

John J. Loch, Washington Department of Wildlife, Fish Management Division
600 N. Capitol Way, Olympia, Washington 98504

and

David R. Miller, Northwest and Alaska Fisheries Center, National Marine Fisheries Service
National Oceanic and Atmospheric Administration, 2725 Montlake Boulevard East, Seattle, Washington 98112

Distribution and Diet of Sea-run Cutthroat Trout Captured In and Adjacent to the Columbia River Plume, May-July 1980.

Abstract

Cutthroat interact with other migrating juvenile and adult salmonids within the Columbia River plume. By collecting basic life history information, we broaden our knowledge of both cutthroat trout migrations within the Columbia River plume and how they interact as a predator on juvenile fish and zooplankton. To study these fish, sea-run cutthroat trout were collected in marine waters within and adjacent to the mouth of the Columbia River plume between Tillamook Bay, Oregon and Copalis Head, Washington. A total of 232 purse seine sets were made during three cruises from late May to early September, 1980. Age, size, and diet were examined. Cutthroat trout were found to range farther offshore than previously reported. They were captured within the Columbia River plume as far as 31 km offshore. Six age groups, 2 to 7 years, were identified. Fifty percent of the aged cutthroat were of hatchery origin. Stomach analysis from the May-June cruise revealed cutthroat trout feed on a wide variety of food items, with fish and mysids predominant.

Introduction

There are few studies of sea-run cutthroat trout, *Salmo clarki clarki*, in marine coastal waters. Information on the distribution and movement in saltwater has been presented by Jones (1974, 1975, 1976) for Alaska, and Giger (1972) for Oregon. Additionally, limited information has been reported for cutthroat stocks within the lower Columbia River and plume (Sumner 1972, Fisher and Pearcy 1985). Food items of cutthroat trout in coastal marine waters have been reported by Clemens and Wilby (1946), Haig-Brown (1947), Armstrong (1971), Giger (1972), Sumner (1972), Simenstad and Kinney (1978), and Brodeur *et al.* (1987).

Historically, cutthroat trout populations have been relatively small when compared to other salmonids. Royal (1972) wrote that historic steelhead, *S. gairdneri*, populations in Washington comprised two to three percent of the total anadromous salmonid populations and that cutthroat trout population levels were thought to be much less than that of steelhead populations.

The purpose of this study was to document distribution, age, size, and diet of adult sea-run cutthroat trout captured within and adjacent to the Columbia River plume. The plume is defined by the freshwater dilution of the coastal waters adjacent to the Columbia River. The study survey

area was located within the inner plume marked by the 27 o/oo isohaline. The outer bounds of the plume, defined by the 32.5 o/oo isohaline (Barnes *et al.* 1972), was not encompassed. Fish were collected as part of a more comprehensive study by the National Marine Fisheries Service to define the marine migrational patterns of juvenile salmonids emigrating from the Columbia River estuary (Miller *et al.* 1983).

Methods

A total of 232 sets were made along ten east-west sampling transects which were established along the Pacific Northwest coast from Tillamook Bay, Oregon, to Copalis Head, Washington (Figure 1). Each transect contained five sampling stations; the first located at the 30 m depth contour, with the others extending seaward at 8 km intervals. Purse seining was conducted during three periods: 27 May-7 June, 4-15 July, and 28 August-8 September 1980.

The sampling net was a 495 x 30 m purse seine that was assumed to fish approximately 24 m deep based on its construction (J. Jurkovich, Gear Specialist, NMFS, Northwest and Alaska Fisheries Center, Seattle, Washington, personal communication February 1981).

