21	1.06	0.73	86.7	65.2	64.6	5.98	5.27	3.61
B-X Creek	13.3	1.49	1.58	1.16	2.33	2.41	2.26	21.6	22.9	16.8	2.94	3.05	2.86
Vernon Cr., Lower	29.5	1.42	1.42	1.14	1.43	1.43	1.15	45.7	45.7	36.7	4.08	4.01	3.22
Mission Creek	725.2	1.00	1.78	0.93	1.76	1.36	1.68	790.5	1407.0	735.1	121.25	93.70	115.74
Okanagan Lake total or average	1055.3	1.49	1.58	1.16	2.33	2.41	2.26	1319.6	1928.3	1134.6	189.64	164.57	166.54

[a] Present gross spawning area x (Relative area increase x relative quality increase - Koshinsky and Millcocks, MS 1973).

[b] Enhanced spawning area x discharge improvement factor x K where K is "natural productivity factor" for average of 1970, 1980, and 2020 levels of Basin development, as follows: Kokanee = 1.09; Rainbow trout - 0.95.

The estimated annual costs of enhancement of natural reproductive habitat for kokanee and rainbow trout in 13 Okanagan and Skaha streams, together with the costs of provision of water for the 1980 level of Basin development, and the total additional harvest made available annually by such measures are presented in Table 17.12. Also included for each tributary is the estimated total annual cost incurred in the production of one harvestable fish.

Since discharge availabilities are based on the 1980 level of development in Table 17.11, and in fact it is anticipated that successively less water will be available to fish after this date, it may be noted that the additional harvests made available by modified discharge regimes are marginally reduced from 1980 to 2020 in four of the six tributaries analyzed in depth (Table 17.11).

(c) Provision of Artificial Reproductive Habitat

The relative productivity and costs of a spawning channel, incubation channel, incubation boxes, and hatchery were investigated for use at a location adjacent to Trout Creek (Hinton, 1972). It was estimated that for the production of 500,000 to 4,000,000 fry of both kokanee and rainbow trout, the ratio of costs of those four facilities were approximately

8 : 2 : 1 : 10

The above ratio of costs did not include additional storage which would be required. Including capital costs of necessary storage at $125.00 per acre-foot it was estimated that the ratio of costs would be approximately

8 : 1 : 1 : 5

The costs proposed by Hinton were independently re-estimated on the basis of the cost of production of one harvestable fish. The effectiveness of different facilities was estimated from consideration of the number of harvestable fish made available per unit area of additional natural reproductive habitat, ("Natural Productivity Factor") adjusted by the comparative effectiveness of artificial facilities with natural reproductive habitat. The principal assumptions embodied in this relationship were:

1) The productivity per unit area of additional natural tributary reproductive habitat is reflected by the additional numbers of harvestable kokanee or rainbow trout divided by the sum of increased tributary reproductive areas multiplied by their individual improvement factor.
2) For kokanee, a spawning channel is five times as effective, and for rainbow trout ten times as effective as natural stream spawning habitat, based on comparative egg-to-fry survival rates respectively.
3) For kokanee, an incubation channel is thirty-five times as effective, and for rainbow trout seventy times as effective as natural stream spawning habitat, based on egg-to-fry survival rates approximately seven and fourteen times as great, and densities of egg deposition about five times as great, respectively.

TABLE 17.12

APPROXIMATE COSTS OF ENHANCEMENT OF NATURAL REPRODUCTIVE HABITAT FOR KOKANEE AND RAINBOW TROUT IN 13 STREAMS TRIBUTARY TO OKANAGAN AND SKAHA LAKES (BASED ON MAXIMUM ANNUAL SUSTAINABLE HARVEST)

STREAM	TOTAL ADDITIONAL HARVEST MADE AVAILABLE BY STREAM ENHANCEMENT NUMBERS OF KOKANEE AND RAINBOW X 1000				CONSTRUCTION AND WORKS		WATER ANNUAL $ X 100	TOTAL ANNUAL COST $ X 100	TOTAL ANNUAL COST PER HARVESTABLE FISH $
	1970	1980	2020	AVERAGE	CAPITAL $ X 1000	ANNUAL $ X 100			
Trout Cr.	98.28	107.23	59.19	88.23	16.5	14.2	0	14.2	0.016
Peachland Cr.	4.95	5.77	4.08	4.93	4.5	3.9	0	3.9	0.079
Trepanier Cr.	240.35	292.88	208.19	247.14	10.5	9.0	281.9	290.9	0.118
Powers Cr.	6.76	9.81	8.85	8.47	11.5	9.9	0	9.9	0.117
Lambly Cr.	6.54	7.90	5.61	6.68	2.5	2.1	7.6	9.7	0.145
Whiteman Cr.	24.10	29.32	20.88	24.77	21.0	18.0	28.3	46.3	0.186
Equesis Cr.	81.36	71.53	64.23	72.37	28.5	24.5	0	24.5	0.034
B-X Cr.	21.69	26.28	18.74	22.24	6.5	5.6	25.4	32.0	0.144
Vernon Cr.,Lwr.	43.70	50.42	37.73	43.95	5.0	4.3	0	4.3	0.010
Mission Cr.	805.27	1525.82	810.35	1047.15	±518.0	±444.4	1444.0	1887.4	0.180
Okanagan Lake, total or ave.	1333.00	2126.96	1237.85	1565.93	±624.5	±535.9	1787.2	2323.1	0.148
Ellis Cr.	2.42	1.69	2.09	2.07	2.0	1.7	2.4	4.1	0.198
McLean Creek	0.61	0.43	0.53	0.52	1.0	0.9	0.6	1.5	0.288
Shingle Cr.	111.84	78.19	96.65	95.56	2.0	1.7	109.0	110.7	0.116
Skaha Lake total or ave.	114.87	80.31	99.27	98.15	5.0	4.3	112.0	116.3	0.118

TABLE 17.13

PRODUCTION AND COSTS OF KOKANEE AND RAINBOW TROUT FROM ARTIFICIAL REPRODUCTIVE HABITAT CONSIDERED FOR OKANAGAN AND SKAHA LAKES (BASED ON MAXIMUM ANNUAL SUSTAINABLE HARVEST)

LOCATION	DESIGNATION	AREA OF GRAVEL SQ. YDS. X 100	CORRESPONDING HARVEST MADE AVAILABLE NO X 1000		TOTAL ANNUAL COSTS INCL. AMORTIZED CAPITAL & MAINTENANCE & DISCHARGE			ANNUAL COST PER HARVESTABLE FISH $
			KOKANEE	RAINBOW TROUT	WORKS	WATER	TOTAL	
OKANAGAN LAKE								
Trout Creek	Incubation channel	0.72	25.44	4.77	17.2	nil	17.2	0.57
Mission Cr.	Incubation channel	2.16	76.31	14.32	27.8	nil	27.8	0.31
Penticton Cr.	Incubation channel	0.72	25.44	4.77	15.0		To be determined.	
Vernon Cr.	Incubation channel	2.16	76.31	14.32	27.8	nil	27.8	0.31
Equesis Cr.	Spawning channel	3.73	18.84	3.54	17.7	nil	17.7	0.79
Okanagan L. shores	Placement of rock & cobbles to enhance shore spawning habitat	As Necessary	As Necessary				To be determined.	
Various	Incubation boxes	Various	AS Necessary				To be determined.	
SKAHA LAKE								
Okanagan R.	Spawning channel	3.73	69.19	0.90	17.7	nil	17.7	0.25

A selection of alternative artificial reproductive habitats is listed in Table 17.13, together with suggested sizes, the corresponding harvest of kokanee and rainbow trout anticipated, and estimated costs based on Hinton's findings[a] It was assumed that modified discharge regimes would be instituted in all corresponding streams prior to the construction of artificial facilities, and accordingly no costs were allocated to the provision of discharges.

