

Richard A. Kirn¹, Richard D. Ledgerwood, and Alvin L. Jensen

Northwest and Alaska Fisheries Center

National Oceanic and Atmospheric Administration, Seattle, Washington 98112

Diet of Subyearling Chinook Salmon (*Oncorhynchus tshawytscha*) in the Columbia River Estuary and Changes Effected by the 1980 Eruption of Mount St. Helens

Abstract

Stomach contents of subyearling chinook salmon (*Oncorhynchus tshawytscha*) captured in the Columbia River estuary from 1979 to 1982 were examined. Prey were identified and assigned an index of relative importance using percent wet weight and percent frequency of occurrence. Diet was examined to document food resources used at Jones Beach (RKm 75) and to determine if extreme turbidity from the 18 May 1980 eruption of Mount St. Helens caused changes in types of food consumed.

Amphipods, a primary dietary constituent in March, April, and June 1979, diminished in importance following the eruption probably due to heavy siltation. They were almost unused as a food source by subyearling chinook salmon from the eruption in 1980 through 1981. Insects and cladocerans became the primary diet constituents. The taxa and morphological stages of the insects consumed did not change after the eruption.

In 1982, mysids were heavily preyed upon by subyearling chinook salmon. The amphipod population apparently became reestablished, but its importance as a diet constituent was less than that of mysids.

The eruption of Mount St. Helens is not expected to have long term effects on the food resources of subyearling chinook salmon.

Introduction

The eruption of Mount St. Helens on 18 May 1980 altered water quality in the lower Columbia River during the peak migration of subyearling chinook salmon (*Oncorhynchus tshawytscha*) (Dawley *et al.* 1986). Heated mud and ash produced by the eruption flowed from the Toutle River into the Cowlitz River and entered the Columbia River at River Kilometer (RKm) 109 (Figure 1). Turbidity and debris arrived at Jones Beach after sampling was complete on 19 May 1980. Turbidity measurements were made by National Marine Fisheries Service (NMFS) personnel 3 Km downstream from the confluence of the Cowlitz and Columbia Rivers. Decreased feeding rates of juvenile chinook salmon were observed at Jones Beach, Oregon, RKm 75 (Dawley *et al.* 1986); and farther downstream in the Columbia River estuary (McCabe *et al.* 1981); coincident with large quantities of debris and increased turbidity (3000 Jackson Turbidity Units—about 500 times normal). Lowered food consumption could decrease juvenile survival (Snyder 1980) and adversely affect adult returns.

¹Present address: Wildlife and Fish Program, University of Vermont, Burlington, Vermont 05405.

The purpose of this study was to document the diet of subyearling chinook salmon at the upstream extremity of the estuary (RKm 75) and to determine the impact of the eruption of Mount St. Helens on that diet.

The fish were collected as part of a study by the NMFS to define migrational characteristics and survival of juvenile chinook and coho salmon (*O. kisutch*) and steelhead (*Salmo gairdneri*) entering the Columbia River estuary (Dawley *et al.* 1985).

Methods

Fish were collected using beach and purse seines during the spring and summer, 1979-1982. The beach seine was 95 m long and 5 m deep with 1 to 2 cm (stretch measure) webbing (Sims and Johnsen 1974). It was fished from the south shore at RKm 75. The purse seine was 206 m long and 11 m deep with 1 to 2 cm (stretch measure) webbing (Johnsen and Sims 1973). It was fished in mid-river at RKm 75. During May and June, the fishing effort consisted of 10 beach seine and 5 purse seine sets each day beginning at sunrise; during other months, the effort was reduced and varied with the number of migrants being captured. Sampling generally began at sunrise and

time intervals between sets were 45 min for the beach seine and 90 min for the purse seine.

