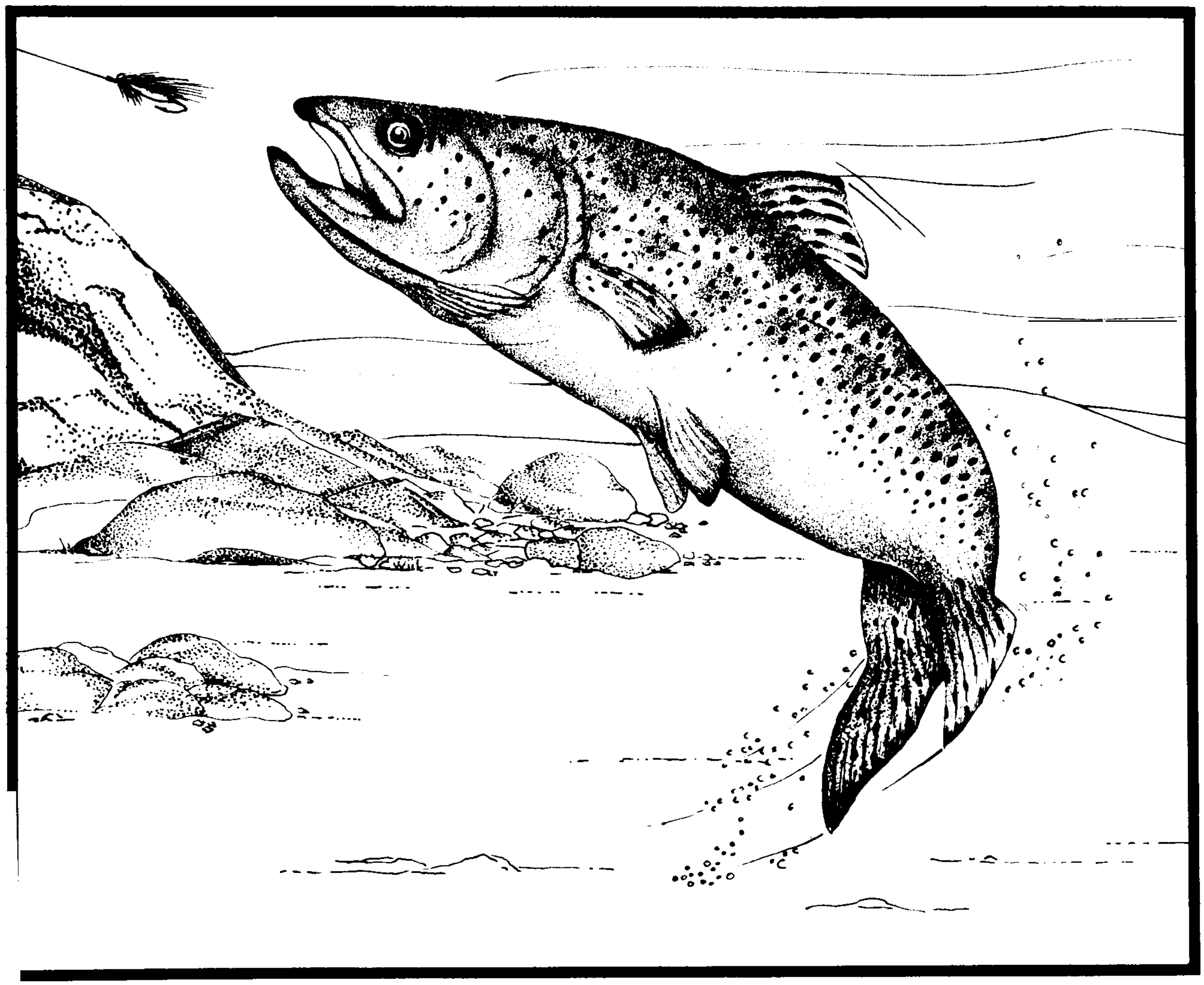
Biological Report 82(11.86)
January 1989

TR EL-82-4

Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest)

SEA-RUN CUTTHROAT TROUT



Fish and Wildlife Service
U.S. Department of the Interior

Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

Biological Report 82(11.86)
TR EL-82-4
January 1989

Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest)

SEA-RUN CUTTHROAT TROUT

by

Gilbert B. Pauley, Kevin Oshima, Karen L. Bowers, and G. L. Thomas
Washington Cooperative Fishery Research Unit
School of Fisheries
University of Washington
Seattle, WA 98195

Project Officer
David Moran
U.S. Fish and Wildlife Service
National Wetlands Research Center
1010 Gause Boulevard
Slidell, LA 70458

This study was conducted
in cooperation with
Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers
Vicksburg, MS 39180

Performed for

U.S. Department of the Interior
Fish and Wildlife Service
Research and Development
National Wetlands Research Center
Washington, DC 20240

This series may be referenced as follows:

U.S. Fish and Wildlife Service. 1983-19__. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates. U.S. Fish Wildl. Serv. Biol. Rep. 82(11). U.S. Army Corps of Engineers TR EL-82-4.

This profile may be cited as follows:

Pauley, G.B., K. Oshima, K.L. Bowers, and G.L. Thomas. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest)--sea-run cutthroat trout. U.S. Fish Wild. Serv. Biol. Rep. 82(11.86). U.S. Army Corps of Engineers TR EL-82-4. 21 pp.

PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

Information Transfer Specialist
National Wetlands Research Center
U.S. Fish and Wildlife Service
NASA-Slide11 Computer Complex
1010 Gause Boulevard
Slidell, LA 70458

or

U.S. Army Engineer Waterways Experiment Statior
Attention: WESER-C
Post Office Box 631
Vicksburg, MS 39180

CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters (m)	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers (km)	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km*)	0.3861	square miles
hectares (ha)	2.471	acres
liters (1)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters (m^3)	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons (t)	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (°C)	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	By	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
pounds (lb)	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (°F)	0.5556 (°F 32)	Celsius degrees

CONTENTS

ACKNOWLEDGMENTS

The authors thank James Johnston of the Washington Department of Game and Howard Fuss of the Washington Department of Fisheries for their reviews and technical suggestions.

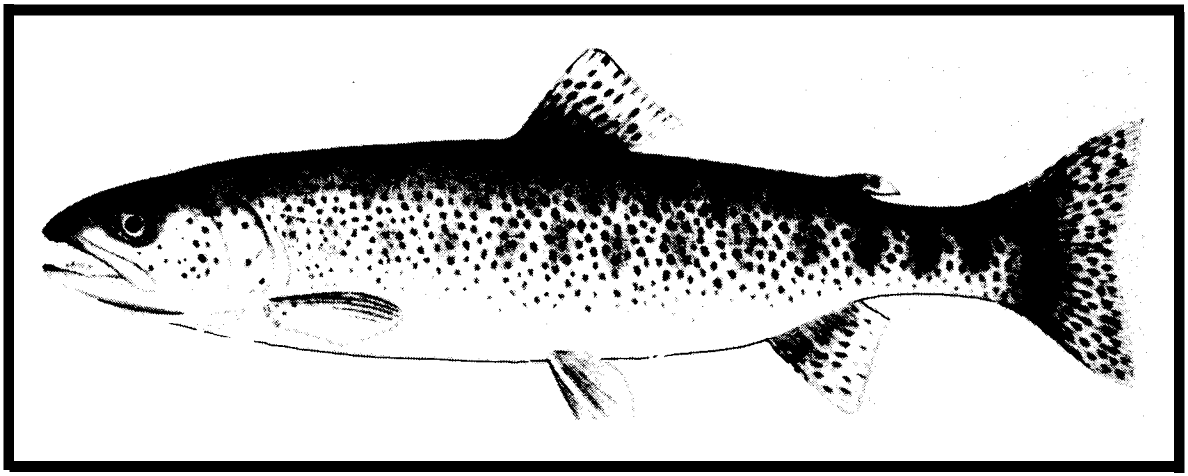


Figure 1. Sea-run cutthroat trout.

SEA-RUN CUTTHROAT TROUT

NOMENCLATURE/TAXONOMY/RANGE

Scientific name.. ..*Salmo clarki clarki*
Preferred common name....Sea-run cutthroat trout (Figure 1)
Other common names....Coastal cutthroat trout, red-throated trout, sea trout, sea-run cutthroat, sea-run cut, blueback trout, autumn trout, harvest trout, yellowbelly.
Class.....................Osteichthyes
Order....................Salmoniformes
Family.....................Salmonidae

Geographic range: In coastal streams from northern California through Oregon and British Columbia and into southeastern Alaska (Figures 2 and 3). Rarely found more than 160 km inland.

MORPHOLOGY/IDENTIFICATION AIDS

The following information is taken from Hart (1973), Scott and Crossman (1973), and Wydoski and Whitney (1978). Morphological differences between coastal cutthroat and inland cutthroat were outlined by Qadri (1959)and Trotter (1987).

Morphology: Fin rays--dorsal fin 8-11, anal 8-12, pectorals 13, and pelvic 9. Adipose, small, fleshy and slender, pelvics abdominal in position with a free-tipped fleshy appendage above insertion. Cycloid scales, 120-180 at lateral line; gill rakers 15-22, rough and widely spaced on first gill arch. Body elongate, slightly compressed.

