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A History of Fisheries Assessments and Stocking Programs in Harding Lake, Alaska, 1939-1989

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Alaska Department of Fish and Game

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A HISTORY OF FISHERIES ASSESSMENTS AND STOCKING PROGRAMS IN HARDING LAKE, ALASKA, 1939 - 1989[1]

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ABSTRACT

This report summarizes the stocking of fish into Harding Lake from 1939 to 1990, and summarizes the evaluations of those introductions. Because of its' size and proximity to Fairbanks, Alaska, Harding Lake has the potential to support a major sport fishery. Most efforts to enhance sport fishing by the introduction of game fish species were not successful because few, if any, stocked fish survived to be harvested. The recent introduction of Arctic char *Salvelinus alpinus* in Harding Lake demonstrated that a sport fishery can be developed through a stocking program utilizing an appropriate species combined with efforts to inform the public of both the presence and appropriate methods for catching the stocked fish.

KEY WORDS: Harding Lake, enhancement, stocking evaluation, Arctic char *Salvelinus alpinus*, coho salmon *Oncorhynchus kisutch*, inconnu *Stenodus leucichthys*, rainbow trout *Oncorhynchus mykiss*, lake trout *Salvelinus namaycush*, burbot *Lota lota*, northern pike *Esox lucius*, least cisco *Coregonus sardinella*, Arctic grayling *Thymallus arcticus*, sockeye salmon *Oncorhynchus nerka*.

INTRODUCTION

Harding Lake is the largest, deepest, and most accessible of the four large roadside lakes (Birch, Chena, Harding, and Quartz) within a two hour drive of Fairbanks, Alaska. Until Chena Lake was created by the Corps of Engineers and opened for recreational use in 1983, Harding Lake was also the closest of these lakes to Fairbanks. Harding Lake has been used for all types of aquatic recreational activity over the years, including boating, swimming, water skiing, waterfowl hunting, and sport fishing. Numerous visitors, area residents, and lake-front property owners enjoy various combinations of the recreational opportunities available.

Over the last 50 years there has been a perception among fishery managers (Federal managers prior to 1959, State managers thereafter) that angling effort was not what it could be at Harding Lake. Fish species indigenous to Harding Lake include northern pike *Esox lucius*, burbot *Lota lota*, least cisco *Coregonus sardinella*, and slimy sculpin *Cottus cognatus*. Northern pike was the only indigenous species targeted in the sport fishery at Harding Lake until fishing for burbot became popular in the late 1960's and early 1970's. By the early 1980's the burbot population had declined, and regulatory restrictions were invoked.

Fishery managers perceived that northern pike were not sought as a sport fish because some anglers considered them to be "rough". The predatory nature of northern pike was considered to be harmful to populations of desired game fish, (and sometimes waterfowl), including stocked rainbow trout *Oncorhynchus mykiss*, and stockings of Dolly Varden *Salvelinus malma*, and sockeye salmon *Oncorhynchus nerka* contemplated in 1941. In addition, northern pike were present in many lakes, sloughs, and ponds along the road system, which reduced their "uniqueness" in Harding Lake. This early perception of the northern pike as a poor game fish persisted until the mid - 1960's. In early reports and communications between fishery managers, northern pike were mentioned as a species present in the lake only in the context of the difficulty of maintaining stocked "game fish" populations in the face of their predation (Anon. 1941; Anon. undated; McKirdy 1960; Andrews 1962). Chemical eradication of the entire fish population of Harding Lake was considered as a solution to the "problem" (McKirdy 1960; Anon. undated). In an early Federal Aid project proposal (Anon., probably 1964), spraying liquid rotenone onto and gill netting concentrations of spawning northern pike was proposed as a method of enhancing the potential survival of lake trout *Salvelinus namaycush* to be stocked into the lake as eyed eggs.

Until 1960 there was no bag, possession, or size limit for sport-caught northern pike in the Tanana drainage, and they could be speared year-round (until 1971). Outside of the Tanana drainage, northern pike could be taken without limit by nets, traps, and spear until 1972, when year-round sport harvest was restricted to spear and hook and line only. Year - round spearing of northern pike was eliminated from the regulations in 1976, and bag and possession limits were instituted outside of the Tanana drainage in 1988. The evolution of the status of northern pike into a valued and protected game fish and the decreased general availability of northern pike along the road system of the Tanana Valley most likely contributed to the increasing angler effort

and northern pike harvest in Harding Lake. In 1984, 1,707 angler days were expended at Harding Lake (Mills 1985) and 766 northern pike were harvested (along with 428 burbot and 65 stocked landlocked coho salmon *Oncorhynchus kisutch*). By 1988 angler effort had increased to 3,256 angler days (Mills 1989) or 2.3 angler days per ha and harvest of northern pike was estimated at 2,092 (Table 1). The northern pike population of Harding Lake may not be able to sustain such high harvest levels. Presently, a fishery management goal of Harding Lake is to provide additional fishing opportunities through the introduction of stocked fish, while restricting harvest on indigenous game fish.

This report is being written as Alaska Department of Fish and Game fisheries managers increasingly focus their efforts upon Harding Lake. It summarizes past fisheries research and management efforts with emphasis on the results of the introductions of non-indigenous fish species. Historical and enhancement efforts are summarized and are provided as a foundation for future fisheries enhancement, research, and management.

AREA DESCRIPTION

Harding Lake is located in the Tanana River drainage in interior Alaska, 54 km (72 km by road) southeast of the city of Fairbanks, near the confluence of the Salcha and Tanana rivers (Figure 1). Harding Lake is generally circular in shape, except for a prominent point in the middle of the southern shoreline (Figure 2). Surface elevation of Harding Lake is 217 m, surface area is 1,000 ha, and maximum depth is 43 m. The surrounding terrain consists of forested hills with elevations from 244 m (in the pass between adjacent Little Harding Lake and the Tanana River) to 457 m (along the southeastern shoreline) and the lowlands of the Salcha Valley to the north.

The water is transparent green except during periods of heavy runoff from the East Inlet, when parts of the lake can become tannic stained. The littoral zone (from the shore to 5 m depth) underlies 33% of the surface area of the lake. The outer margins of the deep weed-beds (*Potamageton* sp.) are at 5 m. The bottom in the shallow areas is sand, sand and gravel, or silt. There are a few areas where larger rubble is mixed in with sand and gravel, but there is nothing that could be characterized as a boulder patch or reef, and there are no bedrock intrusions. The deeper water is underlain by a layer of loose organic and clay sediment (Nakao 1980). Aquatic vegetation ranges from emergent grasses along shallow areas and in swamps through pond-weeds, tape grasses and rushes in deeper nearshore zones to large beds of *Potamageton* in deeper littoral flats and along drop-offs. Beds of *Chara* sp. carpet the bottom along the outer edge of some of the deep *Potamageton* beds. Aquatic vegetation other than attached algae is not found in large areas of the littoral zone along the north end of the lake and a smaller zone along the middle of the southern shoreline. Macrophytes are probably not able to colonize these areas because of bottom type (sand and gravel), wave action, freeze-down, and ice-scouring. Lily pads, common in many Tanana Valley lakes, (including Little Harding Lake) do not exist in Harding Lake.

Table 1. Harding Lake sport fish harvest and effort, 1984-1989[a].

Year	Anglers	Trips	Days Fished	Species								
				Coho Salmon	Lake Trout	Arctic Char	Rainbow Trout	Arctic Grayling	Sheefish	Northern Pike	Burbot	Other
1984	436	1,219	1,707	65	0	0	0	0	0	766	428	0
1985	583	910	850	35	0	0	0	0	0	503	0	0
1986	1,590	1,758	2,064	0	24	0	0	0	0	673	0	0
1987	3,371	4,032	5,125	0	0	0	118	79	0	1,886	53	0
1988	2,599	3,806	3,256	0	55	0	73	0	73	2,092	73	0
1989	2,976	4,098	4,935	0	119	141	456	0	0	1,764	10	0

a Mills 1986 -1989; and personal communication, 333 Raspberry Rd, Anchorage, Ak.

