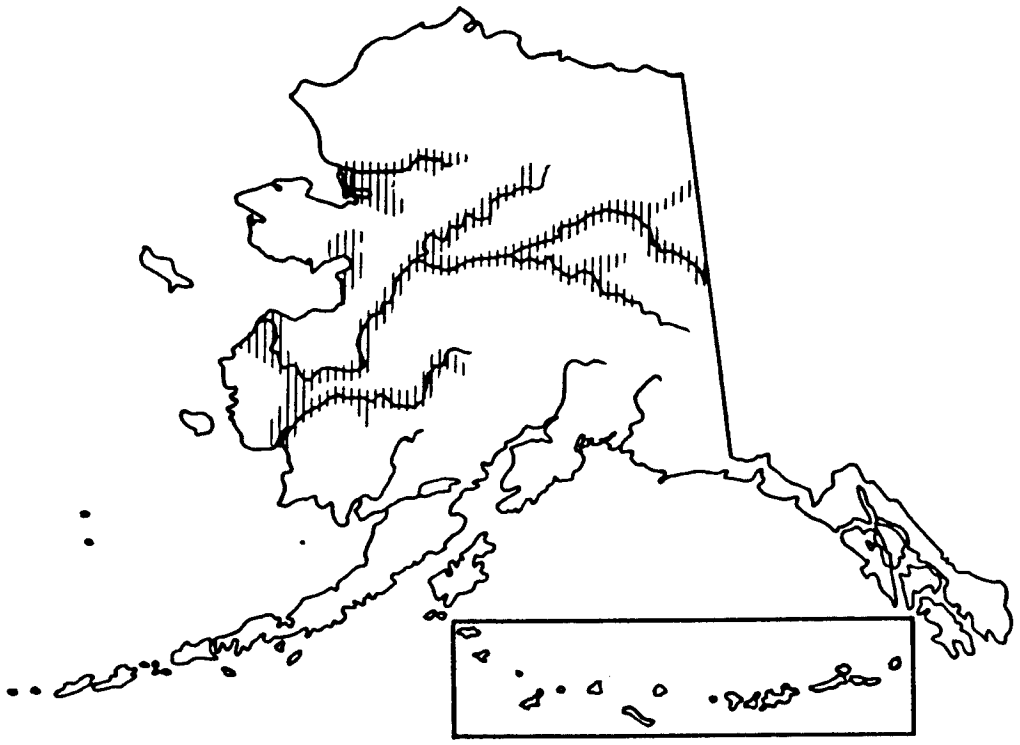
Sheefish Life History and Habitat Requirements
Arctic, Western, and Interior Regions



Map 1. Range of sheefish (ADF&G 1978)

I. NAME

A. Common Name

Inconnu is the accepted common name for this species (Robins et al. 1980); however, in Alaska sheefish is the most frequently used common name.

B. Scientific Name: Stenodus leucichthys

C. Native Names: See appendix A.

II. RANGE

A. Statewide

Sheefish in Alaska have been separated into five major groups (Alt 1969a, 1977). The Minto flats and upper Yukon River populations are year-round residents in the eastern part of Interior Alaska (ADF&G 1978). The lower Yukon and Kuskokwim

populations overwinter in the delta areas of these two rivers. Lower Yukon River sheefish move upstream to spawn as far as the middle Yukon River above Rampart and the upper Koyukuk River (Alt 1975, 1981, and pers. comm.). Kuskokwim River sheefish travel upstream as far as Highpower Creek to spawn (Alt 1981). The Selawik-Kobuk population overwinters in Hotham Inlet and Selawik Lake and travels to spawning grounds approximately 200 km up the Selawik River and in the Kobuk River 38-100 km above Kobuk Village (Alt 1967 and pers. comm.).

B. Regional Distribution Maps

To supplement the distribution information presented in the text, a series of blue-lined reference maps has been prepared for each region. Sheefish distribution information is included on the 1:250,000-scale maps titled Distribution of Selected Freshwater Fish. These maps are available for review in ADF&G offices of the region or may be purchased from the contract vendor responsible for their reproduction. In addition, a set of colored 1:1,000,000-scale index maps of selected fish and wildlife species has been prepared and may be found in the Atlas that accompanies each regional guide.

