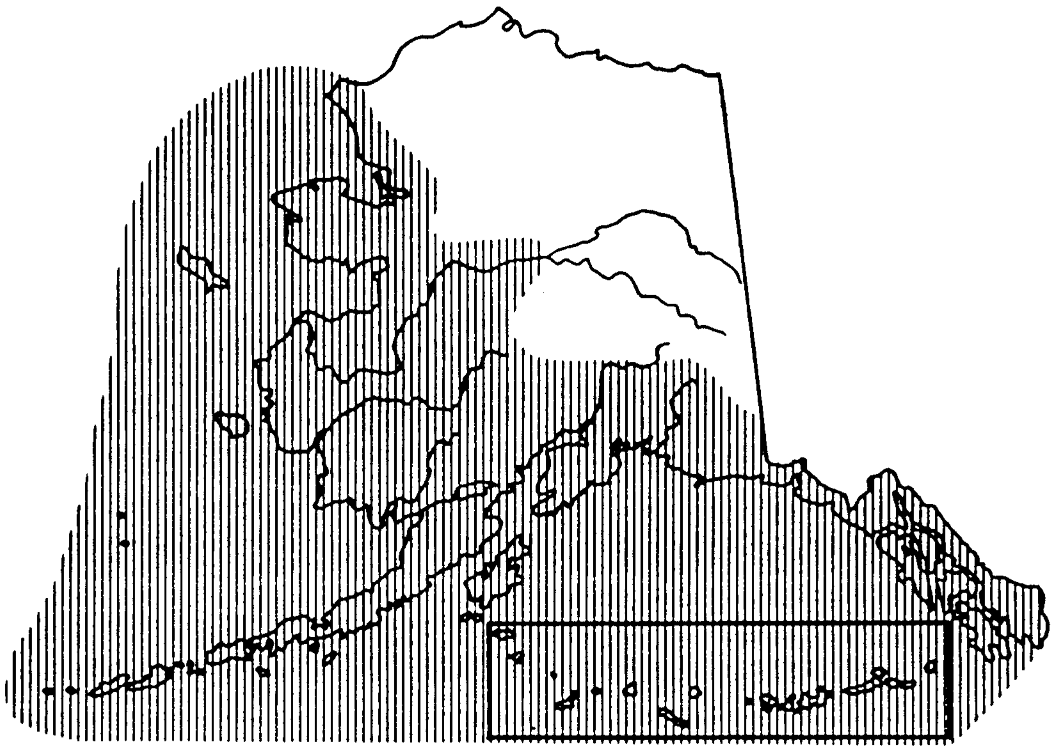
Sockeye Salmon Life History and Habitat Requirements
Southwest, Southcentral, Arctic, Western, and Interior Regions



Map 1. Range of sockeye salmon (Morrow 1980)

I. NAME
   A. Common Names: Sockeye salmon, red salmon, blueback salmon
   B. Scientific Name: Oncorhynchus nerka
   C. Native Names: See appendix A.

II. RANGE
   A. Worldwide

In North America, the sockeye salmon ranges from the Klamath River, California, north to Point Hope, Alaska. In Asia, sockeye salmon are found from northern Hokkaido, Japan, to the Anadyr River in northeastern Siberia (Scott and Crossman 1973).

B. Statewide

The sockeye salmon is found in stream and river drainages from Southeast Alaska to Point Hope, Alaska. Spawning rivers are usually those with lakes in their systems (Hart 1973).

C. 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. In this series, sockeye salmon distribution information is included on the 1:250,000-scale maps titled Distribution of Anadromous 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.

D. Regional Distribution Summary

1. Southwest. In the Kodiak area, major sockeye salmon spawning and rearing waters include the Karluk, Red (or Ayakulik) River, and Upper Station systems (ADF&G 1977c). The introduced sockeye salmon run in the Fraser Lake system is growing in productivity (Pedersen, pers. comm.).

   In the Bristol Bay area (for waters from Cape Newenham to Cape Menshikof and north-side Alaska Peninsula systems south to Cape Sharichef), major sockeye salmon-producing waters include the Togiak, Igushik, Snake, Wood, Nushagak, Kvichak, Alagnak (or Branch), Naknek, Egegik, Ugashik, and Bear river systems. Other important runs are located at Nelson Lagoon, Sandy River, Ilnik, and Urilla Bay (ADF&G 1977b).