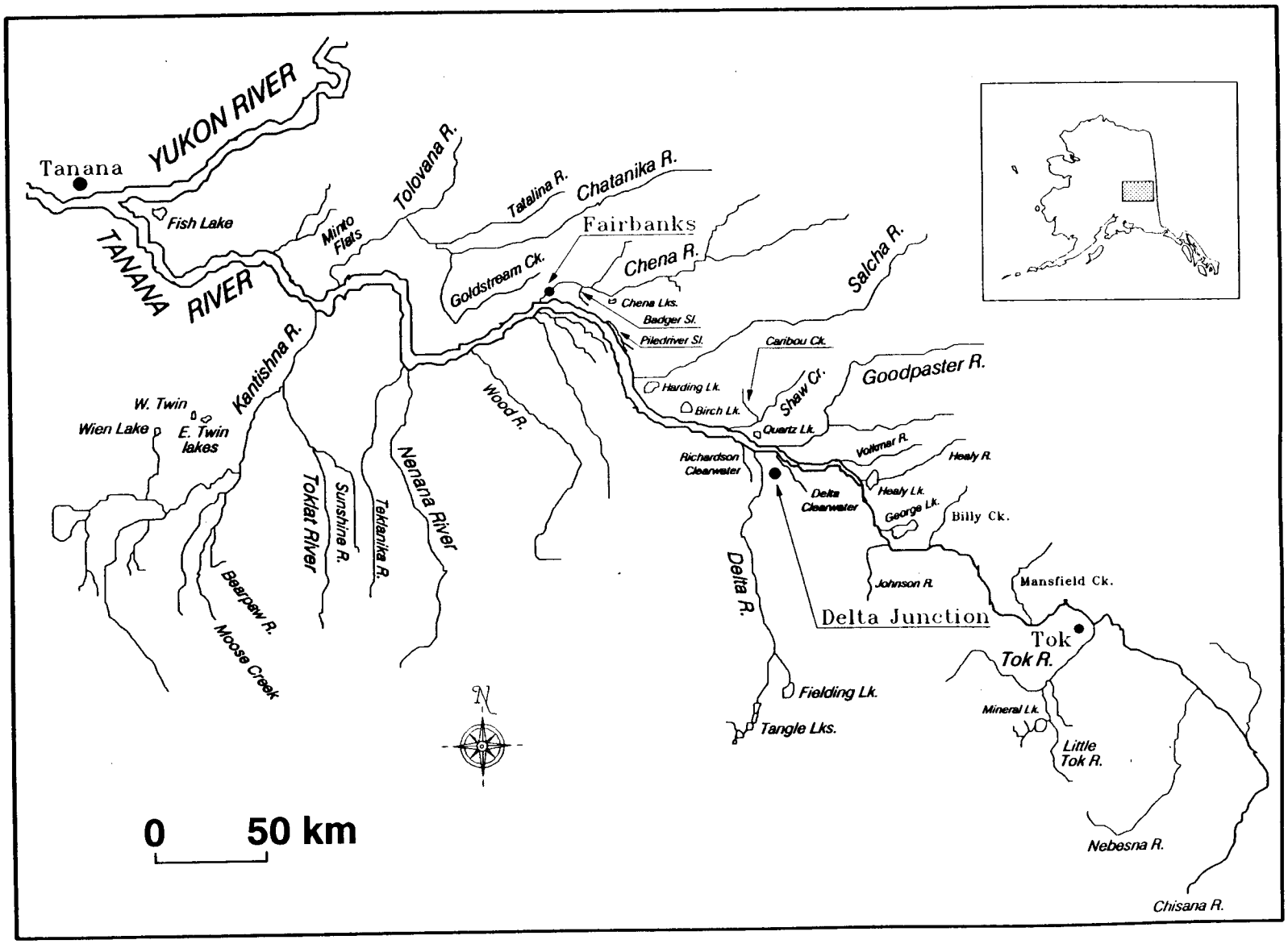

Figure 1. Tanana drainage waters.

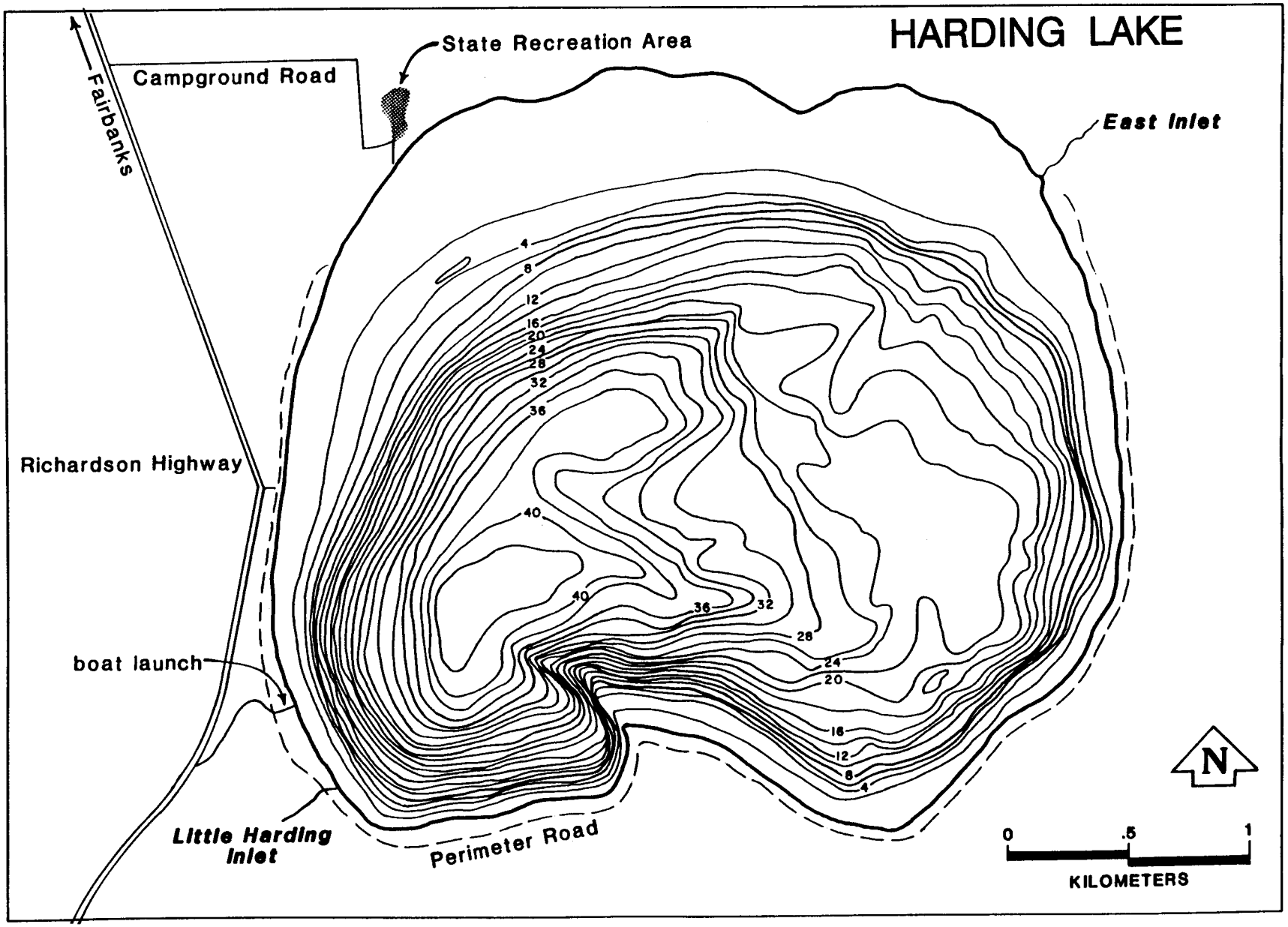

Figure 2. Access to and contours (2 meter intervals) of Harding Lake.