C. Regional Distribution Summary

1. Arctic. Sheefish are found in the Selawik and Kobuk rivers but are absent north of Kotzebue Sound across the arctic slope until they are again encountered in rivers east of Demarcation Point (Alt 1969b). The Kobuk-Selawik population overwinters in Selawik Lake, Hotham Inlet, and Kotzebue Sound and travels upstream to spawning grounds approximately 200 km up the Selawik River and in the Kobuk River 40-50 km above Kobuk Village (ibid.). Rearing immature sheefish of ages 4 to 10 are found in Hotham Inlet, Selawik Lake, and in estuarine areas around Kotzebue and Sheshalik (Alt 1980 and pers. comm.). Rearing sheefish are also found in the lower Kobuk, lower Selawik, and Tuklomarak rivers (Alt 1980). A small population of sheefish is also found in the Koyuk River, which drains into Norton Bay (ADF&G 1978). These fish are found 10 mi up the Koyuk River (Alt, pers. comm.). (For more detailed narrative information on sheefish distribution in the Arctic Region, see volume 2 of the Alaska Habitat Management Guide for the Arctic Region.)

2. Western and Interior. In the Western and Interior regions, sheefish are found in the Kuskokwim and Yukon river drainages.

   Kuskokwim River sheefish overwinter in brackish water and lakes and sloughs in the lower reaches of the river. During the summer, these sheefish move upstream to feed at tributary stream mouths and in the Holitna River (Alt 1981). Spawning areas for Kuskokwim River sheefish are documented at Big River and Highpower Creek (ibid.).

   The lower Yukon River anadromous sheefish population overwinters in the lower Yukon River and nearby brackish

water. Yukon River sheefish feed at the mouths of tributary streams and in the Innoko River (Alt 1983). These sheefish spawn in the Koyukuk River at Hughes and in the Alatna River in the Koyukuk drainage. Another segment of the Yukon River anadromous population spawns in the Yukon River drainage somewhere above the Dalton Highway bridge across the Yukon River (Alt 1975).

Nonanadromous sheefish populations are also found in the middle and upper Yukon areas. Nonanadromous sheefish are found in the Nowitna River, the Minto flats area, the lower Tanana River, the Porcupine River drainage, and at the mouths of nearly all middle and upper Yukon tributaries. (For more detailed narrative information, see volume 2 of the Alaska Habitat Management Guide for the Western Interior regions.)

III. PHYSICAL HABITAT REQUIREMENTS

A. Water Quality

1. Temperature. Surface water temperatures in areas where sheefish feed range from 22°C in July to 0°C during the winter (Alt 1973). Water temperatures at time of spawning in the Kobuk River ranged from 1.4 to 4.6°C in 1965 and 1966 (Alt 1967). In 1967 in the Koyukuk River, water temperatures at the time of spawning ranged from 4.8 to 4.3°C (Alt 1968), and in 1971 in Highpower Creek (Kuskokwim drainage) spawning began at 3°C and peaked at 1°C (Alt 1972). Spawning temperatures vary from watershed to watershed, and the time of spawning is apparently more related to gonad development than to water temperature (Alt 1969a).

   Bogdanova (1977) found that the development of sheefish larvae held at a temperature of 3.8°C was slower than development of larvae held at 11.4°C, although the rate of survival at the lower temperature was high.

2. The pH factor. PH readings from areas in Alaska where sheefish are found range from 6.7 to 7.9; however, a comprehensive study relating chemical values and sheefish distribution has not been conducted (Alt 1973).

3. Dissolved oxygen (D.O.). Little information is available on the D.O. requirement of sheefish. Alt (1981) noted that in 1980 sheefish stocked in Island Lake had good overwinter survival although surface D.O. readings from the lake were quite low (2 to 2.5 ppm) during both February and March. No fish were recovered in the lake in 1981 and 1982, however, indicating that they may have perished from low D.O. conditions in late winter (Alt, pers. comm.).

4. Turbidity. Little information is available on the effects of turbidity on sheefish populations in Alaska. Alt (1969b) notes that eggs carried to areas with slow-moving water may be covered with silt and thus have reduced chances of survival.

