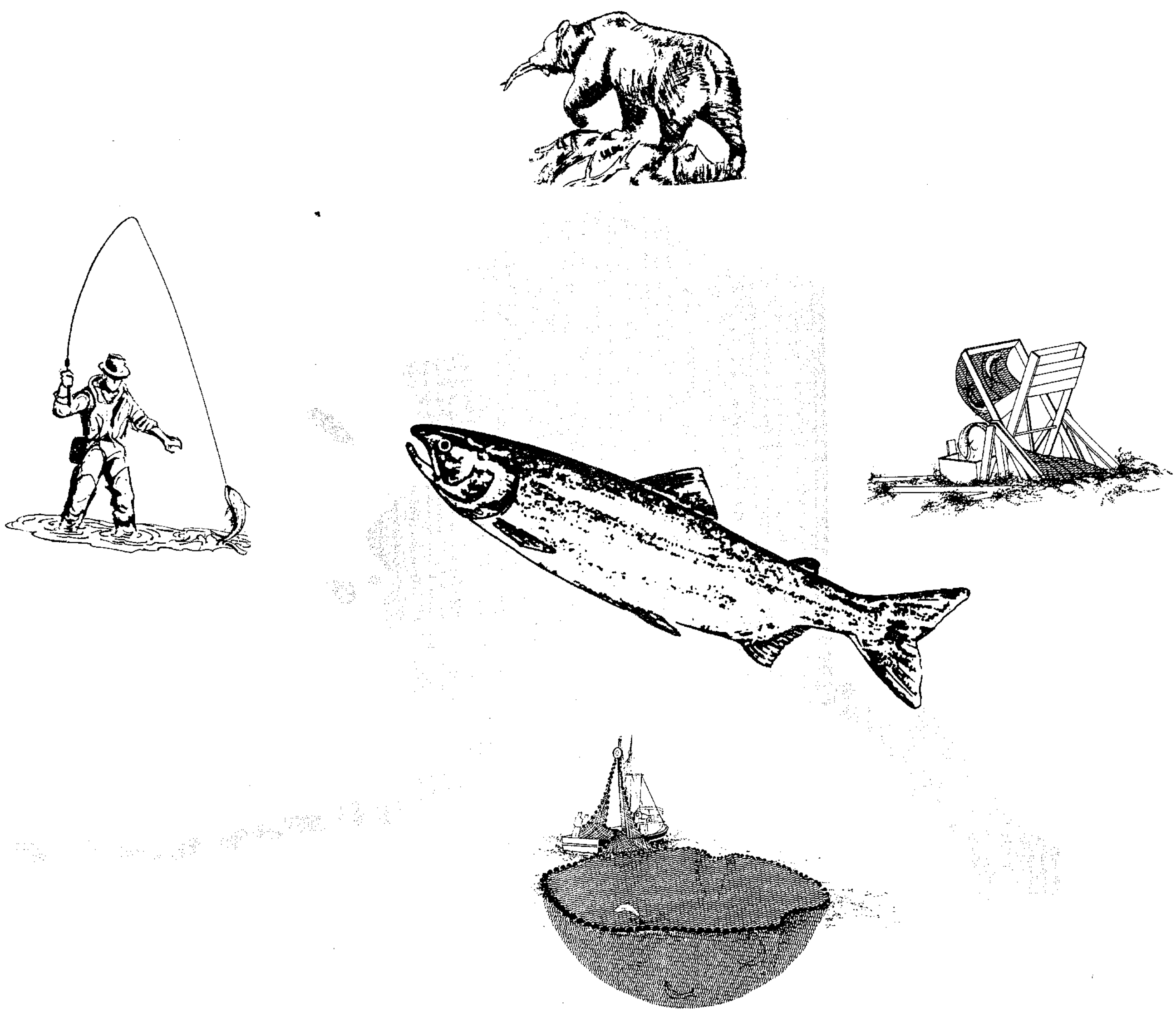
Alaska Fisheries Technical Report Number 7

QUANTIFICATION AND DISTRIBUTION OF WINTER WATER WITHIN LAKES OF THE 1002 AREA, ARCTIC NATIONAL WILDLIFE REFUGE



April 1990

Region 7
U.S. Fish and Wildlife Service
Department of the Interior

QUANTIFICATION AND DISTRIBUTION OF WINTER WATER WITHIN LAKES OF THE 1002 AREA, ARCTIC NATIONAL WILDLIFE REFUGE, 1989

GEORGE V. ELLIOTT

Water Resources Branch
Fisheries Management Services
U.S. Fish and Wildlife Service
1011 East Tudor Road
Anchorage, Alaska 99503

April 1990

Abstract

An inventory of lake basins was conducted in the 1002 area of the Arctic National Wildlife Refuge as part of an effort to develop a hydrologic data base, map sources of winter water, and determine water availability for oil and gas activities.

From June 24 to August 17, 1989, depth profiles of 52 lakes within the 1002 area were measured using a recording fathometer. The depth profile data were used to construct contour maps, calculate lake volumes, and estimate winter water volumes beneath ice cover.

Total estimated volume of the study lakes was 42,215 acre-ft when free of ice and 3,021 acre-ft beneath 7 ft of ice. Ninety-five percent of the water available beneath 7 ft of ice was found in 10 lakes. The occurrence of lakes deeper than the normal thickness of maximum ice development was much more frequent and widespread than previously suspected.

Fish presence in lakes was also much more frequent and widespread than previously suspected. Fish were found in 34 of the study lakes, of which 30 were new records of reported fish presence.

The correct citation for this publication is;

Elliott, G.V. 1990. Quantification and distribution of winter water within lakes of the 1002 area, Arctic National Wildlife Refuge, 1989. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 7, Anchorage, Alaska.

