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DISTRIBUTION, ABUNDANCE, AND GROWTH OF JUVENILE SALMONIDS OFF THE COAST OF OREGON AND WASHINGTON, SUMMER 1980

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July 1982

Abstract

Juvenile salmonids (<50 cm) were sampled by purse seine off the Pacific coast from Tillamook Bay, Oregon, to Copalis Head, Washington, during the period May through September 1980. Temporal distribution and abundance of the major Columbia River species were determined. Spring chinook salmon (Oncorhynchus tshawytscha) and steelhead (Salmo gairdneri) were present only during early cruises and were distributed almost entirely in the Columbia River plume and the sample area to the north. Coho salmon (O. kisutch) and fall chinook salmon were distributed more uniformly throughout the sampling area and were relatively abundant throughout the sampling period. Concentrations of fish were found only within 28 km of the shore. A number of fish that had been marked before or during their outmigration from Columbia River system were recaptured. It appeared possible that with concentrated sampling in areas with high fish abundances, sufficient numbers of marked juvenile salmonids could be captured to provide relative survival estimates between different stocks of Columbia River fish.

INTRODUCTION

The Columbia River historically is one of the major salmon (*Oncorhynchus* spp.) and steelhead (*Salmo gairdneri*) producing systems of the North Pacific Ocean (Netboy 1980). Salmon production has decreased in recent years due to increased juvenile mortality and loss or degredation of spawning habitat resulting from hydroelectric development of the system (Raymond 1979). The National Marine Fisheries Service (NMFS) and the fisheries agencies of Washington, Oregon, and Idaho have conducted considerable research to alleviate passage and mortality problems at dams. In addition, hatcheries have been constructed to mitigate the loss of spawning habitat. In spite of these efforts, adult salmon returns continue to decline.

NMFS and the U.S. Army Corps of Engineers have developed a juvenile transport system whereby smolts are collected at upriver dams, transported around the obstructions, and released below the lowermost dam (Park 1980). Results of transport research indicate that the success or failure of a year-class may be significantly influenced by events that occur downstream from the point of release. In addition, correlation between returns of precocious males and subsequent adult return indicate that the success or failure of a year-class is determined within the first 6 months of estuarine and/or ocean existence (W. Ebel, Fisheries Research Biologist, NMFS, Northwest and Alaska Fisheries Center, Seattle, personal communication, May 1982.

Some knowledge of juvenile salmonid life history off the Washington-Oregon coast in this critical 6-month period was acquired from the limited purse seining by NMFS in shallow nearshore al., 1981), and from two preliminary surveys off the Oregon coast by Oregon State University (OSU) in 1979 and 1980. Sampling during the OSU surveys was restricted to deeper water areas beyond 30 m (W. Pearcy, OSU, Corvallis, Oregon, personal communication). A total of 656 juvenile salmonids (less than 300 mm in length) were captured in the 2 years.

NMFS surveyed the near shore marine waters (>30 m) near the mouth of the Columbia River beginning in the spring of 1980. The objectives of this study were to provide needed information relative to the abundance, distribution, and growth of juvenile salmonids in the area and to determine if sufficient numbers of marked fish could be recaptured to define behavioral and/or survival differences among the various stocks of Columbia River hatchery fish.

METHODS

Ten east-west transects were established between Tillamook Bay, Oregon, and Copalis Head, Washington, and named for readily identifiable shore landmarks (F1). Each transect contained five sampling stations; the first located at the 30 m depth contour, with others extending seaward at 8 km intervals. Stations were chosen on the basis of a one-half hour running interval by the fishing vessel and not on the basis of fish populations. The latitude and longitude of each station was fixed using LORAN C.

A 17-m commercial salmon drum seiner, the Flamingo, was chartered for sampling. The sampling net was a 495-m x 30-m purse seine. The body of the net was constructed of 32-mm knotted nylon web with 30 meshes of 127-mm knotted nylon hung along the bottom above the lead line. The bunt was made of 18-mm knotted nylon web. Based on its construction, the net was