5. Salinity. Sheefish are generally not found in salt water, and saltwater barriers may limit their range expansion into the Seward Peninsula area and from Kotzebue Sound into northwestern Alaska and northern Alaska (Alt 1973). Sheefish rear and overwinter in brackish water in Hotham Inlet and in Norton Sound. Local fishermen in the Kotzebue area, however, have said that extremely high tides tend to bring about mass movements of sheefish into river mouths or into Selawik Lake (Arthur D. Little, Inc. 1963). Kirilov (1962) stated that sheefish inhabited areas of the Lena River delta in Siberia with a salinity not exceeding 6 to 7 parts per thousand (ppt).

B. Water Velocity and Depth

Sheefish are not strong swimmers, and both Russian and Alaskan studies indicate that they will not ascend streams with rapid current or even small falls (Alt 1973).

Water velocity is a very important factor in successful sheefish spawning. Spawning in the Kobuk River occurs in the relatively swift main current, both where it moves along the cut bank and also in the center of the channel as the current swings to the opposite shore (Alt 1969b). No spawning was observed on gravel bars on the inside curve of the river where the current is slower. Water velocity in spawning areas of Highpower Creek was measured at less than 100 cm/sec (Alt, pers. comm.). The Big River spawning area in the Kuskokwim drainage, which Alt (1981) considered to be far superior to the Highpower Creek spawning area, had a water velocity of 100 to 130 cm/sec.

The depth of water in spawning areas is also important. In the Yukon River above Rampart, sheefish must spawn in water deeper than 5 m to prevent the eggs from freezing when the Yukon water level drops over the winter (Alt 1975). In other areas, sheefish may successfully spawn in shallower water. Spawning in the Kobuk River in 1965 and 1966 occured at depths of 1.2 to 2.7 m, with the major spawning in waters 1.5 to 1.8 m deep (Alt 1967). Spawning in Highpower Creek in 1971 took place at depths of 1.3 to 2.7 m and in Big River in 1980 at depths of 0.6 tO 1.5 m (Alt 1981). In Great Slave Lake, sheefish are seldom found in depths greater than 30 m (Fuller 1955).

C. Substrate

Alt (1969b) noted that in optimum sheefish spawning habitat the substrate is composed of differentially sized coarse gravel, with no silt and some sand present. Apparently, the presence of differentially sized gravel is neccessary to ensure lodging of the eggs. With a bottom of uniformly sized gravel, Alt (1969b) speculated that the eggs might fail to lodge because of the swift current and be carried out into the slow-moving water where there is more silt, thus reducing chances for survival. In a study on the lower Volga River in Russia, it was found that sheefish eggs laid over a substrate where suitable shelter was available had better survival than those laid over an open sandy substrate

(Letichevskiy 1981). Other fishes intensely prey on the sheefish eggs on the open sandy spawning grounds, and practically none survive to the completion of embryogenesis (ibid.). Alt (1981) described the sheefish spawning ground substrate in Big River as generally composed of 5% sand, 15% gravel less than 0.5 inches (1.3 cm), 30% gravel 0.5 to 1 inches (1.3 to 2.5 cm), and 50% coarse gravel and rocks.

Sheefish stocked in Four Mile Lake near Tok, Alaska, successfully spawn in the lake over a mud and silt bottom (Alt 1980, 1984). This is the only record of sheefish spawning in a lake or over such substrate (Alt 1980).

D. Cover Requirements

In Big River, sheefish use small eddies created by downed timber and log jams as holding or resting areas during their upstream spawning migration (Alt 1981).

## IV. NUTRITIONAL REQUIREMENTS

A. Food Species Used

Adult sheefish are piscivorous (Fuller 1955, Alt 1965). Sheefish fry feed on plankton but are feeding actively on crustaceans and insects by the summer of their first year of life (Alt 1973). By July and August, they also begin feeding on fry of other fish and by the second year of life are almost entirely piscivorous (ibid.). Sheefish introduced into lakes barren of fish show excellent growth during the first four years of life on a diet of insects and freshwater shrimp, but sheefish must switch to feeding on fish after three or four years to maintain a good growth rate (Alt 1973, 1980). Sheefish mouth configuration prevents them from consuming prey larger than about 30 cm in length (Alt 1973). In the middle Yukon River, sheefish seldom eat prey over 15 cm in length (Alt 1975).

