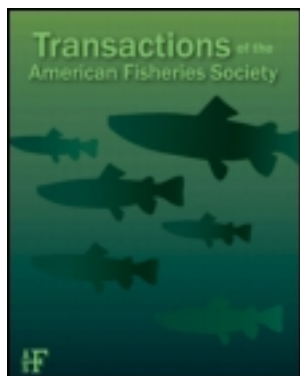


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Observation of Fishes Associated with Spawning Salmon

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sons: First, because the Gulf menhaden is generally considered to be a winter-spawning fish (Hildebrand, 1963; Suttkus, 1956) and scales have been shown on young-of-the-year collected in April, it may now be safely assumed that scales from larger and older individuals carry growth histories that begin with the first spring of life. Second, the intercept value of 18.61 (19) permits more accurate calculation of growth of scales of Gulf menhaden.

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Observation of Fishes Associated with Spawning Salmon¹

INTRODUCTION

The U. S. Bureau of Commercial Fisheries, in cooperation with the U. S. Forest Service, Alaska Department of Fish and Game, and the U. S. Bureau of Sport Fisheries and Wildlife, began a 4-year study of the effects of DDT on aquatic life in 1961. Chemical and biotic data were collected from four watersheds at Skowl Arm, Prince of Wales Island, to determine the natural conditions for comparison with post-spray conditions (Reed, 1967, in press). Old Tom Creek, located about 30 miles from Ketchikan (Figure 1), was the base camp for the study, and one of

the two control watersheds. Therefore, it was very convenient during the various field seasons to collect additional data on the movement, feeding behavior, and relative density of some fish species in the stream.

Seven species of fish were observed in Old Tom Creek. A weir above the high tide level, operated from 1949 to 1958, enumerated adult pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) escapement (Roppel, 1956; Sheridan, 1962). A small run of coho salmon (*O. kisutch*) also enters the stream in late fall to spawn. In addition to salmon, rainbow trout (*Salmo gairdneri*), cutthroat trout (*S. clarki*), Dolly Varden (*Salvelinus malma*) and prickly sculpin (*Cottus asper*) were present.

MATERIALS AND METHODS

Dolly Varden were collected by angling and anesthetized with MS-222. A subcutaneous tag was placed under the skin in the area between the pelvic and pectoral fins for future identification. This tag, developed by Butler (1957) for rainbow trout, was also used by Reed (1964) on Arctic grayling. Limited mortality occurred when the Dolly Varden were returned to the water. These specimens were preserved and used to determine feeding habits. Stomach contents of Dolly Varden were examined and the estimated percentage of total volume of food items was recorded. The percentages were determined visually because of the impracticability of making actual volumetric measurements. Several workers (McCormick, 1940; Raney and Lachner, 1942) have used this procedure.

Underwater survey was made in a 2,500-foot section to observe behavior and to determine relative abundance (Figure 1). I wore a 0.25-inch neoprene "wet suit" for protection against the cold water and a snorkel was used for air. The use of skin diving to observe and enumerate fish populations has proven rather effective (Keenleyside, 1961; Northcote and Wilkie, 1963). Each survey started at the forks approximately 2,500 feet upstream from the weir and proceeded downstream. The study area encompassed approximately 1.3 surface acres. The numbers of fish observed were relayed to an assistant on shore who recorded them. The position and feeding

¹ Saltonstall-Kennedy Funds were used, in part, to support this project. Administration of funds by the Auke Bay Biological Laboratory, U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Auke Bay, Alaska.