   In the waters draining the south side of the Alaska Peninsula and the Aleutian Islands are found numerous small runs of sockeye salmon. On the south peninsula, Thin Point and Orzinski lakes are important producers of sockeye salmon (Shaul, pers. comm.). The most significant Aleutian Island run is at Kashega on Unalaska Island. In the Chignik area, almost all are found in the Chignik River system (ADF&G 1977b), although there are several other minor systems in the area (Shaul, pers. comm.). (For more detailed narrative information, see volume 1 of the Alaska Habitat Management Guide for the Southwest Region.)

2. Southcentral. In the Northern and Central districts of Cook Inlet, the majority of the sockeye salmon are produced in the Kasilof, Kenai, Susitna, and Crescent rivers and Fish Creek (Big Lake) systems (ADF&G 1982a). In lower Cook Inlet, systems producing smaller runs of sockeye salmon are the English Bay Lakes, Leisure Lake, Amakdedori, and Mikfik creeks, and Aialik, Delight, and Desire lakes (ADF&G 1981; Shroeder, pers. comm.). In the Prince William Sound area, the Copper River drainage is the major producer of sockeye salmon, with runs also found in the Bering, Eshamy, and Coghill systems (ADF&G 1978a). (For more detailed narrative

information, see volume 2 of the Alaska Habitat Management Guide for the Southcentral Region.)

3. Arctic. Sockeye salmon are rare in the Norton Sound District and have been documented in only one first-order system (first-order systems are those with mouths at salt water). This is the Sinuk (Sinrock) River system (Lean, pers. comm.). In the Port Clarence District, sockeye salmon are found in the Pilgrim River-Salmon Lake-Grand Central River complex of the Kuzitrin River system (ADF&G 1977d, 1984).
   Within the Kotzebue District, sockeye salmon have been found in the Noatak and Kivalina rivers, Rabbit Creek, and Kelly Lake (ADF&G 1984).
   The presence of sockeye salmon has not been documented in Northern District waters.
   (For more detailed narrative information, see volume 2 of the Alaska Habitat Management Guide for the Arctic Region.)
4. Western. Both the Kuskokwim and Yukon rivers traverse the Western Region and serve as migration corridors for sockeye salmon. Sockeye salmon in the Yukon River, however, are extremely rare (Barton 1984), and no spawning or rearing areas have yet been documented for that portion of the drainage that lies within the Western Region (i.e., downstream of the village of Paimuit) (ADF&G 1985a). Important Western Region sockeye salmon-producing waters of the Kuskowim River system (i.e., those tributaries located downstream of and including the Holitna River drainage) include the Eek, Holokuk, Oskawalik, Holitna, Hoholitna, Kogrukluk, and Chukowan river systems (ADF&G 1977d, 1978b). South of the mouth of the Kuskokwim River, sockeye salmon are produced in the Kanektok River system, with most spawning occurring in Lake Kagati at the headwaters. The Arolik Lake and River system provides spawning grounds for sockeye salmon, as does the Goodnews River system. There are nine known sockeye spawning lakes in the Goodnews River system. One of the more important spawning areas is Goodnews Lake; others include Canyon and Kukaktlim lakes (ibid.). The Dooksook Creek system on Nunivak Island is known to be populated by sockeye salmon (ADF&G 1985a). (For more detailed narrative information, see volume 2 of the Alaska Habitat Management Guide for the Western and Interior regions.)
5. Interior. The Kuskokwim and Yukon rivers serve as pathways for sockeye salmon bound for spawning areas in the Interior Region. Sockeye salmon are extremely rare in the Yukon River (Barton 1984). For that portion of the river found in the Interior Region (i.e., main stem and tributaries upstream of the village of Paimuit), sockeye salmon have been reported taken in the main Yukon River upstream of Rampart (river km 1,227) (ADF&G 1983b), and spawning has been reported in the Innoko River drainage by local residents (Barton 1984).

Exact spawning areas, however, have not yet been documented by the ADF&G (Barton 1984, ADF&G 1985b). Within that portion of the Kuskokwim River drainage in the Interior Region (i.e., that portion upstream of the Holitna River drainage), sockeye salmon are found in the Stony River drainage and in the Big Salmon Fork of the Little Tonoza River in the South Fork Kuskokwim River drainage (ADF&G 1985b). (For more detailed narrative information, see volume 2 of the Alaska Habitat Management Guide for the Western and Interior regions.)

