CARP IN MALHEUR LAKE MARSH

An Analysis of the Problem and Alternative Solutions

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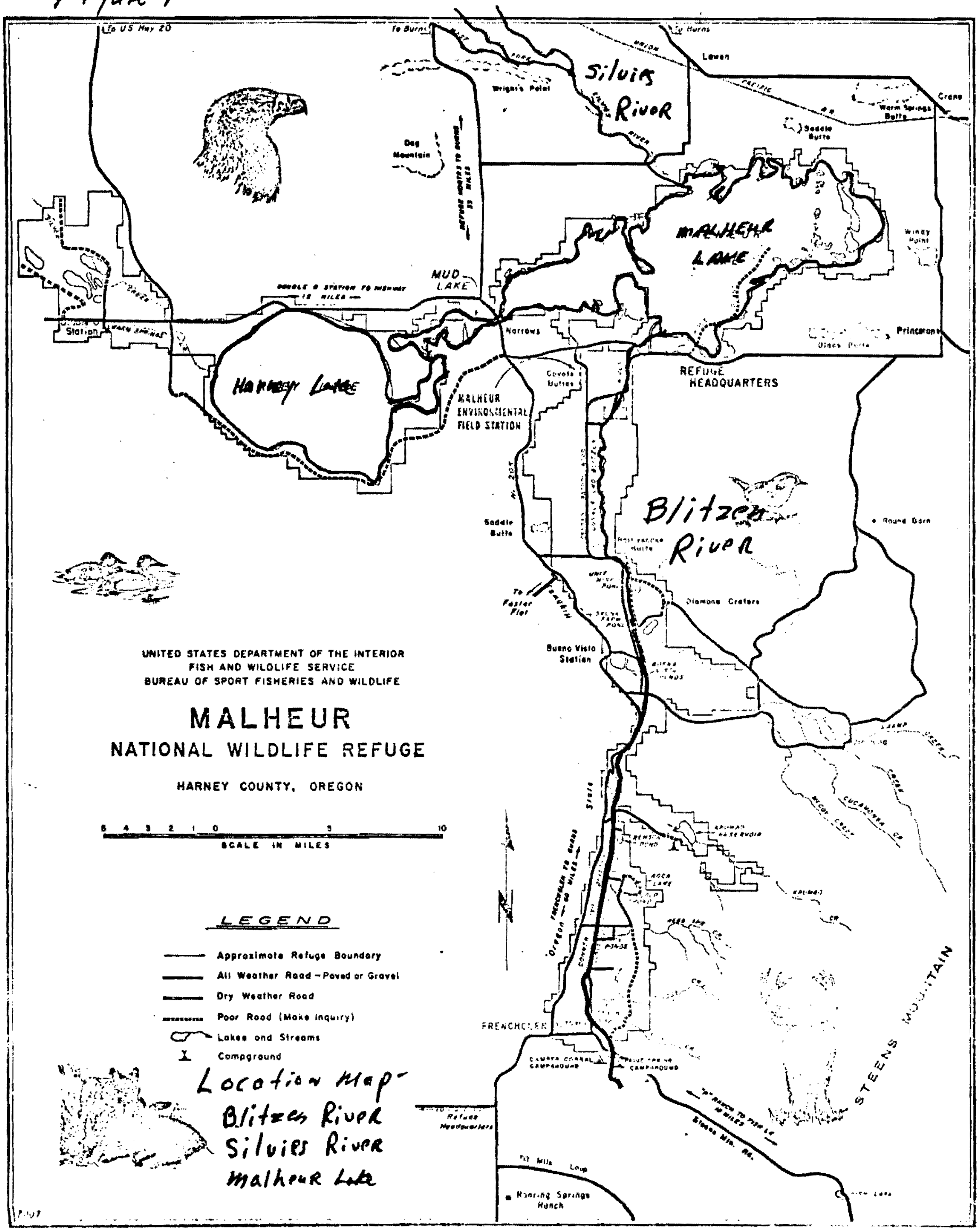
I. Introduction

The Malheur Lake is the largest fresh water marsh in western North America. The Silvies River from the Blue Mountains and the Donner und Blitzen River from the Steens Mountain find their final destination in the marsh. See figure 1.

Malheur Marsh has been important to wildlife, particularly migratory birds, since before recorded history of the area. Waterfowl have nested and raised their young on the lake, as well as resting during migration by the hundreds of thousands. Particularly famous are the nesting colonies of water and marsh birds. These included pelicans, cormorants, herons, egrets, ibis and terns. Nesting colonies of egrets were so famous that plume hunters in the late 1800's nearly eliminated them. In reaction to this, President Theodore Roosevelt in 1908 gave protective status as the Lake Malheur Reservation. Since then management of the marsh has been as a refuge. However, management has generally been limited to protection. Little physical manipulation has occurred, leaving the marsh in a near natural state.

Figure 1


To US Hwy 20
To Burns
Lawen
Crane
Silvies River
Wright's Point
Dog Mountain
Saddle Butte
Warm Springs Butte
Malheur Lake
Windy Point
Mud Lake
Narrows
Station
Princeton
Harney Lake
Refuge Headquarters
Malheur Environmental Field Station
Coyote Buttes
Blitzen River
Saddle Butte
Round Barn
Diamond Craters
Buena Vista Station
UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
MALHEUR
NATIONAL WILDLIFE REFUGE
HARNEY COUNTY, OREGON
5 4 3 2 1 0 5 10
SCALE IN MILES
LEGEND
Approximate Refuge Boundary
All Weather Road – Paved or Gravel
Dry Weather Road
Poor Road (Make inquiry)
Lakes and Streams
Campground
Frenchglen
Steens Mountain
Steens Mtn. Rd.
Roaring Springs Ranch
Location Map-
Blitzen River
Silvies River
Malheur Lake

This analysis will present historic values of the marsh, as well as documenting the detrimental effects of the carp. Specific goals in the form of use days and numbers produced will be presented as objectives to be attained through carp control. A variety of alternative solutions are given primarily to document a wide range of thoughts, Where possible, costs and benefits of a solution will be given. By discussing solutions, a list of unknown factors was compiled. These unknowns must be answered before alternative solutions can be judged. The options for collection of these data are given as well as the final recommendation.

II. Historical Role of Malheur Lake and Harney Basin

Peter Skene Ogden was the first white man to visit Malheur Lake and the Harney Basin. In 1826, he crossed eastern Oregon and stopped at Harney Lake which apparently was in a dry cycle as Indians camping on the shores of the lake were starving.

Little more was heard of the Malheur-Harney Lake area again until the 1850's. Gold miners reported well-watered valleys, grassy hills, and an abundance of game. In the mid-1860's, Charles Bendire provided the first detailed writings on the vast numbers of waterfowl and shorebirds of the Malheur Lake region. He wrote of great migrations of ducks, geese, swans, sandhill cranes, pelicans, and other birds.

There is little information on the exact population numbers in the late 1800's and early 1900's. However, early naturalists raved about the great numbers and flocks of waterfowl and marsh birds that frequented the area. In 1908, President Theodore Roosevelt established the Lake Malheur reservation primarily to protect the colonial nesting birds from plume hunters.

Early reports from game wardens and biologists told of the tremendous flights of birds during migration and of the large numbers of waterfowl and other marsh birds that were produced on Malheur Lake in the early 1900's. With the drought of the 1930's, conservationists recognized the importance of water for the wildlife of Malheur Lake so the Blitzen Valley was purchased to protect the major water supply.

Malheur National Wildlife Refuge has continued to be an important resting and production area for waterfowl, especially as the intensity of land use has increased throughout the Pacific Flyway. Of course, marsh and water birds are now limited to the remaining marshes, such as Malheur Lake, which have been preserved from drainage and development.

Duebbert (1969) indicated that Malheur Lake is one of the outstanding aquatic habitats in the western United States. Jenson and Chattin (1964) said that Malheur, Tule Lake-Klamath, Summer Lake, Stillwater, and the Great Salt Lake units produce more than 200 thousand young ducks annually which is more than two-thirds of the production from all western marshes managed by State and Federal conservation agencies. During fall migration, a significant percentage of the Pacific Flyway waterfowl population may stop at Malheur as indicated in Table 1.

The most recent information on Malheur Refuge's role in the Pacific Flyway was gathered by Chattin and Smith (personal communication) in 1975. They indicated Malheur NWR is the most important refuge in Region One in terms of waterfowl production and water-oriented birds. They said that Malheur annually produces approximately one half of the ducks and geese raised on Oregon's National Wildlife Refuges. Chattin and Smith also indicated Malheur produces the following percentages of birds produced on National Wildlife Refuges in Region One.

Trumpeter Swan	33 percent
Grebe	28 percent
Greater Egret	84 percent
Snowy Egret	55 percent
Black-crowned Night Heron	69 percent
White-faced Ibis	64 percent

It would seem imperative from the population data gathered that Malheur Refuge and especially Malheur Lake must be managed to provide optimum habitat conditions for wildlife production. Malheur's influence on the Pacific Flyway populations is significant and will become of greater importance as expanding land development reduces other remaining wildlife habitat.

Pacific Flyway Winter Waterfowl Survey Numbers
for Swans in Relation to Peak Fall Numbers
of Swans on Malheur NWR

Year	Flyway Swan Numbers (thousands)	Refuge Fall Peak Swan Numbers (thousands)	Fall Peak Percentage of Winter Numbers
1955	46	1	2.2
1956	43	9	20.9
1957	50	18	36.0
1958	40	2	5.0
1959	36	1	2.8
1960	41	3	7.3
1961	33	(200 - actual)	0.6
1962	46	1	2.2
1963	30	2	6.7
1964	43	3	7.0
1965	37	6	16.2
1966	49	8	16.3
1967	49	13	26.5
1968	75	2	2.7
1969	31	14	45.2
1970	99	15	15.2
1971	83	11	13.2
1972	34	16	47.1
1973	70	3	4.3
1974	54	5	9.3
1975			

Pacific Flyway Winter Waterfowl Survey Numbers for Canvasbacks in Relation to Peak Fall Canvasback Numbers on Malheur NWR

Year	Flyway Canvasback Numbers (thousands)	Refuge Fall Peak Canvasback Numbers (thousands	Fall Peak Percentage of Winter Numbers
1955	59	2	3.4
1956	155	82	52.9
1957	142	153	-
1958	109	10	9.2
1959	51	1	1.2
1960	57	9	15.8
1961	45	(400 - actual)	0.9
1962	101	(300 - actual)	0.3
1963	81	2	2.4
1964	55	1	1.8
1965	46	23	50.0
1966	78	7	9.0
1967	70	13	18.6
1968	67	1	1.5
1969	63	15	23.8
1970	49	21	42.9
1971	51	31	60.8
1972	55	15	27.3
1973	83	1	1.2
1974	79	1	1.3

Pacific Flyway Winter Waterfowl Survey Numbers
for Ducks in Relation to Peak Fall Numbers
of Ducks on Malheur NWR

Year	Flyway Duck Numbers (millions)	Refuge Fall Peak Duck Numbers (thousands)	Fall Peak Percentage of Winter Numbers
1955	7.4	124	1.7
1956	6.6	448	6.8
1957	8.6	617	7.2
1958	9.4	154	1.6
1959	7.7	182	2.4
1960	7.7	174	2.3
1961	7.4	34	0.5
1962	8.1	78	1.0
1963	7.6	151	2.0
1964	8.0	286	3.6
1965	5.9	374	6.3
1966	6.3	265	4.2
1967	5.6	194	3.5
1968	5.6	63	1.1
1969	7.9	99	1.3
1970	9.0	101	1.1
1971	8.6	183	2.1
1972	7.8	145	1.9
1973	7.4	90	1.2
1974	8.5	58	0.7

Table 1

Malheur NWR's Peak Fall Numbers Expressed as
Percent of Pacific Flyway Wintering Population Numbers

	Percent of Winter Flyway Numbers on Refuge During Fall Peak		
Year	Ducks	Swans	Canvasbacks
1955	2.2	1.7	3.4
1956	20.9	6.8	52.9
1957	36.0	7.2	100.0+
1958	5.0	1.6	9.2
1959	2.8	2.4	1.2
1960	7.3	2.3	5.8
1961	0.6	0.5	0.9
1962	2.2	1.0	0.3
1963	6.7	2.0	2.4
1964	7.0	3.6	1.8
1965	16.2	6.3	50.0
1966	7.0	4.2	9.0
1967	26.5	3.5	18.6
1968	2.7	1.1	1.5
1969	45.2	1.3	23.8
1970	15.2	1.1	42.9
1971	13.2	2.1	60.8
1972	47.1	1.9	27.3
1973	4.3	1.2	1.2
1974	9.3	0.7	1.3

III. History of Carp and Carp Control in the Harney Basin

Carp were initially introduced to the Harney Basin as a food fish in the late 1800's, but not until the early 1920's were carp noted in the Silvies River system north of Malheur Lake. Carp numbers increased within this system, but were not evident in the marsh until the late 1930's and early forties. Carp reproduction and their subsequent buildup of numbers in Malheur Lake were apparently limited for some unknown reason until the late forties and early fifties (McLaury, 1968). Extremely high discharge rates of the Silvies River occurred during April of 1952 and this could very possibly have flushed large numbers of brood carp into the marsh at this time (Marshall, 1957). A definite buildup in the carp population following 1952 was evident to refuge personnel. The early 1950's saw a rapid increase in carp numbers and an inverse relationship in waterfowl use during fall migration. Waterfowl use on Malheur Lake dropped from 39,833,000 use-days in 1952 to 5,430,000 use-days in 1955 for the September-December period (Marshall, 1957).

During 1955 carp were so abundant that very little aquatic food (principally sago pondweed (*Potomogeton pectinatus*)) was produced for waterfowl, although Malheur Lake contained approximately 12,000 surface acres of water. This prompted the first control program for carp within the Harney Basin in the fall of 1955.

The carp eradication program in 1955 was on a massive scale that involved toxicant applications to the Blitzen and Silvies River system as well as the 12,000 acres of Malheur Lake and 700 acres of Boca Lake (Marshall, 1960).

The total cost for the project was $37,650, of which 79% went toward 7,427 gallons of Pro-noxfish (Rotenone) fish toxicant. The application of Rotenone took approximately 2 1/2 weeks with an estimated kill of 1,500,000 carp. However, carp were not totally eradicated and biologists estimated that at least 2,000 carp survived and spawned successfully in the marsh during 1956 (Marshall, 1957).

With the subsequent elimination of major carp numbers within the Malheur Lake system and the increase of water levels, which in turn covered thousands of acres of aerated marshland in 1956, a tremendous response in desirable aquatic vegetation resulted. Over 20,000 acres of Malheur marsh were vast sago pondweed beds. This in turn affected waterfowl use, which rose to 42,860,000 use-days for the September-December period as compared to 5,430,000 use-days during the same period in 1955 (Marshall, 1957).

However, this sudden vigorous condition of the marsh was short-lived. Enough of the carp breeding stock remained to reproduce and start repopulating the system. During 1957 and 1958, marsh water levels remained high (60,000 acres $\pm$) and carp numbers had increased until a substantial population was present. Turbidity increased and sago production along with waterfowl production and use decreased rapidly.

The dry winter of 1958-1959 resulted in low lake levels during the summer of 1959. Less than a thousand acres of sago was estimated, carp were abundant and the water was extremely turbid. A spot control using Rotenone was initiated on the display pond and the lower 16 miles of the Blitzen River; approximately 58,000 carp were poisoned (Marshall, 1960).

Another low water year in 1959-1960 caused the lake level, in the fall of 1960, to drop to 4,000 acres. This extreme low water condition, together with an almost total lack of new submergent plant growth, resulted in a sharp reduction in waterfowl use, and also forced a concentration of the carp population into the lower Blitzen River. A control program was implemented on the river and drip stations of Rotenone positioned at Witzel Bridge, 40 miles upstream from Malheur Lake. Approximately 200,000 carp were eliminated in the first treatment, with an additional 200,000 killed in the second treatment. Total kill was estimated at 400,000 to 500,000 carp. Due to the concentrations of fish in the treatment area, the project proved very economical with $423 spent for Rotenone (105 gallons) and approximately 80 man-hours of work. This control was imcomplete and many carp escaped or recovered from treatment, with 500-1,000 carp seen spawning along the Cole Island dike in April, 1961 (Marshall, 1960).

Low water conditions prevailed into the summer of 1961 and Malheur Lake had evaporated to only 600-650 acres by early July. Rotenone was again applied to the system from Bridge Creek downstream and to the remaining pool of Malheur Lake. During the 10-day operation, an estimated 150,000 carp were poisoned. Females predominated in the kill and were all heavy with eggs. This control was thought to be much more successful than the 1955 operation (12,000+ lake acres treated) since treatment involved much smaller acreages. An estimated 50 carp survived the treatment program (Narrative Report, 1961).

Over the next few years, carp numbers remained low. Lake water levels increased to 20,000 acres in 1963 and were 60,000+ acres by 1965.

Increases in carp numbers were also noted in 1965. By 1967, the carp population was increasing rapidly, sago production and waterfowl production on the marsh decreased.

Again evidence of a large carp population existed in the Blitzen River and Malheur Lake. Marsh waters were extremely turbid during the summer of 1968. Only 100 acres of sago pondweed were estimated. The spring peak of Malheur Lakes's 19,000 acres receded during the ensuing months to approximately 3,500 acres in September, 1968. Another control program was initiated using some 850 gallons of Rotenone. Approximately 59 miles of flowing water (19 drip stations) and

950 acres of Malheur Lake were treated. Due to the limited amount of chemical, only carp concentration areas on the lake were treated. An estimated 190,000-240,000 carp were removed, 100,000-150,000 of these being poisoned in Malheur Lake. Total cost of the operation was $5,254, 67% of this went toward purchasing the toxicant (McLaury, 1968).

Spot control in the summer of 1969 continued in the Blitzen Valley sloughs and ditches. The Blitzen River had 215 gallons of Rotenone metered by 10 drip stations from 5-mile bridge to Malheur Lake.

The water levels in Malheur Lake increased from 3,500 acres in 1968 upward through the early 1970's, to the present. Carp numbers also remained high during the 1970's, despite the control effort of the late 1968-69. Waterfowl production and sago production increased steadily through 1971 in correlation with the increasing acreages of Malheur Lake. The carp population became increasingly abundant and despite the additional water habitat provided by Malheur Lake after 1971, waterfowl and sago production began steadily dropping due to the influence of high carp numbers. Waterfowl production on Malheur Lake had dropped from a 1971 high of 19,300 (record high in waterfowl production for Malheur Lake since carp control was initiated in 1955) to an estimated 5,500 birds produced in 1973 due to this loss of vigor in the Malheur marsh system. The lake levels have remained high through 1975, covering over 55,000 acres. Waterfowl production dropped to 3,674.

