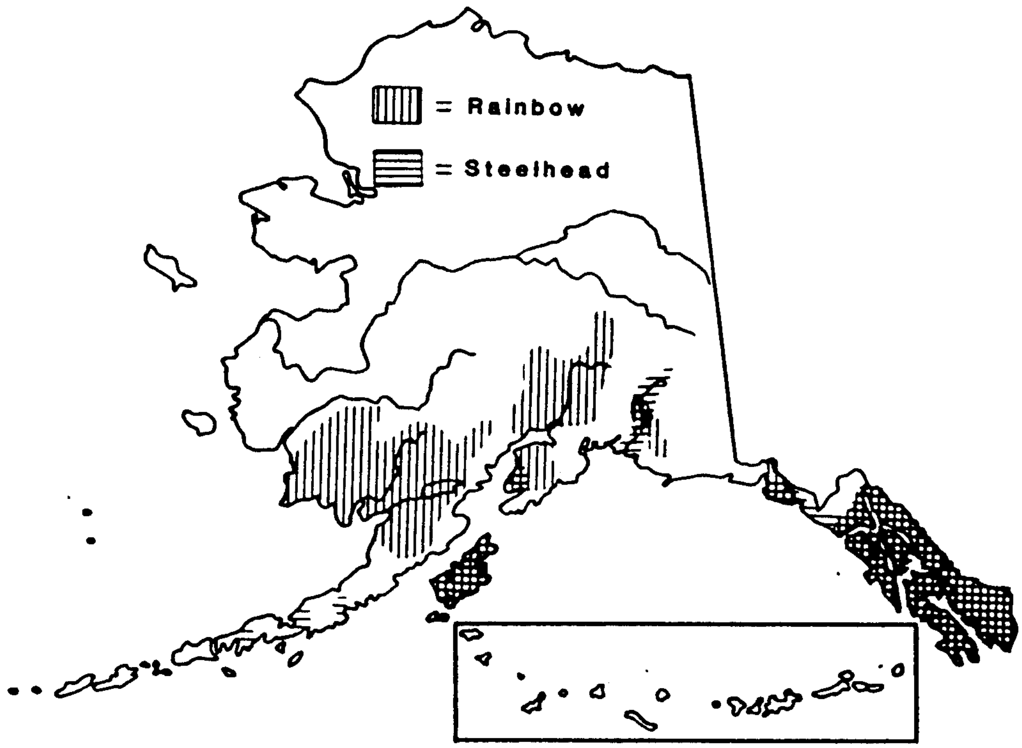
Rainbow Trout/Steelhead Life History and Habitat Requirements
Southwest, Southcentral, and Western Regions



Map 1. Range of rainbow trout/steelhead trout (ADF&G 1978)

I. NAME
   A. Common Names: Rainbow trout and steelhead trout
   B. Scientific Name: Salmo gairdneri
   C. Native Names: See appendix A.

II. RANGE
   A. Statewide

Rainbow trout are found throughout Southeast Alaska, west to the Alaska Peninsula, and up the Kuskokwim River as far as Sleetmute (ADF&G 1978).

Steelhead are found throughout Southeast Alaska, in the Copper River drainage, on the lower Kenai Peninsula as far up as the Kasilof River, on Kodiak Island, and on the Alaska Peninsula.

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. For rainbow trout, the maps in this series are at 1:250,000 scale. 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. Southwest. Native rainbow trout are found on Kodiak Island. Some of the more important Kodiak rivers are Karluk, Ayakulik, Portage, and Afognak. Native rainbow trout are also found in Bristol Bay drainages north of Becharof Lake and the Egegik River to the Kuskokwim River (ibid.). Largest trout are found in most lake-river systems, such as the Naknek, Kvichak, and Alagnak (ibid.).

   Steelhead trout are also native to Kodiak Island, where they are most abundant in the Karluk and Ayakulik rivers (Murray, pers. comm.). Steelhead are also found in a few streams on the north side of the Alaska Peninsula, including the Sandy River, Bear River, King Salmon River, and Steelhead Creek. On the south side of the peninsula, steelhead have been documented in the Chignik River and a stream that drains into Ivan Bay (ADF&G 1984). (For more detailed narrative information, see volume 1 of the Alaska Habitat Management Guide for the Southwest Region.)