During the period 1977-1989, freeze-up dates (the day the last of the open water became ice covered) ranged from October 25 to November 19. Breakup dates (referring to the day when the last of the ice disappeared from the lake) ranged from May 12 to June 6. Maximum ice thickness recorded during this period was 107 mm. Winter water temperatures ranged from 2.5° C just under the ice to 3.5° C in deeper water (Doxey 1984).

The contiguous lake basin has a drainage area of 1,000 ha. In addition to hillside runoff, the lake is fed by springs, permafrost seeps (Nakao 1980) and two inlets. One of the inlets is from Little Harding Lake. The other is the East Inlet, draining a 2,580 ha basin to the east of Harding Lake. This stream comes to a divide at which most of the water sometimes flows into the Salcha River and sometimes into Harding Lake. Harding Lake has no outlet to the Tanana or Salcha River system or to any other lake. Lake water flows into small areas of adjacent wetlands during periods of high water levels. The lake level has varied historically from extreme high water margins at forested banks, to low levels with large areas of swamps and dry flats. These cycles occur in response to drainage changes and climatological trends.

The most recent drying cycle began after 1967. In August 1967, heavy rains created flooding and high ground water levels throughout the central Tanana Valley, including the Salcha River Valley. By freeze-up, water level of Harding Lake was at the forested banks. By the mid-1970's the water level declined to a level about 1 m lower than the level in 1979 and 1980. Large areas of productive, swampy flats at the north end of the lake dried up, and willow and birch thickets grew in what had been spawning and rearing habitat for northern pike, rearing habitat for young least cisco, and generally productive littoral habitat. By 1982, the drying trend had visibly reversed itself, and the lake had come up about 0.3 m from its lowest level (Doxey 1983). By 1989, the water had reclaimed much of the area that had dried up, although not to the high level previously noted. The willows and birch trees that had colonized the dried up wetlands were dying, and the swamps were once again being utilized by aquatic life. Some aquatic habitat loss may occur, however, if (as in the past) woody debris creates backwaters that eventually become bogs. Nakao (1980) conducted water budget and lake level stability studies at Harding Lake in July of 1978, when the level of the lake was dropping and nearing the low point of the most recent low water cycle. Since that time, the East Inlet has periodically discharged water into the lake from its entire potential drainage, including the area above the divide at which the water must either flow into the Salcha River or into Harding Lake. This discharge has helped to raise the lake level, and was measured at 0.65 m^3/s during peak spring runoff on May 9, 1983 (Doxey 1984).

The productivity of Harding Lake is generally described as low (LaPerriere 1975; Nakao 1980) and analysis by the USGS Central Laboratory in Salt Lake City, Utah of water samples taken in 1975 confirms this. Conductivity and hardness are indicators of total dissolved solids which in turn is an indicator of lake productivity. Conductivity was measured at 70 μmhos for Harding Lake, compared to 110 μmhos for Birch Lake and 400 μmhos for Quartz Lake. Similarly, total hardness was 27 mg/l for Harding Lake, compared to 55 mg/l for Birch Lake and 200 mg/l for Quartz Lake. These measurements were

taken during a dry period, and may not be indicative of productivity at times of higher water levels.

Access to Harding Lake is provided by three roads exiting the Richardson Highway (Figure 1). One leads to the campground managed by the Alaska Department of Natural Resources. The other two roads connect with Salchacket Drive, which parallels approximately three fourths of the shoreline. There is no road access to the north shore. Some recreational users travel to the lake in float planes. There are private cabins, homes, and other human development along 50% of the shoreline. Docks, rafts, and boat lifts dot the inhabited areas of the shoreline in the summertime. The large State campground on the northwestern shoreline has a boat launch and channel, a swim beach, numerous campsites and parking spots, athletic fields, and some undeveloped areas for hiking and unstructured outdoor recreation. In some years, concessionaires have canoes and small boats for rent. There is one other public boat launching area (known as the Borough Landing or Old Landing) on the western shoreline, with limited parking. The U.S. Army manages a recreation area on the southern shore, consisting of a parking and rest area, undeveloped beach, a toilet, and a camping area on the hillside above the rest area. Some improvements have been made in the past few years. The Presbyterian Church runs a summer camp (Camp Bingle) with a lodge, cabins, outbuildings, and a swimming beach located on the southeastern shore. There are no commercial lodges or hotels on the lake. Recreational use of Harding Lake peaks during hot weekends in June and July, and consists predominantly of swimming, boating, and water skiing. In winter the campground is closed and public access is very limited (due to drifted snow). Numerous trails in the nearby woods are used by snowmobilers and cross-country skiers as is the frozen lake itself.

During the summer, anglers usually wade through the swamps along the north end of the lake fishing for northern pike, or fish along the margins of the swamps and the littoral areas from boats for that species. A few anglers fish in deep water for lake trout or burbot. Winter fishing has consisted of limited effort for burbot, and a low level of effort for northern pike and lake trout. Little Harding Lake, adjacent to Harding Lake, is stocked with rainbow trout, Arctic char, and coho salmon *Oncorhynchus kisutch*. This 21 ha lake is accessible from Salchacket Drive and there is a parking lot and launching area for small boats and canoes. Two other small lakes to the northeast of Harding Lake (Spencer Lake and Whale Lake) are inhabited by populations of stunted northern pike. Rainbow trout have been stocked into Spencer Lake. Access to these lakes is by trail.

SUMMARY OF DATA COLLECTED ON INDIGENOUS SPECIES

Information has been collected from northern pike during fisheries evaluations and assessments through the years, but no major studies specifically targeting the Harding Lake northern pike population occurred prior to 1990. Harvest of northern pike in Harding Lake was estimated at 766 in 1984, 673 in 1986, 1,886 in 1987, and 2,092 in 1988 (Mills 1985, 1987, 1988, 1989). Concurrently, angler effort increased from 1,707 man-days in 1984 to 4,935 man days in 1988. Northern pike captured during studies by the Alaska Department of Fish and

Game (ADFG) were sampled for length, and stomach contents. Some length-at-age information was compiled and included in Federal Aid Reports (Doxey 1983, 1985; Hallberg 1978). Mean lengths of northern pike sampled from 1959 through 1978 ranged from 464 mm (n=16) in 1966 (Roguski 1967) to 533 mm (n=35) in 1959 and 1960 (McKirdy 1960, Unpub.). Mean length of northern pike measured in 1978 was 500 mm (n=85). Mean lengths of northern pike sampled after 1979 are not representative of net catches, because larger fish were returned to the water with as little handling as possible to minimize injury to spawning sized fish which were considered to be decreasing in abundance. Smaller northern pike were more likely to be sacrificed for examination of stomach contents and collection of structures for age-length determinations. The largest northern pike documented at Harding Lake was a female (1,140 mm and 13.62 kg) taken with a gill net in 1976. Few other northern pike over 5 kg have been documented. Northern pike have not been captured at depths greater than 14 m (Doxey 1982) but have been captured above the thermocline over deep (30 m) water. Northern pike spawn and rear in very shallow waters (generally less than 1 m) and heavily vegetated areas of Harding lake. Optimal northern pike spawning areas were summarized by Wright and Shoesmith (1988) as dense mats of short grasses and sedges in shallow water. The consequences of the loss of over half of the northern pike spawning and rearing habitat due to the dry period of the 1970's was undocumented.