Captured fish were separated by species; those containing coded wire tags (CWT) (Bergman *et al.* 1968) were sacrificed for tag information. Subyearling chinook salmon predominantly of the fall and summer races (Van Hyning 1973) were separated from yearlings (predominantly of the spring race) by mark information. Stomachs (esophagus to the pyloric caeca) were excised from CWT fish and cleaned of external fatty tissue. Fullness was visually assessed by the proportion of the total stomach length containing food (Terry 1977). A subsample of stomachs containing food was preserved with a buffered 10 percent formaldehyde solution in individual vials for later weight measurements and content analyses. To minimize the effects of digestion on prey identification and to avoid possible bias in our analyses resulting from low counts of prey items from nearly empty stomachs, only stomachs judged half full or greater were selected for content identification.

Organisms were identified to the lowest practical taxon; insects were further separated by metamorphic stage. When dismembered prey were present, parts were weighed together and counts based upon the number of head capsules present. Weight of unidentifiable material was not included in the total weight used for ranking relative importance in the diet.

Stomach contents were examined from 492 subyearling chinook salmon collected from March through June of 1979-1982, and 74 collected from July through September 1980. Data from each year were grouped into 14 d intervals. Comparisons between years were limited to the March-June period.

A modified index of relative importance (IRI') for each taxon present within each 14 d interval was calculated:

$$\text{IRI}' = \% \text{W} \times \% \text{FO}$$

where %W = percent of the total content weight from all stomachs

%FO = percent frequency of occurrence of all salmonids which contain the designated taxon.

The IRI' used was a modification of the multi-variable index, IRI, formulated by Pinkas

et al. (1971); which included numerical, volumetric, and FO percentages. The modified IRI was used to decrease bias resulting from large numbers of small food items (MacDonald and Green 1983). The IRI' for each taxon is presented as a percentage of the summed IRI's for all food items.

Results and Discussion

During March-June, 1979-1982, Insecta (54 percent IRI') and Crustacea (41 percent IRI') comprised the major food items found in subyearling chinook salmon (Table 1). The most important order of insects was Diptera, 16 percent IRI'; however, unidentifiable Insecta represented 35 percent IRI'. The most important crustaceans were Amphipoda and Cladocera, which represented 19 and 12 percent IRI', respectively. Mysidacea were important only in 1982 (32 percent IRI'). In July 1980, insects were the most important source of food (62 percent IRI'), but during August and September of that year, Cladocera became the most important constituent of the diet, 94 percent IRI' (Figure 2).

TABLE 1. Percent modified index of relative importance (IRI')^a of diet items identified in stomach contents from subyearling chinook salmon captured at Jones Beach, Oregon (RKm 75); March-June, 1979-1982.

Diet item	1979	1980	1981	1982	Average
Insecta					
Unidentifiable	38	33	54	14	35
Diptera	6	12	27	18	16
Misc. Insecta	2	3	4	5	3
Total	46	48	85	37	54
Crustacea					
Amphipoda	40	16	2	17	19
Cladocera	8	25	8	9	12
Mysidacea	2	1	1	32	9
Misc. Crustacea	0	2	1	0	1
Total	50	44	12	58	41
Miscellaneous total	4	8	3	5	5

^a IRI' = % weight x % frequency of occurrence.

Insecta

Insecta were of major importance in the diet during March-June in all years, particularly in 1981 (85 percent IRI'), when the availability of amphipods appeared to be limited (Table 1).