2. Southcentral. Native rainbow trout are found in most drainages of the northern and western Kenai Peninsula, from Anchor River north to the Chickaloon River (ADF&G 1978). They are found in the lower Susitna River drainage and, to a lesser extent, the Matanuska drainage and some of the larger rivers flowing into northwestern Cook Inlet. Rainbows are also found in some clearwater tributaries of the Copper River, most importantly the Gulkana River (ibid.). In addition to native fish, several lakes in Southcentral Alaska are stocked with rainbow trout on a put-and-take basis.

   Steelhead trout are found in several Kenai Peninsula streams between Homer and the Kasilof River (ibid.). They are also found in the Copper River drainage, especially the Gulkana River (ibid.). Steelhead trout in the Middle Fork of the Gulkana River may be the northernmost natural steelhead population in Alaska (Williams, pers. comm.). (For more detailed narrative information, see volume 2 of the Alaska Habitat Management Guide for the Southcentral Region.)

3. Arctic. In the Arctic Region, brightly colored char are frequently called rainbow trout, but this is a misnomer. The Arctic Region contains no known populations of rainbow or steelhead trout.

4. Western and Interior. Natural populations of rainbow trout are found in the southwest portion of the Western Region. They are found in streams flowing into Kuskokwim Bay south of the Kuskokwim River and in the Kuskokwim River drainage as far as 125 mi upstream from Aniak (Alt 1977). Natural populations of rainbow trout are not found in the Interior Region, but they have been stocked in many Interior lakes and support many popular Interior sport fisheries. (For more detailed narrative information on rainbow trout distribution in the Western and Interior regions, 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. Preferred temperatures for rainbow trout from hatchery and wild populations in the Great Lakes, Ontario, and New York State have been reported to be between 11.3 and 20°C (McCauley et al. 1977, McCauley and Pond 1971, Cherry et al. 1977). Upper lethal temperatures for Great Lakes and New York rainbow were 25 to 26°C (Bigood and Berst 1969, Hokanson et al. 1977, Cherry et al. 1977). The lower lethal temperature is 0°C (McAfee 1966).

Russell (1977) reported that rainbow spawning in Talarik Creek (tributary to Lake Iliamna in Southwest Alaska) peaked at 5 to 7°C and terminated at 7 to 16°C. Allin and Baxter (1957) observed rainbow spawning in Cottonwood Creek (drainage of Wasilla Lake in Southcentral Alaska) at temperatures of 6.7 to 7.8°C.

McAfee (1966) found increased mortality in rainbow embryos at temperatures less than 7°C and normal development at temperatures between 7 and 12°C.

Jones (1972) reported temperatures for the adult steelhead spawning migration to be 2 to 6°C in Petersburg Creek in Southeast Alaska. In 1973, however, temperatures were 0 to 4°C, and he stated that temperature did not appear to affect in-migration (Jones 1973).

Sutherland (1973) reported that the limits of steelhead distribution in the open ocean conform to the 5°C isotherm in the north and the 15°C isotherm in the south.

b. The pH factor. Rainbow trout have been found to acclimate to pH from 5.8 to 9.8 (McAfee 1966, Murray and Ziebell 1984); however, acclimization to pH levels above 8.5 must take place gradually (over at least four days) (Murray and Ziebell 1984).

c. Dissolved oxygen (D.O.). Optimal oxygen levels for rainbow trout are given by Raleigh and Hickman (1982) to be 7 mg/l or greater at temperatures less than 15°C and 9 mg/l or greater at temperatures higher than 15°C. State of Alaska water quality standards for growth and propagation of fish require D.O. levels greater than 7 mg/l (ADEC 1979).

Lethal levels of D.O. reported for adults and juveniles range from 2.9 mg/l at 10 to 20°C (Downing and Merkens 1957) to 0.5 to 1.5 mg/l at 15°C (Streltsova 1964). Raleigh and Hickman (1982) state that the lethal level is approximately 3 mg/l.