Data has been collected on burbot in Harding Lake during fisheries studies (Parker 1987, 1988, 1989). In the mid - 1970's and early 1980's burbot in Harding Lake were targeted by anglers using set-lines intensively during the early winter (Doxey 1981). Effort had declined, probably in response to diminished catches, by the mid - 1980's. In 1987 fishing with set-lines was prohibited by emergency order because of low catch-per-unit of effort (0.45 burbot per hoop net per day) in the spring of 1987 (Parker 1988), compared to that from other lakes of similar size. In 1988, a regulation prohibiting the use of set lines for burbot was passed by the Board of Fisheries and is still in effect. Mean length of 114 burbot sampled in 1987 was 434 mm (SE=12). Burbot are present in shallow water (less than 1 m under the ice) in late fall and winter, but are generally restricted to deeper water in summer (Doxey 1988). Burbot prey on least cisco and slimy sculpin, and occasionally on a large type of caddis nymph that occurs in Harding Lake.

The least cisco population in Harding Lake consists primarily of fish of ages 0 - 3, with a small proportion of larger, older fish (Doxey 1985; Clark and Doxey 1989). Mean length of 22 least cisco collected with gill nets in 1972 was 157 mm (Peckham 1973). Mean length of 28 least cisco sampled in 1974 was 156 mm (Kramer 1975). Mean length of 219 least cisco collected with a tow net in October, 1988 was 155 mm (Clark and Doxey 1989). Adult least cisco have been documented as inhabiting almost all portions of Harding Lake, from the margins of the emergent vegetation to water 36 m in depth. Occasionally least cisco have been found at 43 m (Doxey 1983).

A sharp decline in the Harding Lake least cisco population was noted in 1977 (Hallberg 1978). CPUE (catch-per-net-night) for 119 net nights was 0.07 fish/net night (nine least cisco were captured during the entire summer of 1977) using sinking monofilament gill nets. In contrast, Peckham (1971) reported capturing 28 least cisco during 14 net nights (2.0 fish/net night) of

sampling in 1969, with the same type of nets used by Hallberg (1978). In 1979, large schools of young least cisco were observed in the surface waters of Harding Lake, and CPUE was 0.98 fish during 42 net nights (Doxey 1980). By 1982 CPUE had increased to 19.6 fish per net night (Doxey 1983), and in 1983 was 19.2 fish per net night (Doxey 1984). Test netting in 1989 produced 13.6 fish per net night.

Hallberg (1978) attributed the decline of Harding Lake least cisco in part to predation from stocked coho salmon. It is likely that lowered water levels contributed to the vulnerability of least cisco to predation. From the time in early spring when the ice is no longer bottom-fast until about mid - June least cisco fry use shallow (0.05-0.35 m) vegetated areas of the lake extensively for feeding and cover. By mid - summer, they move offshore. Auvinen (1988) noted similar behavior in vendace *Coregonus albula* in Lake Pyajarvi in southeastern Finland. Loss of the vegetated shallow zone during periods of low water may affect the forage base used by juvenile least cisco, and at the same time increase their vulnerability to predation. Mclain and Magnusen (1988) suggested (and provided supporting evidence) that introduced smelt preyed heavily on juvenile least cisco moving into open water in Wisconsin Lakes. Adult least cisco have been observed preying upon least cisco fry in the shallows of Harding Lake in the springtime (Doxey 1985). Recovery of the least cisco population in Harding Lake coincided with the cessation of the stocking of large numbers of coho salmon fingerlings, a rise in lake level, and heavy exploitation of the burbot population by anglers using set-lines.

Least cisco are an important food item for the large predatory fish of Harding Lake. Kramer (1974) reported that of the 52% of the 116 northern pike stomachs that had identifiable contents, a majority (40%) contained least cisco remains. Hallberg (1979) examined 85 northern pike stomachs in 1978, and of the 42% that had recognizable contents, 21% contained least cisco Hallberg also reported least cisco present in the stomachs of lake trout and burbot. Doxey (1983) reported least cisco remains in 13 of 21 northern pike stomachs examined (six stomachs were empty).

Slimy sculpin are preyed upon by burbot. Hallberg (1979) found that 11% of the northern pike stomachs containing identifiable food items contained slimy sculpin. Slimy sculpin remains predominated in the 15 burbot stomachs examined in 1984 (Doxey 1985). Little documentation of slimy sculpin life history or abundance exists.

HISTORICAL REVIEW OF INTRODUCTIONS

Species Introduced

By the late 1930's, fishery managers had concluded that angling potential at Harding Lake should be improved. The recreational value of the largest roadside lake in the Tanana drainage had been recognized. By the mid-1980's, the value of stocked lakes as a management tool to direct angler effort away from heavily-utilized wild populations had been recognized, and the development of new fisheries in waters such as Harding Lake became more

important. The first documented stocking of Harding Lake was the introduction of 12 lake trout in 1939 (Table 2). The introduction was apparently a joint effort of the Alaska Game Commission and the U.S. Fish and Wildlife Service, with the U.S. Forest Service providing the fish. Rainbow trout were also stocked, but no survival or harvest was documented (Anon. 1941). Plans were made in 1941 to increase the number of lake trout and rainbow trout stocked into Harding Lake and to expand the program by stocking sockeye salmon *Oncorhynchus nerka*. There was an agreement with the Tanana Valley Sportsmen's Association (TVSA) for them to help capture and transport lake trout brood stock, and possibly assist with the maintenance of rearing facilities. Work was to start in the spring of 1942. By then all of the spare civilian manpower and time was devoted to the War effort, and no further reference to fisheries work exists in historical documents until 1960, when a report mentions the stocking of rainbow trout fingerlings beginning in 1956 (McKirdy 1960).

In 1963, 252 adult lake trout were transferred from Boulder and Twobit lakes in the Alaska Range to Harding Lake. This was a cooperative venture between ADFG and the United States Army, which provided manpower and transported the fish in military helicopters (Heckart 1964). The event was repeated in 1965, when 235 adult lake trout were removed from Monte Lake and stocked into Harding Lake. Both stockings of adults were from populations of stunted, slow growing fish. In mid-winter of 1965, 88,000 eyed lake trout eggs were lowered through the ice in wire hatching baskets. These eggs were taken from Susitna Lake in October and incubated to the eyed stage at the Fire Lake Hatchery. An estimated 75,000 eggs were successfully hatched (Heckart 1966). In 1967, 31,200 fingerlings were stocked. Lake trout were next stocked in 1990, when 72,000 fingerlings were released from an in-lake net-pen rearing facility (Viavant et. al 1991 in draft).

Coho salmon were stocked into Harding Lake from 1968 to 1981. Numbers stocked ranged from 32,215 in 1981 to 697,500 in 1976. All coho salmon were stocked as fingerlings with the exception of 20,000 in 1973 and 2,301 in 1975 (Table 2). In these cases, larger fish were stocked as part of an experiment in which coho salmon were reared for a year in a more productive nursery lake (Little Harding Lake) and subsequently stocked into Harding Lake as smolts in order to compare their survival and subsequent contribution to the fishery to that of coho salmon stocked as fingerlings (Kramer 1977). Hallberg (1980) summarizes these experiments in detail.