All fish collected were anesthetized with benzocaine, counted by species, measured to fork

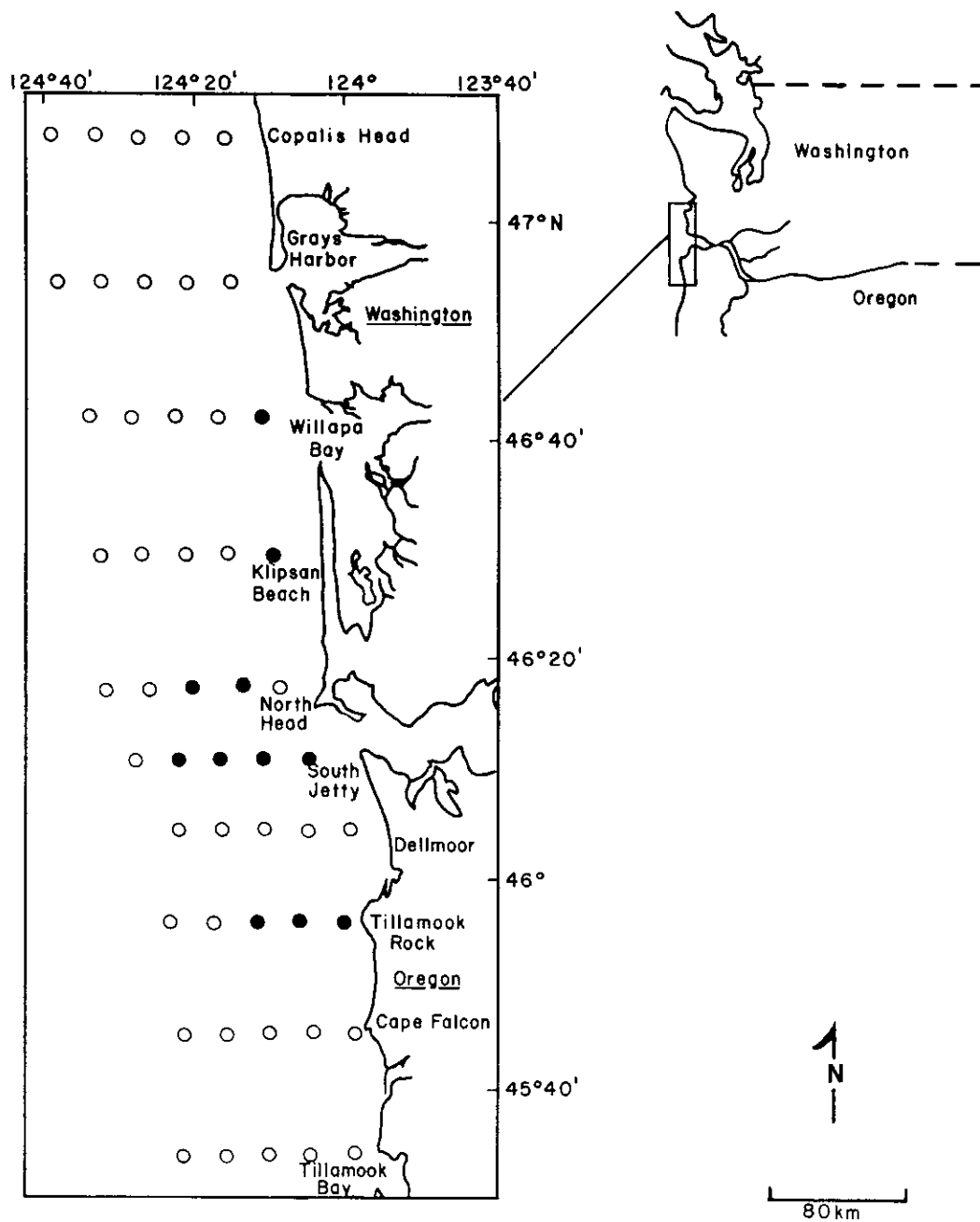


Figure 1. Location of transect stations (circled areas) for off shore marine purse seining of salmonids along the Oregon and Washington coast, 1980. Darkened circles are areas of cutthroat captures.

length and examined for identifying marks. Stomachs (esophagus to the pyloric caeca) were removed and preserved with buffered 10 percent formaldehyde solution in individual vials for later analysis. Processing of the stomachs was as described by Cailliet (1977). Organisms were identified to the lowest practical taxon.