Phillips and Campbell (1962) found that steelhead embryos from Oregon did not survive at D.O. levels of 7.2 mg/l or less. Silver et al. (1963) found that steelhead eggs from an Oregon hatchery survived to hatching at D.O. levels as low as 2.6 mg/l but that the time to hatching increased from a mean of 36 days at 11.2 mg/l to a mean of 44 days at 2.6 mg/l (at a water velocity of 6 cm/hr). Shumway et al. (1964) also found an increase of hatching time and a decrease in weight of newly hatched fry at decreased D.O. levels (from approximately 11 mg/l down to approximately 3 mg/l). Fry that are small and have taken long to develop may not be viable in the natural environment.

d. Turbidity. High levels of turbidity may abrade and clog fish gills, reduce feeding, and cause fish to avoid some areas (Reiser and Bjornn 1979). Turbidity and sedimentation may smother food organisms and reduce primary productivity (Bell 1973). Turbid water will absorb more solar radiation than clear water and may thus indirectly erect thermal barriers to migration (Reiser and Bjornn 1979).

Herbert and Merkens (1961) found that suspended mineral solids in excess of 90 ppm caused increased mortality of rainbow trout. Rainbow trout held in tanks with high concentrations of suspended solids suffered damage to their gills (thickening of epithelial cells and fusion of adjacent lamellae) and increased susceptibility to fin-rot disease. Olson et al. (1973) also found gill damage in rainbow trout held in water with high turbidity levels and decreased feeding of rainbow trout when turbidity exceeded 70 JTU (Jackson Turbidity Units).

Kramer and Smith (1965) found that suspended wood fiber at concentrations as low as 60 ppm (the lowest level studied) caused significant sublethal stress to rainbow trout juveniles. Responses to suspended fiber included reduced breathing rate, heart rate, respiration rate, and growth rate. Fiber clogged buccal and gill cavities and killed a high proportion (up to 100% at 250 ppm) of alevins within 48 hours of hatching (Kramer and Smith 1965). Excess turbidity from organic materials in the process of oxidation may reduce oxygen below acceptable levels (Bell 1973). Studies of rainbow trout habitat in the Susitna River indicate that rainbow trout generally avoid turbid water. However, when no other form of protective cover is available, the trout apparently use the turbid water for cover (Suchanek et al. 1984).

2. Water quantity. In the Susitna River, adult rainbow trout were typically caught by boat electrofishing in areas with water velocities less than 46 cm/sec (Suchanek et al. 1984). Hook and line sampling indicated that rainbow trout preferred pools with velocities less than 15 cm/sec and depths greater than 0.6 m (ibid.). During spawning, stream velocity influences the ease with which bottom materials are moved for redd excavation and affects the energy expenditure required for a spawner to maintain position above the redd site (Russell 1977). Sufficient water velocity and depth are needed to allow proper intragravel water movement so that dissolved oxygen is transported to eggs and alevin and metabolic wastes are removed (Reiser and Bjornn 1979). Smith (1973) gave depth and velocity requirements for spawning steelhead in Oregon as at least 0.24 m deep and 40 to 91 cm/sec. Rainbow trout values were at least 0.18 m deep and 48 to 91 cm/sec. Allin and Baxter (1957) noted that spawning rainbow trout prefer water .1 to .25 m deep with a moderately swift velocity (less than 1.2 m/sec) in Cottonwood Creek, Alaska. Jones (1975) found that spawning steelhead in Petersburg Creek in Southeast Alaska favored water 0.2 to 0.35 m deep but that they were also found spawning on shallow riffles not exceeding 0.16 m in depth. In Lower Talarik Creek (draining into Lake Iliamna, Alaska), rainbow trout redds are located in areas where stream velocities are 30 to 60 cm/sec (Russell 1977).

   Withler (1966) noted that temporary high-water flows (freshets) may be necessary to initiate upstream movement of spawning steelhead in British Columbia. Jones (1973) also noted that water level is the most important factor influencing immigrating steelhead in Petersburg Creek, Alaska. Steelhead moved upstream most readily on rising stream levels.