Identification aids: Red or orange streak along the inner edge of lower jaw in fresh specimens. Small teeth at the back of the tongue between the second gill clefts. Teeth well developed on upper and lower jaws. Maxillary usually extends beyond the posterior margin of the eye in fish longer than 10 cm. Back is greenish-blue tending toward metallic blue in fresh sea-run fish; sides silvery; distinct black spots on back, head,

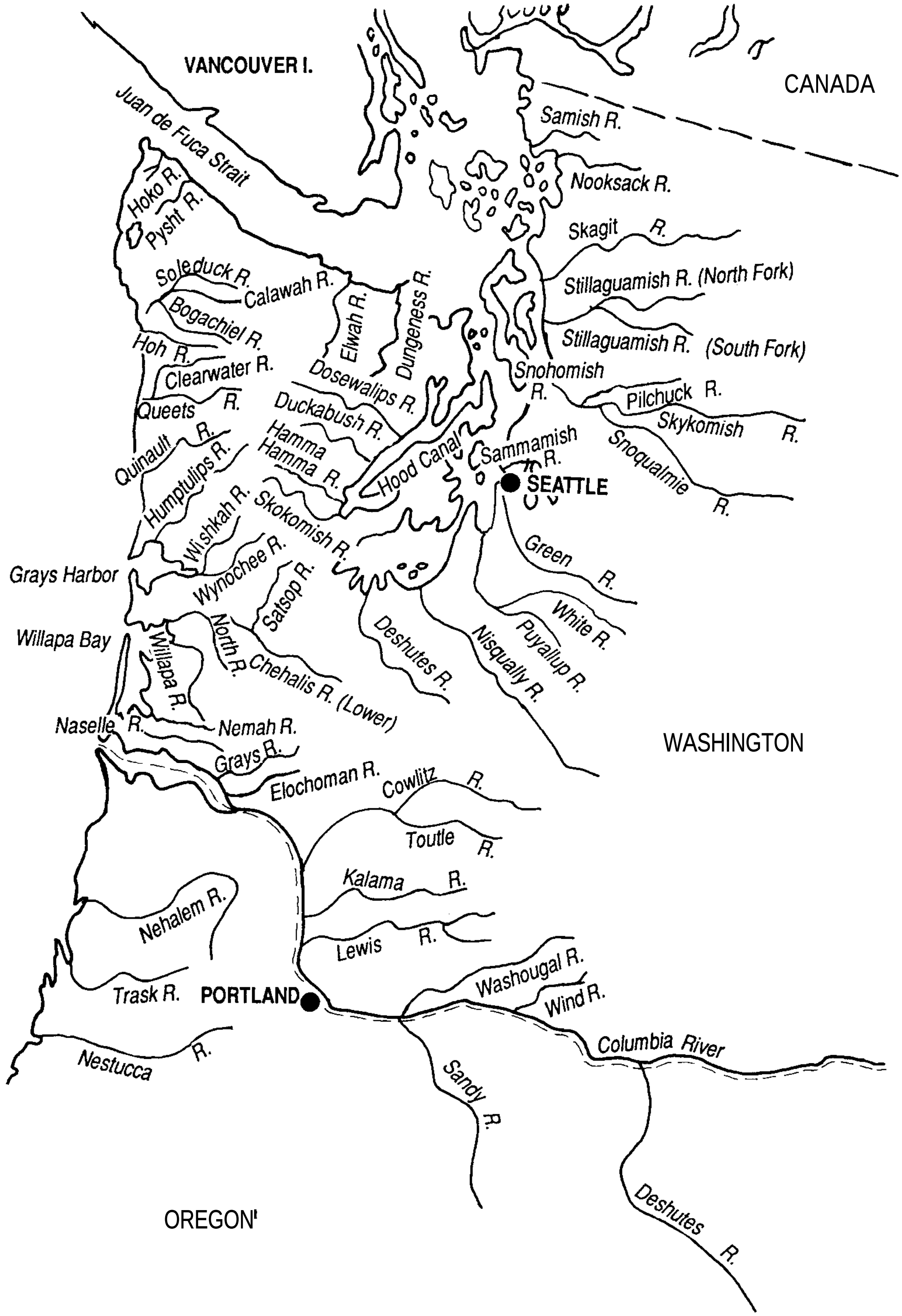
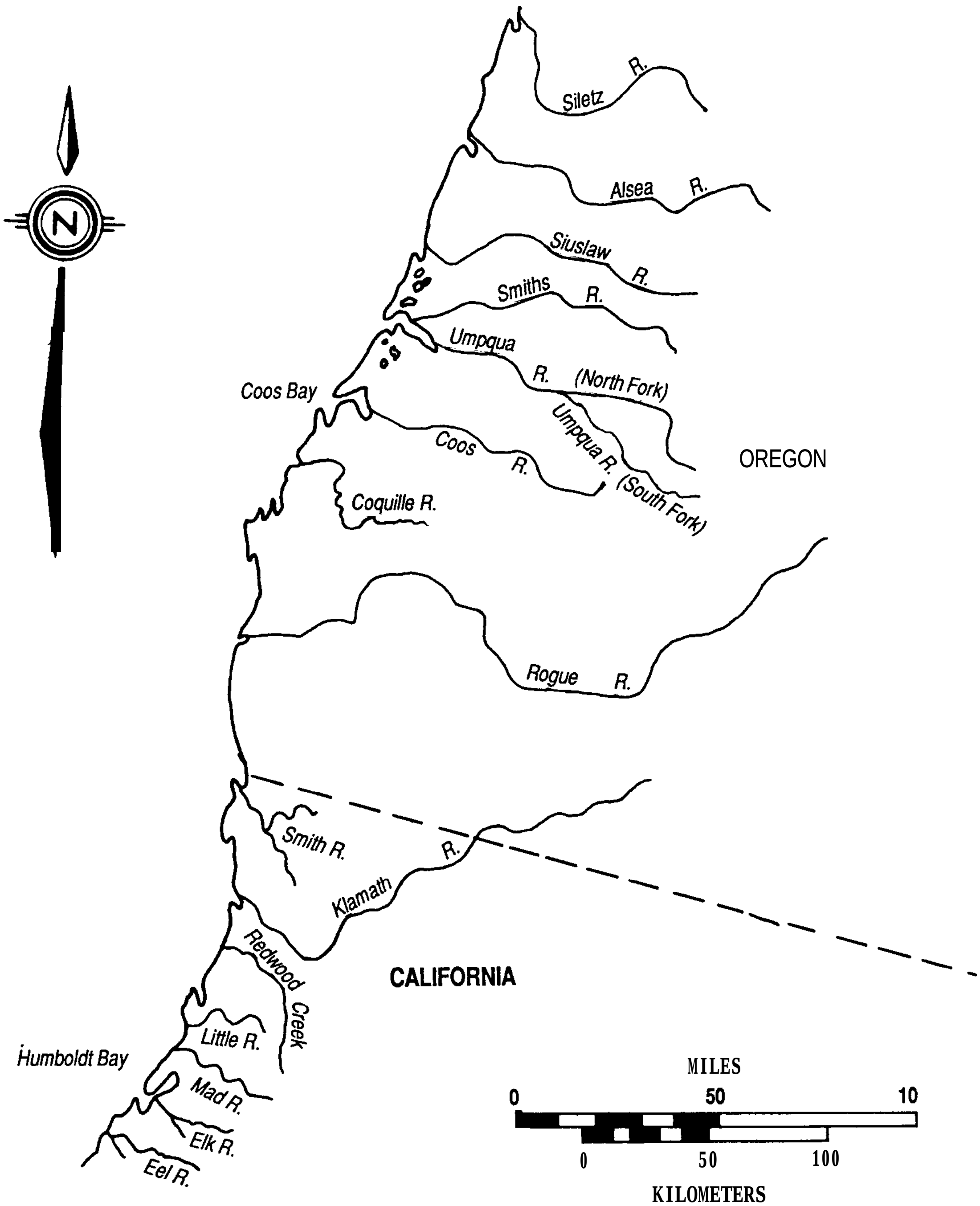


Figure 2. Map showing major rivers that support sea-run cutthroat trout in the Pacific Northwest. It should be noted that many small streams too numerous to be shown on this map also support sea-run cutthroats. An active sport fishery



exists for these fish in saltwater throughout Puget Sound and Hood Canal as well as in the rivers.

