# FRESHWATER HABITAT RELATIONSHIPS

## BROAD WHITEFISH - COREGONUS NASUS

ALASKA DEPARTMENT OF FISH & GAME
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# I. INTRODUCTION

## A. Purpose

This report presents available information on the freshwater habitat requirements of the broad whitefish, Coregonus nasus (Pallas) and evaluates the habitat parameters which are most important to the species or are most often critical to survival or limiting to production.

Because the range of the species includes coastal brackish waters which are used as summer feeding areas or as overwintering areas, information from such areas was also considered.

The emphasis of this report is on habitat requirements, primarily those of a physical or chemical nature. Certain biological factors affecting the well-being of the population such as feeding, predation, competition, and disease are not comprehensively treated.

This report is intended to support habitat evaluation activities by presenting a data base for the species and by pointing out where more data are needed.

Although information has been examined from throughout the range of the species, emphasis is placed upon Alaska. While there appears to be wide differences in growth rates between different populations within the state, there is insufficient information to show that habitat requirements differ among the various populations. There are some problems with the taxonomy of the species. Information referring to Coregonus nasus (Pallas) sensu Svardson in Scandinavia was not used because that species evidently is different from the Coregonus nasus (Pallas) of Siberia, Alaska, and northwest Canada.

The life history of the broad whitefish, especially that of the early life stages, is not well known. Even less is known of habitat tolerances, preferences, and requirements. The broad whitefish appears to have fairly wide habitat tolerances. Several reports on the life histories of related species are presented in the Biology of Coregonid Fishes, edited by Lindsey and Woods (1970).

B. Distribution

The broad whitefish is a lacustrine-fluvial species, but is found more often in rivers than in lakes. It also occurs in brackish areas of coastal waters.

It is distributed in North America in Bering Sea and Arctic Ocean drainages from the Kuskokwim River system in Alaska north and east to the Perry River, Northwest Territories. In the USSR, it is distributed from the Pechora River near the Ural Mountains east in Arctic Ocean drainages and south in Bering Sea drainages to the Bay of Korf, and in the Penzhina River on the northeastern corner of the Sea of Okhotsk (Berg, 1948; McPhail and Lindsey, 1970; Scott and Crossman, 1973). The southern limit inland is approximately 60° N.

In Alaska, the broad whitefish is found in most drainages north of the Kuskokwim River system, where it is common, and the Alaska Range. (Figure 1). It occurs in the Yukon River system from the mouth to the headwaters in British Columbia (Morrow, 1980), including the Koyukuk River and Porcupine River drainages. It is common in the Minto Flats area of the Tanana River system but apparently uncommon further upstream. It is widespread in the drainages emptying into the Bering Sea (Kuskokwim River and north), Chukchi Sea, and Beaufort Sea. The Susitna River and the Copper River drainages have no broad whitefish (Alt, 1971).

