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LIFE HISTORIES OF ANADROMOUS CUTTHROAT WITH EMPHASIS ON MIGRATORY BEHAVIOR

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Abstract

Anadromous cutthroat (Salmo clarki clarki) are distributed among the Pacific Coast of North America from northern California to southeast Alaska (3,025 km), but rarely penetrate inland more than 160 km. Within that range, the cutthroat has adapted to a variety of climatological conditions, diversity of marine and freshwater habitats, and competition with other salmonids for food and space. This adaptation is reflected in several life history and migratory behavior patterns which include: 1) Selection of spawning and fry rearing areas in tiny headwater tributaries upstream from more dominant salmonids. 2) Age and size are greater for smolts migrating directly into the open ocean than for smolts migrating into protected inland saltwater areas. 3) Few over-winter in salt water; most return to freshwater coincidental to adult salmon migration timing. 4) In most Oregon and Washington coastal rivers (other than the Columbia), stocks are sexually mature at first return to freshwater, whereas a large percentage of Columbia River, Puget Sound, British Columbia and Alaska cutthroat females do not spawn during the winter of first return to fresh water; a migratory behavior apparently evolving from younger smolting age and historicaly abundant food source (salmon eggs). 5) Spawning fish home precisely to specific tributaries while non-maturing fish do not always return to their home stream to feed or when seeking an over-winter habitat. 6) Two distinct migration times in Puget Sound and southern British Columbia: September-October for large rivers and January-February for small streams flowing directly to saltwater, probably an adaptation to flow conditions and food availability.

The coastal cutthroat (Salmo clarki clarki) is the most abundant of thirteen recognized cutthroat subspecies and occurs over the most broad geographic range. This distribution extends along the Pacific coast from northern California to Prince William Sound, Alaska, a distance of 3025 km, but rarely penetrates inland more than 160 km. Records of natural distribution of all western salmonids indicate that cutthroat were the first to populate our western rivers. Interior cutthroat forms are believed (based on chromosome studies) to have arisen from a major divergence in cutthroat evolution between coastal cutthroat and an ancestral interior form (Behnke, 1979).

Coastal cutthroat occur as resident and anadromous populations, which are almost always found in the same watersheds. Within these drainage basins, resident populations are generally found in streams and lakes upstream from barriers to adult anadromous cutthroat. Although resident and anadromous populations have been reported to occur in sympatry, more information is needed to determine if gene flow between the populations is truely absent. Even isolation above a barrier to anadromous fish may not eliminate gene flow from the resident to the anadromous population.

Taxonomists currently feel that evidence for the divergence of resident from anadromous coastal cutthroat into separate subspecies is lacking. They are also hesitant to apply quantitative taxonomic methods to interpret the high incidence of variability of diagnostic characteristics such as basibranchial teeth and scale counts among the coastal cutthroat populations (anadromous and resident). The general feeling is that taxonomic chaos would occur if attempts were made to describe new subspecies for populations that exceed a normal range of variation (Behnke, 1979).

Fishery managers are also cognizant of variability demonstrated by coastal cutthroat. While the taxonomist must deal with such variables as spotting patterns and chromosome numbers to classify the fish, the fishery manager must develop management plans partially based upon highly variable life

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histories. Variability in coastal cutthroat life history and ecological adaptations for such traits as migratory behavior, age at smolting, age at sexual maturity, growth, and maximum age evolve rapidly in local populations geographically isolated. Variability in such traits are characteristic of local populations. The most important life history traits to fishery managers tend to be those traits common to geographically grouped populations. In keeping with that management consideration, this paper highlights anadromous cutthroat life histories in Washington State, with special emphasis on migratory behavior. Migratory behavior deserves attention since any movement of fish from their place of origin will be selective and decrease changes for survival. The better we understand complex migratory behavior, the better we can manage anadromous cuttthroat.