Some control techniques were experimented with during the summer and fall months of 1975. An attempt was made to determine whether carp moved into the Blitzen River from Malheur Lake late in summer, or if they could be baited into the river. Drip stations of Rotenone treated the Blitzen River from Sodhouse Dam to Malheur Lake in July. Approximately 50,000 carp (38,000 of which were young-of-the-year) were eliminated from the river system. Sour mash barley was used as bait in the river in hopes of attracting carp from the lake. The lower section of the river from Kado Bridge to the mouth was retreated in September. Only 1,400 fish were killed (500 adult carp, 400 young-of-the-year carp, 500 bluegill). It appears that significant numbers of carp do not run up into the Blitzen River late in summer to the cooler water.

Bait sites were also established in the lake near the mouth of the Blitzen River. Granular antimycin is supposed to have an advantage in that carp cannot detect its presence. At least a few carp were known to be in the area, but after treatment with antimycin no dead ones were found.

Limited baiting and trapping was attempted at the Double - O area. Some carp were attracted to sour barley bait stations in traps on main canals. This technique may have some application for limited control.

Hopefully, more precise data will be collected in the near future on carp interactions on the Malheur marsh ecosystem. Total eradication is not the answer as can be readily seen from earlier control programs (table 2). Carp are too environmentally adaptive to be totally controlled in large systems such as Malheur Lake.

Table 2

CARP CONTROL - MALHEUR NWR

Control Years	Area of Control	Numbers Poisoned	Ave. Wt/Ave. L.	Cost	Lake Size
*Fall 1955	Blitzen & Silvies R., Malheur Lake, Boca Lk.	1,500,000	5.5 lbs./21.5 inches	$37,650	12,000 Ac.
Summer 1959	Lower Blitzen River, Display Pond	58,000	1.6 lbs./12.8 inches		
Fall 1960	Lower Blitzen River (Witzel Lane to Lake)	400,000-500,000	4.5 lbs./20.7 inches	$423+ 80 Man Hours	4,000 Ac.
*Summer 1961	Lower Blitzen River (Bridge Creek to Lake) Malheur Lake	150,000	8.5 lbs./26.0 inches		600-650 Ac.
*Summer 1968	Blitzen River Malheur Lake	190,000-240,000	7.5 lbs./22.5 inches	$5,254	3,500 Ac.
Summer 1969	Blitzen River (5-Mi.-Lk.) Spot Control Blitzen Valley	Several thousand young-of-year	Small		6,800 Ac.
Summer 1974	Display Pond - YCC Project	6,000	---		
Summer 1975 Fall	Experimental Control Lower Blitzen River (Sodhouse to Lake)	50,000 (38,000 were young-of-year)	.8 lbs./10.4 inches		
	Double O Springs				

* - Control on Malheur Lake

Literature Cited - Section II

Carp Control Files - Malheur NWR

1. Carp Control Program

   E. L. McLaury, 1968

2. Carp Control Program at Malheur Lake, Oregon

   D. Marshall, 1957

3. Carp Control Writeup (1955-1960)

   D. Marshall, 1960

4. Narrative Report, 1961

5. Experimental Carp Control - Memo, 1975

   L. Napier, 1975

6. The Ecology of Malheur Lake and Management Implications

   Harold F. Duebbert, 1969

7. Waterfowl Tomorrow

   G. Hortin Jensen and John E. Chattin, 1964

IV. Impact of Carp on the Ecology of Malheur Lake and Its Wildlife Values

A. Introduction

The effects of carp on aquatic systems have been noted since their introduction to this country in the late 1800's. The carp's tremendous fecundity (up to 2,000,000+ eggs) and habit of rooting along soft bottoms ejecting unwanted material makes it most damaging to a complex marsh ecosystem such as Malheur Lake. In years of good run-off when marsh levels are relatively high, high photosynthetic rates are necessary to maintain vigor throughout the marsh system. With the introduction of carp, this essential mechanism is severely hampered due to water turbidity caused by their activities. Invertebrates (insects, crustaceans, annelids, protozoans, and mollusks) are regularly eaten by carp and are the major food source for young-of-the-year (Carp in Canada, 1968). The foraging of carp on both vegetable and animal matter puts them in direct competition with marsh wildlife.

Basic interrelationships of the many elements that comprise a marsh system are just beginning to be understood. The effects of an extraneous influence such as carp on a system like Malheur's complicates things further. The direct and indirect effects of carp in abundance on Malheur Lake reflects visible changes in productivity on a massive scale throughout the system. Data on these effects are present in terms of resource information collected through the years by the refuge in monitoring marsh habitat (water acreages, aquatic plant acreages, wildlife use and production estimates). The information brought forth in this discussion portrays basic trends and lends one to speculate as to what is actually transpiring within Malheur Lake in regards to its loss of productivity and what part carp play in this problem.

Attached graphs and tables were compiled from refuge data, primarily narrative reports and filed biological data. The graphs show various types of wildlife use and production compared to maximum marsh levels and sago pondweed acreages by years. Maximum marsh levels were the only consistent acreage figures available and sago pondweed estimates included a certain percentage of other pondweeds and submergents (samples of beds yielded approximately 85% plus sago pondweed, McLaury, 1971). Malheur Lake is referred to as a marsh due to its characteristics (Inland Deep Fresh Marsh Classification, Duebbert, 1969).

B. <u>Malheur Lake Prior to 1955</u>

During the mid-1940's, Malheur Lake was in one of its most productive states. Carp had not yet invaded the marsh in any discernable numbers and water levels remained high after the drought years of the 1930's. Waterfowl production within the marsh soared. Precise production information for Malheur Lake's units is unavailable, but total refuge diver production (principally redhead, ruddy and canvasback) during the period 1946-48 was in excess of 95,000 ducks produced. Diver production and use occurred primarily on Malheur Lake. Total waterfowl production for the marsh can be safely assumed to have been over 30,000 ducks produced on certain years, well over the total production of ducks on the refuge today (approximately 18,000). Fish-eating birds also fared well during this period with production records of over 5,000 birds produced during the years 1948-1949. These levels have yet to be exceeded in recent times.

Fall peak populations were equally impressive with populations of over 300,000 plus ducks from 1940-1953, with a peak of over 700,000 migrants in the fall-winter period of 1948. Lake levels during the mid-late 1940's remained relatively high, ranging from 50,000 to 60,000 acres.

It was during this period that carp numbers were becoming numerous within the lower Silvies River system and probably a limited population occurred within Malheur Lake. Marshall, 1957, surmised that through the lack of young age classes (0-2 years) and 7 year+ age classes in carp eradicated during the 1955 control, that some event took place which caused a sudden accumulation of carp in Malheur Lake in the early 1950's. He suggested that high discharge rates during April of 1952 flushed large numbers of brood age carp into Malheur Lake from the Silvies River. In subsequent years after 1950, carp numbers became increasingly apparent to refuge personnel.

The buildup of carp within the marsh was a slow process initially. Waterfowl use and production remained high; during 1949-1954, the average breeding population for Malheur, Harney, and Mud Lakes was estimated at 9,890 ducks and geese, producing an estimated 19,000 young to flight stage. The average annual waterfowl use/days during this period was estimated at 63,000,000 (Marshall, 1957).

Marsh size remained in excess of 40,000 acres through 1954. By 1955, carp numbers could be classed as abundant and their activities created such a turbidity problem that desirable aquatics were eliminated (Duebbert, 1969). The abundance of carp in probable conjunction with the fact that the marsh had had peak water levels in excess of 40,000 acres for the last 14 years (1941-11954) severely taxed the productivity of the marsh due to the activities of carp, plus lack of bottom aeration, and production plummeted in 1955. This prompted the first control program for carp on Malheur Lake (Section II and Table 1).

C. <u>Waterfowl-Sago Relationships</u>

Waterfowl production and use are linked closely with the size of the annual crops of desirable aquatics. These submergent crops are a function of the marsh's productivity. This correlation can easily be seen when graphed, but it is most striking when one looks at sago pondweed production as related to a duck that uses it extensively, such as the canvasback.

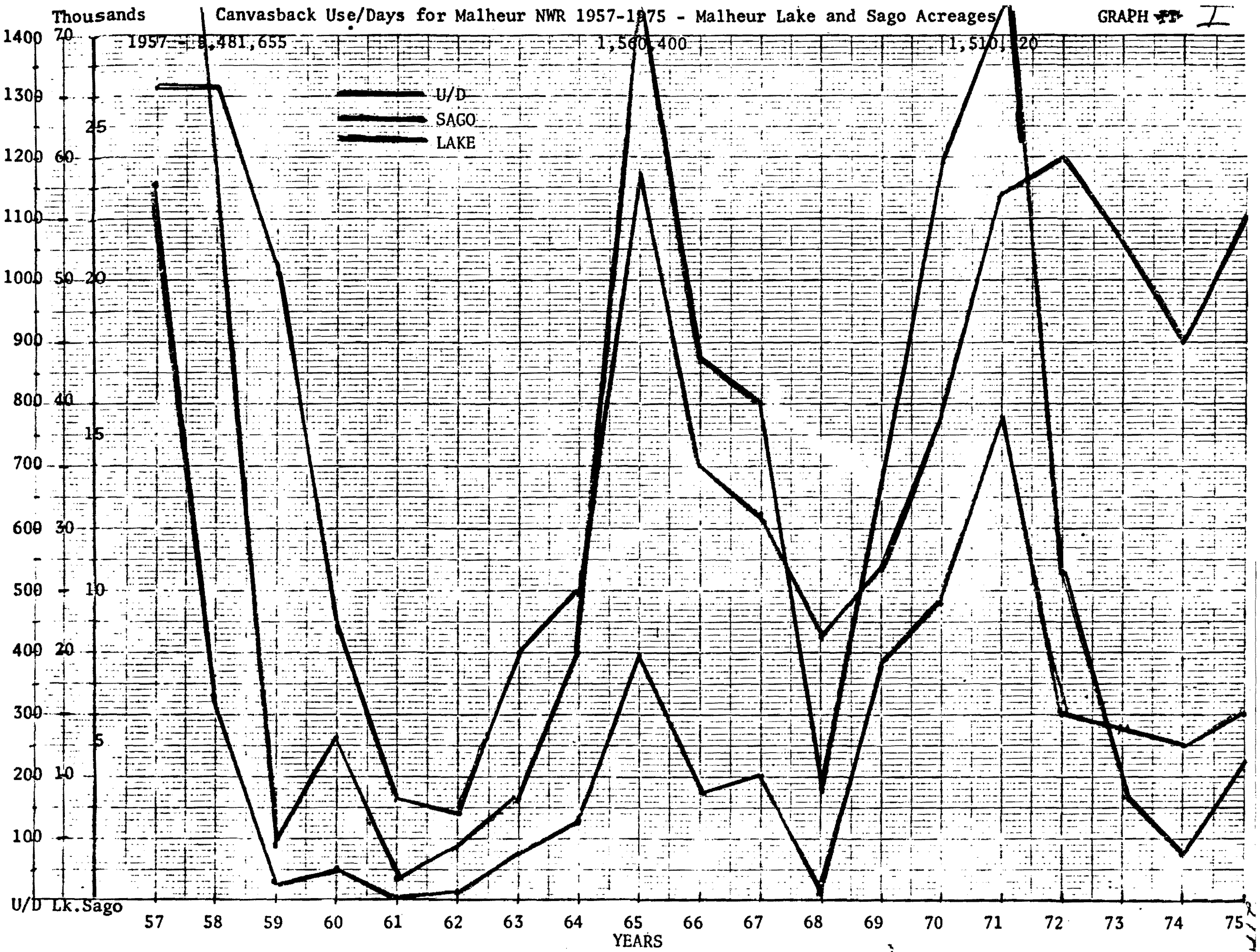
1. <u>Canvasback Use</u>

Over 90% of the total refuge canvasback use occurs on Malheur Lake (McLaury, 1971). Canvasback use soared in response to high sago acreage during 1957, 1965, and 1971 (graph I). A record 5,000,000 use-days were recorded in 1957 in response to the 23,000 acres of sago that blossomed two years following carp control. Three years after the 1968 carp control, sago acreages had increased to 15,000 acres (exceeded only in 1957) and canvasback use soared that fall and winter (1,500,000 use-days) despite early freezeup conditions during that October of 1971.

By 1974, canvasback use on Malheur Lake had dropped severely (72,200 use-days), due to poor sago production (5,000 ac.), despite the marsh size of 45,000 acres. The above fluctuations in use for canvasbacks can easily be understood since the fall diet of canvasbacks consists of 97% vegetable matter (Martin, 1951), sago being the preferred food source at Malheur.

2. <u>Swan Use</u>

Swan use, primarily whistling swan, on Malheur Lake is also tied closely to submergent production. During the period 1965-69, approximately 70% of the total refuge swan use was on Mlaheur Lake (McLaury, 1971). Whistling swan use occurs primarily on the 18,400 acres of



Thousands
Canvasback Use/Days for Malheur NWR 1957-1975 - Malheur Lake and Sago Acreages
GRAPH I
1957 - 1,481,655
1,560,400
1,510,120
U/D
SAGO
LAKE
1400 70
1300
25
1200 60
1100
1000 50 20
900
800 40
15
700
600 30
500 10
400 20
300
5
200 10
100
U/D Lk. Sago
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
YEARS

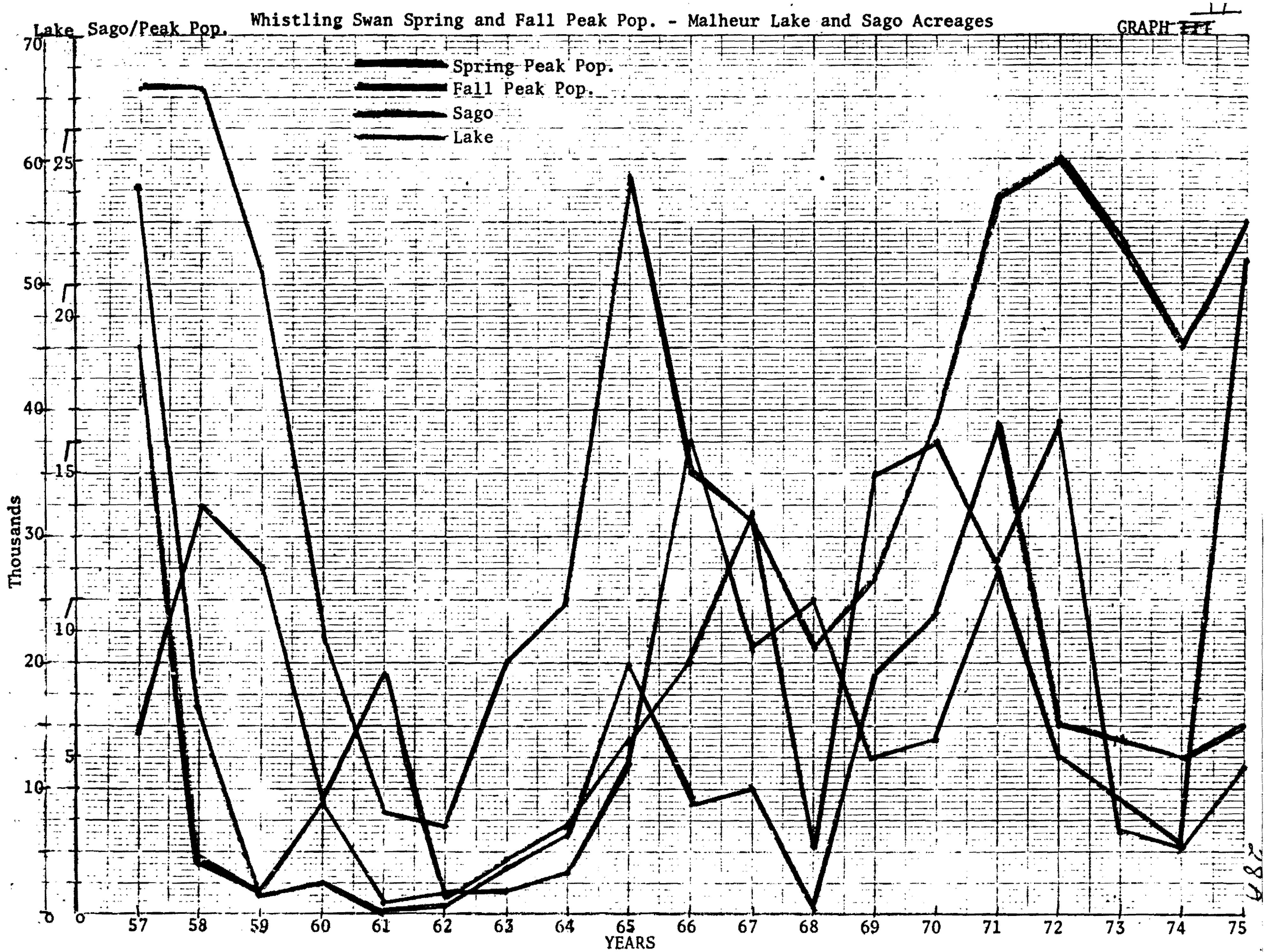
Unit 6, where large open-water tracts in conjunction with dense sago pondweed beds provide optimum habitat for migrant swans during both spring and fall periods.

Fall swan use follows the same basic pattern as canvasbacks, but is not as graphic (graph II). A deviation from the norm occurred during the spring of 1975. Spring swan use increased tremendously (highest numbers since 1945), but sago production was considered only fair. Spring came late during 1975 and this could possibly explain this buildup of transient swans. The whistlers arrived on schedule at the refuge, but delayed further movements north until weather permitted, staging up in large numbers on Malheur Lake.

Spring use by swans correlates well with sago production, but has a staggered effect when graphed due to the need of spring migrants to forage on the previous year's rhizone and tuber production. Thus, when sago peaked in 1965, the following spring brought a sharp increase in swan use, up 220% over spring, 1965.