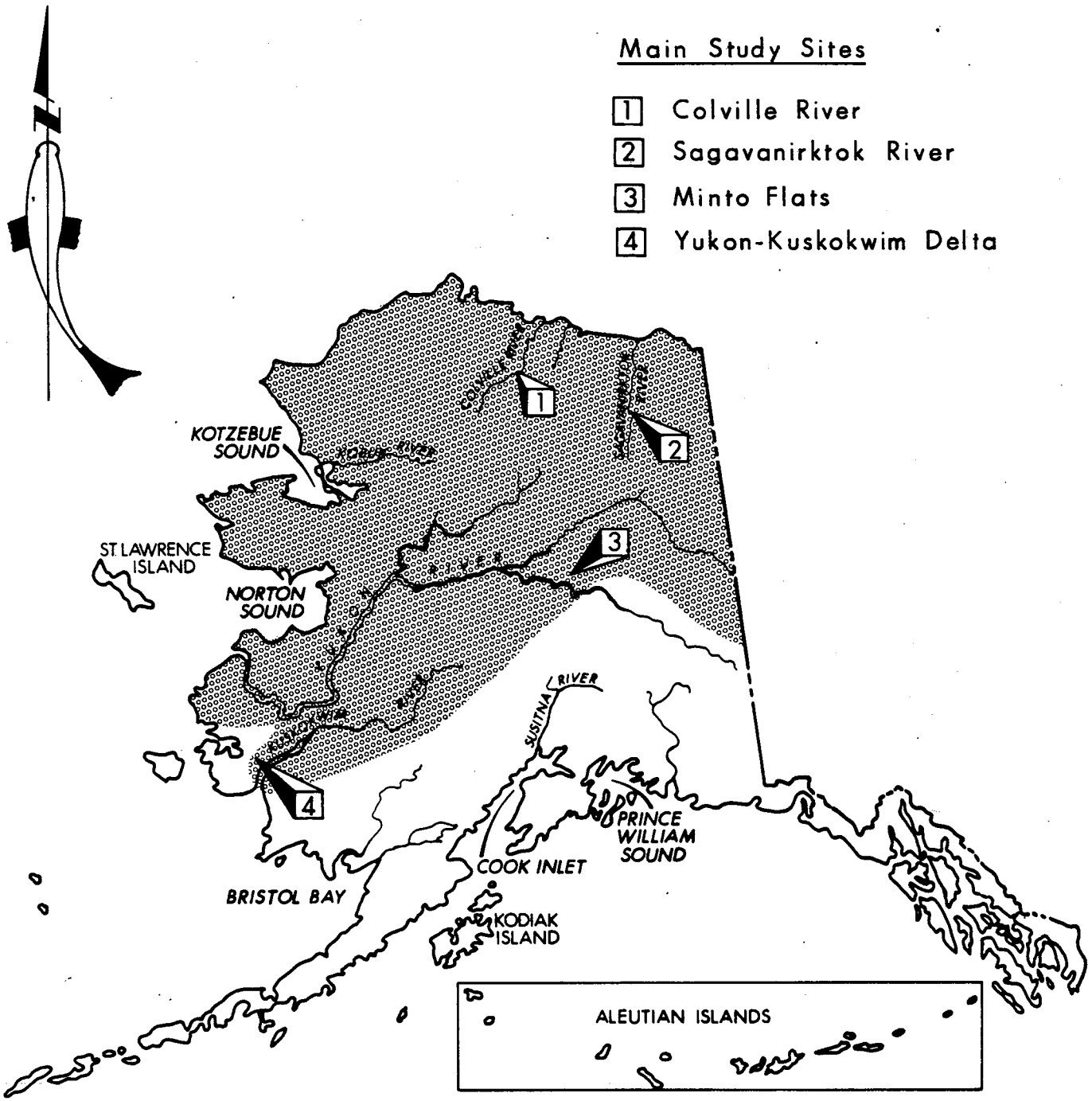


Figure 1. Distribution of broad whitefish in Alaska (R. Baxter, personal communication; Morrow, 1980) and main study sites.

C. Life History Summary

The life history of the broad whitefish is not well known. Migrations occur between summer feeding areas, spawning areas, and overwintering areas. In general, spawning migrations occur in the late summer and fall as the fish move out of summer feeding areas and move to spawning areas. Baxter (1973) has noted that, in the Kuskokwim River area, the ripening females move downstream out of the tundra lakes, ponds, and streams in August and September and begin a slow migration up the Kuskokwim River. They are followed by the sexually developing males in September and by the non-spawning adults of both sexes in late September through October. Immature fish leave the tundra in October through December. Broad whitefish apparently migrate downstream out of the Minto Flats into the Tanana River in August (Kepler, 1973; Townsend and Kepler, 1974). On the North Slope, fish that had been feeding in coastal areas enter the Sagavanirktok River in late August to migrate to the spawning areas (Bendock, 1977). A sizeable spawning run moves up the Colville River in August (Bendock, 1979). Alt and Kogl (1973) found that the Colville run is spread over several months and peaks in late July.

Wynne-Edwards (1952, cited by McPhail and Lindsey, 1970) stated that upstream spawning migration of broad whitefish occurred in the lower Mackenzie River in July and August. Evidently, the migration up the Mackenzie peaks in the inner delta during September and October (DeGraaf and Machniak, 1977). In the upper Yukon River, broad whitefish on spawning migrations have been observed entering small tributaries in September; ripe fish have been captured in the main river in early October (McPhail and Lindsey, 1970). Spawning in the Mackenzie River apparently takes place in back eddies during October (DeGraaf and Machniak, 1977). Spawning in the USSR takes place in October and November (Berg, 1948).

Morrow (1980) states that spawning of the broad whitefish in Alaska occurs in September and October and possibly into November. Baxter (1973) found that the spawning season in the lower Kuskokwim River lasts from October to early December. Adults do not spawn every year. Broad whitefish in the Colville River apparently spawn in September in the upper section of the river (Alt and Kogl, 1973). Cohen (1954) reported that broad whitefish (Coregonus nasus kennicotti) spawn in Ikroavik Lake near Barrow in July and possibly in June.