Table of Contents

Introduction

The location and quantity of water potentially available from natural lakes in the 1002 area of the Arctic National Wildlife Refuge (Figures 1 and 2) were evaluated to identify potential sources for oil and gas exploration and development activities. Exploration and development will require significant quantities of water. Information on the spatial and temporal distribution of potential water sources is required to make informed decisions concerning the management of potential development so as to best protect aquatic habitats and the fish and wildlife resources that use them.

The availability of water during winter months is influenced by extremely low air temperatures and short, cool summers. Total annual precipitation averages 6.2 inches on Barter Island (Arctic Environmental Information and Data Center 1986). Ninety-nine percent of the 1002 area is classified as wetlands. However, water is limited and confined to the shallow zone above permafrost (Clough et al. 1987). Lake depth also influences winter water availability. Clough et. al (1987) reported that most lakes have basins less than 7 ft deep and freeze to the bottom by late winter. Wilson et. al (1977) reported that maximum ice thickness in Arctic lakes normally doesn't exceed 6.6 ft except in extremely severe winters.

Few lakes in the 1002 area have been measured to determine their depth. West and Fruge (1989) estimated the depth of nine study lakes based on fetch along the direction of prevailing winds (Carson and Hussey 1962). Three of the nine lakes were estimated to be deeper than 5.9 ft; two of these lakes are located on Kaktovik Inupiat Corporation lands withdrawn from the 1002 area. Childers et. al (1977) reported water depth and ice thickness for six lakes within the boundaries of the 1002 area. The total depth from the ice surface ranged from 6.2 to 10.0 ft. Three of these lakes are on Kaktovik Inupiat Corporation lands.

Lake depth is thought to restrict the presence of fish in Arctic lakes during the winter. Hobbie (1984) found that fish are present only in lakes deeper than 5.6 ft. Nine lakes within the 1002 area are reported to support fish (Ward and Craig 1974; West and Fruge 1989). All are in close proximity to the Canning River except one lake near the Jago River. Two lakes are approximately 25 mi upstream from the Canning River delta and six are within 5 mi of the mouth of the Canning River or one of its distributaries. Six species of fish are reported to inhabit these lakes: broad whitefish (Coregonus nasus), round whitefish (Prosopium cylindraceum), Arctic grayling (Thymallus arcticus), Arctic char (Salvelinus alpinus), ninespine stickleback (Pungitius pungitius), and Arctic flounder (Liopsetta glacialis).

Data gaps identified by Elliott (1989) provided the basis for investigations to determine the availability of winter water in the 1002 area. The objectives of this study were: 1) to quantify lake volumes and depth in 52 of the largest 1002 area lakes, 2) to evaluate the relationship between maximum fetch distance and maximum lake depth, and 3) to document fish presence.