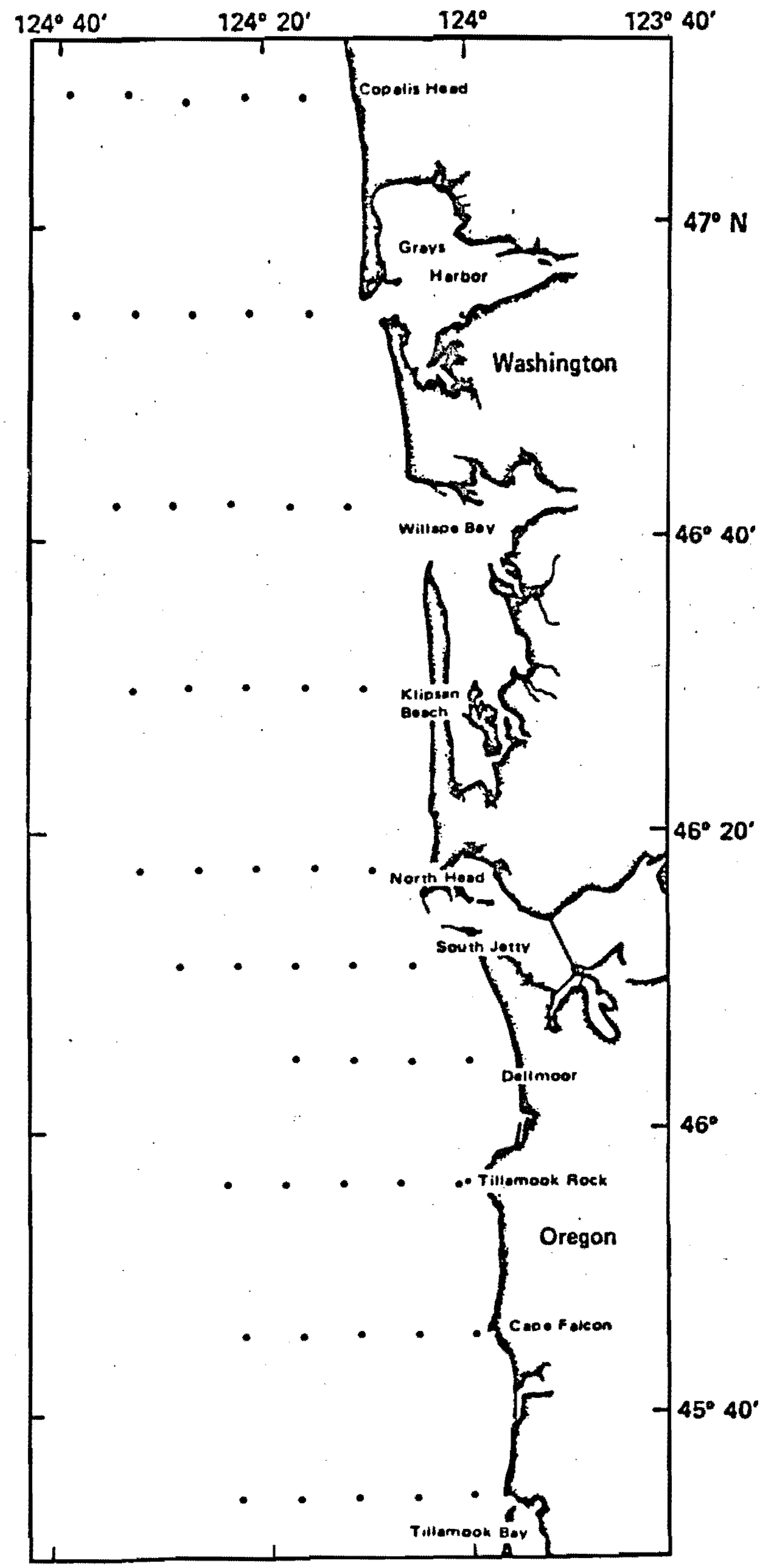

Figure 1.--Transects and stations sampled during offshore purse seining

assumed to fish to approximately 24 m deep (J. Jurkovich, Gear Specialist, NMFS, Northwest and Alaska Fisheries Center, Seattle, personal communication, February 1981).

Purse seining was conducted during three periods: 27 May-7 June, 4-15 July, and 28 August-8 September 1980. One day of sampling time was allotted per transect. The number of sets per transect and the number of stations sampled varied depending upon weather, sea conditions, and travel time to the transect. The Flamingo worked out of Westport, Washington, for the northern transects; Astoria, Oregon, for the central transects; and Garibaldi, Oregon, for the southern transects.

Conductivity, salinity, and temperature measurements were taken at the surface and at 30 m at each sampling station with a Beckman RS5-3 salinometer[1/]. The purse seine was then set with a 5-minute tow toward the south, closed, pursed, and juvenile salmonids dipnetted from the bunt. The procedure was repeated with a tow toward the north.