   Steelhead and rainbow fry in streams are found in shallower water and slower velocities than at other life stages (Miller 1957, Horner and Bjornn 1976). Everest and Chapman (1972) found underyearling steelhead in an Idaho stream in water less than 0.5 m in depth and of less than 0.3 m/sec velocity. Age 1+ steelhead were in water greater than 0.6 m in depth and of greater than 0.5 m/sec velocity. Jones (1972) stated that the most favored rearing habitat type in Petersburg

Creek, Alaska, is a stream section 0.15 to 0.60 m deep with moderate-to-fast flow (no actual velocity measurements were taken).

3. Substrate. In the Susitna River, adult rainbow trout use rocks with diameters over 8 cm for cover (Suchanek et al. 1984). The substrate composition of salmonid spawning beds influences the development and emergence of fry. Substrates with low permeability result in lower apparent velocities and reduced oxygen delivery to, and metabolite removal from, eggs (Reiser and Bjornn 1979). Successful fry emergence is also hindered by excessive amounts of sand and silt in the gravel (ibid.).

   Phillips et al. (1975) found that emergent survival of steelhead alevins from an Oregon stream was only 18% in a substrate mixture of 70% sand (less than 3.3 mm diameter), compared to 94% survival in the control substrate with no sand. McCuddin (1977) reported that survival and emergence of steelhead embryos was reduced when sediments less than 6.4 mm in diameter made up 20 to 25% or more of the substrate.

   Jones (1975) found that steelhead in Petersburg Creek, Alaska, generally select redd sites in areas with gravel 5 to 10 cm in diameter; however, some redds were in areas comprised of fine gravel (less than 5 cm) and in areas of large cobble and boulders. Allin and Baxter (1957) observed that rainbow trout in Cottonwood Creek in Southcentral Alaska prefer to spawn on gravel loose enough for digging to a depth of 10 to 13 cm. Gravel taken from one Cottonwood Creek redd consisted of 72% particles greater than .85 cm in diameter.

   Large substrate is important as cover for overwintering steelhead fry in streams. Bustard and Narver (1975) found that rubble in the 10 to 25 cm range was used as cover by over 50% of age 0 steelhead fry overwintering in a Vancouver Island stream. In streams where larger substrate is available, overwintering steelhead fry may be associated with rubble 20 to 40 cm or larger (Everest 1969, Hartman 1965). Hiding in rubble in the winter reduces downstream displacement during freshets and probably also is a means of avoiding predation in winter, when swimming ability is reduced (Bustard and Narver 1975).

   Substrate size also influences stream invertebrate populations, which are important as the food source of rearing salmonids. Reiser and Bjornn (1979) stated that highest invertebrate production is from areas with gravel and rubble-size materials.

B. Terrestrial

Protective cover is provided by overhanging vegetation and undercut banks (in addition to instream cover provided by such factors as rocks, submerged logs, and turbulent water) (Giger 1973, Suchanek et al. 1984). Nearness of cover may be important to fish waiting to spawn, as spawning often takes place in open segments of streams where fish are vulnerable to disturbance and predation (Reiser and Bjornn 1979). Jones (1976) noted that adequate cover to escape predation is the most important factor in redd site selection in small tributary streams of Petersburg Creek in Southeast Alaska.

IV. NUTRITIONAL REQUIREMENTS

A. Food Species Used

Rainbow and steelhead are largely opportunistic feeders, consuming whatever is available in their environment (Morrow 1980). Generally, those in fresh water feed on insects (especially larval and adult dipterans) and crustaceans (such as Gammarus) (ibid.). Large adult rainbows eat other fishes (ibid.). In the open ocean, steelhead feed on squid, amphipods, and greenling (Hexagrammidae) (Sheppard 1972).