3. Duck Use and Production

Approximately 70% of the 1965-1969 refuge duck use-days occurred on Malheur Lake (McLaury, 1971). Total duck use on the marsh is directly related to submergent plant crops, but not necessarily to marsh size. In recent years, marsh acreages have remained high, but as aquatic crops decreased after 1971, corresponding reductions in duck



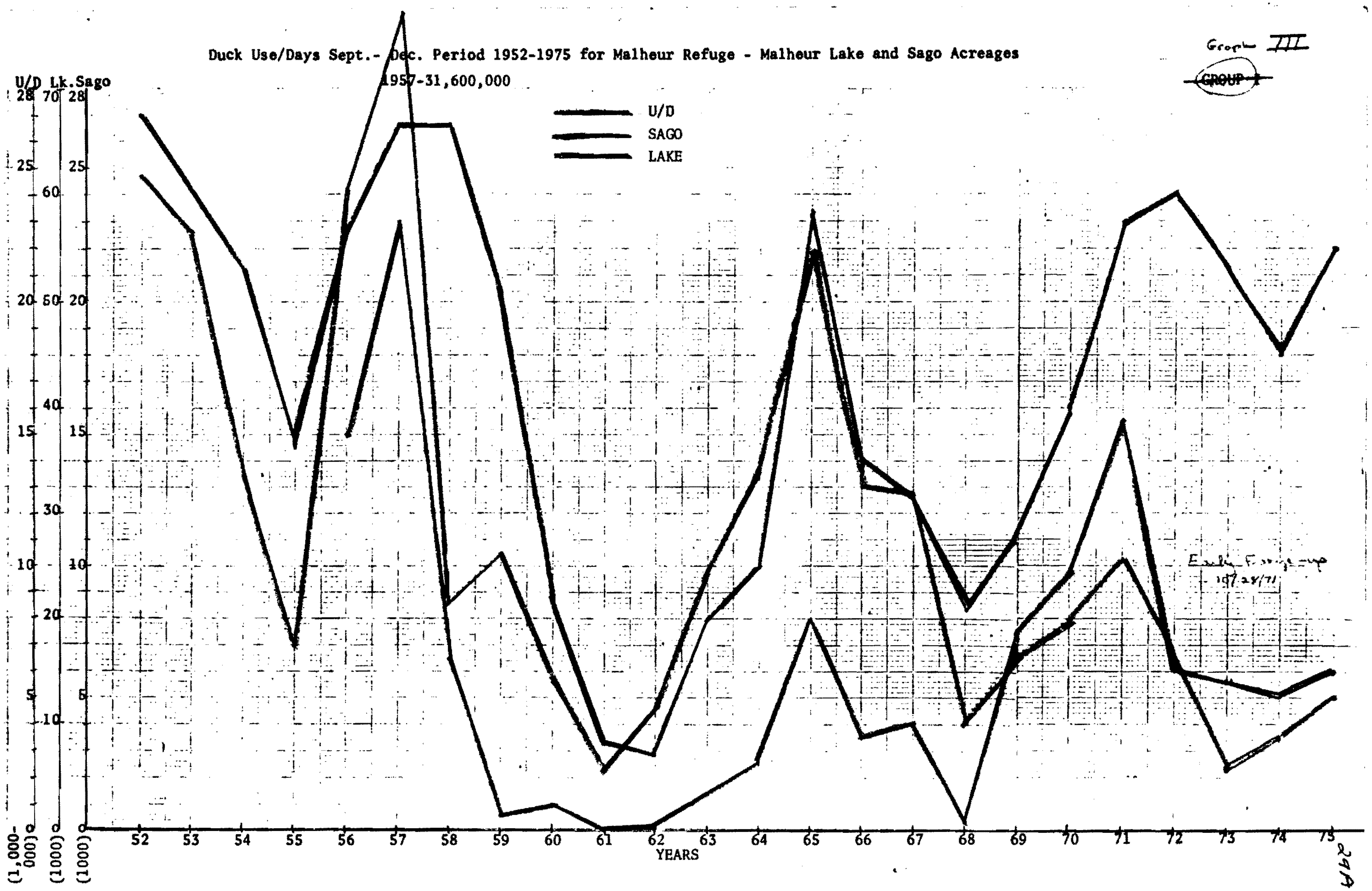
Lake Sago/Peak Pop.
Whistling Swan Spring and Fall Peak Pop. - Malheur Lake and Sago Acreages
GRAPH
Spring Peak Pop.
Fall Peak Pop.
Sago
Lake
Thousands
YEARS
57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75

use (consistently below 7,000,000 use-days) on the marsh resulted (graph III).

Waterfowl production also correlates well with sago production (graph IV), due primarily to the fact that increased submergents reflect the relative productivity of the marsh. Those sections of the marsh that maintain abundant aquatics, in turn provide excellent habitat for a myriad of invertebrate life. The importance of invertebrates to nesting waterfowl, both puddlers and divers, is well documented and is a vital element for breeding pairs, especially hens and young ducklings, in terms of their consumption as high protein foods.

D. Carp-Sago Relationships

Prior to 1955, Malheur Lake maintained its productive state by following its natural cycle of high and low water periods. Years of drought or low runoff allowed aeration of mud bottoms over large segments of the marsh. The resulting gaseous exchange with the atmosphere and the subsequent decomposition of animal and plant matter recharged the system releasing the needed nutrient elements required to produce a productive environment. Subsequent reflooding sets this productive cycle in motion and is still occurring today in those areas of Malheur Lake that periodically dry up. Carp primarily have an adverse effect on water quality, aquatic plants and invertebrates during the high water periods.



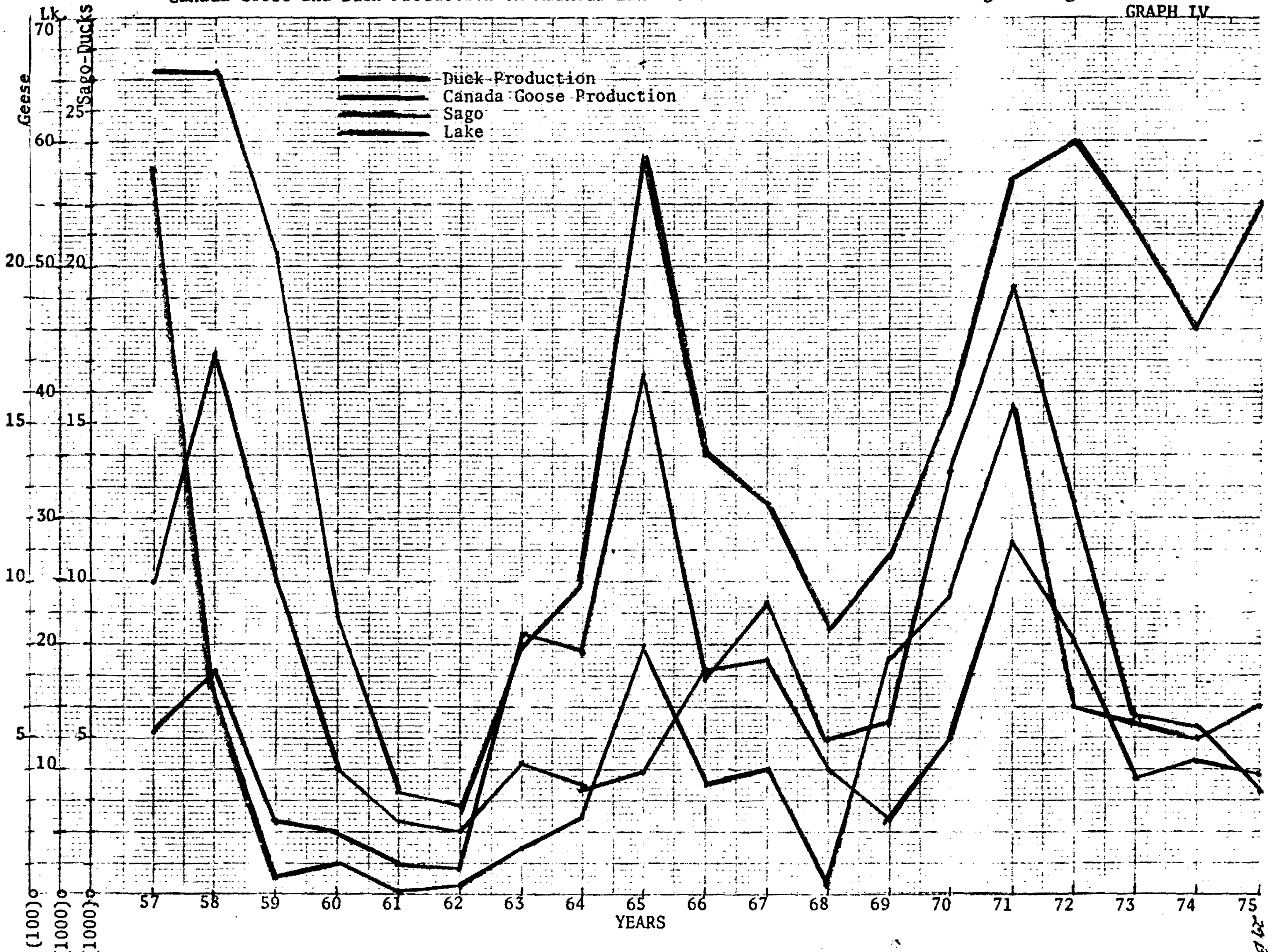
Graph III

~~GROUP I~~

29A

Canada Goose and Duck Production on Malheur Lake 1957-1975 - Malheur Lake and Sago Acreages

GRAPH IV



Carp, even in moderate numbers, have a definite impact on the marsh, and in abundance, void large sections of the Malheur Lake of aquatic plants and animals. The decade prior to 1955 saw Malheur Lake relatively free of carp and was not only a most productive period for marsh wildlife, but maintained high water levels (40,000 +) as well. With the present situation, the productive period during high water years has been reduced as low as 2-3 years depending on carp reproduction. Sections of the marsh, such as Unit 5 (center section - 23,200 ac.), due to its depth, rarely dry up and in recent years have been poor in producing wildlife benefits, with the exception of fish-eating colonial nesters. During years of drawdown, such as in 1968, portions of this unit went dry. Carp were also controlled in 1968. The following spring saw a tremendous increase in sago from 100 acres estimated in 1968 to 7,600 acres in 1969, increasing to a peak in 1971 of 15,000 acres. Water quality was greatly improved with aeration and major carp removal, with the resulting effect of sago being produced in the majority of open-water areas of Unit 5 (McLaury, 1975). Plant beds were so dense that hunters had difficulty maneuvering their boats during the fall hunting season (McLaury, personal communication).

This clearly demonstrates the productive potential in such a system, and also the enormous recuperative powers of sago pondweed. A single plant of sago in 6 month's time can develop over 36,000 tubers and 63,000 seeds (Yeo, 1965). With this potential in mind and keeping in account the key role submergents play in waterfowl use and production, one can readily see the value of Malheur marsh in a productive state.

E. Fish-eating Bird-Carp Relationships

1. White Pelican Use

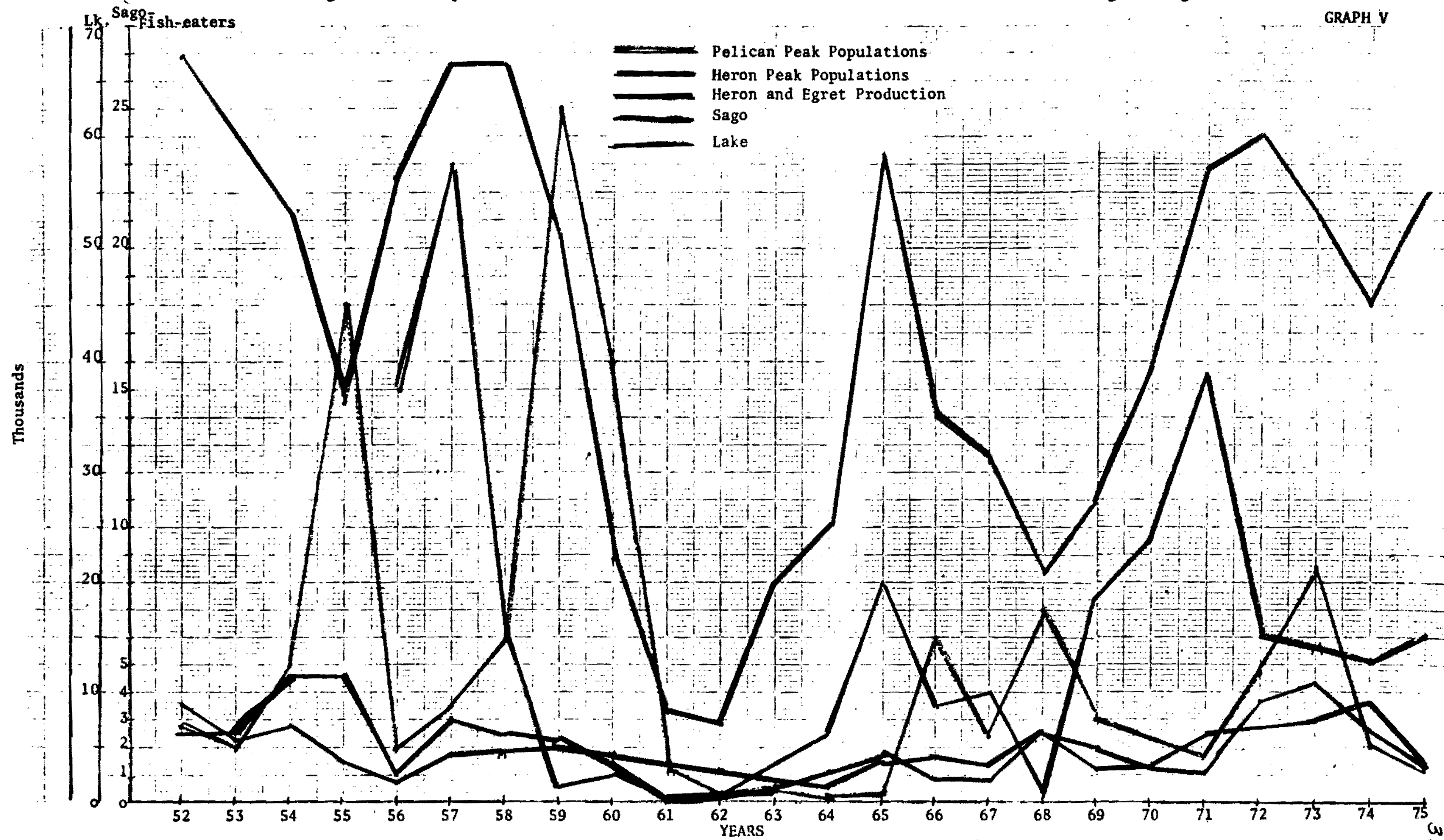
Peak populations of white pelicans occur at Malheur during the summer months and have fluctuated greatly during the last 25 years. The pelican's food source is almost solely fish and this determines their relative numbers and distribution.

Graph V depicts a definite relationship between pelican use and relative carp numbers. Another way to look at it would be to say that peak pelican populations demonstrate an inverse relationship to sago pondweed acreages. The quantity of pondweed being an indicator of relative carp numbers (graph V). During 1959, white pelicans peaked at a record of 25,000 birds. Abundant numbers of carp attracted these birds to the marsh just prior to carp control efforts in 1960 and 1961. Sago production was estimated at only 500 acres. The year following carp control in 1962, pelican use plummeted to a population peak of 200. The attractiveness of large fish populations to pelicans is well defined.

Water levels also determine, to a great extent, peak use periods. Years of low water levels concentrate the carp and result in high

Fish-eating Bird Peak Populations and Production for Malheur Lake 1952-1975 - Malheur Lake and Sago Acreages

GRAPH V



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pelican use. During the summer of 1968, marsh acreages receded from 20,000 acres to a September low of 3,500 acreages. The abundant carp population was concentrated and pelican use of Malheur Lake increased correspondingly from 2,300 peak in 1967 to 7,000 pelicans in 1968. High pelican use is not totally dependent on low marsh levels, but rather forage fish numbers. Years of high water with abundant carp numbers had excellent pelican use, such as in 1959.

2. <u>Heron and Egret Use and Production</u>

Malheur Lake's colonial nesting herons and egrets along with pelicans comprise a major segment of the fish-eating bird population on the marsh. Small fish are used extensively by herons and egrets, with the larger species such as great blue herons, consuming larger sized fish. Smaller species such as black-crowned night herons and snowy egrets frequently utilize various aquatic invertebrates such as crustaceans and insects. Small frogs and other marsh vertebrates are taken when available by all herons and egrets (Martin, 1951).

Availability of food and relative fish size are important to the productive status of these birds. Abundant numbers of carp in old age classes would preclude the colonial nesting species from obtaining adequate food supplies. High carp populations would also eliminate alternate food sources of aquatic invertebrates and vertebrates, directly through foraging or indirectly through degradation of the environment.

Prior to 1950, production levels for herons, egrets, and grebes were higher than today. This was during a period when carp were not yet a problem and substantiates the point that a productive marsh environment will provide the necessary production elements not only for Malheur's colonial nesters, but all marsh and shorebirds that utilize the system.

F. Summary - Discussion

The effect of carp on Malheur Lake is a definite and readily visible impact, but is not totally autonomous. The Malheur Lake system is extremely complex and interactions between the other marsh ingredients may be part of the underlying productivity problem (pH levels, dissolved O_2, chemical interactions, emergent encroachment, water level fluctuations, etc.).

One relationship stands out and that is the important role desirable submergent growth, such as sago pondweed, has on wildlife use and production. The preceding discussions exemplified this many times over.

Sago pondweed is a mandatory element in the canvasbacks and swans use pattern at Malheur. It also provides the necessary food elements such as invertebrate proteins for pre-breeding and post-breeding maintenance, such as brood rearing.

In addition, many marsh birds and some shorebirds benefit due to the abundance of invertebrates associated with submergent growth. Water clarity affects the necessary photosynthetic rates for plant growth and the necessary dissolved oxygen levels to sustain animal life.

The foraging and roiling effects of carp are totally counterproductive to the marsh, except in terms of producing more carp. Their total eradication is not feasible, a carp maintenance program on some lower population level would be the next best approach. The alternative methods to achieve this are discussed in Section VI.

Carp reduction in Malheur Lake would affect wildlife use in the following ways.

Sago pondweed would extend its present growth area due to increased water clarity and quality. A subsequent increase in invertebrate life would reflect increases in waterfowl use and production and marsh and shorebird use.

The effects of a smaller population of carp on fish-eaters such as pelicans would result in a probable decrease to some static use level.

Colonial nesters, such as herons and egrets, would remain productive. Their primary forage source of carp would still be present in reduced numbers in addition to a probable presence of other small fish species such as centrachids, dace, roach, and shiner resulting from improved water quality and vacated habitat. This is in addition to the diversity of invertebrate life a productive marsh can provide.

Malheur Lake due to its vastness has tremendous potential. Hopefully through some concerted effort in the near future, its productivity can be improved to respectable levels.

Literature Cited - Section Vi

1. Carp in Canada, Bulletin 165
Fisheries Research Board of Canada, Ottawa, 1968

2. Carp Control Program at Malheur Lake, Oregon
Marshall, 1957

3. Life Histories of North American Gulls and Terns
A. C. Bent, 1963

4. Life Histories of North American Petrels and Pelicans and
Their Allies
A. C. Bent, 1964

5. Life Histories of North American Marsh Birds
A. C. Bent, 1963

6. American Wildlife and Plants - A Guide to Wildlife Food Habits
A. C. Martin, H. S. Zim, A. L. Nelson, 1951

7. The Ecology of Malheur Lake
H. F. Duebbert, 1969

8. Refuge Objectives - Malheur NWR
Waterfowl Maintenance and Production Sections
McLaury, 1971

9. Life History of the Sago Pondweed
R. R. Yeo, 1965 Weeds 13(4): 314-321

V. Carp Management Objectives

A. Objective levels of outputs have been developed for Malheur Refuge. They have been broken down by refuge units. Individual wildlife objectives are discussed.