No definitive suggestions concerning possible locations, sizes or costs of incubation boxes are included. These were detailed by Hinton (1972) and further discussion relating to the use of incubation boxes for kokanee or rainbow trout is hypothetical prior to testing.

The possibility of enhancing reproductive potential by the placement of angular rock and cobbles adjacent to beach-spawning kokanee sites has been suggested, but further discussion would be premature until the practicability of this measure had been tested.

(d) Construction of Hatchery for Enhancement of Sport Fishery in Main Valley Lakes

As indicated in the previous section, it was estimated by Hinton that the unit cost of a hatchery operation could be 5-10 times that of an incubation channel. However, it is postulated that the relatively large number of competitors and predators in Skaha Lake with respect to rainbow trout may promote a "management bottleneck" in the provision of sufficient harvestable rainbow trout in that lake. Kokanee may also be subject to excessive predation. However, due to occupation of a somewhat different ecological niche, this cannot be directly inferred.

A means of circumventing such a bottleneck might be to stock trout and kokanee at sizes of 50/lb or larger rather than allowing them to immigrate into the lake from tributaries at the more vulnerable size of 2500/lb. Accordingly, approximate costs were determined for the raising of sufficient kokanee and rainbow trout for stocking in Skaha Lake to satisfy angling demands to the year 2020 at continued 1970 angling success rates. Costs of a proposed hatchery operation are given in Table 17.14. Amortized costs of construction, operation, egg collection and fish liberation are included. It was assumed that prior to hatchery construction, certain other modifications, including enhancement of discharge regimes and natural spawning habitat would be undertaken.

Survival rates for both kokanee and rainbow trout from sizes of 50/lb to 10/ 1b to the age-at-catching in Skaha of 2.5 and 3 respectively were assumed to be the same as those estimated for rainbow trout in the headwater lakes.

[a]Storage cost adopted by Hinton is probably low by a factor of about 2X (Leach, personal communication)

TABLE 17.14

APPROXIMATE COSTS AND BENEFITS OF HATCHERY RAISED KOKANEE AND RAINBOW TROUT FOR THE SATISFACTION OF ANGLING DEMAND IN SKAHA LAKE, 1980 to 2020

YEAR	ADDITIONAL HARVEST REQ'D NUMBER X 1000	CORRESPONDING NUMBER X 1000 @ 2500/lb.	CORRESPONDING NUMBERS X 1000 AT WEIGHTS INDICATED 50/lb	10/lb	ANNUAL COST TOTAL X $1000	PER HARVEST-ABLE FISH $
KOKANEE						
1980	23	383	43.5	12.6	29.4	1.28
2000	55	917	104.2	33.0	70.4	1.28
2020	178	2,967	337.2	97.5	227.9	1.28
RAINBOW TROUT						
1980	0	0	0	0	0	
2000	0.48	8.0	0.91	0.26	0.61	1.28
2020	2.60	43.3	4.92	1.42	3.33	1.28

ANNUAL BENEFITS

KOKANEE AND RAINBOW TROUT	ACTUAL (X $1000)	SOCIAL
1980	19.0	58.4
2000	27.2	84.5
2020	48.4	169.1

(e) Productivity and Costs of Alternative Fishery and Water Management Options in Okanagan and Skaha Lakes, 1970 to 2020.

It was determined that without artificial enhancement of salmonid stocks in Okanagan and Skaha Lakes, the angling success rates measured as number of fish caught per hour can be expected to fall as shown in Table 17.15.

TABLE 17.15

EXPECTED DECLINE IN FISHING SUCCESS IN OKANAGAN AND SKAHA LAKES. ASSUMING NO ENHANCEMENT OF KOKANEE AND RAINBOW TROUT STOCKS

Year	Estimate	CATCH PER UNIT EFFORT: Okanagan Lake Kokanee	Okanagan Lake Rainbow	Skaha Lake Kokanee	Skaha Lake Rainbow
1970	-	1.264	0.019	0.048	0.022
1980	high	1.059	0.013	0.024	0.072
	low	1.051	0.013	0.021	0.019
2000	high	0.634	0.008	0.009	0.006
	low	0.601	0.008	0.016	0.012
2020	high	0.283	0.004	0.003	0.002
	low	0.276	0.004	0.011	0.007

The cost of production of one harvestable fish in Okanagan and Skaha Lakes was found to be approximately as follows:

Rehabilitation of natural habitat	$ 0.02 - 0.29
Construction of incubation channel	0.25 - 0.57
Construction of spawning channel	0.35 - 0.73
Construction of hatchery	1.28 - 1.37

The alternative enhancement measures of construction of incubation boxes, and of placing suitable material for beach-spawning kokanee on the shore of Okanagan Lake require field testing before adequate productivity and cost analyses can be made.

The additional sub-basin storage requirements for the satisfaction of full fishery discharge requirements for reproduction were determined for six tributaries to Okanagan Lake, under both historic and modified discharge operations (Appendix X). By 2020, assuming high growth and irrigation demands, fishery demand deficits will amount to 20,780 acre-feet per year, if historic water management techniques prevail. An annual deficit of 11,335 acre-feet will occur under modified operations. Costs of storage to make up these deficits are 5.2 million dollars and 2.8 million dollars respectively. It might be noted that well over one-half of these deficits are on Mission Creek.

On the basis of the alternative measures considered above, specific programs for the enhancement of kokanee and rainbow trout stocks in order to maintain or improve angling success rates are suggested for Okanagan and Skaha Lakes. These are put forward in the following sections. It is clearly recognized that a considerable part of the information used in this analysis is based on insufficient or tentative data, and that a significant number of the relationships are based on incomplete evidence and intuitive assumptions. Nevertheless, the evaluation is considered to be of considerable worth in the future management of sport fisheries of the Basin for the benefit of man. Where significant gaps in the data and relationships are apparent, it is the task of management to ensure that applied research is directed toward elucidating the necessary information.