III. PHYSICAL HABITAT REQUIREMENTS

A. Aquatic

1. Water quality:

a. Temperature. Egg hatching under experimental conditions has occurred across a wide range of temperatures, including 4°C, 15°C, and at descending habitat temperatures of 13.0 to 5.1°C. The amount of time to 100% hatching in these tests was 140 days, 48 days, and 70 to 82 days, respectively (Scott and Crossman 1973).
For juvenile sockeye salmon from Washington, the upper lethal temperature limit is 24.4°C (Brett 1952), and preferred temperatures range from 12 to 14°C (ibid.). Smolt out-migration from freshwater nursery lakes takes place when surface water temperatures approach 4 to 7°C (Hart 1973).
Adult spawning has occurred in temperatures ranging from 3 to 10°C (McLean et al. 1977, Scott and Crossman 1973.) Water temperatures of 20°C and more have caused death in upstream-migrating adult sockeye (Foerster 1968).

b. The pH factor. There is no optimum pH value for fish in general; however, in waters where good fish fauna occur, the pH usually ranges between 6.7 and 8.3 (Bell 1973). State of Alaska water quality criteria for freshwater growth and propagation of fish call for pH values of not less than 6.5 or greater than 9.0, with variances of no more than 0.5 pH unit from natural conditions (ADEC 1979).

c. Dissolved oxygen (D.O.). Foerster (1968) cites studies from the USSR indicating that adult spawning has occurred in lakeshore areas, streams, and spring areas where the mean D.O. level was 11.47 mg/l at 3.82°C and 86.13% saturation (range of 10.22 to 12.50 mg/l, 3.05 to 4.44°C, and 77.05 to 92.14%, respectively).
State of Alaska water quality criteria for growth and propagation of fish state that "D.O. shall be greater than 7 mg/l in waters used by anadromous and resident fish. Further, in no case shall D.O. be less than 5 mg/l to a depth of 20 cm in the interstitial waters of gravel utilized by anadromous or resident fish for spawning. . . . In no case shall D.O. above 17 mg/l be

permitted. The concentration of total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection."

d. Turbidity. Sedimentation causes high mortality to eggs and alevin by reducing water interchange in the redd. If 15 to 20% of the intragravel spaces become filled with sediment, salmonoid eggs have suffered significant (upwards of 85%) mortality (Bell 1973). Prolonged exposure to turbid water causes gill irritation in juveniles, which can result in fungal and pathogenic bacterial infection. Excess turbidity from organic materials in the process of oxidation may reduce oxygen below safe levels, and sedimentation may smother food organisms and reduce primary productivity (ibid.). Turbid water will absorb more solar radiation than clear water and may thus indirectly raise thermal barriers to migration (Reiser and Bjornn 1979).

2. Water quantity:

a. Instream flow. Sufficient water velocity ("flow," in the case of rivers and streams; and "springs" or seepage, in the case of lake spawning) and depth are needed to allow proper intragravel water movement. This flow is required to provide oxygen to the developing eggs and alevins and to carry away metabolic waste products (Reiser and Bjornn 1979, Foerster 1968).

Upon emergence from the gravel, the juveniles must have sufficient water available to be able to move to their nursery lake.

Excessive velocities may impede upstream migrating adults. Experiments in Canada discussed by Foerster (1968) concluded that none of the 406 mature sockeye salmon tested could withstand a current of 2.86 m/s for two minutes, and 50% could not maintain position for 65 seconds. Reiser and Bjornn (1979) suggest that 2.13 m/sec is the maximum velocity that sockeye salmon can successfully negotiate during their spawning runs. They also suggest that optimal velocity at spawning sites ranges from .21 to 1.01 m/sec and that depth of water is usually .15 m or less. No information for adult sockeye salmon migration or spawning criteria in Alaska were found during the literature review.