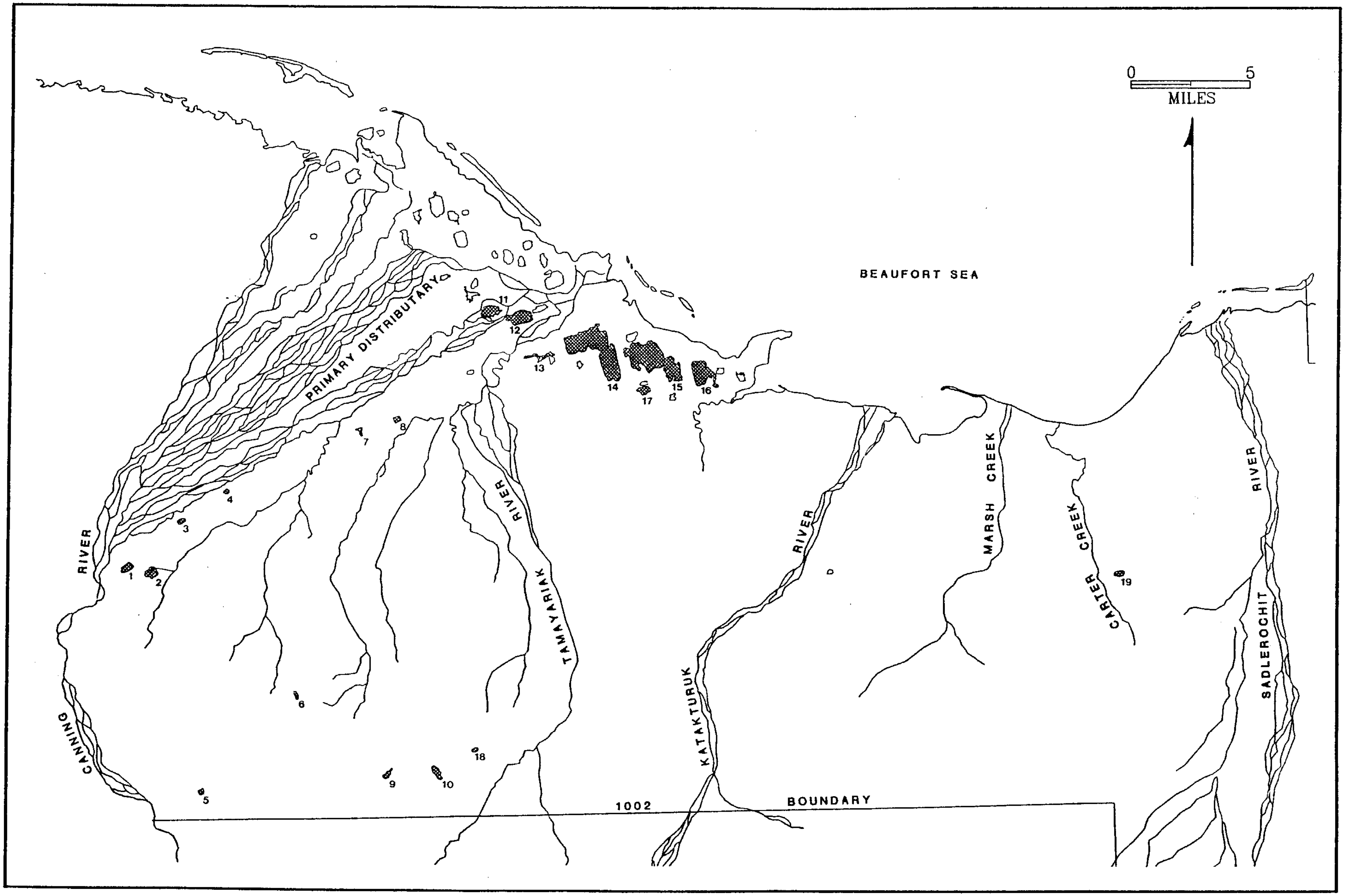


Figure 1.--Western portion of the 1002 area, Arctic National Wildlife Refuge, with study lakes (shaded) and lakes recommended for future study (unshaded).

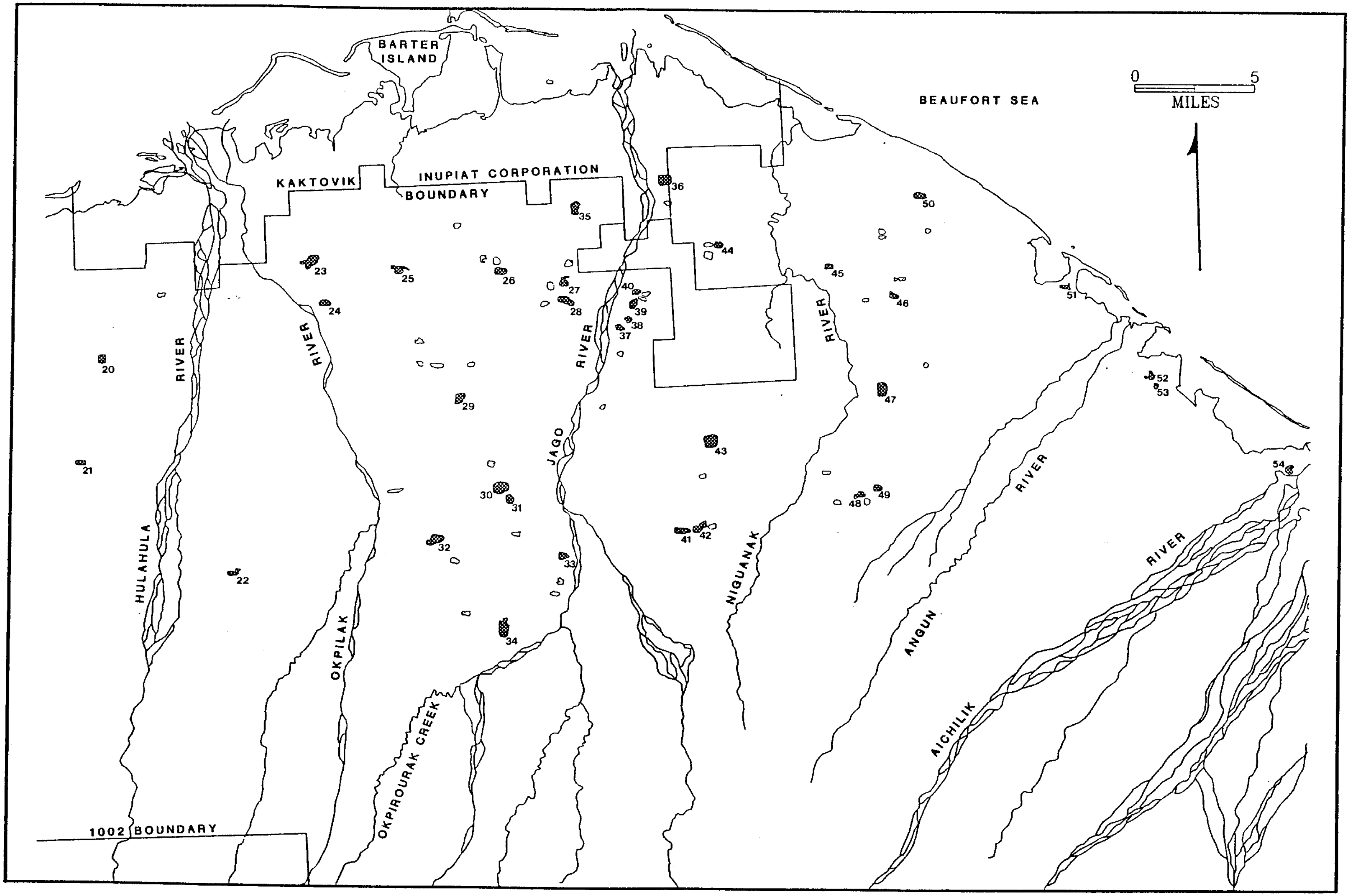


Figure 2.-Eastern portion of the 1002 area, Arctic National Wildlife Refuge, with study lakes (shaded) and lakes recommended for future study (unshaded).

Methods

Lakes were selected for study from U.S. Geological Survey (1:63,360) maps based on size. Fifty-two of 118 lakes larger than approximately 25 surface acres were selected from within the 1002 area. The number of lakes was restricted due to logistical support constraints. Transect data collected from two additional lakes during 1988 were incorporated into the data base and analyzed as described below for the lakes studied in 1989. Because these lakes are not named, they are identified by legal locations and latitude-longitude map coordinates (Appendix).