Scales were collected for age determination. Methods similar to Narver and Withler (1971) were used to age cutthroat scales. Briefly, age was assigned using a chronological arrangement (i.e., 2. + F + S +) of arabic numerals to designate the number of consecutive winters in freshwater. A period (.) indicates the point of initial saltwater

entry. Each plus sign (+) denotes saltwater residence less than one year in duration. Spawning checks are designated with a capital letter "S," where a "+ S" denotes one chronological year. Not all returning adult sea-run cutthroat spawn on their first re-entry to freshwater from saltwater. We define a freshwater re-entry from saltwater and temporary residence with no spawning before migrating back to saltwater (as evident by no scale resorption) as a "feeding run" and we designate this "feeding run" with the letter "F." An "+ F" indicates one chronological year. Therefore, a fish aged 2. + F + S + would have spent two winters in freshwater after

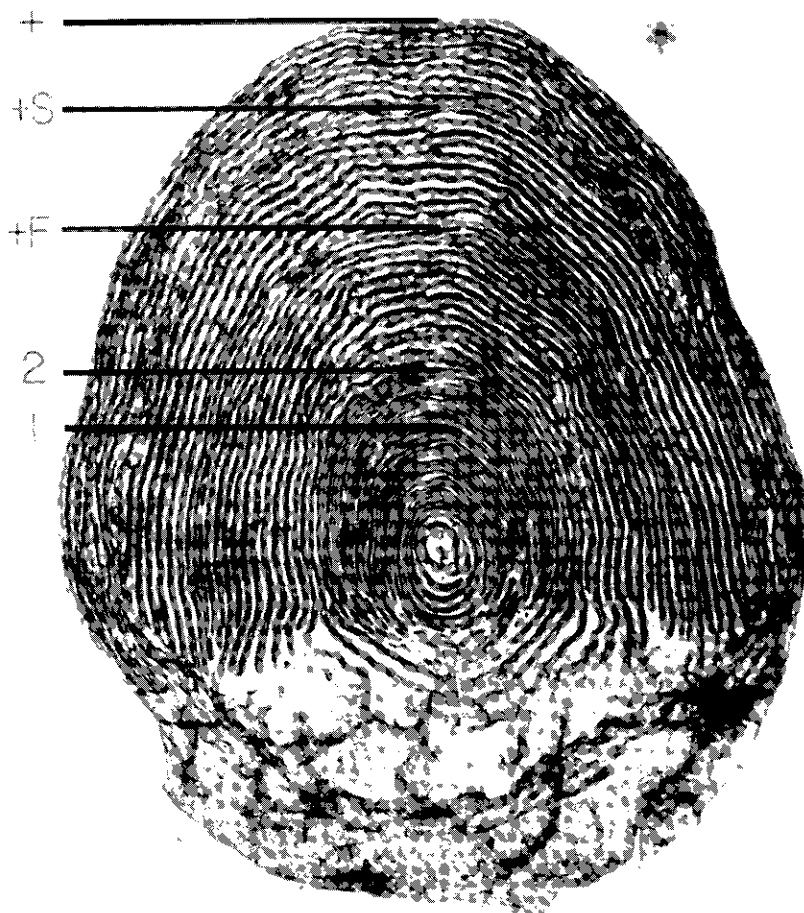


Figure 2. Sea-run cutthroat trout scale with two years of freshwater growth. Marine growth and "feeding" check (+F) followed by additional marine growth and a spawning check (+S) follow the freshwater growth. The last scale check (+S) is followed by marine growth (+) for a total age of 4+.

hatching, another summer period at sea, freshwater re-entry and return to the ocean, freshwater re-entry spawning, and was captured during its third saltwater migration at an age of 4+ (Figure 2). All age 1 fish were assumed to be of hatchery origin.

Results and Discussion

Distribution

Cutthroat were collected along the coast from Tillamook Bay, Oregon, to Willapa Bay, Washington (Table 1). Catches were made 3.0 to 31.5 km offshore, over bottom depths ranging from 30 to 134 m. All of the cutthroat trout collected were captured within the Columbia River plume. In 1978 and 1979, no cutthroat trout were captured during sampling with a 305 x 11 m purse seine inside the 30 m depth contour from May to September (Dawley *et al.* 1978, 1979, 1980).