Fish were held in 114-liter plastic tubs with circulating seawater. All juvenile salmonids less than 50 cm in length were anesthetized with benzocaine, counted by species, measured to fork length, and examined for identifying marks. After processing, all fish not being kept were returned to a tub of circulating water and allowed to recover from the effects of the anesthetic before being returned to the sea.

All salmonids with clipped adipose fins were sacrificed for coded wire tag (CWT) identification. Heads from these fish were placed in vials containing a potassium hydroxide solution to free the CWT.

[1/]Reference to trade names does not imply endorsement by the National

Chinook salmon from the Columbia River system are generally designated as spring, summer, or fall run fish. The designations refer to the period of the year that adults enter the river on their upstream spawning migration. In native populations, juveniles of spring run and Snake River summer run fish spend 1 year in fresh water and migrate to the sea as yearlings, whereas juveniles of fall run and Columbia River summer run fish migrate to sea as subyearlings. In these populations, yearling fish are noticeably larger than subyearlings. With hatchery produced fish, however, size is no longer an accurate determinant between the two strains of fish. As no scales were taken on fish captured in the ocean, chinook salmon were considered together as a group. Differentiation between spring and fall strains of fish were only made where marked fish with a known origin were recaptured.

RESULTS

A total of 233 purse seine sets were made on the three cruises: 70 sets during 27 May to 7 June, 77 sets 4 to 15 July, and 86 sets 28 August to 8 September. Catches of juvenile salmonids ranged from 1,739 on the first cruise to 250 on the second (T1). A total of 144 fish captured were previously marked either with CWT, cold brands, or fin clips (T2)[2/] With the exception of coho salmon from the Washougal Hatchery [Washington Department of Fisheries (WDF)], only a few tags from any particular marked group were caught.

Distribution and Abundance

Fish abundance was lowest on Cruise 2 and the low catch was associated with water temperatures above those normally associated with salmonids

2/ Complete mark recaptured information is given in Dawley et al. (1981).

Table 1.--Purse seine catches of juvenile salmonids captured in 1980 off the Washington-Oregon coast, by cruise and species.

	Catch			
	Cruise 1 (27 May-7 Jun)	Cruise 2 (4-15 Jul)	Cruise 3 (28 Aug-8 Sep)	Total
Juvenile (<50 cm)				
Chinook salmon	467	183	549	1199
Coho salmon	858	56	241	1155
Sockeye salmon	44	1	2	47
Chum salmon	6	2	25	33
Steelhead	364	8	0	372
	1739	250	817	2806
Adult (>50 cm)				
Chinook salmon	87	41	164	292
Coho salmon	133	108	61	302
Pink salmon	0	0	1	1
Steelhead	1	1	1	3
Cutthroat	17	17	0	34
	238	167	227	632

Table 2.--Numbers of marked juvenile salmonids captured in 1980 off the Washington-Oregon coast, by type of mark and species.

Species (Brood year)	Coded wire tagged	Branded	Fin clipped
Chinook salmon (1978)	22	16	12
Chinook salmon (1979)	5	2	0
Coho salmon (1978)	38	3	22
Steelhead (1978 & 1979)	3	8	13
	68	29	47

(T3). Surface salinities averaged 27.3 °/oo, 29.1 °/oo, and 30.0 °/oo on Cruise 1-3, respectively. The range of salinities between all stations was from 17.1 to 33.0 °/oo. No correlations between surface salinities and juvenile fish abundances were found.

Juvenile chinook salmon were predominantly found in the area adjacent to the Columbia River mouth on Cruise 1, but displayed a fairly uniform north-south distribution over the entire sampling area during Cruises 2 and 3 (F2-4). The largest catches of chinook salmon were within 20 km of the shore; few fish were caught at the outer sampling sites. Considerably fewer chinook salmon were caught on Cruise 2 than on the other cruises. Yearling chinook salmon (based upon recaptured marks) had a fairly specific temporal and spatial distribution. No yearling marked fish of Columbia River origin were captured on either Cruise 2 or 3, and of the 31 marked fish captured on Cruise 1, 27 were located at and to the north of the Columbia River mouth.

Coho salmon had a fairly uniform north-south distribution over the entire sampling area on each of the three cruises and few fish were found at distances greater than 20 km from the shore (F2-4). Of the 38 tagged Columbia River coho salmon that were recaptured in the ocean, 22 were from releases at the Washougal Hatchery. These fish had the same overall distribution as the unmarked fish and were found from the most southerly transect to the most northerly transect. The overall abundance of coho salmon varied considerably between cruises. Many more coho salmon were captured on Cruise 1 than on the other two cruises.