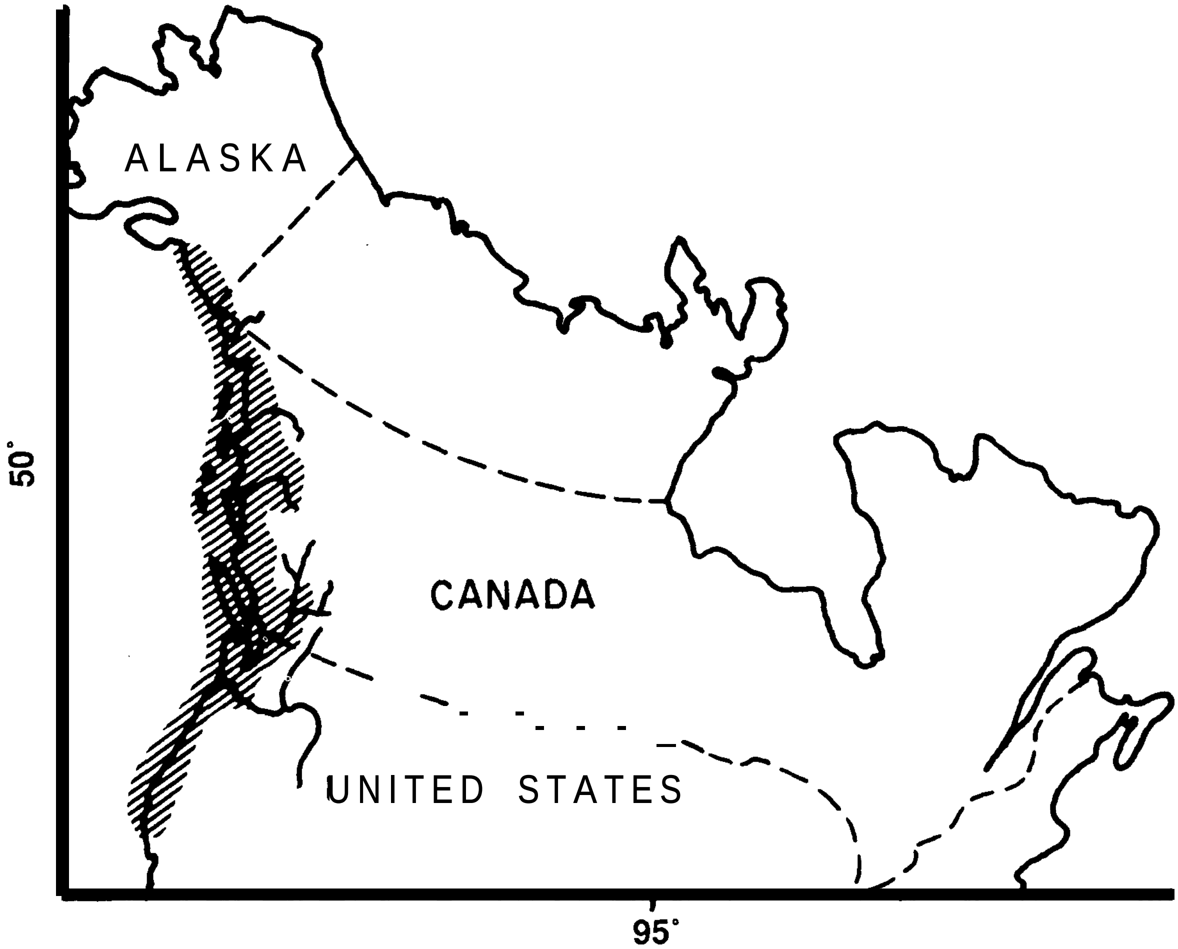


Figure 3. Sea-run cutthroat trout coastal distribution from northern California to southeastern Alaska and the general limits of inland distribution in North America (after Johnston and Mercer 1976).

anal fin, tail, and sides (extending well below lateral line). Size range of adults is 0.5 to 2.7 kg.

REASON FOR INCLUSION IN SERIES

Although not quite as well-known as its larger cousin the steelhead (Salmo gairdneri), the sea-run cutthroat trout is extensively sought by anglers through the rivers and small streams of Northern California, Oregon, Washington, and British Columbia that flow into saltwater. The freshwater sport fishery takes place in the fall, while an extensive saltwater sport fishery exists year round in inland waters such as Puget Sound. The sea-run cutthroat is highly sought after by fly-fishermen.

LIFE HISTORY

Spawning

Sea-run cutthroat trout have a variable life history, which will be discussed below. Like salmon, sexually mature sea-run cutthroat trout return to their natal streams to spawn. Spawning sea-run cutthroat trout home precisely to specific tributaries, while immature fish do not always return to their home stream to feed or when seeking an overwinter habitat (Johnston 1982). Homing of native sea-run cutthroat is extremely precise (Campton 1980), although hatchery-planted fish may stray as much as 30%, which makes survival rates impossible to determine (Johnston and Mercer 1976). Gel electrophoretic studies have shown that cutthroat populations are genetically discrete at the small stream level (Campton 1980), although there is limited hybridization with hatchery-propagated steelhead trout (Campton and Utter 1985).

The time of return to freshwater for spawning is fairly consistent among cutthroat trout from the same stream, but varies widely by geographical location (Johnston and Mercer 1976; Johnston 1982). In Oregon and Washington, cutthroat trout re-enter freshwater anytime from July through March (Sumner 1952; Anderson and Narver 1975). Very few overwinter in saltwater (Johnston 1982). A spring run has been observed only in Alaska (Jones 1972). In addition, a small percentage of the immigrants are sexually immature individuals (Jones 1973-76; Johnston 1982; Tipping 1986). In most coastal rivers of Washington and Oregon, the stocks of fish are sexually mature at first return to freshwater; however, a large percentage of cutthroat females in the Columbia River, Puget Sound, British Columbia, and Alaska do not spawn during the winter of their first return to freshwater (Johnston 1982). Anadromous cutthroat trout travel farther upstream toward the headwaters of the watershed than either steelhead trout or coho salmon and rear sympatrically with resident cutthroat populations (Johnston 1982; Michael 1983).

Spawning generally takes place in late winter and spring, but timing varies by geographic location (Dymond 1932; Cramer 1940; Scott and Crossman 1973). In Puget Sound and southern British Columbia, coastal cutthroat trout exhibit two distinct migration times: (1) fish returning to large river systems begin entering in July and peak in September-October (early entry fish) and (2) fish returning to small streams draining directly to saltwater begin entering in November and peak in January-February (late entry fish) (Johnson 1982; Mercer 1982). This difference is most likely due to food availability, saltwater tolerance, or stream flows (Johnston 1982). Throughout their range, sea-run cutthroat trout spawn in small tributaries of large or small streams with a drainage area less than 13 km and may thereby avoid competition for rearing area with steelhead (sea-run rainbow trout, Salmo gairdneri) and coho salmon (Oncorhynchus kisutch) (Cramer 1940; Sumner 1952; DeWitt 1954; Glova and Mason 1977; Johnston 1982). Cutthroat trout prefer spawning habitat with small-to-moderate-size gravel (Hunter 1973).

Spawning behavior in cutthroat trout is typical of other stream-spawning salmonids such as steelhead and salmon (Smith 1941; Cope 1957; Scott and Crossman 1973). The female digs a redd in the gravel and deposits her eggs. Simultaneously, the male covers the eggs with milt. The female then buries the eggs under a layer of gravel. Although cutthroat trout are repeat spawners, post-spawning mortalities are sometimes high due to weight loss and the rigors of spawning (Cramer 1940; Sumner 1952; Giger 1972; Scott and Crossman 1973). The fish that survive migrate downstream in early to late spring. Kelts (spent adults) enter saltwater earlier than smolting juveniles (Giger 1972; Jones 1975). Sumner (1952) stated that 39% of the cutthroat survived the first spawning in Oregon, 17% the second, and 12% the third. These data are representative of conditions where a targeted cutthroat fishery does not exist. Sportfishing pressure reduces the survival of spawning adults following the first migration (Giger 1972).

Eggs and Fecundity

The spherical eggs of cutthroat trout range in size from 4.3 to 5.1 mm in diameter. Fecundity depends on the size and age of the female. In Alaska, fish ranging in size from 34 to 46 cm produced 486 to 2,286 eggs per female (Jones 1975). In Washington, females ranging from 20 to 43 cm produced 226 to 4,420 eggs (Johnston and Mercer 1976). Average number of eggs was between 1,100 and 1,700 for females of all sizes pooled (Scott and Crossman 1973). Mercer (1982) showed a strong linear correlation between increased length and increased number of eggs, with an "r" value of .97. Eggs normally hatch in 28 to 40 days, but may require 50 days or more (Merriman 1935; Cope 1957; Scott and Crossman 1973). Hatching is temperature-dependent (Merriman 1935).

Alevins and Fry

Newly hatched yolk-sac larvae, called alevins, remain in the gravel in the redd for 1 to 2 weeks before they emerge as fry. The fry are less than 3 cm long and commonly live in the shallow, low-velocity stream margins (Johnston and Mercer 1976). However, their distribution is often governed by the presence of other salmonid species (see Ecological Role section). The first scales are formed when the fish are 3.5 cm in fork length (FL)--a length normally attained during the first summer of life (Cooper 1970; Giger 1972).

The fry are sensitive to many kinds of environmental changes. Logging (Moring and Lantz 1974), increased temperatures (Golden 1975), loss of cover (Lowery 1965), reductions in food supply, and siltation (Bustard and Narver 1975) can all increase larval mortality. Johnston and Mercer (1976) listed a number of natural sources of mortality, such as interspecific competition with other salmonids, intraspecific competition, and crowding induced by low summer flows, but they indicated that habitat alteration was probably the greatest threat to cutthroat trout stocks.

Juveniles and Smolting

Prior to smolting and entering saltwater, juveniles (parr) may migrate up- and downstream several times (Sumner 1953; Moring and Lantz 1975). This migration can result in confusion for someone trying to count or estimate the number of smolting cutthroat trout migrating downstream and out into the marine environment. The age at which smolting first occurs is extremely variable, being somewhat size-dependent and occurring between Age I and Age IV (Moring and Lantz 1975) or even later (Johnston and Mercer 1976; Jones 1977; Fuss 1978). A good working average is between Ages III and IV. Fuss (1978, 1982) noted that most initial migrants are Aged III or IV and outlined several reasons why initial migration occurs at different ages. Fish in these age groups average 20-25 cm FL. In Washington and Oregon, downstream movement of smolts takes place from March to June, but peaks in mid-May (Johnston and Mercer 1976).

