AN ANNOTATED BIBLIOGRAPHY OF SELECTED REFERENCES OF FISHES OF THE NORTH SLOPE OF ALASKA, WITH EMPHASIS ON RESEARCH CONDUCTED IN NATIONAL PETROLEUM RESERVE - ALASKA

for

North Slope Borough
Barrow, Alaska

by

J.F. Winters, P.K. Weber, A.L. DeCicco, and N. Shishido
Alaska Department of Fish and Game
Divisions of Habitat and Subsistence

May 1988

TABLE OF CONTENTS

List of Tables

List of Figures

INTRODUCTION

The National Petroleum Reserve in Alaska (NPR-A) encompasses a considerable portion of the North Slope of Alaska. Within or near NPR-A are five communities, Point Lay, Wainwright, Barrow, Atqasuk, and Nuiqsut, that use the area for harvesting renewable resources as part of their wage/subsistence economies. Consequently, subsistence users within these villages are concerned that resource development may interfere with traditional uses of resources or may have an adverse effect on populations of fish and wildlife. In an effort to continue economic growth on the North Slope, while minimizing adverse effects of resource development on important fish and wildlife resources, the North Slope Borough (NSB) is beginning development of comprehensive management plans for caribou, fishes, and their habitats within NPR-A. One component of this process is the preparation of an annotated bibliography of references pertaining to fish species found within NPR-A boundaries.

The annotated bibliography contains selected references concerning 12 species of freshwater and anadromous fish found within NPR-A. Table 1 lists these species along with secondary species that were discussed in many of the references. The 12 primary species were selected based on their importance to the subsistence fisheries, their relative importance in northern aquatic ecosystems, and any unique physical requirements that a species may possess.

References selected for inclusion in the annotated bibliography generally contained information discussing important life history functions (e.g., spawning or overwintering areas), basic biological parameters (e.g., length, age), distribution of the fish species, harvest of fish, or documented impacts of resource development on fish. References that did not directly discuss fish but contained information on habitat concerns (e.g., studies of water availability for proposed water withdrawals) or stream invertebrates were also included.

The geographic scope of the annotated bibliography was to be restricted to waters within or bordering NPR-A. Because relatively few studies of fish have been conducted in NPR-A, it was necessary to include references on the primary species from other arctic areas to obtain sufficient information for most fish species. Thus, references on fish from the entire North Slope of Alaska were included, as well as references from the arctic areas of Canada's Yukon Territory and Northwest Territories. The Mackenzie River and a few of its major northern tributaries served as the eastern boundary of references included in this bibliography. In addition, a few references discussing one or more of the primary species in areas of Alaska outside of the North Slope were included.

Several sources were used to locate and obtain references for inclusion in this annotated bibliography. References contained within the offices of the NSB Department of Wildlife Management in Barrow, and within the offices of the Alaska Department of Fish and Game's (ADF&G) Divisions of Habitat, Sport Fish, and Subsistence in Fairbanks were examined for their applicability to this project. These sources provided many of the reviewed references. An electronic search of ADF&G's Division of Habitat library holdings in Anchorage was conducted and provided a list of references that were examined for applicability. Many of the reviewed references were located by examining Literature Cited sections of papers under review for this study. Several unpublished lists of references on arctic

Table 1. Common and scientific names of fish discussed in the annotated bibliography.

COMMON NAME	SCIENTIFIC NAME
Primary species	
Arctic char	*Salvelinus alpinus*
Arctic cisco	*Coregonus autumnalis*
Arctic grayling	*Thymallus arcticus*
Burbot	*Lota lota*
Broad whitefish	*Coregonus nasus*
Chum salmon	*Onchorhynchus keta*
Humpback whitefish	*Coregonus pidschian*
Least cisco	*Coregonus sardinella*
Lake trout	*Salvelinus namaycush*
Northern pike	*Esox lucius*
Pink salmon	*Onchorhynchus gorbuscha*
Round whitefish	*Prosopium cylindraceum*
Secondary species	
Alaska blackfish	*Dallia pectoralis*
Arctic cod	*Boreogadus saida*
Arctic flounder	*Liopsetta glacialis*
Arctic lamprey	*Lampetra japonica*
Bering cisco	*Coregonus laurettae*
Capelin	*Mallotus villosus*
Coho salmon	*Onchorhynchus kisutch*
Chinook salmon	*Onchorhynchus tshawytscha*
Fourhorn sculpin	*Myoxocephalus quadricornis*
Longnose sucker	*Catostomus catostomus*
Ninespine stickleback	*Pungitius pungitius*
Pond smelt	*Hypomesus olidus*
Rainbow smelt (boreal smelt)	*Osmerus mordax*
Saffron cod	*Eleginus gracilis*
Sheefish	*Stenodus leucichthys*
Slimy sculpin	*Cottus cognatus*
Sockeye salmon	*Onchorhynchus nerka*
Invertebrates	

fishes were also examined for applicable sources of information. This annotated bibliography likely does not review all references on the fishes of NPR-A, but should reflect a review of most of the major studies conducted there and in nearby areas. Copies of the reviewed references are on file at the ADF&G Division of Habitat office in Fairbanks.

Two indexes to the annotated bibliography are provided to allow the user to find those references that discuss fishes within a specific river system or geographic area, or that discuss a specific species of fish or life function of a specific species. The primary index was developed from the fish species reported in the annotated references. For each of the 12 primary species, those references containing information on a particular species are listed under that species by page number of their locations within the bibliography. In addition, those references dealing with particular species are further indexed by life function category. A list of the life function categories used in this index and the information contained in these categories are presented in Table 2. Indexing of annotations discussing secondary species is also presented by species but not by life function category.

The second index was developed from the locations for which data on fishes are presented in the annotations. This index provides the user with the ability to identify those annotations that pertain to a specific region or river system (e.g., the Colville River drainage; the Point Lay-Wainwright area). The North Slope of Alaska and Canada was divided into seven areas to facilitate indexing. These areas are depicted in Figure 1 and are described below.

Point Hope Area. This area contains the area of Point Hope and extends as far south as Kivalina. Major drainages within the area include the Kukpuk, Pitmigea, Ipewik, Kivalina, and Wulik rivers.

Point Lay-Wainwright Area. This area is approximately bordered by the village of Point Lay and Peard Bay, and contains the drainages of the Kukpowruk, Kokolik, Utukok, Kuk, and Kugrua rivers, Kasegaluk Lagoon, and Peard Bay.

Barrow Area. This area is bordered by Peard Bay on the west and ranges eastward to the Colville River drainage. This area contains Teshekpuk Lake, Elson Lagoon, Smith Bay, part of Harrison Bay, and the Inaru, Meade, Chipp, and Ikpikpuk rivers.

Colville River Area. This area includes the entire Colville River drainage, and portions of Harrison Bay and Simpson Lagoon.

Kuparuk-Sagavanirktok Area. This area contains the drainages of the Kuparuk, Toolik, Sagavanirktok, Kadleroshilik, Shaviovik, and Kavik rivers, and Gwydyr, Prudhoe, Foggy Island, and Mikkelsen bays.

Arctic National Wildlife Refuge. This area contains that portion of the Arctic National Wildlife Refuge draining into the Beaufort Sea and includes the drainages of the Canning, Sadlerochit, Hulahula, Jago, Aichilik, Kongakut, and Clarence rivers.

Yukon Territory-Northwest Territories Area. This area includes the drainages from the Alaska-Canada border eastward to and including the Mackenzie River. Major drainages include the Malcolm, Firth, Babbage, Blow, and Mackenzie rivers.

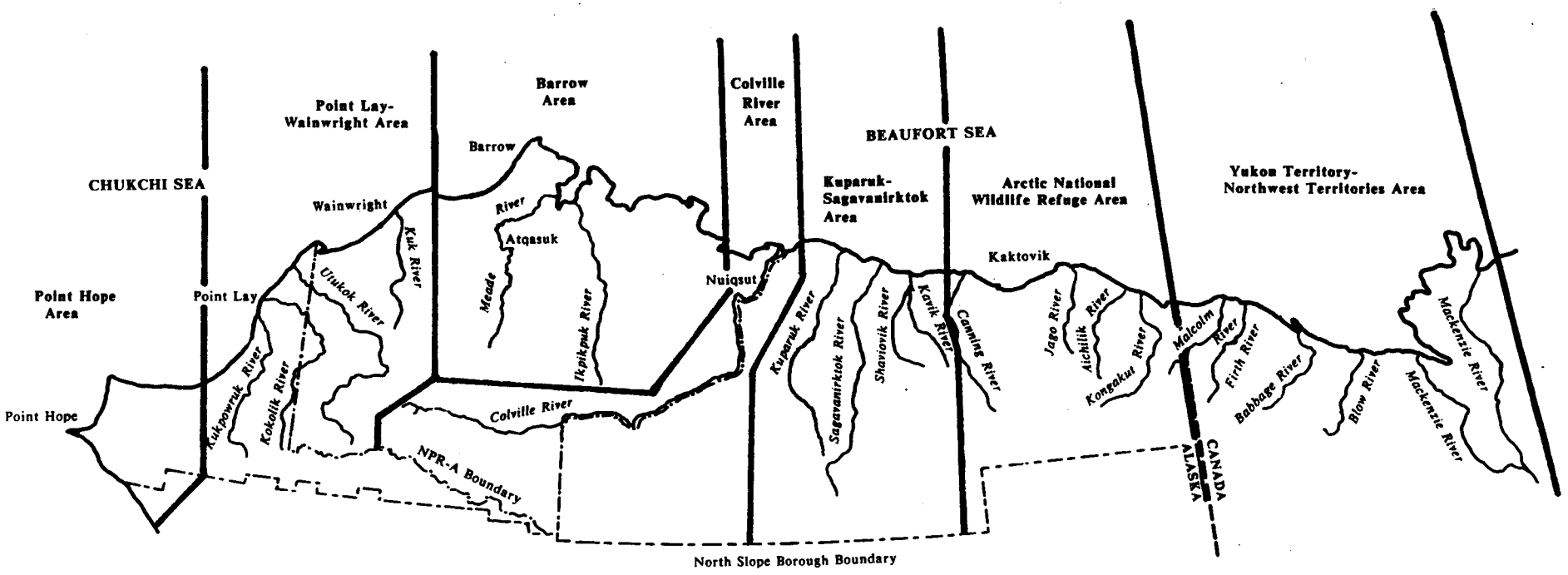

Figure 1. Map of the North Slope of Alaska and Canada depicting the areas used to index annotations by location.

Table 2. Life function categories.

Age and Growth - presents age, length, and weight data

Behavior - describes habits and patterns of behavior

Distribution - presents data on spatial and temporal locations of fish

Food habits - describes organisms eaten by fish

Harvest - presents data from sport, subsistence, or commercial fishing activities

Impacts - describes documented impacts of resource development on fish and fish habitat

Life history - presents general descriptions of a species life cycle

Movements - presents data on patterns of migrations, movements associated with feeding

Modeling - presents predictive statistical and computer generated estimates of population parameters

Overwintering - presents data on locations used by fish during winter

Parasites and disease - describes diseases and parasites found in fish

Physiology - describes biochemical, neurological, and physiological parameters

Population dynamics - presents data on population levels, observed rates of change, changes in population structure

Spawning and reproduction - describes spawning areas, reproductive condition, sexual maturity

Taxonomy - describes classification of species, meristic characteristics

Miscellaneous areas. This category includes all applicable references that discuss research in areas other than the seven previously described areas.

Following the list of keywords on some annotations are headings titled Activity and Impacts. These headings refer to one or more types of activities associated with resource development or land uses, and the documented (i.e., observed) effects of these development activities on fish and their habitats. These activity and impact categories are listed in Tables 3 and 4 and were developed as part of the Alaska Habitat Management Guide series (ADF&G 1986). Refer to this document for detailed descriptions of the activity and impact categories, and for additional information concerning impacts to fish.. Users of this annotated bibliography should note that a lack of documentation reported for many activity/impact categories does not necessarily imply that these activities do not result in adverse impacts to aquatic resources.

Appendix 1 contains an alphabetical listing of the citations of all references included in this bibliography.

Table 3. List of activity categories (from ADF&G 1986).

1. Blasting
2. Burning
3. Channelizing waterways
4. Chemical application
5. Clearing and tree harvest
6. Draining
7. Dredging
8. Drilling
9. Fencing
10. Filling and pile-supported structures (aquatic and wetland habitats)
11. Filling (terrestrial)
12. Grading/plowing
13. Grazing
14. Human disturbance
15. Log storage/transport
16. Netting
17. Processing geothermal energy
18. Processing lumber/kraft/pulp
19. Processing minerals
20. Processing oil/gas
21. Sewage disposal
22. Solid waste disposal
23. Stream crossing - fords
24. Stream crossing - structures
25. Transport of oil/gas/water - land
26. Transport of oil/gas/water -water
27. Transport of personnel/equipment/material - land
29. Transport of personnel/equipment/material - water
30. Water regulation/withdrawal/irrigation

Table 4. List of impact categories (from ADF&G 1986).

1. Change in water temperature
2. Change in depth or velocity of water
3. Change in turbidity or suspended sediments
4. Addition of substrate materials
5. Removal of substrate materials
6. Physical disturbance of substrate materials
7. Alteration of natural cover:
    - Riparian vegetation
    - Aquatic vegetation
    - Overhanging bank or shoreline vegetation
8. Addition of physical barriers
    - Impoundments
    - Diversions
    - Partial obstructions
    - Other
9. Increase in hydrostatic pressure or noise
10. Impingement or entrainment or entanglement
11. Physical trampling or crushing
12. Change in concentrations of dissolved oxygen or nitrogen
13. Change in concentrations of pH, alkalinity, or hardness
14. Change in concentration of salinity
15. Change in concentrations of heavy metals
16. Change in concentrations of chlorinated compounds
17. Change in concentrations of biocides
18. Change in concentrations of other toxic compounds:
    - Bark or log leachates
    - Sulfurous compounds
    - Other
19. Change in concentrations of hydrocarbons
20. Change in concentrations of nutrients
21. Introduction or removal of species
22. Artificial attractant to biological organisms

DATA GAPS

Although some fisheries surveys and a limited number of intensive fisheries investigations have taken place within NPR-A, a considerable amount of information remains to be collected on the fishes of this region. Such information includes data on distribution, basic life history parameters, and delineation of critical habitat areas.

Complete data on the distribution of fish within NPR-A are lacking. Most of the streams and lakes within the area either have not been surveyed or have been surveyed only once or twice at a few selected sites. Data on distribution of fish during winter are particularly lacking. By far, the most complete information on distribution of fish can be found for the Colville River and some of its major tributaries.

Except for the Colville River and a few isolated areas, basic life history data are lacking for most fish species found within NPR-A. Data that need further collecting include timing and extent of movements, food habits, growth rates and population structure, productivity, and habitat requirements. This information is particularly lacking for those species not extensively used by humans or impacted by Prudhoe Bay area oil development (e.g., round whitefish, lake trout, northern pike). Much of the available knowledge of anadromous whitefishes, arctic char, and arctic grayling on the North Slope comes from studies associated with Prudhoe Bay causeways or from studies associated with proposed natural gas pipelines across northeastern Alaska and Canada, and is commonly extrapolated to other areas of the North Slope such as NPR-A.

Further information on habitats critical to fish, such as spawning and overwintering areas is needed for NPR-A. Data concerning the location of these areas and the physical parameters of these sites are needed.

REFERENCES

Alaska Department of Fish and Game. 1986. Impacts of land and water use on fish and their habitat. Part I; Indices, and Part II; Annotated Bibliography. Alaska Habitat Management Guide. ADF&G, Div. of Habitat, Juneau. 337 pp; 739 pp.

Adams, B., and T.C. Cannon. 1987. Overwintering study. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 7, Part V. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 33 pp.

This report concerns field studies conducted during the winter of 1985-86 in the Sagavanirktok River delta to locate overwintering habitat, determine use of these habitats by fish, identify any stress factors and estimate the overwintering capacity of the overwintering areas in the river and delta. Fifteen potential overwintering sites were located in the lower Sagavanirktok River and in the delta front.

Fall gillnetting at the six delta front sites produced no anadromous fish. Four other sites were thought not to provide overwintering habitat because of thick slush ice under the surface ice. Broad whitefish and arctic grayling were captured in three fresh water channel sites whereas broad whitefish, arctic grayling, arctic cisco, and round whitefish were captured at two brackish water delta channel sites.

One freshwater site (no. 10), showed a rise in salinity from 0.0 ppt to 1.5 ppt by 2 May with dissolved oxygen remaining high at 11.0 mg/L. One hundred broad whitefish, 50 arctic grayling and 2 round whitefish were observed. At another freshwater site (no. 11), salinity was low but dissolved oxygen had dropped to 0.8 mg/L resulting in a fish kill. About 300 dead fish (50% broad whitefish, 25% arctic grayling, 20% arctic cisco, and 5% round whitefish) were observed in a 20 minute dive; only 10 live fish were seen.

At a brackish water site (no. 14), salinity had increased from 22-24 ppt in November to 27.7 ppt in early May. Only one anadromous fish, an arctic cisco was seen.

On June 11-14 these same sites were checked again as the river was beginning to break-up. At site 10, water was flowing over bottom fast ice, by 14 June that ice had washed away. Almost five hours of gillnet fishing produced no fish.

One small arctic char was captured at site 12. A large bottom fast piece of ice broke loose and released over 1,000 dead fish consisting of arctic cisco, arctic grayling, and broad whitefish. Salinity was 0.0 ppt at all locations at this time.

Fish did not appear to change location or habitat type during the course of the winter once ice thickness exceeded 1 m. The winter kill at site 11 was probably due to low oxygen levels resulting from overcrowding. The winter carrying capacity of the Sagavanirktok River delta is limited by available space and estimated at several thousand fish. Schmidt et al. (1987) estimated 1,000-3,000 arctic cisco overwintered there in 1986.

KEYWORDS: Sagavanirktok River / overwintering / arctic cisco / broad whitefish / arctic grayling / round whitefish.

Alt, K.T. 1972. A life history study of sheefish and whitefish in Alaska: Distribution, movements, age and growth, and taxonomic status of whitefish (*Coregonus* sp.) in the Arctic-Yukon-Kuskokwim area. ADF&G, Fed. Aid. in Fish. Rest. Ann. prog. rept. Vol. 13. Project F-9-4, Job R-II-G. Juneau. 12 pp.

This study summarizes whitefish data from the Arctic-Yukon-Kuskokwim area collected during 1971. Arctic cisco were found to be present in the Sagavanirktok River and round whitefish were abundant in its upstream areas. Broad whitefish were collected in the lower Sagavanirktok River and in adjacent estuarine areas of the Beaufort Sea. No broad whitefish younger than age 7 were captured. Back calculated age and growth data for broad whitefish are presented. Sagavanirktok River broad whitefish grew slower than those from other areas of Alaska.

KEYWORDS: Sagavanirktok River / arctic cisco / broad whitefish / round whitefish / age and growth.

Alt, K.T. 1973. Contributions to the biology of the Bering Cisco (*Coregonus laurettae*) in Alaska. J. Fish. Res. Board Can. 30:1885-1888

This paper discusses life history aspects of Bering cisco (*Coregonus laurettae*) in Alaska, based on data collected in whitefish studies during 1971 and 1972. The Bering cisco is similar in appearance to the arctic cisco (*Coregonus autumnales*) differing only in number of gill rakers. Mean gill raker counts of Bering cisco from the Yukon River, Norton Sound, and Seward Peninsula ranged from 33.8 to 36.6 whereas those from arctic cisco from the Colville River were 42.1.

Taxonomy, movements, age and growth, and food habits of Bering cisco are discussed for the areas covered in this study. Arctic Slope fishes are only mentioned in relation to taxonomy and distribution. The range of Bering cisco extends northward to Oliktok. Arctic cisco were present in the Colville River.

KEYWORDS: Bering cisco / arctic cisco / Yukon River / Kuskokwim River / Port Clarence / Grantley Harbor / Koyuk River / Colville River / taxonomy / age and growth / movements / food habits.

Alt, K.T. 1976. Age and growth of Alaskan broad whitefish (*Coregonus nasus*). Trans. Amer. Fish. Soc. 105(4):526-528

This paper presents age and growth data and age at maturity data on 341 broad whitefish (*Coregonus nasus*) from five populations in Alaska sampled in 1970 and 1971. Fish from the Porcupine River, Minto Flats, the Holitna River, Imuruk Basin, and the Sagavanirktok River are represented. Fish from the Sagavanirktok River and Imuruk Basin grew slower than those from the other three populations. Sagavanirktok River fish were the slowest growing, reaching 300 mm in fork length by age 5 and 47.5 cm by age 9. Limited data indicate that Sagavanirktok River males mature at age 7 to 9 and females at age 8 to 10.

KEYWORDS: broad whitefish / Sagavanirktok River / age and growth / spawning

Alt, K.T. 1979. Contributions to the life history of humpback whitefish in Alaska. Trans. Amer. Fish. Soc. 108:156-160.

This paper discusses life history aspects of humpback whitefish (*Coregonus pidschian*) from many areas of Alaska based on data collected from 1967-1977. Distribution, spawning, age and growth, age at maturity, and human use of the fish are discussed. Colville River fish are represented in samples, but little of this paper deals directly with fish from the North Slope. In Alaska, whitefish from the Colville River were slower growing and later to mature than fish from interior Alaska. In most areas of Alaska, humpback whitefish were mature by age 5 to 6 but Colville River fish did not mature until age 8. It was recommended that all Alaska humpback whitefish be considered a single species.

KEYWORDS: Humpback whitefish / age and growth / distribution / harvest / life history / movements / spawning and reproduction / taxonomy / Alaska

Alt, K.T., and R.A. Furniss. 1976. Inventory and cataloging of North Slope waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 17. Project F-9-8, Job G-I-O. Juneau. 22 pp.

This report presents data collected from the spring of 1975 through the fall of 1976 in the Sagavanirktok and Kuparuk river systems and at Prudhoe Bay.

Eleven potential fish overwintering sites were located by aerial survey in the Sagavanirktok River system in the late fall of 1974. Three major sites were investigated in March 1975. Ice depths at the east bank Franklin Bluffs site ranged from 2 to 2.7 m with water depths of 0.9 to 1.8 m; water temperature was 0^{0} C with dissolved oxygen of 4.8 ppm. Round whitefish and arctic grayling were captured at this location. At the west bank Sagwon Bluffs site ice thickness was from 1.1 to 2.0 m with water depths of 0.2 to 0.7 m. Water temperature was 0^{0} C and dissolved oxygen was 1.6 ppm. No gill nets were set because of shallow water and no fish were captured by angling. At the last site, 10 km north of Sagwon Bluffs, the river was frozen to the bottom and no water was located. Minnow traps captured juvenile arctic char and slimy sculpin in open water spring areas of the Echooka, Ivishak, and Lupine rivers. Ice depth at a potential overwintering site on the Ivishak River exceeded 4 m. Layers of water were encountered flowing between layers of ice. Water temperature was 0.3^{0} C and dissolved oxygen was 12 ppm. Observations suggest that this is an overwintering area. Only 1 arctic char was captured in the Sagavanirktok River during high water between June 9 and June 11.

Tagging and helicopter surveys in the Echooka River indicated that some arctic char spawners remain in the river throughout the summer in the year of spawning.

The Kuparuk River and its headwater lake were surveyed. Arctic grayling sampled in the river ranged from 245 to 280 mm in length and from age 5 to 10. An estimate of 90 arctic grayling/km was calculated by mark-recapture. Data on arctic grayling food habits are presented. Arctic grayling and lake trout were captured in "Kuparuk" Lake. Arctic grayling age/length composition was similar to that found in the river. Lake trout ranged in length from 257 to 459 mm and in age from 10 to 28 yrs.

Creel census at the then new 4,500 foot dock into Prudhoe Bay (West Dock) indicated that little sport fishing was taking place.

Aerial counts of arctic char gave lower numbers than in past years, especially in the Echooka River. 1975 counts were done by a different observer and might not be directly comparable to past counts. Counts indicate that many arctic char had moved into index areas between the first count on Sept. 7-10 and the last counts on Sept. 21-22.

KEYWORDS: Sagavanirktok River / Prudhoe Bay / Kuparuk River / overwintering / population estimate / arctic char / arctic grayling / lake trout / round whitefish / age and growth / distribution / aerial surveys

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

This field research report presents data on five species of whitefish collected in the Colville River, Alaska during summer 1970. Broad whitefish, humpback whitefish, round whitefish, arctic cisco, and least cisco were collected by beach seine, rotenone, and gill nets at two sites during this river survey. Netting operations were conducted in the Colville River delta from July 2 to July 11 and in the vicinity of Umiat from June 2 through September 6. Data concerning meristic characteristics, age, length, age of sexual maturity, and reproductive condition were presented for all species (except round whitefish, for which length data only were presented). Results indicated least cisco were the most abundant whitefish captured in the various channels of the Colville River delta. Test netting throughout the summer in the Umiat area indicated no arctic cisco or least cisco had passed through the area by September 6 when netting was terminated. Broad whitefish predominated in the catch at Umiat. Fry and immature fish of all five species of whitefish were taken in the Colville River delta in July. Broad and humpback whitefish are suspected to spawn in the upper Colville River in late autumn. Round whitefish spawn in tributary streams in the fall. No information on spawning in the Colville River is available for least cisco. It is suspected that arctic cisco spawners enter the Colville River delta later [after mid-July] and spawn in the lower reaches of the rivers. A commercial fishery operating in the Colville River delta since 1950 annually takes about 3,000 broad whitefish and 1,000 humpback whitefish during the summer fishery, and 20,000 least cisco and 40,000 arctic cisco in the fall fishery.

KEY WORDS: NPR-A / Colville River / arctic cisco / least cisco / humpback whitefish / broad whitefish / round whitefish / age and growth / spawning and reproduction / harvest

Bendock, T.N. 1976. De-watering effects of industrial development on Arctic fish stocks. Unpubl. rept. for the Alaska Board of Fisheries. ADF&G, Div. Sport Fish, Fairbanks. 13 pp.

This paper addresses the problems of water use by industry in Prudhoe Bay, Alaska during the early 1970's. During this time period, the three major sources of fresh water in Prudhoe Bay were shallow coastal lakes, rivers, and thawbulbs or aquifers beneath larger streams and lakes. Lakes are shallow, but can provide water through mid-winter. Snow fence and styrofoam insulation applied to lakes failed to reduce ice depth enough to allow water use throughout the winter. By late winter, rivers freeze to the bottom initially at riffles leaving a series of discontinuous pools under the ice. By this time, only large pools have substantial quantities of water. These areas provide the only overwintering habitat for arctic anadromous and freshwater fish. Because there was no source of water in winter to replenish that which was removed from these holes, many locations had been subjected to complete dewatering or removal to critically low levels.

Several holes in the Sagavanirktok River had been dewatered by January 1976 with disastrous consequences to overwintering fish. Holes were found to be anaerobic prior to complete dewatering. Death was complete; masses of dead insect larvae and arctic grayling fry were found floating in anaerobic holes.

Thaw bulbs beneath streams have not been shown to be reliable in winter. Deep wells through permafrost produced only saline water. The physical alteration of upland lakes to increase storage capacity had successfully provided a year round water source. It was hoped that water in such reservoirs will meet or exceed needs for fresh water. The author estimated that domestic use in Prudhoe Bay demanded 100 gallons per day per person. In addition 2,000 gallons per day for the first two weeks and 1,000 gallons per day thereafter are required in the drilling of a single well. A third need for water is ice road construction. In one case 166,666 gallons per mile of ice road was found to be inadequate. During the winter of 1974-1975 nearly every water hole was tapped and dewatered between Franklin Bluffs and the mouth of the Sagavanirktok River.

In summer of 1975 ADF&G instituted permitting procedures under AS 16.05.870 for winter water uses in areas of the North Slope where water depletion was even remotely possible. The permits set forth stipulations for the removal of water from anadromous fish streams.

Overwintering areas were investigated during the winter of 1975-1976. Four sites on the Sagavanirktok River and seven on the Kuparuk River were examined. In holes that contained fish, water depths varied from 0.18 m in a dewatered hole to 1.65 m in a hole where no water had been removed. Maximum ice thickness was 2.26 m. Arctic grayling, round whitefish, broad whitefish, humpback whitefish, burbot, and slimy sculpin were found in the Sagavanirktok River and arctic grayling, round whitefish, burbot, slimy sculpin, and ninespine stickleback were found in the Kuparuk River.

KEYWORDS: Prudhoe Bay / oil development / water use / dewatering / overwintering habitat.

Bendock, T.N. 1977. Beaufort Sea estuarine fishery study. RU-233. Pages 670-729 *in* Environmental assessment of the Alaskan continental shelf. Final reports of principal investigators. Vol 4. Biological studies. 1979. USDC: NOAA; USDI: MMS. 1979.

This report presents findings from field studies conducted in the Beaufort Sea from 1975 through 1977. The study area included the nearshore marine and river delta areas from the eastern margin of Harrison Bay to Flaxman Island, a linear distance of approximately 164 km along the north coast of Alaska.

A summary of the current state of fishery knowledge of the area is provided through 1976.

Fish were captured with gill nets, beach seines, fyke traps, try trawl, and hook and line at 76 sampling sites. A total of 28,369 fish representing 7 families and 15 species were captured. Fish over 200 mm in length were tagged.

Migration patterns of marine and anadromous fish are discussed. Marine species were not captured until late June when lifting sea ice allowed mixing of Prudhoe Bay's saline waters with land based freshwater spring runoff. During 1975 and 1976 it was found that short term variations in salinity and temperature did not affect species distribution or abundance. In 1977, however, salinities were considerably higher than in previous years and catches of anadromous fish species were lower, indicating a preference by these fish for lower salinities. Catches of anadromous fish over 200 mm increased during July and peaked in early August, then decreased rapidly in September. This decrease corresponded to the migration of these fish into rivers for spawning and overwintering. Immature arctic char and arctic cisco remained in fresh water until freeze-up.

Ten potential overwintering locations were examined during March and April of 1976 in the lower Sagavanirktok and Kuparuk rivers. Arctic grayling, round whitefish, burbot, slimy sculpin, and ninespine stickleback were found in the Kuparuk River and arctic grayling, round whitefish, broad whitefish, burbot, humpback whitefish, and slimy sculpin were found in the Sagavanirktok River. Burbot were the only species found to be feeding during the winter. The potential impacts of water withdrawal for industrial or domestic purposes and of seismic activity in critical overwintering areas are discussed.

Individual species accounts of fish captured are given providing available information on age and growth, movements, maturity and food habits.

KEYWORDS: Beaufort Sea / Prudhoe Bay / Sagavanirktok River / Kuparuk River / Colville River / north coast / nearshore / overwintering / movements / maturity / age and growth / distribution / tagging / arctic char / arctic cisco / least cisco / humpback whitefish / broad whitefish / round whitefish / arctic flounder / burbot / round whitefish.

Bendock, T.N. 1979. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 20. Project F-9-11, Job B-I-I. Juneau. 64 pp.

This report presents baseline fisheries information on lakes and streams of the western North Slope [NPR-A], with emphasis on the Colville River drainage. Data were collected on species composition, life histories, and migration patterns and timing. Chemical and physical characteristics of the waters examined are presented.

Sixteen species of fish were captured in the Colville River drainage. Species diversity and abundance in the Colville River decreases in an upstream direction. Arctic grayling have the widest distribution within the drainage and were found in all streams surveyed. An upstream spawning migration of humpback whitefish and broad whitefish occurs in the Colville River during late August. Small runs of pink salmon and chum salmon enter the Colville, Utukok, Kokolik, and Kukpowruk rivers in late July and early August. Anadromous arctic char were found in the Anaktuvuk and Chandler rivers. Surveys were conducted on the Colville River and portions of two major tributaries including the Itkillik, Anaktuvuk, Chandler, Killik, Kurupa, Etivluk, Awuna, Ipnavik, Kuna, and Nuka rivers. The Utukok, Kokolik, and Kukpowruk rivers were also surveyed.

Fish found in mountain lakes were lake trout, arctic char, arctic grayling, round whitefish, and least cisco; thaw lakes along the foothills had populations of arctic grayling. Northern pike were captured only in lakes within the Killik River valley. Lake surveys were conducted on Shainin, Sitchiak, Ahaliorak, Chandler, Killik, Udrivik, Imiaknikpak, Kaniksrak, Tululik, Kurupa, Cascade, Tukuto, Betty, Akuliak, Etivluk, West Smith Mountain, Swayback, Liberator, Noluck, Teshekpuk and three unnamed lakes.

Waters within the study area are characteristically soft, having low values for alkalinity and hardness and neutral pH. Rapid changes in water level and turbidity in response to precipitation on the watershed were observed throughout the open water season.

Overwintering habitat is abundant throughout the middle reaches of the Colville River but is less available or absent in the tributary streams. Seven species of fish were captured while netting under the ice in the Colville River during October 1977, and March and April of 1978.

Available life history information is summarized for fish species encountered in these surveys.

[Rev. note: Refer to Hablett (1979) for additional information on fish of the Colville River drainage.]

KEYWORDS: NPR-A / Colville River / Coastal Plain / North Slope / lake surveys / spawning / migration / arctic char / arctic grayling / pink salmon / chum salmon / broad whitefish / humpback whitefish / round whitefish / least cisco / arctic cisco / burbot / lake trout / northern pike / longnose sucker / slimy sculpin / ninespine stickleback / distribution.

Bendock, T.N. 1980. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish Rest. Ann. performance rept. Vol. 21. Project F-9-12, Job G-I-I. Juneau. 31 pp.

This report of field investigations conducted in 1979 discusses results of winter fish surveys in the lower Colville River, aerial counts of arctic char in the Ivishak and Anaktuvuk rivers, creel census and sport fishing opportunities along the North Slope Haul Road (Dalton Highway) and surveys of lakes adjacent to the Haul Road corridor.

The fish and game licenses of 41 anglers were checked along the Haul Road and were found to be held by Alaska residents. Of 81 checked in Prudhoe Bay, 71% were residents and 98% possessed sport fishing licenses. Catch per unit effort (CPUE) of anglers responding to a voluntary creel census was 2.8 fish/hour.

Counts of overwintering arctic char were conducted on systems of the North Slope in late September, 24,403 were counted in the Ivishak River, 814 in the Echooka River, 15,717 in the Anaktuvuk River, and 934 in the Nanushuk River. These were the first counts made on the Anaktuvuk and Nanushuk rivers. No concentrations of fish were seen in the Toolik, Kuparuk, Itkillik, Chandler or Killik rivers in the fall of 1979.

The Colville River was investigated at eight locations for the presence of overwintering fish during March and April. Dissolved oxygen values ranged from 0.6 to 4.6 ppm in water depths of 1.2 m to 4.9 m under ice from 0.9 m to 1.7 m. Arctic grayling, round whitefish, longnose sucker, burbot, ninespine stickleback, slimy sculpin, broad whitefish, and lake trout were captured. A total of 375 fish were captured in 1,164 net hours, 90% of the catch was arctic grayling which were found at all locations.

The results of surveys of 18 lakes, 17 of which are adjacent to the Haul Road, are given. Sport fish species captured in order of abundance included arctic grayling, arctic char, lake trout, and burbot. Round whitefish were captured in five lakes. Only one species of fish was found in six lakes and four lakes had no fish.

KEYWORDS: creel census / Haul Road / North Slope / lake surveys / aerial surveys / sport fishing / arctic char / arctic grayling / lake trout / burbot / broad whitefish / round whitefish / Colville River / Anaktuvuk River / Ivishak River / Sagavanirktok River / overwintering.

Bendock, T.N. 1981. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 22. Project F-9-13, Job G-I-I. Juneau. 33 pp.

This report discusses the results of field investigations conducted during 1980 on the North Slope of Alaska. Sport fishing pressure along the Haul Road (Dalton Highway) was assessed and found to be light with most effort taking place in the vicinity of Alyeska Pump Stations 4 and 5, in lakes adjacent to the Haul Road, and in the upper Kuparuk River. In addition, small catches of arctic char were made in Prudhoe Bay and the lower Sagavanirktok River.

Aerial counts of arctic char were attempted but adverse weather prevented their completion. The Killik River was surveyed and fish overwintering locations were sampled in the Colville River. Arctic char were investigated in the Anaktuvuk River and information is presented on the life history of this population.

The Killik River is described from a float survey conducted in July. Net sites were few and only round whitefish and arctic grayling were captured above the Okokmilaga River. Arctic grayling captured ranged from 210 to 343 mm in fork length and 3 to 9 yrs of age. All fish over 280 mm were mature.

Overwintering sites in a 97 km stretch of the Colville River downstream of the Anaktuvuk River were investigated. Data on 11 sites netted in 1978, 1979, and 1980 are presented. Dissolved oxygen values ranged from 0.6 to 5.6 ppm in water depths from 0.6 to 4.9 m. Ice thickness ranged from 0.9 to 1.8 m in sampling locations. Fish species captured included arctic grayling, broad whitefish, lake trout, longnose suckers, round whitefish, burbot, ninespine stickleback and slimy sculpin. Arctic grayling accounted for 88% of the catch. All species except broad whitefish contained food items and the species distribution during the winter was similar to that found in summer months. When locations were netted in consecutive months, catch per unit of effort dropped from 1.13 in October to 1.08 in March.

Seaward migrating arctic char were captured in the lower Anaktuvuk River in early June; it was presumed that they had overwintered somewhere upstream of this location. Inmigrating arctic char were first captured in the lower Colville River during mid-August. Paired spawners were occupying redds as early as September 5. Some fish were still spawning on November 4. Four spawning concentrations were found on the Anaktuvuk River. Twelve arctic char were implanted with radio transmitters in September; none had moved more than one mile from the tagging location by early November. Arctic char from the Anaktuvuk River had similar growth rates to Sagavanirktok River arctic char through age 1, but were longer at age after their fifth year and attained a greater size. Longevity was similar between the two systems. The male to female sex ratio was 1:1.4. All arctic char sampled in the fall had empty stomachs. In contrast, 38 arctic char taken in June all had food items in their stomachs.

KEYWORDS: Haul Road / sport fishing / Killik River / Anaktuvuk River / Colville River / overwintering / spawning / life history / movements / arctic grayling / broad whitefish / arctic char / radio tagging / round whitefish / lake trout / burbot / aerial survey.