Coho and chinook salmon had the same general north-south and nearshore-offshore distribution. Spearman rank correlations were computed

Table 3.--Average water temperatures (°C) in 1980 at the surface and 30-m depth, at sampling stations off the Washington-Oregon coast, by cruise.

	Cruise 1 (27 May-7 June)	Cruise 2 (4 July-15 July)	Cruise 3 (28 August-8 September)
Surface			
Average temperature	12.3	15.2	13.4
Range	11.1-13.2	14.2-16.2	10.6-14.7
30-m depth			
Average temperature	8.6	9.1	8.2
Range	8.1-10.9	7.5-12.5	7.4-10.4

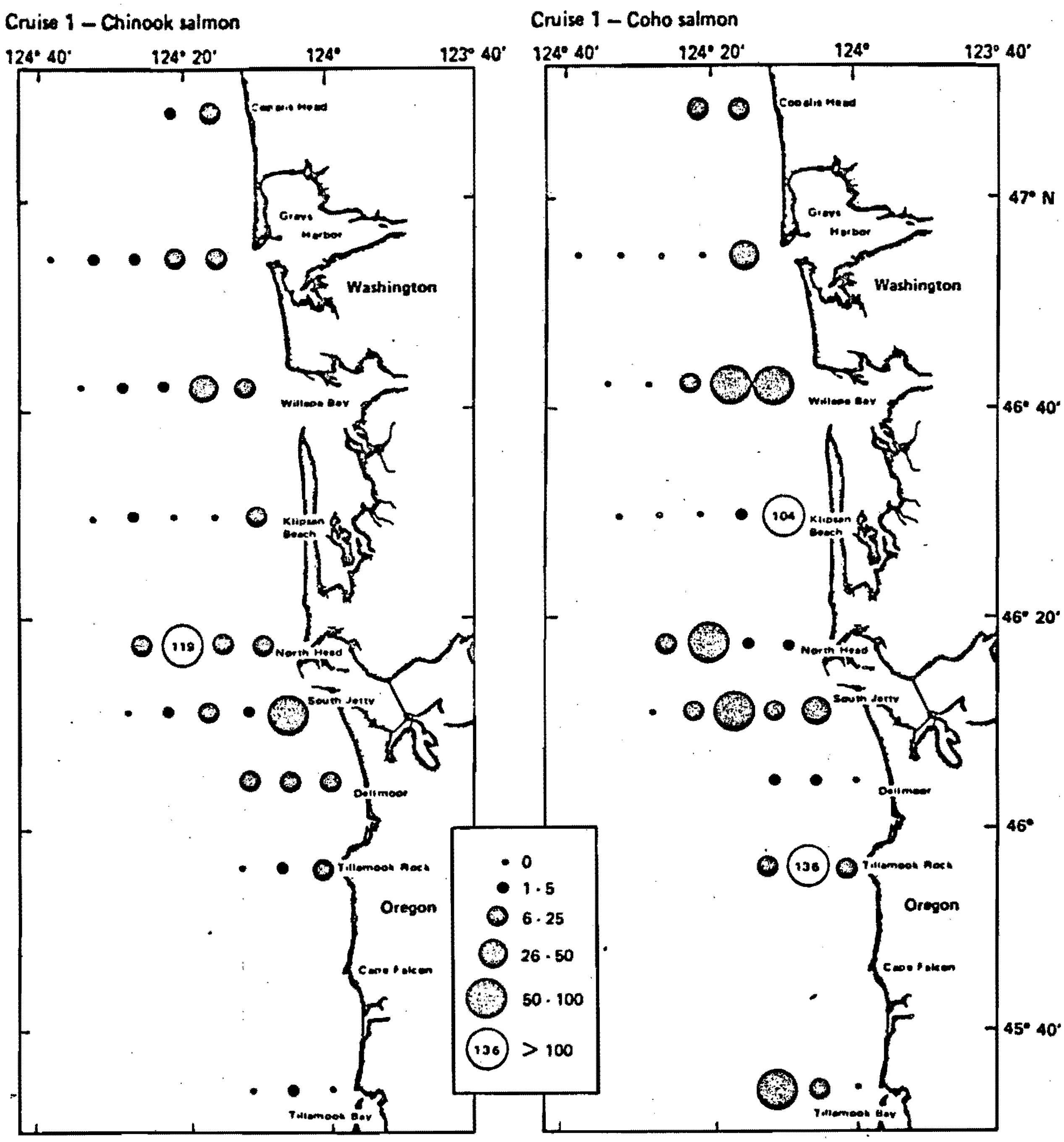

Figure 2.--Relative abundances of juvenile chinook and coho salmon taken by purse seine, 27 May-7 June, 1980.