Spawning usually takes place in rivers. In Alaska, there are spawning populations of broad whitefish in Lake Minchumina (Baxter, 1973) and possibly also in the Killick Lakes of the North Slope (Terry Bendock, personal communication). Cohen (1954) reported a spawning population of broad whitefish in Ikroavik Lake. Kuz'min (1969) reported that an attempt to raise broad whitefish in lakes from spawn taken from rivers was not successful because the females did not come to sexual maturity. Kuz'min suggested that running water is a requirement for successful reproduction of these populations.

Broad whitefish broadcast their eggs over substrates ranging from mud and sand to gravel and cobble (Baxter, 1973; Kogl, 1971; Morrow, 1980). Little else is known about their spawning habitat needs.

The fecundity of a sample of 11 females from the Mackenzie River ranged from 26,922 to 65,798 eggs/female with a mean of 39,721 eggs/female (DeGraaf and Machniak, 1977). Three fish from the Kuskokwim River had fecundities ranging from an estimated 46,219 to 127,707 eggs/female (Baxter, 1973).

Apparently, in several stocks, there is a post-spawning downstream migration of adults to overwintering areas in deep sections of rivers or in brackish water areas or lakes (Baxter,

personal communication; Bendock, 1977; Berg, 1948; Morrow, 1980; Scott and Crossman, 1973). In the Mackenzie River, this downstream migration occurs in early November. Broad whitefish overwinter in the outer Mackenzie Delta and in lakes of the inner Delta (DeGraaf and Machniak, 1977).

In the lower Kuskokwim River, the population which overwinters in the main river migrates back to the summer feeding areas of the tundra system in late May or early June after spring runoff (Baxter, 1973). A similar migration occurs in the Minto Flats area. Broad whitefish move in June from the Tanana, Tolovana, and Chatanika Rivers to feed in the lakes and sloughs of the Flats (Kepler, 1973). On the North Slope, some broad whitefish migrate out of the larger rivers such as the Colville, Canning and Sagavanirktok when these rivers break up in early June and move into shallow bays and lagoons of the Beaufort Sea for summer feeding (Bendock, 1977). Other broad whitefish remain in the rivers throughout the summer.

Young broad whitefish hatch in the spring and apparently migrate to summer feeding areas which may include lakes (Baxter, 1973; Berg, 1948; Morrow, 1980). There is no information on whether or not the young-of-the-year fish have rearing areas separate from the immature and adult fish.

The broad whitefish is apparently a bottom feeder. The diet includes gastropods, pelecypods, chironomids including midge larvae and pupae, mosquito larvae, other dipteran larvae and adults, terrestrial insects, trichopterans, amphipods, mysids, copepods, and phytoplankton (Bendock, 1977 and 1979; Berg, 1948; Boughton and Clemens, 1966; DeGraaf and Machniak, 1977; Furniss, 1975; McPhail and Lindsey, 1970; Scott and Crossman, 1973). Apparently, little feeding, if any, occurs during overwintering. Stomachs of fish captured while overwintering in the Colville River (Bendock, personal communication; Kogl and Schell, 1975)

and the Sagavanirktok River (Bendock, 1977) have been empty. In the Kuskokwim River area, the fish do not feed from the time they leave the tundra system in the fall until the time they return to the tundra lakes and streams in the spring (Baxter, 1973). Stein et al. (1973, cited by DeGraaf and Machniak, 1977) collected broad whitefish from lakes in the Mackenzie Delta during the summer. They reported that a lower percentage of fish taken from lakes had empty stomachs than those taken from the Mackenzie River, indicating the importance of lakes as feeding areas.

Most broad whitefish reach sexual maturity at about age five to seven (Alt, 1976; Berg, 1948). At that time, they are around 35 - 50 cm fork length and weigh around 0.5-2 kg (Alt, 1976; Bendock, 1979; Berg, 1948). Specimens have been captured in Siberia weighing up to 12 kg and perhaps 16 kg; the longest fish reported was 86 cm long (Berg, 1948). The maximum age reported to date is 22 years (Craig and Haldorson, 1980).

The broad whitefish is the largest of the Alaskan whitefish (Morrow, 1980) except for the sheefish. The maximum length reported for most populations of Alaskan broad whitefish is around 65 cm fork length (Alt, 1976; Bendock, 1979; Kogl, 1971); the largest fish from the Kuskokwim River was 72.4 cm fork length and weighed 7.6 kg (R. Baxter, personal communication). Most Alaskan broad whitefish captured are between 25-60 cm fork length, between 0.5 - 2.5 kg in body weight, and are four to eight years of age (Alt, 1976; Bendock, 1979; Furniss, 1975). The average weight of fish in the commercial harvest in the lower Kuskokwim is 3.3 kg (R. Baxter, personal communication). There are considerable differences in growth rates and in size of broad whitefish among different geographical areas.