Sheefish are opportunistic feeders, and their diet varies from place to place, depending on food availability. In the Selawik area, sheefish feed on least cisco (Coregonus sardinella), Mysis relicta (a small pelagic crustacean), Mesidotea entomon (an isopod), ninespine stickleback (Pungitius pungitius), humpback whitefish (Coregonus pidschian), broad whitefish (C. nasus), burbot (Lota lota), and blackfish (Dallia pectoralis), herring, smelt, and lamprey (Alt 1969b, 1979). In estuarine areas around Kotzebue, sheefish captured in June and September had consumed ninespine stickleback, shrimp, smelt, and fish remains (Alt 1979). Sheefish feed on tomcod (probably Eleginus gracilius) in brackish water at the mouth of the Kuskokwim River (Alt 1970).

In the Holitna River (upper Kuskokwim drainage), summer foods include fingerlings of chum, coho, and chinook salmon and Pacific lamprey (Entosphenus tridentatus) (Alt 1972). Sheefish in this area show a preference for salmon fingerlings (ibid.). Nonspawning and immature sheefish that spend the summer and fall in the lakes and streams of the lower Kuskokwim drainage feed very little on salmon fingerlings but rather use ninespine stickleback,

northern pike (Esox lucius), and whitefish (ibid.). In the winter on the lower Kuskokwim River, least cisco are the main food item (ibid.).

In the middle Yukon River from May to September, sheefish feed on arctic lamprey (Lampetra japonica), humpback whitefish, least cisco, and suckers (Catostomus catostomus) (Alt 1975). In the upper Yukon River, chinook salmon fingerlings and broad whitefish are the major food items, with sheefish near mouths of tributary rivers feeding mainly on salmon and those in adjacent quiet water of the Yukon feeding mainly on whitefish (Alt 1965). Finally, in the Minto flats area sheefish feed heavily on northern pike during the summer (Alt 1968).

Fuller (1955) reported that adult sheefish in the Big Buffalo River taken before their downstream run into Great Slave Lake were gorged with young sheefish; however, Alt has reported only one case of cannibalism in Alaska. The stomach of one sheefish taken from the middle Yukon River contained 14 other sheefish up to 14 cm in length (Alt 1975).

B. Types of Feeding Areas Used

Sheefish from the Selawik and Kobuk drainages overwinter and feed in Hotham Inlet, Selawik Lake, Inland Lake, and the lower reaches of the Selawik and Kobuk rivers (Alt 1977). In early June, sheefish in these areas feed close to the surface, jumping almost completely out of the water as they pursue least cisco (Alt 1969b). In late June, as air and water temperatures increase, most sheefish are found at depths of 2 to 3 m (ibid.).

The lower Yukon River sheefish population feeds in the lower reaches of tributaries of the lower and middle Yukon, such as Hess Creek and Ray River, and in slack-water areas of the main Yukon (Alt 1975, 1981). The two main feeding areas of upper Yukon River sheefish are the mouths of tributary rivers and the adjacent quiet-water areas (Alt 1965). In the Kuskokwim River, feeding sheefish are widely distributed in lakes and sloughs of the lower Kuskokwim River and the Holitna River, with smaller concentrations along the Kuskokwim River and its tributaries (Alt 1981). The Holitna River is a major feeding area, and sheefish arrive there in early June, with smaller sheefish arriving first (ibid.).

The Minto flats area is the main summer feeding and rearing area for the Minto flats sheefish population. Sheefish move into the Minto flats in May (Alt 1977).

C. Factors Limiting Availability of Food

Little information could be found in the available literature on factors limiting availability of food. Sheefish stocked in Four Mile Lake near Tok apparently competed with land-locked coho salmon and rainbow trout, which were also stocked in the lake (Alt 1978, 1979). Fuller (1955) noted that in Great Slave Lake sheefish probably do not compete with lake trout for food because the lake trout are found in deeper areas than the sheefish.