From June 24 to August 17, 1989, water depth was recorded along several transects across each lake using a recording fathometer from an inflatable boat. The entire length of each transect was run at a constant throttle setting. The goal was to take three transects in a north-south direction and three transects in an east-west direction at one-quarter intervals across each axis. This transect configuration was altered to allow for lake shape and size, for example: 1) more than three transects were taken across the long axis of long, narrow lakes, 2) fewer than three transects were taken across the short axis of narrow lakes or on lakes judged as small in the field, and 3) additional transects were taken to better describe lakes with irregular shapes.

Several soundings were taken at each lake using a weighted line to develop a correction factor for the depth recorded by the fathometer. Sounding depths were read to the nearest 0.1 ft. The depths recorded on the fathometer strip charts were adjusted to true depth soundings using a mylar overlay scribed with the strip chart depth scale. The overlay scale was placed over the strip chart records and aligned to calibration depth records marked on the strip chart. The location of each 1 ft depth contour interval was then identified along each transect using the overlay scale.

Maximum fetch distance parallel to prevailing wind direction (approximately WSW-ENE) was measured to the nearest 100 ft from enlargements of 1:63,360 scale topographic maps. The relationship between lake depth and maximum fetch distance was determined with a simple linear regression.

Lake shoreline maps were made from approximately 9X enlargements of 1:63,360 scale U.S. Geological Survey topographic maps. Contour interval locations were placed on lake maps using the proportion of chart transect length to map transect length. Contour lines were drawn on each lake map through corresponding points of depth. The area within each 1 ft contour was read to the nearest 0.001 in^2 with a planimeter, then converted to the nearest 1 acre based on the lake map scale. Lake volume was calculated using the following formula (Welch 1948):

$$V = \sum[h/3\ (a_1 + a_2 + \sqrt{a_1\ a_2}\ )]$$

where, V = lake volume (acre-ft)
h = strata height (ft)
a_1 = area of top surface of strata (acres)
a_2 = area of bottom surface of strata (acres).

Volumes, potentially available in winter, were calculated by subtracting 1 ft strata volumes from the ice-free volume to estimate volume of water beneath successive 1 ft layers of ice. Dates that ice thickness reached the 1 ft intervals were approximated from averaged data of ice thickness over time for Barter Island Lake reported by Bilello and Bates (1969, 1971, 1972, and 1975) representing 8 years of record.

Each lake was examined for the presence of fish during August. The margins of several lakes were visually inspected to determine the most heavily used shoreline habitat type. All of the lakes were then sampled along selected shoreline areas using a long handled dip net and any fish captured were identified to species.

Results

The 52 lakes selected for study in 1989 were representative of the distribution of all lakes within the 1002 area greater than approximately 25 surface acres with the exception of those to the north of the primary Canning River distributary (Figure 1). The two lakes surveyed in 1988 are the two largest lakes southeast of the Canning River delta (lakes 14 and 15). Surface area for individual lakes ranged from 22 to 1,533 acres. Maximum recorded depth ranged from 1.7 to 24.8 ft (Table 1). Thirty-one of the lakes surveyed exceeded 7.0 ft in maximum depth. No correlation was found between lake depth and maximum fetch distance ($r^2 = 0.05$).

Lake volumes during ice-free conditions ranged from 25 to 9,285 acre-ft and totaled 42,215 acre-ft for the 54 lakes. In early January, when ice thickness is approximately 4 ft, lake water volume totaled 14,683 acre-ft. With 7 ft of ice cover, lake water volumes declined to a total of 3,021 acre-ft. Depending on ice thickness, 65-78 percent of the water volume was found in the 18 lakes west of the Katakturuk River (Figure 3).

Ninespine sticklebacks were captured in 34 of 52 lakes surveyed in 1989 (Table 1). No other species were captured. Fish were limited to two areas; between the Canning and Katakturuk Rivers and between the Okpilak and Aichilik Rivers. No fish were found in lakes sampled in the central portion of the 1002 area between the Katakturuk and Okpilak Rivers. Ninespine sticklebacks were observed in one lake adjacent to Okpirourak Creek that was not included in this inventory (SW1/4, S.32, T5N, R34E). Fish were found in 83 percent of the lakes greater than 7 ft deep and in 43 percent of the lakes less than 7 ft deep.

Discussion

Lake depths measured during this study were consistently greater than depths estimated and measured for the same lakes investigated during previous studies. Childers et al. (1977) measured ice surface to lake bottom depths of 6.2, 7.3, and 7.5 ft in three lakes for which maximum depths of 6.4, 9.0, and 8.5 ft, respectively, were measured during this inventory. However, their measurements were taken at a single point in each lake.

TABLE 1.--Volume (acre-ft) of water in selected lakes in the 1002 area at various ice thicknesses. Average date of ice thickness in parentheses.