3. Substrate. Egg incubation and development occur in substrates ranging widely in size and composition. Morrow (1980) states that spawning nests are usually constructed where the bottom is fine gravel but that they may be over large pebbles of 5 to 10 cm in diameter or even over large rocks. Preferred sites have less than 10% of the gravel larger than 7.5 cm in diameter, about 50% of the gravel between 2.5 and 7.5 cm in diameter, and the remaining gravel smaller than 2.5 cm in diameter (ibid.).

B. Terrestrial

1. Conditions providing security from predators or other disturbances. No information was found in the literature.
2. Conditions providing protection from natural elements. Gravel over fertilized eggs provides protection from surface ice and sunlight.

IV. NUTRITIONAL REQUIREMENTS

A. Food Species Used

Upon hatching, young alevin remain in the gravel for several weeks until the yolk sac is absorbed. After emerging from the gravel, they usually swim to a lake to begin feeding. Juveniles, during their first few weeks in the nursery lake, feed largely on ostracods, cladocerans (water fleas), insects, and insect larvae (Morrow 1980, Hart 1973, Foerster 1968). After moving to deeper water, the young sockeye salmon become pelagic and feed on plankton in the upper 20 m or so. The major summer food items are copepods (Morrow 1980). Juvenile sockeye salmon were found to be feeding on a broad range of invertebrates in slough habitats of the middle reach of the Susitna River during August and September. Midges (Diptera: Chironomidae) were the numerically dominant taxa and were consumed as larvae, pupae, and adults (ADF&G 1982b). In some samples, zooplankton (copepods and cladocerans) became numerically important, but because they are very small their volumetric contribution to the diet was not great. On other occasions, however, the juveniles appeared to have taken advantage of a transient zooplankton bloom, as evidenced by the majority of the stomach contents being comprised of copepods and cladocerans (ibid.).

While in salt water, young sockeye salmon near shore eat insects, small crustaceans or zooplanktons (e.g., copepods, amphipods, decapods, barnacle larvae, ostracods, and euphausiids), and such young fishes and larvae as sand lance, bigeye whiting, rockfishes, eulachon, starry flounder, herring, prickle backs, and hake (Hart 1973).

On the high seas, the growing fish consume ever larger prey, which includes such crustaceans as euphausiids, amphipods, and copepods and also includes squids and young fishes (ibid.).

B. Types of Feeding Areas Used

When they first enter the nursery lake, sockeye salmon juveniles feed along the shore for a few weeks but soon move out over the deeper water in the body of the lake, where they are concentrated in the top 10 or 20 m but may be found as deep as 40 m or more (ibid.). In the Wood River system, Bristol Bay area, Alaska, Burgner (1958) reports that "while the fry do leave the rivers between lakes soon after emergence, downstream migration of fry in most of the tributary creeks is not completed for some time after breakup of the lake ice. In many creeks a portion of the fry population remains to feed and sometimes the fry acquire considerable growth before entering the lake. Sockeye fry in the

Wood River lakes are observed in abundance along the lake shores for at least a month after breakup of the lake ice. When the lake level is high early in the season they are to be found in droves in flooded grass along protected areas of the lake shore."

After migrating to salt water, the young sockeye salmon at first stay fairly close to shore (within 50 km) (Morrow 1980, Hart 1973, French et al. 1976), although they are not seen regularly near shore for several weeks during the summer as young pink salmon and chum salmon are (Ricker 1966).

As the young sockeye salmon get bigger and stronger, they head out to sea. Vertical distribution studies discussed by French et al. (1976) show that sockeye salmon in the ocean occupy depths to at least 61 m and may go deeper; most catches (90%), however, were within 15 m of the surface. These studies also suggest that the thermocline may limit the depth to which sockeye salmon descend.

Morrow (1980) states that the area bounded on the north by the Aleutians, on the south by 50° north latitude, on the west by 165 to 170° east longitude, and on the east by 160° west longitude is an important late spring, summer, and autumn feeding area. By late winter, the sockeye salmon have left this area and are found in a broad band across the North Pacific south of 50°N.

C. Factors Limiting Availability of Food

The well-being and growth of young sockeye salmon depend primarily on 1) the abundance of the food organisms on which they subsist, 2) the numbers of young sockeye salmon present, and 3) the numbers of other species of fish in the lake that compete with sockeye salmon for food (Foerster 1968). Further, temperature conditions, water transparency, and chemical conditions (particularly the amounts of nitrates, nitrites, phosphates, and silicates) all have a direct influence on the production of plankton populations, which are the main food of the young fish (ibid.).