Bendock, T.N. 1982. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 23. Project F-9-14, Job G-I-I. Juneau. 43 pp.

This report of field investigations conducted in 1981 discusses the results of surveys conducted on 19 lakes in the coastal plain and 4 mountain lakes on Alaska's North Slope, investigation of arctic char overwintering areas in the Anaktuvuk River drainage, and the results of aerial arctic char counts. It also documents the experimental stocking of arctic grayling near Pt. Barrow and discusses the sport fishery along the Dalton Highway.

Tulugak, Irgnyivik, Lower Anayak and Natvakruak lakes were surveyed in late July. All are mountain lakes. Lake trout and round whitefish were common to all lakes. Other species caught were arctic grayling, slimy sculpin, and least cisco. Nineteen lakes were surveyed in the central part of the Arctic Coastal Plain. Thirteen are located between the Ikpikpuk and Colville rivers. Thirteen of 16 lakes lying west of the Colville River contained fish. Fish encountered in order of abundance were least cisco, broad whitefish, lake trout, round whitefish, humpback whitefish, burbot, and arctic grayling. Ninespine stickleback and slimy sculpin were found as food items in other fish. Age, length, distribution, growth, and feeding habits are discussed for the major species sampled.

Winter movements of overwintering arctic char in the Anaktuvuk River were monitored using radio transmitters implanted in fish during the fall in an area of the river used for both spawning and overwintering. Both spawners and nonspawners were radio tagged. Movements of individual fish were slight ranging from 2.6 km to only a few meters until April. Overwintering habitat was investigated on the ground in April and is described and mapped. Fish were located under ice and sampled.

Four additional overwintering sites were investigated. It was apparent that fish segregated by species and by size, with only one species captured in some areas and only large or immature fish captured in others. This is one aspect of upriver spring fed overwintering areas that contrasts with downriver intermittent pool overwintering areas.

Fourteen arctic char were radio-tagged in the Sagavanirktok River, results were not available at the time that this report was authored.

Aerial counts of arctic char were conducted in the Sagavanirktok and Anaktuvuk rivers. Counts were 24,873 (Ivishak River); 316 (Echooka River); 10,563 (Tuluga River); and 1,005 (Nanushuk River).

No significant increase in sport fishing activity was found to have occurred along the Dalton Highway after the lower end (to Atigun Pass) was opened to public access.

KEYWORDS: Coastal Plain / North Slope / Sagavanirktok River / lake surveys / Anaktuvuk River / Pt. Barrow / Dalton Highway / arctic char / arctic grayling / lake trout / broad whitefish / least cisco / humpback whitefish / radio tagging / overwintering.

Bendock, T.N. 1983. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 24. Project F-9-15, Job G-I-I. Juneau. 28 pp.

This report discusses findings of field work conducted during the summer of 1982 and the spring of 1983 in the Sagavanirktok and Colville river drainages of the North Slope of Alaska.

The winter movements of 16 radio tagged arctic char in the Sagavanirktok River tributary streams were monitored. The average distance traveled between September and January by 11 fish that moved was 3.4 km, with 3 moving upstream and 8 moving downstream. The greatest distance travelled (10.1 km) was by fish moving upstream. No fish tagged as spawners moved to other streams, but two nonspawners tagged in the Ivishak River moved upstream to the confluence of the Sagavanirktok River by January 26. Sampling in April confirmed the presence of nonspawning arctic char in the Sagavanirktok River where no nonspawners were observed during fall aerial surveys. Arctic char tagged from the same areas undertook similar movements in direction and distance. In all cases, tagged arctic char avoided open water areas, favoring under-ice habitat downstream from open spring fed leads. Pre-smolt and resident male arctic char were the only life history forms captured in open water portions of streams, whereas larger sized spawners and nonspawners were only captured in ice covered areas. Age and length data are given for arctic char sampled. Only pre-smolt and resident male arctic char were feeding. Arctic char densities in overwintering areas appeared to be high due to restricted habitat. Because overwintering habitat is limited, it is suggested that damaging effects of gravel or water extraction or heavy equipment operation in these areas could jeopardize entire populations of fish, and that man-made disturbances in these areas should be avoided.

An aerial survey in September 1982 showed an estimated 36,432 arctic char in the Ivishak River and 6,222 in the Anaktuvuk River. Eleven burbot were radio-tagged in the middle reaches of the Sagavanirktok River during late September 1982. Tracking was not complete at this report's writing.

Seven unnamed lakes were surveyed in the vicinity of the Dalton Highway. Arctic char and arctic grayling were captured in two of the lakes; no fish were found in the other lakes. Arctic grayling and ninespine stickleback were the only fish captured in a float survey of the Etivluk and Nigu rivers. Age, length, and weight data are given for arctic grayling. Arctic grayling and arctic char were captured in a float survey of the Anaktuvuk River. An objective of this survey was to determine if pre-spawning adult arctic char remain in this river during the summer prior to spawning. Although eight pre-spawning arctic char were captured between July 24-27, the author stated that it was impossible to conclude that these fish had not gone to sea that spring. Age, length and weight data are given for 22 arctic grayling sampled.

Sportfishing effort along the Dalton Highway was light and concentrated in the vicinity of the Alyeska pump stations.

KEYWORDS: North Slope / lake surveys / Sagavanirktok River / Anaktuvuk River / Etivluk River / Dalton Highway / overwintering / age and growth / arctic grayling / arctic char / burbot / radio telemetry / aerial surveys.

Bendock, T.N., and J.M. Burr. 1984. Freshwater fish distributions in the central Arctic Coastal Plain (Ikpikpuk River to Colville River). Unpubl. rept. ADF&G, Div. Sport Fish , Fairbanks. 54 pp.

This report presents results from field work conducted between 1977 and 1983 and from other available fish surveys conducted during the same time period. Data on fish species distribution are given for 26 stream survey sites in 8 drainages and 62 lakes in the central Arctic Coastal Plain.

Twelve freshwater and two marine fish species were captured in Coastal Plain streams. Arctic grayling were the most frequently captured species, being taken at 21 of 26 sampling sites. Humpback whitefish, broad whitefish, and slimy sculpin were also widely distributed, being taken at 10 sites each. The greatest diversity of freshwater fish was found in the Ikpikpuk River drainage where 10 fish species were found. Kogosukruk River and Fish Creek both contained seven species of fish. Drainage descriptions and species diversity are given for all streams surveyed. Fish presence data are given for the Ikpikpuk, Price, Kalikpik, Ublutuoch, Kikiakrorak, Kogosukruk, and Smith rivers, and Fish, Inigok, Judy, and Kealock creeks and an unnamed tributary to Teshekpuk Lake.

Thirteen different species of fish were captured in 51 of the lakes surveyed; 9 lakes contained no fish. Fish were captured in shallow (1.8 m) and deep (21.3 m) lakes, and in lakes lacking inlets and outlets. Least cisco, lake trout, and broad whitefish were the most frequently occurring species and were captured in 70%, 49%, and 43% of the lakes, respectively. Following in frequency of occurrence were arctic grayling (19%), round whitefish (17%), burbot (13%), and humpback whitefish (4%). Northern pike, arctic cisco, and longnose sucker were captured in one lake each.

Teshekpuk Lake was the largest and the only named lake surveyed. It also contained the greatest diversity of fish with eight species captured. Least cisco represented 87% of the total catch followed in decreasing order of abundance by broad whitefish, lake trout, arctic grayling, arctic cisco, and humpback whitefish. Burbot and ninespine stickleback were also taken.

Species accounts discussing distribution, catch rates, age, length, weight, and food habits are provided for least cisco, lake trout, longnose sucker, broad whitefish, arctic grayling, round whitefish, humpback whitefish, burbot, arctic cisco, and northern pike. Distribution maps are provided for each species.

The documentation of lake trout in this area represents a range extension for this species; they were found to be fairly widely distributed. Northern pike, however, were restricted in distribution to the middle and upper reaches of the Ikpikpuk River, and were found in a single oxbow lake in the Ikpikpuk floodplain.

KEYWORDS: NPR-A / Arctic Coastal Plain / lake surveys / stream surveys / fish distribution / Ikpikpuk River / Teshekpuk Lake / least cisco / broad whitefish / lake trout / arctic grayling / humpback whitefish / round whitefish.

Bendock, T.N., and J.M. Burr. 1984. Inventory and cataloging of arctic area waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 24. Project F-9-16, Job G-I-I. Juneau. 46 pp.

This report discusses findings from field studies conducted on the North Slope in 1983.

Radio tags were placed in 11 burbot in the Sagavanirktok River in September 1982. Most stayed in the same vicinity in which they were tagged; the greatest movement was 8.9 km downstream by one fish. Overwintering sites were investigated and found to be either deep-isolated under-ice pools or spring-fed areas formed by groundwater that flowed through much or all of the winter. Ice thickness at overwintering sites varied from 0.6 to 4.4 m

Six small mountain lakes in the vicinity of Campsite Lake near the Dalton Highway were surveyed. Arctic char, lake trout and burbot were captured. Lake trout ranged in length from 155 to 765 mm and arctic char from 310 to 430 mm. Sport fishing effort along the Dalton Highway has remained light with local effort concentrated in the vicinity of Alyeska pump stations.

Least cisco, arctic cisco, lake trout, broad whitefish, humpback whitefish and arctic grayling were captured at several sites in Teshekpuk Lake. Broad whitefish ranged to 540 mm in length and to 16 yrs. Least cisco ranged to 398 mm in length and 21 yrs. A bimodal length distribution of least cisco indicated that two forms may sympatrically exist in this lake. Lake trout were the largest and oldest species captured, ranging in age from 8 to 50 yrs and in length from 442 to 892 mm.

Data were collected on fish distribution, water characteristics, and size from 23 unnamed lakes in the central Arctic Coastal Plain. Lake trout, broad whitefish, round whitefish, least cisco, arctic grayling, burbot, and ninespine stickleback were captured. Data are combined with previous surveys and are provided for 39 lakes. Eight lakes contained no fish. A brief discussion of fish by species is presented.

The Ikpikpuk River and seven smaller coastal streams in the vicinity were also surveyed. Northern pike, burbot, broad whitefish, arctic grayling, humpback whitefish, longnose sucker, least cisco, round whitefish, slimy sculpin and ninespine stickleback were captured.

The experimental stocking of arctic grayling in Isatkoak Lagoon near Point Barrow was assessed. Arctic grayling fry were stocked in 1981, but none were found when this area was netted in 1983. It was determined that this stocking did not succeed.

Aerial surveys were flown to count overwintering arctic char in the Ivishak and Anaktuvuk rivers. Estimates were 27,820 for the Ivishak River and 8,743 for the Anaktuvuk River.

KEYWORDS: winter habitat / radio telemetry / fish surveys / aerial survey / Dalton Highway / Sagavanirktok River / Teshekpuk Lake / Ikpikpuk River / Arctic Coastal Plain lakes / arctic char / lake trout / broad whitefish / least cisco / northern pike / arctic grayling / burbot / longnose sucker / arctic cisco / round whitefish.

Bendock, T.N., and J.M. Burr. 1985. Freshwater fish distributions in the central Arctic Coastal Plain (Topagoruk River to Ikpikpuk River). Unpubl. rept. ADF&G, Div. Sport Fish, Fairbanks. 29 pp.

This report presents information on the distribution of freshwater fish in a 7,770 km^2 section of the central Arctic Coastal Plain between the Topagoruk and Ikpikpuk rivers. Surveys were conducted during 1984 on 33 lakes and 7 streams in the 2 river drainages. The data covered in this report was also included in the 1985 Inventory and Cataloging of Arctic Waters by Bendock and Burr.

Stream flows peak shortly after breakup and decline throughout the open water season, sometimes becoming discontinuous by late July. The Alaktak River, a distributary of the Ikpikpuk River that became discontinuous in summer, contained least cisco, broad whitefish, arctic grayling, pink salmon, northern pike, burbot, arctic char, humpback whitefish, and ninespine stickleback.

The Chipp River is another distributary of the Ikpikpuk River that flows into Admiralty Bay. This stream is used by Barrow residents for hunting and fishing. Fish present in the Chipp River included least cisco, broad whitefish, humpback whitefish, pink salmon, burbot, and ninespine stickleback.

The Oumalik River, a slow flowing single channel tributary to the Chipp River, contained humpback whitefish, arctic grayling, northern pike, broad whitefish, burbot, ninespine stickleback, and slimy sculpin.

The Titaluk River, the largest tributary of the Ikpikpuk River, had flows that were nearly intermittent during low water. Fish species captured in the Titaluk River were humpback whitefish, round whitefish, arctic grayling, northern pike, burbot, and longnose sucker.

A single northern pike was captured in Bronx Creek and arctic grayling and longnose sucker were captured in the Kigalik River. Both Bronx Creek and the Kigalik River are tributaries to the Ikpikpuk River.

In contrast to the Ikpikpuk River, the Topagoruk River contained few fish. Only seven fish were captured at six sites, including humpback whitefish, broad whitefish, arctic grayling, and ninespine stickleback.

Three general types of lakes made up the 33 lakes sampled. Oxbow lakes are formed from abandoned river channels. Fish associations in oxbow lakes included least cisco, northern pike, and ninespine stickleback. Northern pike on the Coastal Plain were found only in oxbow lakes. Thaw lakes are created by melting of the ground surface, are usually quite shallow, and only the deeper ones provide suitable habitat for fish. Fish associations in thaw lakes usually included least cisco, broad whitefish, and ninespine stickleback. Deflation lakes are formed by wind erosion of the land surface. They were typically over 6 m in depth and had an extensive littoral area created by surface thawing along their margins. Fish associations in deflation lakes included lake trout, whitefish, arctic grayling, ninespine stickleback, and slimy sculpin. Oxbow lakes are restricted to river valleys, and deflation lakes are most common south of Teshekpuk Lake, whereas thaw lakes were widespread across the coastal plain. Length, weight, age, and sex data are presented for fish captured within this study area.

Perennial sources of groundwater do not occur within the study area, and under-ice habitats in streams were limited. Streams with adequate depth to potentially overwinter fish included the Price, Titaluk, Oumalik, Topagoruk, Chipp, and Ikpikpuk rivers. Fish Creek, a tributary to Harrison Bay, was also thought to contain suitable overwintering habitat. One lake and three river sites were investigated for overwintering in the Ikpikpuk River drainage. One lake and three river sites were investigated in April of 1984 for overwintering conditions in the Ikpikpuk River drainage. Levels of dissolved oxygen were 10.4 ppm in the lake, 4.6 ppm in the Price River, 7.8 ppm in the Chipp River, and 2.2 ppm in the Ikpikpuk River. Only the Chipp River site was sampled for fish: two least cisco and a broad whitefish were captured.

KEYWORDS: Arctic Coastal Plain / Ikpikpuk River / Topagoruk River / fish distribution / age and growth / overwintering / lake surveys / stream surveys / Teshekpuk Lake.

Bendock, T.N., and J.M. Burr. 1985. Inventory and cataloging of arctic area waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 26. Project F-9-17, Job G-I-I. Juneau. 40 pp.

This report summarizes findings from 1984 field studies on the Arctic Coastal Plain.

Least cisco, broad whitefish, humpback whitefish, burbot, arctic grayling, round whitefish, northern pike, longnose sucker, ninespine stickleback, slimy sculpin, and pink salmon were captured in eight rivers including the Chipp, Alaktak, Oumalik, Titaluk, Kigalik, Kigalik, and Topagoruk rivers and Interlake and Bronx creeks.

Ten species of fish were captured in 25 of the 33 lakes surveyed in the Coastal Plain; 8 contained no fish. Least cisco had the widest distribution of any fish species, occurring in 20 lakes. Broad whitefish inhabited nine lakes, lake trout were found in two lakes, and arctic char occurred in only one. Age, length, and weight summaries are provided for arctic grayling, humpback whitefish, broad whitefish, least cisco, and northern pike from coastal plain systems.

Arctic char, arctic grayling, and lake trout were caught at Amiloyak and Agiak lakes. Lake trout, least cisco, and round whitefish were captured in a winter survey of Elusive Lake. Arctic grayling and stickleback were reported from an earlier survey. Elusive Lake is unique in that it is the only upper Sagavanirktok River drainage lake to contain least cisco and no arctic char. Many other lakes in the system have arctic char, but no least cisco.

No fish were found in five Coastal Plain lakes located in the Kuparuk Oil Field. Location, depth, and chemical data for these lakes are given.

Overwintering habitat in the Chandler River was investigated using radio tagged burbot to locate overwintering areas. Of three burbot fitted with transmitters, one left the system and overwintered in the Colville River travelling approximately 805 km downstream. The other two overwintered in the same area, one after travelling 11.3 km downstream, the other after moving 9.7 km upstream. The site was found to have 0.3 m of water under 2.6 m of ice. Four overwintering sites were investigated in the Ikpikpuk River. Least cisco, broad whitefish, and burbot (the radio tagged fish was not recaptured) were found in one deep pool under 2.1 m of ice. Not all of the overwintering sites were netted.

Five burbot in the Colville River were fitted with radio transmitters for future investigations of overwintering areas in that drainage.

Sport fishing effort along the Dalton Highway was reported to be low but concentrated around Alyeska pump stations and road maintenance camps.

Aerial counts of overwintering arctic char gave estimates of 24,818 and 5,462 in index areas on the Ivishak and Anaktuvuk rivers. The Anaktuvuk River count was the lowest estimate in five years.

KEYWORDS: winter habitat / Chandler River / Ikpikpuk River / Topagoruk River / Arctic Coastal Plain lakes / surveys / radio telemetry / aerial survey / fish distribution / arctic char / lake trout / least cisco / broad

whitefish / humpback whitefish / burbot / arctic grayling / Chipp River / Kuparuk Oil Field

Bendock, T.N., and J.M. Burr. 1986. Arctic area trout studies. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 27. Project F-9-18, Job T-7-1. Juneau. 75 pp.

This report presents baseline fisheries information collected during 1985 in the lakes and stream channels of the Colville River Delta. Data on the diversity, distribution, growth, and maturity of freshwater and anadromous fish sampled in June and August are presented. A survey of Amiloyak Lake at the headwaters of the Chandler River is included, and a summary of an arctic char egg-take from this lake is presented.

Gill nets, beach seines, hoop traps, and baited hooks were used to capture fish at a combination of 91 locations in the lower 80 km of the Colville River and 16 lakes in the Colville River Delta. Fish of the family Salmonidae made up 90% of the catch with whitefish accounting for 77%. Least cisco were the most widespread and numerous of any single species, accounting for 57% of the total catch in all areas. The Colville River delta provides important habitat for juvenile fish during the open water season, and is an important migration route for larger fish. A total of 1,205 fish was captured in gill nets and 1,787 were caught in beach seines. Gill net catches in the Colville River were composed of least cisco (23.9%), broad whitefish (13.4%), arctic cisco (12.0%), arctic grayling (11.2%), humpback whitefish (10.8%), and arctic char (10.7%). The remaining 18% was composed of longnose sucker, round whitefish, rainbow smelt, fourhorn sculpin, burbot, pink salmon, and lake trout. In lakes, only two species made up the majority of the catch, least cisco (56.7%) and broad whitefish (31.8%). The remaining 11.4% was composed of arctic cisco, humpback whitefish, longnose sucker, fourhorn sculpin, ninespine stickleback, Alaska blackfish, round whitefish, and arctic flounder.

Brief species accounts are provided for each species captured and are categorized by lake and river life history forms. Information included in these accounts covers distribution, age, length, weight, and maturity. Fecundity data are provided for selected species.

Amiloyak Lake was surveyed prior to collecting arctic char for an egg-take. This lake is located in the headwaters of the Chandler River drainage and contains arctic char, lake trout, arctic grayling, round whitefish, and slimy sculpin. A total of 298 lake resident arctic char were captured, of which 229 were tagged and 63 were sampled for sex, maturity, and age. They ranged in length from 57 to 619 mm, and in age from 0 to 19 yrs. Fecundity averaged 3,169 eggs/female between 490 and 520 mm in length. Age, length, weight, sex ratio and food habits are also presented for lake trout, round whitefish, and arctic grayling. Approximately 27,000 eggs were taken, of which 13,000 proved to be viable. Hatching began at 803 temperature units (measured in degrees F) and was completed after 837 temperature units. [Reviewers note: Fry were subsequently stocked in a barren lake in the Kantishna River drainage, approximately 130 km west of Fairbanks.]

KEYWORDS: Colville River / North Slope / Colville Delta / Amiloyak Lake / arctic char / whitefish / egg take / lake and stream surveys / aerial surveys / fish distribution / age and growth / fecundity / food habits.

Bickham, J.W., S.M. Carr, B.G. Hanks, D.W. Burton, and B.J. Gallaway. 1986. Genetic analysis of population variation in the arctic cisco using electrophoretic, flow cytometric, and mitochondrial DNA restriction analyses. Pages 1-32. *in* B.J. Gallaway, ed. Genetic and overwintering studies of the arctic cisco (*Coregonus autumnalis*), 1985-86. Prepared by LGL Ecological Research Associates, Inc. for Standard Alaska Production Company, Anchorage, Alaska and the North Slope Borough, Barrow, Alaska. 140 pp.

This paper reports the results of genetic studies conducted on arctic cisco from Alaska and Canada to test the hypothesis that all North Slope arctic cisco are derived from one or more breeding stocks associated with the Mackenzie River system. In this hypothesis, Alaska populations are thought to be replenished periodically by arctic cisco transported from Canada by longshore oceanic currents. Collections of arctic cisco were obtained from the Arctic Red and Peel rivers within the Mackenzie River system, from Phillips Bay, Yukon Territory, from the Sagavanirktok and Colville river deltas, and from near Barrow, Alaska. A sample of the closely related Bering cisco from the Yukon River was also obtained for comparison. Collections of the Mackenzie River drainage samples were made in September 1985. Collections of the Phillips Bay samples were made in July 1985. The dates of collection of the Alaska samples were not reported, but presumably were also made during 1985. Tissue samples were analyzed by protein electrophoresis, flow cytometry, and by mitochondrial DNA restriction analysis. Results found levels of electrophoretic variation within and among populations of arctic cisco that fell within the range reported for salmonid species. The loci used in this study failed to reveal the presence of unique alleles or fixed populational differences sufficient to resolve the Alaska and Canadian population samples into discrete stocks, thus lending support for the "single stock" hypothesis. Results indicated the Peel and Arctic Red rivers contain separate populations of arctic cisco, and suggest that the Mackenzie River basin is characterized by multiple breeding populations that exhibit spawning site fidelity but mix in the ocean and at overwintering sites. Insufficient spawning site samples were obtained to be able to identify which spawning populations of arctic cisco were represented in Alaska waters or the relative proportion of the overall stock represented by each population. The authors hypothesize that arctic cisco possibly originated as recently as 10,000 years ago following glacial recession, and that the Yukon River Bering cisco population, which is only slightly genetically different, gave rise to the Mackenzie River arctic cisco population, either by chance migration or by stream capture.

KEYWORDS: North Slope / Colville River / Mackenzie River / arctic cisco / Bering cisco / genetics.

Bond, W.A., and R.N. Erickson. 1987. Fishery data from Phillips Bay, Yukon, 1985. Can. Data Rept. Fish. Aquat. Sci. No. 635. Dept. Fisheries and Oceans, Winnipeg, Manitoba. 44 pp.

This paper presents findings from fishery surveys conducted at Phillips Bay, Yukon Territory in the vicinity of the mouth of the Babbage River from 29 June to 21 August 1985.

Gill nets and small mesh seines were used to sample fish at 11 inshore sites and 5 offshore sites along the 5 m isobath. Anadromous fish species captured in order of abundance were arctic cisco, least cisco, rainbow smelt, and arctic char. In addition, fourhorn sculpin and arctic flounder were captured.

Arctic cisco comprised 53.0% of the gill net catch and 60.7% of seine catches. Large arctic cisco were present in the study area throughout the sampling period. Virtually all arctic cisco captured in seines were young-of-the-year with the largest single catches occurring on 13 July and 10 August. They arrived in the study area on 12-13 July. Data on age and growth, maturity, and food habits are presented. Evidence to support the theory that Colville River arctic cisco originate from the Mackenzie River is suggested by the timing of catches of age 0 fish in this study and subsequent catches at Kaktovik Lagoon and the Colville River in other studies being conducted. Least cisco were the next most abundant species. Only six were captured in offshore locations indicating an affinity for nearshore areas. Small least cisco were not common in catches. Sixty two percent of least cisco were between 250 and 324 mm in length and only 2% of these fish were between 75 and 174 mm. Data on age and growth, sex, maturity, and food habits are presented.

Fourhorn sculpin were most abundant nearshore, but were also common offshore, comprising 18% of the catch at offshore stations. Data on age and growth, sex, maturity, and food habits are presented.

Arctic char were not common in catches, comprising only 3.1% of gill net catches and 0.2% of seine catches. Information on the weight/length relationships, sex composition and food habits is given for arctic char, rainbow smelt, and arctic flounder. Numbers of other species taken in this study were 14 broad whitefish, 16 lake whitefish (humpback), 20 inconnu (sheefish), and 22 saffron cod.

KEYWORDS: Yukon Coast / Beaufort Sea / fishery surveys / least cisco / arctic cisco / arctic char / fourhorn sculpin / age / growth / sexual maturity / food habits.

Brooks, J.W., J.C. Bartonek, D.R. Klein, D.L. Spencer, and A.S. Thayer. 1971. Environmental influences of oil and gas development in the Arctic Slope and Beaufort Sea. U.S. Fish and Wildl. Serv. Resour. Publ. 96. Washington, D.C. 24 pp.

This report briefly describes the environmental characteristics and renewable resources of the Arctic Slope and the Beaufort Sea. Little of this report addresses fish although their importance to people of the North Slope and the potential for recreational fisheries are mentioned. Problems associated with industrial activities are identified and recommendations for minimizing environmental and resource damage are proposed. The simplicity of arctic ecosystems, the slow rate of organic processes, and the presence of permafrost create unique problems with pollution, waste disposal, and activities that disturb the vegetated surface. In the Beaufort Sea, the shallowness of the continental shelf and the presence of pack ice present serious physical obstacles to oil development and transportation. The authors conclude that the risk of serious environmental and resource damage will be greatly lessened by the imposition of high operational and safety standards. Legal authority to promulgate regulations must be strengthened and government and industry must cooperate during oil development, and fund research that addresses potential environmental problems.

KEYWORDS: oil / industry / development / Arctic Slope / Beaufort Sea / impacts / problems.

Brunskill, G.J., D.M. Rosenberg, N.B. Snow, G.L. Vascotto, and R. Wagemann. 1973. Ecological studies of aquatic systems in the Mackenzie-Porcupine drainages in relation to proposed pipeline and highway developments. Vol. I & II. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Environment Canada. Rept. No. 73-40 and 73-41. 131 pp; 343 pp + append.

This report presents the findings and conclusions of baseline aquatic invertebrate surveys in the Mackenzie and Porcupine river systems during 1971 and 1972. The impacts and responses of aquatic invertebrate communities to changes in siltation and to crude oil introduced into aquatic systems were evaluated.

Within the Mackenzie River delta, clear lakes had a higher density of organisms ($6{,}426/m^2$) than did silty lakes ($495/m^2$) and diversity in delta lakes was considerably higher than that in channels. During ice covered periods invertebrate densities were one third to one half of the peak summer values.

Crude oil was pumped onto a small turbulent stream to assess its effects on the stream invertebrates. The drift of all invertebrate taxa increased immediately, with total drift magnitude reaching six times that of the previous week. After 24 hours, the number of invertebrates in the oiled section was 2/3 that of controls, and after 2 weeks oil was still present in sediment.

Crude oil pumped into a delta lake trapped many invertebrates in its surface film and reduced the number of littoral benthic organisms by more than one third. An experimental oil spill in Yellowknife Bay produced an interesting effect in that the average number of organisms per square meter was nearly twice that of the control area in shallow regions but the number of taxa was fewer. At two meters there was an 81% reduction in the number of benthic organisms in the polluted area.

Increases in siltation resulted in a reduction in the number of benthic organisms present. At the site of a natural mudslide, with suspended sediment values of 3.82 mg/L above and 10.6 mg/L below, a 70% reduction in benthic organisms was found below the slide.

In general, the upper parts of streams were found to have a higher standing crop of invertebrates per unit area than lower reaches. Suspended sediments caused by mechanical disturbances of streams caused a reduction in the number and diversity of invertebrates. A tentative significant level of suspended sediments was 10-15 mg/L. Below this level, lake or river habitats were "productive," and above this level they were "impoverished." Recommendations are made for location, timing, and types of stream crossings to minimize disturbance to streams. This is an interesting and well written report with direct applicability to construction activities in arctic regions and their potential environmental effects.

KEYWORDS: Mackenzie River / Porcupine River / invertebrate / oil spill effects / sedimentation / impacts / construction.

ACTIVITY: transport of oil/gas/water - land and water (experimental).

IMPACT: change in levels of hydrocarbons.

Byran, J.E. 1973. The influence of pipeline development on freshwater fishery resources of northern Yukon Territory. Aspects of research conducted in 1971 and 1972. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Rept. 73-6. Ottawa, Ontario. 63 pp.

This report presents findings [some preliminary] of studies conducted during 1971 and 1972 assessing the potential damage to fishery resources along two proposed pipeline routes across northern Yukon Territory from Alaska to the Mackenzie River Valley. This report briefly discusses potential impacts of pipeline construction, including increased sedimentation during construction, gravel removal, toxic chemical and domestic sewage disposal, and increased sport fishing. The majority of this report, however, deals with fisheries surveys conducted along the proposed routes.

Data are presented on stream dimensions, discharge current speed, oxygen concentration, pH, total alkalinity, and total dissolved solids for 29 sampling dates on 21 streams and rivers along the proposed routes. Suspended sediments were found to be very low before breakup in the Porcupine River system, but they increased markedly in the spring following breakup. Sediment loads in the Porcupine River right after breakup were similar to those produced by excavations.

Species composition was more diverse in the Porcupine River system with 16 species represented whereas only 7 species were found in Beaufort Sea drainages. Arctic grayling and arctic char were the predominate species in Beaufort Sea drainages, with the proportion of arctic grayling being higher in eastern drainages and that of arctic char higher in western rivers. In the Porcupine River drainage, the greatest number of species were captured in the Porcupine River. Arctic grayling, round whitefish, and sculpins dominated the upstream catches in Porcupine River tributary streams. Maps of fish distribution, spawning, and winter open water sites are provided.

Seasonal movements of fish in both areas are briefly discussed. Large catches of many species were made in the Porcupine River before breakup, and they remained high for a few weeks thereafter before decreasing markedly. These data indicated that fish moved from tributary streams to overwinter in the Porcupine River and then returned to tributaries after breakup.

It was recommended that the coastal route would be preferred to the Porcupine River route because important arctic char habitat were mostly located upriver from crossings and appropriate timing of construction could minimize impacts at stream crossing sites. Other recommendations and construction safeguards such as what activities should require permitting, scheduling of construction activities, and location of roads, equipment pads, etc. are outlined in 38 precautionary stipulations.

KEYWORDS: Porcupine River / Beaufort Sea drainages / fish distribution / Yukon / gas pipeline / stream characteristics / seasonal fish movements / suspended sediments / fry distribution / spawning areas / pipeline construction / impacts / recommendations.

Cannon, T.C., B. Adams, D. Glass, and T. Nelson. 1987. Fish distribution and abundance. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 6. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 129 pp.

This study presents data collected in fish surveys conducted in the Alaska central Beaufort Sea during 1985. Fyke net stations were set up at 27 locations from Foggy Island Bay in the east to Gwydyr Bay in the west. Sampling was conducted from 13 June through 15 September to monitor distribution and relative abundance of fish in the study area.

Species composition in order of abundance consisted of arctic cisco (n = 103,545), fourhorn sculpin (n = 100,314), arctic cod (n = 88,747), arctic char (n = 20,226), least cisco (17,588), broad whitefish (11,959), ninespine stickleback (n = 3,143), arctic flounder (n = 2,514), and saffron cod (n = 1,117). Within regions of the study area, least cisco made up a higher proportion of the catch in Gwydyr and Prudhoe bays, arctic cod made up a lower proportion of the catch in the Gwydyr and Foggy Island bays, and broad whitefish made up a higher proportion of the catch in the Sagavanirktok River delta.

Summaries are provided describing catches by species/size group by week in the study area. Noteworthy is the sequence of occurrence of small (< 100 mm) arctic cisco that showed up on August 19 in Foggy Island Bay headed west. By the first week of September they were common in shoreline traps in western Prudhoe Bay and Gwydyr Bay. Correlations of species-size groups were calculated for mid-summer (15 July - 15 August) and late summer (16 August - 15 September). The strongest relationship in mid-summer was between large arctic cisco, large broad whitefish, and both sizes of least cisco. Small arctic char were strongly correlated with large arctic cisco, but not large broad whitefish nor least cisco. Intermediate sized arctic cisco were correlated with intermediate sized broad whitefish. During late summer a strong relationship was still evident between large arctic cisco, least cisco, and broad whitefish. Intermediate sized arctic cisco, broad whitefish, and fourhorn sculpin were strongly correlated. Higher correlations were found between all anadromous fish than earlier in the summer.

Relationships are provided between fish catch and water conditions. Water temperature and salinity were most associated with catch whereas wave height, turbidity, and water level were less associated. The Sagavanirktok River delta platform received the most consistent high use over the season by many of the fish groups. Coastal areas of bays and lagoons were important for feeding in July and as migrational routes in August. The delta front and barrier islands received only limited use. Delta channels and the delta platform protected by the causeway were extensively used by juvenile fish. Least cisco and broad whitefish showed an association with warm, low salinity water whereas cod and arctic char preferred cooler waters in mid-summer. Fish prey species were more abundant in brackish water and estuarine habitats. Copepods were more prevalent at intermediate salinity ranges (15-25 ppt).

KEYWORDS: Central Beaufort Sea / Prudhoe Bay / Foggy Island Bay / Gwydyr Bay / Sagavanriktok River / anadromous fish / marine fish / fish distribution / fish abundance / water conditions / fyke netting / species associations / West Dock / Endicott Causeway.

Cannon, T.C., M.S. Brancato, and S.C. Jewett. 1987. Fish food habits. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 7. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 63 pp.

This report documents the contents of fish stomachs collected from anadromous fish from the Alaska central Beaufort Sea in conjunction with Endicott causeway studies. Stomachs were collected from 179 arctic cisco, 130 least cisco, 172 arctic char, and 79 broad whitefish, preserved with formalin in the field, and processed at the University of Alaska.

Small arctic cisco fed primarily on copepods and small mysids. Intermediate sized (100-200 mm) arctic cisco fed on amphipods, mysids, and copepods. Mysids, amphipods, copepods, isopods, and small fish were selectively eaten by large arctic cisco. Mysids were the most important single food item over the whole summer at all locations whereas amphipods were important food items at the western end of the study area in late summer.

Least cisco fed on a wide variety of prey, including mysids, amphipods, copepods, and polychaetes. During early summer, larval and small fish occured in the diet, of least cisco. Amphipods, isopods, and copepods were important to least cisco near the Sagavanirktok River delta and in Prudhoe Bay whereas mysids were more prevalent in fish from Foggy Island and Gwydyr Bays.

Arctic char fed on a wide variety of prey, with mysids, amphipods, isopods, and small fish being the most important. Small fish were a dominant food item during late summer, especially for large arctic char; amphipods were also important. The ration size often reached 3-5 percent of an arctic char's body weight. The diet of broad whitefish varied little in type and amount; amphipods were the dominant food, but chironomids and copepods were also important.

Fish prey importance by region [sampling area] is provided by prey species.

The diet of arctic and least cisco overlapped most frequently, particularly during early summer and fall. Least cisco diets became more diversified during mid summer. Arctic char diets overlapped with the two cisco diets during the late summer and fall periods. Diets of fish from different areas showed general consistency with dropnet invertebrate sampling, except for small fish and copepods that were not effectively sampled with dropnets.

Fish of the same species collected the same day from the same location often fed on different prey at varying rates. Fish probably fed on a concentration of a single prey item once it was located, or were opportunistic feeders. Several large arctic cisco fed exclusively on over 30,000 copepods. Fish in general fed on a wide variety of available prey.

KEYWORDS: Central Beaufort Sea / Prudhoe Bay / Sagavanirktok River / Gwydyr Bay / Foggy Island Bay / Endicott Causeway / anadromous fish / food habits.

Cannon, T.C., J.A. Knutzen, and B. Adams. 1987. Mark recapture study. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 6. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 38 pp.

This report documents the results of field mark and recapture studies conducted in the Alaska central Beaufort Sea in 1985. Fish between 100 mm and 240 mm in length were freeze branded, and fish over 240 mm (200 mm in some cases) were tagged with numbered tags. A total of 4,578 arctic char, 11,751 arctic cisco, 9,925 least cisco and 5,548 broad whitefish were tagged. Of these 234 arctic char (5.1%), 131 arctic cisco (1.1%), 567 least cisco (5.7%), and 217 broad whitefish (3.9%) were recaptured. Branded small fish numbered 8,388 arctic char, 3,399 arctic cisco, 917 least cisco and 4,226 broad whitefish. Of these, 401 arctic char (4.8%), 39 arctic cisco (1.2%), 1 least cisco (0.1%), and 100 broad whitefish (2.4%) were recaptured.

Large-sized arctic char moved to both the east and west during June and July. Toward the end of July movement of large-sized arctic char was generally eastward, with recaptures split between the Sagavanirktok River delta area and Foggy Island Bay. During August there was some movement of arctic char from West Dock toward the Sagavanirktok River, some movement eastward to Foggy Island Bay, and some local movement in Prudhoe Bay and around the Endicott causeway. Movements of small-sized arctic char were local and oriented around the Sagavanirktok River delta until late summer when there was a general movement westward to Prudhoe Bay and eastward to Foggy Island Bay.

Migration of large-sized arctic cisco through mid-August was both east and west with little discernable pattern. August to early September movements were strongest to the west as fish moved toward the Colville River. Few small arctic cisco were recaptured, movements were both east and west with no pattern discernable.

The general movements of large least cisco were east through mid-July to and probably past Foggy Island Bay. Movements after mid-July were generally west, a movement toward the Colville River is suggested. It is suggested that small least cisco remain close to the Colville River mouth. Broad whitefish showed the least movement among the areas investigated. Most movement was between stations in Gwydyr Bay and the Sagavanirktok River delta. Late season movements were mainly toward the Sagavanirktok River delta.