<u>Okanagan Lake</u>

Before evaluating the feasibility and costs of increasing headwater storages and for pumping from Okanagan Lake, harvest potential of both kokanee and rainbow trout from tributary stream spawning assuming adequate flows, was calculated (Tables 17.16 and 17.17). Under assured flows for fisheries, Mission Creek could increase its harvest capacity from 84,000 to almost 400,000 kokanee, accounting for over 90% of all tributary stream spawning potential under present development of reproductive habitat. The only other creek exhibiting a significant increase in harvest potential under assured flows is Equesis, which could deliver 54,000 harvestable kokanee. A similar pattern holds for rainbow trout - Mission Creek providing potential for 26,000 fish under assured flows compared to 9,000 at present. These figures represent total allowable potential harvests to maintain a

TABLE 17.16
KOKANEE HARVESTS IN OKANAGAN LAKE
1970-2020 UNDER VARIOUS FISHERY MANAGEMENT ALTERNATIVES

CREEK	PRESENT HARVEST 1970 STORAGE HISTORIC DISCHARGE	ABILITY OF LAKES TO PRODUCE AT A MAXIMUM SUSTAINED YIELD		HARVEST POTENTIAL - 2020 MAINTAINING 1970 ANGLER SUCCESS RATES			
		1970 LEVEL POTENTIAL HARVEST AVAILABLE ASSURED FLOWS NO ENHANCED HABITAT	1970 MAXIMUM POTENTIAL HARVEST FULL ENHANCEMENT OF REPRODUCTIVE HABITAT & ASSURED FLOWS	HISTORIC OPERATION INCREASED STORAGE NO ENHANCEMENT		MODIFIED OPERATION INCREASED STORAGE NO ENHANCEMENT	
				HIGH IRRI-GATION DEV-ELOPMENT	LOW IRRI-GATION DEV-ELOPMENT	HIGH IRRI-GATION DEV-ELOPMENT	LOW IRRI-GATION DEV-ELOPMENT
COLUMN	X 1000 (1)	X 1000 (2)	X 1000 (3)	X 1000 (4)	X 1000 (5)	X 1000 (6)	X 1000 (7)
Mission	84.3	399.4	953.5	90.75	108.8	163	326.7
Trepanier	2.8	19.8	394.4		No Hydrological Data		
Trout	0.1	0.8	4.5	0	0.1	0.1	0.14
Vernon (lower)	.3	1.8	39.8	1.8	1.8	1.8	1.8
Equesis	7.5	54.0	205.8	6.1	6.9	7.0	11.40
Whiteman	0.2	1.2	2.4		No Hydrological Data		
B-X Creek	0	0.8	1.4		No Hydrological Data		
Powers	2.0	9.6	14.5	.91	1.8	1.75	2.1
Peachland	1.3	6.0	18.3	1.02	1.07	2.4	3.3
Lambly	5.1	0.8	1.8		No Hydrological Projections		

TABLE 17.17
RAINBOW TROUT HARVESTS IN OKANAGAN LAKE
1970-2020 UNDER VARIOUS FISHERY MANAGEMENT ALTERNATIVES

CREEK	PRESENT HARVEST 1970 STORAGE HISTORIC DISCHARGE	ABILITY OF LAKES TO PRODUCE AT A MAXIMUM SUSTAINED YIELD		HARVEST POTENTIAL - 2020 MAINTAINING 1970 ANGLER SUCCESS RATES			
		1970 LEVEL POTENTIAL HARVEST AVAILABLE ASSURED FLOWS NO ENHANCED HABITAT	1970 MAXIMUM POTENTIAL HARVEST ASSURED FLOWS FULL ENHANCEMENT	HISTORIC OPERATION INCREASED STORAGE NO ENHANCEMENT		MODIFIED OPERATION INCREASED STORAGE NO ENHANCEMENT	
				HIGH IRRI-GATION DEV-ELOPMENT	LOW IRRI-GATION DEV-ELOPMENT	HIGH IRRI-GATION DEV-ELOPMENT	LOW IRRI-GATION DEV-ELOPMENT
COLUMN	X 1000 (1)	X 1000 (2)	X 1000 (3)	X 1000 (4)	X 1000 (5)	X 1000 (6)	X 1000 (7)
Mission	9.2	26.44	157.56	3.27	6.98	34.2	41.19
Trepanier	0.31	1.17	2.05	-	No Hydrological Data		-
Trout	0.02	0.05	0.28	0.0	0.01	0.05	0.07
Vernon (Lower)	0.03	0.04	0.95	0.04	0.04	0.04	0.04
Equesis	0.81	1.60	6.12	0.55	0.62	0.78	0.98
Whiteman	0.02	0.05	0.10	-	No Hydrological Data		-
B-X Creek	0.02	0.05	0.07	-	No Hydrological Data		-
Powers	0.21	0.97	1.44	0.14	0.36	0.63	0.71
Peachland	0.14	0.92	2.05	0.08	0.17	0.48	0.56
Lambly	0.02	0.05	0.09	-	No Hydrological Data		-

viable sustained fish population, but would result in a significant decline in angler success rate.

If minimum flow requirements were met either through modified flows or increased storage, it would then be feasible to improve spawning habitats in the lower reaches of selected tributaries. Such action would not be justified at present due to the high frequency of flow deficits during the summer months. Tables 17.16 and 17.17 show that habitat improvement would generally increase potential harvest capacities for both trout and kokanee in Mission, Trepanier and Equesis Creeks. Indeed, these three creeks would account for almost all potential harvest available from tributary spawning kokanee and trout.

The potential harvests discussed above are based on maximum harvests allowable to maintain a sustained fishery population, though angling success rates would drop sharply. To maintain current angling success rates, a smaller potential harvest capacity is available, and evaluated for both high and low projections of water withdrawals to 2020 in columns 4-7 inclusive, of Tables 17.16 and 17.17. Mission and Equesis Creeks continue to provide most of the fishery potential. In view of the potential importance of these creeks and Trepanier Creek, detailed evaluations of water management alternatives required to assure minimum flows were assessed.

Mission Creek

By 2020, if the present operation and storage capacities in Mission Creek watershed remain unchanged, only about 10% and 4% of potential harvests of kokanee and trout respectively would be available. Modified operation of existing storages, however, would significantly decrease water deficiencies for fisheries from 11,900 acre-feet to 8,000 acre-feet in dry years (Table 17.18). By itself, this management alternative would not improve kokanee harvest capacities as zero flows would still occur in dry and average runoff years in September though trout harvest capacities would be enhanced.

TABLE 17.18

WATER DEFICITS FOR FISHERIES IN MISSION CREEK BY 2020 ASSUMING EXISTING STORAGE AND ALTERNATIVE OPERATING RULES

OPERATING RULE	HIGH LEVEL OF IRRIGATION DEVELOPMENT DEFICITS (Acre-Feet)		LOW LEVEL OF IRRIGATION DEVELOPMENT DEFICITS (Acre-Feet)	
	DRY YEAR	AVERAGE YEAR	DRY YEAR	AVERAGE YEAR
Present Operation	14,800	9,800	11,100	5,700
Modified Operation	11.300	5,400	8,000	500
Reduction in Deficits	3,500	4,400	3,100	5,200

To enhance the sport fishery in Mission Creek, full fishery flows should be assured in approximately 8 years out of 10 in the average of dry and average runoff conditions. Thus, an additional 3,000 to 4,000 acre-feet of storage would be required over and above modified operation of existing storages. Preliminary hydrologic investigations indicate that approximately 4,000 acre-feet of additional storage are available in McCullock Creek, tributary to Mission Creek (Table 17.18). Development of this storage would cost approximately $1,000,000 or about $110,000 annually.