The natal streams of Washington's anadromous cutthroat have one common characteristic: small size. The creeks favored by the coastal cutthroat for spawning are the headwater tributaries to larger streams. Few of these natal creeks exceed 10 cfs during the summer low flow and most average less than 5 cfs at that time of year.

Selection of these isolated headwater streams by anadromous cutthroat for spawning, and the first year of rearing, serves to isolate populations. This mechanism functions to reduce interactions with other salmonids, primarily steelhead (Salmo gairdneri) and coho (Oncorhynchus kisutch), which typically spawn and rear immediately downstream from age 0+ and age 1 cutthroat nursery zones.

This general spatial separation between anadromous coastal rainbow (steelhead) and anadromous cutthroat at spawning, in conjunction with partial temporal spawning separation, reduces the incidence of hybridization between the two species. Hybridization does occur at the interface zone (Sumner, 1972; Campton, 1980). If anadromous cutthroat were less site-specific in spawning, or if hatchery-origin steelhead, with an earlier spawning time, were to over-run the cutthroat zone, the results would probably be genetically lethal to anadromous cutthroat populations. We can look at what has happened to interior cutthroat as an example. The interior cutthroat is isolated above barriers. Below barrier falls in the Columbia Basin, where interior cutthroat came into contact with later invading rainbow trout, the cutthroat were generally replaced (Behnke, 1979).

Another selective advantage for isolation of coastal cutthroat can be observed in the outcome of social interactions with anadromous rainbow and coho salmon. Competitive interactions for food and space between anadromous rainbow and cutthroat juveniles are most frequently decided in favor of the rainbow. Similarly, when in sympatry with juvenile coho, social dominance is asserted by the salmon due to their earlier emergence and larger body size (Glova and Mason, 1976). The result of interaction with either coho or steelhead tends to be the displacement of the subdominant juvenile age 0+ cutthroat from the preferred pools to the riffles. The cutthroat generally return to the pools after falling water temperatures reduce aggressive interaction and winter flows threaten displacement (Glova and Mason, 1977).

Isolation thus favors anadromous cutthroat survival, and management practices that include the artificial introduction of hatchery-origin coho or rainbow fry into stream sections historically inhabited only by cutthroat can have an adverse impact on the latter. The instream movement of age 0+ cutthroat from pool to riffle and back again, when in sympatry with other salmonids, can be characterized as the initiation of a lifelong migration influenced by interactions with other salmonids.

Juvenile non-smolting cutthroat of age 1 and older have wider ranging instream movement than age 0+ fish. Upstream movement has been noted from November through January, while downstream movement occurs in virtually every month of the year (Sumner, 1952, and unpublished Minter Creek, Washington trapping data, 1939-1954). Downstream migration of these parr begins in mid-winter and peaks in late spring. This instream movement can transport the fish from headwater tributaries downstream to the estuary, with varying lengths of stay at points in between. The parr reside in both the mainstem and estuarine habitat throughout the summer and early fall (Giger, 1972, and Johnston, 1980). Many of these fish migrate from the estuary and mainstem back into tributary streams with the onset of winter floods (Cederholm, personal communication). The migratory behavior of the parr may be explained by seasonal physiological changes, changes in food requirements or availability, crowding from recruitment, increasing body size, and stream flow fluctuations. Fisheries managers must be cautious in setting minimum size limits for trout fishing in mainstem and estuarine areas that are inhabited by these parr. Fork lengths of these parr average 185 mm (7.3 inches) by early fall (Mercer and Johnson, 1979).

The earliest recorded age at which anadromous cutthroat smolt and migrate to the marine environment is age I (Lowery, 1975) and the oldest is age VI (Giger, 1972). In Washington, the juvenile migrations peak in mid-May (Kalama River) and follow the peak steelhead smolt migration (Chilcote, 1980).