D. Feeding Behavior

Juveniles in nursery lakes feed in schools (Hartman 1971).

Maturing sockeye salmon stop feeding as they near fresh water, and the spawning fish derive nourishment from oils and proteins of their flesh, skeletal structures, and scales (ibid.).

V. REPRODUCTIVE CHARACTERISTICS

A. Reproductive Habitat

Spawning occurs primarily in streams that connect with lakes (Morrow 1980), although some populations spawn along lake shore beaches and island beaches in lakes (Morrow 1960, McPhail 1966), and other populations spawn in streams with slow-moving reaches but no lakes in the system (Morrow 1980; Roberson, pers. comm.). Factors determining the selection of spawning sites are variable and include stream gradient, water depth and velocity, and the size of the streambed materials (substrate). Spawning sites are usually selected where there is a good waterflow through the gravel (ADF&G 1977a). These areas may be 1) in the streams flowing into the lake, 2) in the upper sections of the outlet river, or 3) along the shores of the lake where "springs" or seepage outflows occur (Foerster 1968).

In summarizing Alaskan spawning waters, Foerster (1968) states: ". . . a review of available evidence indicates that in general, while stream spawning is still the most important, lake-beach spawning increases in extent and significance (when compared to Canadian waters). At Karluk Lake on Kodiak Island, it is reported that about 75 percent of the spawning occurs in the streams, the remaining 25 percent on the lake beaches. For Bristol Bay and its highly productive sockeye salmon areas there appears to be a transition in importance of specific types of spawning ground. In the eastern part, stream spawning ranks as the most important. The Naknek and Kvichak River systems each have a number of smaller lakes auxiliary to the main lake. Salmon spawn in streams tributary to these lakes as well as in streams connecting them to the main lake. . . the spawning in both systems is confined to stream bed areas rather than beaches. Further west, however, in the Nushagak River system which comprises 10 major lakes, the sockeye salmon spawn principally in the rivers between lakes and along lake shore beaches, although there are also a few important tributary streams."

During 1965, a study of Iliamna Lake revealed that island beaches used for spawning showed no evidence of upwelling water; apparently the eggs are washed by means of wind-caused lake currents (McPhail 1966).

Vining et al. (1985), from chum salmon incubation studies of main stem, tributary, side channel, and slough habitats within the middle reach of the Susitna River, Alaska, caution that because of the effects of dewatering and freezing, the amount of available habitat at the time when adult salmon are spawning is a poor indicator of the amount of actual habitat that is available as potential incubation habitat. Estimates of available incubation habitat must take into account the differential effects of dewatering and freezing in various habitat types.

B. Reproductive Seasonality

In Alaska, adult sockeye salmon ascend their natal streams from early May to October, depending on the geographic location (Morrow 1980; ADF&G 1977a; Roberson, pers. comm.). Region-specific run timing and spawning time information is presented in the salmon Distribution and Abundance narratives prepared for each of the regions addressed in this series of publications.

In general, fish breeding in lakes and their outlet streams spawn later than those spawning in streams (ADF&G 1977a). This breeding characteristic, however, is by no means universal (Morrow 1980). Roberson (pers. comm.) notes that several factors affect the periods that have evolved to become the spawning times of different populations of sockeye salmon. Among these factors are the average water temperatures during egg incubation and alevin development, the feeding potential upon emergence from the gravel, and water temperature and velocity during adult migration.

A few exceptions to the general spawning time characteristics mentioned above are found in Upper Mendeltna Creek (outlet stream of Old Man Lake), where spawning occurs early and spawners are dead by June 30; in Dickey Lake (at the headwaters of the Middle Fork of the Gulkana River), where spawning occurs early and spawners are dead by July 30; and in the Gulkana River Springs, where spawning occurs late and spawners are dead by late November (ibid.). Likewise, the general timing characteristics do not hold true for Bear Lake on the north side of the Alaska Peninsula or for Chignik Lake on the south side of the Alaska Peninsula (Shaul, pers. comm.).