## D. Ecological and Economic Importance

The broad whitefish is of excellent quality as a food fish and is important in commercial and subsistence fisheries. In Alaska, a limited commercial summer fishery on the Colville River delta takes about 3000 broad whitefish or about 7,000 kg per year (Alt and Kogl, 1973). The broad whitefish is the target species in the Nechelik Channel of the Colville (Kogl and Schell, 1975). Another small commercial fishery exists in the Yukon-Kuskokwim Delta area. The broad whitefish is widely used throughout its range in Alaska for subsistence food. In the Kuskokwim River delta area, it is second only to salmon in importance (Baxter, 1973). It is taken year round by gill nets; in the summer, fish fences and dip nets are also used. Small numbers are taken each year in Alaska by sportfishermen.

## II. SPECIFIC HABITAT REQUIREMENTS

### A. Adults

Broad whitefish have been captured in Alaska and northwest Canada in water temperatures ranging from 0 to 16°C (Bendock, 1977; Craig and Haldorson, 1980; Kogl, 1971; Muth, 1969). They may tolerate summer temperatures in shallow ponds of the Kuskokwim River delta up to about 20°C (R. Baxter, personal communication). There is no information on preferred temperatures, but fish from the Mackenzie River (0 to 15.5°C annual range) have a greater growth rate than Coppermine River fish (0 to 10.0°C annual range) which may suggest that summer temperatures above 10°C are more favorable for growth (Muth, 1969). The longer growing season and the greater food abundance in the Mackenzie could also be factors. Alt (1976) suggests that the slower growth rate of broad whitefish from the Sagavanirktok River and Imuruk Basin (Seward Peninsula) as compared to other populations within Alaska may be a result of the shorter ice-free period in those two areas.

Broad whitefish in Alaska generally occur in streams where the gradient is less than 0.75 m/km (Alaska Department of Fish and Game, unpublished manuscript; Kogl, 1971). Current velocities for several bodies of water on the North Slope where broad whitefish occur range from 0 to around 180 cm/sec. (Kogl, 1971).

The broad whitefish occurs in Alaska in tundra ponds where the pH can range down to pH 5.5 or 6.0 (K. Alt, personal communication; R. Baxter, personal communication). They also occur in lakes where the pH at the surface can range upward to 8.1 (Boughton and Clemens, 1966). However, the exact range that they can tolerate or that they prefer is unknown.

Broad whitefish have been caught in waters with salinities of: 11.4 to 40.8 parts per thousand (ppt) in April on the Colville River Delta (Kogl and Schell, 1975), 0-30 ppt in coastal areas of the North Slope (Craig and Haldorson, 1980), 4-28 ppt in Prudhoe Bay (Bendock, 1977), and occasionally in brackish water of 5-6 ppt in coastal areas of Siberia (Berg, 1948). Alt (1976) states that they are seldom taken in waters of greater than 20 ppt salinity. They have been caught in waters of the North Slope with turbidities of 2-146 NTU (Craig and Haldorson, 1980) and 5-10 ppm (Kogl, 1971).

1. Spawning Migration

In laboratory experiments at 12 - 13°C, Jones (197?) found that the critical velocity for broad whitefish with a fork length of about 35 cm was approximately 65 cm/sec. Jones projected that adult broad whitefish could move 100 m in 10 minutes against a current velocity of 40 cm/sec. Upstream migrations could be inhibited by higher current velocities or stream reaches longer than 100 m with velocities in the range of 40 cm/sec. However, the fish occur in the summer in streams of the North Slope which have current velocities of 80 to 180 cm/sec (Kogl, 1971).

2. Spawning

Broad whitefish spawn at water temperatures close to 0°C (K. Alt, personal communication; R. Baxter, personal communication; Berg, 1948). Spawning takes place at about the time of freezing of lakes and streams. The upper temperature limit is unknown.

Spawning takes place over substrates ranging from mud and sand to gravel, cobble, and boulders with perhaps fine

gravel being the most common substrate (Alt, personal communication; Baxter, personal communication; Kogl, 1971).