Allin and Baxter (1957) found that 75% of the total food intake by rainbow from Cottonwood Creek and Wasilla Lake was fish, predominantly sticklebacks (Gasterosteidae). They also noted that lake fish feed more heavily on sticklebacks than do stream resident fish. Engel (1970) found that sticklebacks comprised more than 75% of the food (by volume) of rainbow trout larger than 254 mm in Gruski Lake on the Kenai Peninsula. Insects (especially Trichoptera larvae) were of secondary importance in the diet of these large fish. Trout less than 254 mm preferred insects (especially Diptera, Trichoptera, and Coleoptera). Engel (1970) noted that the rainbow trout switched to a diet of fish after attaining a size of 204 to 254 mm, regardless of the availability of other food.

Rainbow trout in Lower Talarik Creek in Southwest Alaska consume mainly eggs of sockeye salmon (Oncorhynchus nerka [Walbaum]); aquatic dipterans (midges); and Trichoptera larvae (Russell 1977). Forage fishes, especially pond smelt (Hypomesus olidus), were eaten by trout over 175 mm in length (Russell 1977). In the Susitna River, rainbow trout concentrate near tributary mouths and in sloughs during the summer, presumably to feed on eggs of pink and chum salmon, which spawn in these areas (Sundet and Wenger 1984).

Russell (1980) reported that rainbows from the Chilikadrotna and Mulchatna rivers in southwestern Alaska frequently consumed small rodents. One Chilikadrotna rainbow stomach contained a total of five shrews.

B. Types of Feeding Areas Used

In streams, the highest invertebrate production usually occurs in riffle areas (velocity 0.46 to 1.07 m/s) with a substrate of coarse gravel (3.2 to 7.6 cm diameter) and rubble (7.6 to 30.4 cm diameter) (Reiser and Bjornn 1979). Everest and Chapman (1972) observed that steelhead juveniles rearing in Idaho streams nearly always were found close to (but not in) areas of fast-water invertebrate production. Steelhead juveniles remained near the bottom in low-velocity areas, except when darting after food items.

Scott and Crossman (1973) state that rainbow trout feed on the bottom most often but also rise to the surface to feed on emerging or egg-laying insects. The presence of large numbers of Trichoptera larvae in rainbow from Gruski Lake (Engel 1970) and Talarik Creek (Russell 1977) supports that statement.

Observations of radio-tagged rainbow trout in the Susitna River revealed that their distribution within a microhabitat may be dependent on the food source (Suchanek et al. 1984). In areas where rainbow trout were feeding on salmon eggs, they were closely associated with spawning salmon and used shallow water riffles with cobble substrate for cover (ibid.). In areas where rainbow trout were apparently feeding on aquatic insects, they were found in deep pools and used turbulent water and depth, along with the rubble/cobble substrate and debris, as cover (ibid.).

C. Factors Limiting Availability of Food

Excessive sedimentation may inhibit production of aquatic invertebrate fauna (Hall and McKay 1983).

Small rainbow trout (less than 230 mm) compete with threespine stickleback (Gasterosteus aculeatus [Linnaeus]), for food in some lakes (Engel 1970). Upon reaching a length of 230 mm, however, forage fish such as sticklebacks become important in the diet. In fact, the availability of forage fish may be necessary for rainbows to reach maximum size (Morrow 1980).

The magnitude of sockeye salmon runs in Southwest Alaska streams may affect the general condition of juvenile rainbows in that area (Russell 1977). Rainbow trout have been reported to follow spawning sockeye salmon upstream in Idavin creek in the Naknek drainage in Southwest Alaska (Gwartney 1983). The availability of large numbers of salmon eggs in the summer may enhance the rainbows' chances of overwinter survival (ibid.). A similar relationship between the size of sockeye salmon runs and the growth of steelhead trout was also noted in Petersburg Creek in Southeast Alaska (Jones 1978).

D. Feeding Behavior

Maciolek and Needham (1952) found that rainbow trout in Convict Creek, California, fed actively all winter, even in frazil ice conditions. The volume of food in rainbow trout stomachs from Paul Lake, British Columbia, was only slightly less in winter than in summer (Larkin et al. 1950). Studies in Gruski Lake on the Kenai Peninsula also indicate that rainbow trout continue to feed in winter under the ice (Engel 1970).