Lake No	Surface Area (acres)	Max Depth (ft)	Volume (acre-ft) Ice Thickness (ft) 0	1 (Oct 31)	2 (Nov 13)	3 (Dec 11)	4 (Jan 4)	5 (Feb 20)	6 (Apr 5)	7 (Apr 16)[a]	Fish Captured
1	94	12.1	824	730	637	543	449	358	272	196	Yes
2	113	10.0	720	607	494	381	273	171	89	35	Yes
3	44	3.8	93	55	25	4	0	0	0	0	Yes
4	23	2.9	44	22	4	0	0	0	0	0	No
5	32	5.1	120	89	57	29	8	<1	0	0	No
6	22	4.3	75	53	31	11	<1	0	0	0	No
7	31	7.7	122	91	60	34	17	8	3	<1	Yes
8	40	3.1	85	45	11	<1	0	0	0	0	Yes
9	46	13.4	328	282	236	190	146	111	79	51	No
10	96	8.2	379	283	187	97	37	9	3	<1	No
11	131	2.3	182	67	3	0	0	0	0	0	Yes
12	303	17.9	3,212	2,009	1,706	1,414	1,138	878	639	432	Yes
13	104	8.7	557	452	348	249	161	90	39	10	Yes
14	1,533	9.0	9,285	7,753	6,220	4,756	3,416	2,220	1,169	340	--[b]
15	1,316	11.0	9,198	7,882	6,565	5,305	4,138	3,067	2,097	1,282	--[c]
16	342	8.3	1,804	1,462	1,120	793	500	245	70	10	Yes
17	96	5.9	441	346	250	159	79	20	0	0	No
18	26	3.5	58	33	9	<1	0	0	0	0	No
19	51	8.0	295	244	193	142	93	55	27	6	No
20	75	4.6	274	199	124	54	7	0	0	0	No
21	56	8.8	373	317	260	205	152	104	62	29	No
22	53	5.7	195	142	92	48	17	2	0	0	No
23	155	6.4	624	469	325	203	101	31	1	0	Yes
24	69	7.9	417	348	280	212	148	88	33	4	Yes
25	83	4.1	263	180	97	28	<1	0	0	0	No
26	84	3.9	248	164	83	17	0	0	0	0	Yes
27	69	11.0	429	361	292	223	158	98	46	11	Yes
28	102	8.7	679	576	474	371	270	174	88	23	Yes
29	87	8.6	477	390	302	215	141	89	49	16	Yes
30	190	3.6	530	340	160	21	0	0	0	0	Yes

TABLE 1.--Continued.

Lake No	Surface Area (acres)	Max Depth (ft)	Volume (acre-ft) Ice Thickness (ft) 0	1 (Oct 31)	2 (Nov 13)	3 (Dec 11)	4 (Jan 4)	5 (Feb 20)	6 (Apr 5)	7 (Apr 16)[a]	Fish Captured
31	65	8.9	393	327	262	197	137	82	38	8	Yes
32	128	8.1	766	638	510	382	259	151	66	13	Yes
33	63	11.6	454	392	329	267	206	149	98	53	Yes
34	168	8.6	788	620	453	299	174	76	25	7	Yes
35	97	3.3	216	119	31	<1	0	0	0	0	Yes
36	164	8.5	1,045	881	717	558	412	280	159	53	Yes
37	46	7.5	262	215	169	127	90	57	28	4	Yes
38	36	6.9	187	151	115	81	50	24	5	0	Yes
39	60	7.8	375	315	254	196	141	91	48	10	Yes
40	41	7.1	226	185	144	106	70	36	10	<1	Yes
41	89	5.9	284	195	112	49	15	2	0	0	Yes
42	99	7.8	610	511	412	313	218	131	56	7	Yes
43	181	7.7	1,003	823	642	475	330	200	79	8	No
44	58	8.2	261	203	145	92	50	20	6	1	Yes
45	43	1.7	25	2	0	0	0	0	0	0	No
46	50	6.2	226	176	127	80	41	11	<1	0	No
47	142	9.2	952	810	669	527	390	262	147	49	Yes
48	55	6.8	207	152	102	62	33	11	1	0	No
49	54	4.8	179	125	71	24	<1	0	0	0	No
50	88	3.3	189	102	34	2	0	0	0	0	No
51	41	7.5	221	180	139	99	64	33	11	<1	Yes
52	45	7.9	148	103	58	22	6	3	1	<1	Yes
53	25	3.1	48	24	6	<1	0	0	0	0	Yes
54	68	24.8	819	751	683	615	548	484	422	363	Yes
Total			42,215	33,991	26,829	20,277	14,683	9,849	5,966	3,021	
Mean	137	7.4									

[a] Seven ft of ice was recorded only during one year of record.
[b] Not sampled in 1989; however, ninespine sticklebacks were reported in this lake (West and Fruge 1989).
[c] Not sampled in 1989; no fish were captured by West and Fruge (1989).