Use for 1975 indicates current use under poor habitat conditions on Malheur Lake. Benefits that can be anticipated through carp control are the difference between Malheur Lake objective levels and current levels of output.

1. Swan Maintenance Objectives

Malheur Refuge is a major migration use area for the Pacific Flyway swan population. The refuge serves primarily as a spring and fall migration stopover for 26-28 percent of the Pacific Flyway population, based on the midwinter waterfowl population estimates for the flyway and peak refuge population estimates in 1967 and 1968.

Swan use on the refuge depends on pond and Malheur Lake water levels and the resulting production of pondweed, especially sago pondweed, a preferred food of swans. In years of ample water, fall swan use is concentrated on the refuge primarily in Malheur Lake; spring use is scattered throughout the Harney Basin as swans feed on flooded meadowlands and remnant pondweed in the Lake. In contrast, during short water years, swan use is concentrated on refuge waters that are available, usually carryover water from the previous years.

Fall swan use on the refuge appears to be governed to a certain degree by pondweed production, expecially sago pondweed in Malheur Lake. Periodic carp control in these waters enhances conditions for pondweed growth, and subsequently influences swan use (McLaury, 1971). Two interesting examples of swan use in conjunction with carp control have been recorded at Malheur. In 1970, whistling swan use-days were 617,800 which was the highest figure recorded since 874,879 use-days in 1957. Both of these high figures followed major carp control programs on Malheur Lake by 2 years (1955 and 1968).

Refuge swan maintenance objectives were set by the Pacific Flyway mandate at 449,000 use-days, which was the average refuge use from 1965-1969. However, in 1970 (500,900 use-days) and 1971 (875,136 use-days), the Lake alone exceeded the refuge objective. The swan maintenance objective for Malheur Lake will be set at 800,000 use-days when the Lake is 50,000 surface acres or greater and in a healthy condition. This objective will be used until more data are collected and the Pacific Flyway mandate is updated.

Swan Maintenance Objective For Malheur Lake	800,000 use-days
1975 Swan Use	643,825

2. Goose Maintenance Objective

The goose maintenance objective for Malheur NWR is 6,000,000 use-days based on the Pacific Flyway mandate of 2/3/71. Goose use for the 1965-71 period averaged 4,068,862 use-days on the total refuge and 2,098,357 use-days on the Lake.

Goose use on the refuge is governed by water conditions and food available (green browse and grain) in the Basin. In years of ample water, spring goose use is scattered over the Basin as geese feed on flood-irrigated meadows; fall use occurs in an on-off pattern with geese returning to refuge ponds and the Lake for water and roosting. During short water years, goose use is concentrated on the refuge, primarily on waters carried over from the previous year.

Goose use on the Lake is made up of Canada, snow, Ross' and white-fronted geese. During the 1965-71 period, the Lake supported 51 percent of the total refuge goose use.

There are many variables which affect the goose use on Malheur NWR. McLaury (1971) identified lack of browse or possibly problems with the goose population itself as limiting factors. The amount of grain available in the Basin or on the refuge has a great influence also.

Fall flooding of selected meadows was started in 1974 and this may increase use in the Blitzen Valley.

In order to reach the refuge objective for goose use, the Lake objective is set at 3,000,000 use-days. The size or condition of the Lake does not influence goose use as drastically as ducks and swans.

Goose Use Objective Level for Malheur Lake	3,000,000 use-days
1975 Goose Use	548,445 use-days

3. Duck Maintenance Objectives

Malheur Refuge, especially Malheur Lake, is a major ancestral migration use area for the Pacific Flyway duck population. Malheur's duck use-day objectives were set at 40,000,000 based on a Flyway Management Proposal of 3/2/71.

Duck use on the refuge and Lake is governed by water conditions, annual freeze-up, ice-out, and food production (both aquatic and grain) in the Basin. Generally, in years of ample water and runoff, spring (January-April) duck use is scattered throughout the Basin with ducks feeding on flood irrigated meadows. Fall (August-December) duck use is generally concentrated on the refuge with puddle ducks feeding on and off the refuge but returning to refuge ponds and the Lake for water and roosting. Fall diving duck use is restricted almost entirely to refuge water areas. During short water years, Harney Basin spring and fall use is primarily on the refuge.

The 1965-1969 annual average refuge duck use-days were 24,098,000 (McLaury, 1971). During that period, approximately 70 percent of the use was on Malheur Lake, depicting the significance of the Lake for waterfowl use. The Lake supported an average of 16,885,100 use-days during the 1965-1969 period.

According to McLaury (1971), Malheur Lake has an ultimate capacity of 60,000,000 use-days. However, our mandate objective at Malheur has been set at 40,000,000 use-days. Therefore, with Malheur Lake supporting approximately 70 percent of the refuge duck use, the Lake objective should be set at 28,000,000 use-days. This figure seems reasonable since 33,042,000 duck use-days were recorded in the Lake in 1957, which is considered the modern "record" year for use.

Duck Maintenance Objective	28,000,000 use-days
1975 Use Days	7,257,881 use-days

The importance of Malheur Refuge to migrating canvasbacks should be noted. To demonstrate this, objective levels of canvasback use are discussed. Objectives for their use are not separate but included in the general duck category objective of 28 million use-days.

Malheur NWR is a major use area for the Pacific Flyway canvasback population, with the Lake supporting over 90 percent of the canvasback use-days on the refuge in most years. Canvasback use appears to coincide with surface acreage and sago pondweed production in the Lake.

Canvasback maintenance averaged 869,825 use-days for the 1957-68 period on Malheur Lake. During this period, the Lake accounted for 94.1 percent of the total refuge canvasback use. Canvasback use-days since 1957 have topped one million in 1957, 1958, 1965, 1970 and 1971. The Lake supported more than 5 million use-days in 1957, thus showing its potential when large acreages of sago pondweed are available. In 1965 and 1971, canvasback use was approximately 1.5 million on the Lake.

Using past data and until more specific guidelines are available on a Flyway basis, the objective level for canvasback use will be set at 1,500,000 use-days when the Lake is 50,000 surface acres or greater and in a productive state for sago pondweed.

Canvasback Maintenance Objective for Malheur Lake	1,500,000 use-days
1975 Canvasback Use	92,561 use-days

4. Trumpeter Swan Production

The trumpeter swan production objective level for Malheur NWR was set at 40 cygnets in 1978 and at 250 cygnets at ultimate total capacity (Refuge Objectives 1971). Past nesting activities on the Lake have been limited to one nest (known) annually.

Swan production is probably dependent on water levels, muskrat house numbers, number of breeders available and the condition of the submergent vegetation and aquatic food sources in the Lake. Banko (1963) indicates that aquatic insects, crustaceans and submergents are important food sources for swans during different life stages. Therefore, it is important that the Lake is in a healthy condition for maximum swan production.

There is much about the trumpeter swan population at Malheur that is presently unknown. McLaury (1971) indicated there could be 80 potential territories when the Lake is at 25,000 acres. He assumed an increase of one nest per year on the Lake and an average of 2.5 cygnets raised per nest.

Trumpeter Swan Production Objective For Malheur Lake	*13 cygnets
1975 Production Level	1 cygnet

5. Canada Goose Production

The Canada goose production objective for Malheur NWR is 3,500 goslings (Refuge Objectives 1971). McLaury indicates 40 percent of the total refuge goose production was on Malheur Lake during the 1967-1971 period. Therefore, objective levels could be set a 1,400 goslings based on these data. Duebbert (1969) indicated that the Lake may produce 1,000 geese under favorable conditions.

Goose production on the Lake averaged 604 goslings during the 1957-1975 period. Production ranged from 1,711 goslings in 1958 to 240 goslings in 1969. High goose production has occurred on years of high Lake levels like 1958 (66,000 acres) and 1971 (57,000 acres). Production is probably also affected by other variables, such as: muskrat house numbers, breeding population fluctuations and the brood rearing conditions of the Lake.

Therefore, the Canada goose production objective level, when the Lake is at 50,000 acres or more and in a healthy condition for goose reproduction, is set at 1,500 goslings.

Canada Goose Production Objective For Malheur Lake	1,500 goslings
1975 Production Level	395 goslings

*Objective level will increase 2.5 cygnets/year.

6. Duck Production - Malheur Lake

The duck production objective for Malheur NWR is 50,000 based on a Flyway Management Proposal of 3/2/71. The 1957-1975 average production for the Lake is 7,284 ducklings. Production ranged from 3,278 in 1975 to 19,300 in 1971. The breakdown for 1971 was 8,380 - Group I, 2,740 - Group II, and 8,180 - Group III ducks for a total of 19,300. Malheur Lake duck production levels primarily depend on Lake levels, number of breeders available, and favorable nesting and brood-rearing conditions.

When high production occurred in 1971, the Lake was at 57,000 acres, sago pondweed growth was excellent, and water conditions were favorable for supporting high numbers of invertebrates.

Duebbert (1969) said Malheur Lake may produce 15,000 ducks on years potential of the Lake. This potential will be increased even more after the land use around the Lake is modified to be completely supportive of waterfowl production. It should also be noted that the Lake serves as brood water for ducklings raised off the refuge which enter the Lake via the Silvies River.

Malheur Lake supported an average of 38 percent of the refuge's duck production for the 1970-74 period. Using 50,000 as an objective level, the Lake should therefore support 19,000 ducklings. McLaury (1971) set the Lake objective level at 9,100 ducklings for a year to year average without annual carp management or changes in land use around the Lake.

After considering previous production levels and probable changes in land use practices, the duck production objective for the Lake is set at 25,000 ducks when the Lake is 50,000 surface acres or greater and in favorable nesting and brood rearing condition.

Duck Production Objective	*25,000 ducks
1975 Production Level	3,278 ducks

7. <u>Marsh and Water Birds - Maintenance</u>

The following section includes the objective levels for birds covered in the Refuge Objectives (McLaury, 1971) which would be influenced by carp control or lack of carp control in Malheur Lake. It was determined that the carp population at any level has little influence on

*Group I	11,250
Group II	3,500
Group III	10,250

shorebirds. The Lake levels do influence shorebird use because of area of exposed shoreline.

It should be noted that some of the marsh and water birds associated with Malheur Lake do part of or all of their feeding off the refuge in surrounding river channels or flooded meadows. Therefore, the food supplied by Malheur Lake may not completely determine the population levels or production of these birds.

Carp control would benefit fish-eating birds by replacing large carp with numerous small ones, providing more food.

a. White Pelican

Pelican use is highest when the lake is low and carp populations are high, but increased use can be expected when the size of carp is reduced.

		90% of Use on Malheur Lake
Refuge Objective	291,000	261,900
1975 Use Days	124,581	112,100

b. Double-crested Cormorant

Cormorants would benefit most when there are high numbers of fish available in the 4 to 8 inch category.

		90% of Use on Malheur Lake
Refuge Objective	44,600	42,400
1975 Use Days	20,399	19,400

c. White-faced Ibis

Ibis diet consists mainly of aquatic insects, crayfish, snails, and small fish. Therefore, ibis would probably benefit most when the carp are small and the Lake is in a productive state for insects and other aninal life.

		95% of Use on Malheur Lake
Refuge Objective - Use Days	21,500	20,400
1975 Use Days	18,865	17,900

d. Grebes

The principal use area for western and eared grebes is usually Malheur Lake. Their diet consists mainly of small fish, aquatic insects, and mollusks. The grebes would probably benefit most when the Lake contains abundant small fish (5 inches or less) and is in a productive condition for aquatic invertebrates.

Eared Grebes

		40% of Use on Malheur Lake
Refuge Objective	933,700	373,500
1975 Use Days	162,990	65,208

Western Grebes

		90% of Use on Malheur Lake
Refuge Objective	293,700	264,300
1975 Use Days	273,315	246,000

Pied-billed Grebes

		30% of Use on Malheur Lake
Refuge Objective	207,000	62,100
1975 Use Days	45,504	13,700

e. Great Blue Herons

Great blue heron's diet usually consists primarily of fish (9 inches or less). However, they also eat insects, crayfish, mice, and frogs. Great blues would probably benefit most when the Lake has a large population of small fish and is in a productive condition for small aquatic animals.

		60% of Use on Malheur Lake
Refuge Objective - Use Days	93,000	55,800
1975 Use Days	88,195	52,900

f. Black-crowned Night Heron

Small fish probably make up over one-half of their diet with the remainder made up of crayfish, aquatic insects, frogs, and some mice. Black-crowns probably benefit most when the Lake has abundant small fish available and is in a productive state for aquatic insects.

		80% of Use on Malheur Lake
Refuge Objective - Use Days	221,800	177,400
1975 Use Days	117,735	94,200

g. Egrets

The primary diet of egrets consists of crayfish, aquatic insects, frogs, fish, snails, and some snakes. Egrets would probably benefit most when the Lake is in a productive state for small fish and other aquatic life.

Snowy Egret

		75% of Use on Malheur Lake
Refuge Objective - Use Days	22,200	16,700
1975 Use Days	29,940	22,500

Great Egret

		75% of Use on Malheur Lake
Refuge Objective - Use Days	111,600	83,700
1975 Use Days	93,525	70,100

h. Franklin's Gull

Franklin's gulls primarily depend on insect life in Malheur Lake. Therefore, it is important for the Lake to be in a productive condition for insect life.

		75% of Use on Malheur Lake
Refuge Objective - Use Days	130,000	26,000
1975 Use Days	71,721	14,300

i. <u>California Gull</u>

California gulls are primarily fish eaters and scavengers. Bird eggs and insects are also eaten. California gulls would probably benefit from large numbers of small fish and high waterfowl production which would occur when the lake is in a highly productive condition.

		20% of Use on Malheur Lake
Refuge Objective	130,000	26,000
1975 Use Days	71,721	14,300

j. <u>Ring-billed Gull</u>

Ring-billed gulls would probably follow the same pattern as California gulls.

		20% of Use on Malheur Lake
Refuge Objective - Use Days	180,000	36,000
1975 Use Days	60,275	12,100

k. Forster's Tern

Forster's terns feed primarily on small fish and would benefit most when the lake supports large numbers of fish (3 inches or less in size). Some aquatic insects are also taken.

		70% of Use on Malheur Lake
Refuge Objective	198,900	139,200
1975 Use Days	87,667	61,400

l. Black Terns

Black terns eat primarily May flies, dragonflies, caddis flies, beetles, and spiders. They would benefit most when the Lake was in a healthy condition for invertebrates.

		60% of Use on Malheur Lake
Refuge Objective - Use Days	415,000	249,000
1975 Use Days	208,885	125,300

m. Greater Sandhill Cranes

C. D. Littlefield (1974) estimates 18 pairs of greater sandhill cranes use the south side of Malheur Lake. Littlefield indicated that carp density in Malheur Lake has little or no effect on the sandhill cranes. The primary use of the lake by cranes is for roosting during fall migration.

8. Marsh and Water Birds - Production

Production data for this group of birds has been analyzed. No specific predictions of response to carp control can be made. Many combined factors appear to influence production in a given year.

Some general statements can be made regarding ecological factors and their effect on colonial nesting birds. See table 3 on the following page for nesting from 1966-1975.

a. Carp were controlled in 1968, but control had no significant adverse effect on production.

b. Production was generally highest during 1972-1974. During these years, the lake level was high, carp were abundant and sago pondweed production was low.

c. In 1975, similar conditions existed, yet colonial nesting declined significantly. Franklin's and California gulls did not nest at all. Carp populaticns and water levels were high, but some factor caused production to drop.

COLONIAL NESTING SPECIES - YEARLY NEST ESTIMATES

Table 3

SPECIES	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
DOUBLE CRESTED CORMORANT	125	50	50	45	50	45	70	85	75	60			
GREAT BLUE HERON	200	125	100	110	100	110	150	200	200	210			
BLACK CROWNED NIGHT HERON	600	250	500	600	500	750	750	775	1000	360			
COMMON EGRET	400	200	400	230	130	150	205	230	350	100			
SNOWY EGRET	50	60	150	60	55	35	80	125	140	55			
WHITE FACED IBIS	10	15	20	20	25	20	25	55	80	40			
FRANKLINS GULL			100	205	325	400	500	1000	1000	0			
CALIFORNIA GULL							10	80	10	0			
RING BILLED GULL								25		0			

Based on the above statements, carp control should not cause significant detrimental effects on colonial bird nesting. Carp control would reduce the number of large adult carp and create better conditions for some colonial nesters (i.e., more young carp for fish-eaters and better sago pondweed for higher invertebrate populations for Feanklin's gulls).

9. Waterfowl Hunting

A. Waterfowl hunting is related to the condition of Malheur Lake. When sago pondweed is abundant, waterfowl are numerous, and hunter interest increases.

The following table shows the estimated number of hunters since 1968.

Table 4 - Annual Number of Waterfowl Hunters

Year	Estimated No. Hunters	Remarks
1968	None	Hunting was closed, lake was nearly dry and carp were controlled.
1969	1,597	Increasing water levels, sago pondweed production and waterfowl use.

Year	Estimated No. Hunters	Remarks
1970	2,075	Highest hunter use, excellent sago production and bird use.
1971	1,608	Excellent sago conditions and bird use; early freezeup (October 28) caused exodus of birds.
1972	1,564	High lake levels, poor sago production, declining waterfowl use.
1973	521	Good lake levels, poor sago production,
1974	555	low waterfow use.
1975	962	

After control, habitat conditions were good on the lake from 1969-1971. Conditions began declining in 1971 and were poor from 1973-1975. The number of hunters averaged 1,760 from 1969-1971 and averaged 680 from 1973-1975. Carp control on Malheur Lake should keep the habitat productive and provide for 1,080 additional hunters over poor habitat conditions.

B. Specific outputs (use-days, birds produced, number of hunters) that can be anticipated to increase annually through carp control on Malheur Lake as summarized.