Equesis Creek

Due to limited developed headwater storage in Equesis Creek, modified operation of this storage would not be feasible without significantly reducing carry-over storage in drought years. Present fishery deficits in average-dry runoff conditions total 700 acre-feet annually, and preliminary hydrologic studies indicate that 150 acre-feet could definitely be developed on Pinaus Lake, and if an additional 550 acre-feet are not available, some or all of that required might be purchased from the irrigation district. Total costs of developing or purchasing water rights for 700 acre-feet are estimated at $175,000. There does not appear to be any additional storage for irrigation, and consequently no expansion of existing agricultural acreage is recommended, so that fishery flows, which command higher net benefits, can be guaranteed.

Trepanier Creek

As no storage sites were identified on Trepanier Creek, the current fishery deficit of 2200 acre-feet would have to be pumped from Okanagan Lake. This alternative is relatively inexpensive as the spawning beds lie within one mile of the creek mouth. Total costs (1970 dollars) are estimated at $137,000 with annual costs (amortization, operation and maintenance) of $55,000. Improvement to natural reproductive habitat would also be required to realize maximum harvest potential, at a cost of approximately $100,000.

The estimated costs of enhancement of natural reproductive habitat for kokanee and rainbow trout in Mission, Equesis and Trepanier Creeks are compared in Table 17.19. It is anticipated that management of these three basins towards the goal of realizing their maximum potential harvest capacities, together with protection and enhancement of shore-spawning habitats, and presently existing stream-spawning habitats, could satisfy potential angling demands to about 2000. As successively less water may be available for fisheries after this date, additional harvest potentials may be expected to decline by 2020. Additional fishery production to meet expanding angler demands would then have to be obtained from artificial spawning facilities, or from enhancement of shore-spawning habitats.

Annual benefits associated with the rehabilitation of natural spawning in the three creeks are also shown in Table 17.19. These benefits include net economic values derived from tourist expenditures as well as social values based on anglers'

TABLE 17.19
OKANAGAN SPORT FISHERY MANAGEMENT EVALUATION MATRIX
IN MISSION, TREPANIER AND EQUESIS CREEKS

ALTERNATIVE	KOKANEE		TROUT		COSTS		CAPITALIZED BENEFITS	
	INCREMENTAL HARVEST	TOTAL HARVEST	INCREMENTAL HARVEST	TOTAL HARVEST	CAPITAL	ANNUAL	ECONOMIC	SOCIAL
	No. x 1000		No. x 1000		($1000)	($1000)	($1000)	($1000)
Mission Creek								
1. modified discharge	-	1212.7	6.9	24.8	-	-		
2. increased storage	78.7	1291.4	28.1	52.9	$ 1,000.0	$ 110.0		
3. streambed improvement	120.8	1412.2	89.0	141.0	400.0	44.4		
TOTAL					$ 1,400.0	$ 154.4	$ 741.8	$ 923.5
Equesis Creek								
1. increased storage	43.0	1418.1	6.0	141.5	$ 175.0	$ 18.0		
2. streambed improvement					28.5	2.5		
TOTAL					$ 202.5	$ 20.5	$ 112.4	$ 139.9
Trepanier Creek								
1. pumping	83.5	1499.6	4.7	145.2	$ 173.0	$ 55.0		
2. streabed improvement					100.0	10.5		
TOTAL					$ 273.0	$ 65.5	$ 202.3	$ 251.8
TOTALS	3,260		131.7		$ 1,876.5	$ 240.5	$ 1,056.5	$ 1,315.2

expression of the value of an angler-day. It was assumed that the existing standing stock would satisfy angler demands to 1975, but there would be a 10% decline in potential angling demands by 1980 if no management measures were implemented. After 1980 it was assumed that 50% of the potential demand would not accrue, due to declining success rates. Under these assumptions, the total economic benefits for Okanagan Lake fishery enhancement capitalized over the next 50 years, would total over $1 million compared with total capital investment (not discounted) of 1.9 million. There are additional social benefits of 1.3 million, which would justify such an investment, provided social values were taken into the evaluation of alternatives.

Artificial Reproductive Habitat

Discussion in the preceding section indicated that the important creeks with fishery spawning potential are all situated along the central or northern part of Okanagan Lake. The creel census survey showed that angler success for both kokanee and trout were very much lower in the southern portion of Okanagan Lake than elsewhere in this lake. In lieu of good natural spawning habitat in the southern tributaries to Okanagan Lake, a number of possibilities to artificially increase harvest potential in this part of the lake were examined.

The relative productivity and costs of:
1) a spawning channel
2) an incubation channel
3) incubation boxes, and
4) a hatchery, were investigated for development on the lower reaches of Trout Creek. An incubation channel was selected as the most feasible alternative for Trout Creek on the basis of costs of production per harvestable fish.

TABLE 17.20

EVALUATION OF AN INCUBATION CHANNEL PROPOSED ON TROUT CREEK

PRESENT HARVEST POTENTIAL (No. X 1000)		HARVEST WITH CHANNEL (No. X 1000)		TOTAL ANNUAL COSTS ($1000)	TOTAL ANNUAL BENEFITS ($1000)	
KOKANEE	RAINBOW TROUT	KOKANEE	RAINBOW TROUT		ECONOMIC	SOCIAL
1.5	0.3	25.4	4.8	17.2	32.6	99.0

Evaluation of such an incubation channel is presented in Table 17.20. At present, the south basin of Okanagan Lake captures approximately 10% of the total Okanagan Lake angling effort, and it was assumed that if the Trout Creek incubation channel was constructed, this demand could rise to 20% or approximately equal to the region's relative share of the total Okanagan Lake Basin population. under this assumption, the benefit : cost ratio of an incubation channel would be about 2:1, if only economic values are accounted, and over 7:1 if social values are included.

In the case of kokanee, additional harvest potential is available from shore-spawning habitats, which presently (1971) deliver an estimated 140,000 harvestable fish. Of the present escapement, about 663,000 could be removed from this population and still maintain a sustained yield, although it is assumed that this extraction would involve a drastic reduction in catch-per-unit-effort.

Harvest potential from shore-spawning kokanee could be increased through better controls on Okanagan Lake levels. Preliminary studies have indicated that all spawning takes place within 5.5 feet of the surface and that kokanee production levels would be maximized if lake levels were to fluctuate less than six inches between October 1 and February 28. Obviously, lake levels cannot be controlled solely for protection of shore-spawning kokanee, but if other factors are taken into consideration, it would appear that more careful management in dry and average runoff years could enhance this component of the Okanagan fishery. Improvements to the shore-spawning habitat could potentially increase harvest yields, but this alternative could only be evaluated with more study on this aspect of kokanee life history.