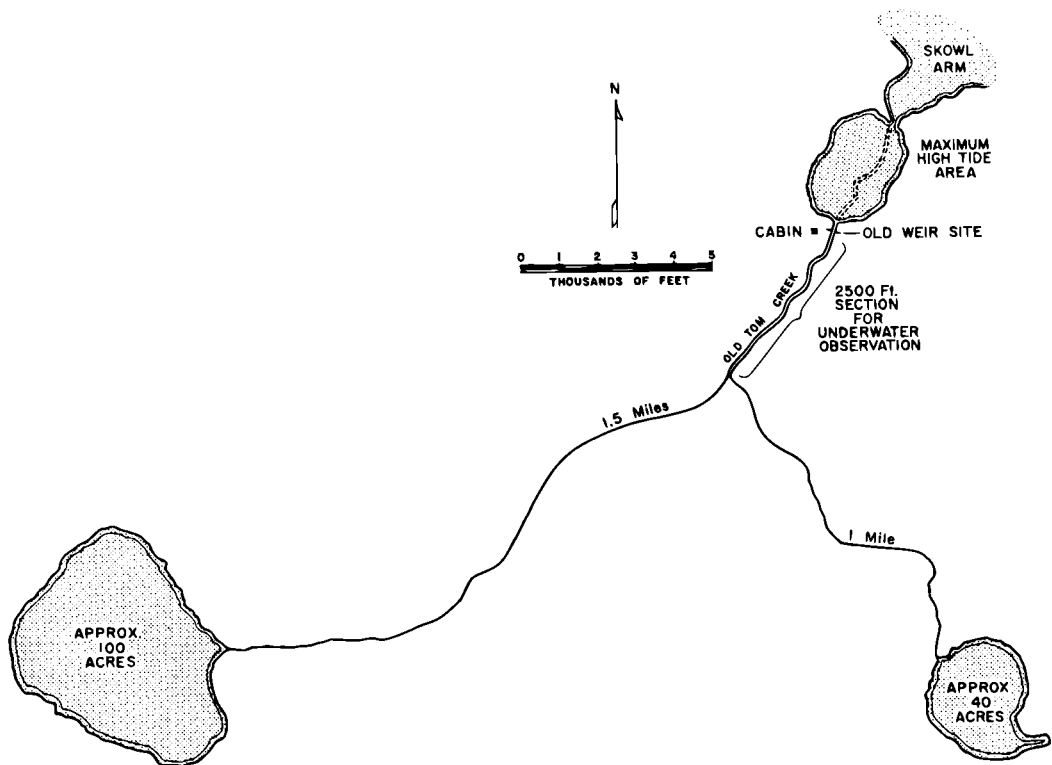


FIGURE 1.—Old Tom Creek watershed on Prince of Wales Island showing cabin, old weir site, and area used in the underwater observations.

behavior of fish in relation to drift salmon eggs were also recorded.

MIGRATION PATTERNS

Dolly Varden

The migration of Dolly Varden into Old Tom Creek was studied by tagging during the summers of 1962, 1963, and 1964. In 1962, between 23 August and 17 September, 724 Dolly Varden were captured by hook and line, tagged, and released at the former weir site (Figure 1). The tagged fish continued their upstream migration and re-entered the area (weir to the forks) where the hook-and-line sampling was in progress. Many traveled to the forks within a 24-hour period and were again captured (Table 1). In 1963, between 9 July and 11 September, 984 Dolly Varden were tagged. The 264 fish recaptured showed a similar upstream movement as in 1962. Fourteen of the Dolly Varden tagged in 1962 were recaptured in 1963. Two biological aides

tagged an additional 120 Dolly Varden during the 1964 field season. Only seven of these fish were recaptured and no conclusions were made about movement. The migration of Dolly Varden into the Eva Lake system on Baranof Island as reported by Armstrong (1965) began on 31 May 1962 and 11 June 1963. However, the majority of these fish did not enter the system until early July each year which corresponds to the migration data obtained at Old Tom Creek (9 July 1962, 10 July 1963, 9 July 1964).

No attempt was made to collect Dolly Varden fry or fingerlings from Old Tom Creek. However, Rowland and Martin (1963)² reported Dolly Varden fry in southeastern Alaska migrating into salt water by early May, and these fish were less than 27 mm in total length.

² Personal correspondence with Richard Rowland and John Martin, Biological Laboratory, U. S. Bureau of Commercial Fisheries, Auke Bay, Alaska.