There appears to be a relationship in Washington State between age/size and the type of marine or estuarine environment the smolts are destined to enter. In the protected waters of Puget Sound, with its 2800 km of beaches relatively free of pounding surf, the cutthroat entering these environs for the first time are primarily age II at an average length of 160 mm (Johnston, 1978; Michael, 1980). Along the more rugged, heavy surf-pounded coast, the smolts are 23% age III (204 mm), 59% age IV (215 mm), and 18% age V (252 mm) (Fuss, 1982). The Columbia River smolts enter a large estuary and, although some go out to sea, it appears most remain in the estuarine environs during the first migration (Tipping, 1981). These Columbia River cutthroat are 65% age II, 33% age III and 2% age IV at smolting and average 160 mm (Chilcote 1980; Tipping, 1981). In Puget Sound, the anadromous cutthroat feed and migrate along the beaches, mostly frequenting waters less than 3 meters in depth. Along the open coast this type of environment is not available to the cutthroat. The inhospitable surf line forces these fish offshore

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where they must contend with a wider variety of predators and larger food organisms. Columbia River cutthroat enter an environment similar to Puget Sound in shoreline turbulence, but those venturing from the estuary into marine environment face conditions similar to those described for the open coast. Therefore it appears that the physical and biological parameters of the marine environment have exerted selective pressures for differing size-age cutthroat at smoltification.

Regardless of age, anadromous cutthroat smolts are believed to begin schooling just prior to their entry into the marine environment. This schooling behavior has obvious survival value and the schools apparently remain intact until the fish return to freshwater (Giger, 1972). While in the marine environment anadromous cutthroat stay relatively close to their homestreams compared to other anadromous salmonids. Limited returns from tagged wild cutthroat in Puget Sound indicates migration does not extend much beyond 50 km from the home stream (Wash. Dept. Game, unpublished data). In Alaska the cutthroat were reluctant to cross large bodies of water (3-8 km in width) and preferred to follow shoreline migration routes up to 70 km from their home stream (Jones, 1976). The general movement of cutthroat along the Oregon coast is believed to be correlated with onshore ocean currents, with the fish staying close to the coastline (Giger, 1972).

Anadromous cutthroat remain in saltwater for varying lengths of time but the majority return to freshwater in the same year they migrate to sea. Columbia River, coastal rivers, and large Puget Sound Basin rivers have stocks of anadromous cutthroat that stay at sea 2 to 5 months during which time the fish increase by an average of 1.0 mm/day. These stocks enter fresh water from July through October, with peak migrations in September and October. While wide variability exists in re-entry timing between streams, the timing is fairly consistent from year to year for specific streams. These autumn-entering cutthroat are called early-entry stocks, as opposed to late-entering stocks which, in mid-winter, enter smaller stream systems that drain directly into marine waters. These late-entry cutthroat remain in saltwater an average of 8 months (Johnston and Mercer, 1976).

The evolution of early and late-entering cutthroat most likely has its foundations in food availability, saltwater tolerance, and/or stream flow conditions. River systems with historically large runs of fall spawning salmon probably provided cutthroat with a rich food source (drifting eggs) that was superior to foods available in saltwater for building energy reserves, required less energy to obtain, and isolated the cutthroat from numerous marine predators. Fifty-eight percent of Alsea River, Oregon cutthroat returning from a summer in saltwater showed scarring indicative of predator attack (Giger, 1972). Saltwater tolerance may also explain early-entry timing. Tests to determine whether two different wild stocks of early-entry, anadromous cutthroat could be held year around in saltwater net-pens following introduction as smolts resulted in up to 98 percent mortality after 6 months in saltwater (Mercer and Johnston, 1979; Mercer, 1980). Late-entry cutthroat held in the same Puget Sound net-pen environment experienced approximately 50 percent mortality. These late-entry stocks are the product of small, usually less than 20 cfs low-flow streams, that flow directly into saltwater. A combination of fall low-flows, less salmon utilization, and/or the timing of salmon spawning may have made it advantageous for those cutthroat stocks to remain in marine waters until just prior to spawning. Some small rivers draining to Hood Canal, Washington receive both early and late-entering stocks. These rivers have a discharge at low flow of between 30 and 70 cfs. Fishery managers should spend some time pondering the fate of the early-entry cutthroat should their egg supply source disappear. Salmon management's increasing reliance on hatchery egg takes versus wild spawning undoubtedly will have an impact upon winter survival of early-entry cutthroat. Dependence on this food source is one reasonable explanation for a migration that takes early-entry cutthroat within one to three days swimming distance of their own spawning grounds but five months too early.