Summary of Okanagan Lake Fishery Management

It is apparent that Okanagan Lake salmonid populations, the mainstay of the main valley lake fishery, are going to fall far short of supplying anticipated angler demands if a number of steps are not taken.

1) Annual extraction of kokanee could be increased almost five-fold and still maintain a sustained yield. However, it is assumed catch-per-unit-effort would drop markedly, as would angler satisfaction. So, while biologically feasible, this alternative is not deemed to be socially acceptable. A two-fold increase in kokanee harvest is potentially possible with modified streamflows and maximum enhancement of natural habitat. Angler demand is espected to increase 4.28 times. Thus, by 2020 artificial facilities are going to have to produce just over one-half of the assumed kokanee demand, based on modified operation of tributaries. It is unfeasible to carry out any natural habitat enhancement programs, if historic water management continues. The minimum flow requirement deficits by 2020 would make improvements superfluous due to lack of water.

2) It is possible to supply kokanee in excess of projected demands to 2000 by modifying flow, creating storage and rehabilitating natural habitat. A corresponding increase in angler success would be expected. Doing nothing-i.e. historic flows and no enhancement, would result in a decrease in the number of harvestable kokanee available in 2020. Considering the lake as a whole, no artificial facilities would be required until after 2000, though the southern portion of the lake is not producing sport fish at an average level, so artificial facilities are considered earlier in Trout Creek in an attempt to correct this intra-lake discrepancy.

3) Rainbow trout production in the lake is similar to kokanee production; the same problems exist. Rainbow trout demands however, can be entirely satisfied

by natural stream enhancement and in fact harvest could be increased 2.5 times in 2020 by this means; creating a much-needed increase in angler success (catch-per-unit-effort) for this species. As with kokanee, this increase is based on assuming modified operation of stream flows. No action on the part of fishery and/or water managers would again result in less fish available in 2020 than at present.

In order to maintain available fish harvest production in step with angling demands from 1970 to 2020, major emphasis has been placed on rehabilitating natural spawning habitats in creeks offering the greatest benefit:cost advantages. Consideration was also given to providing additional fish harvests in the southern basin of Okanagan Lake through provision of artificial spawning facilities. A suggested sequential fisheries enhancement program for both kokanee and rainbow trout is presented in Table 17.21. It should be noted that the angler success rates for kokanee may marginally decrease from present rates over the next 50 years, that for rainbow trout should increase two-fold. By implementing this program, the stated objective of maintaining or enhancing angling success with justified investments can be essentially achieved.

Skaha Lake

The level of water quality in Skaha Lake has reached optimum conditions for the production of salmonid sport fish stocks. Any further enrichment of the lake would likely create oxygen deficiencies in the hypolimnion and rapid reduction in salmonid fishes. Even assuming that water quality will be maintained or improved, if no fishery enhancement program is undertaken, angler success levels may be expected to fall significantly (Table 17.15).

Due to limited natural stream spawning habitat around Skaha Lake, any significant increase in kokanee or rainbow trout harvest capacities will be dependent on artificial propagation. Furthermore, as rainbow trout and possibly kokanee are subject to excessive predation in the lake, natural or artificial stocking at 2500/lb would possibly result in little increase in harvest capacities. This 'bottleneck' can be overcome by stocking trout and kokanee in sizes of 50 and 10/lb.

Costs and benefits of a proposed hatchery for Skaha Lake are presented in Table 17.14. It was assumed that prior to hatchery construction, certain other modifications including improvement of Okanagan River discharges and enhancement of natural spawning habitat would be undertaken. This stocking program would likely increase angling success rates substantially, particularly for rainbow trout, but would cost some $228,000 annually by 2020.

Annual benefits associated with the enhancement of Skaha Lake sport fishery were estimated on the basis that 65% of the projected angling-day demands (high estimate) above the 1970 level would be due to improved rainbow trout fishing. This assumption is based on the finding that 65% of the main valley lake fishermen preferred catching trout to kokanee.

TABLE 17.21
SPORT FISHERY MANAGEMENT PROGRAM FOR KOKANEE AND RAINBOW TROUT IN OKANAGAN LAKE, 1970-2020

IMPROVEMENT	DATE OF COMMEN-CEMENT	INCREASED HARVEST		ANNUAL COSTS $1000	ANNUAL COST PER HARVESTABLE FISH
		KOKANEE	TROUT		
		No. x 1000			
1. Implement Okanagan Lake operation improvements	1974	47.2	0	nil	nil
2. Initiate modified operations on Mission Creek	1975	0	6.9	nil	nil
3. Development of Storage on Mission Creek	1976	78.7	28.1	110.0	$1.03
4. Pumping and Streambed improvement on Trepanier	1980	83.5	4.7	65.0	$0.74
5. Incubation Channel in Trout Creek	1980	25.4	4.8	17.2	$0.57
6. Rehabilitate Mission Creek spawning area	1990	120.8	89.0	44.4	$0.21
7. Rehabilitation and Storage on Equesis Creek	1990	43.0	6.0	20.5	$0.42
8. Enhancement of shore-spawning kokanee habitats	2000+	To be determined			
9. Establishment of incubation boxes as required	2000+	To be determined			

Under this assumption, anticipated increases in net expenditures by nonresident anglers would not pay for the hatchery program. However, social benefits over and above net economic values could exceed annual costs if the number of angling days in the lake were to increase to some 34,000 by 2020. This demand is possible due to the values placed on good rainbow trout fishing and the general lack of it in the main valley lakes. Development of such a stocking program could also relieve angling pressure on the headwater lakes, and thus should be coordinated with any future stocking program for these lakes.

CHAPTER 18

Okanagan River
Fishery Management

Rainbow trout and some mountain whitefish are taken by anglers in various reaches of Okanagan River, but particularly in the short section immediately below Skaha Lake and in the "unimproved" section below the S.O.L.I.D. Dam. Predominantly coarse fish are caught in other parts of the river, with some game species taken in association with the drop structures just above Osoyoos Lake. Sockeye salmon spawn in the lower river section, particularly in the unimproved reach below S.O.L.I.D.

The river, except for the unimproved section, has little inherent sport-fish producing capability. Availability of fish in the river appears to be heavily dependent on migration from the main valley lakes, and hence is most realistically evaluated on that basis. It could not be shown that the preferred sport fishes were particularly sensitive to realistic discharge alternatives, so no serious evaluation was attempted in this regard.

Sockeye salmon reproduction in the river, on the other hand, is very sensitive to discharge by way of a complex array of seasonally dependent relationships. Various discharge alternatives were evaluated against present operation and in turn against a hypothetical idealized regime in terms of relative suitability for sockeye. It was assumed that escapement would be reduced in proportion to the extent to which discharge regime departed from the ideal. Enhancement measures were evaluated in view of the carrying capacity of Osoyoos Lake for progeny, derived on the basis of Zooplankton standing crop which is a function of lake productivity.