Outputs	Malheur Lake Objective	1975 Outputs	Benefits of Carp Control
Waterfowl Maintenance	31,800,000	8,450,151	23,349,849 Use-Days
Swans	800,000	643,825	
Geese	3,000,000	548,445	
Ducks	28,000,000	7,257,881	
Waterfowl Production	26,513	3,674	22,839 No. Prod.
Trumpeter Swan	13	1	
Canada Goose	1,500	395	
Ducks	25,000	3,278	
Water and Marsh Bird Maintenance	1,868,900	944,700	924,200 Use-Days
Grebes	699,900	324,900	
White Pelican	261,900	112,100	
Double-crested Cormorant	42,400	19,400	
Egrets	100,400	92,600	
Herons	233,200	147,100	
Wh.-faced Ibis	20,400	17,900	

Outputs	Malheur Lake Objective	1975 Outputs	Benefits of Carp Control
Gulls	122,500	44,000	
Terns	388,200	186,700	
Waterfowl Hunting	1969-71 Average	1973-75 Average	
Number of Hunters	1,760	680	1,080 Hunters

VI. Presentation of Alternative Solutions

Ideas for a variety of carp control techniques are presented. These thoughts show the wide range of possibilities in dealing with the problem. Wherever possible, general costs and benefits are included. These factors should not be given too much weight since most techniques have not been attempted so it is not even known if they are feasible.

The principal value to this section is to list possible control techniques which can be investigated. By describing each method, a list of unknown ecological relationships can be assembled.

The investigator's assignment will be to obtain answers for their relationships and present recommendations for solutions to the carp problem. Final recommendations are not expected to be limited to only those possible solutions presented in this analysis.

A. No Action

1. The natural water cycle and associated ecological results would be allowed to take place. There would be 5-10 years of fairly high fluctuating water levels with the maximum lake size above 35,000 acres. Periodically (once in 10 years) the lake would recede to 15,000 acres or less, so much of the lake's bottom would be exposed.

2. Costs Involved - none.

3. People Required - none.

4. Benefits - This plan would have no benefits related to carp management. During the dry period, carp would be concentrated. Some control would be exercised through carp being stranded in pockets where they would die, but most would make it to the deepest part of the lake where they could survive. As water becomes more abundant, the lake size would increase, but the density of carp might be lower than previous to the drought. This may provide some temporary benefit if water cleared somewhat. Pondweed may increase in small amounts resulting in slightly higher waterfowl use. Use by fish-eating birds would increase if production of carp occurred. These increases would last three or four years at the most, until the lake would again be saturated with adult carp. This condition would persist with decreased pondweed production and bird use until the next drought period.

5. Time Required to Complete - none.

6. Conflicts - Wildlife objectives of production and use-days would be held down as a result of the adverse effect that high populations of adult carp have on the marsh ecosystem.

7. Political Considerations - There may be some difference of opinion concerning the management of Malheur Lake. Some people feel that the marsh should be left alone to allow ecological changes to occur on their own. However, carp are not part of the natural ecosystem and play a significant destructive force. A strong public feeling is one that carp should be managed so that other natural processes can occur without their interference.

8. Problems Associated with No Action - If nothing is done to the carp population, in most years the lake has low wildlife use. Large portions of the lake will be nearly barren of submergent plants and invertebrate life. The fish population, consisting principally of large, adult carp, will no longer provide a food source. Results are that most bird use will be severely reduced. This includes blackbirds, wrens, Franklin's gulls, and waterfowl broods who feed on invertebrates; grebes, pelicans, cormorants, herons, and egrets who feed on small fish; and waterfowl who feed on submergent plants.

B. Spot Control, Including Baiting and Trapping, Baiting and Poisoning, Poisoning on Spawning Grounds, and Poisoning Under Ice.

1. These actions, singly or combined, constitute a method of attempting to hold the carp population at a moderate level where fish production would occur. Spot control would be done only at fish concentrations. The effectiveness of any of these techniques would have to be proven. These techniques involve the use of either rotenone or antimycin as a poison. Rotenone is used only in a liquid form and is cheaper than antimycin. Antimycin has two advantages, one is that it comes in a granular form allowing different distribution of the poison. The second advantage is that carp cannot detect anitmycin in the water and they will not attempt to move out of the area like rotenone forces them to do. Rotenone acts as a smothering agent, covering gills and suffocating the fish. Antimycin is a nerve agent, being abosrbed through the skin where it attacks the nervous system.

A description of each technique follows.

a. Baiting and Trapping - Large clover-leaf shaped traps with funnel entrances would allow fish to enter but not easily escape. These traps would be baited with sour grain. A source has been located and is available free of charge. After a sufficient number of carp are trapped, they will be removed by netting or poisoning with rotenone. These traps will have to be scattered abundantly through areas of fish concentrations.

(1) Costs Involved:

Each trap - 100" roll mesh wire - $35		
	17 steel fence posts at $1.20	
	$55 per trap - 20 traps	$1,100
Airboat - $10/hr. 12 days + 3 days/week		
	for 11 weeks = 45 days x 3 hrs/day	1,350
Rotenone - 1 barrel		470

Labor	Erect	Remove	Check	
$4.30 GS-5	7	5	33 days	
$8.60 GS-11	7	5	5 days	2,720
				$5,640

(2) People Required - The Biologist and Biological Aid would erect dispensers, keep them operational and keep the area baited.

GS-5	45 man days
GS-11	17 man days

b. Baiting and Poisoning - This is a variation of technique a. Fish concentration areas are baited. Rather than traps, automatic dispensers of granular antimycin are placed in baited areas. Since carp cannot detect antimycin, they remain in the baited area until they die.

(1) Costs Involved:

Poison Dispensers - $50 each, 6 in series		
	10 series	$3,000
Antimycin - $10/gal.		
	2 gal/dispenser/summer	1,200
Airboat - 130 hrs.		1,300
Labor - GS-5 $4.50	45 days	
GS-11 $8.60	17 days	2,720
		$9,220

(2) People Required - The Biologist and Biological Aid would erect dispensers, keep them operational, and keep the area baited.

GS-5	45 man days
GS-11	17 man days

c. Poisoning on Spawning Grounds - If carp select certain areas of Malheur Lake in which to spawn, poisoning of these areas may be possible. One such spawning area was located in 1975, along the grassy shoreline of Pelican Island. Thousands of carp had moved into several miles of the shoreline. Possible treatment would be spreading a barrier of rotenone around the spawning area to prevent escape of the fish, then proceeding through the area with rotenone.

Another method would be to erect automatic dispensers of anitmycin on spawning areas since carp cannot detect its presence.

(1) Costs Involved:

Airboat - $10/hr.			
	Locating fish - 25 hrs.		
	5 treatments - 30 hrs.		$ 550
Rotenone - 2 barrels			940
Labor -	Locating Fish	5 Treatments	
GS-5	5 days	5 days	
GS-11	5 days	5 days	1,030
			$2,520

(2) People Required - The Biologist and Biological Aid would locate and map spawning concentrations. Then they would treat the selected areas with rotenone from the airboat.

GS-5	10 man days
GS-11	10 man days

d. Poisoning Under Ice - Another possible treatment centers around carp concentrations under several premises. One is that oxygen is depleted from water under the ice at Malheur Lake. Another is that the oxygen content is higher in water near the mouth of the Blitzen River where it enters the lake. A third premise is that carp will concentrate near the mouth of the river in water with a higher oxygen content. Control may be possible under these circumstances by applying antimycin under the ice.

(1) Costs Involved:

Poisoning Devices - 5 at $25 each		$125
Antimycin - 2 gal./device = 10 gal.		100
Labor - 1 day to erect		
2 hrs./day, twice/week for 5 wks.		
GS-5 $4.30		
GS-11 $8.60	3.5 days	360
		$585

(2) People Required - The Biologist and Assistant will place poisoning devices and check them twice a week for five weeks during the period when the lake is covered with ice. Two people are necessary for SAFETY purposes.

2. Cost Involved for All Spot Control Programs

Baiting and Trapping - use of 20 traps	$ 5,640
Baiting and Poisoning - 10 groups of dispensers	9,220
Poisoning on Spawning Grounds - 5 treatments	2,520
Poisoning Under Ice	585
	$17,965

3. People Required For All Spot Control Programs

	GS-5	GS-11
Baiting and Trapping	45	17
Baiting and Poisoning	45	17
Poisoning On Spawning Grounds	10	10
Poisoning Under Ice	3.5	3.5
	103.5	47.5 Man Days

4. Time Required to Complete - These treatments would be part of annual management. Most would occur around the spawning period or when concentrations could be expected to occur. Control periods would be from late May through August. For poisoning under ice, the best time would be from late December through January.

5. Benefits - This spot control has not been attempted so it is not known if it would be successful. If the techniques are successful, they may have to be expanded for use as a management tool. Aims would be to reduce the carp population enough to allow submergent plants to thrive and to increase the number of young carp. The extent of the benefit of this program depends on how successful it is. Since they have not been attempted, results cannot be predicted.

If the aims of spot control were achieved, some areas of the lake should produce more submergent plants. Higher waterfowl use on these areas could be anticipated compared to low current use over most of the lake except where beds of sago pondweed do exist. These beds support most of the use on Malheur Lake. Fish-eating birds could also be expected to benefit. The additional fingerling carp would increase their food supply significantly. The present carp population appears to be comprised primarily of large adult carp which have little food value to fish-eating birds. Waterfowl production would probably receive the smallest benefit. Broods would use the scattered sago beds, seeking the abundant invertebrate life living in this environment. The increases of waterfowl production would be localized around these plant beds.

6. Conflicts - No conflicts are foreseen. The only reduction would be to the carp population and only benefits would be derived from such a program. The total amount of poisoning would be small on the lake which would break down within days.

7. Policital Considerations - Public reaction could be expected to be favorable. All public comment encourages us to do something to get rid of the carp.

8. Problems Associated with this Control - Any baiting for carp with grain will attract some waterfowl. Most of this problem can be eliminated by keeping the grain in burlap bags; however, a certain amount must be scattered. The effect on waterfowl feeding in an area concentrated with antimycin is unknown.

Another problem we have encountered is ducklings, particularly redheads, getting stuck in one-inch chicken wire. This wire is the best for construction of carp traps. Two-inch mesh could be tried, but smaller fish could escape. Adult ducks may find their way into traps and not be able to escape if they are flightless. The greatest hazard is if a hen with a brood gets in a trap and the brood attempts to join her. Most would get stuck in the fence.

With any control, we are concerned about the dead carp in the lake. With an extensive kill, it is impractical to attempt to remove the carp from the lake. In fact, it would be desirable to recycle the nutrients to the lake. The problem is the potential hazard of the carcasses to waterfowl. After one control in the past on Malheur Lake, a botulism outbreak in waterfowl occurred. It was felt the botulism got started in the carcasses.

One of the problems of using antimycin is water pH. The chemical's effectiveness is reduced at pH 8.0 - 8.5. Water quality should be analyzed before any treatment.

Another factor relating to treatment is oxygen content of water in winter. The extent oxygen depletion from water under the ice should be known as well as determining if it is higher near the mouth of the Blitzen River.

The location of fish concentrations should be learned for various times of year, such as wintering under the ice or during spawning.

C. Physical Removal - Commercial Fishing

1. An abundant supply of protein in the form of carp is available for pet food, commercial trout food or human consumption. If commercial outlets and fishermen were aware of this source, interest in fishing for carp may be generated. Fish could be gathered through the use of traps, gill nets, and purse seines.

2. <u>Costs Involved</u> - Costs of the program to the refuge would be small. Most of the costs would be borne by the fishermen. Some administrative work involving permits, record-keeping, and policing of the operation by the Biologist would be necessary.

Administrative Officer at $5.85/hr. 1 day	$ 50
Biologist at $8.60/hr.	$350

3. <u>People Required</u> -

Administrative Officer	1 man day
Refuge Biologist	5 man days

4. <u>Time Required to Complete</u> - This would be a periodic control, profitable only during years when carp were highly abundant. Commercial fishing would have to be done at concentration areas. probably during spawning. Most activity could be anticipated during May to July.

5. <u>Benefits</u> - Benefits from this operation alone would be very limited. It appears doubtful that fishing alone could reduce carp populations enough to affect marsh ecology. Perhaps combined with other methods of spot control, better success could be achieved.

6. Conflicts - A potential hazard exists if diving birds are caught in nets (discussed under Problems).

7. Political Considerations - Little adverse public reaction would be anticipated from this control method. If birds were caught in nets and drowned and the public became aware of it, there would be some adverse reaction.

8. Problems Associated with Commercial Fishing - This control method would have limited effectiveness by itself. Its highest efficiency would occur when carp were most abundant. If some control could be achieved, the initiative of the fishermen would be reduced by the smaller catch.

Control using nets during summer would have potential hazards to diving birds. Grebes, pelicans, cormorants, redheads, canvasbacks, and ruddy ducks could be caught and drowned. The extent of this hazard depends upon the location of the nets in the lake and the density of birds there.

The effectiveness of nets or seines would have to be demonstrated in the marsh environment. An alternative could be the use of fish traps.

The biggest problem is a lack of market for carp. If there was an economic potential in carp, someone would devise a collecting method.

D. Mechanical Barriers to Spawning Grounds

1. If certain areas of the lake are used for spawning, they could be identified. Barriers could then be erected preventing adult carp from reaching these areas. Barriers would be wire, either mesh or welded type.

It would be impossible to protect all spawning areas, in fact they may spawn over the entire lake. One area that has been considered is the portion of Malheur Lake east of Cole Island Dike. For the sake of assessing this method, protection of that part of Malheur Lake will be discussed.

An incomplete Cole Island Dike separates the eastern part of Malheur Lake known as Unit 6. Carp spawn in large numbers on the grassy shoreline of Pelican Island in Unit 6. Cole Island Dike has two breaks and is incomplete for 600 yards. There is free exchange of water and carp between units of the lake. If the Cole Island Dike could be made into a barrier to fish movement, adult carp could be kept out and Unit 6 would be more productive. The south break in the dike, about 15 yards wide, was fenced in the summer of 1975. The second break is approximately 400 yards wide and would be difficult to fence. The incomplete section of dike, approximately 600 yards wide would create problems in fencing. It is a solid stand of bulrush.

After a barrier was erected, adult carp would be trapped inside Unit 6. These should be poisoned out when water levels are low. Once carp are killed, this unit should remain in a productive status for several years. Small carp will get through the barrier and eventually spawn. Then the area would have to be retreated.

2. Costs Involved - Costs will be estimated to block off Cole Island Dike. Fencing appears to be the most practical barrier. It could be made with 1-inch mesh chicken wire; however, a heavier welded wire could last longer. Its life span will still be relatively short in the water before it rusts apart. Life span is estimated at three years.

Length of fence - 15 + 400 + 600 = 1,015 yards	
Fence - welded wire - 1" x 2" x 6' mesh - 100' roll = $100	
= 31 rolls =	$3,100
Wire to attach fence to posts	50
Steel posts - 1 every 10' at $1.20 ea. = 305 posts	370
Labor - 3 men - averate $6/hr. - 12 days	1,730
Total	$5,250

Cost of fencing = $5,250 with life expectancy of 3 years - $1,750 per year.

Part of the control plan would be aerially poisoning Unit 6 every five years.

Estimated water acreage during treatment:

8,000 acres x 1.5 feet depth = 12,000 acre feet.

Amount of rotenone needed to achieve 2 ppm treatment:

1 gallon/acre foot = 12,000 gallons		
55 gallons = $470	12,000 gallons =	$103,000
Aerial application of rotenone -		
Pilot and plane $2/acre to spray 8,000 acres =		16,000
Assistants to help load plane -		
2 people - 10 days		1,000
Flagmen - 2 people - 10 days		1,000
Total cost of Rotenoning Unit 6		$121,000

3. People Required -

Fence Construction - every 3 years

3 Laborers for 12 days 36 man days

Aerial Rotenone Application - every 5 years

4 Laborers for 10 days 40 man days

4. Time Required to Complete - It is estimated that three men could build the fence in twelve days. The longevity of the fence is estimated to be three years, when it would have to be rebuilt.

The aerial application is estimated to take ten days and retreatment would be required every five years.

5. Benefits - Unit 6 is composed of short saltgrass shorelines with large expanses of open water. Parts of the lake have dense stands of bulrush. Most of the benefits would be with waterfowl use. There would be no effect on nesting habitat, but broods would benefit from increased invertebrate life. Fish-eating birds may benefit for there would probably be more small carp.

Sago pondweed would be the plant that would benefit most. Diving ducks and swans use this food plant heavily, as well as pintails and other dabblers. The amount of increased use is unpredictable, depending upon the size of the lake and the number of acres of sago produced.

One note of skepticism should be mentioned. In 1975 large numbers of carp spawned in Unit 6. Many stayed there during the summer, but it is felt that many did move to the deeper, cooler water west of Cole Island Dike late in summer. Carp spawned in the unit and stayed there in large numbers during summer; yet, sago pondweed growth was excellent. Approximately 6,000 acres of good to excellent sago beds were surveyed. Approximately 187,400 swan use-days, 574,200 goose use-days and 7,214,000 duck use-days were totaled from August through December. Use by whistling swans and canvasbacks was impressive. Just how much better habitat on this area could be achieved with carp control is not known.

6. Conflicts - None foreseen.

7. Political Considerations - No adverse public reaction is foreseen. Favorable reaction could be anticipated that something was being done with the carp problem.

8. Problems Associated with the Fence - There are several problems. One relates to the section of fence erected in 1975. The mesh of the wire must be small to hold 10-inch carp which are capable of spawning. Unfortunately, the 1-inch mesh used also caught redhead ducklings. During the summer, approximately ten ducklings were found trapped in 15 yards of fence. If an additional 1,000 yards were erected, substantial losses could occur.

Another problem is with the fence itself. Life expectancy was estimated to be three years. This may be true if there was no ice in winter. The section built in 1975 did hold up over winter, but it is short and protected by expanses of bulrush on both sides of the dike. The larger sections, 400 and 600 yards, would be much more sensitive to ice movement. It is possible that the entire fence could be taken out by ice each winter. Even if small sections were damaged, they could not be repaired until the ice was gone so the airboat could be used. By that time, it is conceivable that many carp could move into the protected area.

Maintenance may be some problem. If the bottom is extremely murky and carp do fight the fence, they may dig holes under it, allowing them to move into Unit 6.

Spawning areas are unknown. If carp spawn widely over the entire lake, this method would be ineffective. It should be determined where the spawning occurs.

E. Introduction of Predaceous Fish

1. Under some circumstances, results may be achieved in controlling carp numbers by predaceous fish. If the carp population is reduced, their numbers may be held down by another species of fish preying on the young carp.

Large mouth bass, northern pike or walleye are fish which are predaceous. Any of these three species could probably live in Malheur Lake, but they would have to be introduced into the ecosystem.

Chemical carp control would probably be necessary prior to an introduction. The present carp population appears to be composed of adults which are too large for predaceous fish to take. Control would temporarily set back the carp and increase their production. Predaceous fish would hopefully consume enough small carp to hold the population significantly lower than previous to chemical control.

Sources of fish for introduction could come from several places. Large mouth bass could probably be obtained from waters within the state. Pike or walleye might be obtained from national fish hatcheries in the mid-west.