D. Feeding Behavior

Sheefish generally cease feeding some time prior to spawning. In the Kuskokwim drainage, sheefish that will spawn in October cease feeding in July (Alt 1981). In the middle Yukon, fish that would spawn in the fall were feeding in June, but nearly all spawning fish examined in August and September had empty stomachs (Alt 1975). Thirteen sheefish taken approximately 100 mi up the Chatanika River in late September had empty stomachs, but four had digested food in the intestine (Alt 1965). In 1973, Alt found one prespawning sheefish in the upper Porcupine River to have been actively feeding on fingerlings of humpback whitefish (Coregonus pidschian) (Alt, pers. comm.), suggesting that at least some feeding takes place during the spawning migration. In Russia, sheefish that leave the Caspian Sea to spawn in the lower reaches of the Volga River do not feed after they enter the river, and their body weight decreases by 15 to 20% during the spawning period (Letichvskiy 1981). Petrova (1976) noted that sheefish from the Irtysh River in Siberia feed most intensively during the winter, but males continue to feed at a lesser level during the spawning migration.

Sheefish fry held in darkened aquaria during a rearing experiment ceased feeding and appeared to enter a state of sleep (LaPerriere 1973). When light was allowed to enter the aquaria the fish slowly revived (ibid.).

Bogdanova (1977) found in laboratory experiments that recently hatched sheefish larvae are able to withstand long periods of starvation (up to 44 days at a temperature of 3.8°C). Bogdanova (1977) speculated that this may be an adaptation to conditions of poor food supply where sheefish are hatched in the spring.

V. REPRODUCTIVE CHARACTERISTICS

A. Reproductive Habitat

Sheefish spawn in the relatively swift main current of rivers in areas with substrate composed of differentially sized coarse gravel.

B. Reproductive Seasonality

Alaskan sheefish spawn in late September and early October. Kobuk River sheefish spawn during the last week of September (Alt 1969b); Koyukuk River sheefish spawn from the last days of September to the first days of October (Alt 1968); Kuskokwim sheefish spawn during the first days of October (Alt 1972); and middle Yukon River sheefish spawn sometime in early October (Alt 1975).

C. Reproductive Behavior

Morrow (1980) summarized reproductive behavior as follows:

> Spawning takes place in the evening, usually beginning about dusk and continuing well into the night. In the spawning act a female accompanied by a male (in rare cases by two or more males) rises to the surface near the upstream end of spawning grounds. She moves rapidly across the current . . .

extruding eggs as she goes. This activity lasts for 1 to 3 seconds. The male, meanwhile, stays below the female. The eggs sink to the bottom through the cloud of sperm released by the male and are fertilized as they sink . . . .

After completing a spawning pass, the female drifts downstream. She may repeat the spawning act over the downstream portion of the spawning area or may move upstream to the head of the grounds before releasing more eggs.

Several spawning passes are needed for a female to release all of her eggs (Morrow 1980).

D. Age at Sexual Maturity

Sheefish from the fast-growing Minto flats and Kuskokwim populations become sexually mature at an earlier age than the longer-living, slower-growing Kobuk-Selawik fish (Alt 1973). Males reach maturity at an earlier age and smaller size than do females (ibid.). Males in the Minto flats population mature at ages 5 to 7, in the Holitna River spawning group of the Kuskokwim population at ages 6 to 8, and in the upper Yukon population at ages 6 to 7 (ibid.). Females in these populations mature at ages 6 to 9 (Alt 1973, 1981). Males in the lower Yukon population mature at ages 6 to 9, females at ages 8 to 10 (ibid.). Males in the Kobuk-Selawik population mature at ages 7 to 11, females at ages 9 to 14 (Alt 1973, 1978). Kuskokwim population sheefish at the Big River spawning grounds in 1980 matured at 4 to 13 years for males and 6 to 9 years for females (Alt 1981).

E. Frequency of Breeding

Sheefish are generally nonconsecutive spawners. The majority of females spawn once every two years and possibly once every three years for older fish (ibid.). A male sheefish used during the 1967 egg take at Hughes was recaptured in ripe condition at the spawning grounds in 1968, indicating that at least some males are capable of reproducing every year (Alt 1969a).

F. Fecundity

Fecundities recorded for Alaskan sheefish range from 27,000 eggs for a 1.6 kg female from the Salmon Fork River in the middle Yukon drainage (Alt 1978) to 286,840 eggs for a 11.9 kg female from Big River in the Kuskokwim draingage (Alt 1981). In a sample of 13 Kobuk River females, ovary weight averaged 20% of body weight, and there were 20,300 eggs per kg of body weight (Lebida 1970). Ovaries from the 11.9 kg Big River female contributed 27% of her body weight (Alt 1981).