V. REPRODUCTIVE CHARACTERISTICS

A. Reproductive Habitat

Spawning takes place in streams, usually in a riffle above a pool (Morrow 1980). Side channels, the tails of pools just above riffles, and areas along the anterior portions of islands are frequently used (Russell 1977). More specific spawning habitat characteristics are included in the Physical Habitat Requirements portion (section III.) of this account.

B. Reproductive Seasonality

Generally, rainbow trout spawn during May and June (ADF&G 1978). Russell (1977) found that rainbow trout in Lower Talarik Creek in Southwest Alaska spawned from late April through mid June, with the spawning peak occurring between early May and early June, depending upon water temperature. In 1983, Susitna River rainbow trout spawned in late May to early June (Sundet and Wenger 1984). Peak steelhead spawning in the Copper River occurs from late May through mid June (Burger et al. 1983). In a sample of 10 steelhead taken from the Anchor River on May 10, two of six males had loose milt and four did not; none of the four females had loose eggs (Wallis and Balland 1983).

C. Reproductive Behavior

Breeding behavior is typically salmonid (Morrow 1980). The female digs a redd by turning on her side and giving several upward flips of her tail. Displaced sand and gravel is washed downstream, eventually resulting in a pit somewhat longer and deeper than the female's body (ibid.). When the redd is finished, the female drops into the pit and is joined by the male. Both fish gape their mouths, quiver, and extrude eggs and milt for a few seconds. One or more small, subordinate males may dart alongside the female and participate in the spawning act (Morrow 1980, Allin and Baxter 1957). As soon as spawning is completed, the female moves to the upstream edge of the redd and digs again, thus displacing gravel downstream and covering the eggs. This process is repeated either with the same or other males until the female's egg supply is exhausted (Morrow 1980).

D. Age at Sexual Maturity

Generally, the age at which these trout reach sexual maturity is between three and five years, with males usually maturing a year earlier than females (Morrow 1980). Most rainbows in Lower Talarik Creek in Southwest Alaska mature at ages 6 and 7 (Russell 1977). In the Susitna River, rainbow trout of both sexes spawn after age 5 (Sundet and Wenger 1984). Steelhead in Southeast Alaska spend from two to five years in the streams before migrating to sea and then spend at least two years at sea before returning to spawn, so they are normally five or six years old at maturity (Jones 1978).

Wallis and Balland (1983) found that among first-time steelhead spawners in the Anchor River, the majority of the females had spent three years in fresh water and two in the ocean. Among the males, there were about equal numbers of fish that had spent one and two years in the ocean; most had spent three years in fresh water.

E. Frequency of Breeding

Many rainbow and steelhead survive to spawn more than once (Morrow 1980). Spring runs of steelhead in Southeast Alaska contain 20 to 50% repeat spawners (Jones 1978). Fall runs of steelhead in

Southeast contain 15 to 25% repeat spawners (Jones 1978). The percentage of repeat spawners among Anchor River steelhead in different years has ranged from 3.5 (Redick 1968) to 33% (Wallis and Balland 1983).

Rainbow trout from Lower Talarik Creek in Southwest Alaska also may spawn several times (Russell 1977). Generally, large, older females are less likely to survive spawning than younger ones, and males are less likely to survive than females (Morrow 1980).

F. Fecundity

Fecundity varies with the size and condition of the females (Allin and Baxter 1957, Scott 1962). Fecundity of steelhead in Petersburg Creek in Southeast Alaska averaged 5,286 eggs per female from 1973 to 1976 (Jones 1976). Fecundity of steelhead 655 to 770 mm in length from the Anchor River ranged from 4,081 to 7,502 eggs in a sample of 10 females (Wallis and Balland 1983). Rainbow from Talarik Creek in Southwest Alaska averaged 3,431 eggs per female (Russel 1977). Rainbow from Cottonwood Creek in Southcentral Alaska averaged 489 to 2,042 eggs per female, depending on size (Allin and Baxter 1957). Morrow (1980) gives a general fecundity value of 3,250 eggs for rainbow trout and steelhead.