A division of migration types seems to exist between cutthroat trout entering the protected water of areas such as Puget Sound and those entering areas of surf-pounded coast. Cutthroat trout entering protected waters are, on average, younger and smaller (Age II, 16 cm FL) (Michael 1983; Johnston 1980), while those entering surf zones are, on average, Age IV and 21 cm (Fuss 1982). Regardless of age or habitat, cutthroat trout school before entering the marine environment and remain schooled throughout their saltwater migrations (Giger 1972)--a behavior which probably has survival value.

Saltwater Life

Although there have been few studies of cutthroat trout movements at sea, it appears that they overwinter in the marine environment and stay close to shore. Although cutthroat remain at sea varying lengths of time, they return to freshwater in the same year in which they migrated out to sea (Giger 1972; Anderson and Narver 1975; Jones 1976; Johnston and Mercer 1976).

In Puget Sound, Washington, the anadromous cutthroat trout feed and migrate along the beaches, mostly in water less than 3-m deep (Johnston 1980). In general, their movement along the coast is believed to be correlated with onshore ocean currents, with the fish staying close to the coastline (Giger 1972; Johnston and Mercer 1976). Regardless of age, anadromous cutthroat trout are believed to begin schooling just before they enter into the marine habitat (Johnston 1980). In Alaska, cutthroat trout were reluctant to cross bodies of water 3 to 8 km wide, and preferred to follow the shoreline (Jones 1976).

Many cutthroat trout have been captured with scars from predator attack while at sea, and that predation is believed to represent a major source of marine mortality (Giger 1972). Estimates from Oregon studies indicate 20%-40% survival of initial migrant fish in the marine environment (Giger 1972). Tipping (1986) noted that survival was considerably higher for hatchery sea-run cutthroat trout that were released as smolts >21 cm FL (12.8% returns) than for fish less than that length (2.3% returns).

AGE AND GROWTH CHARACTERISTICS

Growth in cutthroat trout varies according to the type of freshwater and saltwater environments they inhabit. Johnston and Mercer (1976) summarized growth of adult cutthroat trout in the Pacific Northwest (Oregon, British Columbia, and Alaska) and stated that fish that live in the lower stream grow more rapidly than fish that reside upstream and that basic stream productivity also influences growth. Nickelson and Larson (1974) indicated that coastal cutthroat trout not only lost weight when food in streams was scarce, but that they also decreased in length. It is not known how frequently this occurs.

Giger (1972) cited problems that were inherent in determining cutthroat trout age and growth due to variable life cycles and different migration strategies. An unusual pattern of age-length distributions exists for initial outmigrants because the fish which spend more time in streams prior to outmigration grow slower. This slower growth may be a result of the greater competition for food in streams than occurs in the marine environment. The result is that fish from the same system entering saltwater for the first time at Age IV are only slightly larger than initial outmigrants of Age II, and are much smaller than Age IV fish that have spent one or more summers at sea. Fuss (1978) indicated that back-calculated lengths for young fish (less than 2 years old) may be in error, but the calculations for fish 2 years old or older are probably accurate because of the near linear relationship between fish length and scale radius for the older fish. According to Fuss (1978), Age I+ cutthroat ranged from 69 to 121 mm and Age II+ cutthroat from 140 to 180 mm. These figures may be misleading because of the additional (+) growth. In a subsequent paper, Fuss (1982) indicated more accurately that Age I fish were 70-77 mm and Age II fish were 100-113 mm. The later work involved more data and better techniques. The growth rate in more northern streams is slower than in the more southern streams (Johnston and Mercer 1976).

Cutthroat trout can live a maximum of 10 years (Jones 1976), but most adult fish runs are made up of individuals between 3 and 6 years of age (Johnston and Mercer 1976; Fuss 1982). Repeat spawners returning for a fourth or fifth spawning attain lengths of 17 to 19 inches (Giger 1972; Johnston and Mercer 1976).

ECOLOGICAL ROLE

The use of isolated headwater streams by cutthroat trout for spawning and the first years of rearing serves to reduce hybridization interactions with other salmonids, primarily steelhead trout and coho salmon, which typically spawn and rear further downstream from nursing zones of young-of-the-year and Age I cutthroat trout (Johnston 1982). Hybridization between cutthroat trout and hatchery rainbow trout does not occur in the few areas of overlap (Sumner 1972; Campton 1980; Campton and Utter 1985). Sympatric and allopatric populations of resident and anadromous cutthroat trout may also live within a watershed (Dewitt 1954; Royal 1972; Scott and Crossman 1973; Moring and Lantz 1975; Jones 1979; Johnston 1982). Another selective advantage for isolation of coastal cutthroat trout, according to Johnston (1982), is in the outcome of social interactions with anadromous steelhead trout and coho salmon. Competitive interactions for food and space between anadromous cutthroat trout and steelhead trout or coho salmon juveniles are most frequently decided in favor of the steelhead trout or the coho salmon (Glova and Mason 1976, 1977; Johnston 1982; Glova 1984). Coastal cutthroat trout in British Columbia also have evolved both a spatial and feeding segregation where they cohabit with the predacious Dolly Varden (Salvelinus malma) (Andrusak and Northcote 1971; Schultz and Northcote 1972).

Habitat selection by juvenile cutthroat trout appears to be governed by the presence of other salmonid species. In the absence of competing species, cutthroat trout have been found to prefer pools (Glova and Mason 1976; Johnston and Mercer 1976; Glova 1984). When sympatric with coho salmon, social dominance is asserted by the coho salmon due to their earlier emergence and larger body size (Glova and Mason 1976; Johnston 1982).

Cutthroat and rainbow trout coexist in the same reaches of many streams (Moring and Youker 1979; Nicholas 1978), and occasionally they hybridize (Campton and Utter 1985). The upper reaches of the stream are usually dominated by cutthroat trout, while rainbow trout dominate the lower sections (Hartman and Gill 1968; Nicholas 1978). In areas where anadromous rainbow trout (steelhead) exist, this arrangement does not always occur because the steelhead juveniles emigrate at Age I and Age II in the spring, which leaves available the pools that the older cutthroat trout seem to prefer in all sections of the streams (Johnston and Mercer 1976). It has been pointed out that there are three distinct life history types of coastal cutthroat trout: only one of these is anadromous, while the other two types spend their entire lives in freshwater (Thomasson 1978; Michael 1983; Fuss 1982, 1984).

The result of interaction with either coho salmon or rainbow trout tends to be the displacement of the juvenile young-of-the-year cutthroat trout from the preferred pools to the riffles. The cutthroat trout generally return to the pools after falling water temperatures reduce aggressive interaction with these other species and the heavier winter flows threaten displacement from the riffles (Bustard and Narver 1975; Glova and Mason 1976).

Cutthroat trout are opportunistic feeders (Behnke and Zarn 1976; Wydoski and Whitney 1978). Aquatic insects, generally the most available food in streams, are the dominant item in most cutthroat trout diets (Dimick and Mote 1934; Lowery 1966; Allen 1969; Carlander 1969; Baxter and Simon 1970; Scott and Crossman 1973; Hunter 1973; Griffith 1975; Glova 1984). Other foods, such as zooplankton (McAfee 1966; Carlander 1969; Trojnar and Behnke 1974; Hickman 1977), terrestrial insects (Lowry 1966; Glova 1984; Martin 1984), and fish (Carlander 1969; Hunter 1973; Martin 1984) are important locally or seasonally. Many of the coastal cutthroat stocks time their runs to coincide with the availability of salmon eggs in the streams (Johnston 1982).

Cutthroat trout become more piscivorous as they increase in size (Idyll 1942; McAfee 1966; Carlander 1969; Baxter and Simon 1970; Wydoski and Whitney 1978). In freshwater, cutthroat trout prey on threespine stickleback (Gasterosteus aculeatus), sockeye salmon (Oncorhynchus nerka), and coho salmon (Lowery 1966; Armstrong 1971). There is considerable similarity and overlap in the diet of young cutthroat trout and young coho salmon, but direct conflict may be avoided by habitat partitioning (Glova 1984). Wilzbach (1985) indicated that food availability is rather important in determining abundance and microhabitat distribution of adult cutthroat trout within a stream.

Freshwater predators of cutthroat fry include rainbow trout, brook trout (Salvelinus fontinalis), Dolly Varden, and shorthead sculpins (Cottus confusus), as well as adult cutthroat trout (Horner and Bjornn 1976). Other possible predators are great blue herons (Ardea herodias), belted kingfishers (Ceryle alcyon), and mink (Mustela vison) according to Horner and Bjornn (1976).

In the marine environment, cutthroat trout feed on gammarid amphipods, sphaeromid isopods, callianassid shrimp, immature crabs, and various fish, including chum salmon (Oncorhynchus keta), pink salmon (Oncorhynchus gorbuscha), and Pacific sand lance (Ammodytes hexapterus) (Armstrong 1971; Simenstad and Kinney 1978); herring and sculpins are also eaten.