Most fish movement around the Endicott causeway was around rather than through the breaches. Only small arctic char and broad whitefish exhibited much use of the breaches and culverts.

KEYWORDS: Central Beaufort Sea / Prudhoe Bay / Gwydyr Bay / Foggy Island Bay / Sagavanirktok River / Colville River / Endicott Causeway / anadromous fish movements / mark and recapture.

Childers, J.M., C.E. Sloan, and J.P. Meckel. 1973. Hydrologic reconnaissance of streams and springs in eastern Brooks Range, Alaska - July 1972. Basic data rept. Water Resources Div., USGS, Anchorage, Alaska. 25 pp.

This report presents hydrologic observations of 11 stream sites and 8 springs in northeastern Alaska. Stream studies were conducted on the Kadleroshilik, Shaviovik, Kavik, Canning, Marsh Fork of the Canning, Sheenjek, Coleen, and East Fork of the Chandalar rivers, and Monument and Strangle Woman creeks. Seven springs were surveyed in the Ivishak River drainage, and one spring (Shublik Springs) in the Canning River drainage.

Bank full channel features including slope, width, depth, and discharge, basin characteristics including area of standing water, drainage area, mean channel slope, mean basin elevation, mean annual precipitation, precipitation intensity, and stream length are given for each stream site. Channel, drainage basin, and flood frequency are given for each stream site. Flood discharge was estimated for 2 yr and 50 yr average recurrence intervals. Oblique aerial and streambed composition photographs are provided for selected sites. Flood observations were made on the Sagavanirktok River at Franklin Bluffs.

Springs were visited in July. Discharge, temperature, and specific conductance were measured in the field. Water samples were taken for laboratory analysis. Spring discharges ranged from 4.2 to 36.5 cfs and temperatures ranged from 2.8^{o} to 9.2^{o} C. Spring water was of the calcium bicarbonate type and low in total dissolved solids. Most springs originate in limestone of the Lisburne Group. Springs produce large aufeis areas and provide winter habitat for arctic char during the winter. These springs could supply a high quality domestic or industrial water source, but impacts on arctic char must be considered. Photographs of five spring areas are provided.

KEYWORDS: hydrologic survey / Brooks Range / Arctic National Wildlife Refuge / Canning River / Shaviovik River / Sagavanirktok River / Ivishak River / Echooka River / springs / flow / flooding / arctic char.

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

The purpose of this field study was to describe age and growth characteristics of broad whitefish and least cisco near Point Barrow, Alaska. Sampling was conducted during the summer of 1952 in freshwater Ikroavik Lake (broad whitefish and least cisco) and in a brackish inlet connected to Elson Lagoon (least cisco only). Examination of the gonads of broad whitefish during the course of the summer indicated that the fish in Ikroavik Lake spawned during the month of July. The eggs hatch in 30 to 60 days rather than the 100 to 150 days more commonly found in other coregonid fishes, perhaps due to the fact that the lake experiences its peak temperatures during the spawning and hatching period. Data concerning age frequency and sex ratio, and body length-scale length relationships are presented for broad whitefish. Least cisco in Ikroavik Lake spawn in September, with the eggs hatching under the ice. Scales in the area of the lateral line and the anterior edge of the dorsal fin form when the young fish are between 54 and 60 mm in fork length. Differences in scale structure and body growth rates were observed between least cisco living entirely in the freshwater lake and those living in marine or brackish waters. Least cisco with growth rates and scale structure intermediate between freshwater and marine fish were also noted, and suggested that fish from marine waters migrated into Ikroavik Lake. Lake fish were found to have higher growth rates and were larger and more robust than marine fish of the same age. Higher water temperatures within the freshwater lakes than in the marine environment was proposed to explain the differences in body form and growth rates. Data concerning age frequency and body length-scale length relationships are also presented for least cisco.

KEYWORDS: Point Barrow / NPR-A / Ikroavik Lake / Elson Lagoon / broad whitefish / least cisco / age and growth / spawning and reproduction.

Craig, P.C. 1984. Fish use of coastal waters of the Alaskan Beaufort Sea: a review. Trans. Am. Fish. Soc. 113(3):265-282.

This review paper summarizes the distribution of fishes and their use of available habitat along the Alaska Beaufort Sea coast. References reviewed are pirmarily from the 1970's and the early 1980's. The anadromous arctic cisco, arctic char, least cisco, broad and humpback whitefish, pink salmon, and rainbow smelt were the focus of much of this review. Marine species receiving primary attention were arctic cod and fourhorn sculpin. In terms of numerical abundance or use by humans, the most important species using the shallow, brackish, nearshore waters of the Beaufort Sea coastline are arctic and least cisco, arctic char, arctic cod, and fourhorn sculpin. The occurrence of a band of relatively warm and brackish water (5-10^{o}C, 10-25 ppt) that lies adjacent to the shoreline in summer provides important feeding habitat for anadromous and marine fishes. This estuarine band extends the length of the coast (750 km), is very narrow (usually 2-10 km wide), and is often distinctly different from adjacent marine waters (-1 to 3^{o} C, 27-32 ppt). Anadromous fishes begin arriving in the nearshore brackish waters with spring breakup (mid-June), and disperse along the coastline, generally concentrating along mainland and island shorelines rather than in lagoon centers. Factors that influence the distribution of anadromous fishes in the nearshore brackish environment include proximity of freshwater sources of anadromous fish stocks, migration timing, and daily responses of fish to temperature and salinity fluctuations in the nearshore environment. Least ciscoes and broad and humpback whitefishes are not commonly found anywhere but near the mainland shoreline, where water temperatures are typically highest and salinities lowest. Arctic cisco and arctic char are distributed more widely in brackish waters and are commonly present along the lagoon side beaches of barrier islands. Arctic char are the most abundant anadromous fish on the seaward side of barrier islands, indicating their greater tolerance of varying temperature and salinity conditions. Marine species tend to increase in nearshore waters as the open-water season progresses and salinities increase. The deltas of the larger rivers, particularly the Colville River, serve as overwintering areas for ciscoes, whitefishes, and arctic char, as well as migratory pathways and spawning areas for some fish. In addition, the Colville River delta supports both commercial and subsistence fisheries on whitefishes and ciscoes. Recent data suggest that arctic cisco harvested in the Colville River delta originate in the Mackenzie River system. A discussion of the potential effects of industrial habitat alteration and seawater withdrawal within the nearshore environment on anadromous and marine fishes is presented. The salient point of this discussion is that most small-scale industrial developments in coastal waters will likely not seriously affect anadromous and marine fishes, particularly when each development is viewed in isolation, but that the cumulative effects of coastwide development may directly and indirectly affect anadromous fish populations.

KEYWORDS: Beaufort Sea / Alaska / Colville River / arctic cisco / least cisco / broad whitefish / humpback / whitefish / arctic char / rainbow smelt / arctic cod / fourhorn sculpin / distribution / movements / overwintering / harvest / food habits / potential impacts.

Craig, P.C. 1985. Aquatic survey of the Kaktovik dredging operation, 1983 and 1984. Prepared by LGL Alaska Research Associates, Inc. for the Materials Source Division, North Slope Borough, Barrow, Alaska. 25 pp.

This paper reports the results of aquatic surveys conducted to observe gravel dredging activities in an embayment of Kaktovik Lagoon along the southeast shore of Barter Island, northeast Alaska, and to identify any potential problems related to local fishes or fisheries. Specific objectives were to document fish distributions in the dredging area, to survey the slurry outlet and the gravel stockpile for fish mortalities, and to document patterns of increased turbidity and suspended sediment in receiving waters due to dredging activities. Length data are presented for arctic char and arctic cisco sampled during this study.

Surveys were conducted during August 9-10, 1983 and July 27-29, 1984. Although this study took place outside the NPR-A boundaries, its results are applicable because similar species are present in each area and gravel dredging has and will likely continue to occur within NPR-A. The activity of dredging produced the following documented impacts: changes in depth of water, changes in turbidity and suspended sediments, removal of substrate materials, and potentially, an increase in salinity. Water depths in the center of the embayment prior to dredging were near 2.7 m; following dredging recorded depths were 9 to 12 m. Survey results indicated that turbidity and suspended sediment levels in the dredged embayment were generally within the range of naturally occurring levels of these variables except in the immediate vicinity of the gravel stockpile outflow.

There was no apparent avoidance or attraction to dredging operations by arctic char or arctic cisco; however, fourhorn sculpin were most abundant in the highly turbid waters of the gravel stockpile outflow. There was no evidence of fish mortality observed in the stockpiled gravel or in the outflow areas. It was proposed that hypersaline water may accumulate in the embayment center, persist year-round, and possibly create conditions unfavorable for fishes, particularly anadromous fishes.

KEYWORDS: Kaktovik / dredging / impacts / arctic char / arctic cisco / age and growth.

ACTIVITY: dredging

IMPACTS: Change in depth of water; change in turbidity or suspended sediments; removal of substrate materials.

Craig, P.C. 1987. Subsistence fisheries at coastal villages in the Alaskan Arctic, 1970-1986. Tech. Rept. No. 129. Alaska OCS Socioeconomic Studies Program. Prepared by LGL Ecological Research Associates, Inc. for Leasing and Environment Office, Minerals Management Service, USDI. 63 pp.

This excellent review paper assembles the available information and assesses the current state of knowledge about modern subsistence fisheries at the Alaska North Slope communities of Point Lay, Wainwright, Barrow, Atqasuk, Nuiqsut, and Kaktovik. References reviewed were primarily from the late 1970's and 1980's, with additional reviewed references dating to 1884. A description of the subsistence fishery for each village is presented and includes the timing of the fishery, the gear used, the most important species harvested, and estimates of the total number of fish harvested. Figures depicting fishing areas are also presented for each village. The fisheries concentrate on anadromous species (whitefish, arctic char, salmon, and rainbow smelt), although freshwater species (arctic grayling) are also taken. The species caught at each village differ, based on distributional patterns of fishes in North Slope waters. Pink salmon (and a few chum salmon) are the principal anadromous fish harvested at Point Lay and Wainwright. Rainbow smelt is also an important anadromous fish to Wainwright residents. Barrow residents primarily harvest humpback and broad whitefish, and least cisco, and to a lesser degree, arctic char, arctic cisco, and salmon. Humpback whitefish and least cisco are the primary species harvested by Atqasuk residents. Nuiqsut residents harvest mostly broad whitefish in summer, and arctic and least cisco in the fall gillnet fishery. Kaktovik residents primarily harvest arctic char and arctic cisco. The estimated total annual harvest of the subsistence fisheries of the six villages in 1985 (based in part on rough estimates made 15 years ago) was roughly 95,450 kg, which in terms of utilizable weight almost equaled the estimate of the villages' annual harvest of bowhead whales. Annual per capita catch of fish was highest at Nuiqsut (109.6 kg), followed by Kaktovik (26.4 kg), Atqasuk (19.5 kg), Barrow (14.5 kg), Wainwright (4.1 kg), and Point Lay (1.8 kg).

KEYWORDS: North Slope / Barrow / Atqasuk / Point Lay / Wainwright / Kaktovik / Nuiqsut / subsistence fishing / arctic cisco / arctic char / arctic grayling / least cisco / broad whitefish / humpback whitefish / pink salmon / chum salmon / rainbow smelt / harvest / distribution.

Craig, P.C., and W.B. Griffiths. 1981. Passage of large fish around a causeway in Prudhoe Bay, Alaska. Arctic 34(4):314-317.

This paper reports the results of field research conducted during the summer and early winter of 1980 to assess movements of fish around the 2.8 km ARCO West Dock solid-fill causeway in Prudhoe Bay, Alaska [the causeway has since been expanded]. During July and August, 1,067 least cisco, 229 arctic cisco, 65 arctic char, 16 broad whitefish, and 8 humpback whitefish were tagged at net sites on both sides of the causeway. This study examined only highly mobile fish greater than 200 mm in length; movements of small anadromous fish have not been studied. Recapture of tagged fish was accomplished in the Colville River commercial whitefish fishery 80 km to the west from October to December 1980. Tagging data indicated that the net movements of large cisco (species combined) were not affected by the causeway (i.e., there was no significant difference in proportions of fish recaptured that did or did not have to swim around the causeway).

Although the causeway apparently did not block the migration of large anadromous whitefish, it did change the local environment. Water temperatures tended to be 2-4^{0} C cooler and salinities 10 ppt higher on the west side of the causeway than on the east side. The authors noted that if more causeways were added, each structure could alter the nearshore temperature/salinity regimes, and the cumulative effect of these changes could be significant to fish in brackish coastal waters. Longer causeways or causeways joining offshore barrier islands might effect the coastal migration of anadromous fish.

KEYWORDS: Prudhoe Bay / causeway / arctic cisco / least cisco / movements / impacts

ACTIVITY: filling (aquatic and wetland habitats).

IMPACTS: change in water temperature; addition of physical barriers - partial obstructions; change in level of salinity.

Craig, P.C., and W.B. Griffiths. 1981. Studies of fish and epebenthic invertebrates in coastal waters of the Alaskan Beaufort Sea. RU-467. Pages 71-145 *in* Environmental assessment of the Alaskan continental shelf. Annual reports of the principal investigators. Vol. 1. Receptors. USDC: NOAA, OMPA; USDI: BLM.

This report presents the result of field investigations conducted in Harrison Bay, Alaska in 1979 and 1980 to examine the distribution of fishes and their prey. Population dynamics of least and arctic cisco were investigated near the Colville River and a fish survey was conducted on the Colville and Chandler rivers.

Fish distribution, composition, and relative abundance was determined with gillnets, otter trawls, and hydroacoustic sounding in transects across Harrison Bay. Least cisco, arctic cisco, boreal smelt (rainbow smelt), arctic cod, fourhorn sculpin and Liparidae were captured in trawls and gillnets. Fish densities as determined with hydroacoustics ranged from 0 to 39.2 fish per 104 m^3. Densities were highest in the eastern portion of the study area. An accumulation of fish targets during hydroacoustic sounding was noted in brackish water where it overlayed cooler more saline water.

During winter surveys in November and April, arctic cod, boreal smelt, fourhorn sculpin, and snailfish were captured. Catch per unit of effort for arctic cod was 30 times greater at the offshore site than the nearshore site.

Mark-recapture estimates of arctic and least cisco using the Colville River commercial fishery as the recapture gave 95% confidence estimates of between 114,857 and 415,781 for arctic cisco and 482,340 and 928,083 for least cisco.

Surveys were conducted at 21 locations on the Chandler River and to find arctic cisco spawning areas. Arctic grayling, round whitefish, longnose suckers, humpback whitefish, broad whitefish, burbot, arctic char and slimy sculpin were captured. No arctic cisco or least cisco were captured and it was concluded that these species do not use this area.

KEYWORDS: fish surveys / Beaufort Sea / Colville River / invertebrate surveys.

Craig, P.C., and L. Haldorson. 1980. Beaufort Sea barrier island-lagoon ecological process studies; final report, Simpson Lagoon studies. Part 4. Fish. RU-467. Annual rept. Prepared by LGL Limited and LGL Ecological Research Associates, Inc. 294 pp.

This report presents the results of a field study conducted from 1977 through 1979 in Simpson Lagoon, between Prudhoe Bay and the Colville River. Gillnets, beach seines and fyke nets were used to collect fish during the open water seasons of 1977 and 1978, and gillnets were used during the winter of 1978-1979.

Anadromous fish accounted for 46% of the total fish biomass captured in fyke nets in both 1977 and 1978, but only 3% of the total number of fish in 1978 and 21% in 1977. Most fish were found in nearshore brackish waters rather than offshore marine locations. Within brackish waters fish numbers were highest along shoreline edges, particularly the mainland shoreline. Marine fishes were not restricted to nearshore waters: in 1977 nearshore average catches ranged from 39.2 fish/24 hr at mainland locations to 2.1 fish/24 hr in the lagoon center. The average catch in offshore gillnets was 0.4 fish/24 hr; however, no anadromous fish were caught in offshore nets. Least cisco, broad whitefish and humpback whitefish were common only along the mainland shoreline. Arctic cisco and arctic char were common along lagoon side beaches of barrier islands and arctic char were the most abundant anadromous fish along the seaward beaches of barrier islands. During rough water periods, most fish were caught several hundred meters offshore. No strong consistent relationships were found between numbers of fish caught and either temperature, salinity or turbidity. During ice covered periods, only marine species were caught in nearshore areas; all anadromous fish had left the marine environment.

Arctic cisco was the first species caught in the spring. They were primarily mature spawners that had left overwintering areas at the first opportunity. They fed heavily in coastal waters, then left after about two weeks. Juvenile and nonspawning arctic cisco were abundant in nearshore environments throughout the openwater period. Daily catches varied greatly suggesting that fish moved through in pulses or schools.

Almost all least cisco captured were over 200 mm in length. They were rare along barrier islands, but abundant along the mainland in mid-summer. Most arctic char moving through Simpson Lagoon were over 200 mm in length. Their distribution was widespread in the lagoon and around barrier islands, and were common in nearshore waters during the open water period. Recaptured arctic char indicated that most using Simpson Lagoon originate in the Sagavanirktok River.

Life history summaries based on many sources are provided for arctic cisco, least cisco, Bering cisco, arctic char, boreal smelt (rainbow smelt), fourhorn sculpin, arctic cod, saffron cod, broad whitefish, humpback whitefish, and arctic flounder. Age and growth, food habits, distribution, spawning and overwintering are discussed for these species.

KEYWORDS: Beaufort Sea / Simpson Lagoon / Colville River / Prudhoe Bay / Sagavanirktok River / anadromous fish / marine fish / summer distribution / nearshore habitats / species distribution.

Craig, P.C., and L. Haldorson. 1986. Pacific salmon in the North American arctic. Arctic 39(1):2-7.

This review paper describes the presence and distribution of the five species of Pacific salmon from the area of Point Hope, Alaska to the Mackenzie River in the Northwest Territories, Canada. References reviewed were primarily from the 1970's and 1980's. All reported sightings of salmon in this area are of adults; no salmon fry have been captured to date in this region. All five species of adult Pacific salmon occur in small numbers between Point Hope and the Mackenzie River; however, only pink and chum salmon appear to have small viable populations north of Point Hope. Chinook, coho, and sockeye salmon have been recorded in arctic waters north of Point Hope; however, these species probably occur in this area only as strays, since often only a single specimen is caught.

Pink salmon are the most common species occurring north of Point Hope. Recent studies indicate that small runs of pink salmon may occur in eight drainages north of Point Hope, and probable strays have been encountered in nine additional drainages east of Barrow. Small numbers of pink salmon have been observed spawning in the Colville River near Umiat, although it is suspected that the Colville River (or other Alaska waters east of Barrow) does not support sustained populations of pink salmon. Arctic pink salmon are smaller than individuals to the south but have similar meristic characters. Data concerning fecundity and feeding are discussed for pink salmon.

Chum salmon have small runs in six arctic drainages and are less common than pink salmon. Most of the chum salmon east of Barrow consist of strays or very small stocks, with the exception of the Mackenzie River drainage, which has a small sustained population. Length and weight data are presented for chum salmon caught in arctic Alaska waters.

Expansion of Pacific salmon into arctic waters appears to be restricted by cold water temperatures, particularly in freshwater environments. Pink and chum salmon are probably able to maintain small stocks north of Point Hope by virtue of their relative cold tolerance and predominantly marine life cycle. It is predicted that salmon populations, particularly pink salmon, in arctic rivers undergo relatively frequent cycles of colonization-extinction compared to other anadromous species and that straying of pink salmon to non-natal streams would allow the species to repopulate marginal sites.

KEYWORDS: NPR-A / North Slope / pink salmon / chum salmon / age and growth / distribution / food habits / spawning and reproduction / taxonomy

Craig, P.C., and G.J. Mann. 1974. Life history and distribution of the arctic cisco (*Coregonus autumnalis*) along the Beaufort Sea coastline in Alaska and the Yukon Territory. Chap. 4. *in* P.J. McCart, ed. Life histories of anadromous and freshwater fish in the western Arctic. Arctic Gas Biol. Rept. Ser. Vol. 20. 33 pp.

This paper reports the results and interpretation of field work conducted in 1972 and 1973 along the North Slope of northeastern Alaska and the Yukon Territory. The report describes meristic characteristics, growth, reproduction, food habits and distribution of arctic cisco in the study area. Fish from Alaska and the Yukon are compared.

Arctic cisco were captured throughout the study area but were restricted to marine and brackish waters, none were captured or reported over 1 km upstream except in the Mackenzie and Colville rivers. Average counts of meristic characters were 42.5 gillrakers, 89.2 lateral line scales, and 133.2 pyloric caecae. Otolith-based aging gave maximum age of 21 years. Ciscoes of age 7-11 predominated in Yukon samples whereas 4 to 7 year old fish predominated in Alaska samples. Ninety one percent of Alaska ciscoes were considered immature whereas only 34% of fish in the Yukon sample were immature. The mean egg count for arctic ciscoes averaging 392 mm was 20,166. Arctic cisco captured in the marine environment fed primarily on amphipods, copepods, mysids, and Diptera larvae. Most fish moving upstream to spawn in the Mackenzie River were not feeding.

All fish collected in the Mackenzie River were mature whereas coastal samples consisted of both mature and immature fish. Few fish taken in the Colville River were judged to be mature. Two migratory trends were noted in the Mackenzie River; an upstream movement of spawners that peaks from July to September and a post spawning movement of fish from the Arctic Red and Peel rivers to the Mackenzie River from October to December. No spawning run was described in the Colville River, but spawning may occur later than in the Mackenzie River because it is a smaller system.

KEYWORDS: Arctic cisco / Beaufort Sea / Mackenzie River / Colville River / life history / fecundity / age and growth.

Craig, P., and P.J. McCart. 1974. Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay and the Mackenzie Delta 1972-1973. Chap. 3. *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon, and Northwest Territories. Arctic Gas Biol. Rept. Ser. Vol. 15. 36 pp.

This report summarizes survey information collected in 1972 and 1973 in the spring (April-May) and fall (September-November). Fish were located and numbers estimated by visual observation from a helicopter. Most streams to be crossed by the pipeline route were flown; however, several streams along each route were not completely surveyed. Most of this report refers to areas used by arctic char. A brief summary of the life history of arctic char is given to point out the importance of spawning and overwintering areas. Groundwater sources often provide the only available overwintering habitat. Spawning and overwintering areas were judged to be critical fisheries habitats. Detailed maps are provided describing critical spawning and overwintering areas for coastal streams from Prudhoe Bay to the Firth River. A more general map includes the entire study area to the Mackenzie River. A description of surveyed areas with numbers of fish seen and critical habits is provided for each stream area. Some areas were sampled to determine species present.

The importance of preventing any industrial activity that would adversely affect spawning and overwintering areas or that would reduce oxygen levels or water quality in these areas is discussed. Impacts of reduced oxygen levels and increased sediment levels in stream on fish, eggs, and other stream dwelling organisms are also addressed. The authors recommended that construction activities in critical areas be limited to spring and summer months when natural silt loads are higher and habitats are less restricted. In non critical areas, it is recommended that construction activities be undertaken during winter months when large portions of streams are frozen solid.

KEYWORDS: Arctic coastal streams / gas pipeline / Yukon Territory / Alaska / fish surveys / overwintering habitat / spawning habitat / critical areas / potential impacts / arctic char.

Craig, P.C., and P.J. McCart. 1975. Classification of stream types in Beaufort Sea drainages between Prudhoe Bay, Alaska, and the Mackenzie Delta, N.W.T., Canada. Arctic and Alpine Research 7(2):183-198.

This research paper presents information describing the physical, chemical, and biological characteristics of arctic streams in Beaufort Sea drainages in Alaska and the Yukon Territory, from the Kuparuk River west to the Mackenzie River Delta. In addition, a classification scheme is proposed for these arctic streams based largely on the stream's geographic origin. Although the streams studied are not within NPR-A, the information presented here is relevant because similar stream types and biological components within the streams exist within NPR-A. Samples of fish, benthic invertebrates, and water were collected from 55 locations in 17 drainages during the summers of 1971, 1972, and 1973.

Streams were classified as mountain, tundra, or spring streams. Mountain streams originate in the Brooks Range, with their flow derived from surface runoff or from perennial springs. Mountain streams are generally clear, except during flood events, have summer water temperatures generally less than 10º C, and contain water that is moderately hard with a predominance of calcium ions, reflecting the nature of the limestone bedrock in which the streams originate. Spring streams are small streams, generally less than 1.5 km in length and only a few meters wide, and are tributary to mountain streams. Spring streams are clear, have relatively low but stable perennial discharge, and have a low average annual temperature variation. Tundra streams tend to be small meandering streams that flow into mountain streams or directly to the sea, usually have a single channel, and with few exceptions, have neither springs nor aufeis and cease flowing during winter. Tundra streams have water temperatures generally higher than other stream types, have water that is often stained yellow or brown, and have a lower pH and lower concentrations of calcium than do mountain or spring streams.

Benthic invertebrates are found in significantly greater densities in spring streams than tundra streams, and in significantly greater densities in tundra streams than in mountain streams. Several fish species are found in these streams, with arctic char and arctic grayling being fairly abundant. Arctic grayling are found in all three stream types; however, spawning is largely restricted to tundra streams. No arctic grayling fry have been found in spring streams, and those found in the lower reaches of mountain streams likely moved downstream from the tundra streams flowing into them. Adult arctic grayling enter tundra streams shortly after the spring thaw, spawn, and then leave the system, although some adults remain throughout the summer and leave at freezeup. Juvenile arctic grayling also enter the stream shortly after breakup, remain throughout the summer, and leave prior to freeze-up. Arctic char are the characteristic species of mountain and spring streams; however, small numbers of juvenile arctic char may enter tundra streams. Anadromous arctic char spawn in the fall in the vicinity of spring sources in the mountain and spring streams. These areas also serve as rearing areas for fry and juvenile arctic char, and serve as overwintering areas for arctic char and other fish.

KEYWORDS: arctic char / arctic grayling / spawning and reproduction / North Slope / invertebrates / water chemistry / streams

Craig, P.C., and V.A. Poulin. 1975. Movements and growth of arctic grayling (*Thymallus arcticus*) and juvenile arctic char (*Salvelinus alpinus*) in a small arctic stream, Alaska. J. Fish. Res. Board Can. 32:689-697.

This paper reports the results of field research conducted on adult and juvenile arctic grayling and juvenile arctic char during the summers of 1972 and 1973 in a small tundra stream in the Kavik River drainage, northern Alaska. Although this study was not located within or near the boundaries of NPR-A, similar tundra streams with similar species composition exist within NPR-A. This study assessed the growth of arctic grayling and the distribution and movements of arctic grayling and arctic char, and compared these parameters to those observed for other arctic and subarctic populations.

Adult arctic grayling entered the study stream shortly after breakup from spring-fed overwintering areas within the Kavik and Shaviovik rivers, spawned, and left shortly thereafter. It appeared that most arctic grayling in the Kavik drainage overwinter at a spring area in the Shaviovik River. Juvenile arctic grayling entered the study stream in large numbers soon after breakup and remained there throughout the summer. Arctic grayling fry emerged from the stream gravels in late June or early July and remained until freeze-up (mid-September).

Arctic char within the study stream were mostly small juveniles between ages 1 and 3 that used the stream for rearing. A few arctic char were small, mature stream-resident males, ages 4 and 5. Most pre-smolt arctic char remain in the main river, although some rear in the tundra tributaries as noted above. Anadromous adult arctic char leave the ocean in fall and early winter and move to their spawning grounds in the Kavik and Shaviovik rivers. These spring areas also serve as overwintering areas for both arctic char and arctic grayling.

The growth rate of arctic grayling in the study stream was among the fastest recorded for arctic populations. Otolith-based age determinations were preferred as scales tended to underestimate the ages of old fish. Maximum observed age for arctic grayling was 16 and age at sexual maturity ranged from 5 to 8. Length data are presented for both arctic grayling and arctic char.

KEYWORDS: Kavik River / Shaviovik River / arctic grayling / arctic char / age and growth / distribution / life history / movements / overwintering / spawning and reproduction

Craig, P.C., and D. Schmidt. 1985. Fish resources at Point Lay, Alaska. Prepared by LGL Alaska Research Associates, Inc. for the North Slope Borough, Barrow, Alaska. 105 pp.

This paper reports the results of field research conducted near Point Lay, Alaska, to determine distributions of fish in freshwater and coastal habitats, to document the subsistence fishery at Point Lay, to monitor baseline hydrological conditions in the lower Kokolik River and Kasegaluk Lagoon prior to gravel dredging in the Kokolik River, to document the distribution of fish in the dredging area during dredging, and to document patterns of turbidity and suspended sediments in the Kokolik River and Kasegaluk Lagoon resulting from the dredging activities. Field studies were conducted during June through September 1983, followed by brief surveys in November 1983, and August and September 1984. Fish species most commonly collected in the lower Kokolik River were rainbow smelt, arctic grayling, pink salmon, and several marine species in the brackish delta waters. The Kokolik River supports a resident population of arctic grayling and a small run of pink salmon and rainbow smelt. A few specimens of arctic char and chum salmon were also collected in the Kokolik River, but were presumed to be strays from other drainages. Catches of fish in Kasegaluk Lagoon consisted primarily of marine species: Pacific herring, arctic and saffron cod, capelin, fourhorn sculpin and arctic flounder. Pink salmon, and occasional arctic cisco, arctic char, least cisco, and chum salmon were also found in Kasegaluk Lagoon. Data concerning food habits, length, and maturity are presented for most species of fish described in this paper.

The summer 1983 subsistence harvest of fish by Point Lay residents was estimated to be 70 kg, of which 78% was contributed by pink salmon and Pacific herring. Residents indicated that about 115-135 kg of arctic grayling were harvested from the Kukpowruk River in the fall fishery of 1983.

Dredging produced documented direct impacts of changes in depth, turbidity and suspended sediments, and removal of substrate materials. Increases in turbidity and suspended sediments were limited in extent and generally small: increased levels were detected at the mouth of the gravel stockpile outflow and for a distance of about 1 km downstream. Pink salmon appeared to successfully migrate past the active dredging operation. A section of the channel was dredged to a depth of 6-7 m (from a pre-dredging depth of 2 m). The deepening of the river channel is expected to have a low impact on fish populations in the area, largely because use of other deep areas in the Kokolik River delta by fish appears to be low.

KEYWORDS: Point Lay / Kokolik River / Kasegaluk Lagoon / Kukpowruk River / arctic grayling / pink salmon / arctic char / arctic cisco / least cisco / age and growth / distribution / food habits / spawning and reproduction / harvest / impacts

ACTIVITY: dredging

IMPACTS: change in depth of water; change in turbidity or suspended sediments; removal of substrate materials.

Craig, P.C., and D. Schmidt. 1982. Survey of potential dredge sites at Wainwright, Point Lay, Atqasuk, Nuiqsut, and Kaktovik. Prepared by LGL Alaska Research Associates for the Materials Source Division, North Slope Borough, Barrow, Alaska. 43 pp.

This study documents the fisheries importance of rivers, lakes, and coastal waters viewed as potential gravel sources for the villages of Wainwright, Point Lay, Atqasuk, Nuiqsut, and Kaktovik, and identifies areas requiring additional study. The methods used consisted of a review of existing information, field sampling of fish with gillnets and seines, and interviews with local residents to evaluate whether locations of possible gravel sources might conflict with subsistence fisheries. Field sampling was conducted from July 19 to August 11, 1981. Additional sampling was conducted at Nuiqsut sites during the summer of 1981 to monitor gravel dredging activities in the Nechelik Channel of the Colville River, and in April 1982 to determine if hypersaline conditions developed during late winter in the dredged pit in the Nechelik Channel. Fish species caught at the dredging sites at the five villages or observed in subsistence catches included arctic char, arctic grayling, arctic cisco, least cisco, Bering cisco, broad whitefish, humpback whitefish, round whitefish, chum salmon, pink salmon, chinook salmon, longnose sucker, boreal smelt (rainbow smelt), Pacific herring, ninespine stickleback, saffron cod, arctic flounder, and fourhorn sculpin. The potential effects of instream dredging on the subsistence fisheries of Wainwright and Kaktovik were considered minimal because dredging sites were not near fishing sites, lacked fish or the desired species, dredging activities were unlikely to block fish migrations, or would occur in areas where naturally variable levels of turbidity occurred. At Point Lay, dredging at sites in the Kokolik River and Kasegaluk Lagoon had potential effects on the subsistence fisheries by interfering with pink salmon migration in the Kokolik River or with fish feeding or movements near the barrier island of Kasegaluk Lagoon. There was concern that dredging in the Meade River near Atqasuk could interfere with the migration of salmon and whitefishes to spawning areas or with the subsistence fishery itself. Dredging in the Nechelik Channel of the Colville River at Nuiqsut produced documented impacts of changes in turbidity and suspended sediments, changes in the depth of water, and removal of substrate material. Approximately 153,000 m^3 of sand and gravel were removed, changing the channel depth from 3.0-3.7 m to 9 m, and creating a trench 800 m long by 76 m wide. No dead fish were observed at the gravel slurry outfall. Increased levels of turbidity were primarily confined to the area of the return water discharge to the Nechelik Channel. Subsistence fishing adjacent to and downstream of the dredging operation appeared to be unaffected. Hypersaline conditions did not develop in the dredged pit during winter.

KEYWORDS: dredging / Wainwright / Point Lay / Atqasuk / Meade River / Nuiqsut / Colville River / Nechelik Channel / Kaktovik / Kokolik River / Kasegaluk Lagoon / subsistence fishing / arctic char / arctic grayling / arctic cisco / least cisco / broad whitefish / humpback whitefish / round whitefish / chum salmon / pink salmon

ACTIVITY: dredging

IMPACTS: change in water depth; change in turbidity or suspended sediments; removal of substrate materials.

Craig, P.C., W.B. Griffiths, L. Haldorson, and H. McElderry. 1985. Distributional patterns of fishes in an Alaskan arctic lagoon. Polar Biol. 4:9-18.

This paper reports the results of field research conducted primarily during June through September, 1977-1978 in Simpson Lagoon, located between Prudhoe Bay and the Colville River delta, Alaska. Additional sampling was conducted during winter in Simpson Lagoon and in nearshore and offshore locations between the Colville and Canning rivers. This study examined the species composition and distribution of fishes inhabiting the nearshore waters within Simpson Lagoon. Although the study was not conducted within the boundaries of NPR-A, it does discuss Simpson Lagoon fish species that also use areas within NPR-A (e.g., the Colville River), particularly as overwintering habitat. Five species of fish accounted for over 91% and 99% of all fish caught during the summers of 1977 and 1978, respectively; arctic cod and fourhorn sculpin, were the numerical dominants in the lagoon, followed by arctic cisco, least cisco, and arctic char. A small run of pink salmon was present in Simpson Lagoon in 1978. The anadromous species remained in the relatively warm and brackish waters near shore, particularly the mainland shoreline where species occurrence and catch per unit effort were highest. This pattern was particularly evident for least cisco, broad whitefish, and humpback whitefish, which were not commonly taken anywhere but in the relatively warm and brackish waters along the mainland. Arctic cisco and arctic char were more widely distributed and were more commonly present along the lagoon side beaches of the barrier islands. Arctic char were the most abundant anadromous fish caught along the seaward beaches of the barrier islands. Virtually all anadromous species vacated Simpson Lagoon and returned to rivers, lakes, and river deltas to spawn or overwinter. Arctic, least, and Bering ciscoes were found in brackish (18-32 ppt) waters of the Colville River delta during winter, indicating that these fish do not necessarily reside in freshwater, but can tolerate brackish water in winter. No ciscoes were found in coastal marine waters (of higher salinities than in the delta) during winter. Marine species and anadromous rainbow smelt were the only fish collected in marine waters during winter. A pre-spawning aggregation of rainbow smelt was present near Thetis Island; these fish probably spawn in the Colville River in spring.

KEYWORDS: Simpson Lagoon / North Slope / Beaufort Sea / arctic char / arctic cisco / least cisco / pink salmon / distribution / movements / overwintering

Dames & Moore. 1987. Appendix B - Fisheries analysis. Lisburne offshore development project. Draft environmental document, Submittal No. 7. November 23, 1987. Anchorage, Alaska. 41pp.

This report presents an analysis of fisheries data collected in the Prudhoe Bay area from 1983 through 1986. The objective of this analysis is to evaluate habitat usage by anadromous fish based on habitat variables of temperature and salinity. Data included in this analysis were from fyke net catches in sets of 24 hours or less with less than 4 ppt change in salinity and less than 2^{o} C temperature increments. Normalized Catch per unit effort (CPUE) was used as an estimate of fish utilization within each habitat category.

Data screening eliminated between 50 and 70 percent of possible net/date catches for the years 1983-1986. Data were analyzed by species and cohort with habitat (temperature and salinity) preferences being shown by higher levels of CPUE.

Arctic cisco cohort 1 (100 to 200 mm) were primarily associated with 0-4 ppt and 12-16 ppt salinities and were distributed across the entire temperature range with a peak at 8^{o} to 12^{o} C. Arctic cisco cohort 3 (>200 mm) were generally associated with lower salinities with a peak below 8 ppt; however, there was a secondary peak at 20-24 ppt. They showed extensive use of temperatures above 6^{o} C with peak utilization >12^{o} C.

Least cisco cohort 1 (<180 mm) utilized the entire salinity range (0-24 ppt) but was strongly associated with water temperatures above 12^{o} C. They showed little use below 10^{o} C. Least cisco cohort 2 (>180 mm) were equally distributed across the entire temperature and salinity ranges.

Broad whitefish cohort 1 (<75 mm) were distributed across the entire salinity range with a peak at 4-8 ppt and were strongly associated with temperatures above 12^{o} C. Cohort 2 broad whitefish showed peak utilization of salinities from 4-8 ppt with a secondary peak at 16-20 ppt. Strongest temperature associations were above 12^{o} C with a secondary peak at 4-8^{o} C. Cohort 3 broad whitefish (>150 mm) showed a strong association with salinities below 8 ppt and were evenly distributed between 2 and 12^{o} C with a peak greater than 12^{o} C.