TABLE 1.—*Dolly Varden tag return data from Old Tom Creek, Prince of Wales Island, Alaska, 1962 through 1964*

Year	1962	1963	1964
Number tagged	724	984	120
Number recaptured once	207	264	7
Number recaptured twice	26	25	—
Number recaptured 3 times	3	2	—
Number recaptured within 24 hours	26	11	—

TABLE 2.—*Numbers of fish observed (per acre) on underwater surveys of Old Tom Creek, Prince of Wales Island, Alaska, 1962 field season*

Date	Imma- ture coho salmon	Rain- bow trout	Dolly Var- den	Prickly scul- pins	Adult pink salmon	Adult chum salmon
8 July	971	706
20 July	916	677	91	58
3 August	865	612	111	71
15 August	761	524	159	103	238	...
25 August	750	473	167	148	425	40
1 September	719	433	275	153	930	52
7 September	622	398	274	215	1,138	111
12 September	431	356	282	228	1,285	745
18 September	355	318	284	234	1,892	1,068

Rainbow trout

Adult rainbow trout (steelhead) arrived at Old Tom Creek in late October. The actual spawning period is unknown for this area, but in nearby British Columbia rivers, it has been reported (Carl, Clemens, and Lindsey, 1959) to take place from late November through April. Rainbow trout fingerlings usually remain in fresh water one or two years, depending on growth rates (Shapovalov and Taft, 1954). Smolts begin their out-migration to sea in April.

Prickly sculpin

Eyed sculpin eggs were found attached to the underside of stones in May, but no adult or immature sculpins were observed in the stream before the first week of July and within 10 days they had migrated to the upper tributaries. Cottid fry were never collected or observed during the study. Therefore, I believe they migrated into salt water sometime in May. All sculpins entering the study area in July were about 50 mm in total length or larger. Adult and immature sculpins were still present in the stream each September when the camp was closed.

Pink, chum, and coho salmon

Spawning migration of pink and chum salmon into Old Tom Creek normally begins in late August. Pink salmon arrive first and are soon followed by chum salmon (Sheridan, 1962). Pink salmon usually outnumber chum salmon. After undergoing development and growth during the fall and winter, pink and chum salmon fry begin their migration to sea in April and it is usually over by early June.

A small run of coho salmon enters the stream in late October when the chum salmon are near the end of their spawning. They spawn until late November. Immature coho salmon remain in fresh water for at least one year and migrate to the sea throughout the spring and early summer.

RELATIVE DENSITY

Underwater observations were made in Old Tom Creek from the forks to the weir 10 times during the summer of 1962. Only young coho salmon and rainbow trout were seen during the first survey on 8 July (Table 2) but on the next survey 12 days later, Dolly Varden and prickly sculpins had moved into the study area. Both pink and chum salmon had started their spawning migration into Old Tom Creek by the 25 August observation. The abundance of these adult salmon increased until the end of the study.

Two trends in the fish populations were noted from the underwater observations: (1) There was a steady decline in the number of immature coho salmon and rainbow trout counted per survey, and (2) the numbers of Dolly Varden and prickly sculpins steadily increased during the period.

The decline in young coho salmon and rainbow trout can be attributed to normal out-migration, natural mortality, and extensive hook and line sampling. Four hundred and ten rainbow trout were taken from the study area for growth analyses and other data during the summer.

The progressive seasonal increase of Dolly Varden is indicative of their normal migration pattern (Armstrong, 1965). The ready source