Another life history variable that must be considered by the management biologist is sexual maturation. Virtually all anadromous cutthroat returning to Washington's large coastal rivers for the first time are fish that will mature sexually during the ensuing winter. Most of these fish are age IV and V at spawning (Fuss, 1982). Cutthroat returning to Puget Sound streams, however, show a high incidence of non-maturity. In the Stillaguamish River, Washington, only 20-27% of the females returning for the first time spawn during the coming winter. Most of the males were maturing sexually. The low incidence of mature females is related to the age at smolting; most were age II at smolting and were going to spend their first winter in fresh water as returning age III fish. Few females mature before age IV. In the case of the Columbia River, one study indicated that for wild anadromous cutthroat females on their first return to freshwater, 53% were sexually mature (Tipping, 1981). This value, higher than for Puget Sound but lower than for coastal streams, probably reflects that the age of the Columbia River smolts was 65% age II. Similar immaturity of initial migrants has been reported for anadromous cutthroat of Alaska (Jones, 1976). The immature feeding-run fish in the Columbia River and Puget Sound streams have probably evolved to re-enter fresh water for the same reason the maturing early-entry stocks do, and the migratory behavior is reenforced by the cohesiveness of schooling behavior.

Anadromous cutthroat are often depicted as fish that frequently stray. Straying as used here means migrating to, and spawning in, some stream other than the natal stream. This conclusion is made from observations of marked hatchery fish that return to some stream other than the one planted in. Studies of native (wild) anadromous cutthroat indicate otherwise. At Snow and Salmon creeks on Washington's Olympic Peninsula studies show that smolts migrating out of Salmon Creek to saltwater will often return in the winter to nearby Snow Creek to overwinter but not spawn. The following year, after a spring

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return to saltwater, these fish re-enter their natal stream to spawn. Some of the Salmon Creek fish will be sexually maturing upon entry to Snow Creek but will later leave Snow Creek to return to Salmon Creek for spawning (Michael, 1980). This type of migration pattern for feeding and/or overwintering, but not spawning, has also been observed in Alaska (Jones, 1976). This represents a complex migratory behavior, not straying.

A study conducted in Washington indicates that homing to the natal stream by spawning anadromous cutthroat is very precise. In this genetic study (Campton, 1980) differences among anadromous cutthroat populations were determined by means of electrophoretic analysis of fish tissue proteins. Age 0+ and I+ juvenile cutthroat were collected from four Skagit River tributaries, eight tributaries to the Stillaguamish River, and ten Hood Canal tributaries. Fifteen protein systems representing 28 biochemical genetic loci were examined electrophoretically in all fish. The findings suggest that anadromous cutthroat trout are finely divided into discrete populations at the tributary level, i.e., each population is highly dependent upon its natal stream for reproduction and sustenance. Additionally, it was determined that at least two genetically-distinct stocks of anadromous cutthroat exist in the Puget Sound Basin: a north Puget Sound stock and a Hood Canal stock. Gene frequency differences between the two stocks are believed to reflect a long term absence of gene flow. Homing instinct is the mechanism that maintains reproductive isolation and, as pointed out, the survival of anadromous coastal cutthroat as a sub-species depends upon spawner isolation.

Survival of anadromous cutthroat following re-entry into fresh water was documented (Wash. Dept. Fish, unpublished report) for Minter Creek, Washington and indicated that an average of 41% (range 23-79%) survived to return to saltwater. Oregon data indicates that out-migration of kelts preceeded the downstream migration of cutthroat smolts (Giger, 1972). Minter Creek, Washington data (Wash. Dept. Fish, unpublished report) indicated kelt migration peaked the first of April while smolt migration peaked in May. Natural selection has probably favored this timing which places the kelts in position to intercept seaward migrating schools of salmon fry (pink and chum salmon) at the estuary.