Cohort 1 arctic char (<300 mm) were strongly associated with salinities below 8 ppt. Temperatures of 2-12^{o} C were used extensively with a peak at 6-8^{o} C. Cohort 2 arctic char (>300 mm) utilized the entire salinity range except for those above 24 ppt with a peak at 6-8 ppt. The temperature range from 2-12^{o} C was evenly utilized with a peak between 2^{o} and 8^{o} C.

KEYWORDS: Prudhoe Bay / arctic cisco / broad whitefish / least cisco / arctic char / temperature preference / salinity preference / habitat utilization.

Dames & Moore. 1987. Kuparuk River unit waterflood project marine life bypass system monitoring program, January - December 1986. Annual report. Prepared by Dames & Moore for ARCO Alaska, Inc., Anchorage, Alaska. 85 pp.

This paper reports the results of field monitoring studies designed to assess the effects of operation of the Kuparuk waterflood project seawater treatment plant that has the capacity to withdraw approximately 28.2 million gal/day from the Beaufort Sea at Oliktok Point, Alaska. Objectives of the monitoring program were to assess the effectiveness of the seawater intake structures in preventing or reducing the entrapment, impingement, or entrainment of marine life, to assess the effectiveness of the marine life bypass system, to note the number, species, and condition of any organism passing through the plant, and to note the availability of species in the area of the seawater intakes. Two 12 hr sampling periods were established each month during 1986, except for June, September, and October. The area around the intake structures was sampled with gill nets from July 31 to September 25, and with a fyke net on August 30. Although not within NPR-A, this seawater treatment plant is located in an area used by anadromous fish that may also use waters within the boundaries of NPR-A. Virtually no entrapment of anadromous fish occurred at the seawater treatment plant during the sampling periods. One 428 mm broad whitefish was collected alive in 1986 in the marine life bypass system but was killed during handling. Other fish found in the marine life bypass system included fourhorn sculpin, arctic cod, sand lance, snail fish, arctic flounder, and saffron cod. Initial survival of fourhorn sculpin collected in the marine life bypass system was 65%. Physical injuries to fourhorn sculpin included hemorrhaging, gill and eye damage, and fragmentation. Gill net and fyke net sampling near the seawater intakes indicated the presence of arctic and least cisco, arctic char, broad and humpback whitefish, rainbow smelt, fourhorn sculpin, arctic cod, and arctic flounder. Length data are presented for the arctic and least cisco.

KEYWORDS: Oliktok Point / North Slope / Kuparuk waterflood / arctic cisco / least cisco / broad whitefish / humpback whitefish / arctic char / fourhorn sculpin / impacts / water withdrawal.

ACTIVITY: water regulation / withdrawal / irrigation.

IMPACT: impingement, entrainment, or entanglement.

deBruyn, M., and P. McCart. 1974. Life history of the grayling (*Thymallus arcticus*) in Beaufort Sea drainages in the Yukon Territory. Chap. 2 *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon, and Northwest Territories. Arctic Gas Biol. Rept. Ser. Vol. 15. 39 pp.

This report contains information on the life history of arctic grayling from field work conducted during 1972 in lakes and streams draining the North Slope of the Yukon Territory in the vicinity of a proposed natural gas pipeline corridor. The Firth, Babbage, and Blow rivers are the largest drainages included in this study.

Arctic grayling were widely distributed in the study area, occurring in all rivers except the Spring River. Of 11 tundra lakes sampled, only two contained arctic grayling, and 5 of 8 foothill lakes contained arctic grayling. First year growth of arctic grayling was found to be more rapid in eastern streams than western streams. This was attributed to earlier breakup on more easterly streams, affording a longer growing season. Differences in growth rates of fry were also found between areas in the Trail River, but no explanation was found for this. Young arctic grayling began forming scales at 35 mm in length. Otolith based aging showed that lake arctic grayling grew faster than stream arctic grayling. Fish to age 22 were found in the Firth River, and were older than fish from other areas of the Canadian and Alaska Arctic. This could be a result of aging techniques because otoliths tend to give higher ages than scales.

Arctic grayling mature earlier in lakes than rivers. Fish were first mature at age 4 in two lakes whereas none younger than age 7 were mature in the Firth River.

The mean fecundity of arctic grayling from several locations was 8968 eggs per female; the number of eggs did not correlate significantly with length of fish. It appeared that once mature, arctic grayling spawn annually. Spawning in the lower Firth River took place about two weeks later than in the upper river, and was closely correlated with spring break-up. Arctic grayling fry occupied shallow calm backwaters. In areas where fry and older fish were found together, fry were in very shallow water and larger fish remained in deeper areas.

Little was learned of movement patterns, but it was assumed that movements were closely related to the availability of overwintering sites. Overwintering habitat was restricted to spring areas and a few deep pools in rivers. Some interconnected lakes also provided suitable winter habitat. Arctic grayling fed on a variable diet of bottom fauna, drift, terrestrial insects, fish, fish eggs, shrews, and plant material. It was noted that arctic grayling from lakes were more heavily parasitized than arctic grayling from streams.

KEYWORDS: arctic grayling / Babbage River / Firth River / Yukon Territory / Beaufort Sea / life history / spawning / age and growth.

Dew, C.B. 1982. Kuparuk field fish survey, 1981. Final report. Prepared by Woodward-Clyde Consultants for ARCO Alaska, Inc., Anchorage. 15 pp.

This report documents field surveys to determine the distribution of fish in four streams in the Kuparuk Oilfield in August 1981. Sampling methods included electrofishing, seining, dip netting, visual observation, and angling. Angling was the only method that produced no fish. East Creek, Central Creek (two unnamed tundra streams flowing into Simpson Lagoon), the Ugnuravik River and two of its tributaries, and the northernmost tributary of Kalubik Creek were surveyed.

Ninespine stickleback was the only fish species captured or observed in Central Creek, East Creek, and Ugnuravik River tributaries. All of these streams are tundra origin and exhibit typical beaded configuration.

The northern Kalubik Creek tributary was beaded in its lower reaches, but became braided and shallow about 2.4 km upstream from its mouth. Round whitefish, rainbow smelt, arctic grayling, fourhorn sculpin, and ninespine stickleback were captured in this stream. All 11 arctic grayling captured were juveniles averaging 125 mm in length, and 9 of 10 round whitefish collected were juveniles. Sticklebacks were found throughout the lower 5 km of the stream. A single rainbow smelt and all fourhorn sculpin were captured just upstream of this stream's confluence with Kalubik Creek.

KEYWORDS: Fish survey / Kuparuk Oilfield / Ugnuravik River / Kalubik Creek.

Doxey, M.R. 1977. Fishery impact survey of ARCO causeway. Unpubl. rept. Prepared by ADF&G, Div. Sport Fish, Fairbanks for Atlantic Richfield Co., Anchorage. 38 pp.

This report covers information collected in a field study conducted in Prudhoe Bay during 1976. Fyke traps and gillnets were used to capture 26,661 fish of 15 species. Catches in order of abundance consisted of least cisco, fourhorn sculpin, arctic cod, arctic cisco, broad whitefish, and humpback whitefish. Rainbow smelt, liparids, arctic grayling, arctic flounder, saffron cod, round whitefish, capelin and ninespine sticklebacks were also taken, but in small numbers.

Nets were set in the vicinity of the old East Dock and the new West Dock to evaluate fish movements in Prudhoe Bay. During June and July, arctic char milled in Prudhoe Bay, larger arctic char appeared first followed by smaller fish (<200 mm) in July. By mid-August slight eastward migrations took place, probably by fish destined for the Sagavanirktok River. By late September, arctic char were virtually absent from the study area. Broad whitefish were present in Prudhoe Bay from June through September. In July and August, larger broad whitefish were present in a higher proportion than in June and September. Humpback whitefish were present in small numbers during July and August. Least cisco moved eastward from July through mid-August. During late August and September they moved to the west. Larger least cisco predominated in July and August catches and small fish dominated in September catches.

Two arctic char tagged in Prudhoe Bay were recaptured later the same year in the Sagavanirktok River. Twenty tagged arctic cisco were recaptured in the Colville River the same fall, and one was recaptured in August at Griffin Point, 241 km to the east of Prudhoe Bay; 265 tagged least ciscoes were recaptured in the Colville River. There were several instances of more than two least cisco tagged in a single day being recaptured sometime later in the same channel and same day on the Colville River, indicating that least cisco school and travel together.

Amphipods and mysids were the most important food items of anadromous species. Arctic cod were an important food item of arctic char.

Salinities, water temperatures, and water color were often different from one side of the new dock to the other. The greatest difference in salinity was 8 ppt on July 30. The average salinity difference was 2ppt. The greatest temperature difference was 5.5^{o} C on August 2 and the mean difference was 1.6^{o} C. Temperatures and salinities could not be correlated with fish movements.

It was concluded that the new dock prevents mixing of waters and often creates two different environments depending on wind and current direction. The effects on fish were not known. It was also concluded that the new dock did not present an obstacle to arctic char movements.

KEYWORDS: Beaufort Sea / Prudhoe Bay / fish movements / fish distribution / causeway impacts.

ACTIVITY: filling (aquatic and wetland habitats).

IMPACTS: change in water temperature; change in level of salinity.

Dryden, R.L., B.G. Sutherland, and J.N. Stein. 1973. An evaluation of the fish resources of the Mackenzie River Valley as related to pipeline development. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Rep. No. 73-2. 176 pp.

This report presents data from fish surveys conducted in 1971 and 1972 on most tributaries of the Mackenzie River from its mouth to Great Slave Lake. The report is a collection of survey forms containing the stream name, watercourse type, riverbank conditions, and a brief assessment of the fish resources and water chemistry data at sampling sites. Survey data are presented for 50 streams. Sampling was conducted with gill nets, seines, and hook and line to collect 26 of the 34 species documented in the Mackenzie River system. Maps of each area are included.

KEYWORDS: river surveys / Mackenzie River / fish distribution

Falk, M.R., and M.J. Lawrence. 1973. Seismic exploration: its nature and effect on fish. Tech. Rept. Ser. No. Cen/T-73-9. Fisheries and Marine Service, Dept. of the Environment, Winnipeg, Canada. 51 pp.

This report is divided into two parts. The first is a detailed review of available information relating to explosive and nonexplosive seismic energy sources and their effects on fish. This review summarizes data from many authors between 1946 and 1972. Various types of nonexplosive seismic systems are then described including those powered by compressed air, electricity, and confined detonations of various gas mixtures.

The second part of this report is a field study conducted in the Mackenzie River concerning the effects on fish of three commonly used seismic energy sources, aquaflex, geogel, and an air gun. Fish were placed in cages and positioned at different distances and depths around each shot. After each shot they were retrieved and examined.

Aquaflex is a linear explosive; 50 m sections were used in the experiment. Lethal areas for trials in 3.1 m of water were calculated to be 604 m^2 at 2.1 m depth and 1533 m^2 at 1 m depth. With aquaflex in 4.5 m of water the lethal area was 3363 m^2 at the surface.

Geogel is a point charge explosive. No caged mortalities were observed using a 1.1 kg charge detonated on the bottom in 1.7-2.3 m of water. Detonation of a 4.5 kg charge 3 m below the surface in 4.5 m of water resulted in mortalities up to 30 m away. The LD 50 (the amount required to kill 50% of the population) was 27.4 m in a horizontal direction, the lethal area was 2370 m^2 and the lethal volume was 10,760 m^3.

The airgun produced the least mortalities. In two shots only two fish suffered swim bladder damage. The lethal radius for the air gun was estimated to be between 0.6 and 1.5 m.

KEYWORDS: Seismic activity / fish / impacts / arctic cisco / broad whitefish.

ACTIVITY: blasting.

IMPACT: increase in hydrostatic pressure.

Fawcett, M.H., and T.A. Carpenter. 1986. Colville River fishes: 1985 biological report. Chapter 2. Prepared by Entrix, Inc. for ARCO and the North Slope Borough. 138 pp + append.

This paper reports the results of 1985 field studies conducted in the Colville River delta, Alaska, to obtain information on relative abundance, length frequency, age composition, growth rates, reproductive status, recruitment patterns, and seasonal movements for arctic and least cisco, and broad and humpback whitefish. Sampling was conducted between July 2 and September 11 at sites in the lower river near Nuiqsut and in the outer delta. Least cisco, arctic cisco, broad whitefish, and humpback whitefish were the most commonly captured anadromous species, followed by arctic char, rainbow smelt, and pink salmon. Marine species captured included fourhorn sculpin, saffron cod, arctic flounder, and arctic cod. Freshwater species captured included round whitefish, arctic grayling, longnose sucker, burbot, ninespine stickleback, slimy sculpin and arctic lamprey. Catch per unit effort data and distribution data are presented for all species except pink salmon, arctic flounder, arctic cod, saffron cod, burbot, and ninespine stickleback. Data on size and age structure, growth, and sexual maturity are also presented for arctic and least cisco, and broad and humpback whitefish. July was characterized by general movement of arctic and least cisco, humpback whitefish, and to a lesser extent, broad whitefish, out of the lower river area and into the delta and coastal waters for summer feeding. Substantial numbers of least cisco, broad whitefish, and humpback whitefish (especially smaller size classes) remained in the delta area, but nearly all of the arctic cisco left the delta area. During August, generally increasing concentrations of arctic and least cisco, and broad and humpback whitefish appeared in the river and delta areas. Young-of-the-year (YOY) least cisco, broad whitefish, and humpback whitefish, which presumably originated in the Colville River system, became abundant during this period. By the third week of August, the spawning run of least cisco was well underway. YOY arctic cisco began appearing in the Colville River delta in the last week of August. Estimated rates of movement of YOY arctic cisco between Kay Point, Yukon Territory (80 km west of the Mackenzie River and 480 km east of the Colville River) and the Colville River delta ranged from 10.9 to 17.2 km per day, depending on the section of Beaufort Sea coast examined. Forty four days elapsed between the first catches of YOY arctic cisco at Kay Point and the first catches at the Colville River delta. Arctic and least cisco increased in abundance at delta and river stations during September. Arctic cisco were probably still arriving from coastal waters when sampling was discontinued on September 11. Broad and humpback whitefish left the delta area and presumably moved upriver to overwintering areas. The 1985 data indicate that the larger individuals of the YOY arctic cisco successfully migrated past (or through the breaches of) the causeways and reached rearing and overwintering areas in the Colville River delta with no apparent delay. It is not known if the causeways affected the smaller, weaker-swimming fish in the population because sampling ceased while catches were still rising. Environmental conditions (e.g., persistent easterly winds) and a strong year-class of YOY arctic cisco likely facilitated the movement of young arctic cisco from the Mackenzie River to the Colville River in 1985.

KEYWORDS: Colville River / Colville River delta / NPR-A / least cisco / arctic cisco / broad whitefish / humpback whitefish / arctic char / arctic grayling / round whitefish / longnose sucker / pink salmon / burbot / rainbow smelt / fourhorn sculpin / ninespine stickleback / saffron cod / distribution / age and growth / movements / spawning and reproduction

Fechhelm, R.G., P.C. Craig, J.S. Baker, and B.J. Gallaway. 1984. Fish distribution and use of nearshore waters in the northeastern Chukchi Sea. RU-635. Pages 121-297 *in* Outer continental shelf environmental assessment program. Final reports of principal investigators. Vol. 32. 1985. USDC: NOAA, NOS; USDI: MMS.

This paper reports the results of field studies conducted during 1983 to assess fish community structure along the northeast Chukchi Sea and to provide an initial assessment of fishery vulnerability to potential petroleum development in the northeast Chukchi Sea. Under-ice fyke netting and gill netting surveys were conducted March 15-28, 1983 at Peard Bay, Ledyard Bay, and Wainwright Inlet. Gillnets and otter trawls were used to sample nearshore and offshore waters at Point Lay, Ledyard Bay, and Wainwright Inlet during the period from August 27 to September 12, 1983. Intensive fyke net and opportunistic gillnet sampling was conducted in the vicinity of Point Lay during July and August 1983. Water quality measurements were made at each of the sampling sites. Winter fyke netting captured 204 arctic cod and one sculpin at the four sampling locations. Fyke and gill netting during the summer at Point Lay captured 17 species of fish totaling 14,437 individuals - 13,345 by fyke net and 1,092 by gillnet. Marine species accounted for nearly 99% of the fyke net catch with the dominant species being arctic cod (39%), capelin (25%), fourhorn sculpin (20%) and arctic flounder (13%). The most abundant species taken by gillnet were Pacific herring (48%), fourhorn sculpin (18%), boreal smelt (rainbow smelt) (17%), and arctic flounder (9%). Only 3 arctic char, 2 least cisco, 2 Bering cisco, 1 chum salmon, and 34 pink salmon were caught in the Point Lay nets, a virtual absence of anadromous fish when compared with results of Beaufort Sea fisheries surveys. Species accounts are presented for species that formed the major component of the Point Lay catch and included in most instances, data on abundance, distribution, length, stomach contents, and reproductive status. Length alone was reported for those species making minor contributions to the Point Lay catch. A general discussion of potential impacts of oil and gas development and the vulnerability of fish to such development is presented for those fish species that are important to regional subsistence fisheries or that constitute important trophic links in the food web of the region.

KEYWORDS: Chukchi Sea / NPR-A / Point Lay / Kasegaluk Lagoon / Peard Bay / Ledyard Bay / arctic cod / capelin / fourhorn sculpin / arctic flounder / saffron cod / Pacific herring / boreal smelt / pink salmon / arctic char / least cisco / Bering cisco / chum salmon / distribution / food habits / age and growth / spawning and reproduction / potential impacts.

Fechhelm, R.G., W.H. Neill, and B.J. Gallaway. 1983. Temperature preference of juvenile arctic cisco *(Coregonus autumnalis)* from the Alaskan Beaufort Sea. Biol. Pap. Univ. Alaska No. 21:24-38.

This paper presents findings of a laboratory experiment designed to establish the preferred temperature range of juvenile arctic cisco taken from the Beaufort Sea during July and August 1981.

Groups of 20-25 fish ranging in size from 83 to 136 mm were held in filtered aquaria under 24 hour overhead lighting. They were acclimated to temperatures of 5^{0}, 10^{0}, and 15^{0} C at 5, 15, and 30 ppt salinities. Their behavior was observed at various experimental temperatures to determine preferred temperatures as indicated by schooling and feeding behavior.

Temperature preferences varied from 11.5^{0} to 15.4^{0} C depending on temperature acclimation and salinity. Fish acclimated to higher temperatures preferred higher temperatures. Preferred temperatures were higher than those normally found in the Beaufort Sea where nearshore waters reach a seasonal maximum of $10\text{-}12^{0}$ C, and average temperatures range from 0 to 8^{0} C.

Arctic cisco are thus biased toward the warmest waters locally available. These warm areas are usually the areas of highest productivity and would thus provide for maximum growth and optimal use of their habitat.

KEYWORDS: temperature preference / arctic cisco / Beaufort Sea / salinity / behavior.

Furniss, R.A. 1974. Inventory and cataloging of arctic area waters. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 15. Project F-9-6, Job G-I-I. Juneau. 45 pp.

This report presents the results of field studies conducted on the North Slope of the Brooks Range during 1973. Physical and biological surveys were conducted on four mountain lakes (Chandler, Shainin, Itkillik and Elusive). Subsistence fisheries at the mouth of the Colville River and Barter Island were monitored. Aerial counts of arctic char were conducted on the Sagavanirktok River and arctic char were sampled in Sagavanirktok River tributaries to recapture previously tagged fish.

Chandler Lake was found to contain lake trout, arctic char, arctic grayling, round whitefish and slimy sculpin. Burbot are mentioned as occurring there but were not captured. Food, length, weight, age, and maturity data are given for arctic char, lake trout, arctic grayling, and whitefish. Lake trout to 927 mm and arctic char to 590 mm were captured. Mean gill raker and pyloric caeca counts from arctic char averaged 27 and 45.3, respectively.

Lake trout, round whitefish, arctic grayling, and sculpins were captured in Shainin Lake. Lake trout ranged to 758 mm in fork length and arctic grayling to 394 mm. Age, length, weight, maturity, and food habit data are given for all fish captured.

Arctic grayling, round whitefish, lake trout and sculpin were captured in Itkillik Lake. Burbot and arctic char had been reported, but were not captured. Lake trout to 77 mm and arctic grayling to 380 mm were captured.

Elusive Lake was found to contain lake trout, round whitefish, least cisco, arctic grayling, and ninespine stickleback. This lake was the only one to contain least cisco. Age, length, weight, maturity and food habits are presented for fish sampled. Lake trout to 867 mm and arctic grayling to 357 mm were represented in samples. Approximately 1,000 broad whitefish were observed at Nuiqsut and characteristics of Barter Island subsistence fisheries are discussed.

Aerial surveys were flown to count arctic char in the Sagavanirktok River system. Counts of 5,068-6,195 spawners and 8,996-9,478 nonspawners were obtained for the system.

Two hundred fifty five of 5,109 arctic char sampled in the Sagavanirktok River were found to have been previously tagged.

KEYWORDS: North Slope / Shainin Lake / Chandler Lake / Itkillik Lake / Elusive Lake / lake trout / arctic char / arctic grayling / round whitefish / least cisco / age / length / weight / food habits / distribution / maturity / aerial survey / Sagavanirktok River / Nuiqsut / Barter Island / Kaktovik / Subsistence.

Furniss, R.A. 1975. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 16. Project F-9-7, Job G-I-I. Juneau. 47 pp.

This report is divided into two parts. Part A, 30 pages, discusses the results of arctic char tagging and life history studies in the Sagavanirktok River drainage, a survey of the Kongakut River, subsistence fisheries, and pipeline monitoring. Part B discusses the results of fisheries studies in Prudhoe Bay. Field work was done in 1974.

Aerial counts of arctic char in the Sagavanirktok River were similar to those from the previous three years. Handling and tagging mortality of arctic char was checked by holding 15 arctic char, of which 1 died. It was estimated that handling mortality would thus be between 5 and 10 percent. Opercular bones were removed from 15 additional arctic char and these fish were held to assess mortality. Mortality was 40%.

Arctic char were found to be highly specific in reproductive homing. Of 255 arctic char tagged on spawning grounds in spawning condition, all were recaptured in the same stream as tagged. Only one fish, which was captured in a spent condition, was in a stream other than where it had been tagged as a spawner. The overall sex composition of spawning arctic char was found to be 1 male to 2.2 females. Of arctic char tagged and recaptured as spawners, only 5% were consecutive spawners and 95% were nonconsecutive. The nonspawning aggregation of arctic char on the Ivishak River was composed of fish from all drainages of the Sagavanirktok River system. Inter-system exchange of arctic char occurs infrequently. The 7, 8, and 9 yr classes were missing from North Slope arctic char populations and it is postulated that weather conditions were a likely cause. Six possible overwintering sites were investigated. Physical conditions at these locations are given.

Age and length data are presented for arctic grayling captured in the Ivishak and Lupine rivers.

The Kongakut River was surveyed in late August and found to contain large numbers of arctic grayling and many spawning arctic char. Arctic char were observed spawning in deep holes located in non-spring areas, the first observation of this find for the North Slope.

Three traditional winter subsistence fishing locations were investigated in the Hulahula River. Arctic char and arctic grayling were captured. Monitoring of oil development and related construction is briefly discussed.

Fish sampling and tagging was done at eight netting stations in Prudhoe Bay (Part B of report) during July 25-30 and August 10-13, 1974. A total of 897 fish comprising 8 species was netted. Least cisco was the most abundant species, arctic char was the second most abundant. Catch per hour of fishing was greater at inshore nets. Least cisco, arctic char, fourhorn sculpin, arctic flounder, broad whitefish, and humpback whitefish were caught predominately at inshore locations. Arctic grayling were caught only near the mouth of the Sagavanirktok River, where salinity was low. Length, weight, and sex for all autopsied fish are presented.

Arctic cisco were captured more frequently at offshore sites. The net site at the proposed dock was the only inshore net to catch a large number of arctic cisco. A total of 302 fish was tagged and released alive but none were recaptured during the study. Movement data were obtained from the direction fish were moving when captured. Amphipods, isopods, mysids, and insects were found to be the major food items in fish stomach samples.

Prudhoe Bay was found to be a feeding area and migratory path for arctic char, least cisco, arctic cisco, broad whitefish, and humpback whitefish. Fourhorn sculpin and arctic flounder were resident to the area.

The then proposed dock site at the west end of Prudhoe Bay would be located at the most productive sampling location. It is stated that the dock would disrupt this important feeding and migration area.

KEYWORDS: Sagavanirktok River / Ivishak River / arctic char / movements / handling mortality / spawning / overwintering / age / length / arctic grayling / sex composition / Kongakut River / survey / Hulahula River / winter subsistence fishing / least cisco / arctic cisco / broad whitefish / arctic flounder / humpback whitefish / Prudhoe Bay / Beaufort Sea / Arctic National Wildlife Range.

Furniss, R.A., and D.L. Ward. 1976. Comparison of water availability for use in construction of proposed gas pipelines on the Alaskan North Slope. Prepared by Alaska Biological Consultants. 70 pp.

This report assesses North Slope water availability along two proposed gas pipeline routes from Prudhoe Bay. The Elpaso Route parallels the oil pipeline along the Sagavanirktok River through Atigun Pass and then continues south. The Arctic Gas Route proceeds east from Prudhoe Bay across the Arctic Coastal Plain to the Mackenzie River. This report considers potential winter water sources as a limiting factor.

Alluvial groundwater wells in the Sagavanirktok River have proven to be unreliable winter water sources. Alluvial gravels under large lakes may have some development potential. Of 8 springs within 26 km of the Arctic Gas Route, only Okerokovik and Kataktuvuk springs are not important for fish and would be available for year round water supply.

Flowing surface water could provide a seasonal supply, but all except the largest rivers freeze solid during winter, with smaller tundra streams ceasing flow earlier than larger mountain streams. The Arctic Gas alignment crosses about 120 streams, 19 of which are mountain streams. The Canning River was frozen at the pipeline crossing on November 5, 1973. Lakes with a dimension greater than 610 m were considered of minimum size to be underlain by "talik" (unfrozen alluvium). Lakes of that size would not freeze to the bottom and would be at least 1.83 m deep. Along the Elpaso alignment there are enough lakes to provide large quantities of water throughout the winter. Along the Arctic Gas Route large quantities of water are available through mid-December between km 0 and km 97. From km 97 to km 314 (to the Alaska/Canada border) few standing water sources exist in reasonable proximity to the alignment. Only 8 small lakes, none greater than 610 m in one dimension, occur within 8 km of the route between km 113 and km 209 and km 225 and km 290. In addition, only a single 7.3 ha lake exists between km 290 and km 306.

Because most water on the North Slope is frozen in winter, the little remaining free water is critical to the survival of aquatic biota. Unfrozen water in large rivers is important for fish overwintering and perennial springs are important spawning, rearing and overwintering areas for arctic char. Most foothill lakes in the Sagavanirktok River drainage and in ANWR support lake trout and arctic grayling populations with some populations of arctic char, round whitefish, and burbot.

Site specific consideration of each water source will be necessary to ensure minimal impact on biological systems. The Arctic Gas Route appears to be deficient in accessible water sources capable of meeting estimated water requirements for road and work pad construction.

KEYWORDS: Water availability / water requirements / Arctic Gas Pipeline / Elpaso Gas Pipeline / Arctic Coastal Plain / lakes / springs / rivers.

Gallaway, B.J., W.J. Gazey, and L. Moulton. In prep. Population trends for arctic cisco *(Coregonus autumnalis)* in the Colville River of Alaska as reflected by the commercial fishery. Biol. Pap. Univ. Alaska. Sept. 1987 draft. 34 pp.

This paper discusses the Helmericks' Colville River arctic cisco commercial fishery, describes and applies the Deriso model as parameterized by Gallaway et al. (1983) based upon catch per unit effort (CPUE) data from that fishery to estimate catches for 1982-1985, and discusses the Mackenzie River stock origin theory. It also evaluates whether existing fisheries causeways have had observable effects on population levels of arctic cisco.

The population model, adjusted to relate to CPUE instead of biomass, was adjusted until a good fit to known CPUE from the commercial fishery was achieved. It was then used to project CPUE the year 2004. The projection indicates declining catch rates until 1991 or 1992, then high catch rates until 1997 (when they will be at approximately 1987 levels), then very low catch rates until 2001. [Low numbers of catchable size arctic cisco are expected in the Colville River in upcoming years because there was little influx of age 0 fish from 1980-1984.]

The theory that the Mackenzie River is the source of arctic cisco in northern Alaska is examined. Genetic work conducted on fish from Mackenzie River spawning streams indicates that spawning stocks are separate in each spawning stream, whereas arctic cisco samples from the Colville River indicate that mixed stocks are present, supporting the theory of Mackenzie River origin. The effects of causeways on age 0, intermediate age, and spawning (age 7+) arctic cisco are discussed. It is concluded that effects on age 0 are negligible because large numbers of 1985 year class arctic cisco circumvented the causeways. Causeways do not appear to be insurmountable barriers to the easternward movement of spawners. This is supported by eight tag recoveries in Phillips Bay, Canada, of fish tagged in Prudhoe Bay. Effects on intermediate size fish are less directly addressed. There is concern that summer habitat is affected by causeway development in Prudhoe Bay, and that fish distribution is impacted, but it is hypothesized that these impacts have little if any impact on "population health." If significant impacts are found in the future they should be viewed in relation to the proportion of the stock subjected to the impact.

KEYWORDS: Deriso population model / arctic cisco / Prudhoe Bay / Beaufort Sea / Colville River / Mackenzie stocks / commercial fishery / development impacts.

Gallaway, B.J., W.B. Griffiths, P.C. Craig, W.J. Gazey, and J.W. Helmericks. 1983. An assessment of the Colville River Delta stock of arctic cisco - migrants from Canada? Biol. Pap. Univ. Alaska No. 21:4-23.

This paper presents an analysis of the Colville River arctic cisco population based on historic catches in the local commercial fishery over a 15 yr period as interpreted by the Deriso model of population dynamics. An observed decline in catch and CPUE was noted in 1978 and 1979. Given a 5 to 7 yr lag in recruitment to this fishery, it was hypothesized that the decline might be attributed to one or more of the following: a) the resettlement of the village of Nuiqsut and hence an increase in local take of fish; b) the construction of the causeway just west of Prudhoe Bay in 1975; and c) other environmental factors. The model was fitted to existing data that reflected similar population trends to those indicated by catches in the Colville Delta for most years. The Deriso Model did not account for an increase in catch found in 1977. The model showed a strong density dependent stock recruitment relationship given a five year lag between spawning and recruitment, but the authors ignored this relationship and used environmental factors to explain the apparent decline in fish populations. In 1974 and 1975, pack ice remained along the mainland coast throughout the summer. Fishing mortality was estimated to be 0.15 and deemed not significant. The authors stated that it is unlikely that the causeway near Prudhoe Bay has contributed to oscillations in population levels as indicated by catch because the incidence of tag recovery from fish marked on different sides of the causeway showed no significant differences.

The authors theorize that a Colville River arctic cisco stock is actually a product of the Mackenzie River; they present a schematic representation of life history to support their theory. The only direct evidence given for this is the recovery of a single fish in the Mackenzie River which was tagged in Prudhoe Bay. Other corroborating evidence is westward transport along the arctic coast by ocean currents, the age structure of Colville River ciscoes and the lack of evidence of arctic cisco spawning in the Colville River.

If this theory is a true representation of the situation on the Beaufort Sea coast, then the application of the model used to describe the population in the earlier part of this paper would need to be vastly modified to include Mackenzie River stocks to describe fluctuations in the Colville River fishery.

KEYWORDS: modeling / arctic cisco / Colville River / commercial fishery / population dynamics / life history / Mackenzie River / stock assessment.

Gavin, A. 1974. Wildlife of the North Slope, a five year study, 1969-1973. Atlantic Richfield Co. 61 pp.

This report describes the results of general field studies conducted from the Colville River east to the Alaska-Canada border, and from the Beaufort Sea to the Brooks Range. The objectives of the studies were to evaluate the effects of oil field development on caribou, waterfowl, other wildlife, and the general environment, to inventory fish and wildlife populations, and to conduct baseline investigations of offshore islands. Observations were conducted April through November for the years 1969-1973. Information presented [generally presented in a non-technical manner for general audiences] included landform, permafrost, weather, and vegetation descriptions, caribou distribution and movements, nesting and brood-rearing of waterfowl and other birds, and observations of other wildlife including furbearers, bears, and moose. Limited data were presented for fish. Emphasis was placed on the Sagavanirktok River drainage and its populations of arctic char. General observations of movements of arctic char to spawning areas and general life history information were presented. The presence of arctic grayling and whitefish in the Sagavanirktok River, arctic char and arctic grayling in the Canning River, arctic grayling in the Kuparuk River, and broad and humpback whitefish, least cisco, arctic char, arctic grayling, burbot, longnose sucker, fourhorn sculpin, and rainbow smelt in the Colville River, were also noted.

KEYWORDS: North Slope / Sagavanirktok River / Colville River / coastal plain / arctic char / arctic grayling / distribution / movements / spawning and reproduction / least cisco / broad whitefish / humpback whitefish / burbot / longnose sucker / fourhorn sculpin / rainbow smelt / waterfowl / caribou / wildlife.

George, J.C., and B.P. Nageak. 1986. Observations on the Colville River subsistence fishery at Nuiqsut, Alaska, 4 July - 1 November 1984. Dept. Wildl. Manage., North Slope Borough, Barrow, Alaska. 35 pp.

Fishing is an important activity for the people of Nuiqsut. The summer fishery takes place from early June through mid-September during the open water period. It was estimated that over 20 families participated in the summer fishery, but only 6 or 8 were heavily involved. The most extensively used areas were near Tiragruak (approx. 3.2 km above the Itkillik River mouth) and the Nechelik channel of the Colville River delta. Broad whitefish are targeted in this fishery, but lake trout, northern pike, humpback whitefish, arctic char, and probably a few pink and chum salmon are also taken. It was estimated that approximately 1,000 broad whitefish were taken in the summer of 1984.

The fall fishery begins when ice cover is safe for travel. CPUE in the fall fishery averaged 15-32 fish/net day as opposed to 2-5 fish/net day in the summer fishery. The entire delta area is fished. Arctic cisco are targeted in this fishery but about half the harvest consists of least cisco. Fishers reported that the northern parts of the delta channels provided the best fishing. CPUE on the Kupigruak channel averaged 55.7 ciscoes (least and arctic) between 23 and 28 October. It was suggested that approximately 10,867 arctic cisco were harvested on the Kupigruak channel, and it is guessed that a minimum of 1,000 arctic cisco were harvested in the Nechelik Channel. People fished with 75 mm and 90 mm stretch nets of 12 to 18 m in length by 2.5 m deep. Parasitic copepods (Coregonicola) were observed on several least and one arctic cisco.

KEYWORDS: Subsistence fishery / Nuiqsut / Colville River / arctic cisco / least cisco.

George, J.C., and R. Kovalsky. 1986. Observations on the Kupigruak Channel (Colville River) subsistence fishery, October 1985. Dept. Wildl. Manage., North Slope Borough, Barrow, Alaska. 60 pp.

This report discusses the Colville River subsistence fishery in the Kupigruak Channel during October 1985. Test netting was conducted with 60, 75, and 90 mm stretch mesh nets at 2 stations in the lower reaches of Kupigruak channel. There were 4,992 fish captured at 2 stations; least cisco and arctic cisco accounted for 93% of this catch. There was an inverse relationship between arctic and least cisco catch rates for 75 and 90 mm meshes. The catch of arctic cisco was 1.9 times that of least cisco in 75 mm nets and 5.3 times higher in 90 mm nets. It is suggested that catch rates are higher in water depths less than 5 m. CPUE was higher in 1985 than in 1984. The mean sizes of arctic cisco captured in 60, 75, and 90 mm nets were 304 mm, 330 mm and 355 mm, respectively. For least cisco in the same nets, mean sizes were 289 mm, 323 mm, and 336 mm. Nets set closest to shore had higher catch rates than those placed offshore. Optimal mesh size was considered to be between 75 mm and 90 mm for this fishery.

Nets with stretch meshes of 20 mm, 40 mm, and 55 mm were used to collect rainbow smelt. Only the 40 mm net caught smelt, a fish considered a delicacy among Nuiqsut residents.

Thirteen arctic cisco were examined for parasites; 11 were uninfected. The other two contained acanthocephalans, adult and larval trematodes, and larval nematodes.

KEYWORDS: Nuiqsut / Colville River / arctic cisco / subsistence fishery.

Glova, G., and P.J. McCart. 1974. Life history of arctic char (*Salvelinus alpinus*) in the Firth River, Yukon Territory. Chap. 3 *in* P.J. McCart, ed. Life histories of anadromous and freshwater fish in the western Arctic. Arctic Gas Biol. Rept. Ser. Vol. 20. 50 pp.

This report presents the results of field research conducted in 1972 and 1973 to document the life history of arctic char in the Firth River which drains into the Beaufort Sea on the north coast of the Yukon Territory. In general, the movements and life history of arctic char from this area are similar to those described for arctic char populations in northern Alaska streams. The fish are the western form of the arctic char or the northern form of the Dolly Varden, the same as anadromous arctic char of northern Alaska. Large sea run fish make up the majority of the population; however, stream resident dwarf males (residuals) also occur. The life history of anadromous arctic char involves several migrations between fresh and salt water. Spawning takes place in late summer and fall in the vicinity of groundwater sources. Young arctic char emerge from the gravel in late May and remain in streams for a varying number of years before smolting and moving to sea in the spring of the year. Seaward migrants feed heavily in the Beaufort Sea before returning to streams in late summer and early fall to overwinter. This pattern is repeated for several years before they mature to spawn for the first time. An individual fish may survive to spawn several times, but not necessarily in consecutive years.

Premigrant and residual arctic char grew slower than migrants attaining a mean length of 317 mm by age 9. Migrants at age 9 averaged 541 mm. In rearing habitats, juvenile arctic char densities as high as 3.1 fish per m^2 were found. In the upper Firth River, most migrant arctic char left to move seaward between June 10 and June 15, 1972, water temperatures were 5^{o} C at this time. Data suggested that larger arctic char migrated earlier than smaller fish. Prespawning arctic char were captured in the upper Firth River on July 24, 1972, indicating that some spawners either do not migrate to sea during the year of spawning, or do so for a very short time. The full inmigration of overwintering fish occurred from the end of August through September 21, 1972. The early part of this movement consisted mostly of mature spawners.