C. Reproductive Behavior

As with other salmon, adult sockeye return from the sea and move into their natal freshwater streams or lakes to spawn. The female selects the spawning site and digs the redd (nest) by turning on her side and thrashing her tail up and down. The current washes loosened substrate material downstream, and a depression 35 to 41 cm deep is formed in the river bottom (Hartman 1971, Morrow 1980). Eggs and sperm (milt) are released simultaneously and deposited in the redd. After egg deposition, the female moves to the upstream margin of the redd and repeats the digging process. Dislodged substrate is washed over the eggs. In this manner, the eggs are covered and prevented from washing away. The process is repeated several times, and the redd appears to move upstream (Burner 1951, Morrow 1980). As a result of the continued digging, the redd may grow to become 1.0 to 7.0 m^2, depending on the concentration of fish in the area, although under "normal" conditions a size of 1.6 m^2 to 2.9 m^2 is more likely (Foerster 1968). The ADF&G (1977a) states that the redds of lake spawners are usually larger than 1.75 m^2 and are more irregular in shape than redds of stream spawners. A female may dig several redds and spawn with more than one male. Males may also spawn with several females (Morrow 1980).

D. Age at Sexual Maturity

Morrow (1980) states: "Most sockeye salmon from British Columbia, Canada, spend one year in fresh water and two in the sea, returning to spawn in their fourth year. Farther north, however, two years in fresh water and two or three in the sea are common. Therefore many Alaskan sockeye salmon return in their fifth or sixth years."

E. Fecundity

The number of eggs produced by individual females varies with the stock, positively with the size of the fish and with the earlier migration history of the individual fish, shorter saltwater life being associated with higher egg counts (Hart 1973). The female usually produces 2,500 to 4,300 eggs (Morrow 1980).

F. Frequency of Breeding

As with all salmon, the spawning cycle is terminal. Both male and female die after spawning.

G. Incubation Period/Emergence

The amount of time required for eggs to hatch is dependent upon many interrelated factors, including 1) dissolved oxygen, 2) water temperature, 3) apparent velocity in gravel, 4) biological oxygen demand, 5) substrate size (limited by percentage of small fine material), 6) channel gradient and 7) configuration, 8) water depth, 9) surface water discharge and velocity, 10) permability, 11) porosity, and 12) light (Reiser and Bjornn 1979, Foerster 1968). Generally speaking, factors 4 through 12 influence or regulate the key factors 1, 2, and 3.

Development of eggs takes six to nine weeks in most areas but may require as long as five months, the time depending largely on water temperature (Hart 1973). Hatching usually occurs from mid winter to early spring, and the alevins emerge from the gravel from April to June (Morrow 1980).

VI. MOVEMENTS ASSOCIATED WITH LIFE FUNCTIONS

A. Size of Use Areas

From studies of Columbia River tributaries, Burner (1951) suggests that a conservative figure for the number of pairs of salmon that can satisfactorily utilize a given area of spawning gravel may be obtained by dividing the area by four times the average size of the redds. Redd area can be computed by measuring the total length of the redd (upper edge of pit to lower edge of tailspill) and the average of several equidistant widths (Reiser and Bjornn 1979). Information obtained by Mathisen (cited in Foerster 1968) from observations in Pick Creek, Wood River system, Bristol Bay area, Alaska, shows that under competitive conditions for space each female usually manages to average 3.7 m^2 as spawning territory. When competition for space is eliminated each female occupies an average area of 6.97 m^2. The ADF&G (1977a) states that a redd (presumably in Alaska) generally averages 1.75 m^2 in stream spawning areas. No specific data on redd size in Alaskan lake-spawning areas were found during literature review.

B. Timing of Movements and Use of Areas

In Alaska, alevins emerge from the gravel during the period April to June (Morrow 1980) and are light-sensitive, tending to hide in the stones and gravel of the stream bottom by day and coming out at night. In a few populations, the fry go to sea during their first summer, but the vast majority spend one or two years (in rare cases three or four years) in a lake (ibid.). After the juveniles emerge from the gravel in lake tributaries, those in inlet streams go downstream to the lake, and those in outlet streams swim upstream to the lake. They migrate singly at night and thus minimize the dangers of predation (Hartman 1971). Once in the lake, the juveniles move about in schools and stay close to shore for the first few weeks before moving to deeper water. In over 30 streams of the Copper River drainage, young sockeye salmon stay in the stream and move to slow-moving sections of the river because no lake is available in the system (Roberson, pers. comm.)