Predators of sea-run cutthroat trout in the marine environment include Pacific hake (Merluccius productus), spiny dogfish (Squalus acanthias), harbor seal (Phoca vitalina), and adult salmon (Giger 1972).

ENVIRONMENTAL REQUIREMENTS

Temperature

Unusual stream temperatures can lead to disease outbreaks in migrating fish, altered timing of migration, and accelerated or retarded maturation (Reiser and Bjornn 1979). Most stocks of anadromous salmonids have evolved to take advantage of temperature patterns in their home streams, and significant abrupt deviations from the normal pattern can adversely affect their survival.

Cutthroat trout are not usually found in waters where the maximum temperature consistently exceeds 22 °C, although they tolerate brief periods of daytime water temperatures as high as 26 °C if considerable cooling takes place at night (Behnke and Zarn 1976). Bell (1973) reported preferred temperatures of 9 to 12 °C for cutthroat trout, with spawning temperatures for cutthroat trout that range from 6 to 17 °C (Hunter 1973).

The duration of egg incubation varies and is dependent upon temperature (Merriman 1935); the optimum temperature for incubation is approximately 10 to 11 °C (Merriman 1935; Snyder and Tanner 1960). Egg survival

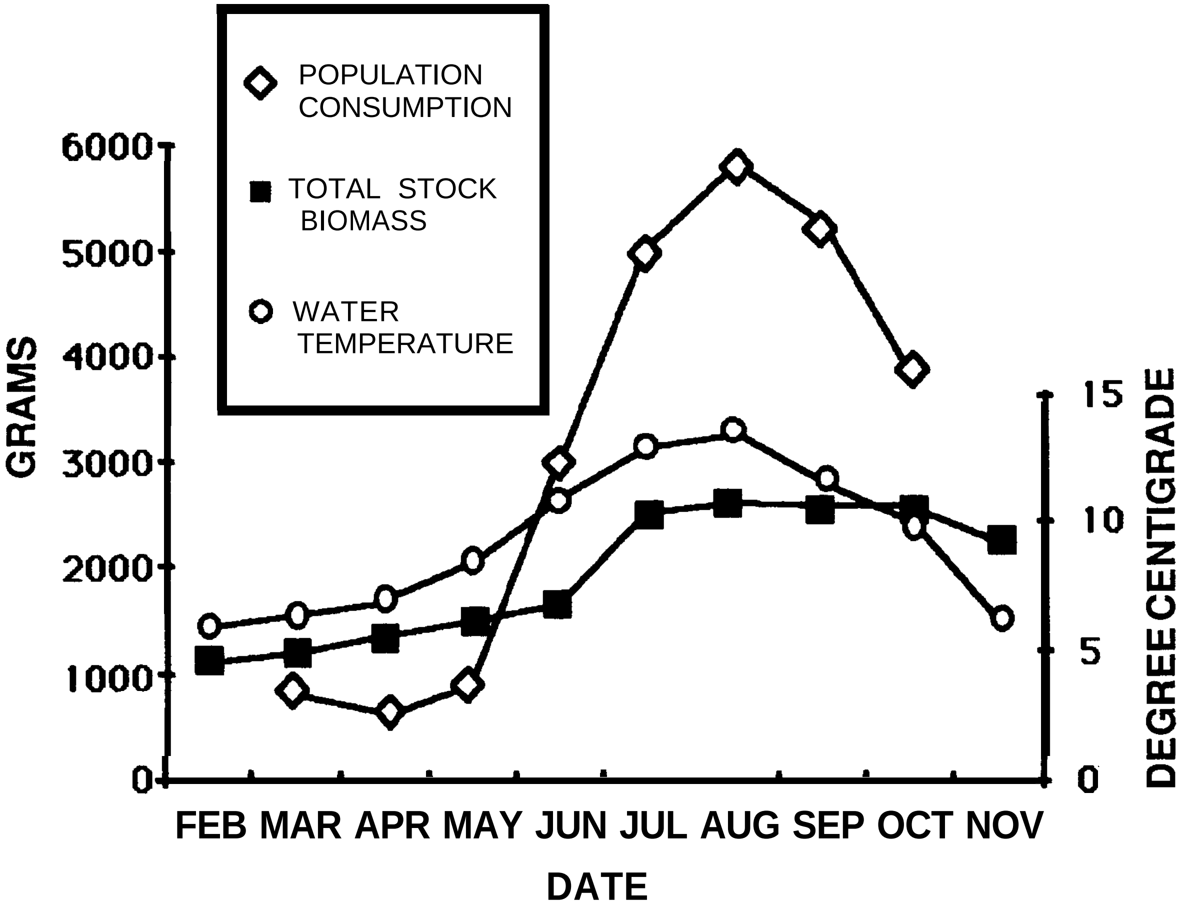


Figure 4. Sea-run cutthroat trout population consumption and total stock biomass (wet weight) versus temperature in a 500-m long section of Bear Creek, Washington (modified from Martin 1984).

is also dependent upon temperature (Smith et al. 1983).

Metabolic rates of juvenile cutthroat trout are highest between 11 and 21 °C (Dwyer and Kramer 1975). According to Martin (1984), stock biomass remained nearly constant in a given section of a small stream in the Pacific Northwest from July to September, but the water temperature rose and food consumption increased parallel to this rise (Figure 4). The optimal temperature for juveniles is 15 °C, and equilibrium and ability to swim is lost between 28 and 30 °C (Heath 1963).

In a study in southeast Alaska, outmigration of cutthroat trout peaked at water temperatures between 4 to 6 °C and inmigration began at 10 to 12 °C and peaked at 9 to 10 °C (Jones 1977).

Substrate and Cover

There is considerable variation in suitable substrate size (gravel diameter) for cutthroat trout; they have been observed spawning in gravel of 2 to 5 cm (June 1981), 0.6 to 10.2 cm (Hunter 1973), and 0.16 to 0.64 cm (Hooper 1973). Hanson (1977) found 1- to 4-year-old cutthroat trout. in streams associated with substrates of

5 to 30 cm. Irving and Bjornn (1984) found that survival of cutthroat embryos increased as the percentage of fine sediments decreased. The size of adult cutthroat trout affects gravel-size selection and the tails of pools in small tributary streams are usually chosen for spawning (Johnston and Mercer 1976).

Cover for fish can be provided by overhanging vegetation, undercut banks, and submerged objects such as logs and rocks, as well as by water depth and turbulence (Giger 1972; Bustard and Narver 1975; Reiser and Bjornn 1979). Cover protects the fish from disturbance and predation and also provides shade. The biomass of cutthroat trout in streams increases with the amount of cover present (Wesche 1974; Lantz 1976; Nickelson and Reisenbichler 1977).

Dissolved Oxygen

Doudoroff and Shumway (1970) reported that salmonids that hatched at low dissolved-oxygen levels tended to be weak and small, to develop slowly, and to show increased abnormalities. Cutthroat trout generally avoid water with less than 5 mg/l of dissolved oxygen in the summer (Trojnar 1972; Sekulich 1974). Doudoroff and Shumway (1970) also demonstrated that both swimming speed and growth rates of salmonids declined as dissolved-oxygen levels decreased.

Turbidity

According to Reiser and Bjornn (1979), salmonid fishes cease movement or migration in streams with very high silt loads (>4,000 mg/l). Because more radiation is absorbed by turbid water than by clear water, a thermal barrier to movement and migration may develop (Reiser and Bjornn 1979). Bachman (1958) reported that cutthroat trout adults stopped feeding and moved to cover at turbidities above 35 ppm.

Suspended sediment levels exceeding 103 ppm, combined with dissolved oxygen concentrations less than 6.9 mg/l and velocities in the redd of less than 55 cm/h, can reduce egg survival to below 10% (Bianchi 1963).

Fry emergence from the gravel may be hindered by excessive sand and silt (Reiser and Bjornn 1979). These conditions may also limit the production of benthic invertebrates necessary for optimum rearing of juvenile fish (Reiser and Bjornn 1979).

Water Velocity

Fry in stream environments prefer shallower water and slower velocities than other cutthroat trout life stages (Miller 1957; Horner and Bjornn 1976). Velocities of less than 0.30 m/s are preferred and the optimum is less than 0.08 m/s (Horner and Bjornn 1976). Juvenile cutthroat trout in streams are most often found in velocities of 0.25 to 0.50 m/s (T.E. Nickelson, unpubl. data). Thompson (1972) found young-of-the-year and 1-year-old cutthroat trout in water velocities of 0.5 to 0.6 m/s. Hanson (1977) found 1-year-old fish in velocities averaging 0.10 m/s. Hanson (1977) also found 2-, 3-, and 4-year-old cutthroat trout at mean velocities of 0.14, 0.20, and 0.14 m/s, respectively.

Cutthroat trout have been found spawning in small streams with flow rates as low as 0.01-0.03 m^3/s (Dimick and Marryfield 1945; Wyatt 1959; Moring and Youker 1979). Spawning may occur in selected areas of large streams (Moring and Youker 1979). Cutthroat trout spawning occurs in water velocities ranging from 0.11 to 0.56 m/s in Washington (Hunter 1973) and 0.30 to 0.90 m/s in northern California (Hooper 1973).