Data from tag returns indicated that some Firth River arctic char overwinter in other river systems during nonspawning years. One tag each was returned from the Canning and Kongakut rivers.

The mean fecundity of arctic char averaging 530 mm was 4955 eggs. The youngest female spawners were 4 years of age with 4.2% mature. All arctic char were mature by 11 years. Spawning began in mid-August and continued through early October. It was assumed that older fish had probably spawned more than once. Three known and one probable spawning locations were found.

KEYWORDS: Arctic char / Firth River / Beaufort Sea / life history / age and growth / fecundity / spawning / migrations.

Griffiths, W.B., P.C. Craig, G.L. Walder, and G.J. Mann. 1975. Fisheries investigations in a coastal region of the Beaufort Sea (Nunaluk Lagoon, Yukon Territory) Chap. 2 *in* P.C. Craig, ed. Fisheries investigations in a coastal region of the Beaufort Sea. Arctic Gas Biol. Rept. Ser. Vol. 34. 219 pp.

This report presents the results of field work conducted in 1974 in and around Nunaluk Lagoon, a Beaufort Sea coastal lagoon off the mouths of the Firth and Malcolm rivers just west of Herschel Island in Canada's Yukon Territory.

In early April the lagoon was frozen to the bottom at all locations. River deltas and nearshore areas were the first to breakup and by June 19 only the western portion of the lagoon was ice covered and sea ice was inundated by river water. Sea ice breakup progressed from east to west and ice moved offshore by the first week of August. Freeze up occurred in late September and on October 10, 30 cm of ice covered the lagoon. Data are presented on the physical and chemical characteristics of the lagoon and seaward sides of the spit during the open water season. Invertebrate samples were taken in the lagoon, in seaward sites, and in tundra ponds. Tundra ponds had the highest concentrations of benthic and epibenthic invertebrates.

Fish were sampled with gillnets and seines in ocean, lagoon, and river delta sites. The greatest number of fish were taken inside the lagoon (n = 1206); only 234 fish were caught outside the lagoon and only 29 in the river deltas. Arctic cisco, arctic char, and fourhorn sculpin were the most abundant species. Least cisco, arctic flounder, arctic grayling, sheefish and ninespine stickleback were also captured. In gillnet surveys, 51 mm and 63 mm stretch meshes caught the majority (64%) of fish and 38 mm and 89 mm meshes took 15.1% and 12%, respectively.

Arctic char were abundant until early August when their numbers declined. Large mature arctic char comprised most of the catch through the end of July and small immature and arctic char comprised most of late season catches. Arctic char were generally equally abundant at both lagoon and seaward locations and abundance was independent of light intensity (day vs night).

After mid-July, arctic cisco dominated lagoon catches. Large numbers were still present at freeze-up and it is suggested that they do not migrate to overwintering areas until after ice formation. It is further suggested that they overwinter in the Mackenzie River drainage. Arctic cisco catches were similar on both the lagoon and seaward sides until early August when they were more abundant in the lagoon. Arctic cisco catches were consistently higher during nights than during days. Fourhorn sculpin were not abundant until September when one third of the entire catch was taken in the last gillnet set. They were equally abundant on both sides of the spit until September when catches increased in the lagoon. Their abundance was not dependent on time of day.

Life history reviews are presented for arctic char, arctic cisco, and fourhorn sculpin.

There is some interdrainage exchange of nonspawning arctic char, but reproductive homings were thought to be high. Most arctic char caught were from 340 mm to 520 mm. This length frequency is similar to that observed for arctic char captured along the Alaska Beaufort Sea coast. No arctic char over 576 mm were captured, but spawners to 730 mm had been reported from Firth River spawning areas in

1973. Length frequency and age data are presented. The youngest arctic char captured in the lagoon was age 2 indicating that some smolt by that age. Females outnumbered males in Nunaluk catches where they comprised 59.5% of the sample. Arctic char were opportunistic feeders consuming a wide variety of organisms.

Arctic cisco from the study area were aged between 1 and 17 years using otoliths. Females tended to be larger than males. Most were mature between age 7 and age 9. Although most of the arctic cisco captured were considered mature, they were not going to spawn during the year of capture. Copepods and amphipods were the predominate food items of arctic cisco.

Fourhorn sculpin ranged from age 1 to age 14. Females tended to be larger than males and reacted older ages and larger sizes (age 14, 329 mm for females vs age 12, 264 mm for males). It is suggested that both males and females spawn annually in the late fall. Benthic isopods and amphipods made up the majority of the fourhorn sculpins diet.

Brief life history information is also given for least cisco and arctic flounder.

KEYWORDS: Beaufort Sea / Nunaluk Lagoon / Firth River / Malcolm River / Yukon coast / water chemistry / arctic char / arctic cisco / fourhorn sculpin / least cisco / arctic flounder / life history / age and growth / food habits.

Griffiths, W.B., D.R. Schmidt, R.G. Fechhelm, and B.J. Gallaway. 1983. Fish ecology. Vol. 3 *in* B.J.Gallaway and R.P.Britch, eds. Environmental summer studies (1982) for the Endicott development. Prepared by LGL Alaska Research Associates, Inc. and Northern Technical Services for Sohio Alaska Petroleum Co. 323 pp.

This report presents the results of fisheries field investigations conducted in 1982 in nearshore areas in eastern Prudhoe Bay, in two channels of the Sagavanirktok River delta and along the delta front in the Beaufort Sea. Six fyke net stations were established and fished from 7 July through 11 September. In addition, six gillnet stations were established off the Sagavanirktok River delta, three in water less than 1.8 m deep and three deeper than 1.8 m to compare abundance of anadromous fish in deep and shallow water. They were fished daily from 20 July to 10 September.

Shallow gillnets captured approximately twice as many fish as deep water gillnets. The frequency at which species appeared in catches was more even in shallow water sets than in deep sets. However, one deep set captured more arctic cisco than any of the other nets. Arctic cisco were abundant in nearshore areas; 38,413 were captured at four fyke net stations across the delta front and 698 were taken in gillnets. Only 14 arctic cisco were captured in river channels. Large arctic cisco were absent from catches after September 1. They were more abundant on the west side of the delta than the east, but were equally abundant between the nearshore and offshore traps. Daily growth of small arctic cisco was estimated at 0.52 mm/day and it is suggested that some growth occurs over the winter. Movement patterns of arctic cisco were unclear. A positive relationship was found between CPUE and temperature.

Catches of large and small broad whitefish were variable until September 1, after which very few were caught. A total of 6,687 small and 716 large broad whitefish was captured in delta fyke nets, 210 were taken in gillnets, and only 31 were caught in the river traps. Large broad whitefish were abundant in front of the delta until September and appeared to move into river channels in small groups starting in August. Three length cohorts corresponding to age classes 1, 2, and 3 were found in fish to 250 mm in length. Daily growth rates for the three groups were 0.83, 0.73, and 0.78 mm/day. It is suggested that small broad whitefish disperse throughout the delta front, then move west in September, but not as far as the Waterflood Causeway. Large broad whitefish CPUE was positively correlated with temperature, and small ones were negatively correlated at two net locations, although it is suggested that they prefer warm brackish waters.

Arctic char were more abundant on the east side than the west side of the Sagavanirktok River delta. Two size groups were found, under and over 250 mm, but they were less apparent near the end of the season. It was found that large arctic char spend little time in the study area and that small arctic char do not remain there for extended periods. Large least cisco (> 250 mm) were more abundant than small least cisco. It is suggested that these fish move into the area of the Sagavanirktok River delta from the west in July, then leave the delta area to the west after mid-August. [There was no recapture effort east of the Sagavanirktok River, so it is not known if movements in that direction occur.] Abundance of large least cisco was positively correlated with temperature.

Of 519 arctic grayling captured, 73.4% were taken in river fyke nets; the remainder were captured in delta nets. No abundance pattern was discernable for

delta fish, but in the river, arctic grayling were more abundant in the early part of the season. From 14 recaptures, it is suggested that arctic grayling are resident within areas of the river.

No seasonal abundance trends were noted for round whitefish. Only fish smaller than 250 mm were taken in the delta, and large and small fish were taken at river sites. No inferences about movement patterns are presented.

A total of 36,747 arctic cod was captured. Their abundance peaked in mid-August and late August to early September. Abundance was highest on the east side of the delta. Arctic cod grew approximately 1 mm/day. It is suggested that arctic cod movements are related to marine intrusion events.

Fourhorn sculpin were most common in nearshore waters where 36,566 were captured. Humpback whitefish, ninespine stickleback, saffron cod, prickleback, and Pacific herring were also taken in the course of this study.

KEYWORDS: Sagavanirktok River Delta / Beaufort Sea / fish distribution / growth / abundance / movements.

Hablett, T.R. 1979. Fish inventories conducted within the National Petroleum Reserve on the North Slope of Alaska, 1977-78. Pages 337-406 *in* P.C. Lent, ed. Studies of selected wildlife and fish and their use of habitats on and adjacent to the National Petroleum Reserve in Alaska 1977-1978. National Petroleum Reserve in Alaska 105(c) Land Use Study. Work Group 3, Field Study 3. Vol. 2. Chap. 10. USDI. Anchorage, Alaska.

This paper reports the results of fisheries field studies conducted in the National Petroleum Reserve in Alaska (NPR-A) by the US Fish and Wildlife Service and the Alaska Department of Fish and Game. Field work was conducted during the open water seasons (June-September) of 1977 and 1978, and during the intervening winter, October 1977 and March-April 1978. The objectives of the study were to determine fish species composition, relative abundance, timing and patterns of migration, examine age-growth relationships and other aspects of life history, and to identify critical habitat including spawning and overwintering areas. Surveys of both lakes and streams within NPR-A were conducted, with a major emphasis placed on the Colville River drainage. Two hundred twenty sites were sampled, of which 88 were lakes and 132 were streams. Thirty-five sites (primarily lakes) yielded no fish. Species found during the surveys were arctic and least cisco, broad, humpback, and round whitefish, pink, chum, and chinook salmon, arctic char, arctic grayling, lake trout, rainbow smelt, ninespine stickleback, slimy and fourhorn sculpin, Alaska blackfish, northern pike, longnose sucker, burbot, and arctic flounder. Arctic char, which were found in the Colville River drainage, were not captured outside of that system, except for one small specimen captured in the Kokolik River. Data presented for the majority of these species included distribution and movements, age and growth information, food habits, and sexual maturity and spawning information. Sampling at overwintering sites in the Colville River recorded arctic grayling, round and broad whitefish, longnose sucker, burbot, slimy sculpin, and ninespine stickleback. Physical parameters for these sites are presented. Potential overwintering habitat is abundant in the Colville River between the mouths of the Itkillik and Killik rivers, and becomes less abundant within the Colville River as one proceeds upstream. The Colville River above the mouth of the Etivluk River has a limited amount of overwintering habitat available. The Ipnavik, Kuna, and Kiligwa rivers, tributaries to the Colville River upstream of the mouth of the Etivluk River, also appear to have poor or unsuitable overwintering habitat. Lakes surveyed were classified by water depth, presence of inlets or outlets, and substrate composition. Lakes greater than 2 m deep and having suitable spawning substrates appeared to support the larger and most diverse populations of fish. Shallow lakes (less than 2 m deep) with spawning substrates that had an outlet or an inlet usually contained several species of fish, indicating these lakes are used by fish provided escapement is possible prior to freeze-up. Species diversity is low in the lakes, with many lakes containing only one or two species of fish. Older fish predominated in net catches at most of the lake sites. [Rev. note: Netsch et al. 1977 provides preliminary data and data sheets for this study. See Bendock (1979) for additional information on the fish of the Colville River drainage.]

KEYWORDS: NPR-A / Colville River drainage / arctic cisco / least cisco / broad whitefish / humpback whitefish / round whitefish / pink salmon / chum salmon / arctic char / arctic grayling / lake trout / northern pike / burbot ninespine stickleback / longnose sucker / slimy sculpin / age and growth / distribution / food habits / movements / overwintering / spawning and reproduction

Heckart, L. 1965. Inventory and cataloging of sport fish and sport fish waters in the interior of Alaska. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 6. Project F-5-R-6, Job 15-A. Juneau. 15 pp.

A small section of this field study refers to a single survey trip to Brooks Range lakes taken during the summer of 1964 with the aide of military aircraft and personnel. North Slope waters surveyed included Fish Lake, Chandler Lake, Little Chandler Lake, Round Lake, Shainin Lake, and Nanushuk Lake.

Fish sampled with hook and line included lake trout ranging from 0.9 to 8.2 kg, arctic char ranging from 0.7 to 2.7 kg and arctic grayling from 355 to 405 mm. Shainin Lake was the only lake in which char were not captured. Round whitefish were observed in all surveyed lakes.

KEYWORDS: Lake trout / arctic char / grayling / distribution / age and growth

Hoffman, D., D. Libby, and G. Spearman. 1988. Land use values through time in the Nuiqsut area. North Slope Borough and the Anthropology and Historic Preservation Section, Cooperative Park Studies Unit, Univ. Alaska, Fairbanks. 89 pp + append.

This publication is a revision of a report originally published in 1978. In 1977 field research and interviews were conducted in Nuiqsut to collect ethnohistorical and archeological information.

A general description of the seasonal harvest in Nuiqsut is presented. Three general types of fishing take place during different times of the year. These include open water net fishing during summer, under ice net fishing in the fall, and hook and line jigging through the ice (niksik) throughout the fall, winter, and spring. The Colville River is the major fishing water for Nuiqsut residents. Fishing with gill nets begins in mid-to-late June after the ice goes out on the Colville River. Most of the nets are set in the Negelik Channel after the spring flooding has subsided and the water has cleared. Broad whitefish is the major species harvested. Broad whitefish are also caught by gill net in Fish Creek during July. In August arctic char and pink salmon begin running up the Colville River and are caught in gill nets. October-November is an important fishing period for arctic and least cisco on the Colville River delta. Fishing for these species is done with nets set through the ice. Jigging for arctic grayling and burbot also takes place at this time.

The location, use, historical information, and features of traditional land use sites are described. These sites range from the prehistoric period to the mid-twentieth century and include a quarry, a battleground, a place of mythological significance, and a caribou gathering and butchering site, as well as numerous hunting, fishing, trapping, and residential localities used by native peoples.

KEYWORDS: Colville River/ arctic grayling/ burbot/ broad whitefish/ least cisco/ arctic cisco/ arctic char/ pink salmon/ archeology.

Johnson, L., and B.L. Burns, editors. 1984. Biology of the arctic char. Proceedings of the international symposium on arctic char, Winnipeg, Manitoba, May 1981. Univ. of Manitoba Press, Winnipeg. 584 pp.

This volume is a compilation of papers presented at the first international char symposium held in Winnipeg, Manitoba in 1981. Authors describe char research conducted in Austria, Great Britain, Iceland, Japan, Norway, Sweden, Switzerland, the United States of America, West Germany, and Canada.

Topics of papers include, taxonomy, systematic organization, parasites, life history, movements, stock identification, reproductive strategies, physiology, genetics, management, historic use and human/char interactions.

There is no work presented in this volume which resulted from studies conducted in northern Alaska; however, because of the circumpolar distribution of this and related species, much of this volume is relevant to Alaska fish populations.

KEYWORDS: arctic char / Dolly Varden / systematics / genetics / life history / movements / stock identification / reproduction / physiology / management / biology

Jones, M.L. 1976. Water availability along the proposed Arctic Gas Pipeline route from Prudhoe Bay, Alaska to the Mackenzie Delta, Northwest Territories. Aquatic Environments Limited. Arctic Gas Biol. Rept. Ser. 101 pp.

This study identifies potential water sources along the proposed pipeline route from Prudhoe Bay to the Mackenzie Delta. It reports data collected in field surveys and extracted from pertinent literature.

Depth, surface area, estimated volume and freewater volume with ice thicknesses of 0.73 m and 1.5 m are provided for 51 lakes along the pipeline route. Mean depth, mean velocity and discharge values are provided for 18 spring water sources. Ice thickness, water depth, conductivity, turbidity, and discharge measurments are given for 28 rivers or river sections along the pipeline route. Fish distribution is provided for 68 site specific locations surveyed or obtained from a review of literature. Water chemical parameters measured in August and September of 1975 at 63 locations include temperature, dissolved oxygen, conductivity, pH, shaken and settled turbidity, suspended solids, and dissolved organic carbon. The pipeline route is arbitrarily divided into 48 to 64 km sections. Water sources are addressed for each section, estimated use levels during the construction phase are given, and water sources to provide for these use levels are described. A guideline water drawdown in lakes of not more than 10% of the total volume is recommended. At this level of use, effects on aquatic habitats is presumed to be minimal.

It is recommended that springs that support fish not be developed as water sources if suitable alternatives are available. Few water sources were located between kilometers 133 and 270 of the proposed route. Overall, estimated water needs for construction would amount to less than 1% of the available water from lakes alone. In addition, some springs not used by fish could be used. Fish distribution is an incidental part of this report, but data on the distribution of ninespine stickleback, arctic char, arctic grayling, broad whitefish, humpback whitefish (referred to as lake whitefish), least cisco, and pond smelt are provided.

KEYWORDS: Water use / water availability / surveys / Arctic Gas Pipeline / Prudhoe Bay / Arctic Slope / water chemistry.

Kinney, P.J., editor. 1985. Fish utilization of Peard Bay. RU-641. Pages 369-405 *in* Environmental characterization and biological utilization of Peard Bay. Outer continental shelf assessment program. Final reports of principal investigators. Vol. 35. Chap. 6. USDC: NOAA, NOS; USDI: MMS.

This paper reports the results of field studies conducted in Peard Bay, eastern Chukchi Sea, northwestern Alaska, during July and August 1983 and March 1984. The objectives were to describe fish community composition, population structure of key fish species, use of habitat by fish, and the timing of use of the area by fish. Fyke nets and gill nets were used as the primary sampling methods during the summer sampling periods. Trammel nets were used during the March sampling period. Four marine species accounted for 99.6% of the total fyke net and gill net catch (n = 11,898). These species were arctic cod, fourhorn sculpin, saffron cod, and arctic flounder. Only 31 anadromous fish were caught in Peard Bay in 1983 from fyke and gill nets. These species included least cisco, rainbow smelt, Bering cisco, and pink salmon. Catches of anadromous fish in Peard Bay were much reduced compared to those from Simpson Lagoon, Prudhoe Bay, and the Beaufort Lagoon areas. It was suspected that suitable spawning and overwintering habitat for anadromous fish is much reduced in the Chukchi Sea coastal rivers in comparison to the much larger river systems east of Point Barrow.

KEYWORDS: Peard Bay / Chukchi Sea / NPR-A / arctic cod / fourhorn sculpin / saffron cod / arctic flounder / least cisco / rainbow smelt / Bering cisco / distribution / age and growth / food habits.

Kogl, D.R. 1971. Monitoring and evaluation of arctic waters with emphasis on North Slope drainages: Colville River study. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 12. Project F-9-3, Job G-III-A. Juneau. 39 pp.

This report presents preliminary findings from fish investigations conducted on the Colville River and nearby waters in 1970.

Fish were captured in the Colville River at Umiat using gill nets from June through September and the Colville River delta was surveyed and sampled in early July. The results of stream surveys on the Colville, Itkillik, Anaktuvuk, Chandler, Kiruktagiak, Oolamnavik, and Killik rivers and Grayling, Ikagiak and Seabee creeks are presented. The Sagavanirktok River was sampled in cooperation with Atlantic-Richfield Corporation. Surveys were also conducted on Shainin, Tatigak, Chandler, Kurupa, Itkillik, Liberator, and Noluck lakes.

Fish captured at Umiat from June 2 through September 6 in order of abundance were arctic grayling, broad whitefish, humpback whitefish, burbot, longnose sucker, arctic char, and lake trout. Catches were higher in July and August than in June. Fish captured in gill nets in the Colville River delta in order of abundance were least cisco, broad whitefish, arctic cisco, and humpback whitefish. Other species captured were fourhorn sculpin, arctic grayling, longnose sucker, rainbow smelt, round whitefish, lake trout, arctic char, and arctic flounder. In a survey of the Colville River, 66 km upstream from the Arctic Ocean, arctic grayling, broad whitefish, humpback whitefish, round whitefish, arctic cisco, least cisco, burbot, longnose sucker, and slimy sculpin were captured. It was noted that onshore winds in Harrison Bay influenced water levels in this location. A brief physical description, discharge and fish species captured are given for other streams surveyed. The standing crop of fishes in surveyed streams ranged from 0 to 79 kg/ha.

Length, age, and maturity data are given for arctic grayling, broad whitefish, and arctic char captured in the Sagavanirktok River.

Fish species found in surveyed lakes were arctic grayling in Noluck and Liberator lakes; arctic char, lake trout, and round whitefish in Kurupa and Shainin lakes; arctic grayling, round whitefish, and lake trout in Itkillik Lake and no fish in Tatigak Lake. Chandler Lake was briefly surveyed, but not sampled for fish. Length, age, and maturity data are given for fish from sampled lakes.

KEYWORDS: broad whitefish / humpback whitefish / round whitefish / least cisco / arctic cisco / arctic grayling / lake trout / arctic char / burbot / slimy sculpin / longnose sucker / North Slope / Arctic Slope / Colville River / Sagavanirktok River / Brooks Range / lakes / age and growth / distribution / maturity.

Kogl, D.R., and D. Schell. 1975. Colville River delta fisheries research. Pages 483-504 *in* Environmental studies of an arctic estuarine system - final rept. Chap. 10. Ecol. Res. Ser. EPA-660/3-75-026. U.S. Environ. Protect. Agency, Corvallis, Oregon.

This paper presents a brief summary of background information on Colville River fisheries and the results of field sampling that occurred in the fall of 1972 (23 Sept. - 15 Nov.) and the spring of 1973 (18 April - 24 April) in the Colville River delta. One open water site on the Chandler River was briefly investigated in May 1972 and an underwater camera was used to survey new underwater sites below the Itkillik River.

Several sites on the east channel of the Colville River were investigated with an underwater camera. The only fish observed were fourhorn sculpin and these were only seen in areas with a gravel bottom. The Chandler River was surveyed from a small aircraft and only a single open water area was located. This site was dug in an effort to capture arctic char alevins or eggs; none were found, but juvenile arctic grayling were observed.

The fall catch consisted of 571 humpback whitefish, 86 least cisco, 69 arctic cisco, 68 broad whitefish, 21 burbot, 16 fourhorn sculpin, 2 longnose suckers, and 1 arctic char.

Humpback whitefish spawned in the east channel and in the Kupigruak Channel of the Colville River. The authors thought that nonconsecutive spawning occurred in females but not males. Some humpback whitefish spawned above Umiat. It is not known if there are two or more discreet spawning populations. Whitefish eggs deposited in the delta hatch in what is essentially the Arctic Ocean as salinities in that area were 32 ppt by April. Length and sex data are given for humpback whitefish. A downstream movement of humpback whitefish was noted in October. Broad whitefish were also spawning in the Colville River delta, but in small numbers. They averaged 467 mm in length with a male to female ratio of 2:3.

The mean length of arctic cisco was 356 mm; of twelve mature females taken, 2 were spent and 10 were nonspawners. Age and length data are presented for arctic and least cisco. The mean length of 22 burbot was 739 mm.

KEYWORDS: Colville River / Chandler River / spawning / commercial fishery / age and growth / humpback whitefish / broad whitefish / least cisco / arctic cisco /fourhorn sculpin / longnose sucker.

Luton, H.H. 1985. Effects of renewable resource harvest disruptions on socioeconomic and sociocultural systems: Wainwright, Alaska. Tech. Rept. No. 91. Alaska Outer Continental Shelf Region. Social and economic studies program. USDI: MMS. 603 pp.

This report discusses the seasonality of harvest, species taken, and general harvest locations in the Wainwright area for 1982 and 1983 but contains little information on harvest quantities.

Summer gill net fishing begins in late June along the coast and mouth of the Kuk River. The most common species caught are pink salmon, chum salmon, and arctic char. The salmon catch has been increasing in the Wainwright area since 1978. The recent increase in salmon numbers has been attributed to the following factors: the general warming trend on the North Slope has been beneficial to salmon, disturbances caused by development in areas to the south have caused salmon to move farther north, and the 200-mile international fishing limit has reduced foreign fishing in U.S. waters. The salmon run appears to be stronger in even years. Fishing along the coast and lower Kuk River has 4 advantages: it can be done in late July and early August before people begin upriver fishing and caribou hunting; salmon, a preferred species, are numerous in this environment; fishing can be done along the coast that is relatively free of mosquitoes, and fishing can be done close to Wainwright with little time investment and in combination with wage employment.

Fishing upriver (along the upper Kuk River and associated tributaries) begins in early August. Upriver fishing areas are the most productive in the Wainwright area, with arctic grayling and least cisco being the most common species, and arctic char, pink and chum salmon, and whitefish also occurring here. After freeze-up some net fishing continues under the ice but jigging for arctic grayling and an occasional burbot becomes a popular means of fishing. Burbot have been scarce since the late 1970's in the Kuk River system and all fishing in the Utukok River is reported to be poor. Use of explosives in seismic exploration has been cited as the major cause for this decline in fish populations.

Capelin spawn along the coastal beaches near Wainwright during August and September and are harvested by scoop nets. Rainbow smelt enter Wainwright Inlet during late winter and are caught by jigging through the ice from January to March. This is one of the most popular harvesting activities in which almost all individuals, old and young, can participate. South winds combined with a rising tide are reported to bring rainbow smelt into the Inlet. Other fish that were reported in the catch include northern pike, sculpin, tomcod, and blackfish.

KEYWORDS: Wainwright/ Kuk River/ Kungok River/ Utukok River/ North Slope/ NPR-A/ pink salmon/ chum salmon/ arctic char/ arctic grayling/ whitefish/ burbot/ dolly varden/ rainbow smelt/ capelin/ northern pike/ sculpin/ blackfish/ tomcod/ harvest/ distribution/ movement.

McCart, P., and H. Bain. 1974. An isolated population of arctic char (*Salvelinus alpinus*) inhabiting a warm mineral spring above a waterfall at Cache Creek, Northwest Territories. Chap. 7 *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon, and Northwest Territories. Arctic Gas Biol. Ser. Vol. 15. 13 pp.

This report discusses information collected in November 1972 and the summer of 1973 from a population of arctic char isolated in a warm mineral spring above a waterfall in Cache Creek, a tributary to the Big Fish River in the Mackenzie River system.

The spring flows at 16°C, is highly mineralized, has a low level of dissolved oxygen (0.2 ppm), and is saline. In winter, the streambed is dry above the spring orifice. A waterfall is located 400 m downstream of the spring.

Resident arctic char are the only species present above the falls. Anadromous arctic char and arctic grayling occur downstream of the falls. Differences were found in gill raker, pyloric caecae, vertebrae, and parr mark counts between arctic char above and below the falls, indicating that they represent distinct populations. A high incidence of fish with protruding eyes (30%) was found with those fish taken closer to the spring orifice showing the highest rates (60%). This appears to be the result of gas accumulation in tissues from super-saturated dissolved gasses in the spring water. No abnormalities in fry were noted.

Spawning occurs in late fall or early winter. Females still had large eggs tightly bound in ovarian membranes on November 11, 1972. Fry collected on May 10, 1973 averaged 33.9 mm in length. Char fry taken from a nearby river one day later averaged 22.7 mm. Growth is either faster or emergence earlier than in nearby systems. Growth of these arctic char was at least as fast as arctic char growth in two springs or in the Canning River.

Conditions at this spring are unusual because of the reversal of the normal temperature regime for springs in the area. Temperatures are highest in the winter when the only source of water is the warm spring, and lowest in spring and summer when surface runoff dilutes spring water. The high levels of dissolved minerals and low levels of dissolved oxygen create less than desirable conditions for fish during the winter, but the arctic char population is apparently doing well.

KEYWORDS: arctic char / stream resident / mineral spring / Yukon Territory.

McCart, P., and P. Craig. 1974. Life history of two isolated populations of arctic char (*Salvelinus alpinus*) in spring fed tributaries of the Canning River, Alaska 1973. Chap. 8 *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon and Northwest Territories. Arctic Gas Biol. Ser. Vol. 15. 13 pp.

This report summarizes life history information collected on two isolated arctic char populations in springs in the Canning River system. Shublik Springs is isolated by a waterfall where it enters the Canning River, but the other spring does not have a physical barrier to fish movement. It enters an aufeis area and then a slow tundra channel to the Canning River. No anadromous arctic char have been observed in the stream and although arctic grayling enter the slow moving section, only resident arctic char have been observed above the aufeis.

Gill rakers and pyloric caecae counts varied between the two populations, but fell within the range of western Bering Sea arctic char (northern Dolly Varden).

Both populations were characterized by small size although fish in Shublik Springs were somewhat larger and faster growing than fish in the unnamed spring. The largest arctic char taken in the unnamed spring was 164 mm whereas those in Shublik Spring ranged to 235 mm. The oldest male in Shublik Spring samples was age 8 whereas the oldest from the unnamed spring was age 5. Comparable ages for females were age 8 and 7. Males and females in both springs were mature by age 5. The youngest males were mature at age 2 and females at age 3. No indication of nonconsecutive spawning, common in anadromous populations, was found. The mean fecundity was 154 eggs per female for Shublik Springs and 114 eggs per female for the unnamed spring. No significant correlation between fish length and number of eggs was found. Spawning probably occurs in November, males were ripe on November 4, but females were still green. Anadromous arctic char in the Canning River were spawning at the end of August. Fish in both populations were opportunistic feeders without specialized feeding habits.

Little difference was found in life history between the two locations. [The article also appears in the Journal of Fisheries Research Board of Canada 30:1215-1220.]

KEYWORDS: Canning River / Alaska / arctic char / isolated springs / life history / stream residents / spawning / age and growth.

McCart, P., P. Craig, and H. Bain. 1972. Report on fisheries investigations in the Sagavanirktok River and neighboring drainages. Prepared for Alyeska Pipeline Service Co. 143 pp.

This report presents information collected in field studies conducted in 1969-1971 along the proposed oil pipeline route on Alaska's North Slope. Systematic and life history studies were carried out on fish in the study area.

Lake resident and migratory forms of arctic char were found. They differed in pyloric caecae and gillraker counts with the lake resident forms having higher numbers of both structures. Lake resident arctic char were considered the Eastern Arctic form and migratory or anadromous arctic char were considered the Western Arctic form.

Anadromous arctic char spawn in streams near springs during late summer and early fall. Young-of-the-year emerge in the spring and may spend several years in streams. Many arctic char remain around spring areas, but some take up summer residence in non-spring areas. After a varying number of years, most migrate seaward for the first time as smolts. After spending the summer at sea feeding, they return to freshwater spring areas to overwinter. They may make this annual journey several times before returning as mature fish to spawn. In the Sagavanirktok River drainage, mature migrants were observed in all large mountain streams with the exception of the Atigun River (that contains no springs) whereas immature migrants were concentrated in mountain streams nearest the sea.

Some stream dwelling arctic char remain in freshwater and mature without having migrated to sea. These are exclusively males and are called residual males.

At emergence, arctic char averaged 23.7 mm in length; by September 1 they were 53.9 mm. Growth of migrant vs residual males diverges when migrants go to sea; mature migrants are nearly twice the length of residual arctic char of the same age. Females comprised 75% of samples of migratory arctic char taken in mountain streams. The presence of residual males is considered a compensatory imbalance of sex ratio.

Arctic char migrated to sea for the first time between age 2 and age 5 and age 8 arctic char were the most abundant group of mature arctic char. Mature migrant arctic char were observed near spawning grounds as early as June 26, but spawning did not take place until September. Fish with a mean fork length of 49.9 mm contained an average of 3669.6 eggs. There was no evidence of immediate post spawning mortality and it is suggested that repeated spawning is likely. A sample of 58 females taken in June 1972 showed that 83% held retained eggs.

Lake resident arctic char were taken in several lakes in the Sagavanirktok River drainage. First year growth of lake residents exceeded that of anadromous fish and the size advantage persisted until anadromous fish went to sea. There were more males than females in samples from Campsite Lake. Youngest females were mature at age 9 and males at age 10. It is suggested that females do not spawn annually upon reaching maturity. Pre-spawning females had eggs from 4.7 to 4.9 mm in diameter by the end of August. Fecundity ranged from 554 to 1229 eggs for lake resident female arctic char from 374 to 445 mm in fork length. Spawning begins in late August and continues into September. Snails were the most frequently consumed food item.

Lake trout were captured in Itkillik and Campsite lakes. They were slow growing, reaching approximately 500 mm in length at 24 years of age. The youngest mature males were 11 years old and the youngest females were 13 years old. Spawning is nonconsecutive, but the frequency of spawning could not be determined. The mean fecundity of Itkillik Lake lake trout females was 2514 eggs for fish averaging 514 mm. The mean fecundity of Campsite Lake lake trout females was 1710 eggs for fish averaging 412 mm. Eggs grew from 3.7 mm in diameter in June to 512 mm during spawning season in September.

Round whitefish are distributed in mountain streams and their associated lakes. Growth was relatively constant until age 9 and then slowed. Youngest males were mature at age 5 and youngest females were mature at age 7. By age 10 all fish of both sexes were mature. It is suggested that round whitefish spawn every year. The mean fecundity of round whitefish was 6297 eggs for females that averaged 356 mm in fork length. Spawning takes place late in the fall; ovaries were still tightly bound when ice formed on September 24.

Arctic grayling were widely distributed in streams and lakes of the study area. On June 26, arctic grayling young-of-the-year were only 13.1 mm in length; by August 24 they were 44.8 mm. Arctic grayling fry in upstream areas of mountain streams showed very slow growth rates. As late as August 30, 65% of those captured in the upper Atigun River were less than 35 mm in length, the length of first scale formation. It is unlikely that these arctic grayling form scales in their first year of life. Arctic grayling from Happy Valley Creek grew more slowly but attained greater ages than those in interior Alaska. Males were first mature at 4 years of age and females at age 6.

Arctic grayling spawn in early June, females between 223 and 328 mm contained an average of 3478 eggs. They spawn every year after reaching maturity.

Arctic grayling move upstream to spawning areas in the spring from overwintering areas. In Happy Valley Creek they left soon after spawning to spend the summer elsewhere. Smaller fish, less than 200 mm, moved upstream as spawners were leaving and remained in the stream during the summer. Fish left Happy Valley Creek in August. Arctic grayling fed on a variety of organisms including bottom fauna, drift, terrestrial insects, fish, fish eggs, shrews, and plant material.

KEYWORDS: North Slope / Sagavanirktok River / arctic char / arctic grayling / lake trout / round whitefish / life history.

McCart, P.J. 1974. Late winter surveys of lakes and streams in Canada and Alaska along the gas pipeline routes under consideration by Canadian Arctic Gas Study Limited, 1972-1973. Chap. 1 *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon and Northwest Territories. Arctic Gas Biol. Rept. Ser. Vol. 15. 181 pp.

This report is a series of forms from surveys conducted in April 1973 on streams to be crossed by a proposed natural gas pipeline from Prudhoe Bay, Alaska, across the Arctic Coast of eastern Alaska and the Yukon Territory. Objectives of surveys were to determine presence or absence of water in lakes and streams along the proposed route, examine the water quality and suitability for fish, and record evidence of presence of overwintering fish. Forms and maps locating survey sites are provided.

KEYWORDS: Winter surveys / Arctic Gas Pipeline.

McElderry, H.I., and P.C. Craig. 1981. A fish survey in the lower Colville River drainage with an analysis of spawning use by arctic and least cisco. Appendix 2. Pages 657-678 *in* Environmental assessment of the Alaskan continental shelf. Final reports of principal investigators. Volume 7. Biological studies. USDC: NOAA, OMPA; USDI: BLM

The purpose of this field study was to survey areas in the Colville River drainage to assess their importance for spawning and overwintering by least and arctic cisco. The survey was conducted on the Colville River mainstem between the delta and Umiat, tributaries such as the Itkillik River, neighboring drainages of the Colville River, and an array of deep coastal lakes. Sampling was conducted August 20-21, 1978, September 8-9, 1978 and September 4-15, 1979. Length and maturity data were presented for all fish collected. The most common species collected were least cisco and broad whitefish. Other species collected included round whitefish, arctic grayling, humpback whitefish, arctic char, fourhorn sculpin, boreal smelt (rainbow smelt), arctic cisco, Alaska blackfish, burbot, longnose sucker, pink, chum, and red salmon, saffron cod, and arctic flounder.

Few (8) arctic cisco were captured during this study and none were judged to be in spawning condition. Based on sampling conducted in this study and other studies, the authors concluded it was unlikely that arctic cisco spawn in deep coastal lakes, the Colville River delta, or in areas upstream of Umiat. The authors speculated that if arctic cisco did spawn in the Colville River drainage, spawning may occur in the main stem between the delta and Umiat or in large tributaries such as the Chandler, Anaktuvuk, or Itkillik rivers. [Reviewer's Note: Refer to Gallaway et al. 1983 for the current hypothesis concerning arctic cisco spawning areas.]

Least cisco were the most abundant species captured in coastal lakes. Virtually all least cisco populations sampled in lakes had mature-green fish (fish that would spawn in the year of capture), although their percentages were low (approximately 8%). No attempt was made to distinguish anadromous and non-migrating populations of least cisco in lakes. Within the Colville River, anadromous least cisco were found upstream of the delta as far as Ocean Point. Six of the seven least cisco taken at Ocean Point were mature-green fish. Previous studies indicated up to 75% of least cisco collected in the Colville River delta in July were potential spawners. Some ripe and spawned-out least cisco were also present in the fall commercial fishery in the lower delta. Least cisco were also capture in several headwater lakes of the Colville River drainage, but these were considered to be non-migratory populations.

Spawned-out pink and chum salmon were observed on the gravel banks of the Itkillik River at Siotukuyuk Bluff and at the mouth of the Itkillik River.

KEYWORDS: North Slope / Colville River / Itkillik River / arctic cisco / least cisco / pink salmon / chum salmon / distribution / age and growth / spawning and reproduction.

McMillan, R.O., and D.R. Barnard. 1983. Stream fish. Chapter 4 *in* D.M. Troy, ed. Prudhoe Bay Unit - Eileen West End environmental studies program, summer 1982. Prepared by LGL Alaska Research Associates, Inc., Fairbanks, for Sohio Alaska Petroleum Company, Anchorage.