Running water prior to spawning may be a requirement of certain stocks of broad whitefish for successful sexual development of females Kuz'min, 1969). However, there appear to be strictly lacustrine stocks. Examples in Alaska are the Lake Minchumina population which evidently spawns on gravel and cobble along the lake shore (R. Baxter, personal communication) and the Ikroavik Lake population (Cohen, 1954).

3. Overwintering

Broad whitefish overwinter at 0°C with no apparent ill effects (Baxter, 1973; Bendock, 1977). Kogl and Schell (1975) found broad whitefish in the Colville Delta in April where at dissolved oxygen concentrations were 2.3 to 7.8 mg/l and Bendock (1980) has found them overwintering in holes of the Colville River where dissolved oxygen levels were 1.4 to 4.6 mg/l. Fish found at the lower dissolved oxygen level appeared healthy. Baxter (1973) stated that 2 mg $O_2$/l is apparently the minimum oxygen level tolerable for Kuskokwim River broad whitefish.

B. Incubation of Embryos

Very little information is available for the embryonic stage of the broad whitefish. Because of their geographic location and time of spawning, must incubate at water temperatures close to 0°C. However, Cohen (1954) states that broad whitefish (Coregonus nasus kennicotti) spawned in Ikroavik Lake near Barrow in July; the eggs developed at 6-12°C and hatched in 30-60 days.

C. Juvenile Rearing

Young of the year and juveniles apparently mix with the adults. It is not presently known if there are differences in habitat requirements among these life stages.

## III. SUITABILITY INDEX CURVES

No suitability index curves were drawn for the broad whitefish because there is not sufficient information to construct meaningful curves. The wide distribution of this species in habitats with differing ranges of habitat parameters further compounds the problem. Tables I and II provide a general overview of certain physical and chemical parameters.

BROAD WHITEFISH Table I. Adults

| Parameter | Observed Values | Remarks | Location | Reference |
|---|---|---|---|---|
| Temperature, °C | 0 | overwintering | Kuskokwim River area | Baxter (1973) |
| | 0 - 1 | overwintering | Colville and Sagavanirktok Rivers | Bendock (1977) |
| | 0 - 15.5 | annual range | Mackenzie River | Muth (1969) |
| | 0 - 10.0 | annual range | Coppermine River | Muth (1969) |
| | 0 - 14 | temperature at time of capture | North Slope | Craig and Haldorson (1980) |
| | 14 - 16 | summer range | North Slope | Kogl (1971) |
| | may go up to 20 | tundra ponds | Yukon-Kuskowim Delta | R. Baxter (personal communication) |
| Dissolved Oxygen, mg/l | 2.3 - 7.8 | overwintering | Colville River Delta | Kogl and Schell (1975) |
| | 1.4 - 4.6 | overwintering | Colville River | Bendock (1980) |
| | 2 | minimum tolerable at 0°C | Kuskokwim River | Baxter (1973) |
| Salinity, ppt. | 11.4 - 40.8 | April | Colville River Delta | Kogl and Schell (1975) |
| | 0 - 30 | | Coastal areas of North Slope | Craig and Haldorson (1980) |
| | 4 - 28 | | Prudhoe Bay | Bendock (1977) |
| | 5 - 6 | | Siberia | Berg (1948) |

BROAD WHITEFISH Table II. Spawning

| Parameter | Observed Values | Remarks | Location | Reference |
|---|---|---|---|---|
| Temperature, °C | around 0 | | Kuskokwim River | R. Baxter (personal communication) |
| | close to 0 | | USSR | Berg (1948) |
| | 0 - 4 | | Alaska | K. Alt (personal communication) |

## IV. DEFICIENCIES IN DATA BASE AND RECOMMENDATIONS

Because so little is known about the habitat tolerances, preferences, and needs of the broad whitefish, information is needed on almost all aspects. There is a need for basic descriptive life history studies, extensive measurements of habitat parameters, and physiological experiments in the laboratory.

LITERATURE CITED

Alaska Department of Fish and Game (unpublished manuscript). Whitefish investigations of the Yukon-Kuskokwim Delta. Commercial Fisheries Division, Bethel.

Alt, Kenneth T. 1971. Distribution, movements, age and growth, and taxonomic status of whitefish (Coregonus sp.) in the Tanana-Yukon drainage and North Slope. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Project F-9-3, Study R-11, Job R-II-F, Vol. 12: 19-31.

Alt, Kenneth T. 1976. Age and growth of Alaskan broad whitefish, Coregonus nasus. Trans. Am. Fish Soc. 105:526-528.