Little information exists regarding the distance offshore that cutthroat trout have been captured. Haig-Brown (1947) reported adult cutthroat range off shore as far as 7 km from the mouth of the Nimpkish River on Vancouver Island, Canada. Sumner (1972) also mentioned sport anglers harvesting cutthroat trout offshore at a similar distance. The greatest offshore distance for cutthroat trout captured during our study was in the river plume (31.5 km) off the

South Jetty at the mouth of the Columbia River. This distance from shore was surprising, since existing evidence suggests that sea-run cutthroat trout avoid traveling in large open bodies of water and tend to follow shorelines (Jones 1976).

This suggests that substantial numbers of cutthroat might be found within the influence of a large riverine plume. Sumner (1972) proposed that cutthroat originating in the Columbia River basin might go out some distance from the coast while remaining within the Columbia plume. This observation agrees with our findings. The offshore distance cutthroat migrate may depend on the Columbia River outflow during their migration to saltwater. Maximum river flows for the Columbia River occur during May, June, and July (Neal 1972). Columbia River sea-run cutthroat emigrate to saltwater in April and early May (Dawley *et al.* 1978, 1979, 1980). Besides the influence of maximum flows, cutthroat might drift with a current while feeding and be relocated to other areas. Prevailing currents during May and June may move cutthroat to areas farther offshore and away from the mouth of the river. Giger (1972) noted ocean currents could redistribute cutthroat to other areas thereby increasing the occurrence of straying to other rivers along the Oregon coast. This might explain marked cutthroat trout stocked into the Alsea River, Oregon, being captured in the estuary of the Siuslaw River, Oregon, in 1967 (Sumner 1972).

Table 1. Location of cutthroat trout caught off Oregon and Washington, May-July 1980.

Date	Number caught	Transect	Station	Distance offshore (km)	Water depth (m)
30 May	1	Tillamook Rock	1	3.0	42
30 May	2	Tillamook Rock	3	17.6	112
31 May	2	Tillamook Rock	2	11.1	84
6 June	2	Klipsan Beach	1	8.2	30
7 June	4	South Jetty	2	16.7	60
7 June	5	South Jetty	3	23.6	101
7 June	1	South Jetty	4	31.5	117
12 July	1	Willapa Bay	1	8.3	30
14 July	1	South Jetty	1	9.3	30
14 July	9	South Jetty	2	16.7	60
14 July	3	South Jetty	3	23.6	101
15 July	1	North Head	2	14.4	71
15 July	2	North Head	3	21.8	128

No correlations between temperatures, salinities, and fish abundance were found. At sites where cutthroat trout were collected, surface water temperatures ranged from 12.2 to 16.4° C, and surface salinities from 26.7 to 28.2 ‰.

Cutthroat trout were captured only during May-June (17) and July (17). None were caught during the August-September cruise. Cutthroat have been reported to re-enter the lower Columbia River estuary in early June (Loch 1982). This return timing is similar to that observed by Sumner (1972) and Giger (1972) for the Nestucca and Alsea estuaries in Oregon, respectively. Cutthroat have been reported to move into the upper Columbia River estuary in early July (Dawley *et al.* 1978, 1979, 1980). Dawley *et al.* also reported a lull in the upstream movement of cutthroat in June. Differences between immigration observations by Loch (1982) and Dawley *et al.* (1978, 1979, 1980) are due to their different sampling locations within the Columbia River estuary. A distance of about 60 km separated the two locations. We feel cutthroat re-entering from saltwater to freshwater remain and feed for a short period of time in the lower and mid-Columbia River estuary before moving farther up stream. This is in conflict with Giger (1972) who reported no feeding by cutthroat while on their migration from saltwater to freshwater. In-

stead, Giger (1972) believed cutthroat moved rapidly through estuaries in Oregon. In support of our hypothesis, Loch (1982) found adult cutthroat actively feeding on Pacific herring, *Clupea harengus pallasi* and bay shrimp, *Crangon franciscorum* in the lower Columbia River estuary. This suggests that at least some adult cutthroat do not directly move into freshwater zones on return from saltwater but actively feed within the marine and estuarine zones.