The purpose of this field study was to describe the stream fish resources in those portions of the Sakonowyak River and two unnamed (referred to as the West and East Tributaries) tributaries of the Kuparuk River that flow through the Eileen West End oil development unit near Prudhoe Bay, Alaska. Fish sampling and discharge and water quality sampling were conducted during July 3-6 and September 1-3, 1982. Fish sampling techniques used included electroshocking, seine, gillnet, dipnet, angling, and visual observations. Habitat descriptions of the surveyed stream reaches are presented. Ninespine stickleback and three juvenile arctic grayling were captured in the Sakonowyak River. Spawning use of the Sakonowyak River appeared restricted to ninespine stickleback as only YOY ninespine stickleback were captured in this stream. The East and West Tributaries contained ninespine stickleback, slimy sculpin, and arctic grayling. YOY slimy sculpin and YOY arctic grayling were found in the West Tributary, indicating spawning within this system. Although evidence of spawning was not observed, habitat appeared suitable for spawning by ninespine stickleback. The West Tributary served as a rearing area for ninespine stickleback, slimy sculpin, and arctic grayling throughout the open water period. The East Tributary also served as a rearing area for all three species during the open water season, and supported ninespine stickleback spawning as evidenced by the presence of young-of-the-year (YOY). It is likely that arctic grayling and slimy sculpin spawning occurred in the East Tributary, even though YOY were not collected, as suitable spawning habitat for both species was available. Based on the maximum depths measured in September (about 2 m), none of the streams appeared to have many potential overwintering sites. Fish resident in the East and West Tributaries during the open water season likely move to overwintering areas in the Kuparuk River as winter approaches. Isolation of the Sakonowyak River by Gwydyr Bay from overwintering areas in the Kuparuk River likely limits the Sakonowyak River to incidental rearing of arctic grayling and spawning and rearing of ninespine stickleback.

KEYWORDS: Kuparuk River / Sakonowyak River / North Slope / arctic grayling / ninespine stickleback / slimy sculpin / distribution / age and growth / overwintering.

Moulton, L.L. 1980. Kuparuk field fish survey. Prepared by Woodward-Clyde Consultants for ARCO Oil and Gas Co., Anchorage, Alaska. 26 pp.

This paper reports the results of field research conducted from July 8 to 16, 1980 on the fisheries of three major drainages crossing the Kuparuk oilfield area, Alaska. The objectives of the fisheries survey were to gather baseline data on the fish using the streams and to assess the habitat available to fish in the surveyed regions. The Ugnuravik River, a tundra-origin stream, discharges into the Beaufort Sea via Simpson Lagoon, and is thus connected primarily to a marine system. Kalubik Creek, also a tundra-origin stream, discharges into Harrison Bay in an area under the influence of the Colville River delta, and can be considered connected to an estuarine system. The Miluveach River is entirely a freshwater foothills-origin stream that discharges into the Colville River. Although these streams are outside NPR-A boundaries, they represent stream types that occur in NPR-A. Small numbers of ninespine stickleback and fourhorn sculpin were captured in the Ugnuravik River. Potential overwintering habitat for fish in the surveyed section of the Ugnuravik River appears to be limited to occasional deep thaw pools. Kalubik Creek contained arctic char, arctic grayling, an unidentified whitefish, ninespine stickleback, and fourhorn sculpin. Ninespine stickleback abundance was greatest in a stretch of river that had three lakes connected. These lakes may provide overwintering habitat. Arctic grayling, round whitefish, and ninespine stickleback were found in the Miluveach River. Numerous fish larvae, presumably arctic grayling, were found in shallow water at scattered locations throughout the study section, suggesting that the Miluveach River may be a significant spawning area for arctic grayling. The overwintering potential of the Miluveach River is low, and most fish probably return to the Colville River to overwinter. Central Creek, a small tundra-origin stream east of the Ugnuravik River, did not produce any fish in the small section surveyed. Lengths were presented for all species captured. Descriptions of stream channels and associated vegetation were presented for each river. Observations of birds and mammals are also presented.

KEYWORDS: Ugnuravik River / Kalubik Creek / Miluveach River / Kuparuk / arctic grayling / arctic char / ninespine stickleback / fourhorn sculpin / age and growth / distribution.

Moulton, L.L. 1983. Lisburne development area: 1983 environmental studies. Final report. Prepared by Woodward-Clyde Consultants for ARCO Alaska, Inc., Anchorage. 142 pp + append.

This report presents information from field work conducted in Prudhoe Bay during the summer of 1983. Eight fyke net stations were operated from July through September 15. In addition, gillnetting was conducted from mid-June through early July and beach seining was done at four locations three times during the summer. Large fish were tagged with floy tags and small fish were freeze branded. Periods for analysis of CPUE and movements were determined based on effects of wind patterns during the overall sampling periods.

Short-term movements as indicated by tag recovery are described for each species and size cohort of fish for each sampling period. In general these movements were not always clearly directional and were not consistently correlated with wind direction, currents, or conductivity; however, some short-term patterns are described.

A total of 14,548 arctic cisco was measured. Four size classes were noted and followed throughout the summer. Age 1 arctic cisco (110-119 mm) were most numerous from 30 July-5 August and from 27 August-2 September. This group grew 20 mm during the summer. Age 2 arctic cisco (180-189 mm) were abundant throughout the summer and increased at least 10 mm by the end of summer. Age 3 fish were present from July through September, but were not present in large numbers after 12 August. They grew 30 mm in just one month. At the outset of the summer, a modal size class of 330-339 mm was present, but they apparently left early in the summer.

Four size classes of least cisco were captured in Prudhoe Bay. A few 30-59 mm least cisco showed up in mid-September. By August 12, a modal size group 90-99 mm was present; they increased to 100-109 mm by 26 August. They were virtually absent from catches in September. A modal size group of least cisco 210-219 mm was present all summer until early September; they increased in size to 230-239 mm. The largest size group 310-319 was dominant numerically and occurred from early July through September 2, but were absent from late September catches. They grew 20 mm during the summer.

Broad whitefish were present throughout the summer. Three size groups, 90-99 mm, 140-149 mm, and 180-189 mm each increased 30 mm by mid-September. A fourth group (250-259 mm) increased 20 mm. A fifth group of small fish, 50-59 mm, were present for two weeks in mid-August.

Only two size classes of arctic char were easily distinguished. The small group, 160-169 mm in early July, had increased to 220-239 mm by the end of summer. A large size mode 260-269 mm increased to 310-319 mm by September.

Marking mortality experiments showed 25% handling mortality early in the season.

KEYWORDS: Prudhoe Bay / Beaufort Sea / anadromous fish / fish movements / fish distribution / size frequency.

Moulton, L.L., and T.A. Carpenter. 1986. Colville River fishes: a literature review. Chap. 1 *in* Colville River Fish Study. 1985 annual report. Final report, May 1986. Prepared by Entrix, Inc. for ARCO Alaska, Inc., the North Slope Borough, and the City of Nuiqsut. 36 pp.

This literature review contain summaries of available data on fish in the Colville River through 1985. The paper is organized by fish species and has sections on arctic cisco, least cisco, broad whitefish, arctic char, humpback whitefish, rainbow smelt, arctic grayling, round whitefish, and burbot. Subsections containing information on abundance, spawning, seasonal movements, and growth and maturity are provided for each species.

This summary document provides a good background of available information on this important river system.

KEYWORDS: Colville River / Beaufort Sea / fish distribution / abundance / movements / maturity.

Moulton, L.L., and C.B. Dew. 1983. Fish utilization of tundra streams between the Colville and Kuparuk rivers. Draft report. Prepared by Woodward-Clyde Consultants for ARCO Alaska, Inc., Anchorage. 37 pp + append.

This paper reports the results of fisheries field surveys of streams within the Kuparuk Oilfield, Alaska, that were conducted during the summers of 1980-1982. The objectives of these surveys were to determine the species of fish present in the streams and to assess the patterns of habitat use of these streams by fish. Sampling was conducted from mid-July to early August by a combination of electrofishing, seining, dip netting, visual observations, and angling.

Five creeks were surveyed and represent three different stream types. Habitat descriptions for each creek are also presented. East Creek, Central Creek, and the Ugnuravik River are tundra-origin streams and discharge into the Beaufort Sea via Simpson Lagoon. Ninespine stickleback were the only fish collected in East and Central creeks. Ninespine stickleback and fourhorn sculpin were found in the Ugnuravik Rivers. Kalubik Creek is a tundra-origin stream that discharges into Harrison Bay in an area under the influence of the eastern Colville River delta. Fish captured in Kalubik Creek included ninespine stickleback, fourhorn sculpin, rainbow smelt, round whitefish, arctic grayling, and arctic char. The Miluveach River is a foothills-origin stream that discharges directly to the Colville River. Ninespine stickleback, round whitefish, and arctic grayling (adults and newly-hatched larvae) were collected in the Miluveach River.

Little overwintering habitat is found in any of the surveyed streams, as these streams are expected to cease flowing during winter. Ninespine stickleback apparently overwinter in relatively small isolated pools in beaded stream reaches. Other species either fail to survive the winter in these streams or move back to larger rivers such as the Colville River. Fish in the Miluveach River likely return to winter in the Colville River.

The studied streams that discharge into coastal waters represent "islands" of freshwater fish habitat that are used as summer feeding areas by fish. These fish are occasionally introduced into the streams by spring breakup flows from large rivers that create large freshwater plumes in the nearshore marine system, such as the Colville or Kuparuk rivers. East Creek, Central Creek, and the Ugnuravik River are more removed from the breakup flows of the larger rivers and are likely to be infrequently colonized by freshwater fish from the larger rivers. Kalubik Creek, that apparently does not support a self-perpetuating population of arctic grayling because of a lack of overwintering habitat and as yet no observed spawning, is likely populated with freshwater fish on a regular basis due to its proximity to the Colville River. These introduced populations experience a high rate of extinction because of the absence of overwintering habitat.

KEYWORDS: Colville River / Kalubik Creek / Ugnuravik River / Miluveach River / arctic grayling / ninespine stickleback / round whitefish / arctic char / rainbow smelt / age and growth / distribution / fourhorn sculpin.

Moulton, L.L., and M.H. Fawcett. 1984. Oliktok Point fish studies - 1983. Final Report. Prepared by Woodward-Clyde Consultants for ARCO Alaska, Inc., Anchorage.

This paper reports the results of field studies conducted at Oliktok Point, Alaska to gather pre-operation fisheries data relating to potential environmental impacts of the dock and waterflood intake facility at Oliktok Point. The specific objectives of this study were to document summer patterns of distribution and abundance of anadromous and marine fish near Oliktok Point through daily sampling, and to document variability in selected meteorological and oceanographic parameters in the vicinity of Oliktok Point and relate the patterns observed to the patterns of fish abundance and distribution. Sampling was conducted between July 9 and September 2, 1983. Results showed catches of anadromous fish in the nearshore Beaufort Sea at Oliktok Point tend to be dominated by least and arctic cisco, broad and humpback whitefish, and arctic char. Seventy two percent of the total catch (154,169 fish) was arctic cod and fourhorn sculpin, 21.8% was arctic and least cisco, and the remaining 6.2% was made up of arctic char, broad, round, and humpback whitefish, Bering cisco, rainbow smelt, sockeye salmon, arctic grayling, ninespine stickleback, Pacific herring, and saffron cod. Wind patterns and their effects on water mass characteristics affected the distribution of anadromous fish in the Oliktok Point area. Easterly winds during mid-July to mid-August led to reduced water temperature and increased conductivity (higher salinity) and reduced catches of small least cisco and humpback and broad whitefish as the Colville River plume was moved westward. There was no apparent immigration from the east of broad or humpback whitefish or small least cisco during easterly winds, supporting the hypothesis that these fish primarily originate in the Colville River. Westerly winds during mid-July to mid-August brought the Oliktok Point area under the influence of the Colville River plume and decreased salinity and increased temperature. Under these conditions, catches of small arctic cisco and least cisco increased substantially. From mid-August to early September, few anadromous fish were associated with the Colville River plume. Most migration activity that was recorded, primarily with large least cisco and small and large arctic char, was probably associated with movements toward wintering areas. Other species or size groups had probably already returned to the Colville River delta, although late-returning species, such as large arctic cisco, may have been missed by sampling. From early to mid-July, large and small arctic cisco, broad and humpback whitefish, small arctic char, and large least cisco were moving eastward towards Simpson Lagoon under the influence of the Colville River plume, presumably from overwintering areas in the Colville River. Capture of fish tagged in Prudhoe Bay at Oliktok Point in late July through August indicated that these fish had overwintered in the Sagavanirktok River and were transported west by currents generated by strong easterly winds in late July. Tagged fish recovered at Oliktok Point included arctic and least cisco, broad whitefish, and arctic char. Capture data suggested that there was no significant westward movement of fish in early to mid-July.

KEYWORDS: Oliktok Point / Simpson Lagoon / Colville River / arctic char / arctic cisco / least cisco / humpback whitefish / broad whitefish / distribution / overwintering / movements / age and growth / arctic cod / fourhorn sculpin / round whitefish / Bering cisco / arctic grayling / ninespine stickleback /rainbow smelt / sockeye salmon.

Moulton, L.L., and T.R. Jennings. 1987. Assessment of the Colville River fall fishery in 1986. Final rept. Colville River fish study. Prepared by Entrix, Inc. for ARCO Alaska, Inc., the North Slope Borough, and the City of Nuiqsut. 50 pp.

Results of the second year of study on the fall fishery at Nuiqsut, Alaska are presented [see Moulton et al. 1986 for a general description of the fishery and results of the 1985 fishery]. Approximately 25 groups of fishermen participated in the 1986 fall fishery. The study area included the Nigliq Channel and the outer Colville River delta.

Estimates for the 1986 catch were 63,000 arctic cisco, and 15,800 least cisco. Although there was a considerable reduction in effort compared to 1985, the highest recorded catch rates (about 195 arctic cisco/day/150 foot net (45.7m) compared to the previous high of 76/day/net in 1981) almost completely compensated for the calculated 38% reduction in fishing effort. The extremely high catch rates for arctic cisco were attributed to the full recruitment of the 1979 and 1980 year-class fish (the dominant age-class fish in previous Beaufort Sea fish studies) into the fishery.

The rates of loss of same-age tagged arctic and least cisco were used to estimate the rates at which these fish leave the population (an indication of annual mortality rate). For least cisco the annual mortality rate was about 35% for 4 years after release, and for arctic cisco it was 68% and 78% for the first 2 years, after which time they disappear from the fishery. The recovery of tagged arctic cisco supported the theory that these fish originate (spawn) in the Mackenzie River area of Canada and a portion of the population overwinters in the lower Colville River.

Salinity, measured in various sections of the Nigliq Channel, is related to catch rates of arctic and least cisco. The relationship between mesh size and species composition and size of the catch is discussed. Age composition of arctic cisco in the catch is also discussed. Results from this study indicate that the estimated 1986 harvest rates on least and arctic cisco are not excessive for the populations of these fish.

KEYWORDS: Colville River/ NPR-A/ Nuiqsut/ North Slope/ least cisco/ arctic cisco/ age and growth/ distribution/ harvest/ life history/ movements/ population dynamics/

Moulton, L.L., L.J. Field, and S. Brotherton. 1986. Assessment of the Colville River fishery in 1985. Chapter 3 *in* Colville River fish study. 1985 Annual rept. Prepared by Entrix, Inc. for ARCO Alaska, Inc., the North Slope Borough, and the City of Nuiqsut. 72 pp.

Field work on the Colville River fishery at Nuiqsut was conducted during the summer and fall of 1985. The study area included the Colville River from Ocean Point to the delta and Fish Creek to the west.

About 20 groups of fishermen participated in the summer gill net fishery from early July to early September. The three major fishing areas included the Nigliq Channel (western Colville River delta) that received 1,000 net-days of fishing effort, Tiragruaq (upper Colville River) with 150 net-days, and Fish Creek with 34 net-days. Broad whitefish made up 80% of the summer fishery. Humpback whitefish, pink salmon, arctic char, and arctic grayling made up relatively small components of the fishery. Estimated total catch was calculated from catch per unit effort (CPUE) data. The total catch in the summer fishery was 4,380 broad whitefish, 300 arctic char, and 300 humpback whitefish.

The fall under ice fishery began in early October when the river ice was about 75 mm to 100 mm thick and extended to late November. About 30 groups of fishermen participated in 3 major areas: Wood's Camp on the lower Nigliq Channel, the upper Nigliq, and the outer Colville River delta (Kupigruak or main channel and the east channel). Broad whitefish were the most abundant fish caught in the upper Nigliq Channel in early October, making up 45% of the sampled catch. Least cisco were next in abundance at 30% and arctic cisco accounted for only 20% of the total catch. By late October until the end of the season, arctic cisco represented 95% of the total catch. The estimate of the catch for the upper Nigliq (where about 25 fishermen had nets) included 18,000 arctic cisco, 2,000 least cisco, and 1,500 broad whitefish. Total estimated catch for all areas was 70,359 arctic cisco and 33,410 least cisco. Differences in catch rates and composition of catch between the different areas were noticeable and are discussed along with differences in catch rates with different sized nets.

The present exploitation rate on least cisco is low, judging from the estimated harvest rate of 10% and the continued presence of greater than age 10 fish in the population. Likewise the exploitation rate on broad whitefish was considered to be low. The presence of ripe and spent least cisco in the sampled catch from the upper Nigliq Channel indicate that this area is used for spawning during September and October. Over 60% of 1,704 tagged fish recaptured in the 1985 fishery were tagged in the 1985 Endicott Project. Most of the tagged fish were arctic and least cisco. Population estimates based on recapture of tagged fish and a Peterson estimator are presented for arctic and least cisco. Mortality rates for cisco from fishing are calculated. Based on the lack of fish in the year classes after 1980 in fyke net catches from the Endicott Monitoring Project, the authors predict low catch rates for arctic cisco from 1987 to the early 1990's.

KEYWORDS: North Slope/ Colville River/ Fish Creek/ Nuiqsut/ NPR-A/ least cisco/ arctic cisco/ broad whitefish/ humpback whitefish/ arctic grayling/ arctic char/ pink salmon/ age and growth/ distribution/ harvest/ spawning and reproduction/ overwintering/ movements/

Moulton, L.L., B.J. Gallaway, M.H. Fawcett, W.B. Griffiths, K.R. Critchlow, R.G. Fechhelm, D.R. Schmidt, and J.S. Baker. 1986. 1984 central Beaufort Sea fish study. Prudhoe Bay Waterflood Project Environmental Monitoring Program. 1984. Vol. 2. Chap. 3. Prepared by Entrix, Inc., LGL Ecological Research Associates, and Woodward-Clyde Consultants for Envirosphere Co., and US Army Corps of Engineers, Anchorage, Alaska. 294 pp + append.

This study focused on West Dock-induced alterations to fish habitat and habitat utilization patterns, and to migrations and feeding movements of anadromous fish. The area covered expanded from the west side of the Kuparuk River delta to the Sagavanirktok River delta. This field study was conducted in 1984, but results contain some comparisons with earlier work conducted in the Prudhoe Bay area.

In 1984, 7,882 small and 5,840 large arctic cisco were marked. Recoveries of these and earlier marked fish suggested that there was little movement of small arctic cisco out of Prudhoe Bay and that the majority of the observed movement around the West Dock causeway was to the outside of the barrier islands. Small arctic cisco did not use the breach. There was little movement of arctic cisco from Prudhoe Bay into the lagoon system or in the opposite direction. Few large arctic cisco used the breach; in general their movements were similar to small arctic cisco. Those that moved out of Prudhoe Bay traveled along the outside of the barrier islands.

Length-weight data indicated that arctic cisco were growing slower in Prudhoe Bay in 1984 than in Prudhoe Bay 1976-77 or in Simpson Lagoon in 1977-78. Fish collected in 1977-78 were also heavier for a given length than those collected in 1984. The 1979 year class is growing more slowly in the Sagavanirktok River region than its equivalent cohort in the Colville River region. The authors suggest that the presence of the West Dock causeway has influenced the recruitment of young arctic cisco to the Colville River in that some recent year classes that would have made it to the Colville River in pre-causeway conditions have taken up residence in the Sagavanirktok River. These fish have exhibited lower growth rates than their Colville River counterparts because prey densities are lower in Prudhoe Bay than in Gwydyr Lagoon. Overwintering areas are limited in the Sagavanirktok River delta, and the addition of these arctic cisco has contributed to overcrowding in overwintering sites resulting in observed overwintering mortality in 1986 at some sites. The causeway also impedes the movement of Sagavanirktok River arctic cisco into Gwydyr Bay for feeding.

A total of 22,913 least cisco was captured in 1984; 71% were large (>250 mm). It is suggested that they were about twice as likely to travel around the causeway as through the breach, and much more likely to travel along the outside of the barrier islands than enter the lagoon system. Least cisco leave the Prudhoe Bay area in the fall to overwinter in the Colville River. It is indicated that least cisco neither spawn nor overwinter in the Sagavanirktok River. It is suggested that more least cisco would use Gwydyr Bay for feeding if the causeway was not present.

Small broad whitefish showed limited movements. Large broad whitefish showed greater movements, but preferred delta habitats. They did not move out of Prudhoe Bay. Broad whitefish are resident in the Sagavanirktok River system and in the Colville River system. Movement between the two systems has been documented so it is assumed that the populations are not entirely separate.

Small arctic char traveled around the causeway into Gwydyr Bay and back into Prudhoe Bay without apparent interference. They also moved longer distance than other fish. Fish released in Prudhoe Bay used the breach whereas those released in the Sagavanirktok River delta went around the causeway.

Habitat alteration near the West Dock causeway was documented in 1984. Salinity in Stump Island Lagoon can increase 15-20 ppt over pre-causeway conditions. As a result, prey densities are expected to be higher, but anadromous fish use of the area between West Dock and Storkersen Point has been reduced because of causeway-induced changes in fish movement patterns.

KEYWORDS: Beaufort Sea / Prudhoe Bay / Gwydyr Bay / Stump Island lagoon / anadromous fish / causeway impacts / movements / invertebrate densities.

ACTIVITY: filling (aquatic and wetland habitats)

IMPACT: change in water temperature; change in concentrations of salinity.

Neakok, W., D. Neakok, W. Bodfish, D. Libbey, E.S. Hall,Jr., and Point Lay elders. 1985. To keep the past alive: the Point Lay cultural resource site survey. North Slope Borough, Barrow, Alaska. 111 pp.

In 1984, Inupiaq elders from Point Lay were interviewed to document the location and use of traditional land use sites. Much of the knowledge of the land and how it was used (traditional equipment used, location of harvest areas, etc.) remains in the memories of the elders as the Inupiaq had no written language to record their history. Many of the sites that were used in the past to harvest resources are still used today.

Two islands located on the ocean side of Kukpowruk Pass were used to set up a fish camp during July to September. Gill nets were used to catch Dolly Varden, trout, humpback whitefish, and herring. During winter, arctic grayling were caught on the Kukpowruk River (upriver to where it enters the Amatusuk Hills), particularly in association with caribou hunting. During August and September, arctic grayling, trout, and occasionally "silver", chum, and pink salmon are caught in gill nets on the Kukpowruk River. The mouth of the Kukpowruk River is good for gill net fishing during summer. After freeze-up most of the fishing is done with a hook through the ice.

Camps were located on the mainland across from lagoon entrances where there was access to the mainland for freshwater and caribou, and access to the sea for marine mammal hunting.

KEYWORDS: Point Lay/ North Slope/ Kukpowruk Pass/ Kukpowruk River/ Kimmikerak/ arctic grayling/ Dolly Varden/ coho salmon/ pink salmon/ chum salmon/ distribution/ harvest/

Neill, W.H., R.G. Fechhelm, B.J. Gallaway, J.D. Bryan, and S.W. Anderson. 1983. Modeling movements and distribution of arctic cisco *(Coregonus autumnalis)* relative to temperature-salinity regimes of the Beaufort Sea near the waterflood causeway, Prudhoe Bay, Alaska. Biol. Pap. Univ. Alaska No. 21:39-61.

A mechanistic model was developed to evaluate the movement patterns of small arctic cisco relative to environmental heterogeneity associated with the Waterflood Causeway, a gravel pier that projects 3.9 km into the Beaufort Sea from the Alaska coast near Prudhoe Bay. Fish movement and resultant changes in fish density were treated as a donor-controlled drift process biased by experimentally determined temperature preferences (given temperature and salinity acclimation) of the fish. Simulated fish density was significantly rank-correlated with actual catch. Goodness-of-fit was improved when observed data were filtered to remove the effects of presumed high-frequency changes in fish catchability.

Under the assumption of model validity, small arctic cisco make appropriate use of the causeway's breach as a passageway. Causeway-induced variation in water quality during August 1981 directed fish movement in a manner that should reduce entrainment and impingement potential of planned water-intake structures, although these same water quality differences resulted in an estimated 7% reduction in fish density that would have been present in the area had environmental heterogeneity provided no directional bias in fish movements. [Reviewer's note: author's abstract]

KEYWORDS: fish movement / thermoregulation / ecological modeling / arctic cisco / Beaufort Sea.

Nelson, R.K. 1981. Harvest of the sea: coastal subsistence in modern Wainwright. North Slope Borough. 126 pp.

This report was based on several periods of study conducted in Wainwright between 1964 and 1981. In addition to fish, this report contains sections on birds, fox, caribou, and marine mammals used by the villagers of Wainwright. Information for the report came from observations, participation, and interviews with Wainwright people.

The habitats used for fishing included open coast, lagoon, estuary, and rivers. Lakes were not used to a great extent. Early summer fishing takes place with gill nets for salmon and arctic char along the coast and at the mouth of the Kuk River. During mid-to-late summer whitefish and arctic grayling begin moving through the Kuk Lagoon and upriver. After freeze-up, fishing through the ice with gill nets and by jigging takes place through November on the upper Kuk River tributaries, on the upper Utukok River, and on the Kukpowruk River. The Kuk River system is the most important source of fish for Wainwright. Water levels and tide movements greatly affect the movement patterns of fish in the Kuk River.

According to Nelson, the most important fish species in the Kuk River system were Bering cisco, least cisco, arctic grayling, burbot, and rainbow smelt. Commonly taken species included whitefish, sculpin, flounder, saffron cod, and arctic cod. Uncommon or rare species in the Kuk River were pink and chum salmon, arctic char, Alaska blackfish, herring, and northern pike. The major species that are caught along the coast are arctic char, pink and chum salmon, Bering cisco, and fourhorn sculpin.

Arctic graying, least cisco, rainbow smelt, and Bering cisco are the most numerous species harvested at Wainwright. Additional species caught include burbot, capelin, saffron cod, arctic cod, and arctic char, pink salmon, and chum salmon. General descriptions of seasonal movements and areas of occupancy are presented for those species harvested by Wainwright residents.

KEYWORDS: Wainwright / Kuk River / Kuk Lagoon / Utukok River / Kukpowruk River / Kungok River / Ivisaruk River / Alatakrok River / Bering cisco / Kugrua River / least cisco / arctic grayling / burbot / rainbow smelt / fourhorn sculpin / flounder / saffron cod / arctic cod / pink salmon / chum salmon / arctic char / Alaska blackfish / herring / northern pike / capelin / broad whitefish /

Netsch, N., E. Crateau, G. Love, and N. Swanton. 1977. Freshwater fisheries reconnaissance of the coastal plain of National Petroleum Resrve-Alaska (NPR-A), July and August 1977. Preliminary report. USDI: USFWS, Anchorage, Alaska. 35 pp + append.

This document reports the preliminary results of fisheries field studies conducted in the National Petroleum Reserve-Alaska (NPR-A) by the US Fish and Wildlife Service during the summer of 1977. The objectives of the study were to determine fish species composition and relative abundance, to examine age-growth relationships and stomach contents of fish, and to obtain water quality and habitat data for those lakes examined. Fish sampling methods included electroshocking, gill nets, bag seine, minnow traps, dip nets, and angling. Data sheets for each sampled lake or stream depicting sampling locations, species captures, sampling effort, water quality, and habitat information are included in an appendix. Fifty nine lakes and 30 streams were sampled during the summer of 1977. Eighteen species of fish were found during this study, the most dominant being ninespine stickleback, least cisco, arctic grayling, and lake trout. Additional species included broad, humpback, and round whitefish, fourhorn sculpin, northern pike, Alaska blackfish, longnose sucker, arctic flounder, rainbow smelt, arctic cisco, chum and pink salmon, burbot, and slimy sculpin. Of 32 lakes surveyed in the western half of NPR-A, 15 did not have fish, and of the 17 that did have fish, 13 contained only ninespine stickleback. Of the 27 lakes surveyed in the eastern half of NPR-A, all except one lake contained fish, and species other than stickleback were taken in 22 lakes. Lakes in the eastern half of the study area were generally deeper than those found in the western half. Lakes that were large, deep, clear, and with outlets were more likely to contain fish than smaller, shallow, turbid lakes without outlets. Lake trout were taken in 10 lakes in the eastern half of NPR-A, all of which were more than 4 m deep and clear. Arctic grayling were found in 19 of the 30 streams surveyed. Pink and chum salmon were found in the Kugrua River and pink salmon were found in the Chipp River. [Reviewer's Note: Refer to Hablett 1979 for the final results of this study. Refer to Bendock 1979 for information on a companion study done concurrently in the Colville River drainage.]

KEYWORDS: NPR-A / North Slope / fish surveys / ninespine stickleback / arctic grayling / lake trout / least cisco / pink salmon / chum salmon / slimy sculpin / broad whitefish.

Percy, R. 1975. Fishery resources of the Beaufort Sea, implications of offshore seismic. Prepared for Offshore seismic seminar, Yellowknife, NWT. May 12-13, 1975. Fisheries and Marine Service. Environment Canada. 11 pp.

This paper is an address to the offshore seismic seminar held on May 1975 in Yellowknife, NWT, Canada. It discusses species distribution and the importance of nearshore areas to fish and specifically points out sensitive coastal areas. Along the Yukon coast, the Herschel Island area, Phillips Bay, and the region around Shingle Point are important areas. Along the outer delta, the Kendall Island area, Mallik Bay, the northeast coast of Richards Island, and most lagoons along the west coast of the Tuk Peninsula are important areas for fish. Many of the Mackenzie River's delta channels are critical migratory routes for anadromous fish. Mallik Bay and several of the deep bays along the northeast coast of Richards Island are probably important overwintering areas. Least cisco have been taken in winter 3.2 km off Tibjak Point along the Tuk Peninsula and winter catches of humpback whitefish and boreal smelt (rainbow smelt) have been taken in Kugmallit Bay.

Most invertebrates and plankton are not adversely affected by seismic blasts, but fish with swim bladders are severely affected. The maximum lethal range of seismic charges for fish with swim bladders is of the order of 46 m for a 2.3 kg charge, 107 m for a 4.5 kg charge, and 152 m for a 11.4 kg charge. The vertical distances for the same respective charges are 46, 61, and 76 m.

Peak pressures of 40 and 60 psi have been observed to be lethal to fish with swim bladders. Pressures exceeding these limits were recorded over 67 m from a 2.3 kg charge. Internal damage including injury to kidney, liver, heart, spleen, and gonads, and under extreme cases, rupture of the body wall of fish, can be caused by underwater explosions. Fish are not always frightened from an area of seismic activity; in fact, they sometimes enter the area to feed on disturbed benthos. Multiple explosions can therefore increase mortality disproportionately.

Fish mortality increases from shots in shallow water. A 4.5 kg charge detonated in shallow water killed 14 times as many fish as one detonated in deeper water, and increasing the charge detonation depth will increase the area of fish kill. If a charge is located over a solid stratum, the lethal effect is intensified by reflection upward. There is a general reduction in the lethal effect with buried charges. Orientation of fish to the shot point has a profound effect on the severity of shock wave damage sustained. Blast mortality is not necessarily confined to any particular age or size group and delayed mortality may be extensive.

KEYWORDS: Seismic activity / fish mortality / Beaufort Sea / effects on fish / impacts.

ACTIVITY: Blasting.

IMPACT: Increase in hydrostatic pressure.

Reynolds, P. 1978. Fish collected at proposed NPR-A wellsites during August 1978. Unpubl. rept. NPR-A, Fairbanks District Office, Bureau of Land Management Fairbanks, Alaska. 10 pp.

The objectives of this field study were to obtain bathymetry, limnological, and fisheries data on lakes and rivers that had been proposed as winter water sources or ice landing strips for the 1978-1979 oil and gas exploration program in NPR-A. Sampling was conducted during August 1978 at Ikroavik Lake, a lake near the Utukok River, Smith River, Kugrua River, and Iteriak Creek. Gill nets set for 5 to 28 hrs, minnow traps set for 22 to 27 hrs, and angling were used as sampling methods. Weights and lengths were taken from most fish captured. Seventy one pink salmon and two chum salmon in spawning condition were caught in the Kugrua River. Reports of large numbers of pink salmon at the mouth of the Pitmegea River and of salmon carcasses at the Carbon Creek confluence on the Utukok River are presented. Least cisco were caught in the Smith and Kugrua rivers, and in Ikroavik Lake. All females, except for one fish from the Smith River, contained small developing eggs. One female from Ikroavik Lake was in spawning condition. Testes were small in all male least cisco that were collected. Three male arctic char, not in spawning condition, were caught in the Smith River. Two arctic grayling were caught in Iteriak Creek. Ninespine stickleback were caught in Ikroavik Lake and one juvenile sculpin was caught in the Kugrua River. No fish were caught in the lake sampled near the Utukok River.

KEYWORDS: NPR-A / Smith River / Kugrua River / Utukok River / Iteriak Creek / Ikroavik Lake / arctic char / arctic grayling / least cisco / pink salmon / chum salmon / ninespine stickleback / age and growth / spawning and reproduction.

Roguski, E.A., and E. Komarek, Jr. 1971. Monitoring and evaluation of arctic waters with emphasis on North Slope drainages: Arctic Wildlife Range study. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 12. Project F-9-3, Job G-III-A. Juneau. 22 pp.

This report gives the results of a cooperative field study between the Alaska Department of Fish and Game and the Bureau of Sport Fisheries and Wildlife conducted in 1970 in lagoons and river mouths along the Beaufort Sea coast of the Arctic National Wildlife Range [Refuge]. This was an initial survey to assess environmental characteristics and fish distribution in coastal waters of ANWR. Surveys were conducted from the U.S./Canada border to the Canning River.

Fish species captured in river mouths included arctic char, arctic grayling, fourhorn sculpin, arctic cisco, and ninespine stickleback. Fish species captured in lagoons included arctic char, arctic grayling, arctic cisco, arctic flounder, and fourhorn sculpin. Fish captured outside reefs included arctic char, arctic flounder, and fourhorn sculpin. Fish were captured with graduated mesh gill nets, dipnets, or by angling.

Salinity measurements in parts per thousand are given for locations along the Beaufort Sea coast at various times during July and August. The only correlation between salinity and fish distribution was found to involve arctic grayling which were never caught in waters with salinities greater than 1 ppt.

Length, sex, and age distributions are given for arctic char, arctic grayling, and arctic cisco.

Arctic char captured were very similar in length frequency and sex distribution to those caught at Thetis Island (Winslow & Roguski 1970), but 35% of those sampled in this study were found to be potential spawners compared to less than 2% for the Thetis Island arctic char. Arctic char were found in waters with salinity from 1 to 22 ppt.

Arctic grayling were found to lag approximately one year in linear growth when compared to Chena River arctic grayling (interior Alaska) but were similar to Sagavanirktok River arctic grayling.

Arctic cisco, like arctic char, were found along the entire coast of the Wildlife Range in salinities ranging from 1 to 22 ppt. Of 31 arctic cisco sampled, only one was less than 325 mm in fork length, with the largest being 445 mm and about half judged to be potential spawners.

It is stated that least cisco, humpback whitefish, and broad whitefish probably occur in these waters.

KEYWORDS: Beaufort Sea / Arctic National Wildlife Range / salinity / arctic char / arctic cisco / arctic grayling / broad whitefish / humpback whitefish / least cisco / fourhorn sculpin / ninespine stickleback / arctic flounder / distribution / age and growth / spawning and reproduction.

Roguski, R.A., and T.H. Nagata. 1970. Observations on the lethal effects of under ice detonations on fish. Alaska Dept. of Fish and Game Informational Leaflet No. 139. Juneau. 30 pp.

This report presents data on fish mortality induced by under ice explosive charges detonated in Blair Lake, 53 km southeast of Fairbanks, by the U.S. Army in February 1966. Alaska Department of Fish and Game took advantage of tests being conducted by the U.S. Army to monitor effects of explosions on fish.

Hatchery raised yearling chinook salmon were placed in wire mesh cages and held at various depths and distances from under ice charges, then checked and held up to 75 hours to assess immediate and delayed mortality. Resident northern pike were used in one test.

Four underwater detonations ranging from 59.3 to 64.8 kg of C-4 and one detonation of 427 kg of C-4 explosive were monitored. Northern pike placed 46 m and 76 m from a 61.4 kg charge died; rib cage, body wall, liver, air bladder, and kidney damage were noted. Damage was worse in fish nearest the charge. Lethal damage to yearling chinook salmon from a similar size charge was found in all cages closer than 137 m to the explosion, yet one fish survived at 76 m and another at 107 m. All fish died within 16 hours and 91 m of a 64.8 kg charge, and all but one fish suffered lethal effects within 91 m of a 64.8 kg charge. A 59.3 kg charge failed to cause immediate total mortality to fish confined as close as 46 m from the detonation.

The lethal range of a final shot of 427 kg of C-4, approximately 7 times larger than previous shots, was not appreciably greater. Two out of three fish at 122 m died within 21 hours, but no fish at 152 m died. Only one of four fish at 183 m died, but this fish may have died of other causes.

Northern pike suffered greater damage than chinook salmon at the same distance from charges. It is suggested that fish body size and shape may contribute to lethal effects of explosive charges.

KEYWORDS: lethal effects / underwater explosive / fish / impacts / northern pike.

ACTIVITY: Blasting.

IMPACT: increase in hydrostatic pressure.

Roguski, E.A., and P.C. Winslow. 1970. Monitoring and evaluation of arctic waters with emphasis on North Slope drainages. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 11. Project F-9-2, Job 15-C. Juneau. 23 pp.