2. Costs Involved - Prior to introduction of predatory fish, chemical control of the lake would be needed to reduce the population.

Estimated Cost of Chemical Control	
for 8,000 acres	$121,000
(taken from alternative No. 8)	

Preliminary Investigations of Habitat Conditions prior to introduction - 5 days at $70/day	350
Introduction of fish - Fly back to mid-west, pick up fish and put them in Malheur Lake	1,500

This means of control cannot be expected to last indefinitely. Eventually, the adult carp population will saturate the lake and chemical control will again be necessary. It is estimated that chemical control will be necessary every fifteen years.

3. People Required

	# People	Man Days
Chemical Control on Malheur Lake (taken from alternative No. 8)	4	40
Introduction of Fish		
Pilot	1	3
Fishery Biologist	1	3
Refuge Biologist	1	6
	3	12

4. Time Required to Complete - To be effective, this control method would have to be repeated on an estimated fifteen year cycle. Even if this was biologically necessary, chemical control could not be done in prescribed years since it would have to wait for the nearest drought period when the lake receded enough to make chemical control feasible.

5. Benefits - After a control, the carp population should be in a state of high production. That is, there would be few adult carp and numerous small ones. Under these conditions, a large population of predatory fish would hopefully exert limitations on the carp population, taking the majority of small fish.

The degree of effectiveness of control by predators will dictate the condition of the marsh ecosystem. Predators cannot be expected to take all the young carp produced each year, so eventually over a number of years, the carp will reach an abundant population similar to an uncontrolled state. However, the degree of increase of the carp populations should be slowed down considerably so chemical control would not be necessary as often, perhaps reduced to fifteen years. This would increase the time of the lake's productiveness by about three times, from a five year cycle to fifteen years.

Increased waterfowl production and migrational use can be expected as well as high fish-eating bird use. A comparison of estimated wildlife use over a fifteen year cycle between no control and assumed effective control by predatory fish is shown.

	15 Years (Similar to 1975 W/O Control	15 Years[1] With Predatory Fish	Estimated Benefits Over 15 Years if Fish Control is Effective
Waterfowl Production - No. Birds	55,110	260,464[2]	205,354
Waterfowl Maintenance - Use-Days	126,752,265	327,450,453	200,698,188
Water and Marsh Bird Maintenance - Use-Days	14,170,500	20,588,650	6,418,150
Waterfowl Hunters	10,200	18,760	8,560

[1]Assumed 1975 level in years 1, 2, and 15; 50% objective level in years 3-5 and 13-14; objective level - years 6-12.

[2]Assumed 10% predation rate by fish on young birds.

6. Conflicts - Several conflicts are evident. The first is the predatory nature of the bass or pike. While they would control small fish, they would also take some small waterfowl and other birds. Losses are estimated at 10 percent. As shown in the benefits section, increase in production outweigh losses.

Another conflict lies in the habitat of pike and walleye to migrate upstream. It is possible that these fish could eventually move up the Blitzen River to Page Springs. If this occurred, there would be a serious conflict with trout fishing.

The most serious potential for conflict lies in the interest of fishermen for these species. If the predatory species establishes itself and become abundant, as would be necessary for carp control, there would be extreme public pressure for a fishing season for them.

Presently, the only boating use authorized on Malheur Lake is during the waterfowl hunting season. Birds are given protection during the reproductive period. If the refuge was pressured to open a fishing season on Malheur Lake, there could be significant losses to bird production, particularly the colonial nesters.

7. Political Considerations - There may be a reaction from people disliking introduction of fish foreign to this water system. This would be a legitimate concern, for only favorable prospects were

foreseen when carp were introduced. There may be more adverse factors involved with such introductions than anticipated.

Opposing viewpoints could be expected from the fishing segment of the public. Trout fishermen would probably oppose the introduction based on the possibility that the fish may work their way into the Blitzen River system. Other fishermen desiring an additional species of sport fish would probably be in favor of the introduction with hopes that someday a season could be established.

8. Problems Associated with Introductions - The major problem would be to get a large population of predatory fish soon enough to obtain control over young carp. After chemical control of carp, a large enough number of large predatory fish could not be introduced to hold the small carp in check immediately. Introduction of fingerlings with hope of future reproduction would be necessary. The question is whether young predatory fish could outgrow young carp and control their numbers or if both species would grow at the same rate with little control over the carp.

Another problem would be encountered when eventual chemical retreatment would be necessary. If all fish were killed, restocking of predatory species must begin again from the start. This problem may be alleviated if numerous adult predators could be seined and held in ponds until the lake was treated. Then adults could be restocked.

F. Introduction of Fish Disease

1. Another alternative control method could be a disease specific to carp. For example, there is a virus that occurs naturally in carp in California. Unfortunately, it has not been isolated. It does not affect young carp, only spawners under periods of stress. Losses are caused periodically, but do not serve as effective population control.

If a similar virus or other pathogen could be isolated for carp, control would be highly effective in the lake.

2. Costs Involved - The method of introduction would determine total costs. Certain costs would be involved in transportation of the pathogen. If the pathogen could be introduced into the water, costs would be low, but if individual fish had to be exposed to it, costs would increase significantly.

The major cost would be in the paper work and red tape of approval for such a project.

3. People Required - Again, the manpower need is unknown. Fewer people would probably be required in the field than those necessary to obtain approval of the pathogen's use. Several state agencies, as well as regional and central office personnel of the U.S. Fish and Wildlife Service, would be involved.

4. Time Required to Complete Action - A lengthy time could be anticipated to put this method into action. Possibly it could take a year to be reasonably sure that the pathogen would be specific to carp. Six months could easily be consumed in obtaining permission to use the pathogen.

5. Benefits - Since it is not known whether a usable pathogen exists, specific benefits cannot be estimated. It can be assumed that total dissemination of the population would not occur, since this is not known anywhere in the U.S.

If a pathogen similar to the one described in California were used, some benefits would likely occur. Adult fish would be the ones affected, which are the ones damaging the ecosystem.

Benefits could be expected to waterfowl use, production, and fish-eating birds.

6. Conflicts - The extent of the conflicts cannot be predetermined. Even after extensive testing, one cannot assuredly say that a pathogen is specific to only carp. Introduction of a foreign disease is accompanied by risks. There are many possibilities that a disease could strike some form of life in the natural ecosystem.

7. <u>Political Considerations</u> - A segment of the informed public would be opposed to the introduction of a disease, based upon risks to many forms of life. Objections would probably be strong enough to reach the political level.

8. <u>Problems Associated with Introduction of a Fish Disease</u> - First, it is doubtful that a usable disease exists. If so, it would be in wide use across the country. A literature search should be made concerning the subject.

Second, after inquiring about the California virus, the recommendation was to seek other methods of control because it was virtually impossible to introduce disease into Oregon. Oregon Department of Fish and Wildlife has strong regulations against such introductions. U.S. Fish and Wildlife Service policy also prevents such introductions.

G. <u>Treatment of Oxygen-depleting Agent Under the Ice</u>

1. Such an agent is not known to exist. The idea is presented to arouse some thought along these lines. If winter can be determined to be a period of stress for carp, an oxygen-depleting agent may cause enough additional hardship on the carp to be a major mortality causing factor.

It should be investigated whether a chemical exists that can take oxygen from the water. If such a chemical could be applied on the lake just prior to ice formation, the result could be a reduction of oxygen content from the water. It may be brought down to a level to cause significant carp mortality.

2. Costs Involved - unknown.

3. People Required - unknown.

4. Time Required to Complete - If such a treatment was attempted when carp were under stress, it must be possible to complete in a matter of days before the stress period is over.

5. Benefits - Total benefits would depend upon the degree of control achieved. At this time, benefits cannot be quantified, for it is not known whether this alternative is even possible.

A certain reduction of the carp population will not result in an equivalent response by the marsh ecosystem. For example, a 5 or 10% reduction in carp will not gain the same wildlife benefits. The reason is the high breeding potential of carp. A 10% reduction of carp could easily be overcome by the remaining females, with the larger ones able to produce over two million eggs. Ninety percent of the present adult carp population could probably retard processes in the ecosystem as well as 100% of them. An unknown significant reduction, perhaps 50%, in adults must take place before responses in habitat would occur.

6. Conflicts - If a chemical or other agent was developed, it must be determined that it has no adverse effect on some other segment of the marsh environment.

7. Political Considerations - There would perhaps be some public reaction in opposition to dumping large amounts of chemicals in the lake by groups who are against extensive use of chemicals in the environment.

8. Problems Associated with this Alternative - Problems cannot be completely anticipated, for such an agent is not known to exist. There should be concern over immediate and long-term effect of such a control method.

With many subtle relationships between segments of the ecosystem, it would be nearly impossible to consider all possible conflicts. Yet, some adverse reaction could disrupt major flows of energy. Habitat features should be investigated such as effect on water pH, trace elements, as well as direct effects on invertebrate and vertebrate physiology.

H. Chemical Control of Lake in Low Water Years

1. Recent control in Malheur Lake has been by this method. During drought periods when the lake receded, rotenone was applied giving an excellent kill of carp. Recovery of wildlife use was slow the first year, but peaked out the second to third year after control. After that point, productivity dropped off rapidly and remained low until the next dry cycle came so that chemical control was again possible.

2. Costs Involved - Costs vary depending on the size of the lake when treated. During control of Malheur Lake, the lower ends of the Blitzen and Silvies Rivers should also be treated. The area of river treatment would remain the same under varying lake size.

Treatment of Rivers -

Rotenone - 4 barrels at $470 each	$1,900
Labor	200
Airboat - $10/hr. - 10 hrs.	100
	$2,200

Treatment of Lake When it Recedes to 1,000 Acres

Concentration of 2 ppm.

Treatment of 1,000 surface acres (average 2' deep)

2,000 gal. of rotenone	$18,000
Airplane - $2/acre	2,000
Labor - 4 people x 1 day	200
Total Cost	$22,400

3. People Required

	Man Days
Treatment of Rivers	
Biologist - $70/day	1
Assistant Manager - $60/day	1
1 Biological Technicial - $50	1
Treatment of Lake	
Biologist	1
1 Biological Technician	1
4 Laborers - 1 day	4

4. Time Required to Complete - The actual time to complete chemical control of the lower end of the rivers and the lake when it is 1,000 acres or less would be a week or less.

5. Benefits - The nearly complete elimination of carp during this type of control gives a tremendous boost to the marsh ecosystem. Natrients that have been tied up in the form of carp are again released to be changed into submergent plants and abundant invertebrate life. Responses are immediate. Yellow-headed blackbirds, marsh wrens and Franklin's gulls respond to increased insects. Fish-eating birds increase with more small carp being produced. Waterfowl production and use increase with more submergent plants, particularly sago pondweed, and associated invertebrates.

The following table is an example of bird use on Malheur Lake prior to and following carp control.

	Total of 4 yrs. (60-61, 67-68) w/High Carp Pop. ea. 2 yrs. prior to Treatment		4 yrs. (62-63, 69-70) ea. 2 yrs. Immed. after Treatment		Benefits of Treatment	
	Total		Total		Total	
	#Birds	Use Days	#Birds	Use Days	#Birds	Use Days
Waterfowl						
Production						
Use Days						
Colonial Nesting Birds						
Breeding Population						

High bird use actually continued for 4-5 years following treatment before the carp population reached the point of affecting that use. Only two years were used following treatment to be comparable to the two years prior to treatment that high carp populations significantly affected habitat conditions. So total benefits from treatment would be higher than shown on the table.

One point that must be considered, however, is that chemical control takes place when the lake is nearly dry. The effect of drying of the lake alone without chemical application is unknown. A significant reduction of carp would occur, but not to the extent that chemical application contributes. Some beneficial response of habitat would take place, but not as great or long-lasting as with chemical control.

6. Conflicts - There appears to be no conflicts. The action is centered around killing of carp with only beneficial results.

7. Political Considerations - No adverse public reactions are anticipated. Feelings could be expected to be in favor of a control program.

There may be some concern over spraying a chemical in the marsh, but rotenone breaks down within hours. Some invertebrates would be killed, but with the poor conditions of the marsh at the time of treatment and small remaining lake size, effects would be minimal.

If there were any forms of life indigenous to Malheur Lake, future chemical control should have no effect for three treatments of the lake have already taken place.

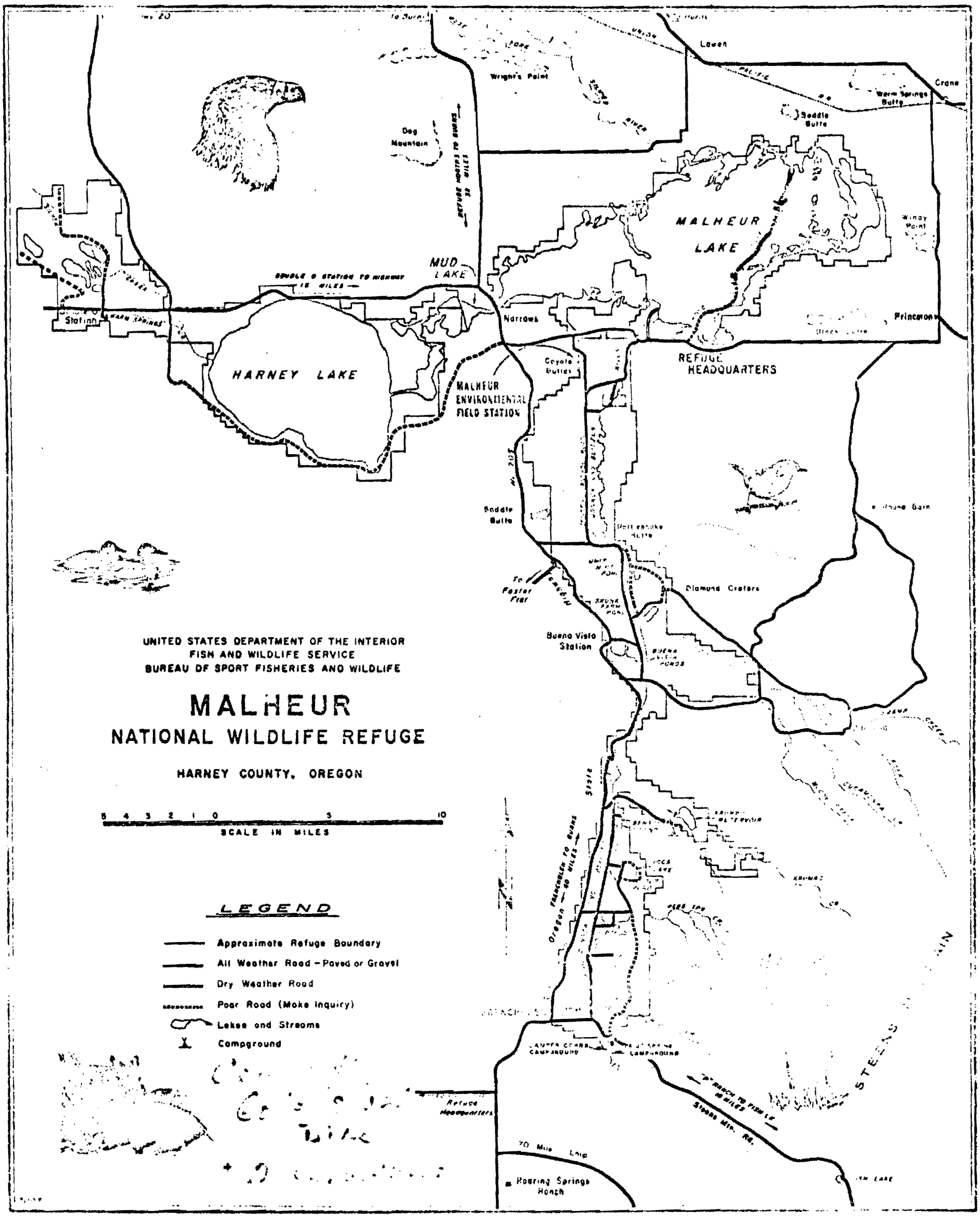
8. Problems Associated with Chemical Control of Malheur Lake - The principal problem is that control cannot be planned and carried out when productivity in the lake declines. It is economically feasible only during drought years when the lake recedes to several thousand acres.

In 1972 marsh productivity declined because of high carp populations. Water conditions have been good to excellent since then, so no control has been possible. Additional control techniques are necessary to manage the carp when they affect marsh ecology.

I. Repair Cole Island Dike, Install Water Control Structures and Manage Area East of Dike (Unit 6) for Sago Production.

1. This alternative is similar to "D", except rather than a fence barrier to carp along Cole Island Dike, a dike would be completed giving absolute control of water levels in Unit 6. See Figure 2.

Figure 2.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MALHEUR
NATIONAL WILDLIFE REFUGE
HARNEY COUNTY, OREGON
SCALE IN MILES
LEGEND
Approximate Refuge Boundary
All Weather Road - Paved or Gravel
Dry Weather Road
Poor Road (Make Inquiry)
Lakes and Streams
Campground
MALHEUR LAKE
HARNEY LAKE
MUD LAKE
REFUGE HEADQUARTERS
MALHEUR ENVIRONMENTAL FIELD STATION
Lawen
Crane
Warm Springs Butte
Saddle Butte
Wright's Point
Dog Mountain
Windy Point
Princeton
Narrows
Coyote Buttes
Station
Saddle Butte
Diamond Craters
To Foster Flat
Buena Vista Station
Roaring Springs Ranch
70 Mile Loop
Steens Mtn. Rd.

Water levels could be manipulated by water control structures. By holding water out of the unit, it could be dried up if desired. Carp could nearly be excluded from the unit by barriers on the structures.

With this type of control, the unit could be drawn down and treated with rotenone to kill carp there. Years of carp-free management would be possible. Unit 6 may be a major spawning ground so a reduction of carp in the rest of the lake may also result. Eventual retreatment of Unit 6 would be necessary when small carp entering through barriers on water structures reached spawning age.

2. Costs Involved - Costs for completion of Cole Island Dike are taken from Malheur Refuge's Master Plan dated 1965. Annual inflation was estimated at 10% for 11 years to obtain current costs.

Rehabilitation of Section of Cole Island Dike	$ 22,300
Construction of New Sections	133,500
Rip-rapping Dike	260,800
Surfacing Dike	105,200
Two Water Control Structures	50,000
	$571,800

3. <u>People Required</u> -

4. <u>Time Required to Complete Dike</u> - The timing of dike construction would have to be considered. The route of the dike through the marsh could be under three to four feet of water. Construction may have to be scheduled during a drought year.

The time required to complete the project is estimated to be

5. <u>Benefits</u> - This action would benefit waterfowl the most. Use by fish-eating birds should decline with carp excluded from the unit.