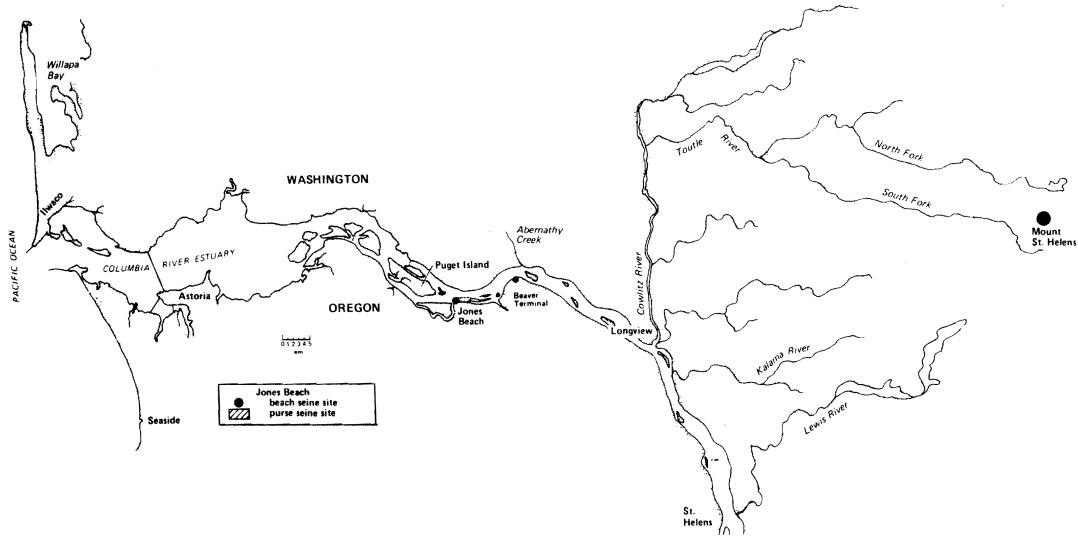


Figure 1. Lower Columbia River showing the Jones Beach sampling site, Cowlitz River, Toutle River and Mount St. Helens.

The types of insects found in the stomachs showed no apparent differences between years, consequently the data for all years were combined by 14 d periods. Diptera were the most numerous insects; 81 percent of 3444 total insects identified to order. There was no seasonal pattern of Diptera consumption for the various metamorphic stages; frequencies of larvae, pupae, and adults were similar. Homoptera and Hymenoptera (mostly adults) were the next most numerous insects—5 percent and 4 percent of the total insects, respectively. Insects representing 10 additional orders were identified; however, each represented less than 3 percent of the total insect count.

Crustacea

The consumption of amphipods varied between years. In 1979, peak consumption of amphipods occurred in late March-early April, 71 percent IRI', followed by a second peak in June, 85 percent IRI' (Figure 2). In 1980, an early April peak at 39 percent IRI' was apparent; however, the June peak observed the previous year was not repeated after the eruption, when the IRI' was only 6 percent. In 1981, minimal amphipod con-

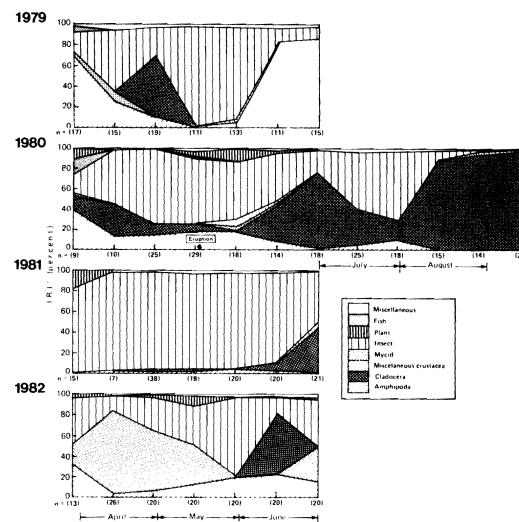


Figure 2. Modified index of relative importance (IRI') for food items consumed by subyearling chinook salmon collected at Jones Beach, Oregon; 1979-1982.

sumption was observed, averaging 3 percent IRI' in March-June. In 1982, amphipods again increased in importance, with peaks in early April

TABLE 2. Amphipod species and percent of total amphipods observed in stomach contents from subyearling chinook salmon before and after the eruption of Mount St. Helens—March-June, 1979-1982.

Species	Before eruption <i>a/</i> (%)	After eruption <i>b/</i> (%)
<i>Corophium salmonis</i>	74	38
<i>Corophium spinicorne</i>	22	45
<i>Eogammarus confervicolus</i>	4	17

a/ 25 March 1979 to 19 May 1980.

b/ 20 May 1980 to 30 June 1982 (excluding data from July to September 1980).

at 33 percent IRI' and in June at 20 percent IRI'. Meyer *et al.* (1981) observed a similar biomodal peak of amphipod consumption by juvenile chinook salmon in the lower Duwamish River, Washington.