G. Incubation Period

Eggs usually develop to hatching in a period of four to seven weeks (ibid.), although the time of development varies with the stream temperature and may take up to four months (ADF&G 1978). Young-of-the-year rainbow trout were found on July 17 in Lower Talarik Creek (Southwest Alaska), 68 days after peak rainbow spawning (Russell 1974). Steelhead fry in Southeast Alaska emerge from the gravel in July (Jones 1978). Allin and Baxter (1957) found that approximately 1100 heat units (based on 11 A.M. daily temperatures ([Fahrenheit]) and presumably calculated by summing the difference of these temperatures from 32°F) were required for eggs to develop to fry with absorbed yolk sacs.

VI. MOVEMENTS ASSOCIATED WITH LIFE FUNCTIONS

Rainbow trout and steelhead populations follow several different life history patterns. Some rainbow trout remain in streams for their entire life and do not undertake any long migrations. Juveniles of other rainbow trout populations move into lakes after a year or more (four to five years in Talarik Creek populations). Rainbows, however, do not spawn in lakes. Most lake-dwelling rainbow trout return to streams to spawn in the spring (Morrow 1980). Russell (1977), however, found rainbow in Talarik Creek that return to the stream in the fall (though they still do not spawn until the following spring). Hartman et al. (1962, 1963, and 1964) also noted rainbows moving from Brooks River into Brooks Lake (both in the Naknek drainage) until late July, followed by a smaller migration from the lake to the river through September. Lake-dwelling rainbows usually move back to the lake three to six weeks after leaving it (Morrow 1980).

Steelhead juveniles remain in the stream for generally one to four years (usually two) (ibid.) and then move downstream in the spring and summer to marine waters. Steelhead are found throughout most of the north Pacific ocean, north of 42° north latitude. Seasonal shifts in distribution of ocean steelhead are associated with changes in water temperature. Steelhead in the North Pacific Ocean generally move north and west in late winter and early spring and shift to a southeasterly movement in late summer, fall, and early winter (Sutherland 1973).

All steelhead spawn in the spring; their return migration to the streams, however, may take place in spring, summer, or fall (Jones 1978). Spring-run steelhead are nearly ripe when they enter the stream from late February to mid June, and they spawn that same spring, spending about a month in fresh water (Jones 1975). Summer-run steelhead enter the stream in June and July and do not spawn until the following spring (Jones 1978). Fall-run steelhead return from mid September to November and also do not spawn until spring.

VII. FACTORS INFLUENCING POPULATIONS

A. Natural

Rainbow and steelhead juveniles are subject to predation by various species of fish, including other trout, chars, and coho salmon smolts (Scott and Crossman 1973). Cannibalism also occurs (McAfee 1966). Diving birds (e.g., mergansers and kingfishers) and mammals also take a small number (Scott and Crossman 1973, McAfee 1966).

Young rainbow trout potentially compete with several other fish for food, including other salmonids and sticklebacks (Scott and Crossman 1973, Engel 1970). Adult rainbows compete for food with other bottom feeders and with other predaceous fish (Scott and Crossman 1973).

High winter mortalities of rainbow trout may be caused by physical catastrophies such as dewatering, collapsed snow banks, and anchor ice formation (Needham and Jones 1959, Needham and Slater 1945).

The greatest natural mortality of salmonids occurs during early life stages and is greatly influenced by environmental factors (Straty 1981). These factors include flooding, sedimentation, stream temperature, and scouring of stream beds by ice.

Wallis and Balland (1981) reported spawning mortalities of 80 to 85% in steelhead from the Anchor River. Rainbow trout also suffer from high spawning mortalities (Sundet and Wenger 1984). For more information on spawning mortality, see the Frequency of Breeding section of this report.

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, vegetation, or large rocks)
- Shock waves in aquatic environment
- Human harvest

(See the Impacts of Land and Water Use volume of this series for additional information regarding impacts.)

VIII. LEGAL STATUS

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

IX. SPECIAL CONSIDERATIONS

Stocks of Salmo gairdneri from different geographic areas have evolved over time to specific habitat conditions. Thus, environmental requirements for one stock may be different from those of a stock in another area. Therefore, caution must be used when applying information gathered from one geographic location to a stock found in a different area.

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