Ages of 18 of the 34 cutthroat trout collected revealed six age groups ranging from 2 to 7 total years (Table 2). Interestingly, only fifty percent of the aged fish were of wild origin. Many lower Columbia River tributaries have been planted with sea-run cutthroat trout since 1957. Plants in Washington have totaled as much as 280,000 cutthroat smolts (Crawford *et al.* 1981). Wild fish were generally older and larger than hatchery cutthroat (Table 2).

All hatchery cutthroat were collected within the Columbia River plume. This information provides fish managers with some of the first evidence that hatchery cutthroat do migrate out into the Columbia River plume where they may compete with other salmonids for food or be preyed upon.

The trout caught in July were very similar in size (mean 301 mm with a range from 240 to

TABLE 2. Age and length of hatchery and wild cutthroat trout sampled by marine purse seine operations adjacent to the mouth of the Columbia River, 1980.

Stock	Numbers captured	Age ¹	Mean fork length ± tSE (mm) ²	Percentage of total
Hatchery	7	1.+	260.3 ± 17.5	77.8
	2	1.+F+	298.0 ± 226.4	22.2
	9			100.0
Wild	6	2.+	287.7 ± 43.5	66.7
	1	2.+S+	365.0 ———	11.1
	1	2.+F+S+	415.0 ———	11.1
	1	3.+S+S+S+	470.0 ———	11.1
	9			100.0

¹ = initial entry to seawater

F = freshwater residence, did not spawn

S = spawned upon re-entry to freshwater from seawater

+ = subsequent marine excursion

² α = 0.05

345 mm) to those captured earlier in the May-June cruise (mean 296 mm with a range from 240 mm to 470 mm).

Diet

Although cutthroat trout fed on a variety of prey items during May and June, they were mainly piscivorous. Of the 17 stomachs examined from the May-June cruises, principal prey items were fish, mysids, brachyuran crab megalops, and euphausiids. By weight, fish were the most dominant food item found in the stomach samples, composing 82.7% of the total food biomass (Table 3). Juvenile cabezon, *Scorpaenichthys marmoratus*, and Pacific sand lance, *Ammodytes hexapterus*, were common species found in stomachs. Other researchers have also found that cutthroat prey primarily on fish. Off the Oregon and Washington coast, Brodeur *et al.* (1987) reported cutthroat to feed on juvenile and adult northern anchovies, *Engraulis mordax*, juvenile kelp greenlings, *Hexagrammus decagrammus*,

and rockfishes, *Sebastes* spp. Sand lance and Pacific herring were mentioned by Haig-Brown (1947) as prey of cutthroat off the mouth of several Vancouver Island streams, British Columbia.

Interestingly, at a time when large numbers of juvenile salmonids were actively migrating to saltwater, no juvenile salmonids were found in our cutthroat stomach samples. Miller *et al.* (1983) reported large numbers of both juvenile chinook, *Oncorhynchus tshawytscha*, and coho, *O. kisutch*, salmon in areas within and adjacent to the Columbia River plume at a time when we were collecting adult cutthroat. Unlike our findings, Brodeur *et al.* (1987) found juvenile salmon in stomach samples from offshore captures of Oregon and Washington cutthroat adults in both 1981 and 1984. Clemens and Wilby (1946) mentioned salmonids as food for cutthroat in some Canadian marine areas and Armstrong (1971) found juvenile salmon in stomachs of cutthroat in the coastal waters of Alaska.

TABLE 3. Stomach contents (prey) of 17 coastal cutthroat trout caught off Oregon and Washington, May-June 1980.