Alt, Kenneth T., and Dennis R. Kogl, 1973. Notes on the whitefish of the Colville River, Alaska. J. Fish. Res. Bd. Can. 30 (4):554-556.

Baxter, Rae, 1973. Coregonus nasus (Pallas). Alaska Department of Fish and Game, Commercial Fisheries Division, Bethel.

Bendock, Terrence N., 1977. Beaufort Sea estuarine fishery study. Final Report OCS Contract No. 03-5-022-69. Alaska Department of Fish and Game, Fairbanks.

Bendock, Terrence N., 1979. Inventory and cataloging of Arctic area waters. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Study No. G1, Job No. G-I-I, Vol. 20: 1-64.

Bendock, Terrence N., 1980. Inventory and cataloging of Arctic area waters. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Study No. G1, Job No. G-I-I.

Berg, Leo S. 1948. Freshwater fishes of the USSR and adjacent countries. (Translated from Russian). Vol. 1, Acad. Sci. USSR Zool. Inst. Translated by Israel Program for Scientific Translations, 1962. 504 pp.

Boughton, R. V., and W. A. Clemens. 1966. The annual production of the whitefishes Coregonus clupeaformis and C. nasus in Teslin Lake, British Columbia. Northwest Science. 40 (4):147-154.

Cohen, Daniel M. 1954. Age and growth studies on two species of whitefishes from Point Barrow, Alaska. Stanford Ichthyological Bulletin 4(3): 168-187.

Craig, P.C., and L. Haldorson, 1980. Beaufort Sea Barrier Island-Lagoon ecological process studies; final report, Simpson Lagoon studies. Part 4. Fish. OCS Annual Report. Contract No. 03-6-022-35193, LGL Limited, Sidney, British Columbia. 259 pp.

DeGraaf, D., and K. Machniak, 1977. Fishery investigations along the Cross delta pipeline route in the Mackenzie delta. Chapter IV, pages 1- 169 in (P. McCart, ed.). Studies to determine the impact of gas pipeline development on aquatic ecosystems. Arctic Gas. Biological Report Series, Vol. 39. Prepared by Aquatic Environments Limited.

Furniss, R.A. 1975. Inventory and cataloging of Arctic area waters. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Project F-9-7, Study G-I-I. Vol. 16, 47 pp.

Jones, David R., (197?). An evaluation of the swimming performance of several fish species from the Mackenzie River. University of British Columbia, Vancouver. 53 pp.

Kepler, P., 1973. Population studies of northern pike and whitefish in the Minto Flats complex with emphasis on the Chatanika River. Alaska Department of Fish and Game. Federal Aid in Fish Restoration. F-9-5, Study G-II, Jog G-II-J. Vol. 14: 59-81.

Kogl, Dennis R., 1971. Monitoring and evaluation of Arctic waters with emphasis on the North Slope drainages: Colville River study. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Project F-9-3, Job G-III-A, Vol. 12:23-61.

Kogl, Dennis, and Donald Schell. 1975. Colville River Delta fisheries research. Chapter 10, pages 483-504 in Environmental Studies of an Arctic Estuarine System -Final Report. Prepared by Institute of Marine Science, University of Alaska. U.S. Environmental Protection Agency, Corvallis. EPA-660/3-75-026. 536 pp.

Kuz'min, A.N., 1969. Development of the reproductive system in female broad whitefish (Coregonus nasus (Pallas)), reared in ponds and lakes of northwest USSR. Problems of Ichthyology. 9(2): 197-205.

Lindsey, C. C., and C.S. Woods (eds.), 1970. Biology of coregonid fishes. University of Manitoba Press, Winnipeg. 560 pp.

McPhail, J. D., and C. C. Lindsey, 1970. Freshwater fishes of Northwestern Canada and Alaska. Fisheries Research Board of Canada Bulletin 173, Ottawa. 381 pp.

Morrow, James E., 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Co., Anchorage. 248 pp.

Muth, K.M., 1969. Age and growth of broad whitefish, Coregonus nasus, in the Mackenzie and Coppermine Rivers, N.W.T. J. Fish. Res. Bd. Canada, 26 (8): 2252-2256.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184. Ottawa. 966 pp.

Townsend, Alan H., and Phil P. Kepler, 1974. Population studies of northern pike and whitefish in the Minto Flats complex with emphasis on the Chatanika River. Alaska Department of Fish and Game. Federal Aid in Fish Restoration. Project F-9-6, Study G-II, Job G-II-J. Vol. 15: 59-79.