After a year in the lake, often two years and sometimes three years in many Bristol Bay areas (Bucher, pers. comm.), smoltification occurs (the young fish lose their parr marks and turn silvery), and they migrate downstream. Most of the migrants move at night (Morrow 1980), the migration apparently being triggered when the nursery lake's temperature approaches 4°C. The peak of the Bristol Bay out-migration occurs during June. Where known, other Alaska specific timing information is contained in the salmon Distribution and Abundance narratives found in this report series.

Following is a summary of ocean chronological distribution, as given by French et al. (1976):

After entering the open ocean in the late spring or early summer the young fish (age .0) generally are found along the coastlines within about 50 km of shore, but tagging has shown that many of them migrate hundreds of kilometers within this coastal belt. Age .0, as used here, refers to immature sockeye salmon during the period of their initial ocean residence. The period ends during December, at which time the young fish have been in the marine environment about six months. The timing and locations of their offshore migrations are unknown. In the winter as age .1 fish (7th through 18th month of ocean residence), they appear to be distributed broadly across the North Pacific Ocean and Bering Sea. The greatest abundance occurred between 50°N and 45°N. By spring, the young age .1 fish have reached their southernmost limit of migration, which in May is about 44°N in western and central North Pacific waters and somewhat north of this latitude in the northeastern Pacific. June finds the age .1 fish moving northward, a migration that continues until August. During the summer, the sockeye salmon extend in a continuous band across the North Pacific Ocean from near 140°W to 160°E and generally between 50°N and 53°N; their movement is pronouncedly westward as they approach the Aleutian Islands from the south and east. The fish are also found in abundance in the central and western Bering Sea, from 175°W to 165°E from the Aleutian Islands to near 61°N.

Little is known of the distribution of the age .1 sockeye salmon in fall other than that migration must be southward for the fish to attain their winter distribution. The winter distribution of the now age .2 fish (19th through 30th month of ocean residence) is generally similar to that which they had as age .1 immatures, although they stay 2 or 3° north of their former range. In winter, the center of concentration is generally north of 49°N in the northeastern Pacific Ocean, east of 165°W, and may extend somewhat farther south in the central and western North Pacific. The fish in winter extend across the North Pacific from near 140°W to about 165°E. In spring, they commence their inshore spawning migrations and have essentially left the high seas by the end of July.

Sockeye salmon that remain in salt water for an additional season (age .3 fish or those in their 31st through 36th month of ocean residence) winter in areas somewhat north of their age .2 range. Both age .2 and age .3 groups occur in the Bering Sea in winter (the age .3 fish apparently in greater abundance than the age .2 fish). The distribution and migration of these stocks until they leave for the spawning grounds is not known. It is known, however, that they are not found in abundance over the continental shelf areas of the eastern Bering Sea except during migration to and from spawning streams but remain in deep water parts of the ocean in the central and western Bering Sea (French et al. 1976).

C. Migration Routes

Freshwater lakes, streams, and rivers serve as corridors for downstream migration of ocean-bound juvenile sockeye salmon and upstream migration of spawning adults. The following ocean migration routes are taken from French et al. (1976).

While in the ocean, juvenile (age .0) sockeye salmon from western Alaska (primarily from streams that are tributary to Bristol Bay) move southwest along the north side of the Alaska Peninsula, then southwestward along the Aleutian Islands, and then south through various passes (most likely east of 175°E) into the North Pacific Ocean. By January 1 of their first year at sea, the now age .1 sockeye salmon have moved south of the Alaskan Stream and Ridge Area to areas primarily south of 50°N in Western Subarctic Intrusion or Transition Area waters. By April, the fish have reached their southern limit from 45°N to 50°N. In June, the sockeye begin a northward movement and by July are found north of 50°N in the Alaska Stream and Ridge Areas, with a broad east to west distribution from about 170°E to about 150°W. There is a pronounced westerly migration during the summer, particularly close to the south side of the Aleutian Islands. Some elements of the population move northwestward into the central and western Bering Sea in summer and are found to at least 60°N and to 166°E. The circuit is generally repeated again with a few minor variations as the stocks separate into mature and immature stages. Suffice it to say that maturing fish tend to stay a bit (2-3°) north of their first year's southern limit. In June, the spawning migration toward Bristol Bay occurs over a broad front from about 166°E to near 140°W.