This report presents the results of preliminary investigations of waters of the North Slope of the Brooks Range and northwestern Alaska. Helmericks' trial commercial fishery for whitefish and arctic char during July and August 1969 at the Colville River delta and Thetis Island was monitored. In 14 net days of fishing at the mouth of the west branch of the Colville River, 486 fish were taken, 394 of which were broad whitefish. In 3 net days at the mouth of the east branch of the Colville River, 158 fish were taken, 141 of which were broad or humpback whitefish. In 41 net days of fishing at Thetis Island, 366 fish were taken, 357 of which were arctic char. Pink salmon, chum salmon, flounder, northern pike, sculpin, smelt, and ciscoes were also taken, but in low numbers. Only 1.4% of Thetis Island arctic char were judged to be potential spawners, whereas 79% of Colville River arctic char were potential spawners.

Elusive, Galbraith, Itkillik, Sagwon, Teshekpuk, and two unnamed lakes were surveyed for fish presence. Lake trout, arctic grayling, broad whitefish, least cisco, and ninespine stickleback were captured, and round whitefish were observed.

Rivers surveyed included the Itkillik, Ivishak, Lupine, Upper Kuparuk, Ribdon, Toolik, and Sagavanirktok. Section Creek and an unnamed tributary of the Sagavanirktok River were also surveyed. Fish species captured in these streams included arctic char, broad whitefish, arctic grayling, round whitefish, and burbot.

In June 1969, the Wulik River was surveyed in an inflatable boat. Only five adult and one juvenile arctic char were captured. In September 1969, several large arctic char were observed, apparently spawning in the mainstem of the Wulik River. It was estimated that 8,402 arctic char weighing 8,578 kg were harvested at Kivalina in the spring of 1969.

KEYWORDS: Arctic char / lake trout / arctic grayling / burbot / broad whitefish / humpback whitefish / northern pike / harvest / distribution / age and growth / Colville River drainage / Sagavanirktok River / Kivalina

Schmidt, D.R., W.B. Griffiths, and L.R. Martin. 1987. Importance of anadromous fish overwintering habitat in the Sagavanirktok River delta, Alaska. Prepared by LGL Research Associates, Inc. for Standard Alaska Production Co. and North Slope Borough. 71 pp.

This report documents field work conducted in the Sagavanirktok and Colville rivers during the winter of 1985-1986. Five sites in the Sagavanirktok River delta and one in the Colville River delta were sampled during each of three sampling periods, 8-24 November, 27 February-16 March, and 24 April-10 May. Sampling was done with under ice gillnets and seines. Fyke nets were tried, but discontinued due to low catches. Fish densities were estimated using divers and video cameras.

Salinities in the Sagavanirktok River delta remained low (0.4-1.3 ppt) at the sampling station 12 km upstream from the coast. At a station 9 km upstream from the coast, salinities of 5 to 6 ppt were encountered, indicating the approximate upper limit of saltwater intrusion. At lower river stations (approximately 1.5 km from the coast) salinities increased from 20 ppt to 28 ppt between the November and March sampling periods. At the Colville River mouth salinities ranged from 15 to 22 ppt. Dissolved oxygen levels were high at all stations except the one located 12 km upstream on the Sagavanirktok River where they fell to 1.1 mg/L during the last sampling period resulting in a fish kill.

All least and arctic cisco were found in brackish water except one least cisco which came from a freshwater site. Most broad whitefish were found in freshwater sites.

Fish abundance estimates indicated that larger arctic cisco moved upstream between the first two sampling periods as salinity increased from 19.8 to 29.0 ppt in the lower river stations. Small arctic cisco remained in the area throughout the winter. The Sagavanirktok River delta was estimated to contain only 1.3 km of linear overwintering area whereas the Colville River delta was estimated to contain 211.9 km of overwintering habitat over 12 m in depth.

Round whitefish, least cisco, broad whitefish, and burbot were found dead in the overwintering site 12 km upstream from the mouth of the Sagavanirktok River on 26 April. Dissolved oxygen levels ranged from 0.3 to 2.7 mg/L. Arctic cisco collected in the Sagavanirktok River ranged in age from 1 to 8 years, but 2 and 4 year olds were missing. Only 34 of these fish were sampled, but age 6 and age 1 cisco were the most numerous. They represented 1985 and 1979 year classes, two years when large numbers of young-of-the-year moved into the region.

Only four least cisco were captured in the Sagavanirktok River whereas 54 were collected from the Colville River. These fish ranged in age from 5 to 13 years. Broad whitefish from both rivers ranged in age from 2 to 21 years.

Broad whitefish lost condition between period 1 and period 2; however, arctic cisco condition was higher in periods 2 and 3 than in period 1. This was attributed to the absence of lighter individuals in late season samples. It was suggested that they died although there were no dead cisco found to support the assumption. Colville River arctic cisco were in better condition than Sagavanirktok River fish. It was suggested that the coastal zone east of West Dock may provide poorer feeding habitat than the zone to the west. There was no difference in condition of

small arctic cisco between the two systems. There was little fish growth over the winter period.

All least cisco, arctic cisco, and broad whitefish examined from the Sagavanirktok River (n = 133) had empty stomachs; 25 of 27 arctic grayling and 11 of 12 round whitefish had empty stomachs. In the Colville River, of 133 fish of all species examined, only 87 had empty stomachs. Arctic cisco exhibited more winter feeding than other species.

KEYWORDS: fish overwintering / Sagavanirktok River / Colville River / condition factors / winter feeding / winter-kill / salinity.

Schmidt, D.R., R.O. McMillan, and B.J. Gallaway. 1983. Nearshore fish survey in the western Beaufort Sea: Harrison Bay to Elson Lagoon. Annual rept. Prepared by LGL Ecological Research Associates, Inc. for Juneau Project Office, NOAA/OCSEAP. 58 pp.

This paper reports the results of a fisheries survey conducted from July 23 to August 7, 1982 along the western Beaufort Sea coast from Harrison Bay to Elson Lagoon, Alaska. The objectives were to document the presence and distribution of fishes in the nearshore environment. In addition to providing catch per unit effort data for net sites and the collected species, species accounts derived from the scientific literature for the 13 species captured during this survey are presented. These species accounts provide a general overview of life history functions and distribution. Emphasis is placed upon the higher profile nearshore anadromous species: arctic cisco, least cisco, broad whitefish, humpback whitefish, arctic char, and pink salmon. Other species collected included round whitefish, Bering cisco, rainbow smelt, capelin, fourhorn sculpin, arctic flounder, and saffron cod. Anadromous catches were dominated by least cisco (42%), followed by arctic cisco (25%). Marine species were dominated by fourhorn sculpin (94%) and arctic flounder (5%). The species composition of catches along the Alaska Beaufort coastline shows some degree of similarity to each other as many of the same species (arctic char, arctic cisco, least cisco, fourhorn sculpin, and arctic flounder) reappear in independent surveys, although some disparity does exist, particularly among whitefishes. A greater number of whitefish species is found farther west along the coast as the distributions of broad and humpback whitefish are discontinuous east of the Sagavanirktok River delta, and Bering cisco are believed to range only as far east as the Colville River. The relative abundance of arctic char and arctic cisco appears to decline from east to west as these fish represented greater percentages of the overall catch in virtually all studies conducted east of Harrison Bay. These differences in fish distribution generally correspond to the east-west variation in physiography of the Alaska arctic coast and the stream types found in the eastern and western sections. West of the Colville River, the slow-moving tundra streams and coastal plain lake systems provide more suitable habitat for anadromous coregonids including least cisco, broad whitefish, and humpback whitefish. East of the Colville River, the steep gradient, braided spring and mountain streams provide spawning and rearing habitat for arctic char.

KEYWORDS: NPR-A / Elson Lagoon / Harrison Bay / Beaufort Sea / Colville River / distribution / life history / pink salmon / arctic char / arctic cisco / least cisco / broad whitefish / humpback whitefish / round whitefish / Bering cisco / rainbow smelt / capelin / arctic flounder / fourhorn sculpin / age and growth / good habits / spawning and reproduction / harvest / movements / overwintering.

Sekerak, A.D., W.B. Griffiths, and N. Stallard. 1985. Aquatic investigations in response to dredging in the Meade River, Alaska. Prepared by LGL Limited, Environmental Research Associates for Materials Source Division, North Slope Borough, Barrow, Alaska. 158 pp + append.

This report discusses the results of aquatic field studies conducted from 1983 to 1984 in the Meade River adjacent to the village of Atqasuk. The objectives of this study were to investigate the effects of gravel dredging on water quality and fish migrations in the Meade River, to obtain information on basic life history patterns of important fish species in the Meade River, to document the fish resources in areas adjacent to Atqasuk, and to obtain estimates of the harvest in the Atqasuk subsistence fishery. Field sampling was performed primarily from June 3 to September 19, 1983, May 1984, and August 1984. Species of fish observed during this study were arctic lamprey, arctic grayling, least cisco, humpback and broad whitefish, longnose sucker, burbot, slimy sculpin, and ninespine stickleback. Information concerning distribution, movements, age, growth, spawning, sexual condition, taxonomy, and food habits are presented for least cisco and humpback whitefish. Distribution, movement, and length data are presented for arctic grayling. Distribution and movement data are presented for broad whitefish and burbot.

The activity of dredging produced documented impacts of changes in turbidity and suspended sediments, change in water depth, and addition and removal of substrate materials. In mid-summer, turbidities and suspended sediments were approximately 25 and 50 times greater, respectively, than background levels. Increased levels of turbidity and suspended sediments extended at least 60 km downstream of the dredge site. The greatest contribution of increased sediments came from excess water draining from the gravel stockpile rather than from the dredge per se. Sediment samples taken in May and August 1984 indicated that sediments from dredging, up to several centimeters thick, covered the river bottom during the winter of 1983-1984, but were scoured away during the 1984 breakup period. It was presumed that the fine sediments from dredging created less than ideal conditions for least cisco egg incubation, although adverse effects of the dredging on whitefish spawning have yet to be documented. Net catches indicated that natural fish movements and migrations were not hindered or stopped by dredging activities. Larval arctic lamprey were found in the gravel stockpile; however, no other fish species were entrained by dredging activities. The subsistence fishery from the Meade and Usuktuk rivers harvested an estimated 4,500 kg of fish during 1983. Humpback whitefish and least cisco were the most important species, representing over 95% of the gill net catch.

KEYWORDS: Atqasuk / Meade River / Usuktuk River / NPR-A / dredging / subsistence / impacts / arctic grayling / least cisco / humpback whitefish / broad whitefish / burbot / arctic lamprey / longnose sucker / slimy sculpin / ninespine stickleback / distribution / age and growth / life history / movements / spawning and reproduction / taxonomy / food habits.

ACTIVITY: dredging

IMPACTS: change in depth of water; change in turbidity and suspended sediments; addition and removal of substrate materials; entrainment.

Silva, J.B., L.G. Adams, and R. Gal. 1985. Habitat evaluation for Teshekpuk Lake Special Area study. Arctic Resour. Area, U.S. Dept. Interior, Bureau of Land Management, Fairbanks, Alaska. 135 pp + append.

The biological resources occurring on the Teshekpuk Lake Special Area (TLSA) are identified and some of the potential impacts of oil and gas are described. A number of deep lakes that provide year around habitat for fish occur south of Teshekpuk Lake. Lakes in this area that are greater than 4 m deep are identified on a topographical map. Major species of fish that occur within the TLSA include arctic grayling, broad whitefish, humpback whitefish, least cisco, arctic char, and lake trout.

Fishing is cited as probably the most significant subsistence activity on the TLSA. Arctic char, smelts, and arctic cisco are harvested along the ocean and bay shores. Fishing takes place throughout the summer and some native allotments are occupied from June through October for fishing. The greatest fishing effort takes place in the fall with nets set through the ice. Some of the areas and specific sites used for fishing are identified on a map.

KEYWORDS: Teshekpuk Lake/ NPR-A/ North Slope/ arctic char/ arctic grayling/ broad whitefish/ humpback whitefish/ least cisco/ lake trout/

Skvorc, P.A., and W.J. O'Brien. 1981. Toxic effects of Prudhoe Bay crude oil to arctic freshwater zooplankton and arctic grayling. Unpubl. rept. Univ. Kansas, Lawrence. 13 pp.

This paper reports the results of laboratory experiments conducted to determine the lethal and sublethal toxicity of Prudhoe Bay crude oil to common arctic zooplankton and arctic grayling. Experiments were performed at the Toolik Lake Research Area, about 240 km south of Prudhoe Bay, Alaska. Dates when the study was conducted were not provided. The sizes of the arctic grayling used in the study were also not provided. Although this study did not occur within NPR-A, the effects of oil spills on arctic grayling and zooplankton within NPR-A would likely be similar.

In situations modeling realistic oil spills, fish as small as 60 mm were not killed as a direct result of very large simulated spills (5.0 L/m^2). No minimum lethal dose was found for arctic grayling. At dosage levels of 7.5 ml/L, respiration rates of arctic grayling declined a maximum of 39%, with a maximum effect at or near 12 hrs after exposure to oil. Three days following exposure to oil, the respiration rate had returned to pre-exposure levels.

Toxicity bioassays indicated that exposure to soluble fractions of Prudhoe Bay crude oil was very harmful to arctic freshwater zooplankton. Toxic components of oil were passively taken up at different rates by each species of zooplankton tested. Those species of zooplankton with large surface area to volume ratios were most susceptible to toxic components. Zooplankton exposed to sublethal doses of oil (0.06 ml/L) experienced decreases in filtering rates of 86%, with filtering rates returning to only 80% of the unexposed animals after 5 days and remaining at this level. Zooplankton exposed simultaneously to oil and zooplankton exposed to the oil/water mix six hours after the oil was added, showed the most marked rates of mortality. As time after the spill increased, the mortality decreased until there was no difference between control mortality and those zooplankton exposed to the oil/water mix for 48 hrs or more. The authors suggested that oil spills during fish spawning periods could be particularly destructive, and removal of zooplankton and other invertebrates from the food web could have considerable and lasting effects. They also suggested that if an oil spill took at least 24 hrs to reach an aquatic system, the spill's effects on aquatic organisms would be negligible, because most of the toxic components would have evaporated or broken down.

KEYWORDS: arctic grayling / zooplankton / oil spills / toxicity / impacts

ACTIVITY: transport of oil; gas; water - land and water.

IMPACTS: change in level of hydrocarbons.

Sloan, C.E. 1976. Fresh water fish and their winter habitat in NPR-4. Anadromous fish study. Memorandum to Officer in Charge, Naval Petroleum Reserve No. 4. 29 pp.

The purpose of this review paper was to examine information discussing the overwintering habitat of freshwater fish in Naval Petroleum Reserve No. 4 (currently NPR-A), as a means of locating known overwintering habitat and easing restrictions on seismic operations. A brief description of the hydrology of the area, along with a list of lakes, their locations, and depths is presented. A brief discussion involving the use of satellite imagery to delineate aufeis fields and depths of lakes is also presented. Brief life history and distribution information is presented for arctic and least cisco, arctic grayling, arctic char, broad, humpback, and round whitefish, burbot, and lake trout. [Reviewer's note: This paper provides a general and not very useful description of the fishery resources of NPR-A, and should not be considered a definitive review of the fishery resources of NPR-A.]

KEYWORDS: NPR-A / review / hydrology / imaging / life history / distribution / arctic grayling / arctic char / least cisco / arctic cisco / broad whitefish / round whitefish / humpback whitefish / burbot / lake trout.

Smith, M.W., and R.S. Glesne. 1982. Aquatic studies on the North Slope of the Arctic National Wildlife Refuge 1981 and 1982. Fish. resour. prog. rept. FY83-1. USFWS, Fairbanks,Alaska. 71 pp.

This report discusses findings of fisheries investigations conducted in 1981 and 1982 on the coastal plain of the Arctic National Wildlife Refuge in the drainages of the Canning, Tamayariak, Katakturuk, Sadlerochit, and Aichilik rivers. The physical characteristics, fish distribution, spawning, overwintering, and movements are discussed for each stream. In addition, age, weight, length, growth, and catch rates are described for the most important species. The Canning River contained the most diverse species composition with arctic cisco, arctic char, arctic grayling, round whitefish, burbot, lake trout, ninespine stickleback, chum, pink and sockeye salmon being present, but only arctic grayling, arctic char, and round whitefish were abundant. Arctic grayling and arctic char were distributed throughout the system and round whitefish were found in all areas except coastal tributaries. The authors estimated that the population in a small coastal tributary was 1,420 juvenile arctic char per hectare with a standing crop of 23 kg/hectare.

Arctic grayling spawning areas were not located, but arctic char spawning areas were found associated with ground water sources in the Marsh Fork and in the Canning River above the Marsh Fork. Concentrations of overwintering arctic char were found in the Marsh Fork and the mainstem of the Canning River above and below the Marsh Fork confluence. Aerial surveys gave estimates of 39,000 arctic char overwintering in the system.

Two arctic grayling and one round whitefish tagged in the lower river were recaptured in September a year later near Shublik Springs, 59.5 km upstream of where they had been tagged. Seven arctic char were fitted with radiotransmitters and tracked from October to April. Most fish moved downstream only a few kilometers, but one moved 6.4 km upstream through an aufeis field.

Only arctic grayling and ninespine stickleback were found in the Tamayariak River. Arctic grayling were found throughout the system with larger fish being captured in downstream sites. Overwintering locations were not documented in the Tamayariak River. The authors stated that the few available overwintering areas were probably restricted to the lower reaches of the river. One arctic grayling tagged in the Canning River in 1981 was recaptured in the Tamayariak River in 1982, indicating that some inter-system movement occurs.

Only one arctic char and one ninespine stickleback were captured in the Katakturuk River. Arctic char, arctic grayling, lake trout, ninespine stickleback, and pink salmon are present in the Sadlerochit River drainage. Lake resident arctic char and lake trout occur in Peters and Schrader lakes at the headwaters of the Sadlerochit River. Of the arctic char captured, only one was thought to be anadromous; other arctic char were stream residents associated with Sadlerochit Springs. Arctic grayling were widely distributed throughout the drainage.

Arctic grayling spawning areas have been located in small tundra stream tributaries to the main river and in the outlet from and tributaries to Peters and Schrader lakes. The only overwintering habitat occurs in Peters and Schrader lakes and in Sadlerochit Springs. Little was learned about fish movements in Sadlerochit River; of 548 arctic grayling tagged in two years, none were recaptured.

Arctic grayling and anadromous arctic char were captured in the Aichilik River. An estimated 2,000-4,000 arctic char were seen in an overwintering concentration just downstream from a spring area. Pool habitats, presumed to be overwintering areas, were limited to the vicinity of two spring areas.

An index was developed to determine the extent of overwintering habitat in streams. Adequate overwintering area was considered in unbraided channels with a stream gradient less than 4% and stream order greater than 4. This index corresponded to observed fish distributions in streams. The index did not consider spring areas.

KEYWORDS: Arctic National Wildlife Refuge / Canning River / Tamayariak River / Katakturuk River / Sadlerochit River / Aichilik River / water chemistry / stream order / arctic char / arctic grayling / round whitefish / age and growth / distribution / spawning / overwintering /ninespine stickleback /sockeye salmon / chum salmon / pink salmon.

Steigenburger, L.W., G.J. Birch, P.G. Bruce, and R.A. Robertson. 1974. Northern Yukon freshwater fisheries studies, 1973. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Rep. No. 74-20. 51 pp.

This report presents results and conclusions from studies conducted in 1973, the third year of field investigations along two proposed pipeline routes across the Yukon Territory. The northern route parallels the Beaufort Sea coast for approximately 24 km of the shoreline, whereas the southern route roughly parallels the north bank of the Porcupine, Bell, and Rat rivers. The latter section of the report summarizes recommendations on route selection, guidelines for stream crossings and construction activities, and recommendations for additional related research. Specific species of fish are usually not discussed in this report, rather the report discusses important fish habitat areas without reference to the fish species found in those areas. Critical areas are identified for both route choices with an emphasis on potential or known fish spawning and overwintering sites. Groundwater sources, aufeis areas, stream sections near river mouths and estuaries were noted as being of greatest potential importance to fish along the northern route. Locations of site specific investigations are given. Deeper lakes with fish populations are also mentioned as areas of concern. The need for further investigation, particularly in estuarine environments, was pointed out. In the Porcupine River system, carrying capacity is limited by adequate overwintering areas. The Old Crow River was identified as a major pathway to overwintering sites in the Porcupine River. Areas important for overwintering include groundwater-fed streams, mainstems of larger rivers, smaller streams with adequate winter flow, and lakes of sufficient depth. Several smaller Porcupine River tributaries were frozen to the bottom or had very low dissolved oxygen levels and were judged uninhabitable. Winter data from northern route streams in the vicinity of proposed crossing sites are given with the recommendation for future study.

Although there were few documented fish migrations, streams used as migration routes to spawning or overwintering areas were deemed as critical as the spawning and overwintering areas. It was also stated that because there are few fish species present, particularly along the northern route, the chain of interdependence of species is short and elimination of any species may have profound effects on others. Therefore, measures should be taken to protect all species. The northern route was the preferred choice from a biological perspective. The northern route has a larger proportion of the drainages and critical areas above crossing sites than the southern route; therefore, it was determined that environmental disruption along the northern route would have a lesser impact on critical areas.

Engineering aspects and stipulations for timing of construction, gravel removal, water use, and future resource use are discussed. The final section of this report addresses information deficiencies and recommends further studies.

KEYWORDS: northern pipelines / critical habitat / Porcupine River / Beaufort Sea / overwintering habitat / spawning areas / Babbage River / Firth River / Old Crow River / engineering considerations.

Stein, J.N., C.S. Jessop, T.R. Porter, and K.T.J. Chang-Kue. 1973. Fish resources of the Mackenzie River valley. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Fish. Serv. Winnipeg, Manitoba. 260 pp.

This report presents biological data on fish collected in the Mackenzie River drainage during field studies conducted in 1971 and 1972. These studies were conducted to provide information for the assessment of pipeline proposals.

Information on abundance, distribution, migrations, spawning, food habits, age, and growth are provided for the most abundant fish species. Distribution ranges were extended significantly northward for mountain whitefish, lake cisco, northern redbelly dace, brook stickleback, and goldeneye.

The Mackenzie River drainage contains many arctic fish species and other fish species not found in Alaska. This study, although not totally applicable to arctic Alaska, contains valuable information that can be compared with data from Alaska.

KEYWORDS: Mackenzie River / fish surveys / distribution / migrations / spawning / food habits / freshwater fish / anadromous fish / arctic char / lake trout / humpback whitefish / broad whitefish / round whitefish / arctic cisco / northern pike / burbot.

Tripp, D.B., and P.J. McCart. 1974. Life histories of grayling (*Thymallus arcticus*) and longnose suckers *(Catostomus catostomus)* in the Donnelly River system, Northwest Territories. Chap. 1 *in* P.J. McCart, ed. Life histories of anadromous and freshwater fish in the western Arctic. Arctic Gas Biol. Rep. Ser. Vol. 20. 91 pp.

This report summarizes field research conducted in 1972 and 1973 in the Donnelly River system, an eastern tributary to the Mackenzie River to be crossed by a proposed gas pipeline. Data in this report describes the life histories of arctic grayling and longnose suckers in this river system. Much information presented is specific to this river system and not appropriate to NPR-A. Some life history aspects, however, are relevant to species common to both areas.

The aging of both arctic grayling and longnose suckers was done using otoliths that were found to give higher ages than scales for larger fish and were considered to be superior to scales. Arctic grayling spawning occurred soon after breakup, with mature arctic grayling moving upstream from the Mackenzie River by May 10. The first ripe male arctic grayling was captured on May 24 and the first ripe female on May 29. The first spent arctic grayling were captured on May 31. Water temperatures were warming at this time and ranged from 4^{o} C on May 26 to 11.5^{o} C on June 2. More than 90% of grayling were mature at age 4 for males and age 5 for females, although some of each sex were mature at age 2.

Arctic grayling that used small tributary streams for spawning left soon after spawning was completed. Arctic grayling that spawned in the main stream and lake area remained in that vicinity for as long as one month after spawning, then moved downstream. There was no upstream movement of arctic grayling after August 8.

It was considered unlikely that arctic grayling overwintered in the Donnelly River and it was suggested that they moved to the Mackenzie River. Reproductive homing was also suggested, but could not be shown conclusively from the data available. Data on food habits are given.

Longnose suckers began spawning about June 6 at water temperatures of about 16^{o} C. After one month fry concentrations were found downstream of spawning areas. Scale formation began on sucker fry over 39 mm. It is suggested that slower growing fry might not form scales in the first year. Otoliths were preferred to scales for aging and gave consistently older ages. Longnose suckers as old as 22 years were found, and they ranged in length to 585 mm. Fecundity of longnose suckers from 425-525 mm ranged from 23,935 to 107,998 eggs. The youngest mature females were age 12 and the youngest mature males were age 9.

After spawning, longnose suckers generally moved downstream dispersing throughout the river system; some even left the river entirely and moved into the Mackenzie River. A fall downstream movement was noted from September 12 through October 3, presumably to overwintering areas in the Mackenzie River.

KEYWORDS: Mackenzie River / Donnelly River / arctic grayling / longnose sucker / age and growth / spawning / movements / life history.

Ward, D., and P. Craig. 1974. Catalogue of streams, lakes, and coastal areas in Alaska along the proposed gas pipeline from Prudhoe Bay, Alaska to the Alaskan/Canadian border. Prepared by Aquatic Environments Ltd. Arctic Gas Biol. Rept. Ser. Vol. 19. 381 pp.

This report consists of a series of survey forms from lakes, lagoons, and streams surveyed along the proposed routes of the gas pipeline from Prudhoe Bay into Canada. Each survey form contains sections on assessment, fish, winter conditions, water chemistry, and benthic invertebrates. For most survey sites only the assessment, fish, and water chemistry sections are included. Most data are from surveys conducted from 1970-1973, although some are from as early as 1959.

Surveys were completed on 29 inshore habitats, 14 North Slope lakes, 37 North Slope streams, 34 stream sites in the Canning River drainage, 13 Canning River springs, 13 Canning River drainage lakes, 20 South Slope streams, and 17 South Slope lakes.

KEYWORDS: Lake surveys / stream surveys / North Slope / South Slope / arctic gas / gas pipeline.

West, R.L., and D.W. Wiswar. 1984. Fisheries investigations on the Arctic National Wildlife Refuge, Alaska, 1984. Fairbanks fish. resour. prog. rept. No. FY85-1. USFWS, Fairbanks, Alaska. 47 pp.

This report presents fisheries data collected in field studies in the Arctic National Wildlife Refuge in 1984. Information on seasonal abundance, age, and food habits of coastal fish in Beaufort Lagoon, arctic char distribution in the Hulahula River, fall movements of arctic char in the Aichilik River and arctic grayling movements to overwintering sites are addressed.

Sampling was conducted in Beaufort Lagoon, 60 km southeast of Barter Island on June 20-29, July 23-31, and August 21-28 using directional fyke nets, gillnets, and a dipnet at five sampling locations. Species captured included arctic char, arctic cisco, least cisco, ninespine stickleback, boreal smelt (rainbow smelt), fourhorn sculpin, saffron cod, arctic cod, arctic flounder, and a species of eelpout. Arctic char made up 37% of the total catch and were most abundant at the inside barrier island station in July. They were moving west at this time. Arctic cisco were the second most numerous anadromous fish captured and were most abundant at mid-lagoon and inside barrier island sites. Fourhorn sculpin were the most abundant marine fish and ranked second in abundance of all fish. They were most abundant at nearshore mainland net stations. Arctic flounder accounted for only 3% of the catch. Saffron cod were numerous at the nearshore mainland station in August, and least cisco were abundant in the lagoon in August.

Arctic char ranged in age from 3+ to 13+ years, 27% were age 7+, and 63% were females. Arctic cisco ranged in age from 4+ to 10+ years, 50% were age 6+, and 55% were females. Fourhorn sculpin ranges in age from 1+ to 11+ years, 74% were between 1+ and 4+ years and 64% were males.

Gammarid amphipods were the most important food item of arctic char with fish ranking second. Fish species present in stomach samples included ninespine stickleback, sculpin, arctic cod, and eelpout. Mysids and gammarid amphipods ranged first and second in importance to arctic cisco diets.

Distribution of arctic char in the Hulahula River was investigated using radio transmitters in adults and with a float survey in July. Radio-tagging in a known overwintering area showed that only one of 29 implanted arctic char left the area. This fish moved to another known overwintering area, Fish Hole 3. Gillnets fished just downstream of Fish Hole 2 produced arctic char from 282 mm to 550 mm. Juvenile were observed throughout the area. During a July float survey, juvenile arctic char were captured throughout the river system and no adults were seen or captured. Large numbers of adult arctic char were concentrated in overwintering areas from August to June. Arctic grayling were observed in spring areas at Fish Hole 2 and Fish Hole 3. Eight were captured ranging in age from 3+ to 6+ years and in length from 224 to 294 mm.

Five large adult arctic char were radio-tagged in the lower Aichilik River. Three of them were located at a spawning/overwintering site 65 km upstream. The other two could not be located after 8/18/84. This is the only known site of its kind in the Aichilik River.

Fifteen radio transmitters were implanted in arctic grayling on Itkilyariak Creek, 3 on the Akutokak River, and 11 on the lower Tamayariak River from 1-19 August. Arctic grayling from Itkilyariak Creek were in the Sadlerochit River by late

August and by October 30. One was in Schrader Lake and two were in the Kekiktuk River 5 to 6 km below the lake outlet. Two of the three arctic grayling tagged on the Akutokat River were relocated on November 1 in the Hulahula River. Of the 11 arctic grayling tagged in the Tamayariak River, 5 were relocated on September 18, all in the Canning River. These fish exhibited major fall movements to overwintering areas in larger river systems.

KEYWORDS: ANWR / fisheries studies / Beaufort Lagoon / arctic char / arctic grayling / distribution / movements / radio-telemetry.

Whitmus, C.J., T.C. Cannon, and S.S. Parker. 1987. Age growth and condition of anadromous fish. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 7. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 34 pp.

This report presents the results of laboratory scale analysis of growth of arctic cisco in the central Beaufort Sea. Length-weight relationships are additionally provided for broad whitefish, least cisco, and arctic char.

The results of this study indicate that the growth pattern of arctic cisco is similar to that observed in prior studies and that there were no differences in growth between areas along the Beaufort Sea coast. [Rev. note: This is in contrast to Moulton et al. 1985, who showed reduced growth of Sagavanirktok River arctic cisco compared to Colville River arctic cisco.]

The number of circuli to the first annulus on arctic cisco scales showed two patterns, one had the first annulus at 3 to 5 circuli and the other had the first annulus at 9-10 circuli. It was suggested that these two patterns may represent two different stocks of cisco.

It was felt that fish collected after August 15 were best for comparative growth purposes because most growth had taken place by that time, and because early season growth was more variable.

The condition of broad whitefish, arctic cisco, and least cisco was not different from that found in earlier years prior to the construction of the Endicott causeway.

KEYWORDS: Central Beaufort Sea / Endicott Causeway / age and growth / least cisco / arctic cisco / broad whitefish / arctic char.

Wilson, W.J., E.H. Buck, 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. Prepared by Arctic Environmental Information and Data Center, Univ. Alaska, Anchorage for Office of Biological Services, USFWS, USDI, Anchorage, Alaska. FWS/OBS - 77/06. March 1977. 221 pp + append.

This review paper attempts to assemble all available information related to fish overwintering, wildlife use of unfrozen water during winter, and winter water conditions north of the crest of the Brooks Range from Cape Lisburne on the west to the Canadian border on the east; to describe development activities that require water in winter and to estimate the amounts needed; to summarize existing regulations and agency responsibilities governing water use; to assess current and future winter water conflicts between man and fish or wildlife; and to present known or possible solutions and data gaps in order of priority. References reviewed date to the late 1800's, although most references concerning fish were from the 1970's. This report presents a description of the distribution and types of waters present in the arctic, describes seasonal availability of water, and describes water quality during winter. A discussion of aquatic habitats required and used by fish for overwintering, including rivers, streams, lakes, and springs, is presented. Detailed species accounts discussing life history, distribution, migration, overwintering, and reproduction are presented for arctic char and arctic grayling. Less detailed accounts are presented for arctic, least, and Bering cisco, Alaska blackfish, rainbow smelt, longnose sucker, ninespine stickleback, slimy sculpin, broad, humpback, and round whitefish, lake trout, pink and chum salmon, burbot, and northern pike. Data concerning the locations of known and potential overwintering sites for fish for lakes and streams, the locations of deep lakes and of springs, and the locations of areas of aufeis conditions are also presented on a summary map of the Alaska arctic at a scale of 1: 500,000. The species of fish known and suspected to occur in the known and suspected overwintering areas are also presented on the map. The amounts of water used by villages, military installations, and petroleum exploration and development are presented. Conflicts between fish and wildlife and human or industrial requirements in the arctic are also discussed. This discussion focuses primarily on water withdrawal from water sources used by overwintering fish, and describes documented and potential impacts to aquatic and terrestrial life when and if water is withdrawn from rivers, lakes, and perennial springs. Short discussions concerning water use regulations, state and federal agency responsibilities, possible solutions to water use conflicts, and information gaps are also presented.

KEYWORDS: Alaska / NPR-A / water use / overwintering / aufeis / arctic char / arctic grayling / arctic cisco / least cisco / broad whitefish / humpback whitefish / round whitefish / lake trout / burbot / northern pike / pink salmon / chum salmon / Bering cisco / rainbow smelt / longnose sucker / ninespine stickleback / slimy sculpin / Alaska blackfish / life history / migration / spawning and reproduction / population dynamics / food habits / distribution.

ACTIVITY: water regulation / withdrawal / irrigation .

IMPACT: change in depth of water.

Winslow, P.C. 1969. Inventory and cataloging of sport fish and sport fish waters in interior Alaska - char in northwestern Alaska. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 10. Project F-9-1, Job 15-A. Juneau. 14 pp.

This report presents the results of a field study of anadromous arctic char [these fish have since been shown to be Dolly Varden char, *S. malma*, Behnke 1980], that was initiated in August of 1968 on the Wulik and Kivalina rivers near Kivalina, Alaska.

Otoliths from 139 arctic char collected in the Wulik River gave a range in age from 3 to 16 yr for fish from 284 to 835 mm in fork length. Arctic char from ages 3 through 9 were most prevalent in the sample with only 5 over 10 yr of age present.

Stomach samples from 52 arctic char taken in September from the Wulik River indicated that they do not feed in freshwater. These fish had recently immigrated from the sea and 49 had empty stomachs. Three stomachs contained unidentified debris.

In an aerial survey flown on September 16, 1968, there were 90,235 arctic char counted in the Wulik River and 27,460 counted in the Kivalina River.

Other fish species identified from the Wulik River included chinook salmon, coho salmon, chum salmon, pink salmon, arctic grayling, Alaska blackfish, and whitefish [probably humpback whitefish that are common in the lower reaches of the Wulik River in the fall].

Kivalina subsistence fishers took an estimated 54,430 kg of arctic char (49,500 fish) from the Wulik River with seines in the autumn of 1968.

A sample of 462 arctic char was measured from this harvest. The fork length of the fish ranged from 241 to 860 mm. The majority of this sample was from 300-500 mm in length.

It was estimated that 70 to 80 sport angler trips were made to the Wulik River in 1967 and 50 to 60 in 1968. Nearly all the sport fishing took place in the fall when arctic char move from salt to fresh water.

Eight arctic char were collected from the Anaktuvuk Pass area, three from Grayling Creek, a tributary of the Anaktuvuk River, and five from Ekokpuk Creek, a tributary of the John River.

KEYWORDS: arctic char / Wulik River / Kivalina River / age and growth / food habits / harvest / migrations / population dynamics / Kivalina.

Wohlschlag, D.E. 1953. Some characteristics of the fish populations in an arctic Alaskan lake. Pages 19-29 *in* I.L. Wiggins, ed. Current biological research in the Alaskan arctic. Vol 11. Stanford Univ. Publ. Univ. Series. Biological Sciences. Stanford, CA. 55 pp.

This paper reports the results of field research conducted during the summer of 1952 on the fishes of Ikroavik Lake, a lake approximately 9.5 km south of the Naval Arctic Research Laboratory at Barrow. The purpose of this study was to determine the magnitude and some of the characteristics of fish populations in Ikroavik Lake and to relate these determinations to possible future development of freshwater fishery resources of the area. Population estimates were made for *Leucichthys [Coregonus] sardinella* [least cisco] and round whitefish. Data concerning reproductive condition and weight were reported for least cisco and round whitefish. Spawning of least cisco was reported to occur in late summer or autumn and quite possibly under the ice, with the young hatching under the ice during winter. Round whitefish were reported to spawn and hatch shortly after the ice melts in early summer. Ninespine stickleback were also present in the lake but were not sampled. Two ripe adult male chum salmon were collected in the lake and were assumed to be strays.

KEYWORDS: NPR-A / Barrow / Ikroavik Lake / round whitefish / least cisco / chum salmon / age and growth / population dynamics / spawning and reproduction.

Wohlschlag, D.E. 1954. Growth peculiarities of the cisco, *Coregonus sardinella* (Valenciennes), in the vicinity of Point Barrow, Alaska. Stanford Ichthyological Bulletin 4:189-209.

The purpose of this field research paper was to describe differences in growth patterns and body forms of least cisco that occur in both marine and freshwater populations at Point Barrow, Alaska. Lengths and weights were recorded for samples of least cisco collected in July 1951 and 1952 in Elson Lagoon. Lengths and weights were also recorded for least cisco collected at Ikroavik Lake from July through September 1952. Results indicated differences in the amount of stored body fat: lake fish had large amounts of visceral fat, whereas marine fish did not. Lake fish were generally heavier than marine fish for any given length above 180 mm. Environmental differences between lacustrine and marine environments, such as salinity, temperature, food supply, and space, were considered possible factors creating the differences in growth patterns and body form that occur in least cisco at Point Barrow.

KEYWORDS: Barrow / NPR-A / Ikroavik Lake / least cisco / age and growth.

Wohlschlag, D.E. 1954. Mortality rates of whitefish in an arctic lake. Ecology 35(3):388-396.