Inconnu or sheefish *Stenodus leucichthys*, were stocked into Harding Lake from 1982 to 1989 in an attempt to develop a fishery. Stocking sizes ranged from fry averaging 0.15 g to a small stocking of adults at 2,367 g (Table 2). Sheefish were stocked through the ice, along the shoreline in summer, and in deep water from a boat to minimize predation. Immediate mortality ranged from 0 in some stockings of larger fish to 100% for one cohort of stressed fingerlings. Sheefish fingerlings experienced a chronic swim bladder problem in which they could not expel gas and consequently gradually self-inflated. Ultimately, these fingerlings swam upside down at the surface of the water with turgid, balloon-like abdomens, or, if stocked under the ice, floated against the bottom of the ice until they died. Fish in such a condition in open water were quickly eaten by seagulls (Doxey 1983). This problem was

Table 2. Harding Lake stocking history, 1939 - 1990[a].

Year	Species Stocked, Size, and Number													
	Lake Trout	Size	Arctic Char	Size (g)	Coho Salmon	Size (g)	Sheefish	Size (g)	Rainbow Trout	Size (g)	Grayling	Size (g)	Sockeye Salmon	Size (g)
1939	12	Adult												
1956									37,000	1.0-2.7				
1958									14,900	0.6				
1959									46,050	0.4-1.0				
1960									23,700	1.2-2.5 g				
1963	252	Adult												
1965	235	Adult												
	75,000	Fry												
1967	31,200	Fing												
1968					375,800	Fing								
1969					338,500	Fing								
1971					232,800	Fing								
1973					149,100	1.0-3.5								
					20,000	12.6								
1975					314,000	1.0-1.8								
					2,301	32								
1976					697,500	0.9-1.8								
1977					468,262	1.1-2								
1978					521,093	0.7-1.8								
1981					32,215	3.0								
1982							221,735	1.0						
							370	150						
1984							211,641	0.6						
1986							88,460	13	187,485	3.3-4.4	79,412	2.0		
1987							239,640	3.7-11.4	544,200	0.2	640,000	0.02		

-continued-

Table 2. (Page 2 of 2).

Year	Lake Trout	Size	Arctic Char	Size (g)	Coho Salmon	Size (g)	Species Stocked, Size, and Number: Sheefish	Size (g)	Rainbow Trout	Size (g)	Grayling	Size (g)	Sockeye Salmon	Size (g)
							35	2367	582,021	2.0				
1988			30,770	52			60,000	0.15	248,658	1.3	1,169,806	0.02	500,000	0.02
1989			8,391	122			109,503	0.99 g	193,757	1.0-1.4			500,000	0.01
			1,885	739										
			12,635	20										
			38,496	108										
1990	72,000[b]	10	1,312	612					1,000	110	30,000	0.25	400,000	0.16
			50,000	20[b]					9,500	121[b]	35,000	5.2[b]		
			32,733	35					1,000	160[b]				
			18,561	54					150,000	1.7				
									150,000	3.2-7.0[b]				

[a] All data from 1939 to 1990 is from archived files at ADFG, 1300 College Rd, Fairbanks, Alaska.
[b] Stocked into net pens at a smaller size, reared, and released.

observed for all stockings of fingerlings but some groups were more severely afflicted than others. Handling, transport, and other sources of stress appeared to aggravate the problem.

Rainbow trout and Arctic grayling *Thymallus arcticus* were stocked as fry or fingerlings (or both) from 1986 through 1989 (Table 2). These stockings were the result of extra hatchery production. In 1990, rearing experiments in floating net-pens began, and totals of 11,500 adult rainbow trout, 150,000 rainbow trout fingerlings, and 35,000 fingerling Arctic grayling were released from net-pens into Harding Lake (Viavant et al. 1991 in draft). An additional 30,000 Arctic grayling fry, 1,000 adult rainbow trout, and 150,000 rainbow trout fingerlings were stocked directly into the lake from source hatcheries.

Sockeye salmon fry from the Gulkana Hatchery were stocked into Harding Lake from 1988 through 1990. They are being evaluated to determine if a game fish population can be established that would occupy the pelagic zone and compete with the indigenous least cisco population (Clark and Doxey 1989). A total of 400,000 sockeye salmon was stocked in 1990.

An Arctic char *Salvelinus alpinus* stocking experiment began in Harding Lake in 1988. Arctic char were becoming available and were judged to be a species and strain (lake resident fish from Aleknegik Lake in the Bristol Bay drainage) that had a high probability of surviving in Harding Lake. Clear Hatchery developed the ability to rapidly produce large numbers of Arctic char ranging from 2 to 750 g. Growth of these Arctic char at Clear Hatchery was accelerated using warm water culture techniques.

Cohorts of Arctic char were stocked in numerically decreasing increments at progressively larger sizes as they grew in the hatchery, filling the raceway to biomass carrying capacity. When the raceway was full to biomass capacity, an increment of the fish were stocked, and the Arctic char remaining in the raceway were reared to a larger size, again filling the raceway to capacity prior to another stocking. For example, a raceway stocked with 680,000 fingerlings was full when fish reached 2 g each, for a total raceway loading of 1,360 kg. Hatchery personnel then stocked three - quarters of the fish, leaving 170,000 fingerlings to be reared to fill the raceway again at 8 g each. After 75% of these fish were stocked 42,500 Arctic char remained to be reared to fill the raceway as 32 g subcatchables. The next such split left 10,500 Arctic char to be reared and released as large subcatchables at 130 g, and the next produced 2,625 adults at 518 g (Table 2). Not all the Arctic char reared at Clear hatchery were stocked into Harding Lake; some were stocked into other locations.

Arctic char were stocked before freeze-up in late fall 1988, followed by stockings under the ice in October 1988 and February 1989 (Table 2). During the first stocking under the ice a periscope was used to observe the behavior of the Arctic char and look for mortalities immediately after stocking. Most of the Arctic char schooled and dispersed within 5 minutes, and the few that rested on the bottom were gone shortly thereafter. No mortalities were observed, and seagull predation was not a factor. The next stocking consisted of 1,885 adults at 739 g, which were released into open water in late May, 1989 as the ice was receding. Initially, the fish did not disperse. Most of

the Arctic char remained in a school in a 1.5 m deep, 8 m wide scour pool at the boat launching area where they were stocked. The fish were readily taken on hook and line by anglers. To prevent a complete harvest within a few days, the Arctic char were captured and moved with seines to slightly deeper water. The fish appeared reluctant to move across the sunlit, sandy bottom, and refused to leave the cover provided by the seines. Eventually the seines were moved in short increments to the edge of the ice at about 3 m of depth, allowing the Arctic char to follow along. The seines were then pulled into the boat and the Arctic char fled under the ice to deep water. Subsequent stockings of Arctic char in 1989 occurred in mid - July and in mid-November. In 1990, 52,606 hatchery reared Arctic char were stocked into Harding Lake (Table 2). An additional 50,000 Arctic char were reared in floating net-pens prior to release (Viavant et al. 1991 in draft).

Growth and Survival

Gill nets were the primary assessment tool used by fisheries biologists over the years to evaluate presence and growth of stocked fish. Test netting techniques evolved from setting gill nets at various depths and locations judged by biologists to be inhabited by fish to systematic test netting as described in Doxey (1988). Beginning in 1987, test netting was conducted in quadrants, and each quadrant was sampled for one night at four depths from about 10 m to about 30 m, the deepest water in the quadrant. Floating, sinking, and vertical gill nets were used. Shallower water along the shoreline was sampled with fyke nets to avoid sampling mortality of northern pike associated with gill nets. A tow net was used to sample mid-water areas in the fall of the year beginning in 1988. Abundance of sockeye salmon and least cisco in the pelagic zone was estimated during September (Clark and Doxey 1989). On site creel surveys, the statewide harvest survey, observation, and rod and reel sampling were all employed to assess stocking results.