18.1 SPORT FISHERY MANAGEMENT ALTERNATIVES

18.1.1 Future Angling Demand and Fishery Potentials

No projections are available of anticipated future angling demand in Okanagan River. The availability of fish in the river, particularly in the channelized reaches, appears to be heavily dependent on migration from the main valley lakes. Thus, the status of populations in the latter will, to a large degree, determine "spin-off" fishery opportunities in the river. The most sought-after species (rainbow trout) appears to be generally insensitive to the feasible mainstem operating alternatives which were modelled. An exception would seem to be Alternative 2, which it is predicted, would exert a definite negative effect on rainbow trout. This negative effect is broadly based on the life history of this species.

It is apparent that future fishery management alternatives for Okanagan River will be largely dictated by the management policies adopted for Skaha and Osoyoos Lakes. Accordingly, no evaluation was attempted

18.2 SOCKEYE SALMON FISHERY ALTERNATIVES

18.2.1 Present Status

The Okanagan River between Vaseux and Osoyoos Lakes is the major reproductive habitat for sockeye salmon ascending the Columbia River. The total Columbia Sockeye escapement has averaged about 95,000 fish annually since 1961, of which an average of about 19,000 have spawned in the Okanagan River.

It is anticipated that future use of the water resources of the Okanagan Basin is likely to cause the sockeye production to fluctuate even more widely from year to year, and to collapse completely before the middle of the next century if present mainstem operations are not revised.

18.2.2 Effects of Mainstem Flow on Reproductive Habitat

Quantity alternatives of the mainstem Okanagan River are outlined in Table 18.1. Effects of these water management activities are also tabulated. Alternative 1(a) is the present operating condition. It is assumed to neither positively nor negatively affect the population for purposes of this analysis. It is noted that only Alternative 2(a) has a negative effect on the salmon population - all other alternatives (except the present 'nul' condition) are expected to approximately double the escapement if present salmon management policies are continued. An approximate doubling of escapement would result in a total annual commercial catch of 56,000 sockeye at the increased catch-to-escapement ratio of 0.3:1 to 0.5:1. Such an increase would be compatible with the availability of natural spawning habitat in the river and the capacity of Osoyoos Lake to accommodate the fry that spend a year rearing in that lake. This analysis is overly liberal as it assumes no change in the population if present mainstem operation continues. In fact, it is not zero, but some negative value thus the other values should also be downgraded to some unknown degree.

18.2.3 Construction of Artificial Reproductive Habitat

It has been proposed that the saving of water by reduction of discharges in the Okanagan River at certain critical seasons would compensate the cost of construction of a spawning channel adjacent to the river. Such a channel would be designed to satisfactorily accommodate an annual escapement of sockeye salmon equivalent to the present average run size, at reduced river discharges.

The channel capacity would be 3,000 female sockeye at a total cost of over $500,000 and with an estimated annual cost including amortized capital, operation and maintenance, of $54,200.

TABLE 18.1

RELATIVE EFFECT ON OKANAGAN RIVER SOCKEYE SALMON
OF VARIOUS MAINSTEM OPERATING ALTERNATIVES

	ALTERNATIVE	RELATIVE SCORE* PRESENT (1970)	FUTURE (2020)
I.	(a) Null operations Fish incidental	0	0
	(b) Null operations Fisheries all the time	+7	-
2.	(a) Water Conservation and Flood Control Fisheries Incidental	-2	-
	(b) Water Conservation and Flood Control Fisheries all the time	+8	+8
3.	(a) Maintenance Okanagan Lake levels under null operation through importation of water Fisheries Incidental	+7	+7
	(b) Maintenance Okanagan Lake Levels with improved intakes and Flood Control Fisheries all the time	+8	-

* 0 - Null Condition = Average Spawning Run of 19,000 Sockeye accommodated

+10 = Maximum Spawning run of 50,000 Sockeye accommodated

-10 = No spawning due to Water Quantity Limitations

Construction of such a channel would allow changes to be made in salmon-oriented flow requirements for the Okanagan River as given in Table 18.2. These changes would allow greater flexibility in choosing water management options for the Okanagan system, while not endangering the salmon run. The total saving of water in one year - assuming minimum flows in all twelve months - would be 19,825 acre-feet.

18.2.4 Osoyoos Lake Constraints

Based on estimates of the kokanee carrying capacity of Osoyoos Lake, the corresponding lake capacity for indigenous sockeye salmon fry was determined. It was estimated that no constraint is likely to be imposed on the number of salmon able to utilize the Okanagan system by this aspect of their life-cycle requirements.

With respect to the outflow from Osoyoos Lake, sockeye smolts migrate downstream to the Columbia River during April, May and June (R. Allen, personal communication). The absolute minimum discharge necessary to ensure successful passage of the outgoing smolt migration is about 50 cfs.

TABLE 18.2

OKANAGAN RIVER DISCHARGE REQUIREMENTS FOR SOCKEYE SALMON IN NATURAL RIVER CHANNEL, AND WITH SPAWNING CHANNEL CONSTRUCTION

MONTH	PRESENT SALMON REQUIREMENTS		SPAWNING CHANNEL REQUIREMENTS	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
August	300 cfs	450 cfs	300 cfs	450 cfs
September	350	550	350	550
October	350	500	100	-
November	175	1000	75	-
December	175	1000	75	-
January	175	1000	75	-
Feb. 1-15	175	1000	75	-
Feb. 16-28	175	1000	175	-
March	175	1000	175	-
April	175	1000	175	-

CHAPTER 19
General Discussion and Conclusions

The present and potential annual fish harvest capacities estimated for the various aggregate components of the Okanagan fishery resource system are summarized in Table 19.3. It is apparent that most of the inherent capacity within the Basin to produce sustainable yields of fish for human use occurs in the headwater and main valley lakes. The streams and river offer relatively little opportunity for in-channel fish production.

Salmonids offer the bulk of present as well as foreseeable future sport harvest opportunities. Kokanee dominate this resource base numerically, primarily due to their prominence in Okanagan Lake, as shown below:

TABLE 19.1

TOTAL SALMONID FISHES[a] AVAILABLE TO PRESENT SUSTAINED ANNUAL HARVEST IN LAKES OF THE OKANAGAN BASIN

LAKE(S)	Number of Lakes	KOKANEE		RAINBOW TROUT	
		No. X 1000	Percent of Total Salmonids	No. X 1000	Percent of Total Salmonids
Headwater lakes	(137)	0	0.0	139+	9.6
Main valley lakes	(6)	1,283	88.8	23	1.6
All lakes	(143)	1.283	88.8	162+	11.2
Okanagan Lake	(1)	1,129	78.1	18	1.2
Skaha Lake	(1)	96	6.6	1	0.1

[a]Based on kokanee and rainbow (+ brook) trout only.