Coastal cutthroat trout prefer to spawn in the headwater tributaries of larger streams. Summer water flow rates in these natal creeks seldom exceed 0.28 m^3/s during low flow and most average 0.12 m^3/s (Johnston 1982).

Water Depth

Cutthroat trout spawn at the tail ends of pools at depths as shallow as 10-15 cm (June 1981) or as deep as 1 m (Johnston and Mercer 1976). Hunter (1973) found cutthroat spawning in water 6-40 cm deep. June (1981) found some redds in riffle areas.

In streams, adult cutthroat trout are found in the deeper pools and slower velocity water, while the fry are found in shallower, faster areas (Griffith 1972; June 1981).

Timber Harvest

Logging practices can directly and indirectly change the physical environments in the small headwater streams that are the important spawning and rearing areas for coastal cutthroat trout. Such changes can significantly alter cutthroat trout populations (Hall and Lantz 1969; Moring 1975; Lantz 1976). Poor logging practices in the vicinity of small streams can cause a variety of changes that are detrimental to the cutthroat trout. These include (1) an increase in both the maximum and the diurnal fluctuation of the water temperature (Hall and Lantz 1969; Moring 1975; Ringler and Hall 1975; Chamberlin 1982); (2) decreases in dissolved oxygen in both surface and intragravel water (Hall and Lantz 1969; Moring 1975; Ringler and Hall 1975; Chamberlin 1982); (3) increased sediments in the stream ana changes in the amount of fines present in the gravel (Hall and Lantz 1969; Moring 1975; Chamberlin 1982); (4) increased stream flow resulting in velocity and depth changes (Moring 1975; Chamberlin 1982); (5) alteration of the amount of woody debris in the stream causing pH changes (Chamberlin 1982); and (6) loss of terrestrial and aquatic vegetation used as food sources and rearing habitat (Moring and Lantz 1974; Moring 1975).

THE FISHERY

Angling for sea-run cutthroat trout occurs in both the marine and freshwater environments (Hisata 1973; Johnston and Mercer 1976; Washington 1977; Mercer 1982). Although only limited data are available on total annual harvest and fishing pressure, the sea-run cutthroat trout fishery represents an important component of the sport fisheries of the Pacific Northwest.

Angler surveys conducted by the U.S. National Marine Fisheries Service in 1974 in the marine area of Puget Sound, Washington, indicated that cutthroat trout were second only to salmon in popularity among saltwater anglers (Johnston and Mercer 1976). An earlier Washington Department of Game survey in 1964 showed a total of 43,700 anglers fished for anadromous cutthroat in marine areas of Washington State (Johnston and Mercer 1976). The average per capita expenditure was $25 per day in 1974, with the total value to the State's economy estimated at $8,850,000 per year. Although this data may have been biased, there is no reason to believe a decline in participation has occurred in the marine fishery. The total participation in and value of the freshwater fishery for anadromous cutthroat in Washington has never been evaluated. However, over 1,800 man-days were expended in 1970 pursuing cutthroat trout in saltwater on southern Hood Canal (Johnston and Mercer 1976).

In Oregon in 1972, anglers caught an estimated 126,000 adult cutthroat, 86% from coastal streams and 14% from the Columbia River and its tributaries (Johnston and Mercer 1976). They estimated the annual value of the stream cutthroat trout fishery to Oregon's economy was $3,750,000, based on an average per capita expenditure estimated at $30 per day in Washington State by Oliver et al. (1975). The projected catch in Washington and its impact on the State's economy has been assumed to be greater than in Oregon due to greater numbers of streams in Washington State that contain cutthroat trout and a larger human population close to these streams (Johnston and Mercer 1976).

Tipping (1981) indicated that 84% of all sea-run cutthroat trout were caught by anglers targeting on them, while 16% were caught incidental to salmon and steelhead. Most angling effort was by plunkers, with boaters second, and drift fishermen third (Tipping and Springer 1980; Tipping 1981). Overall cutthroat trout angling effort is highest in August (Tipping and Springer 1980), but the highest catch was in the first 2 weeks of September (Tipping 1981). Most anglers caught one fish or less per trip (Tipping and Springer 1980; Tipping 1981). The majority of fish caught were sexually mature (Tipping 1981).

The amount of angler participation will likely double between 1972 and 1990 in Oregon and a similar trend may occur in Washington (Johnston and Mercer 1976). The value of the cutthroat fishery to both Oregon and Washington economies is expected to increase along with fishing pressure; however, it is anticipated that the native stocks of sea-run cutthroat will not increase and may decline due to habitat degradation and possible overfishing (Johnston and Mercer 1976). New restrictive regulations (2 fish per day and 12-inch minimum size) within British Columbia and Washington, which were designed to increase spawner escapement, have significantly increased the abundance of older, larger fish in many watersheds (J. M. Johnston, unpubl. data). Johnston (1980) indicated that a two-fish limit in the Stillaguamish River would reduce the total harvest of sea-run cutthroat trout by about 20%. A 14-inch minimum size limit on sea-run cutthroat caught in all marine waters and selected freshwater streams was put in force in Washington State in 1987.

Concurrent with habitat protection, agencies responsible for the management of sea-run cutthroat populations have attempted to spread the harvestable portion of the stocks to more anglers by imposing restrictions on catch and possession, size, season, and gear.

LITERATURE CITED

Allen, K.R. 1969. Limitations on production in salmonid populations in streams. Pages 3-18 in T.G. Northcote, ed. Symposium onisalmon and trout in streams. H.R. MacMillan Lectures in Fisheries, University of British Columbia, Vancouver.

Anderson, B.G., and D.W. Narver. 1975. Fish populations of Carnation Creek and other Barkley Sound streams--1974: data record and progress report. Fish Res. Board Can. MS Rep. No. 1351. 73 pp.

Andrusak, H., and T.G. Northcote. 1971. Segregation between adult cutthroat trout (Salmo clarki) and Dolly Varden (Salvelinus malma) in small coastal British Columbia lakes. J. Fish. Res. Board Can. 28 (7):1259-1268.

Armstrong, R.H. 1971. Age, food, and migration of sea-run cutthroat trout, Salmo clarki, at Eva Lake, Southeastern Alaska. Trans. Am. Fish. Soc. 100 (2):302-306.

Bachman, R.W. 1958. The ecology of four north Idaho trout streams with reference to the influence of forest road construction. M.S. Thesis. University of Idaho, Moscow. 97 pp.

Baxter, G.T., and J.R. Simon. 1970. Wyoming fishes. Wyoming Game Fish Dep. Bull. 4. 168 pp.

Behnke, R.J., and M. Zarn. 1976. Biology and management of threatened and endangered western trout. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. RM-28. 45 pp.

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineering North Pacific Div., Contract DACW57-68-C-0086. 92 pp.

Bianchi, D.R. 1963. The effects of sedimentation on egg survival of rainbow trout and cutthroat trout. M.S. Thesis. Montana State College, Bozeman. 28 pp.

Buckley, R.V. 1966. Catch of the 1965 tidewater cutthroat sport fishery and notes on the life history of the coastal cutthroat in the Siuslaw River, Oregon. Oreg. Game Comm. Fish. Res. Rep. No. 4, Oregon State University, Corvallis. 29 pp.

Bustard, D.R., and D.W. Narver. 1975. Preferences of juvenile coho salmon (Oncorhynchus kisutch) and cutthroat trout (Salmo clarki) relative to simulated alteration of winter habitat. J. Fish. Res. Board Can. 32(3):681-687.

Campton, D. 1980. Genetic structure of sea-run cutthroat populations in the Puget Sound area. Sea-run status Report, 1980. Wash. State Game Dep. Rep. 80-14:185-186.

Campton, D.E., and F.M. Utter. 1985. Natural hybridization between steelhead trout (Salmo gairdneri) and coastal cutthroat trout (Salmo clarki clarki) in two Puget Sound streams. Can. J. Fish. Aquat. Sci. 42(1):110-119.

Carlander, K.D. 1969. Handbook of freshwater fishery biology. Iowa State University Press, Ames. Vol. 1. 752 pp.

Chamberlin, T.W. 1982. Timber harvest. Pages 1-30 in W.R. Meehan, ed. Influence of forest and rangeland management on anadromous fish habitat in Western North America. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. PNW-136.

Cooper, E.L. 1970. Growth of cutthroat trout (Salmo clarki) in Chef Creek, Vancouver Island, British Columbia. J. Fish. Res. Board Can. 27:2063-2070.

Cope, O.B. 1957. The choice of spawning sites by cutthroat trout. Proc. Utah Acad. Sci. Arts Lett. 34: 73-79.

Cramer, F.K. 1940. Notes on the natural spawning of cutthroat trout (Salmo clarki clarki) in Oregon. Proc. Sixth Pacific Sci. Congr. No. 3:335-339.

Dewitt, J.W. 1954. A survey of the coast cutthroat trout, Salmo clarki clarki Richardson, in California. Calif. Fish Game 40(3):329-335.

Dimick, R.E., and F. Marryfield. 1945. The fishes of the Willamette River system in relation to pollution. Oregon State College Eng. Exp. Stn. Bull. No. 20. 58 pp.

Dimick, R.E., and D.C. Mote. 1934. A preliminary survey of the food of Oregon trout. Oregon State College Agric. Exp. Stn. Bull. No. 323. 23 pp.