The first documented evidence of survival of fish stocked into Harding Lake occurred in 1960, when McKirdy (1960) captured a 10 kg lake trout thought to be a survivor of the 1939 plant. The fish was not aged, and the possibility exists that it was a product of natural reproduction of those fish. However, if there was a small reproducing population of lake trout in Harding Lake no additional evidence of their survival was documented prior to resumption of the stocking of lake trout in 1963. After lake trout introductions ended in 1967 (Table 2) lake trout were captured periodically with gill nets, and were occasionally reported to have been harvested by anglers during the 1970's. No evidence of natural reproduction was found, and all of the lake trout taken were large, old fish. The length range of 14 lake trout collected in 1978 was 749 - 914 mm with a mean length of 829 mm. Ages ranged from 19 to 31 years (Hallberg 1979). However, one of three lake trout collected in 1981 was an age 7, sexually immature, female weighing 2,340 g. This was the first solid evidence of natural reproduction of the introduced lake trout population (Doxey 1982). By the end of the 1984 field season, a cumulative total of 16 young, naturally reproduced lake trout had been captured (Appendix A1). Lengths of these fish ranged from 110 to 738 mm, weights ranged from 104 to 4,850 g, and ages ranged from 2 to 11 years. Growth of these lake trout had been rapid. Alt (1977) compared length at age data for three Kuskokwim

drainage lakes to similar data from Paxson Lake (Van Wyhe and Peck 1968) and Great Bear Lake (Miller and Kennedy 1948). The length at age data for lake trout of Harding Lake (Appendix A1) lie well above the ranges reported by Alt (1977). The older lake trout in Harding Lake were deep bodied fish with heavy visceral fat. Three larger males were ripe, and two age 7 females were in prespawning condition, indicating that second generation spawning was about to begin (Doxey 1985). Stomach contents were composed primarily of the remains of least cisco and slimy sculpin. After 1986 large live lake trout were released from the gill nets immediately, so few age and stomach contents samples were collected. Weights were estimated at the time of release. Of 25 lake trout released in 1987, 16 were judged to weigh less than 5,000 g and to be second generation fish, while four were estimated to weigh between 9,000 and 11,000 g and to be from the original introductions (Doxey 1988). In summer lake trout occupy depths from 10 to 40 m (Doxey 1988). In fall they are periodically captured in water less than 2 m deep (Doxey 1983).

Overwinter survival of coho salmon in Harding Lake was first documented in 1972 when eight fish from the 1971 stocking of 232,800 fingerlings were captured in gill nets (Peckham 1973). Test netting during the mid 1970's produced few fish. Little difference in growth and survival was documented between coho salmon stocked as fingerlings and as smolts (Hallberg 1979). Coho salmon stocked into Harding Lake sometimes grew to exceptionally large sizes for the species in a landlocked environment. In October 1976, test netting produced 23 age 3 (mature, terminal year) coho salmon with lengths ranging from 350 to 672 mm and weights up to 4,987 g (Kramer 1977). Similarly, in fall 1977 a total of 20 age 3 coho salmon was collected. Lengths ranged from 381 to 597 mm and weights ranged from 680 to 3,175 g (Kramer 1978).

However, the location and catchability of stocked coho salmon in sufficient abundance to support a viable sport fishery remained unknown until 1978. Intensive test netting and angling effort in all habitats beginning through the ice cover in March 1978, and continuing through the spring and summer until freeze-up in October 1978, produced very few age 1 and 2 fish and no age 3 fish. Hallberg (1979) concluded that the majority of stocked coho salmon had not survived. While growth of captured fish was deemed good, so few coho salmon survived to reach catchable size that a fishable population was not present (Hallberg 1979). This conclusion was reaffirmed in subsequent years, when few or no coho salmon were captured during annual test netting. Examination of the stomach contents of northern pike, burbot, and lake trout during years when coho salmon were present in the lake indicated that coho salmon fingerlings were preyed upon by these large predators (Hallberg 1979). Least cisco and slimy sculpin were found in the stomachs of larger coho salmon.

Results of sheefish fingerling introductions were very similar to results for coho salmon, except that high mortalities were sometimes observed immediately after stocking due to the swim bladder problem discussed earlier. Efforts to determine the survival of sheefish began the summer after they were first stocked (Doxey 1982) and continued annually. Quadrant sampling with gill nets was the primary method of assessment. While sheefish fingerlings were captured and observed in the lake in early summer, shortly after they had been

stocked, they seemed to disappear by late summer (Doxey 1988) and no evidence of overwinter survival of sheefish stocked as fingerlings was documented. A sheefish fingerling captured in a fyke net in late July of 1987 was extremely thin. Sheefish fingerlings were also held in a net-pen to observe mortality rates immediately after stocking. This experiment was conducted twice, for one week in 1984 and for two weeks in 1986. The net-pen was set nearshore in shallow, warm water. Both times the only mortalities were the result of northern pike on the outside of the net-pen striking sheefish that strayed too close to the side of the pen. Gulls were observed feeding heavily on schools of fingerling sheefish from the time they were stocked in early June until late July. Sheefish fingerlings were found in the stomachs of northern pike shortly after they were stocked in early summer, but not after late summer.

Survival of large sheefish was better, but not enough to produce significant angling effort. Three of the 35 large, tagged (surplus broodstock) adult sheefish stocked in 1987 were captured that summer in nets, and anglers reported catching and releasing a few. A single large untagged sheefish was seen at close range by the author in 1988, and was judged to be from the stocking of 370 sheefish at 150 g in 1982. No sheefish were captured during test netting in 1989 (Table 3). Anglers have occasionally reported the sighting or harvesting of large (1,400-2,300 g) sheefish. It appears that there is a very small population of large sheefish in Harding Lake. The reproductive capability of this group of fish is unknown.

Overwinter survival has been documented for only a single rainbow trout of the 1,562,364 fingerlings and fry stocked from 1986 through 1988. A single Arctic grayling was captured in 1987 that was likely a survivor from the stocking of fingerlings in 1986.

Survival to fall of 1988 of the initial stocking of 500,000 sockeye salmon was estimated at 5-6% and mean length was 75 mm (Clark and Doxey 1989). A single sockeye salmon was collected with a gill net in midsummer 1989 (110 mm, Table 3). Tow net sampling was again conducted in fall of 1989, and survival of sockeye salmon stocked in 1989 was estimated to be 5.1% (Clark 1991 in press).

Arctic char fingerlings were captured in gill nets shortly after stocking began (Doxey 1989). Anglers reported seeing and harvesting 100 to 200 g fish in March 1989, within a month after stocking. These fish were the first harvestable-sized Arctic char in Harding Lake. Investigations during summer, fall, and winter of 1989 indicated that Arctic char were surviving and becoming a numerically dominant species in deeper waters of the lake. Arctic char were outnumbered only by least cisco in gill net catches, and were an order of magnitude more abundant than lake trout and burbot, the other two deep water sport species (Table 3). They were captured in sinking gill nets at all depths sampled during 1989 (Table 4). Distribution of the Arctic char by depth zone changed between summer and fall, 1989. In the summer, Arctic char were captured with greatest frequency at depths exceeding 30 m. In late fall (October) capture frequency declined at depths greater than 30 m (Table 5).

Table 3. Number and size of fish sampled[a] in Harding Lake, 1989.

Species	Number Sampled	Length Range (mm)	Weight Range (g)
Lake Trout	4		1,500 - 9,000[b]
Northern Pike	9	200 - 562	340 - 1,800
Least Cisco	220	100 - 220[c]	
Burbot	12	339 - 467[c]	360 - 832
Sockeye Salmon	1	110	-
Arctic Char	106	110 - 476	9 - 1,289

[a] Gear used included gill nets and fyke nets.
[b] Estimated weights.
[c] Estimated lengths.

Table 4. Species caught and sampling effort while netting Harding Lake, 1989.