This paper reports the results of field research conducted on least cisco and broad whitefish from July 15 through September 1952 at Ikroavik Lake near Barrow, Alaska. The purpose of the study was to determine rates of mortality for the estimated 5,700 least cisco and 200 broad whitefish (having fork lengths in excess of 180 mm for both species) found in this lake. Results of the study indicated that least cisco of ages 8 to 11 died at greater rates than did fish of ages 5 to 8. This increased rate of mortality for fish of ages 8 to 11 was proposed to have resulted from increased mortality associated with spawning. Death rates of least cisco during summer were almost twice those projected for the remainder of the year. It was observed that the higher summer death rates corresponded to the season when water temperatures were highest. Data were insufficient to estimate mortality rates for broad whitefish.

KEYWORDS: least cisco / population dynamics / Ikroavik Lake

Wohlschlag, D.E. 1957. Differences in metabolic rates of migratory and resident freshwater forms of an arctic whitefish. Ecology 38(3):502-510.

This paper reports the results of laboratory experiments designed to determine possible differences in metabolic rates between least cisco from a freshwater lake and migratory least cisco from marine waters that could account for differences in body fat and body weight. The study was conducted at Barrow from July to September 1954, and used least cisco from Ikroavik Lake, and least and arctic cisco from Elson Lagoon. Ciscoes used in the experiments ranged in weight from 104 to 365 gm. Results of the study indicated that the more slender migratory forms of least cisco in marine waters had higher respiratory and metabolic rates over the body weight, temperature, and activity ranges studied than did fatter, deeper bodied least cisco isolated in a freshwater lake. The total seasonal energy expenditure by a migratory least cisco was proposed to be greater than a lake resident least cisco because of increased energy requirements in marine waters for osmoregulation, seasonal migrations, and a generally higher level of activity because of currents in marine waters. These factors were proposed as the reason why lake resident least cisco are fatter and deeper-bodied than the migratory forms. Arctic cisco from Elson Lagoon, in contrast to least cisco, were very fat suggesting that a more complete whitefish adaptation to marine habitats is accomplished by lowered metabolism and more fat accumulation.

KEYWORDS: Ikroavik Lake / Elson Lagoon / arctic cisco / least cisco / physiology.

Yoshihara, H.T. 1972. Monitoring and evaluation of arctic waters with emphasis on the North Slope drainages. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 13. Project F-9-4, Job G-III-A. Juneau. 49 pp.

This report presents data collected during field studies in the summer of 1971 in the Sagavanirktok River drainage. Data are presented from surveys conducted on waterways scheduled to be crossed by the Trans-Alaska pipeline and Haul Road [Dalton Highway]. Physical, chemical, and biological characteristics of streams are presented. Counts from aerial surveys to determine distribution and relative abundance of arctic char are included as are some aspects of arctic char life history.

Data are presented on 64 streams or reaches of streams to be crossed by the pipeline or Haul Road. Data include fish species presence, timing of migration, fish productivity (low, medium, or high as determined by the relative abundance of fish at the time of the survey) and survey status 1, 2, or 3 (1 = adequate survey, 2 = only some knowledge of fish presence, 3 = not extensively surveyed or aircraft survey). Fish species encountered in these surveys included arctic char, arctic grayling, arctic cisco, pink salmon, chum salmon, broad whitefish, least cisco, burbot, ninespine stickleback, round whitefish, and slimy sculpin. The standing crop of fish was estimated on sections of five streams to be crossed by the Haul Road and ranged from 4.5 to 94.3 kg/ha. Physical characteristics are listed for 29 pipeline stream crossing sites.

All major Sagavanirktok River tributaries were surveyed. Only Gilead Creek was found to contain no fish. Arctic grayling were found in all other tributaries, and arctic char were found in all others except the Atigun River. Aerial survey estimates of numbers of arctic char in Sagavanirktok River tributaries ranged from 11 in Section Creek to 20,994 in the Ivishak River. The length frequencies of arctic grayling, round whitefish, and arctic char are given. It is suggested that overwintering habitat in the Sagavanirktok River is very limited. Fish movements were monitored with a weir on the Lupine River. Arctic grayling movements were found to correlate with water temperature; a definite downstream movement occurred shortly after minimum water temperatures reached 0^{o} C. Food habits of arctic grayling are presented; chironomids (Diptera) were both most numerous and probably constituted the greatest bulk of food items. The round whitefish movement out of the Lupine River was similar to the arctic grayling out-migration. Spring out-migration of arctic char occurred soon after breakup with some out-migrants being caught in the delta on June 17 and 18. Arctic char migrating to sea for the first time ranged in age from 0 to 7. Arctic char moved into the Sagavanirktok River beginning in mid-August. Upstream catches in the Lupine River reached a peak on August 25. Spawning and nonspawning arctic char were segregated in the Ivishak River, with spawners being concentrated in the vicinity of groundwater sources. The modal size of 3361 Sagavanirktok River arctic char was 460 mm.

KEYWORDS: Sagavanirktok River / Lupine River / Accomplishment Creek / Ivishak River / stream crossings / pipeline / Haul Road / survey / arctic grayling / round whitefish / arctic char / life history / length-frequency / movements / spawning / tagging.

Yoshihara, H.T. 1973. Monitoring and evaluation of arctic waters with emphasis on the North Slope drainages. Part A: some life history aspects of arctic char. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 14. Project F-9-5, Job G-III-A. Juneau. 63 pp.

This report presents results of a field study of arctic char conducted on the Sagavanirktok River in the vicinity of the then proposed Trans-Alaska oil pipeline and adjacent Haul Road during 1971 and 1972.

Age and growth of males and females were determined from 1,831 pairs of otoliths. As a further aid in age determination, 3,571 length measurements were obtained from otoliths. Natural mortality usually occurs by age 11, although two females collected were age 18. Length frequencies of arctic char from various locations of the Sagavanirktok River drainage are presented and discussed. No fork length:body weight difference is realized between the sexes of arctic char. Mean length and weight for 1,331 arctic char greater than 200 mm was 444.1 mm and 947.0 gm, respectively.

Spawning is discussed in relation to spawning period, age composition, and sex ratios. A description of an arctic char redd is presented along with descriptions of ripe ova and deposited ova. Female arctic char begin to develop productive gonads when mean ovum diameters are 2.6 mm with a maturity index of about 5.0%. Age at maturity begins at age 6 (2.4%) for females. By age 7, 38% are potential spawners and 69% are potential spawners at age 8. Relationships affecting fecundity are discussed and regression formulas for calculating fecundity were developed. Calculated number of ova for 336 females ranged from 2,554 to 7,087 with a mean of 4,129 ova.

Arctic char ova are deposited in redds during late September and incubate within the gravel, hatching in mid-April. Length range of pre-emergent yolk-sac fry is 17-21 mm. Fry begin to emerge from the gravel during mid-June at a length of approximately 25 mm.

Immediately following ice breakup in June downstream migration of smolt occurs. The age range of these smolt are 2 to 5, with 95% aged as 3 and 4. Peak upstream migration of potential spawners into tributaries occurs between August 21-25. Peak upstream migration of non-spawners into tributaries occurs between September 1-6.

Arctic char feed extensively on mysids whereas in the ocean environment and within the estuarine area of the river delta. Chironomid larvae serve as the major food item for arctic char in the tributaries. Of the 1,750 stomachs examined, 63% did not contain any prey items.

KEYWORDS: Sagavanirktok River / Ivishak River / Foggy Island / Echooka River / Lupine River / North Slope / Ribdon River / Accomplishment Creek / migrations / life history / food habits / length-weight / age and growth / length-frequency / maturity / fecundity / spawning.

Yoshihara, H.T. 1973. Monitoring and evaluation of arctic waters with emphasis on North Slope drainages. Part B: pipeline and Haul Road crossing surveys. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 14. Project F-9-5, Job G-III-A. Juneau. 21 pp.

This report presents data from surveys conducted at 26 stream sites proposed to be crossed by the Trans-Alaska oil pipeline and Haul Road in 1972. In addition, 14 crossing sites of the Sagavanirktok River were surveyed. Data concerning species distribution, migration timing, survey status, fish productivity, and physical, chemical and biological characteristics at each site are presented.

Twenty eight of the 40 sites were found to have fish. Sagavanirktok River sites had more fish species than smaller tributaries. Arctic cisco, least cisco, humpback whitefish, broad whitefish, round whitefish, arctic char, arctic grayling, pink salmon, chum salmon, burbot, ninespine stickleback, and slimy sculpin were collected from the mainstem of the Sagavanirktok River whereas smaller streams contained up to four species. Fish productivity was rated as low, medium, or high based on fish abundance at the time of the survey.

Catch rates for arctic grayling, arctic char, and whitefish are given for nets fished in the Koozata River on St. Lawrence Island and a subsistence harvest of 35,733 arctic char is given for Kivalina Village.

Sport fishing catches as high as 16.4 arctic char per angler hour were recorded in the Ivishak River.

KEYWORDS: Pipeline / crossing sites / survey / Sagavanirktok River / Kivalina / St. Lawrence Island / subsistence.

INDEX OF KEY FISH SPECIES

INDEX OF MISCELLANEOUS FISH SPECIES AND AQUATIC INVERTEBRATES

INDEX BY GEOGRAPHIC AREA

APPENDIX 1: LIST OF CITATIONS

Page

Adams, B., and T.C. Cannon. 1987. Overwintering study. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 7, Part V. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 33 pp. 11

Alt, K.T. 1972. A life history study of sheefish and whitefish in Alaska: Distribution, movements, age and growth, and taxonomic status of whitefish (*Coregonus* sp.) in the Arctic-Yukon-Kuskokwim area. ADF&G, Fed. Aid. in Fish. Rest. Ann. prog. rept. Vol. 13. Project F-9-4, Job R-II-G. Juneau. 12 pp. 12

Alt, K.T. 1973. Contributions to the biology of the Bering Cisco (*Coregonus laurettae*) in Alaska. J. Fish. Res. Board Can. 30: 1885-1888. 13

Alt, K.T. 1976. Age and growth of Alaskan broad whitefish (*Coregonus nasus*). Trans. Amer. Fish. Soc. 105(4): 526-528. 14

Alt, K.T. 1979. Contributions to the life history of humpback whitefish in Alaska. Trans. Amer. Fish. Soc. 108: 156-160. 15

Alt, K.T., and R.A. Furniss. 1976. Inventory and cataloging of North Slope waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 17. Project F-9-8, Job G-I-O. Juneau. 22 pp. 16

Alt, K.T., and D.R. Kogl. 1973. Notes on whitefish of the Colville River, Alaska. J. Fish. Res. Board Can. 30(4): 554-556. 17

Bendock, T.N. 1976. De-watering effects of industrial development on Arctic fish stocks. Unpubl. rept. for the Alaska Board of Fisheries. ADF&G, Div. Sport Fish, Fairbanks. 13 pp. 18

Bendock, T.N. 1977. Beaufort Sea estuarine fishery study. RU-233. Pages 670-729 *in* Environmental assessment of the Alaskan continental shelf. Final reports of principal investigators. Vol 4. Biological studies. 1979. USDC: NOAA; USDI:MMS. 1979. 19

Bendock, T.N. 1979. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 20. Project F-9-11, Job B-I-I. Juneau. 64 pp. 20

Bendock, T.N. 1980. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish Rest. Ann. performance rept. Vol. 21. Project F-9-12, Job G-I-I. Juneau. 31 pp. 21

Bendock, T.N. 1981. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 22. Project F-9-13, Job G-I-I. Juneau. 33 pp. 22

Page

Bendock, T.N. 1982. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 23. Project F-9-14, Job G-I-I. Juneau. 43 pp. 23

Bendock, T.N. 1983. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 24. Project F-9-15, Job G-I-I. Juneau. 28 pp. 24

Bendock, T.N., and J.M. Burr. 1984. Freshwater fish distributions in the central Arctic Coastal Plain (Ikpikpuk River to Colville River). Unpubl. rept. ADF&G, Div. Sport Fish , Fairbanks. 54 pp. 25

Bendock, T.N., and J.M. Burr. 1984. Inventory and cataloging of arctic area waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 24. Project F-9-16, Job G-I-I. Juneau. 46 pp. 26

Bendock, T.N., and J.M. Burr. 1985. Freshwater fish distributions in the central Arctic Coastal Plain (Topagoruk River to Ikpikpuk River). Unpubl. rept. ADF&G, Div. Sport Fish, Fairbanks. 29 pp. 27

Bendock, T.N., and J.M. Burr. 1985. Inventory and cataloging of arctic area waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 26. Project F-9-17, Job G-I-I. Juneau. 40 pp. 29

Bendock, T.N., and J.M. Burr. 1986. Arctic area trout studies. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 27. Project F-9-18, Job T-7-1. Juneau. 75 pp. 31

Bickham, J.W., S.M. Carr, B.G. Hanks, D.W. Burton, and B.J. Gallaway. 1986. Genetic analysis of population variation in the arctic cisco using electrophoretic, flow cytometric, and mitochondrial DNA restriction analyses. Pages 1-32. *in* B.J. Gallaway, ed. Genetic and overwintering studies of the arctic cisco (*Coregonus autumnalis*), 1985-86. Prepared by LGL Ecological Research Associates, Inc. for Standard Alaska Production Company, Anchorage, Alaska and the North Slope Borough, Barrow, Alaska. 140 pp. 32

Bond, W.A., and R.N. Erickson. 1987. Fishery data from Phillips Bay, Yukon, 1985. Can. Data Rept. Fish. Aquat. Sci. No. 635. Dept. Fisheries and Oceans, Winnipeg, Manitoba. 44 pp. 33

Brooks, J.W., J.C. Bartonek, D.R. Klein, D.L. Spencer, and A.S. Thayer. 1971. Environmental influences of oil and gas development in the Arctic Slope and Beaufort Sea. U.S. Fish and Wildl. Serv. Resour. Publ. 96. Washington, D.C. 24 pp. 34

Page

Brunskill, G.J., D.M. Rosenberg, N.B. Snow, G.L. Vascotto, and R. Wagemann. 1973. Ecological studies of aquatic systems in the Mackenzie-Porcupine drainages in relation to proposed pipeline and highway developments. Vol. I & II. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Environment Canada, Rept. No. 73-40 and 73-41. 131 pp; 343 pp + append. 35

Byran, J.E. 1973. The influence of pipeline development on freshwater fishery resources of northern Yukon Territory. Aspects of research conducted in 1971 and 1972. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Rept. 73-6. Ottawa, Ontario. 63 pp. 36

Cannon, T.C., B. Adams, D. Glass, and T. Nelson. 1987. Fish distribution and abundance. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 6. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 129 pp. 37

Cannon, T.C., M.S. Brancato, and S.C. Jewett. 1987. Fish food habits. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 7. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 63 pp. 38

Cannon, T.C., J.A. Knutzen, and B. Adams. 1987. Mark recapture study. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 6. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 38 pp. 39

Childers, J.M., C.E. Sloan, and J.P. Meckel. 1973. Hydrologic reconnaissance of streams and springs in eastern Brooks Range, Alaska - July 1972. Basic data rept. Water Resources Div., USGS, Anchorage, Alaska. 25 pp. 40

Cohen, D.M. 1954. Age and growth studies on two species of whitefishes from Point Barrow, Alaska. Stanford Ichthyological Bulletin 4(3): 168-187. 41:

Craig, P.C. 1984. Fish use of coastal waters of the Alaskan Beaufort Sea: a review. Trans. Am. Fish. Soc. 113(3): 265-282. 42

Craig, P.C. 1985. Aquatic survey of the Kaktovik dredging operation, 1983 and 1984. Prepared by LGL Alaska Research Associates, Inc. for the Materials Source Division, North Slope Borough, Barrow, Alaska. 25 pp. 43

Craig, P.C. 1987. Subsistence fisheries at coastal villages in the Alaskan Arctic, 1970-1986. Tech. Rept. No. 129. Alaska OCS Socioeconomic Studies Program. Prepared by LGL Ecological Research Associates, Inc. for Leasing and Environment Office, Minerals Management Service, USDI. 63 pp. 44

Page

Craig, P.C., and W.B. Griffiths. 1981. Passage of large fish around a causeway in Prudhoe Bay, Alaska. Arctic 34(4): 314-317. 45

Craig, P.C., and W.B. Griffiths. 1981. Studies of fish and epebenthic invertebrates in coastal waters of the Alaskan Beaufort Sea. RU-467. Pages 71-145 *in* Environmental assessment of the Alaskan continental shelf. Annual reports of the principal investigators. Vol. 1. Receptors. USDC: NOAA, OMPA; USDI: BLM. 46

Craig, P.C., and L. Haldorson. 1980. Beaufort Sea barrier island-lagoon ecological process studies; final report, Simpson Lagoon studies. Part 4. Fish. RU-467. Annual rept. Prepared by LGL Limited and LGL Ecological Research Associates, Inc. 294 pp. 47

Craig, P.C., and L. Haldorson. 1986. Pacific salmon in the North American arctic. Arctic 39(1): 2-7. 48

Craig, P.C., and G.J. Mann. 1974. Life history and distribution of the arctic cisco (*Coregonus autumnalis*) along the Beaufort Sea coastline in Alaska and the Yukon Territory. Chap. 4. *in* P.J. McCart, ed. Life histories of anadromous and freshwater fish in the western Arctic. Arctic Gas Biol. Rept. Ser. Vol. 20. 33 pp. 49

Craig, P., and P.J. McCart. 1974. Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay and the Mackenzie Delta 1972-1973. Chap. 3 *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon, and Northwest Territories. Arctic Gas Biol. Rept. Ser. Vol. 15. 36 pp. 50

Craig, P.C., and P.J. McCart. 1975. Classification of stream types in Beaufort Sea drainages between Prudhoe Bay, Alaska, and the Mackenzie Delta, N.W.T., Canada. Arctic and Alpine Research 7(2): 183-198. 51

Craig, P.C., and V.A. Poulin. 1975. Movements and growth of arctic grayling (*Thymallus arcticus*) and juvenile arctic char (*Salvelinus alpinus*) in a small arctic stream, Alaska. J. Fish. Res. Board Can. 32: 689-697. 52

Craig, P.C., and D. Schmidt. 1982. Survey of potential dredge sites at Wainwright, Point Lay, Atqasuk, Nuiqsut, and Kaktovik. Prepared by LGL Alaska Research Associates for the Materials Source Division, North Slope Borough, Barrow, Alaska. 43 pp. 53

Craig, P.C., and D. Schmidt. 1985. Fish resources at Point Lay, Alaska. Prepared by LGL Alaska Research Associates, Inc. for the North Slope Borough, Barrow, Alaska. 105 pp. 54

Craig, P.C., W.B. Griffiths, L. Haldorson, and H. McElderry. 1985. Distributional patterns of fishes in an Alaskan arctic lagoon. Polar Biol. 4: 9-18. 55

Page

Dames & Moore. 1987. Appendix B - Fisheries analysis. Lisburne offshore development project. Draft environmental document, Submittal No. 7. November 23, 1987. Anchorage, Alaska. 41 pp. 56

Dames & Moore. 1987. Kuparuk River unit waterflood project marine life bypass system monitoring program, January - December 1986. Annual report. Prepared by Dames & Moore for ARCO Alaska, Inc., Anchorage, Alaska. 85 pp. 57

deBruyn, M., and P. McCart. 1974. Life history of the grayling (*Thymallus arcticus*) in Beaufort Sea drainages in the Yukon Territory. Chap. 2 *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon, and Northwest Territories. Arctic Gas Biol. Rept. Ser. Vol. 15. 39 pp. 58

Dew, C.B. 1982. Kuparuk field fish survey, 1981. Final report. Prepared by Woodward-Clyde Consultants for ARCO Alaska, Inc., Anchorage. 15 pp. 59

Doxey, M.R. 1977. Fishery impact survey of ARCO causeway. Unpubl. rept. Prepared by ADF&G, Div. Sport Fish, Fairbanks for Atlantic Richfield Co., Anchorage. 38 pp. 60

Dryden, R.L., B.G. Sutherland, and J.N. Stein. 1973. An evaluation of the fish resources of the Mackenzie River Valley as related to pipeline development. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Rep. No. 73-2. 176 pp. 61

Falk, M.R., and M.J. Lawrence. 1973. Seismic exploration: its nature and effect on fish. Tech. Rept. Ser. No. Cen/T-73-9. Fisheries and Marine Service, Dept. of the Environment, Winnipeg, Canada. 51 pp. 62

Fawcett, M.H., and T.A. Carpenter. 1986. Colville River fishes: 1985 biological report. Chapter 2. Prepared by Entrix, Inc. for ARCO and the North Slope Borough. 138 pp + append. 63

Fechhelm, R.G., P.C. Craig, J.S. Baker, and B.J. Gallaway. 1984. Fish distribution and use of nearshore waters in the northeastern Chukchi Sea. RU-635. Pages 121-297 *in* Outer continental shelf environmental assessment program. Final reports of principal investigators. Vol. 32. 1985. USDC: NOAA, NOS; USDI: MMS. 64

Fechhelm, R.G., W.H. Neill, and B.J. Gallaway. 1983. Temperature preference of juvenile arctic cisco (*Coregonus autumnalis*) from the Alaskan Beaufort Sea. Biol. Pap. Univ. Alaska. No. 21: 24-38. 65

Page

Furniss, R.A. 1974. Inventory and cataloging of arctic area waters. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 15. Project F-9-6, Job G-I-I. Juneau. 45 pp. 66

Furniss, R.A. 1975. Inventory and cataloging of arctic waters. ADF&G, Fed. Aid in Fish. Rest. Ann. performance rept. Vol. 16. Project F-9-7, Job G-I-I. Juneau. 47 pp. 67

Furniss, R.A., and D.L. Ward. 1976. Comparison of water availability for use in construction of proposed gas pipelines on the Alaskan North Slope. Prepared by Alaska Biological Consultants. 70 pp. 69

Gallaway, B.J., W.J. Gazey, and L. Moulton. In prep. Population trends for arctic cisco (*Coregonus autumnalis*) in the Colville River of Alaska as reflected by the commercial fishery. Biol. Pap. Univ. Alaska. Sept. 1987 draft. 34 pp. 70

Gallaway, B.J., W.B. Griffiths, P.C. Craig, W.J. Gazey, and J.W. Helmericks. 1983. An assessment of the Colville River Delta stock of arctic cisco - migrants from Canada? Biol. Pap. Univ. Alaska No. 21: 4-23. 71

Gavin, A. 1974. Wildlife of the North Slope, a five year study, 1969-1973. Atlantic Richfield Co. 61 pp. 72

George, J.C., and B.P. Nageak. 1986. Observations on the Colville River subsistence fishery at Nuiqsut, Alaska, 4 July - 1 November 1984. Dept. Wildl. Manage., North Slope Borough, Barrow, Alaska. 35 pp. 73

George, J.C., and R. Kovalsky. 1986. Observations on the Kupigruak Channel (Colville River) subsistence fishery, October 1985. Dept. Wildl. Manage., North Slope Borough, Barrow, Alaska. 60 pp. 74

Glova, G., and P.J. McCart. 1974. Life history of arctic char (*Salvelinus alpinus*) in the Firth River, Yukon Territory. Chap. 3 *in* P.J. McCart, ed. Life histories of anadromous and freshwater fish in the western Arctic. Arctic Gas Biol. Rept. Ser. Vol. 20. 50 pp. 75

Griffiths, W.B., P.C. Craig, G.L. Walder, and G.J. Mann. 1975. Fisheries investigations in a coastal region of the Beaufort Sea (Nunaluk Lagoon, Yukon Territory) Chap. 2 *in* P.C. Craig, ed. Fisheries investigations in a coastal region of the Beaufort Sea. Arctic Gas Biol. Rept. Ser. Vol. 34. 219 pp. 76

Griffiths, W.B., D.R. Schmidt, R.G. Fechhelm, and B.J. Gallaway. 1983. Fish ecology. Vol. 3 *in* B.J.Gallaway and R.P.Britch, eds. Environmental summer studies (1982) for the Endicott development. Prepared by LGL Alaska Research Associates, Inc. and Northern Technical Services for Sohio Alaska Petroleum Co. 323 pp. 78

Page

Hablett, T.R. 1979. Fish inventories conducted within the National Petroleum Reserve on the North Slope of Alaska, 1977-78. Pages 337-406 *in* P.C. Lent, ed. Studies of selected wildlife and fish and their use of habitats on and adjacent to the National Petroleum Reserve in Alaska 1977-1978. National Petroleum Reserve in Alaska. 105(c) Land Use Study. Work Group 3, Field Study 3. Vol. 2. Chap. 10. USDI. Anchorage, Alaska. 80

Heckart, L. 1965. Inventory and cataloging of sport fish and sport fish waters in the interior of Alaska. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 6. Project F-5-R-6, Job 15-A. Juneau. 15 pp. 81

Hoffman, D., D. Libby, and G. Spearman. 1988. Land use values through time in the Nuiqsut area. North Slope Borough and the Anthropology and Historic Preservation Section, Cooperative Park Studies Unit, Univ. Alaska, Fairbanks. 89 pp + append. 82

Johnson, L., and B.L. Burns, editors. 1984. Biology of the arctic char. Proceedings of the international symposium on arctic char, Winnipeg, Manitoba, May 1981. Univ. of Manitoba Press, Winnipeg. 584 pp. 83

Jones, M.L. 1976. Water availability along the proposed Arctic Gas Pipeline route from Prudhoe Bay, Alaska to the Mackenzie Delta, Northwest Territories. Aquatic Environments Limited. Arctic Gas Biol. Rept. Ser. 101 pp. 84

Kinney, P.J., editor. 1985. Fish utilization of Peard Bay. RU-641. Pages 369-405 *in* Environmental characterization and biological utilization of Peard Bay. Outer continental shelf assessment program. Final reports of principal investigators. Vol 35. Chap. 6. USDC: NOAA, NOS; USDI: MMS. 85

Kogl, D.R. 1971. Monitoring and evaluation of arctic waters with emphasis on North Slope drainages: Colville River study. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 12. Project F-9-3, Job G-III-A. Juneau. 39 pp. 86

Kogl, D.R., and D. Schell. 1975. Colville River delta fisheries research. Pages 483-504 *in* Environmental studies of an arctic estuarine system - final rept. Chap. 10. Ecol. Res. Ser. EPA-660/3-75-026. U.S. Environ. Protect. Agency, Corvallis, Oregon. 87

Luton, H.H. 1985. Effects of renewable resource harvest disruptions on socioeconomic and sociocultural systems: Wainwright, Alaska. Tech. Rept. No. 91. Alaska Outer Continental Shelf Region. Social and economic studies program. USDI: MMS. 603 pp 88

Page

McCart, P., and H. Bain. 1974. An isolated population of arctic char (*Salvelinus alpinus*) inhabiting a warm mineral spring above a waterfall at Cache Creek, Northwest Territories. Chap. 7 *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon, and Northwest Territories. Arcitc Gas. Biol. Ser. Vol. 15. 13 pp. 89

McCart, P., and P. Craig. 1974. Life history of two isolated populations of arctic char (*Salvelinus alpinus*) in spring fed tributaries of the Canning River, Alaska 1973. Chap. 8 *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon and Northwest Territories. Arctic Gas Biol Ser. Vol. 15. 13 pp. 90

McCart, P., P. Craig, and H. Bain. 1972. Report on fisheries investigations in the Sagavanirktok River and neighboring drainages. Prepared for Alyeska Pipeline Service Co. 143 pp. 91

McCart, P.J. 1974. Late winter surveys of lakes and streams in Canada and Alaska along the gas pipeline routes under consideration by Canadian Arctic Gas Study Limited, 1972-1973. Chap. 1 *in* P.J. McCart, ed. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon and Northwest Territories. Arctic Gas Biol Ser. Vol. 15. 181 pp. 93

McElderry, H.I., and P.C. Craig. 1981. A fish survey in the lower Colville River drainage with an analysis of spawning use by arctic and least cisco. Appendix 2. Pages 657-678 *in* Environmental assessment of the Alaskan continental shelf. Final reports of principal investigators. Volume 7. Biological studies. USDC: NOAA, OMPA; USDI: BLM. 94

McMillan, R.O., and D.R. Barnard. 1983. Stream fish. Chapter 4 *in* D.M. Troy, ed. Prudhoe Bay Unit - Eileen West End environmental studies program, summer 1982. Prepared by LGL Alaska Research Associates, Inc., Fairbanks, for Sohio Alaska Petroleum Company, Anchorage. 95

Moulton, L.L. 1980. Kuparuk field fish survey. Prepared by Woodward-Clyde Consultants for ARCO Oil and Gas Co., Anchorage, Alaska. 26 pp. 96

Moulton, L.L. 1983. Lisburne development area: 1983 environmental studies. Final report. Prepared by Woodward-Clyde Consultants for ARCO Alaska, Inc., Anchorage. 142 pp + append. 97

Moulton, L.L., and T.A. Carpenter. 1986. Colville River fishes: a literature review. Chap. 1 *in* Colville River Fish Study. 1985 annual report. Final report, May 1986. Prepared by Entrix, Inc. for ARCO Alaska, Inc., the North Slope Borough, and the City of Nuiqsut. 36 pp. 98

Page

Moulton, L.L., and C.B. Dew. 1983. Fish utilization of tundra streams between the Colville and Kuparuk rivers. Draft report. Prepared by Woodward-Clyde Consultants for ARCO Alaska, Inc., Anchorage. 37 pp + append. 99

Moulton, L.L., and M.H. Fawcett. 1984. Oliktok Point fish studies - 1983. Final Report. Prepared by Woodward-Clyde Consultants for ARCO Alaska, Inc., Anchorage. 100

Moulton, L.L., and T.R. Jennings. 1987. Assessment of the Colville River fall fishery in 1986. Final rept. Colville River fish study. Prepared by Entrix, Inc. for ARCO Alaska, Inc., the North Slope Borough, and the City of Nuiqsut. 50 pp. 101

Moulton, L.L., L.J. Field, and S. Brotherton. 1986. Assessment of the Colville River fishery in 1985. Chapter 3 *in* Colville River fish study. 1985 Annual rept. Prepared by Entrix, Inc. for ARCO Alaska, Inc., the North Slope Borough, and the City of Nuiqsut. 72 pp. 102

Moulton, L.L., B.J. Gallaway, M.H. Fawcett, W.B. Griffiths, K.R. Critchlow, R.G. Fechhelm, D.R. Schmidt, and J.S. Baker. 1986. 1984 central Beaufort Sea fish study. Prudhoe Bay Waterflood Project Environmental Monitoring Program. 1984. Vol. 2. Chap. 3. Prepared by Entrix, Inc., LGL Ecological Research Associates, and Woodward-Clyde Consultants for Envirosphere Co., and US Army Corps of Engineers, Anchorage, Alaska. 294 pp + append. 103

Neakok, W., D. Neakok, W. Bodfish, D. Libbey, E.S. Hall,Jr., and Point Lay elders. 1985. To keep the past alive: the Point Lay cultural resource site survey. North Slope Borough, Barrow, Alaska. 111 pp. 105

Neill, W.H., R.G. Fechhelm, B.J. Gallaway, J.D. Bryan, and S.W. Anderson. 1983. Modeling movements and distribution of arctic cisco (*Coregonus autumnalis*) relative to temperature-salinity regimes of the Beaufort Sea near the waterflood causeway, Prudhoe Bay, Alaska. Biol Pap. Univ. Alaska No. 21:39-61. 106

Nelson, R.K. 1981. Harvest of the sea: coastal subsistence in modern Wainwright. North Slope Borough. 126 pp. 107

Netsch, N., E. Crateau, G. Love, and N. Swanton. 1977. Freshwater fisheries reconnaissance of the coastal plain of National Petroleum Resrve-Alaska (NPR-A), July and August 1977. Preliminary report. USDI: USFWS, Anchorage, Alaska. 35 pp + append. 108

Page

Percy, R. 1975. Fishery resources of the Beaufort Sea, implications of offshore seismic. Prepared for Offshore seismic seminar, Yellowknife, NWT. May 12-13, 1975. Fisheries and Marine Service. Environment Canada. 11 pp. 109

Reynolds, P. 1978. Fish collected at proposed NPR-A wellsites during August 1978. Unpubl. rept. NPR-A, Fairbanks District Office, Bureau of Land Management Fairbanks, Alaska. 10 pp. 110

Roguski, E.A., and E. Komarek, Jr. 1971. Monitoring and evaluation of arctic waters with emphasis on North Slope drainages: Arctic Wildlife Range study. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 12. Project F-9-3, Job G-III-A. Juneau. 22 pp. 111

Roguski, R.A., and T.H. Nagata. 1970. Observations on the lethal effects of under ice detonations on fish. Alaska Dept. of Fish and Game Informational Leaflet No. 139. Juneau. 30 pp. 112

Roguski, E.A., and P.C. Winslow. 1970. Monitoring and evaluation of arctic waters with emphasis on North Slope drainages. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 11. Project F-9-2, Job 15-C. Juneau. 23 pp. 113

Schmidt, D.R., W.B. Griffiths, and L.R. Martin. 1987. Importance of anadromous fish overwintering habitat in the Sagavanirktok River delta, Alaska. Prepared by LGL Research Associates, Inc. for Standard Alaska Production Co. and North Slope Borough. 71 pp. 114

Schmidt, D.R., R.O. McMillan, and B.J. Gallaway. 1983. Nearshore fish survey in the western Beaufort Sea: Harrison Bay to Elson Lagoon. Annual rept. Prepared by LGL Ecological Research Assoc., Inc. for Juneau Project Office, NOAA/OCSEAP. 58 pp 116

Sekerak, A.D., W.B. Griffiths, and N. Stallard. 1985. Aquatic investigations in response to dredging in the Meade River, Alaska. Prepared by LGL Limited, Environmental Research Associates for Materials Source Division, North Slope Borough, Barrow, Alaska. 158 pp + append. 117

Silva, J.B., L.G. Adams, and R. Gal. 1985. Habitat evaluation for Teshekpuk Lake Special Area study. Arctic Resour. Area, U.S. Dept. Interior, Bureau of Land Management, Fairbanks, Alaska. 135 pp + append. 118

Skvorc, P.A., and W.J. O'Brien. 1981. Toxic effects of Prudhoe Bay crude oil to arctic freshwater zooplankton and arctic grayling. Unpubl. rept. Univ. Kansas, Lawrence. 13 pp. 119

Sloan, C.E. 1976. Fresh water fish and their winter habitat in NPR-4. Anadromous fish study. Memorandum to Officer in Charge, Naval Petroleum Reserve No. 4. 29 pp. 120

Page

Smith, M.W., and R.S. Glesne. 1982. Aquatic studies on the North Slope of the Arctic National Wildlife Refuge 1981 and 1982. Fish. resour. prog. rept. FY83-1. USFWS, Fairbanks,Alaska. 71 pp. 121

Steigenburger, L.W., G.J. Birch, P.G. Bruce, and R.A. Robertson. 1974. Northern Yukon freshwater fisheries studies, 1973. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Rep. No. 74-20. 51 pp. 123

Stein, J.N., C.S. Jessop, T.R. Porter, and K.T.J. Chang-Kue. 1973. Fish resources of the Mackenzie River valley. Environ.-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Fish. Serv. Winnipeg, Manitoba. 260 pp. 124

Tripp, D.B., and P.J. McCart. 1974. Life histories of grayling (*Thymallus arcticus*) and longnose suckers (*Catostomus catostomus*) in the Donnelly River system, Northwest Territories. Chap. 1 *in* P.J. McCart, ed. Life histories of anadromous and freshwater fish in the western Arctic. Arctic Gas Biol. Rep. Ser. Vol. 20. 91 pp. 125

Ward, D., and P. Craig. 1974. Catalogue of streams, lakes, and coastal areas in Alaska along the proposed gas pipeline from Prudhoe Bay, Alaska to the Alaskan/Canadian border. Prepared by Aquatic Environments Ltd. Arctic Gas Biol. Rept. Ser. Vol. 19. 381 pp. 126

West, R.L., and D.W. Wiswar. 1984. Fisheries investigations on the Arctic National Wildlife Refuge, Alaska, 1984. Fairbanks fish. resour. prog. rept. No. FY85-1. USFWS, Fairbanks, Alaska. 47 pp. 127

Whitmus, C.J., T.C. Cannon, and S.S. Parker. 1987. Age growth and condition of anadromous fish. *in* 1985 final report for the Endicott Environmental Monitoring Program. Vol. 7. Prepared by Envirosphere Co. for U.S. Army Corps of Engineers, Anchorage, Alaska. 34 pp. 129

Wilson, W.J., E.H. Buck, 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. Prepared by Arctic Environmental Information and Data Center, Univ. Alaska, Anchorage for Office of Biological Services, USFWS, USDI, Anchorage, Alaska. FWS/OBS - 77/06. March 1977. 221 pp + append. 130

Winslow, P.C. 1969. Inventory and cataloging of sport fish and sport fish waters in interior Alaska - char in northwestern Alaska. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 10. Project F-9-1, Job 15-A. Juneau. 14 pp. 131

Page

Wohlschlag, D.E. 1953. Some characteristics of the fish populations in an arctic Alaskan lake. Pages 19-29 *in* I.L. Wiggins, ed. Current biological research in the Alaskan arctic. Vol 11. Stanford Univ. Publ. Univ. Series. Biological Sciences. Stanford, CA. 55 pp. 132

Wohlschlag, D.E. 1954. Growth peculiarities of the cisco, *Coregonus sardinella* (Valenciennes), in the vicinity of Point Barrow, Alaska. Stanford Ichthyological Bulletin 4: 189-209. 133

Wohlschlag, D.E. 1954. Mortality rates of whitefish in an arctic lake. Ecology 35(3): 388-396. 134

Wohlschlag, D.E. 1957. Differences in metabolic rates of migratory and resident freshwater forms of an arctic whitefish. Ecology 38(3): 502-510. 135

Yoshihara, H.T. 1972. Monitoring and evaluation of arctic waters with emphasis on the North Slope drainages. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 13. Project F-9-4, Job G-III-A. Juneau. 49 pp. 136

Yoshihara, H.T. 1973. Monitoring and evaluation of arctic waters with emphasis on the North Slope drainages. Part A: some life history aspects of arctic char. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 14. Project F-9-5, Job G-III-A. Juneau. 63 pp. 137

Yoshihara, H.T. 1973. Monitoring and evaluation of arctic waters with emphasis on North Slope drainages. Part B: pipeline and Haul Road crossing surveys. ADF&G, Fed. Aid in Fish. Rest. Ann. prog. rept. Vol. 14. Project F-9-5, Job G-III-A. Juneau. 21 pp. 138