Sago pondweed would hopefully increase as well as associated invertebrates. This may attract waterfowl broods but not necessarily increase nesting efforts in that unit. Increased sago would have the greatest effect on migrating waterfowl. Swans, canvasbacks, and redheads can be expected to increase the most, with a slightly smaller increase of pintails and mallards.

The amount of bird use is related to the increases of sago pondweed. It is difficult to estimate how much more sago can be produced by controlling carp and water in Unit 6. As was pointed out in a previous section, in 1975 approximately 6,000 acres of sago pondweed were produced on Unit 6 with no control of carp there.

6. <u>Conflicts</u> - One danger that exists with this project is the ability to manage for stable water levels. This is something related to highly fluctuating water levels. Areas that are shallow and dry up frequently are the producers of sago pondweed. Deeper areas covered with water most years produce little pondweed. Stable levels also tend to encourage expansion of bulrush which would infringe on sago beds.

7. <u>Political Considerations</u> - There would be some adverse feelings about completing a dike across Malheur Lake. It would probably be based on a purist attitude of wanting to keep the marsh intact. It is doubtful that such a sentiment would be very strong.

8. <u>Problems Associated with Completing Cole Island Dike</u> - No serious problems are foreseeen. The best control of carp could be achieved by this technique. Water level management must be planned carefully.

J. <u>Dike Malheur Lake into Three Units as was Outlined in the Original Master Plan.</u>

1. This action has been considered at different times to achieve better management of water as well as to control carp. The lake could be divided into three units. Cole Island Dike would separate

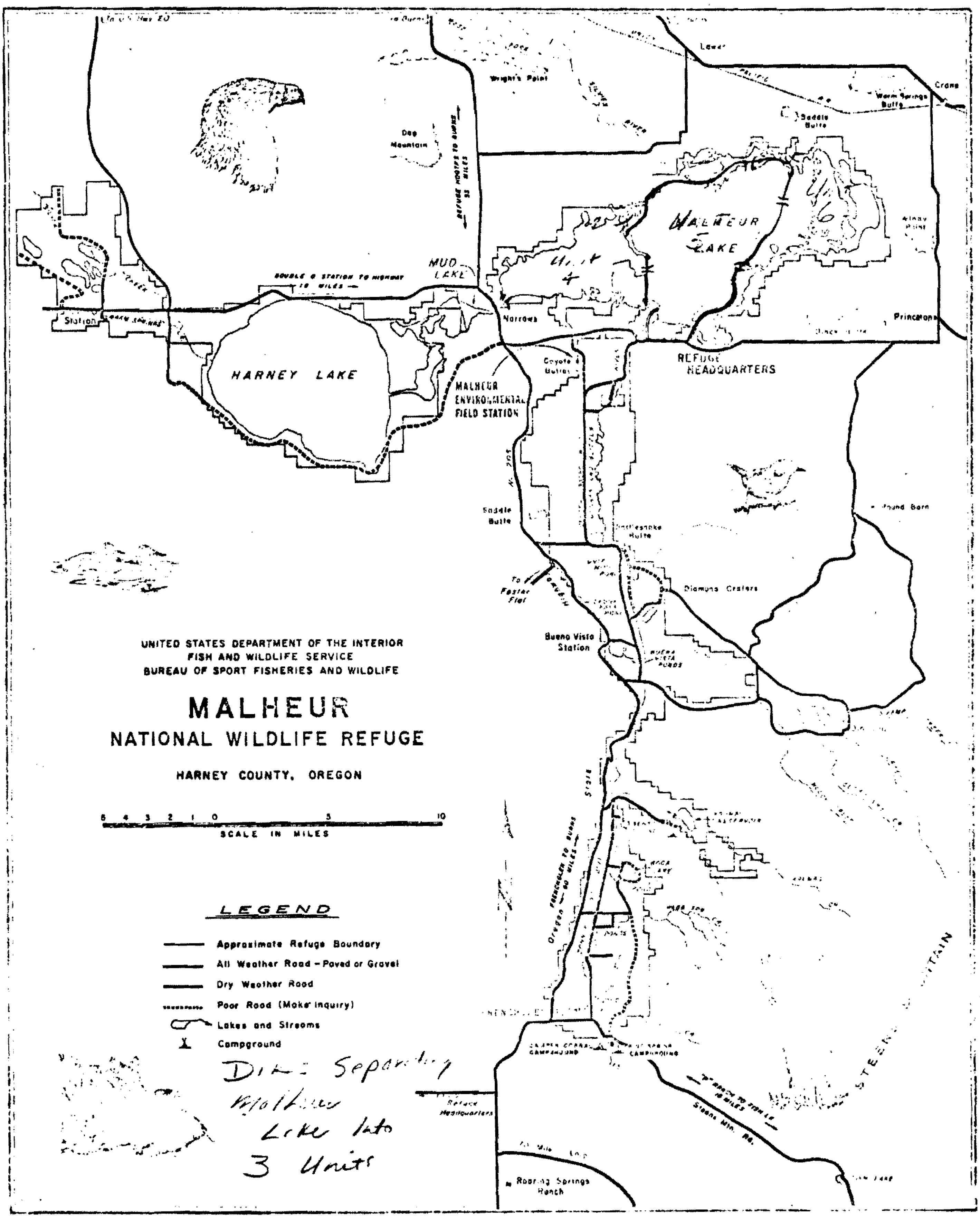
the easternmost Unit 6. A dike through the middle of the lake from a peninsula on the northern shore to the southern shore would divide the rest into the middle Unit 5 and the western Unit 4. A dike at the Narrows where highway 205 crosses would hold back water, thus giving water level control for Unit 4. Another dike across the mouth of the Silvies River would permit water flow into any of the three units. See Figure 3.

Diked units would give the capability to manage for proper distribution and density of emergent vegetation and control water to achieve maximum use. Carp could be managed in each unit for optimum bird use.

2. Costs Involved - Costs are based on engineering estimates made in 1965 found in the refuge Master Plan. An inflation of 10% per year was used to estimate current costs.

Cole Island Dike		
Rehabilitation of Present Dike	$ 22,300	
Construction of New Dike	133,500	
Riprap	260,800	
Surfacing	105,200	
Two Water Control Structures	50,000	
		$ 571,800

Figure 3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Coyote Buttes
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Diamond Craters
Bueno Vista Station
To Foster Flat
Wright's Point
Dog Mountain
Crane
Warm Springs Butte
Princeton
Station
Roaring Springs Ranch
Steens Mtn. Rd.
Dike Separating Malheur Lake Into 3 Units

Middle Dike		
Construction of New Dike	$ 71,400	
Riprap	151,800	
Surfacing	23,500	
Water Control Structure	35,500	
Spillway	1,900	
		$ 284,100
Narrows Dike		
Construction of New Dike	$ 12,200	
Riprap	10,700	
Surfacing	2,300	
Water Control Structure	35,500	
Spillway	1,900	
		$ 62,600
Silvies Diversion Dike		
Construction of New Dike, Riprap and Surface	$837,000	
Water Control Structure to Unit 5	37,400	
Water Control Structure to Unit 6	37,400	
Spillway to Unit 6	1,900	
		$ 913,700
Total Cost of Project		$1,832,200

3. People Required -

4. Time Required to Complete - Construction would have to be timed to a drought period to work in the center of the lake.

Estimated time of construction:

5. Benefits -

6. Conflicts - There could be a conflict between natural fluctuations of the lake and controlled water levels. Natural fluctuations influence and limit spread of bulrush. Receding water levels create mudflats for shorebird habitat. Lake bottoms that dry during the winter are aerated and produce submergent aquatics.

Water levels could be controlled to duplicate natural fluctuations, but there is a tendency to maintain stable water levels. This practice could encourage spread of bulrush and eliminate shallow flooded mudflats. Over a period of years, a lake with stable water levels loses productivity.

There may be a conflict regarding water rights of Larry Dunn. He has certain rights to water that overflows from Malheur Lake through the Narrows, natural overflow would be distrupted. There may be a legal conflict involved.

7. Political Considerations - Since costs are so high, funding for this project would probably have to come from Congressional appropriation. To achieve this, Oregon's Congressional representatives would have to be fully briefed and convinced of the necessity of the project.

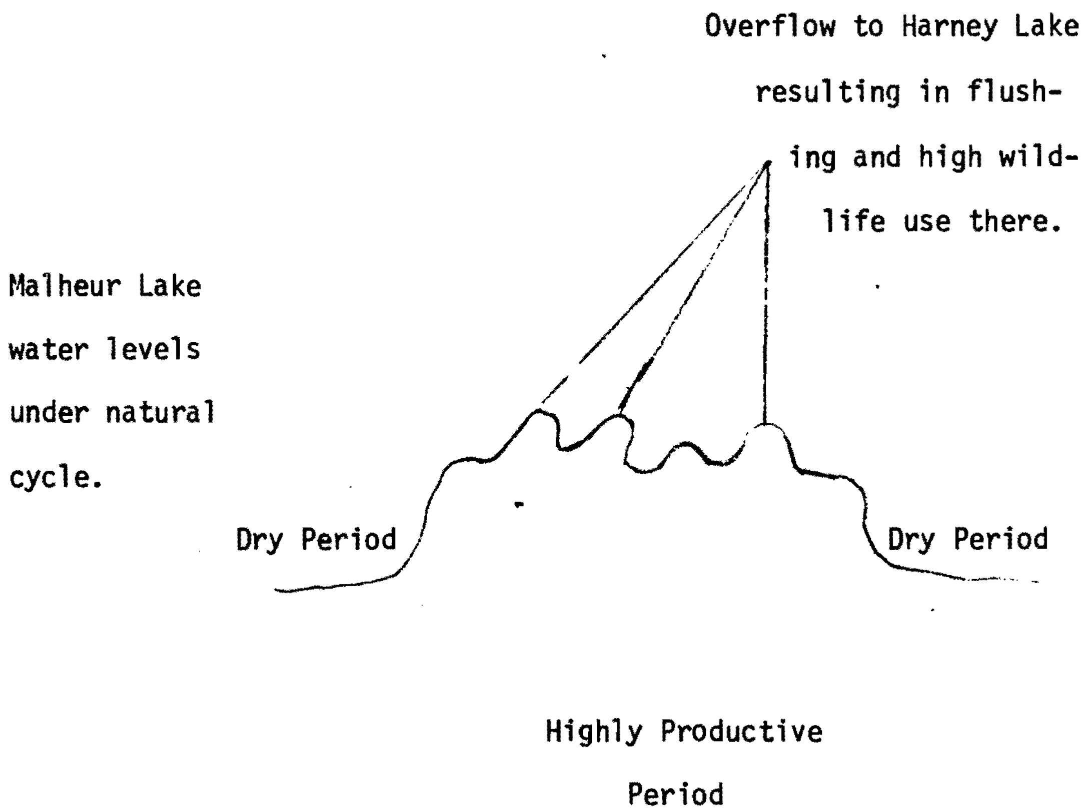
Strong opposition could be expected to proponents of diking of Malheur Lake into units. The marsh is one of the largest in western North America, mostly still in its natural state. Several groups would oppose changing its natural state and disrupting water distribution.

8. Problems Associated with Diking - The natural cycle of water flow in Malheur Lake was that during high water years Malheur Lake overflowed through the Narrows into Harney Lake. Accumulated salts in Malheur Lake were flushed out and replaced by much fresher water. Use by migrating waterfowl was also high on Harney Lake.

The dikes on Malheur Lake, particularly the one at the Narrows could hold back more water from reaching Harney Lake. Dikes would restrict water circulation and create stagnant areas where water salinity could be expected to rise. Reduction of flushing would result in more salts being deposited in Malheur Lake. With extreme care of water management, these problems could be minimized or prevented.

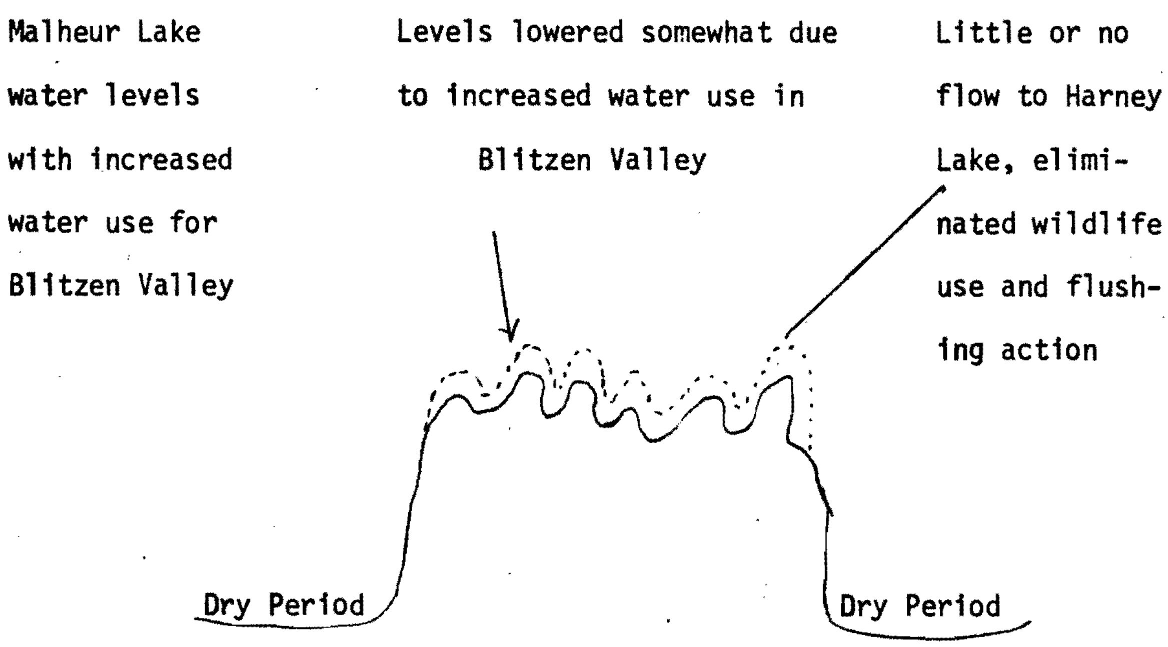
K. <u>Drain Ditch from Center of Malheur Lake to Narrows, with Water Control Structure near Narrows.</u>

1. This alternative addresses a problem more extensive than just carp control for Malheur Lake. The natural cycle must be reinstated or duplicated as much as possible to achieve maximum operation of the marsh ecosystem. During a drought period, Malheur Lake dried up, aerating and aiding decomposition of bottom material. Some emergents died out, producing openings. With the return of high lake levels bulrush and submergent plant growth was vigorous. High levels of wildlife use was the response to abundant plant growth. During periods of peak water levels, Malheur Lake overflowed into Harney Lake, flushing salts into that basin. High use by waterfowl, water birds and shorebirds occurred during these periods on Harney Lake. Probably productivity in Malheur Lake tapered off before the next dry period, depending upon the number of years between dry cycles.

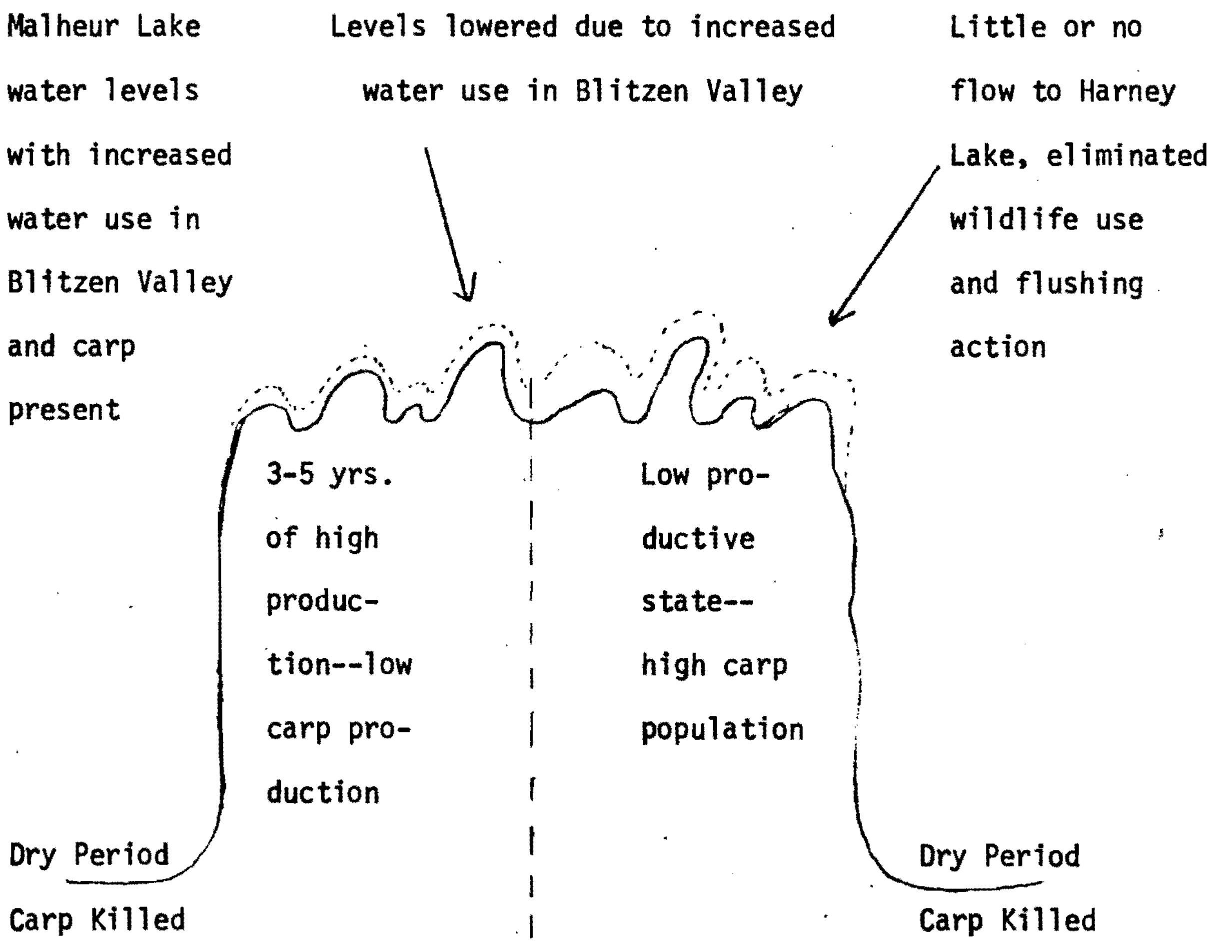


Since white man came to the Blitzen Valley, he began manipulating river water, resulting in less water entering Malheur Lake. Management of Malheur Lake has essentially been full protection. Bulrush has increased in area and density. Litter several feet thick has built up on the west sides of the lake. Even during periods of high water, such as 1975, little water can flow through the Narrows. To obtain his water right, Larry Dunn has placed an earthen dam in the channel between the Narrows and Harney Lake to redirect water that does flow out of Malheur Lake.