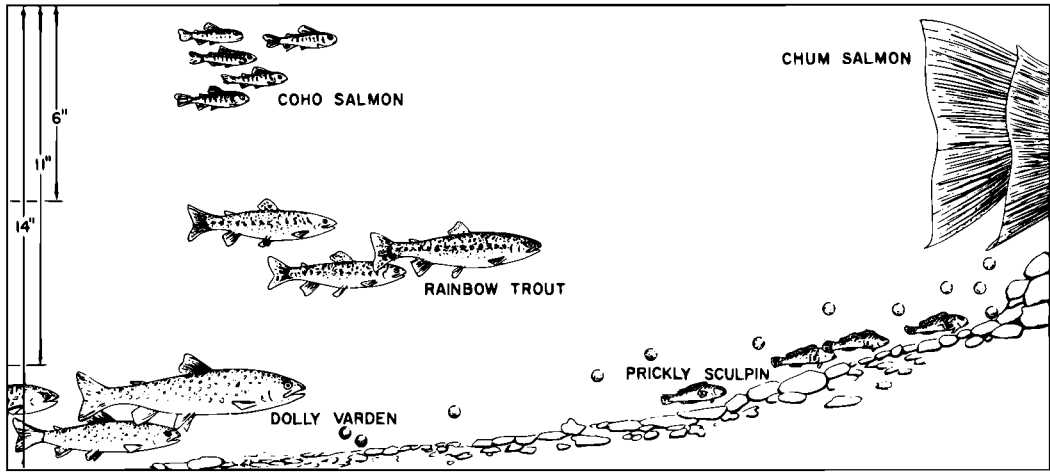


FIGURE 2.—Relative position of four fish species to a chum salmon redd in Old Tom Creek, Prince of Wales Island, southeastern Alaska.

of drift salmon eggs after 25 August may have also contributed to the increase. The prickly sculpin had spawned in the spring and then migrated into salt water. Later, they returned to fresh water to feed primarily on salmon eggs.

BEHAVIOR AND FEEDING HABITS

Considerable time was spent making underwater observations on the behavior and feeding habits of fish in Old Tom Creek. Visibility was excellent within the range of observation which normally did not exceed 8 feet. The observer rested in about 18 inches of water at the tail of a riffle below a pair of spawning chum salmon. Each of the four species in the area at the time, Dolly Varden, rainbow trout, prickly sculpin and coho salmon, had a characteristic position and behavior pattern in relation to the redd. These relative positions are illustrated in Figure 2.

Dolly Varden occupied positions about 4 inches above the streambed slightly downstream from the rainbow trout. Their proximity to the streambed afforded them an environment with less current. They were seldom attracted to insects drifting downstream and were the last fish to have access to the salmon eggs. Dolly Varden, larger than 10 inches in fork length, were normally found in pools rather than in the riffle areas where the smaller fish schooled. In mid-September,

when the salmon spawning activity reached its peak, these larger fish fed on eggs which partially covered the pool bottom.

Most Dolly Varden did not feed during July and early August. However, the isopod (*Exposhaeroma oregonensis*) and limited numbers of Coleoptera adults were occasionally consumed by some individuals (Table 3). In general, Dolly Varden fed little in fresh water until salmon spawning began. The limited feeding period lasted 43 days in 1961, 45 days in 1962, and 48 days in 1963. Data obtained during my underwater observations indicated a high utilization by Dolly Varden of only drift salmon eggs, and I believe this type of predation contributed little to salmon egg mortality. The possibility of these eggs overwintering is slight. Therefore, Dolly Varden may gorge themselves on drifting eggs but contribute very little to direct egg mortality.

Other workers have made studies on Dolly Varden feeding habits in Alaska. DeLacy (1941) found that 81.4% of the Dolly Varden adults taken from the Karluk Lake drainage during their outmigration had empty stomachs. Roos (1957) found that 52.8% of all Dolly Varden stomachs examined during a 4-month period (May to August) at Chignik Lake, Alaska, were empty.

The three field seasons at Old Tom Creek started each year after the peak of the salmon fry outmigration (Roppel, 1956) and there-

TABLE 3.—Percentage frequency of occurrence and percentage total volume (in parentheses) composed by food items in stomachs of Dolly Varden from Old Tom Creek, Prince of Wales Island, 1961–63