The dominant position of the Okanagan Lake fish fauna in the overall Okanagan Basin sport-fishery resource base is a direct reflection of lake areas. Table 19.2:

TABLE 19.2

TOTAL SURFACE AREA OF ALL LAKES IN THE OKANAGAN BASIN

HARBORING SPORT-FISHING OPPORTUNITIES

LAKE(S)	Number of Lakes	Acres	Percent
Headwater lakes	(137)	10,904	9.5
Main valley lakes	(6)	104,054	90.5
All lakes	(143)	114,958	100.0
Okanagan Lake	(1)	85,990	74.8
Skaha Lake	(1)	4,967	4.3

TABLE 19.3

SUMMARY OF ESTIMATED PRESENT (AND REALISTIC POTENTIAL) MEAN ANNUAL SUSTAINABLE FISH HARVEST CAPACITIES FOR THE BASIC OKANAGAN BASIN FISHERY COMPONENTS, 1970 LEVEL OF DEVELOPMENT

FISHERY COMPONENT	PREFERRED SPORT FISH: Kokanee Present (Pot.) (No. X 1000)	PREFERRED SPORT FISH: Rainbow Trout[a] Present[b] (Pot.)[c] (No. X 1000)	PREFERRED SPORT FISH: Other Present only (Lb. X 1000)	Marginal Sport Fish Present only (Lb. X 1000)	Sockeye Salmon Present (Pot.)[d] (No. X 1000)	Lake Whitefish Present only (Lb. X 1000)	Coarse Fish: Preferred (Lb. X 1000)	Coarse Fish: Marginal (Lb. X 1000)
A. Headwater lakes (El.)	-							
< 3501[e]	- (-)	57.9 (183.8)	-	-	-	-	-	-
3501 - 4000[f]	- (-)	14.4 (53.2)	-	-	-	-	-	-
4001 - 4500	- (-)	53.6 (304.5)	-	-	-	-	-	-
4501 - 5000	- (-)	5.1 (54.2)	-	-	-	-	-	-
5001 - 5500	- (-)	6.5 (54.3)	-	-	-	-	-	-
> 5500	- (-)	1.5 (23.4)	-	-	-	-	-	-
TOTALS	- (-)	139.0 (678.4)	-	-	-	-	+	+
B. Tributary streams	- (-)	32.2 (38.4)	-	-	-	-	-	-
C. Main valley lakes:								
Wood	7.1 (13.2)	0.1 (1.4)	0.5	-	-	-	28.9	18.8
Kalamalka	25.7 (37.3)	2.8 (6.5)	2.2	-	-	-	1.2	1.3
Okanagan	1128.7 (2347.7)	17.9 (197.0)	4.5	13.0	-	18.9	28.4	35.3
Skaha	95.8 (209.8)	1.4 (2.3)	0.6	0.2	-	13.3	7.0	8.1
Vaseux	0.5 (0.8)	0.1 (0.1)	0.1	0.3	-	3.3	1.4	3.8
Osoyoos	25.5 (40.2)	0.2 (0.2)	1.3	0.2	-	3.9	15.6	5.1
TOTALS	1283.3 (2649.0)	22.5 (207.5)	9.2	13.7	15.1(58.0)	39.4	82.5	72.4
D. Okanagan River	+ (+)	0.5 (0.5)	+	+		-	+	+
E. TOTALS: All Components	1283.3 (2649.0)	194.2 (924.8)	9.2+	13.7+	15.1(58.0)	29.4	82.5+	72.4+

[a]Includes brook trout with respect to headwater takes and tributary streams, Tuguinuit Lakes.

[b]Based on present management and with reference to "present" stocking.

[c]Ultimate potential.

[d]Based on adoption of mainstem operating alternative 1b, or 3a and 3b, plus certain other assumptions (See Table 18.1).

[e]Excludes Swan, Ellison and

[f]Excludes Hydraulic Lake.

Okanagan Lake dominates the sport-fishing participation in the Basin, but anglers do show a measure of preference for fishing the headwater lakes, so that the dominance of Okanagan Lake in regard to angling participation is much less overwhelming than is its surface area and its basic fish harvest capacity, as illustrated in Table 19.4.

TABLE 19.4

TOTAL ANNUAL (1971-72) ANGLING PARTICIPATION ON ALL LAKES IN THE OKANAGAN BASIN HARBORING SPORT-FISHING OPPORTUNITIES

LAKE(S)	Number Of Lakes	Angling Days	Percent
Headwater Lakes	(137)	65,882	43.8
Main Valley Lakes	(6)	84,600	56.2
All Lakes	(143)	150,482	100.0
Okanagan Lake	(1)	70,350	46.7
Skaha Lake	(1)	6,650	4.4

Among the six main valley lakes, Okanagan Lake with 83% of the surface area also receives 83% of the angling participation. It can thus be surmized that the better availability of fish in Okanagan Lake, as indicated by catch per-unit-effort more than double that of any other main valley lake, over-rides the negative influences of the large surface area to some extent.

The total annual sport-fish harvest is much greater from the headwater lakes than would be anticipated on the basis of proportionate surface areas alone, as shown in Table 19.5 below:

TABLE 19.5

TOTAL ANNUAL (1971-72) SPORT-FISH CATCH[a] FROM ALL LAKES IN THE OKANAGAN BASIN HARBORING SPORT-FISHING OPPORTUNITIES

Lake(s)	Number Of Lakes	Number Of Fish	Percent
Headwater Lakes	(137)	125,465[b]	32.4
Main Valley Lakes	(6)	262,047	67.6
All Lakes	(143)	387,512	100.0
Okanagan Lake	(1)	248,777	64.2
Skaha Lake	(1)	7,258	1.9

[a]Based on boat-fishermen only

[b]Actually based on 57 "key" lakes only.

It is apparent that the headwater lakes sport-fish catch is not as great as would be anticipated from the distribution of angling participation. Indirectly evident here is the higher catch-per-unit-effort in Okanagan Lake than in any of the other lakes (except those lightly-fished headwater lakes at the highest elevations). The high catch-per-unit-effort from Okanagan Lake is mainly a reflection of the availability of kokanee. This comparison is shown in Table 19.6.

TABLE 19.6

TOTAL FISH KEPT PER ANGLING-HOUR FROM ALL LAKES IN THE OKANAGAN BASIN HARBORING SPORT-FISHING OPPORTUNITIES

LAKE(S)	Number of Lakes	Kokanee	Rainbow Trout	Other	Total
Headwater Lakes[a]	(137)	0.000	0.513[b]	0.000	0.513
Main Valley Lakes (Excluding Okanagan Lake)[c]	(5)	0.270	0.046	0.043	0.359
Okanagan Lake	(1)	1.265	0.059	0.001	1.325
Skaha Lake	(1)	0.314	0.072	0.000	0.386

[a]Based on boat-fishermen and ice-fishermen only (Weighted according to angling participation at each elevation range).

[b]Includes some brook trout.

[c]Based on boat-fishermen only.

The Okanagan Basin harbors a sport fishery of considerable value. Presently, much of the economic value associated with it is based on activities of non-resident anglers who come to the Basin primarily to fish. There appears to be an increase in non-resident participation in the fishery, but much of this is attributable to tourists who come to the Okanagan to enjoy a "package" of outdoor recreation experiences. To maximize economic benefits, improved fishery management might be linked with publicizing the resource to more serious anglers who would visit the Okanagan primarily to angle.