Results are that little or no water now flows to Harney Lake. Periods of high wildlife use on this lake are gone. Flushing of salts from Malheur Lake has nearly been eliminated. The natural productive cycle of Malheur Lake can continue temporarily; but with salts now being dumped into Malheur Lake with no outflow, in 50 or 100 years they will have a significant depressing effect on productivity. This has happened on other refuges in the west, particularly to Stillwaater Refuge in Nevada.

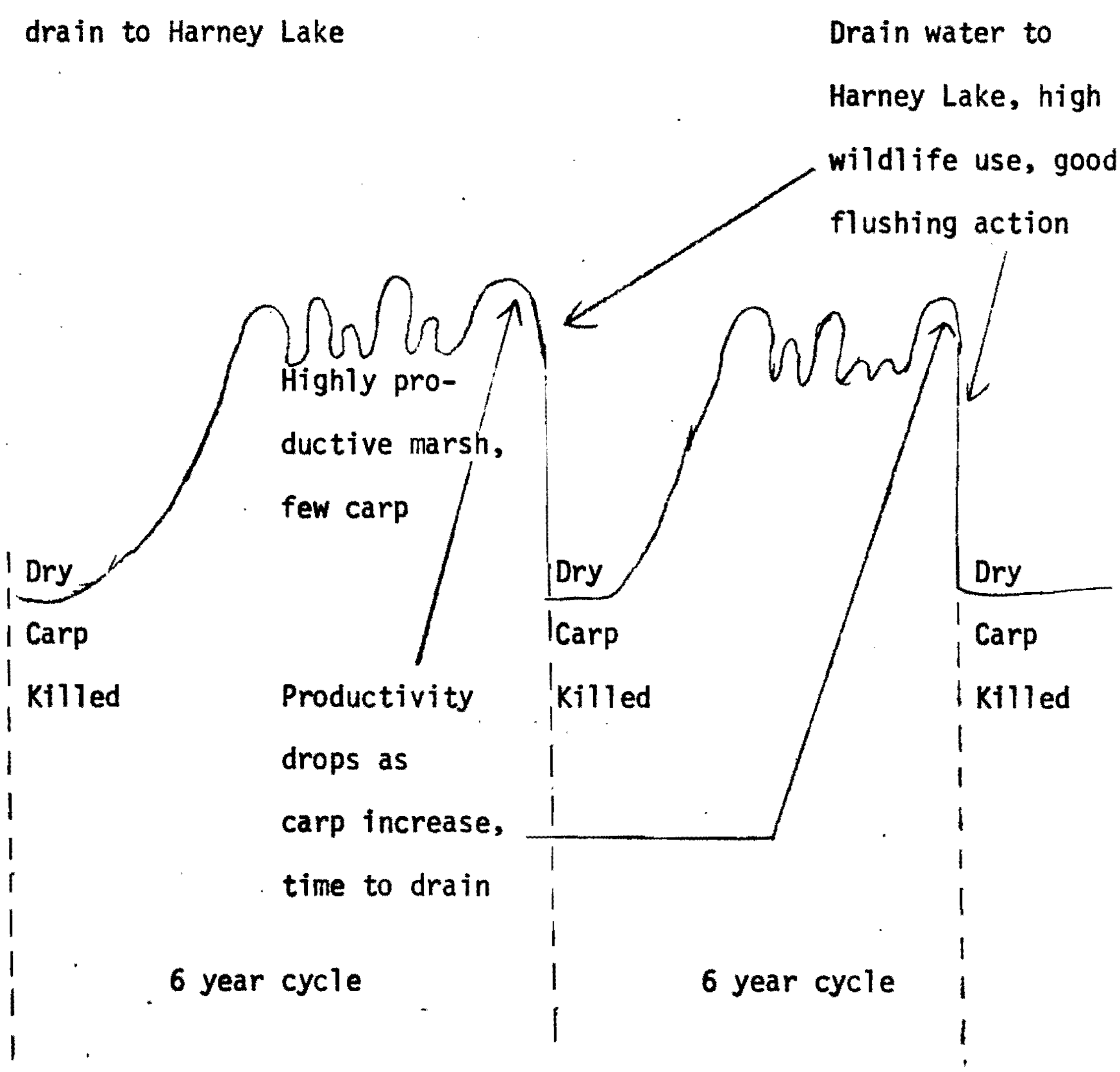


The next adverse effect to Malheur Lake was the introduction of carp. If the lake dried up completely, fairly good natural control of the fish could occur. However, some would survive in the river systems leaving brood stock to repopulate the lake. Upon refilling, the lake would be highly productive for three to five years. Then carp would again be so abundant that the lake's productive potential would be destroyed. The following years until the next drought would have a high population of carp with moderate to low wildlife use. This is the current phase of management for Malheur Lake.



A drain through Malheur Lake could be used to duplicate again the natural cycle of water flow. There is a need to bring on the dry period more often, for more than five years after control productivity is low and carp numbers high. It would also reinstate regular outflow to Harney Lake, thereby allowing flushing of salts and increased wildlife use there. If the lake was drained every six years, it would be in a highly productive state.

Malheur Lake water levels with operation of central drain to Harney Lake



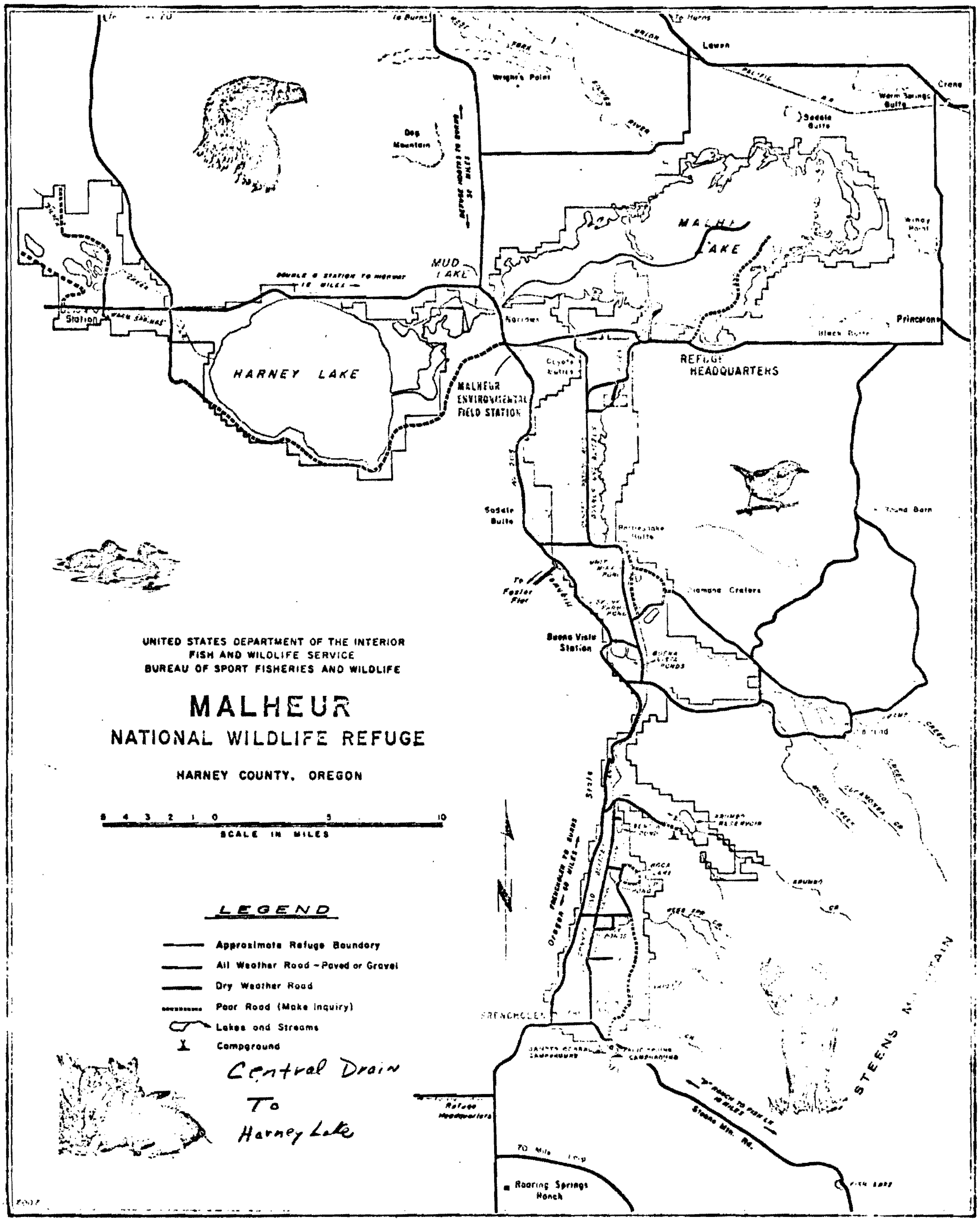
Such a drain would have to emanate from the lowest part of Malheur Lake to permit complete drainage. It should have several meanders in it to reduce any unaesthetic appearance of a long straight canal. A water control structure would be necessary near the Narrows to hold water in Malheur Lake except for drainage and to meet Dunn's water right. See Figure 4.

2. Costs Involved - Work could be performed by two methods. A dredge could be used when the lake was relatively full. When the lake was dry, a Cat and can, and dragline could be used. The cheapest cost would dictate the method.

To obtain a general idea of the costs, comparative work at another refuge was used.

		1976 Cost
1971 - narrow canal 3.7 miles long was constructed by dragline and Cat and can on dry land	- $12,600	
	$3,400/mile -	$5,100/mile
1969 - wide canal 1.0 mile long (40,000 cu. yds.) constructed by dragline on dry land	- $ 7,000 -	$12,000

Figure 4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Black Butte
Narrows
Station
Coyote Buttes
Rattlesnake Butte
Diamond Craters
Buena Vista Station
Round Barn
To Foster Flat
Frenchglen
STEENS MOUNTAIN
Roaring Springs Ranch
Steens Mtn. Rd.
Fish Lake
To Burns
To Harns

The $12,000/mile cost would be more applicable to the type of ditch needed. Work would probably be with dragline on mats even under the best conditions. Doubling the cost per mile to $24,000 should provide for the most expensive method.

Estimating the ditch to be 18 miles long, the cost should not exceed $432,000. A concrete structure is estimated at $35,000.

3. People Required -

4. Time Required to Complete - If the work is done by dragline, work would have to wait until the lake is dry.

5. Benefits - Of all the alternatives considered, this one would be anticipated to provide the most benefits. The reason is that it not only controls the carp but also keeps Malheur Lake in a highly productive state as well as providing wildlife habitat on Harney Lake.

In the fall of 1959, when Harney Lake had water, a peak of 50,000 ruddy ducks were present. In similar years, thousands of shovelers also on Harney Lake. In 1960, white pelicans, California gulls, and Caspian terns nested on an island along the south shore of

Harney Lake. If more flows were sent to Harney Lake as a result of management of Malheur Lake, many of these values could be restored as well as high shorebird use during migration.

Benefits on Malheur Lake

6. Conflicts - One conflict centers around the status of Harney Lake. It is designated a Natural Resource Area. As such, it is to be protected and natural processes allowed to occur. Consideration must be given to planned releases of water from Malheur Lake. A decision would have to be made whether this is a natural process or not. Under natural processes, water historically overflowed to Harney Lake creating the extensive alkali sump. Some may argue that planned flow to Harney Lake simulates historic flows more accurately than current management.

One factor that would be different would be that carp as well as water would flow onto Harney Lake bed. A higher amount of nutrients would be deposited there perhaps than under natural conditions.

Proponents of keeping Malheur Lake in a natural state may be opposed to any physical development. This may be a factor if Malheur Lake is again considered for wilderness status.

7. <u>Political Considerations</u> - Strong opposition could be expected. Some would not like the connotation or idea of "draining a marsh" and would oppose a "drain ditch." Some feel that the marsh should remain unmanaged and not scheduled.

Supporters would probably be more oriented toward management of natural resources. Their contention would probably be that manipulations could better simulate natural and historic conditions than present management.

8. <u>Problems Associated with Operation of a Drain Ditch in Malheur Lake</u> - Close coordination would be necessary when drainage of Malheur Lake is planned. Water management of the Blitzen Valley must be considered. As much river water as possible would have to be held in the valley.

When water is released from the valley to refill the lake, care must be exercised so a large number of carp are not introduced back into the lake. Some form of carp control would probably be necessary in the Blitzen Valley prior to drainage of Malheur Lake.

Another problem concerns Dunn's water right. During high water levels in the lake, releases could be made to fill the water right without detrimental effects to habitat. However, there could be occasions when habitat conditions are critical and a demand for water be made. If the refuge was legally required to deliver water to him under these conditions, wildlife habitat in the marsh may suffer.

VII. Information Needed

A. Ecological Data - needed as basis for evaluating the foregoing alternative solutions.

1. Location of carp concentration areas and period of year. Do carp concentrate near the mouth of the Blitzen River under the ice?

2. Location of spawning grounds. Do carp concentrate for spawning on certain parts of the lake or do they also spawn in the open marsh?

3. Identify any carp/vegetation, carp/water depth, carp/water temperature relationships.

4. Distribution of various age groups of carp under different conditions.

5. Investigate properties of the water in Malheur Lake.

   a. Is oxygen depleted from water under the ice and is water higher in oxygen content near the mouth of the Blitzen River?

b. Analysis of water pH changes over the year and parts of the lake.

6. Probability of numerous carp carcasses starting a botulism outbreak.

7. Test the effectiveness of nets and seines and traps for catching carp in the marsh environment.

8. Test effectiveness of different fencing types - mesh size/fish size holding capability, rate of deterioration of different fencing materials, and effect of different meshes on mortality of other wildlife.

9. Check the literature for the following:

   a. Effectiveness of predatory fish in controlling carp and which species would be best adapted to Malheur Lake.

   b. Diseases specific to carp.

   c. Sources to deplete oxygen under the ice - such as introduction of chemical, bacteria.

B. Legal and Regulatory Information

1. What are the implications of a dike or drain development as they relate to Dunn's water right in Mud Lake? Dunn presently gets water only when Malheur Lake spills through the Narrows. If Malheur Lake is at a level where water does not presently flow to the Norrows, could the refuge be forced to meet Dunn's water right when a drain is present?

2. What are the implications of a dike or drain development as they relate to Silvies River development proposals?

3. Would Corps of Engineers' permits be required?

C. Other

1. How would a dike or drain development alter the Blitzen Valley water management plan?

VIII. Options for Collection of Ecological Data

A. Graduate Student

Oregon State University was contacted and the refuge has been assured that a graduate student could work on the problem. A student could be available by July 1, 1976. For a Master's degree program, probably two years of field work would be necessary, and even longer for a doctorate.

To obtain some of the information, irregular year-round data collection would be necessary. This may be difficult for a student. Class requirements may interfere with data collection since considerable travel would be involved between the college and Malheur Refuge.

Since this would be a learning experience for a student, knowledge and working experience would be limited. This could be a disadvantage. It will be necessary to have expertise in some basic carp ecology to obtain needed information quickly for making management recommendations.

The cost for this option is probably the lowest, approximately $5,000 per year. Cost should be a selecting factor, but not an overriding one. This carp problem has been present on the refuge too long and requires solutions as quickly as possible. Tremendous wildlife values are continually being lost each year. The quickest and best recommendations should be the goal.

B. Part-time Assignment of Service Employee from Fishery Services or Division of Research

The second alternative would be part-time assignment to the refuge from another duty station. This could be an employee from the Division of Fishery Services or Research.

Such an assignment should be capable of being arranged by July 1, 1976. Part of a spawning season would be lost, however. The assignment periods would probably encompass two summer periods and one winter. Tentative dates for assignment to the refuge would be July-September, December-January, and April-September. This would include 11 months between July, 1976 and September 30, 1977. Perhaps more time would be needed for analyzing results and writing recommendations. This could be done at his permanent duty station. One problem of temporary assignment from a permanent station is priority of work. There is a tendency to sideline field work when there is a conflict with report deadlines, etc. Under this type of work assignment, there may be problems maintaining the desired schedule in the field.

Costs would be more than using a graduate student. Equipment expenses for airboat, etc. are estimated to be $2,000. The employee grade would probably be GS-7 or 9. Considerably more experience could be expected from a GS-9. Salary costs could be expected to include approximately 12 months with total costs ranging from $13,500 to $16,000.

With this option, there would not be the problem of obtaining clearance for a new position. The ceiling number of positions would not have to be considered.

C. Full-time Temporary Assignment of Service Employee at Refuge

The third option is to establish a full-time temporary position at the refuge. July 1, 1976 should be possible for a starting date, if not sooner. An 18 month appointment would enable field study for one complete spawning and winter cycle as well as several months of additional investigations. Adequate time would be available for data analysis and completion of recommendations.

By being stationed full-time at the refuge, more time would be available to collect data at various times of the year. There would be time to investigate more ecological relationships of Malheur Marsh as well as relationships to the rest of the refuge.

There may be some problem getting a full-time appointment for 18 months. Perhaps this could be filled by a 39 hour a week appointment.

This would be the most expensive of the options. A fishery biologist with good basic knowledge could be expected at a GS-7 salary. For one with enough experience to work independently with a minimum of supervision, one would require at least a GS-9.

Additional costs of $2,500 could be anticipated for airboat operation and the expenses. Total costs would range between $19,750 for a GS-7 and $23,500 for a GS-9.

IX. Recommendations

This analysis has attempted to show historic wildlife uses of Malheur Lake compared to the much smaller present uses. Most of the difference can be attributed to detrimental effects of carp on lake ecology. Suggested methods of carp control were presented, demonstrating the kinds of information that are unknown. These are the questions that must be answered to determine which solutions to the carp problem are feasible. Then, feasible solutions must be analyzed to determine which would afford the best control over carp populations.

Three options were presented to collect necessary biological data. A graduate student would be cheapest, but would have difficulty gathering data at various times of the year. As part of a college graduate program, two years of investigation would probably be involved and another year before the final thesis was completed. At that rate, it would be three years before answers would be obtained.

The alternative is to use a Service employee. By this method, results could be obtained in approximately 18 months. By borrowing an employee from another division for part-time work, it would be less expensive, but again the time for data collection is interrupted and does not provide a smooth accumulation of knowledge.

The best option appears to be establishing a position at the refuge where the employee will stay for the duration of the study. Field work and data analysis can continue throughout the entire period. This is the most expensive option, but the additional insight and experience gained through continuous exposure to the problem is worth the extra funds. At the end of 18 months, a final report can be expected. A list of alternative solutions would have been considered, and management can then make the final selections for control techniques.