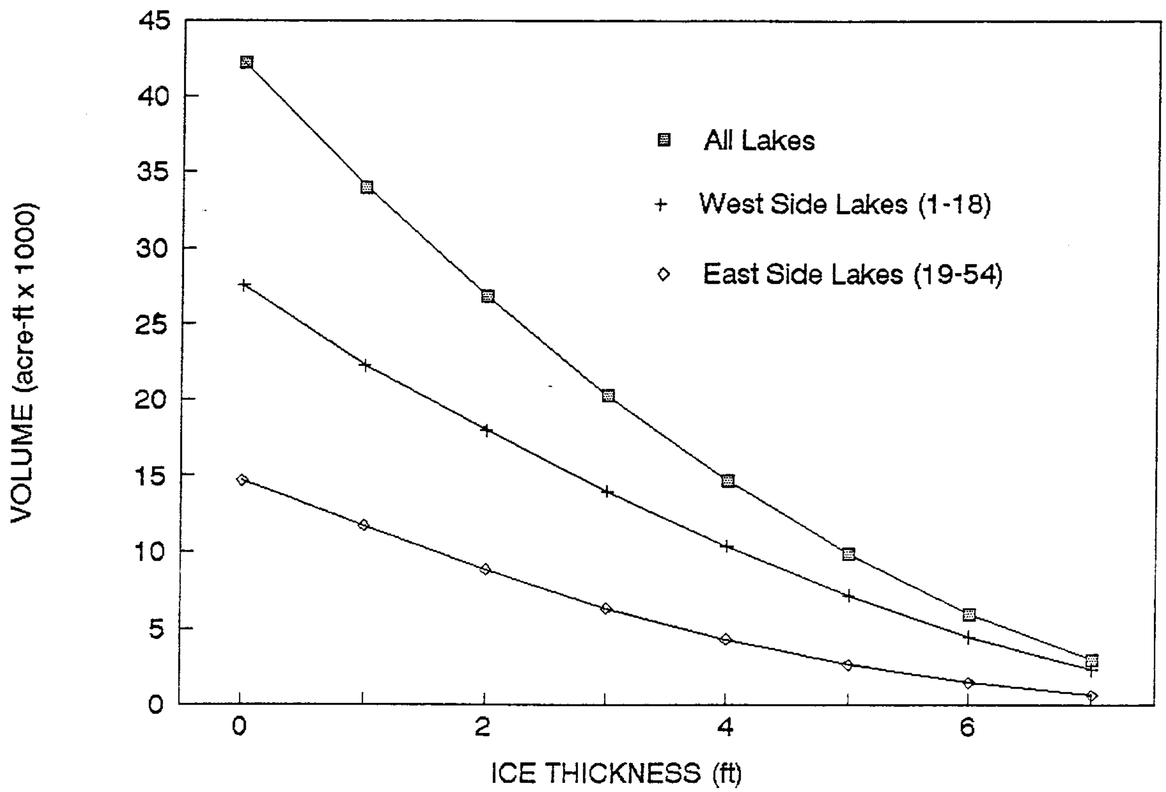


Figure 3.--Estimated volume of water in the 54 study lakes at various ice thicknesses.

West and Fruge (1989) estimated depths of four lakes as 4-5, 4-5, 6+, and 3-4 ft based on fetch distance. The same lakes measured during the present inventory had maximum depths of 7.7, 8.5, 9.0, and 9.2 ft, respectively. The method used to estimate lake depth based on fetch distance does not apply to most lakes in the 1002 area. Forty-five lakes were within the range of fetch distances reported by Carson and Hussey (1962) illustrating "the ideal depth-fetch relationship." However, the depth of 41 of the 45 lakes was underestimated by this relationship. Only 14 (31 percent) of the 45 lakes were within ± 2 ft of the ideal relationship. The Arctic Coastal Plain province is divided into two sections, the Teshekpuk section which is characterized by flat topography, and the White Hills section which is characterized by scattered groups of low hills (Wahrhaftig 1965). The "oriented lakes" discussed by Carson and Hussey (1962) are found in the Teshekpuk section, which extends into the 1002 area only near the mouth of the Canning River. Most of the lakes in the 1002 area are within the White Hills section of the Arctic Coastal Plain province and their shape is defined more by topography than prevailing wind direction.

The number of lakes on the coastal plain within the 1002 area that offer a potential winter water source is greater than implied by Clough et al. (1987). Based on the proportion of various size classes of surveyed lakes with depths greater than 7 ft, approximately 62 of 118 lakes can be expected to exceed 7 ft in depth and could be considered as potential sources for industrial water use during the winter. An estimated 3,021 acre-ft of water was found to be available beneath 7 ft of ice in 31 of the 54 lakes surveyed. Twenty-three of the lakes surveyed freeze to the bottom by mid-April. The water available in the lakes before January 4, when average ice thickness reaches 4 ft, is estimated to be 14,500 acre-ft. However, in terms of water availability and proximity to potential development, these lakes are not evenly distributed across the 1002 area. Most are located near the Canning and Jago Rivers. In addition, not all these lakes offer the same potential; 42 percent of the volume available beneath 7 ft of ice was contained in one lake, and nearly 95 percent of the volume was in 10 lakes.

Lakes provide a more abundant source of winter water than naturally occurring water pools found in rivers (Elliott and Lyons 1990). The total estimated volume of water present beneath ice hummocks in the 1002 area during 1989 was approximately 27 acre-ft (Elliott and Lyons 1990) compared to 25 acre-ft in the lowest volume lake measured during this study. The only other naturally occurring sources of winter water in the area are perennial springs. The largest spring in the 1002 area, Sadlerochit Spring, discharges an average of 80 acre-ft per day (Lyons 1990).

Lakes deeper than 7 ft can also be considered potential winter fish habitat. The withdrawal of water from lakes inhabited by fish should be considered on a case by case basis, taking into account the amount of water necessary for overwinter survival. If there are no environmental concerns with winter water withdrawal where a lake freezes to the substrate, larger volumes of water are available by removing the water prior to maximum ice development. For example, 152 acre-ft instead of 29 acre-ft could be obtained from lake 21 prior to January 4, before ice thickness reaches 4 ft (Table 1). Using this criterion, lakes shallower than 7 ft could also be used as a winter water source.

The distribution of fish in lakes of the 1002 area is much more widespread than previously reported. With the exception of one lake near the Jago River, the only lakes in the 1002 area in which fish presence has been reported are near the Canning River. During 1989, eight lakes surveyed for fish presence by Ward and Craig (1974) and West and Fruge (1989) were resurveyed. Fish were observed in seven of the eight lakes, of which five were previously reported to contain fish. Fish were captured in 30 lakes for which there was no previous record of fish presence.

Fish presence in lakes was associated with maximum lake depth. Although fish were most commonly found in lakes deeper than 7 ft, they were also found in lakes shallower than 7 ft. The presence of fish in these shallower lakes is not clearly understood. Some of the lakes have direct connections to the Beaufort Sea or rivers that support fish populations and may provide habitat only for summer residence. Other possible explanations include: 1) presence of a deep hole that could be used for overwinter residence was not identified by the depth profile inventory, 2) a spring source in the lake bottom, and 3) tolerance to high salinity and depressed freezing point resulting from accumulation of salts during ice formation.