Prey	Number of prey	Weight of prey (g)	Occurrence ¹ (%)	Composition (%)	
				Number ²	Weight ³
Northern anchovy <i>Engraulis mordax</i>	1	10.97	5.88	1.96	34.07
Cabezon <i>Scorpaenichthys marmoratus</i>	2	2.97	11.76	3.92	9.22
Pacific sand lance <i>Ammodytes hexapterus</i>	1	1.17	5.88	1.96	3.64
Surf perch (Embiotocidae unidentified)	1	2.08	5.88	1.96	6.47
Crab megalops	6	0.31	17.65	11.76	0.95
Euphausiacea	1	<0.01	5.88	1.96	0.01
Mysidacea (unidentified)	31	0.55	11.76	60.78	1.71
<i>Neomysis kadiakensis</i>	8	0.25	5.88	15.69	0.79
Unidentified digested fish	—	11.51	47.06	—	35.73
Unidentified digested other material	—	2.39	70.59	—	7.42
Empty	—	—	11.76	—	—

¹Number of occurrences/total number of stomachs examined.

²Number of prey item/total number of prey.

³Weight of prey item/total weight of prey.

Although a major portion of the biomass in the stomach samples from cutthroat consisted of fish, numerically mysids were a dominant food item (Table 3). Both Clemens and Wilby (1946) and Haig-Brown (1947) mention crustaceans as food items, neither define what species of crustaceans were consumed. Simenstad and Kinney (1978) found gammarid amphipods to be the dominant prey item followed by sphaeromatid isopods, cumaceans, and callinassid shrimp in cutthroat trout captured in Hood Canal, Washington. Brodeur *et al.* (1987) found euphausiids and insects numerically dominant in stomachs collected in waters off Oregon and Washington in 1984. Because cutthroat tend to be opportunistic, feeding on what is available, differences observed in our samples from those of other

researchers may be due to seasonal occurrence and abundance of cutthroat prey items.

Acknowledgements

Our thanks to Jim Johnston and Steven Leider, Washington Department of Wildlife, and Terry Durkin, Robert McConnel, and Jerry Monan, National Marine Fisheries Services, for their critical review of the manuscript. Thanks, also, to Gene Vitalich, Captain of the F/V FLAMINGO and his crew for the tremendous efforts they expended under adverse conditions to purse seine in the open ocean. Our thanks to Marita Loch for her graphic work.

Funding for this study was provided by the Pacific Northwest Regional Commission and the National Marine Fisheries Service.