Three species of Amphipoda were found in the stomachs: *Corophium salmonis*, *C. spinicorne*, and *Eogammarus confervicolus*. Diet composition after the eruption (Table 2) indicated reduced utilization of *C. salmonis*. Before the eruption *C. salmonis* comprised 74 percent of all amphipods identifiable to species, compared to 38 percent after the eruption. A substantial reduction of *C. salmonis* in the diet of juvenile salmonids following the eruption was also observed in the lower Columbia River estuary by McCabe *et al.* (1981) and Emmett (1982). The greater reduction of *C. salmonis* could be a function of different substrate requirements (Chang and Levings 1976, Albright 1982). Brzezinski and Holton (1981) found that amphipod abundance (primarily *C. salmonis*) was decreased after the eruption in areas of the estuary that had a benthic layer of ash.

In the Columbia River estuary, *C. salmonis* exhibit a bivoltine life cycle (Davis 1978, Wilson 1983). The previous fall generation produces a spring brood in May which matures throughout the summer and subsequently produces a fall brood. The reduction of *C. salmonis* in the diet of subyearling chinook salmon following the eruption suggests that the 1980 spring brood of *C. salmonis* was disrupted by heavy deposition of sediment and that effects continued into 1981 as well.

In March-June, 1979, 1981, and 1982, Cladocera were of major importance in the diet of

subyearling chinook salmon (>10 percent IRI') during only one 14 d interval each year (Figure 2). During March-June, 1980, Cladocera were more important (averaging 25 percent IRI'), with a sharp increase following the eruption coincident with decrease consumption of amphipods. In August and September 1980, cladocerans were the major item in the diet. Craddock *et al.* (1976) observed that cladocerans were an important portion of the diet for chinook salmon captured during August-October in the Columbia River at Rkm 118.

Mysids (*Neomysis mercedis*) were rare, except in 1982, when they were the dominant food from mid-April to mid-May.

Fluctuations in the abundance of cladocerans and mysids in the diet were apparently unrelated to effects from the eruption (Figure 2). Cladoceran populations are known to exhibit extreme variability in their seasonal and annual abundance (Pennak 1978). *N. mercedis* abundance and distribution have been associated with a number of environmental factors including salinity, temperature, dissolved oxygen, light, and river flow (Hopkins 1958, Heubach 1969, Orsi and Knutson 1979). However, extreme variations in population abundance from one year to the next, unrelated to environmental changes, have been reported (Hopkins 1958, Heubach 1969). It is possible that increased mysid availability in 1982 masked the true extent of amphipod recovery. The decreased consumption of amphipods and increased consumption of insects, mysids, and cladocerans appears to be a temporary change. Partial restoration of amphipod consumption was observed in 1982 and continued improvement of benthic substrate should allow complete recovery to pre-eruption levels. The eruption of Mount St. Helens is not expected to have long term effects on the food resources of subyearling chinook salmon.

Miscellaneous Prey

Fish larvae (Osmeridae) were of minor dietary importance in late March and early April 1979 and 1980, 6 and 15 percent IRI', respectively; none were present in 1981 or 1982.

Immediately following the eruption (20 May-2 June 1980), consumption of plant material increased from 0 to 12 percent IRI'. Relatively high consumption of plant material also occurred 25

March-8 April in 1980 and 1981, 9 and 17 percent respectively, and 6-19 May 1982, 10 percent.

Geographical Differences

From March through June prior to the eruption, subyearling chinook salmon captured at Jones Beach consumed similar proportions of insects and amphipods, whereas upstream from Jones sand amphipods, whereas upstream from Jones

Beach in the reservoir of McNary Dam (RKm 470-521) fish consumed insects and cladocerans (R. Fairly, U.S. Fish and Wildlife Serv., Cook, Washington, personal communication) and further upstream in the free flowing Hanford reach (RKm 591-629) fish consumed primarily insects (Becker 1973). Fish captured downstream from Jones Beach (RKm 4-40) consumed primarily amphipods (Durkin et al. 1977, 1981).

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