The fish sampling effort during this study was limited by time and helicopter availability and was cursory by necessity. Lakes in which no fish were found should not be considered devoid of fish solely on the basis of this effort. The sampling method targeted fish species and age classes most likely to be found along shallow lake margins with aquatic vegetation, i.e., ninespine sticklebacks and young-of-the-year Arctic grayling. Different sampling methods are required to document the presence of larger fish.

More extensive fish surveys are recommended for 12 lakes that were investigated during this inventory (lake numbers 2, 9, 10, 12, 14, 15, 24, 27, 32, 33, 47, and 54). These lakes were selected based on their location (proximity or connection to drainages with fish other than ninespine sticklebacks) and depth (greater than 9 ft).

An inventory of the remaining lakes within the 1002 area larger than 25 acres is recommended due to the poor correlation between depth and fetch ($r^2 = 0.05$). Water volumes should be quantified and fish presence documented for the remaining 64 lakes not inventoried in 1989.

References

Arctic Environmental Information and Data Center. 1986. Alaska climate summaries. Alaska Climate Center Technical Note Number 3, Anchorage, Alaska.

Bilello, M.A., and R.E. Bates. 1969. Ice thickness observations, North American Arctic and Subarctic, 1964-65, 1965-66. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory Special Report 43, Part IV, Hanover, New Hampshire.

Bilello, M.A., and R.E. Bates. 1971. Ice thickness observations, North American Arctic and Subarctic, 1966-67, 1967-68. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory Special Report 43, Part V, Hanover, New Hampshire.

Bilello, M.A., and R.E. Bates. 1972. Ice thickness observations, North American Arctic and Subarctic, 1968-69, 1969-70. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory Special Report 43, Part VI, Hanover, New Hampshire.

Bilello, M.A., and R.E. Bates. 1975. Ice thickness observations, North American Arctic and Subarctic, 1970-71, 1971-72. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory Special Report 43, Part VII, Hanover, New Hampshire.

Carson, C.E., and K.M. Hussey. 1962. The oriented lakes of Arctic Alaska. Journal of Geology 70:417-439.

Clough, N.K., P.C. Patton, and A.C. Christiansen, editors. 1987. Arctic National Wildlife Refuge, Coastal Plain resource assessment. Report and recommendation to the Congress of the United Stated and final legislative environmental impact statement. U.S. Department of the Interior, Washington, D.C.

Childers, J.M., C.E. Sloan, J.P. Meckel, and J.W. Nauman. 1977. Hydrologic reconnaissance of the eastern north slope, Alaska, 1975. U.S. Geological Survey Open-file Report 77-492, Anchorage, Alaska.

Elliott, G.V. 1989. Winter water availability on the 1002 area of the Arctic National Wildlife Refuge. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 3, Anchorage, Alaska.

Elliott, G.V., and S.M. Lyons. 1990. Quantification and distribution of winter water within rivers of the 1002 area, Arctic National Wildlife Refuge. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 6, Anchorage, Alaska.

Hobbie, J.E. 1984. The ecology of tundra ponds of the Arctic coastal plain: A community profile. U.S. Fish and Wildlife Service, FWS/OBS-83/25, Washington, D.C.

Lyons, S. 1990. Water resource inventory and assessment Arctic National Wildlife Refuge, 1989 stream discharge gaging data. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 8, Anchorage, Alaska.

Wahrhaftig, C. 1965. Physiographic divisions of Alaska. U.S. Geological Survey Professional Paper 482, Washington, D.C.

Ward, D., and P. Craig. 1974. Catalogue of streams, lakes, and coastal areas in Alaska along routes of the proposed gas pipeline from Prudhoe Bay to the Alaskan/Canadian border. Canadian Arctic Gas Study Ltd./Alaskan Arctic Gas Study Co. Biological Report Series 19, Calgary, Alberta.

Welch, P.S. 1948. Limnological Methods. The Blakiston Company, Philadelphia, Pennsylvania.

West, R.L., and D.J. Fruge. 1989. A review of coastal plain fish surveys and the results of 1986 fish surveys of selected coastal lakes and streams, Arctic National Wildlife Refuge, Alaska. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 4, Fairbanks, Alaska.

Wilson, W.J., E.H. Eugene, G.F. Player, and L.D. Dreyer. 1977. Winter water availability and use conflicts as related to fish and wildlife in Arctic Alaska--A synthesis of information. U.S. Fish and Wildlife Service, FWS/OBS-77/06, Washington, DC.

APPENDIX

Legal descriptions of study lake locations.