Date	Number stom- achs	Per- cent- age empty	Percentage frequency of occur- rence and percentage total volume (in parentheses) of:				
			Cole- op- tera	Isop- oda	Eggs	Fish	De- bris
1961							
15 July	25	88.0		100.0 (63)			100.0 (37)
13 Aug.	46	87.0	66.6 (45)	33.4 (17)			100.0 (38)
10 Sept.	35	15.0			90.0 (76)		100.0 (24)
1962							
14 July	44	95.0	50.0 (45)	50.0 (45)			100.0 (10)
24 July	17	100.0					
30 Aug.	70	8.4	12.0 (8)	39.0 (30)	47.0 (40)	<1.0	94.0 (21)
1–					100.0 (92)		58.0 (8)
18 Sept.	35	8.8					
1963							
July	15	100.0					
August	20	60.0	15.0 (7)	40.0 (14)	45.0 (50)		100.0 (29)
Sept.	15	9.5			100.0 (86)		45.0 (14)

fore no evaluation could be made of predation by Dolly Varden on fry. Several investigators have shown that Dolly Varden feed actively on sockeye salmon smolts; Rounsefell (1958) at Karluk Lake; and Pritchard (1936) at McClinton Creek, British Columbia. However, in studies at Kitoi Lake, Alaska, Smoker (1956) reports that all Dolly Varden examined had empty stomachs. Lagler and Wright (1962) found that the diet of Dolly Varden at the mouth of a southeastern Alaska salmon stream was relatively free of salmon remains during fry migration. Recently, Narver and Dahlberg (1965) reported limited feeding by Dolly Varden on sockeye salmon smolts in Chignik Lagoon, Alaska.

In general, rainbow trout were the most vigorous in their feeding and swimming activity. Positioned in the riffle area midway between the stream's surface and the substrate, they usually schooled in aggregates of 9 to 15 fish. They seldom were observed in pools. An occasional rainbow trout would rise to the surface for floating insects or bits of debris. They fed readily on aquatic insects and occasionally on drifting salmon eggs.

Prickly sculpin normally rested on the

streambed immediately behind the spawners and often within the redd, their numbers varying from 8 to 20. Sculpin about 60 mm in total length had difficulty in grasping the whole egg. However, they were very successful in breaking the egg membrane and ingesting the yolk. All sculpin within the redd fed actively on eggs and I consider them a major predator on eggs which potentially could survive the freshwater mortality phase of the pink and chum salmon life cycle. Heard (1965) summarized the literature pertaining to cottid predation on several species of salmon fry. However, Phillips and Claire (1966) have found in their aquaria study that the reticulate sculpin (*Cottus perplexus*) was capable of penetrating some sizes of gravel and preyed upon steelhead fry.

Immature coho salmon usually swam a few inches below the surface. Groups of two to eight competed with rainbow trout for the same food (aquatic and terrestrial insects). They apparently preferred insects to salmon eggs, although a fingerling would occasionally swim to the substrate to pick up an egg. Other groups of coho salmon fingerlings were also seen in large pools between riffles.

DISCUSSION

A face plate and snorkel proved very effective as equipment for the enumeration and observation of fish living in Old Tom Creek. Practice enabled the diver to use the snorkel as a speaking tube which eliminated the necessity to raise his face out of the water to speak. After the initial survey the individual recording on shore had no difficulty in understanding the diver.

No improvement could be made in collecting the fish density data. However, I realize the feeding behavior aspect lacks detailed data. Salmon eggs consumed per minute for each species, attacks and threats within and between species, etc., should have been noted. My inexperience with the technique caused this deficiency.

The Dolly Varden is not the major salmon egg predator based on underwater observations made in Old Tom Creek. The prickly sculpin apparently assumes this vital role and it should be evaluated under laboratory and field conditions.

ACKNOWLEDGMENTS

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Susceptibility of Rainbow Trout *Salmo gairdneri* Richardson, to *Clostridium botulinum* Toxins

INTRODUCTION

The food used for raising fish in ponds is to some extent of animal or piscine origin, and accordingly subject to rather rapid deterioration if it is not preserved efficiently. In this connection the question of food intoxication in rainbow trout is of importance, and in this communication, experiments aiming at elucidation of the susceptibility to botulinum toxins are reported. The botulinum toxin is produced by the *Clostridium botulinum* bacteria which is a spore-forming anaerobic organism mainly found in soil and bottom sediments. The toxin produced by the organism has caused severe diseases from contaminated food in both human beings and in animals. There are six types, A, B, C, D, E, and F of which toxin from type A, B, E, and F has resulted in food poisoning of human beings, and diseases from type C and D have been observed in some warm-blooded animals. A concen-