Sockeye salmon stocks from the Alaska Peninsula (south-side streams), Southcentral, and Southeast Alaska generally mix during their residence in the northeastern Pacific Ocean. Depending on origin, they move northward, westward, or southward in a general counter-clockwise pattern along the coast as age .0 juveniles. By January, the age .1 fish have moved generally west and south into feeding grounds well offshore. In the spring (June), a northerly movement begins, and by July they are widely spread throughout the northeastern Pacific Ocean. By late summer, migration is westward and southwestward until their distribution lies probably west of 145°W and north of 49°N (some may go as far west as 177°E during their second summer at sea). In the fall, the fish turn southward and eastward and by mid winter occupy an area from near 140°W to 165°W. There is some separation of age groups of fish at this time: the maturing fish age .2, the ones that will spawn the next season, tend to be in more northern areas of the winter range in the northeastern Pacific Ocean. In the spring, the maturing fish migrate northerly, easterly, and westerly from an area generally east of 160°W and north of 46°N towards their respective spawning streams. The circuit is repeated for those sockeye salmon that remain in the marine environment for three and, rarely, four years.

VII. FACTORS INFLUENCING POPULATIONS

A. Natural

Deposition of silt in the redd, reducing water flow, may result in heavy mortality of eggs and alevins (Morrow 1980). Juveniles in their nursery lakes must compete for food with other species and are preyed upon by Dolly Varden, char, rainbow trout, coho salmon, and prickly sculpin (Hart 1973). Adults may be preyed on by Pacific harbor seals (Phoca vitulina richardsi), bears, and sea gulls (Foerster 1968). An increase in the abundance of predatory marine fishes may also be a very big factor (Shaul, pers. comm.).

B. Human-related

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

- Alteration of preferred water temperatures, pH, dissolved oxygen, and chemical composition
- Alteration of preferred water velocity and depth
- Alteration of preferred stream morphology
- Increase in suspended organic or mineral material
- Increase in sedimentation and reduction in permeability of substrate
- Reduction in food supply
- Reduction in protective cover (e.g., overhanging stream banks or vegetation)
- Shock waves in aquatic environment
- Human harvest

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

VIII. LEGAL STATUS

A. Managerial Authority

1. The Alaska Board of Fisheries develops regulations governing the commercial, sport, and subsistence harvest of salmon in Alaska. The Alaska Department of Fish and Game manages salmon populations in the fresh waters of the state and in the marine waters to the 3-mi limit.
2. The North Pacific Fishery Management Council is composed of 15 members, 11 voting and 4 nonvoting members. The 11 are divided as follows: 5 from Alaska, 3 from Washington, 3 from

state fishery agencies (Alaska, Washington, Oregon). The four nonvoting members include the director of the Pacific Marine Fisheries Commission, the director of the U.S. Fish and Wildlife Service, the commander of the 17th Coast Guard District, and a representative from the U.S. Department of State.

The council prepares fishery management plans, which become federal law and apply to marine areas between the 3-mi limit and the 200-mi limit. With regard to salmon, the only plan prepared to date is the Salmon Power Troll Fishery Management Plan.

3. The International North Pacific Fisheries Commission (INPFC), a convention comprised of Canada, Japan, and the United States, has been established to provide for scientific studies and for coordinating the collection, exchange, and analysis of scientific data regarding anadromous species.

   With regard to salmon, the INPFC has also prepared conservation measures that limit the location, time, and number of fishing days that designated high seas (beyond the 200-mi limit) areas may be fished by Japanese nationals and fishing vessels.

IX. LIMITATIONS OF INFORMATION

The physical habitat requirements for sockeye salmon are less well documented than other aspects (timing and movement patterns, e.g.) of this species' freshwater residency in Alaska.

X. SPECIAL CONSIDERATIONS

A freshwater form of this species exists and is known as the kokanee. The kokanee is generally very similar to the anadromous sockeye salmon except that it is smaller in ultimate length and weight and spends its entire life in fresh water. It, too, dies after spawning.

Caution must be used when extending information from one stock of sockeye salmon to another stock. Environmental conditions for one area must not be treated as absolute; the stocks (races) have acclimated or evolved over time and space to habitat conditions that can vary greatly.

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