Future fishing patterns might be controlled through economic means such as charging for access or increasing licence fees. Such an approach would involve many political and economic implications associated with the pricing of access to public lands. As it appears likely that future sport fishery management in the Okanagan will cost considerably more than at present if projected demands are to be satisfied, the question of who shall pay will become at once both more important and more complex. Since more non-resident anglers might be attracted to the Okanagan, the region will benefit directly and indirectly through their spending. Also, improved sport fishery management not only provides a greater range of recreational opportunity for Valley residents, but also leaves them with some satisfaction that the environment is being properly cared for. In general, the Okanagan Basin residents would be the principal beneficiaries of intensified fishery management. Presently there is not an adequate financing system to apportion costs on an equal basis. It was beyond the scope of this study to attempt to fit the Okanagan Basin sport fishery into a provincial context, either economically or on a priority basis. This now becomes a function of the responsible management agency.

The capability of the headwater lakes to produce harvestable trout is heavily dependent upon artificial stocking programs. Intensification of current programs may keep the numbers of harvestable trout at a level to maintain 1971 success rates <u>on the average.</u> The margin of safety by 2020 is small (about 4%) and it may be expected that some lakes will receive extreme angling pressure within the next 10 to 15 years, if management guidelines are not formulated to spread the angler utilization more evenly among most of the 137 lakes.

Stocking requirements will reach 5.2 million fry by 2020, an increase of 3.05 times the average number presently being stocked. Current management dictates stocking of trout at about 500/1b size. In the future, consideration should be given to stocking of larger sizes (i.e. 50/lb). Specific heavy-use lakes may require "put and take" stocking of catchable size fish, as demand surpasses lake productive capacity.

The potential trout harvest capacities of tributary streams was estimated to be about 32,000 trout annually, which could be increased by about 16% by more beneficial water management. However, such changes in water management may have detrimental effects upon main valley lake spawning populations and possibly upon headwater populations. Such implications should be kept in mind in future management decisions. Despite their low absolute potentials, it is noted that stream fisheries do provide a different type of recreational experience than does lake fishing. If managers deem diversification of angling experiences valuable, then stream fisheries will warrant some special considerations.

It is evident (Figures 17.1 to 17.4) that drastic intensive management steps are going to be necessary to maintain the main valley lakes fisheries in keeping with future angling demands. The basis for all of the management requirements is a revised operation of stream discharge taking some cognizance of fishery requirements. without adequate water at critical periods and large capital investment in habitat improvements, and artificial spawning and rearing facilties, the sport fishery of the Okanagan main valley lakes is certain to steadily decline.

The basic productive capacity of the main valley lakes is more than adequate to maintain a sport fishery to 2020 at present or enhanced angler success rates. The limiting factor is reproductive habitat. Significant opportunities exist in most cases to enhance salmonid populations by improving natural reproductive habitats. In Okanagan Lake for example, potential harvests of rainbow trout and kokanee could be increased 8.0 and 2.5 times respectively if tributary discharges were modified, if specific fisheries storage were acquired and if existing habitat were improved to optimum levels.

Projected demands on Okanagan Lake can be satisfied to about the year 2000 if Mission, Trepanier and Equesis Creeks are assured of minimum required flows (by storage, modified operation or both) and if the natural spawning areas are maximally enhanced. Adequate minimum flows in all but drought years are essential prior to any full-scale enhancement program. The necessary stream water is the keystone to building a good spawning and rearing area in Okanagan tributary streams. After 2000 the tributary streams, even fully enhanced, will not supply adequate numbers of fish to the lakes to satisfy projected demands. Artificial facilities must then be depended upon.

Because of the large sizes and complex indigenous fish faunas of the main valley lakes, artificial reproductive facilities are generally less attractive than for headwater lakes. Important exceptions do exist, where potential for natural reproductive systems is meagre or lacking. Three such cases are suggested:

(a) with regard to rainbow trout in Skaha Lake,

(b) with regard to rainbow trout in Osoyoos Lake

(c) with regard to kokanee in the south end of Okanagan Lake.

A main lakes hatchery is proposed to resolve the first two problems, while an incubation channel is suggested for the third.

The Okanagan River sport fishery is dependent primarily upon sport fish populations of Skaha, Vaseux and Osoyoos Lakes. No projections of future angling demand were made, and no recommendations are made.

Sockeye salmon that spawn annually in the Okanagan River may be eliminated before the middle of the next century if current mainstem operations are continued. However, of six viable operating alternative investigated, four could cause the salmon run to increase two-fold. By a judicious combination of water quality management and better management of the commercial fishery, the contribution of the Okanagan River excapement to the commercial catch would be increased by at least two-fold.

An alternative to discharge regime improvement to benefit the salmon, is the construction of a spawning channel, which would ensure propagation of the present annual escapement at an annual cost in excess of $50,000. Although this would allow greater flexibility in river discharge operations, it is not recommended as a viable alternative at the present time.

The present analysis revealed no instances where lake carrying capacities were exceeded, or even approached, by the enhancement measures for fry production (kokanee, rainbow trout, and sockeye salmon) which were identified. This is perhaps the most significant and over-riding conclusion to emerge from the analysis, i.e. that extensive excess rearing capacity for salmonid fishes does exist in all of the Okanagan lake categories, and that this excess is particularly large for:

(a) Kokanee in all the main valley lakes,

(b) Rainbow "trout in all the main valley lakes(except perhaps Kalamalka Lake, and

(c) Rainbow (or brook) trout in headwater lakes at all elevations.

It is again emphasized that most of the data base and procedures employed in this analysis incorporated hypothetical and arbitrary elements, so that the exercise is primarily demonstrative rather than definitive. One of the major and recurrent shortcomings was the need, in the absence of data, to assume linear relationships for the various models which were developed. In fact, most of the biological inter-relationships and causes-and-effects probably have a much more complex form.

It is none-the-less proposed that the fundamental conclusions advanced are valid in general scope and principle if not in detail. A "practical" demonstration of this has been the recent successful introduction of lake trout to Kalamalka Lake (Northcote *et al* MS 1972). Present utilization of Kalamalka Lake carrying capacity by rainbow trout (the top indigenous carnivore species) is estimated to be 32%, highest among all the main valley lakes. Yet the residual excess carrying capacity (in approximately this same ecological niche) was sufficient to permit the lake trout to become firmly established. Fifteen hundred lake trout were initially stocked, at an average weight of 1 pound, in October of 1970. By the summer of 1971, lake trout in Kalamalka Lake:

(a) contributed more (by weight) to gillnet catches than kokanee and rainbow trout combined,

(b) contributed more (by weight) to angling catches than any other species,

(c) attained a mean weight of 2.3 pounds in the gillnet catch, and 2.7 pounds in the angling catch.

The general conclusion then, is that a broad productivity base exists in the waters of the Okanagan Basin, and primarily in the lakes, upon which enhancement of salmonid stocks may be undertaken in an attempt to satisfy projected angler demands. This may be accomplished by improvement of water regimes and habitat, water storage, and/or by use of artificial reproductive systems.