Zone	Depth (m)	Mid Summer Species[a] Caught	Mid Summer Fishing Effort (net-night)	Late Fall Species[a] Caught	Late Fall Fishing Effort (net-night)	Total Species[a] Caught	Total Fishing Effort (net-night)
Nearshore[b]	0-1.3	NP	2	-	0	NP	2
Offshore[c]	3-13	LCI, AC	2	AC, NP	1	LCI, AC NP	3
	14-23	LCI, BB, AC, LT	6	AC	1	LCI, BB AC,, LT	7
	24-31	LCI, BB, AC	4	LCI, AC, BB, LT, RS	1	LCI, BB, AC, LT, RS	5
	32-38	BB, LCI, AC	3	AC	1	BB, LCI, AC	4
	39-44	AC	1	-	0	AC	1

[a] NP = northern pike BB = burbot LT = lake trout LCI = least cisco, RT = rainbow trout AC = Arctic char RS = sockeye salmon

[b] Fyke nets.

[c] Gill nets.

Table 5. Catches of Arctic char and fishing efforts in Harding Lake, 1989.

Depth (m)	Summer			Late Fall		
	Net Nights[a]	No. Char Caught	Catch Per Net Night	Net Nights[a]	No. Char Caught	Catch Per Net Night
3 - 13	2	2	1.0	1	25	25
14 - 23	6	8	1.3	1	27	27
24 - 31	4	5	1.2	1	16	16
32 - 38	3	14	4.6	1	8	8
39 - 49	1	1	1.0	0		

[a] Gill nets were used as capture gear.

Overlapping lengths of stocking cohorts and subsequent growth make it difficult to assign many of the Arctic char sampled in the lake to a specific stocking cohort. However, by May, 1989, there were three identifiable stocking cohorts of Arctic char in Harding Lake. A portion of the 30,770 Arctic char stocked at 53 g in late 1988 (10,479) were marked by removing the adipose fin. Arctic char stocked at 122 g in February of 1989 (8,391) were marked by removing their right pelvic fins. Arctic char stocked in May 1989 (1,885) were marked with Floy anchor tags (Table 6). Cumulatively there were 21,025 marked fish, 51% with adipose fin clips, 40% with right pelvic clips, and 9% with tags. If these fish are considered separately from the balance of the Arctic char stocked into the lake which were unmarked, the capture rate of fish with different marks can provide assessment of the relative survival of these three. Sixteen marked fish were captured in July with gill nets, and 31 marked fish were captured in December with hook and line gear. The proportions of the three marked groups of fish within these two samples were very similar. In both samples just over 6% had adipose fin clips, about 40% had right pelvic fin clips, and over 50% were tagged. Proportions of fish at recapture was inverted from that at stocking for the smallest (adipose fin clipped) and largest (tagged) Arctic char stocked, while the proportion of marked fish recaptured from the mid-sized group (122 g) remained at about the same 40% proportion at which they were stocked (Table 6).

Mean length of the entire cohort of tagged adults (N = 1,854) when they were stocked in May, 1989 (measured individually in the hatchery as the fish were tagged) was 361 mm. Fourteen individuals from that cohort were captured in December. Mean length of those 14 at stocking was 367 mm. Mean length of those same 14 Arctic char in December was 364 mm, indicating that growth was negligible over the growth period. Mean length of the 122 g Arctic char released in February 1989 was 210 mm, and a sample of 13 fish measured in December 1989 had a mean length of 266 mm. Mean length of Arctic char with adipose fin clips released at 53 g in November 1988 was 165 mm. A sample of five of these fish measured in July, 1989 had a mean length of 202 mm (range 172-250 mm), and lengths of two captured in December, 1989 were 238 and 275 mm. The length range of all of the unmarked Arctic char captured in December was 162-262 mm. Mean length was 216 mm (n=127, SE=1.57). Most of these fish were probably from the cohort of 38,696 Arctic char stocked in October, 1989 (Table 2). Based on the low abundance of Arctic char with adipose fin clips (from the stocking of 10,799 fish at 50 g each in November 1988) in the total sample of Arctic char collected in December (two out of 172), it is assumed that similarly low numbers of Arctic char from the cohort of 20,021 unmarked fish stocked in October 1988 (Table 2) were present among the fish sampled. It is possible that some of the Arctic char stocked at a mean weight of 20 g in July 1989 were represented in the lower end of the size range of the cohort of unmarked fish in this sample.

Stomach contents of the Arctic char included caddis and other insect nymphs, snails, and slimy sculpin remains. A few of the larger males and one large female captured in December were sexually mature.

Table 6. Number and size of marked Arctic char stocked and captured during test fishing, Harding Lake, 1989.

Mark	Date Stocked	Size at Stocking (g)	Number Stocked (percent)	(percent) Number Captured By: Gill Net In July	Hook & Line In December
Adipose Clip	11/88	53	10,479	1	2
Right Pelvic	02/89	122	8,391	6	13
Tag	05/89	739	1,885	9	16
Total			21,025[a](100)	16	31

[a] Marked cohorts comprised 21,025 of the total of 92,177 Arctic char that had been stocked into Harding Lake by the end of 1989.

Estimated Harvest of Introduced Species

Angling potential of stocked species prior to 1977 was evaluated through anecdotal reports from anglers. Since 1977, angling effort has been evaluated by the Statewide Harvest Survey, on-site creel surveys, and intensive hook and line sampling in the summer of 1978 (Hallberg 1979), and in December 1989. Angler reports up to 1989 gave a generally dismal picture of the results of the stocking efforts, with the exception of lake trout, for which catch rate was expected to be low. Because lake trout were few but large (some over the 20 pound minimum weight qualification for the State Trophy Fish Program), many of the lake trout harvested were thought to have been reported to Sport Fish Division personnel. Up to three such reports were received annually. After 1982 the harvest of smaller lake trout was occasionally reported. Few coho salmon were caught through the 1970's, and none of the exceptionally large specimens that appeared in 1975 and 1976 were taken by anglers, despite considerable publicity. Similarly, the experimental angling undertaken by Sport Fish Division biologists in 1978 produced no coho salmon, although test netting indicated that they were present in the lake in small numbers (Hallberg, 1979). The thousands of sheefish stocked from 1982 to 1989 (Table 2) produced only a few scattered reports of angler harvest. Again considerable publicity accompanied the sheefish stocking program. A single angler reported catching a rainbow trout during the summer of 1988. No reports of Arctic grayling or sockeye salmon harvest have been received by staff of ADFG.

Each winter one or two ice fishing shanties are placed on Harding Lake. They are primarily used by anglers attempting to spear northern pike and burbot, and have a large hole cut in the ice beneath them for that purpose. Within a month after the February, 1989 stocking of Arctic char, anglers using ice fishing shanties began reporting seeing schools of Arctic char and catching some on hook and line. Only one angler reported successful fishing for Arctic char during the summer months of 1989 (other than that which occurred on the school of large fish that refused to leave the area where they were stocked). Anglers again began to report harvest during late November of 1989. By then 49,000 larger fish had been stocked.