Lake Number	Map Location	Latitude	Longitude
	Mt. Michelson (D-4)[a]		
1	SW1/4 NW1/4 Sec. 11, T.6N., R.23E.	69°53'30"	146°20'28"
2	NW1/4 SW1/4 Sec. 12, T.6N., R.23E.	69°53'20"	146°17'58"
3	SW1/4 NW1/4 Sec. 31, T.7N., R.24E.	69°55'08"	146°14'55"
4	NW1/4 NW1/4 Sec. 28, T.7N., R.24E.	69°56'14"	146 10'08"
5	SE1/4 SE1/4 Sec. 30, T.5N., R.24E.	69°45'21"	145°12'57"
6	NW1/4 SW1/4 Sec. 1, T.5N., R.24E.	69°48'51"	146°02'57"
7	NE1/4 SE1/4 Sec. 8, T.7N., R.25E.	69°58'22"	145°55'55"
8	NE1/4 NW1/4 Sec. 10, T.7N., R.25E.	69°58'46"	145°52'10"
9	NW1/4 NE1/4 Sec. 28, T.5N., R.25E.	69°45'58"	145°53'40"
10	SW1/4 SE1/4 Sec. 23, T.5N., R.25E.	69°46'00"	145°48'36"
	Flaxman Island (A-3)		
11	NW1/4 SW1/4 Sec. 17, T.8N., R.26E.	70°02'41"	145°42'45"
12	SE1/4 SW1/4 Sec. 16, T.8N., R.26E.	70°02'27"	145°39'30"
13	NE1/4 SW1/4 Sec. 27, T.8N., R.26E.	70°58'00"	145°37'28"
14	SE1/4 SE1/4 Sec. 24, T.8N., R.26E	70°01'35"	145°31'15"
15	NW1/4 SW1/4 Sec. 28, T.8N., R.27E.	70°01'05"	145°22'55"
16	SW1/4 NW1/4 Sec. 35, T.8N., R.27E.	70°24'00"	145°20'00"
	Mt. Michelson (D-3)		
17	NE1/4 NE1/4 Sec. 5, T.7N., R.27E.	69°59'43"	145°26'20"
18	NE1/4 NW1/4 Sec. 19, T.5N., R.26E.	69°46'48"	145°44'45"
	Mt. Michelson (D-2)		
19	SW1/4 NE1/4 Sec. 15, T.6N., R.30E.	69°52'33"	144°36'18"
	Mt. Michelson (D-1)		
20	SW1/4 SW1/4 Sec. 20, T.7N., R.32E.	69°56'34"	144°13'08"
21	NE1/4 NE1/4 Sec. 13, T.6N., R.31E.	69°52'50"	144°15'40"
22	SW1/4 SW1/4 Sec. 6, T.5N., R.33E.	69°48'36"	144°20'00"
	Demarcation Point (D-5)		
23	NE1/4 NE1/4 Sec. 3, T.7N., R.33E.	69°59'52"	143°50'52"
24	SE1/4 SW1/4 Sec. 11, T.7N., R.33E.	69°58'18"	143°49'43"
25	NE1/4 SE1/4 Sec. 5, T.7N., R.34E.	69°59'24"	143°41'55"
26	SW1/4 SE1/4 Sec. 1, T.7N., R.34E.	69°59'11"	143°31'30"
27	SE1/4 NW1/4 Sec. 9, T.7N., R.35E.	69°58'40"	143°24'50"
28	NE1/4 NW1/4 Sec. 16, T.7N., R.35E.	69°58'00"	143°24'40"
29	NE1/4 NE1/4 Sec. 3, T.6N., R.34E.	69°54'40"	143°36'13"
30	SE1/4 SW1/4 Sec. 24, T.6N., R.34E.	69°51'20"	143°32'30"
31	SW1/4 NE1/4 Sec. 25, T.6N., R.34E.	69°50'51"	143°31'32"
32	SW1/4 SE1/4 Sec. 33, T.6N., R.34E.	69°49'34"	143°39'22"

Lake Number	Map Location	Latitude	Longitude
	Demarcation Point (D-5)		
33	SW1/4 SE1/4 Sec. 5, T.5N., R.35E.	69°48'45"	143°26'22"
34	NW1/4 SW1/4 Sec. 24, T.5N., R.34E.	69°46'14"	143°32'50"
	Barter Island (A-4)		
35	NE1/4 NE1/4 Sec. 28, T.8N., R.35E.	70°01'23"	143°23'20"
36	SE1/4 NE1/4 Sec. 19, T.8N., R.36E.	70°02'11"	143°13'25"
	Demarcation Point (D-4)		
37	SW1/4 NE1/4 Sec. 23, T.7N., R.35E.	69°57'13"	143°19'08"
38	NW1/4 NW1/4 Sec. 24, T.7N., R.35E.	69°56'56"	143°18'10"
39	SE1/4 NW1/4 Sec. 13, T.7N., R.35E.	69°57'46"	143°17'32"
40	SE1/4 SW1/4 Sec. 12, T.7N., R.35E.	69°58'11"	143°17'08"
41	NE1/4 NE1/4 Sec. 6, T.5N., R.36E.	69°49'26"	143°13'20"
42	SW1/4 SE1/4 Sec. 32, T.6N., R.36E.	69°49'28"	143°11'40"
43	SE1/4 NW1/4 Sec. 16, T.6N., R.36E.	69°52'40"	143°10'05"
44	NW1/4 NW1/4 Sec. 3, T.7N., R.36E.	69°59'42"	143°08'08"
45	SW1/4 NE1/4 Sec. 8, T.7N., R.37E.	69°58'32"	142°56'32"
46	NE1/4 SW1/4 Sec. 14, T.7N., R.37E.	69°57'30"	142°49'53"
47	NW1/4 SE1/4 Sec. 3, T.6N., R.37E.	69°54'07"	142°51'35"
48	SE1/4 SW1/4 Sec. 28, T.6N., R.37E.	69°50'21"	142°54'40"
49	NW1/4 SW1/4 Sec. 27, T.6N., R.37E.	69°50'34"	142°52'45"
	Barter Island (A-3)		
50	NW1/4 SE1/4 Sec. 25, T.8N., R.37E.	70°01'05"	142°46'35"
	Demarcation Point (D-3)		
51	SW1/4 SE1/4 Sec. 13, T.7N., R.38E.	69°57'24"	142°31'35"
52	SW1/4 SW1/4 Sec. 3, T.6N., R.39E.	69°54'00"	142°23'07"
53	NW1/4 NW1/4 Sec. 10, T.6N., R.39E.	69°53'37"	142°22'41"
	Demarcation Point (D-2)		
54	NW1/4 NE1/4 Sec. 33, T.6N., R.40E.	69°50'10"	142°09'20"

[a] Map names refer to U.S. Geological Survey 1:63,360 topographic maps.