Following return to saltwater the kelts display a similar migratory behavior as previously mentioned for the initial marine migrants. Data from Sand Creek, Oregon for a population of cutthroat not subjected to marine angling mortality indicated 39% of the cutthroat survived between the first and second spawning migrations, 17% between the 2nd and 3rd and 12% between the 3rd and 4th migrations (Summer, 1952). Data from Oregon also indicates that repeat spawning fish are the first fish to return to the rivers each summer from their marine migrations (Giger, 1972).

From the foregoing discussion we perceive that anadromous cutthroat exhibit a complex migratory behavior that reflects their subordinate yet dependent relationship with other anadromous salmonids. It appears that this subspecies, whether inhabiting the tiny headwater streams or inshore marine waters, spends a lifetime migrating and filling the niches other anadromous salmonids least prefer.

References

Behnke, R. J. 1979. Monograph of the native trouts of the genus Salmo of western North America. USDA Forest Service:163 p.

Campton, D. 1980. Genetic structure of sea-run cutthroat trout populations in the Puget Sound area. In: Sea-Run Cutthroat Status Report, 1980. Wash. State Game Dept., Rep. 80-14:185-186.

Chilcote, M. W. 1980. Kalama River sea-run cutthroat. In: Sea-Run Cutthroat Status Report, 1980. Wash. State Game Dept. Rep. 80-14:191-193.

Fuss, H. 1982. Life history characteristics and biology of cutthroat of some coastal tributaries based on scale interpretation. M.S. Thesis, Univ. Wash., Seattle.

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

Glova, G. J., and J. C. Mason. 1976. Interactive ecology of juvenile salmon and trout in streams. Fish. Res. Board Can. Manuscript Rep. Series No. 1391:24 p.

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. Manuscript Rep. Series No. 1428:36 p.

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

Johnston, J. M. 1978. Sea-run cutthroat: Stillaguamish River creek census and harvest limit recommendations. Wash. State Game Dept.

Johnston, J. M. 1980. Stillaguamish River sea-run cutthroat creek survey. 1979. In: Sea-Run Cutthroat Status Report, 1980. Wash. State Game Dept.:208-220.

Jones, D. E. 1976. Steelhead and sea-run cutthroat life history study in southeast Alaska. Alaska Dept. of Fish and Game. Prog. Rep. AFS-42. 1975-1976.

Lowery, G. R. 1975. The Alsea watershed study: Part I--biological studies. Oregon Dept. Fish and Wildl. Fish. Res. Rep No. 9:66 p.

Mercer, S. P., and J. M. Johnston. 1979. Sea-run cutthroat: development and evaluation of a new enhancement technique. Wash. State Game Dept. Fish. Res. Rep:45 p.

EX5055-000004-TRB

Mercer, S. P., and J. M. Johnston. 1979. Sea-run cutthroat: development and evaluation of a new enhancement technique. Wash. State Game Dept. Fish. Res. Rep:45 p.
Mercer, S. P. 1980. Sea-run cutthroat: development and evaluation a new enhancement technique. Wash. State Game Dept. Fish. Res. Rep.:11 p.
Michael, H. 1980. Sea-run cutthroat trout. In: Sea-Run Cutthroat Status Report, 1980. Wash. State Game Dept. Rep. 80-14:187-190.
Sumner, F. H. 1952. Migrations of salmonids in Sand Creek, Oregon. Trans. Am. Fish. Soc. 82:139-150.
Sumner, F. H. 1972. A contribution to the life history of the cutthroat trout in Oregon. Oregon State Game Comm.:142 p.
Tipping, J. M. 1981. Cowlitz sea-run cutthroat study. Wash. State Game Dept. Rep. No. 81-12:26 p.
Washington State Department of Fisheries. Unpublished progress reports. (Minter Creek data).

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