Petrova (1976) estimated that the average fecundity of sheefish from the Irtysh River in Siberia was 137,000 eggs per female, or 22 to 33 thousand eggs per kg of body weight.

G. Incubation Period and Time of Emergence

Eggs collected from sheefish in the Koyukuk and Kobuk rivers and Highpower Creek in the Kuskokwim drainage from September 29 to October 3 hatched at the Fire Lake Hatchery from late January through March 15 (Alt 1968, 1970, 1972). Vork (1948) mentioned

that sheefish from the Ob River in Russia had an average incubation period of 182 days.

## VI. MOVEMENTS ASSOCIATED WITH LIFE FUNCTIONS

Sheefish in the Kobuk-Selawik, lower Yukon, and Kuskokwim populations overwinter and feed in the brackish inlets, deltas, and lower reaches of these rivers. In the summer months, they move far upstream to reach spawning areas in the fall. After spawning in September and October, sheefish move back downstream to overwintering areas. Immature and nonspawning sheefish do not migrate as far upstream as spawning adults. Sheefish fry are swept downstream from spawning areas by spring floods and remain in the lower reaches of large rivers and brackish inlets to feed year-round.

In the middle Yukon, there are local sheefish populations that may mix with fish from the anadromous lower Yukon poulation during the summer but that are not themselves anadromous (Alt 1981).

The Minto flats sheefish population spawns in the Chatanika River, migrates downstream to overwinter in the lower Tolovana and Tanana rivers, and enters the Minto flats area to feed in late May after breakup (Alt 1977).

## VII. FACTORS INFLUENCING POPULATIONS

### A. Natural

In the Kobuk River, grayling and whitefish were observed to prey on sheefish eggs released at the water surface during spawning (Geiger et al. 1968). Fuller (1955) reports that adult sheefish from Great Slave Lake feed heavily on immmature sheefish; Alt (1975), however, has recorded only one Alaskan example of cannibalism.

Sheefish are not strong swimmers (Alt 1973), and their migrations may be affected by velocity barriers created by periods of high water (Alt 1983).

### B. Human-related

Any disturbances within a system that degrade sheefish spawning, rearing, or feeding habitats, degrade water quality, or block migration routes may affect population levels of sheefish occupying that system. Sheefish have stringent spawning requirements, and whole populations spawn in relatively few areas. Any disturbances of spawning areas would have the potential to strongly affect the entire population.

Sheefish are not as strong swimmers as salmon. Because of this, developments that increase water velocity along migration routes may be especially detrimental to sheefish stocks.

The sheefish spawning and overwintering migration behavior makes them available for harvest by commerical, subsistence, and sport fisheries throughout their life cycle and increases their vulnerability to overharvest (ADF&G 1983). In addition, the sheefish's slow maturation rate increases the time required to restore depleted populations (ibid.).

A summary of possible impacts from human-related activities includes the following:

- Changes in biological oxygen demand, nutrient loading
- Changes in chemical composition of water
- Changes in dissolved oxygen, temperature, pH, salinity
- Changes in flow or water level, entrapment
- Changes in riparian or aquatic vegetation
- Changes in sedimentation rates, turbidity, suspended solids
- Changes in substrate composition and location
- Competition with introduced species
- Increased susceptibility to harvest or predation
- Inducement of impingement or entrainment
- Physical barriers to movement
- Shock waves, blasting

(For additional impacts information, see the Impacts of Land and Water Use volume of this series.)

VIII. LEGAL STATUS

The Alaska Board of Fisheries develops regulations governing the sport harvest of fish in Alaska. Research and monitoring of sheefish populations is conducted mainly by the Alaska Department of Fish and Game, Division of Sport Fish.

IX. LIMITATIONS OF INFORMATION

Kenneth Alt has contributed over 20 years of research on sheefish stocks in Alaska. As a result of his efforts, a great deal of information is available on Alaskan sheefish, especially with respect to distribution and movements. Information on habitat requirements, however, remains incomplete. More extensive information is needed on velocity, depth, temperature, and salinity requirements, for example. Russian scientists have conducted a great deal of sheefish research, including many studies on hatchery production, which have been published in Russian language journals for which translations are not readily available. (Several examples of these are cited in Petrova 1976.)

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