Doudoroff, P., and D.L. Shumway. 1970. Dissolved oxygen requirements of freshwater fishes. FAO (Food Agric. Organ.) United Nations, Fish. Tech. Pap. 86. Rome. 291 pp.

Dwyer, W.P., and R.H. Kramer. 1975. The influence of temperature on scope for activity in cutthroat trout, Salmo clarki. Trans. Am. Fish. Soc. 104(3):552-554.

Dymond, J.R. 1932. The trout and other game fishes of British Columbia. Can. Dep. Fish., Ottawa, Canada. 51 pp.

Fuss, H.J. 1978. Some life history characteristics obtained by scale analvsis of sea-run cutthroat trout (Salmo clarki clarki) from streams near Forks, Washington. Pages 127-133 in J.R. Moring, ed. Proceedings of the Wild Trout-Catchable Trout Symposium. Oregon Dep. Fish Wildl., Eugene.

Fuss, H.J. 1982. Age, growth and instream movement of Olympia Peninsula coastal cutthroat trout (Salmo clarki clarki). M.S. Thesis. University of Washington, Seattle. 191 pp.

Fuss, H.J. 1984. Age, growth and instream movement of Olympia Peninsula coastal cutthroat trout (Salmo clarki clarki). Pages 125-134 in J.M. Walton and D.B. Houston, eds. Proceedings of Olympic Wild Fish Conference. U.S. Park Service and Peninsula College. Port Angeles, Washington.

Giger, R.D. 1972. Ecology and management of coastal cutthroat trout in Oregon. Oregon State Game Comm. Fish Res. Rep. No. 6. 61 pp.

Glova, G.J. 1984. Management implications ofthe distribution and diet of sympatric populations of juvenile coho salmon and coastal cutthroat trout in small streams in British Columbia, Canada. Prog. Fish. Cult. 46(4):269-278.

Glova, G.J., and J.C. Mason. 1976. Interactive ecology of juvenile salmon and trout in streams. Fish. Res. Board Can. MS Rep. Ser. No. 1391. 24 pp.

Glova, G.J., and J.C. Mason. 1977. Interactions for food and space between sympatric populations of underyearling coho salmon and coastal cutthroat trout in a stream simulator during summer. Fish. Res. Board Can. MS Rep. Ser. No. 1428. 36 pp.

Golden, J.T. 1975. Lethal temperatures for coastal cutthroat trout under fluctuating temperature regimes. Oregon Fish Wildl. Dep. Rep. Unpubl. MS. 7 pp.

Griffith, J.S. 1972. Comparative behavior and habitat utilization of brook trout (Salvelinus fontinalis) and cutthroat trout (Salmo clarki) in small streams in northern Idaho. J. Fish. Res. Board Can. 29(3):265-273.

Griffith, J.S. 1975. Utilization of invertebrate drift by brook trout (Salvelinus fontinalis) and cutthroat trout (Salmo clarki) in small streams in Idaho. Trans. Am. Fish. Soc. 103(3):440-447.

Hall, J.D., and R.L. Lantz. 1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. Pages 355-375 in T.G. Northcote, ed. Symposium on salmon and trout in streams. University of British Columbia, Vancouver.

Hanson, D.L. 1977. Habitat selection and spatial interaction in allopatric and sympatric populations of cutthroat and steelhead trout. Ph.D. Dissertation. University of Idaho, Moscow. 76 pp.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Can. Bull. 180. 740 pp.

Hartman, G.F., and C.A. Gill. 1968. Distributions of juvenile steelhead and cutthroat trout (Salmo gairdneri and S. clarki clarki) within streams in southwestern British Columbia. J. Fish. Res. Board Can. 25(1):33-48.

Heath, W.G. 1963. Thermoperiodism in sea-run cutthroat trout (Salmo clarki clarki). Science 142:486-488.

Hickman, T.J. 1977. Studies on relict populations of Snake Valley cutthroat trout in western Utah 1976. U.S. Bureau of Land Management, Salt Lake City, Utah. 41 pp.

Hisata, J.S. 1973. Evaluation of stocking hatchery reared sea-run cutthroat trout in streams of Hood Canal. Wash. State Game Dep. Final Rep. AFS-44. 38 pp.

Hooper, D.R. 1973. Evaluation of the effects of flows on trout stream ecology. Calif. Dep. Eng. Res., Emeryville. 97 pp.

Horner, N., and T.C. Bjornn. 1976. Survival, behavior, and density of trout and salmon fry in streams. Univ. Idaho, For. Wildl. Exp. Stn., Contract 56, Prog. Rep. 1975. 38 pp.

Hunter, J.W. 1973. A discussion of game fish in the State of Washington as related to water requirements. Wash. State Dep. of Ecol., Olympia. 66 pp.

Idyll, C. 1942. Food of rainbow, cutthroat and brown trout in the Cowichan River system, B.C. J. Fish. Res. Board Can. 5(5):448-457.

Irving, J.S., and T.C. Bjornn. 1984. Effects of substrate size composition on survival of kokanee salmon and cutthroat and rainbow trout. Idaho Coop. Fish. Res. Unit Tech. Rep. 84-6. 21 pp.

Johnston, J.M. 1980. Stillaguamish River sea-run cutthroat creel survey (1979). Pages 208-219 in Sea-run cutthroat census report, 1980. Wash. State Game Dep. Rep. No. 80-14.

Johnston, J.M. 1982. Life histories of anadromous cutthroat with emphasis on migratory behavior. Pages

123-127 in E.L. Brannon and E.O. Salo, eds. Salmon and trout migratory behavior symposium. University of Washington Press, Seattle.

Johnston, J.M., and S.P. Mercer. 1976. Sea-run cutthroat in saltwater pens: broodstock development and extended juvenile rearing (with a life history compendium). Wash. State Game Dep. Fish. Res. Rep. AFS-57-1. 92 pp.

Jones, D.E. 1972. Life history study of sea-run cutthroat trout and steelhead trout in southeast Alaska. Federal aid in fish restoration, annual report of progress, 1971-1972. Alaska Dep. Fish Game Proj. F-9-4, 13(G-11-1):1-18.

Jones, D. E. 1973. Steelhead and sea-run cutthroat trout life history in southeast Alaska. Anadromous fish studies, annual report of progress, 1972-1973. Alaska Dep. Fish Game Proj. AFS-42, 14(AFS-42-1):11-18.

Jones, D. E. 1974. Life history of sea-run cutthroat trout in southeast Alaska. Anadromous fish studies, annual report of progress, 1973-1974. Alaska Dep. Fish Game Proj. AFS-42, 15(AFS-42-22):15-31.

Jones, D.E. 1975. Life history of sea-run cutthroat trout in southeast Alaska. Anadromous fish studies, annual performance report, 1974-1975. Alaska Dep. Fish Game Proj. AFS-42, 16 (AFS-42-3-B):Section J, 23-24.

Jones, D.E. 1976. Life history of sea-run cutthroat trout in southeast Alaska. Anadromous fish studies, annual performance report, 1975-1976. Alaska Dep. Fish Game Proj. AFS-42, 117 (AFS-42-4-B):Section M, 29-53.

Jones, D.E. 1977. Development of techniques for enhancement of anadromous cutthroat trout in southeast Alaska. Anadromous fish studies, annual performance report, 1976-1977. Alaska Dep. Fish Game Proj. AFS-42, 18 (AFS-42-5-BV):28-42.

Jones, D. E. 1979. Development of techniques for enhancement of anadromous cutthroat in southeast Alaska. Anadromous fish studies, annual performance report, 1978-1979. Alaska Dep. Fish Game Proj. AFS-42, 20 (AFS-42-7-B):27-57.

June, J.A. 1981. Life history and habitat utilization of cutthroat trout (Salmo clarki) in a headwater stream in the Olympic Peninsula, Washington. M.S. Thesis. University of Washington, Seattle. 116 pp.

Lantz, R.L. 1976. Protection of salmon and trout streams in logging operations. Pages 14-20 in A.P. Grove, ed. Stream management of salmonids. Trout-Winter Supplement, Denver, Colorado.

Lowery, G.R. 1965. Movement of cutthroat trout, Salmo clarki clarki (Richardson), in three Oregon coastal streams. Trans. Am. Fish. Soc. 94(4):334-338.

Lowery, G.R. 1966. Production and food of cutthroat trout in three Oregon coastal streams. J. Wildl. Manage. 30 (4):754-767.

Martin, D.J. 1984. Growth, food consumption, and production of cutthroat in relation to food supply and water temperature. Pages 135-144 in J.M. Walton and D.B. Houston, eds. Proceedings of Olympic Wild Fish Conference. U.S. Park Service and Peninsula College. Port Angeles, Washington.

McAfee, W.R. 1966. Lahonton cutthroat trout. Pages 225-231 in A. Calhoun, ed. Inland Fisheries Management. Calif. Dep. Fish Game, Sacramento.

Merriman, D. 1935. The effect of temperature on the development of the eggs and larvae of the cutthroat trout (Salmo clarki clarki Richardson). J. Exp. Biol. 12(4):297-305.

Mercer, S.P. 1982. Sea-run cutthroat: Broodstock development and evaluation of enhancement techniques. Wash. State Dep. Game Fish. Res. Rep. F-68-R-6. 55 pp.