In December 1989, a study was initiated to investigate the angling potential for Arctic char in Harding Lake. The lake was stratified by depth zone (shallow and deep littoral and shallow, middle and deep profundal), by location in the water column (just under the ice, mid-water, and just off the bottom), and by habitat type (over weed-beds, on drop-offs, and over sand/gravel and silt flats). Hook and line sampling occurred in these strata by gear type (bait, various lures, and jigs). The objective was to determine where and how Arctic char could be harvested in a winter sport fishery. Sampling locations were selected to first sample the depth zones judged most likely to produce catches of Arctic char, and to sample all of the habitat types within those zones. Transects were laid out from the shallow littoral zone (1-3 m) across the intervening depth and habitat zones to the middle profundal zone (10-20 m). The deep profundal zones (20-30 m and 30 m+) were to be sampled later if shallower zones failed to produce fish. Two holes were drilled through the ice at each sampling location, and two fishing poles were used by each angler to systematically test hook and line techniques at each

location in the water column. Over a period of three days the sampling effort was moved around the lake as a transect was sampled each morning from just before sunrise (about 09:30 in December) until about 12:30. A second transect was sampled from about 13:30 until after sunset at 15:30. A total of 90.5 man hours of angling was expended during the sampling event. By noon of the second day it was apparent that Arctic char were concentrated near bottom at a depth of 5 to 7 m. The catch rate in these locations was 3.4 fish per hour (Table 7). A total of 158 Arctic char was collected during 46.5 man hours of angling at that depth. Arctic char were often biting so rapidly at the 5-7 meter depth that it was difficult for the angler to maintain steady fishing effort at both assigned fishing holes. Anglers sampling shallower and deeper water along the transect on either side of the concentration of fish collected few fish. A total of 14 Arctic char was collected during 44 hours of sampling away from the 6 m contour, for a catch rate of 0.3 fish per hour. Arctic char were attracted and taken with bright orange spoons about 4 cm long jigged very close to the bottom. They also struck at bait (shrimp and salmon eggs) fished just off the bottom through the adjacent hole. Fishing was best from dawn until the brightest part of the day, and again from when the sun was low on the horizon until early twilight. No other species of fish were taken during the 90.5 hours of angling.

When sampling was completed, the public was notified by news release that Arctic char were available and being caught in Harding Lake. Angler effort increased and a creel survey was begun in late December.

Harvest of stocked species was not quantitatively documented prior to 1984, when harvest estimates for Harding Lake first appeared in the Statewide Sport Fisheries Harvest report (Mills 1985). There was an estimated harvest of 65 coho salmon in 1984, 24 lake trout in 1986, 118 rainbow trout and 79 Arctic grayling in 1987, and 55 lake trout, 73 rainbow trout, and 73 sheefish in 1988.

No on-site creel survey was undertaken prior to 1989 because spot checks, angler reports, and observations made during sampling events indicated that angler effort and harvest of stocked species was so low that creel sampling would not be cost effective. In spring, 1989, an on-site creel survey was begun to assess the summer harvest of Arctic char, and a winter creel survey was conducted for the same purpose from late December 1989 to late March 1990. During the summer a stratified random sampling program was conducted. At predetermined times a creel clerk circled the lake with a boat, interviewed all anglers encountered, and recorded species and size of fish caught. The winter creel survey followed the same pattern, except that the mode of transportation for the creel clerk was a snowmachine (Merritt et al. 1990). No Arctic char were observed harvested during the creel survey during the summer of 1989. During December 1989, prior to the beginning of the creel survey, ADFG requested that anglers call in reports of Arctic char harvest as well as report any tagged fish that were caught. Based on phone reports and spot checks, 146 Arctic char were reported harvested. It is likely that more were harvested. It was estimated that 49 were harvested during the portion of the winter of 1989-1990 when the creel survey was underway. January of 1990 was extremely cold, and little fishing effort occurred. Most fish were taken in early February, and the estimated harvest rate was 0.75 Arctic char per

Table 7. Hook and line fishing effort and catches of Arctic char, Harding Lake, December 1989.

Depth (mm)	Fishing Effort (Angler Hours)	No. of Char Caught	Catch Rate (Fish/Hour)
1 - 14	44.0	14	0.3
5 - 7	46.5	158	3.4
Total	90.5	172	1.9

hour. By late February angling effort along the 6 m contour was producing no Arctic char, and estimated harvest was zero in March.

DISCUSSION

Research and stocking experiments conducted by fisheries scientists in Harding Lake with increasing intensity over the last 50 years have produced a modest increase in recreational fishing effort. Information has been developed which may facilitate a further increase in recreational fishing effort, and which, after the last 20 years of unsuccessful stockings, is very encouraging.

Perhaps the most important single fish stocking concept rising from these efforts is embodied in the colloquialism "Bigger is Better". Lake trout adults grew to a large size, spawned successfully, and have established the species in the lake. No survivors of the fingerling and fry stockings have been documented. Coho salmon that survived from small sizes at stocking grew very well, but survival was so low that no additional recreational fishing effort occurred as a result. The thousands of sheefish, Arctic grayling, and rainbow trout fingerlings and fry that were stocked into Harding Lake virtually disappeared. Only a few survivors of stockings of sub-adult and adult sheefish have been collected during intensive sampling efforts or documented as being harvested by anglers. The success of the sockeye salmon fry stocking experiments remains to be determined. The contribution to the harvest of Arctic char stocked at different sizes appears to be directly related to size at stocking, with more fish resulting from cohorts stocked at larger sizes.

The low productivity of Harding Lake combined with predatory pressure and competition for food from indigenous species may in combination, be responsible for the failure of these introductions. Coho salmon stockings failed even when the abundance of least cisco was low during the mid- and late 1970's. Rainbow trout and Arctic grayling do well when stocked in other waters, but have not been observed to survive at an acceptable rate in Harding Lake.

Besides lake trout, Arctic char are perhaps the non-indigenous species most uniquely suited to survive in Harding Lake. Their preference for deep water in summer decreases their susceptibility to predation by northern pike for at least part of the year. Small populations of lake trout and burbot share the profundal zone with Arctic char. The Arctic char are from a lake spawning stock, and reproduction within Harding Lake is a distinct possibility. They are demonstrating the ability to take advantage of a wide variety of available food items, and some growth is occurring. Catch of Arctic char during sampling is very encouraging, and some level of initial survival has been documented from each cohort stocked. Similarly, during the short period in mid-winter 1989-90 when they were readily available to anglers using conventional ice fishing methods, the harvest of Arctic char was almost as large as the combined harvest estimates of all of the other cohorts of fish ever stocked in Harding Lake. Their failure to produce angling opportunity in late winter and summer, however, is a matter of some concern. Hopefully more angling effort will develop as the population builds through continued

stocking, and as the surviving Arctic char become better acclimated to the environment of Harding Lake.

No northern pike, burbot, or lake trout have been harvested during winter angling efforts directed toward Arctic char. Should this trend persist, incidental catch of these valuable large predators that are present in low abundance in Harding Lake may be minimal, and the presence of a stocked species that is readily taken by anglers may divert fishing pressure from them. Conservation measures should preserve fishable populations of northern pike and burbot, as well as maintain angling opportunities for these indigenous species. Because productivity of Harding Lake is low, future introductions should be carefully conceived and monitored to ensure that the carrying capacity of Harding Lake is not exceeded (Ricklefs 1973; Donald 1987).

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APPENDIX A

Appendix A1. Date captured, length, weight and age for naturally produced lake trout in Harding Lake, 1981-1984.

Captured[a]	Length (mm)	Weight (g)	Age	Sex	Maturity
07/22/83	110	104	II	Male	Developing
08/06/82	262	183	III	Male	Developing
08/24/84	268	220	III	Male	Developing
08/22/84	280	250	III	Unknown	Developing
08/24/84	293	310	IV	Female	Developing
08/24/84	340	515	IV	Female	Developing
08/24/84	347	560	III	Male	Developing
08/23/84	487	1,700	VI	Female	Developing
10/15/81	585	2,340	VII	Female	Developing
08/24/84	589	3,350	VIII	Female	Developing
08/05/82	596	3,400	VII	Female	Prespawner
07/26/83	616	3,675	VII	Female	Prespawner
08/23/84	625	3,850	VIII	Male	Ripe
07/22/83	629	3,480	VI	Female	Developing
08/24/84	636	4,200	VIII	Male	Ripe
08/23/84	738	4,850	XI	Male	Ripe

[a] Lake trout were captured with gill nets.