Literature Cited

- Armstrong, R. H. 1971. Age, food, and migration of sea-run cutthroat trout, *Salmo clarki*, at Eva Lake, southeast Alaska. *Trans. Amer. Fish. Soc.* (2):302-306.
- Barnes, C.A., A.C. Duxbury, and B.A. Morse. 1972. Circulation and selected properties of the Columbia River effluent at sea. In A. T. Pruter and D. L. Alverson (eds.) *The Columbia River estuary and adjacent ocean waters; bioenvironmental studies.* Univ. Wash. Press, Seattle. Pp. 19-40.
- Brodeur, R. D., H. V. Lorz, and Wm. G. Pearcy. 1987. Food habits and diet variation of pelagic nekton off Oregon and Washington, 1979-1984. NOAA Tech. Memo. (IN PRESS)
- Cailliet, G. M. 1977. Several approaches to the feeding ecology of fishes. In C. A. Simenstad and S. J. Liposvsky (ed.) *Fish food habits: 1st Pacific Northwest Technical Workshop, Proceedings.* Univ. Wash., Seattle, Div. Mar. Resour., Wash. Sea Grant, WSG-WO 77-2. Pp. 1-13.
- Clemens, W. A., and G. V. Wilby. 1946. *Fishes of the Pacific coast of Canada.* 2nd ed. Fish. Res. Board. Can. Bull. 68:443.
- Crawford, B. A., R. Lucas, J. M. Tipping, and S. Springer. 1981. *Cutthroat status report for southwest Washington.* Washington State Game Dept. Fish Manage. Div. Rep. 80-14: 98-105.
- Dawley, E. M., C. W. Sims, and R. D. Ledgerwood. 1978. A study to define the migrational characteristics of chinook and coho salmon and steelhead trout in the Columbia River estuary. National Marine Fisheries Service Coastal Zone and Estuarine studies. Annual Rep. 1979. Pp. 35.
- Dawley, E. M., C. W. Sims, R. D. Ledgerwood, D. R. Miller, and F. P. Thrower. 1979. A study to define the migrational characteristics of chinook and coho salmon and steelhead trout in the Columbia River estuary. National Marine Fisheries Service Coastal Zone and Estuarine studies. Annual Rep. 1979. Pp. 35.
- Dawley, E. M., C. W. Sims, R. D. Ledgerwood, D. R. Miller, and J. G. Williams. 1980. A study to define the migrational characteristics of chinook and coho salmon and steelhead in the Columbia River estuary. National Marine Fisheries Service Coastal Zone and Estuarine studies. Annual Rep. 1980. Pp. 53.
- Fisher, J. P., and W. G. Pearcy. 1985. *Studies of juvenile salmonids off the Oregon and Washington coast, 1985.* Oregon State Univ. Sea Grant College Program Pub. ORESU-7-85-004. 31 p.
- Giger, R. D. 1972. *Ecology and management of coastal cutthroat trout in Oregon.* Oregon Game Comm., Fish Res. Rep. No. 6. Pp. 61.
- Haig-Brown, R. L. 1947. *The western angler—an account of Pacific salmon and western trout in British Columbia.* Wm. Morrow and Co., New York.
- Jones, D. E. 1974. *Life history of sea-run cutthroat trout in southwest Alaska.* Alaska Dept. Fish Game, Div. Sport Fish., Anadromous Fish Studies, July 1, 1973 to June 30, 1974. Study AFS-42:15-31.
- _____. 1975. *Life history of cutthroat trout.* Alaska Dept. Fish Game, Sport Fish Div., Anadromous Fish Studies, July 1, 1974 to June 30, 1975, Vol. 16 Study AFS-42-3-B: 23-42.
- _____. 1976. *Steelhead and sea-run cutthroat trout life history study in southeast Alaska.* Alaska Dept. Fish Game, Sport Fish Div., Anadromous Fish Studies, July 1, 1975 to June 30, 1976, Study AFS-42-4:26-38.

- Loch, J. J. 1982. Juvenile and adult steelhead and sea-run cutthroat trout within the Columbia River estuary, 1980. Washington State Dept. Game Fish. Manage. Div. Annual Rep. 82-2. Pp. 83.
- Miller, D. R., J. G. Williams, and C. W. Sims. 1983. Distribution, abundance and growth of juvenile salmonids off the coast of Oregon and Washington, summer 1980. Fish. Res. 2:1-17.
- Narver, D. W., and F. C. Withler. 1971. Age and size of steelhead trout (*Salmo gairdneri*) in angler's catches from Vancouver Island, British Columbia, streams. Fish. Res. Bd. Can., Biol. Sta. Nanaimo, B.C. Circular 91. Pp. 26.
- Neal, V. T. 1972. Physical aspects of the Columbia River and its estuary In A. T. Pruter and D. L. Alverson (eds.) The Columbia River estuary and adjacent waters; bioenvironmental studies. Univ. of Washington Press, Seattle. Pp. 19-40.
- Royal, L. 1972. An examination of the anadromous trout program of the Washington State Game Department Volume I. Washington St. Game Dept. Rep., Olympia. Pp. 112.
- Simenstad, C. A. and W. J. Kinney. 1978. Trophic relationships of outmigrating chum salmon in Hood Canal, Washington, 1977. Washington State Dept. Fisheries Finals Report FRI-UW-7810. Pp. 75.
- Sumner, F. H. 1972. A contribution to the life history of the cutthroat trout in Oregon (with emphasis on the coastal subspecies, *Salmo clarki clarki* Richardson). Oregon State Game Comm. Rep. Pp. 180.

Received 1 July 1987

Accepted for publication 1 December 1987