Mercer, S.P., and J.M. Johnston. 1979. Sea-run cutthroat: development and evaluation of a new enhancement technique. Wash. State Game Dep. Fish. Res. Rep. F-68-R-3. 45 pp.

Michael, J.H. 1983. Contribution of cutthroat trout in headwater streams to the sea-run population. Calif. Fish Game 69(2):68-76.

Miller, R.B. 1957. Permanence and size of home territory in stream dwelling cutthroat trout. J. Fish. Res. Board Can. 14(5):687-691.

Moring, J.R. 1975. The Alsea watershed study: effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part III-Discussion and recommendations. Oreg. Dep. Fish Wildl. Fed. Aid Proj. AFS-58. Rep. 9. 24 pp.

Moring, J.R., and R.L. Lantz. 1974. Immediate effects of logging on the freshwater environment of salmonids. Oreg. Wildl. Comm., Res. Dev. Proj. AFS-58, Final Rep., Portland. 101 pp.

Moring, J.R., and R.L. Lantz. 1975. The Alsea watershed study: Part I--biological studies. Oregon Dep. Fish Wildl., Fish Res. Rep. 9. 66 pp.

Moring, J.R., and R.L. Youker. 1979. Oregon rainbow and cutthroat trout evaluation. Oreg. Dep. Fish Wildl. Proj. F-94-R. Final Rep. 64 pp.

Nicholas, J.W. 1978. A review of literature and unpublished information on cutthroat trout (Salmo clarki clarki) of the Willamette watershed. Oreg. Dep. Fish. Wildl. Res. Sect., Inf. Rep. Ser. Fish. No. 78-1. 20 pp.

Nickelson, T.E., and G.L. Larson. 1974. Effect of weight loss on the decrease of length of coastal cutthroat trout. Prog. Fish-Cult. 36(2):90-91.

Nickelson, T.E., and R.R. Reisenbichler. 1977. Streamflow requirements of salmonids. Oreg. Dep. Fish Wildl. Prog. Rep. AFS-62. 24 pp.

Oliver, W.H., C. Young, and D. Eldred. 1975. A short form for bioeconomic evaluations of wildlife in Washington State. Wash. State Game Dep. Applied Res. Bull. No. 7. 15 pp.

Qadri, S.U. 1959. Some morphological differences between the subspecies of cutthroat trout, Salmo clarki clarki and Salmo clarki lewisi, in British Columbia. J. Fish. Res. Board Can. 16(6):903-922.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. Pages 1-54 in W.R. Meehan, ed. Influence of forest and rangeland management on anadromous fish habitat in the Western United States and Canada. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. PNW-96.

Ringler, N.H., and J.D. Hall. 1975. Effects of logging on water temperature and dissolved oxygen in spawning beds. Trans. Am. Fish. Soc. 104(1):111-121.

Royal, L.A. 1972. An examination of the anadromous trout program of the Washington State Game Department. Wash. State Game Dep. Final Rept. AFS-49. 197 pp.

Schultz, D.C., and T.G. Northcote. 1972. An experimental study of feeding behavior and interaction of coastal cutthroat trout (Salmo clarki clarki) and Dolly Varden (Salvelinus malma). J. Fish. Res. Board Can. 29(5):555-565.

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184. 966 pp.

Sekulich, P.T. 1974. Role of the Snake River cutthroat trout (Salmo clarki ss.) in fishery management. M.S. Thesis. Colorado State University, Fort Collins. 102 pp.

Simenstad, C.A., and W.J. Kinney. 1978. Trophic relationships of outmigrating chum salmon in Hood Canal, Washington, 1977. Wash. State Dep. Fish. Final Rep. Contract No. 877. FRI-UW-7810. 76 pp.

Smith, C.E., W.P. Dwyer, and R.G. Piper. 1983. Effect of water temperature on egg quality of cutthroat trout. Prog. Fish-Cult. 45(3):176-178.

Smith, O.R. 1941. The spawning habits of cutthroat and eastern brook trouts. J. Wildl. Manage. 5(4):141-147.

Snyder, G.R., and H.A. Tanner. 1960. Cutthroat trout reproduction in the inlets to Trappers Lake. Colo. Fish. Game Tech. Bull. 7. 85 pp.

Sumner, F.H. 1952. A contribution to the life history of the cutthroat trout in Oregon. Oregon State Game Commission, Salem. 142 pp.

Sumner, F.H. 1953. Migration of salmonids in Sand Creek, Oregon. Trans. Am. Fish Soc. 82:139-150.

Thomasson, T. 1978. Aae and growth of cutthroat trout (Salmo clarki clarki, Richardson) in the Rogue River, Oregon. M.S. Thesis. Oregon State University, Corvallis. 65 pp.

Thompson, K. 1972. Determining stream flows for fish life. Pages 59-74 in Proceedings of the Instream Flow Requirement Workshop. Pacific Northwest River Basin Commission, Vancouver, Wash.

Tipping, J.M. 1981. Cowlitz sea-run cutthroat study 1980-81. Wash. State Game Dep. Rep. No. 81-12. 26 pp.

Tipping, J.M. 1986. Effect of release size on return rates of hatchery sea-run cutthroat trout. Prog. Fish-Cult. 48(3):195-197.

Tipping, J.M., and S.G. Springer. 1980. Cowlitz River sea-run cutthroat creel census and life history study. Pages 106-126 in Sea-run cutthroat census report, 1980. Wash. State Game Dep. Rep. No. 80-14.

Trojnar, J.R. 1972. Ecological evaluation of two sympatric strains of cutthroat trout. M.S. Thesis. Colorado State University, Fort Collins. 59 pp.

Trojnar, J.R., and R.H. Behnke. 1974. Management implications of ecological segregation between two introduced populations of cutthroat trout in a small Colorado lake. Trans. Am. Fish. Soc. 103(3):423-430.

Trotter, P.C. 1987. Cutthroat: native trout of the West. Colorado Associated University Press, Boulder, Colo. 219 pp.

Washington, P. 1977. The sea-run cutthroat trout resource and sport fishery. Mar. Fish. Rev. 39(12): 20-22.

Wesche, T.A. 1974. Relationship of discharge reductions to available trout habitat for recommending suitable stream flows. Wyo. Water. Resour. Res. Inst. Ser. No. 53. 71 pp.

Wilzbach, M.A. 1985. Relative roles of food abundance and cover in determining the habitat distribution of stream-dwelling cutthroat trout (*Salmo clarki*). Can. J. Fish. Aquat. Sci. 42(10):1668-1672.

Wyatt, B. 1959. Observations on the movements and reproduction of the Cascade form of cutthroat trout. M.S. Thesis. Oregon State University, Corvallis. 60 pp.

Wydoski, R., and R.W. Whitney. 1978. Inland fishes of Washington. University of Washington Press, Seattle. 220 pp.

50272 -101

REPORT DOCUMENTATION PAGE	1. REPORT NO. Biological Report 82 (11.86)*	2.	3. Recipient's Accession No.

4. Title and Subtitle	5. Report Date
Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest)--Sea-run cutthroat trout	January 1989
	6.
7. Author(s) Gilbert B. Pauley, Kevin Oshima, Karen L. Bowers, and Gary L. Thomas	8. Performing Organization Rept. No
9. Performing Organization Name and Address: Washington Cooperative Fishery Research Unit, University of Washington, Seattle, WA 98195	10. Project/Task/Work Unit No.
	11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address: U.S. Department of the Interior, Fish and Wildlife Service, Research and Development, National Wetlands Research Center, Washington, DC 20240; U.S. Army Corps of Engineers, Waterways Experiment Station, P.O. Box 631, Vicksburg, MS 39180	13. Type of Report & Period Covered
	14.

15. Supplementary Notes

*U.S. Army Corps of Engineers Report No. TR EL-82-4

16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the taxonomy, morphology, range, life history, and environmental requirements of coastal aquatic species. They are designed to assist with environmental impact assessments. The sea-run cutthroat trout (Salmo clarki clarki) is anadromous and is found in most coastal streams from Southeast Alaska to Northern California. A thriving sport fishery exists both in these freshwater streams and in protected marine waters. Many of the small streams containing cutthroat trout can be adversely altered by poor timber operations. Optimum temperature for incubating is 10 to 11 °C and eggs hatch in 28-40 days. Optimum temperature for juveniles is 15 °C and ability to swim is lost at about 28 °C. Adults prefer fairly slow-moving water with plenty of cover. Spawning occurs in small diameter gravel. Like steelhead trout, they may return from saltwater to spawn several times.

17. Document Analysis a. Descriptors

Temperature
Estuaries
Animal migrations
Feeding habits
Trout
Life cycles

b. Identifiers/Open-Ended Terms

Sea-run cutthroat trout
Coastal cutthroat trout
Salmo clarki clarki
Ecological role
Environmental requirements
Timber harvest

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unlimited distribution	Unclassified	21
	20. Security Class (This Page) Unclassified	22. Price

See ANSI-239.18) | OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

As the Nation's principal conservation agency, the Department of the interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

TAKE PRIDE
in America

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
National Wetlands Research Center
NASA-Slidell Computer Complex
1010 Gause Boulevard
Slidell, LA 70458

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF THE INTERIOR
INT-423