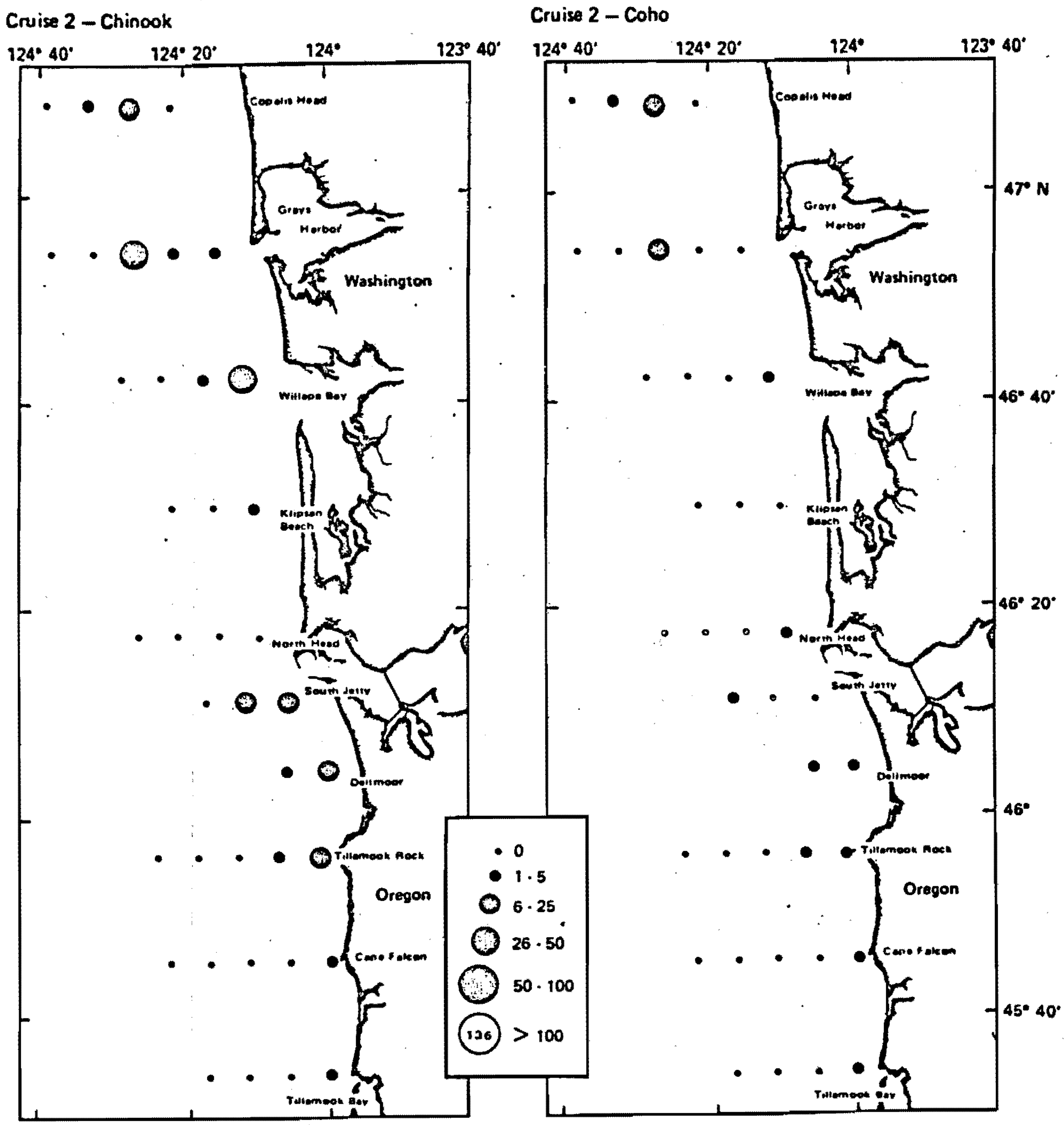

Figure 3.--Relative abundances of juvenile chinook and coho salmon taken by purse seine, 4-15 July, 1980.

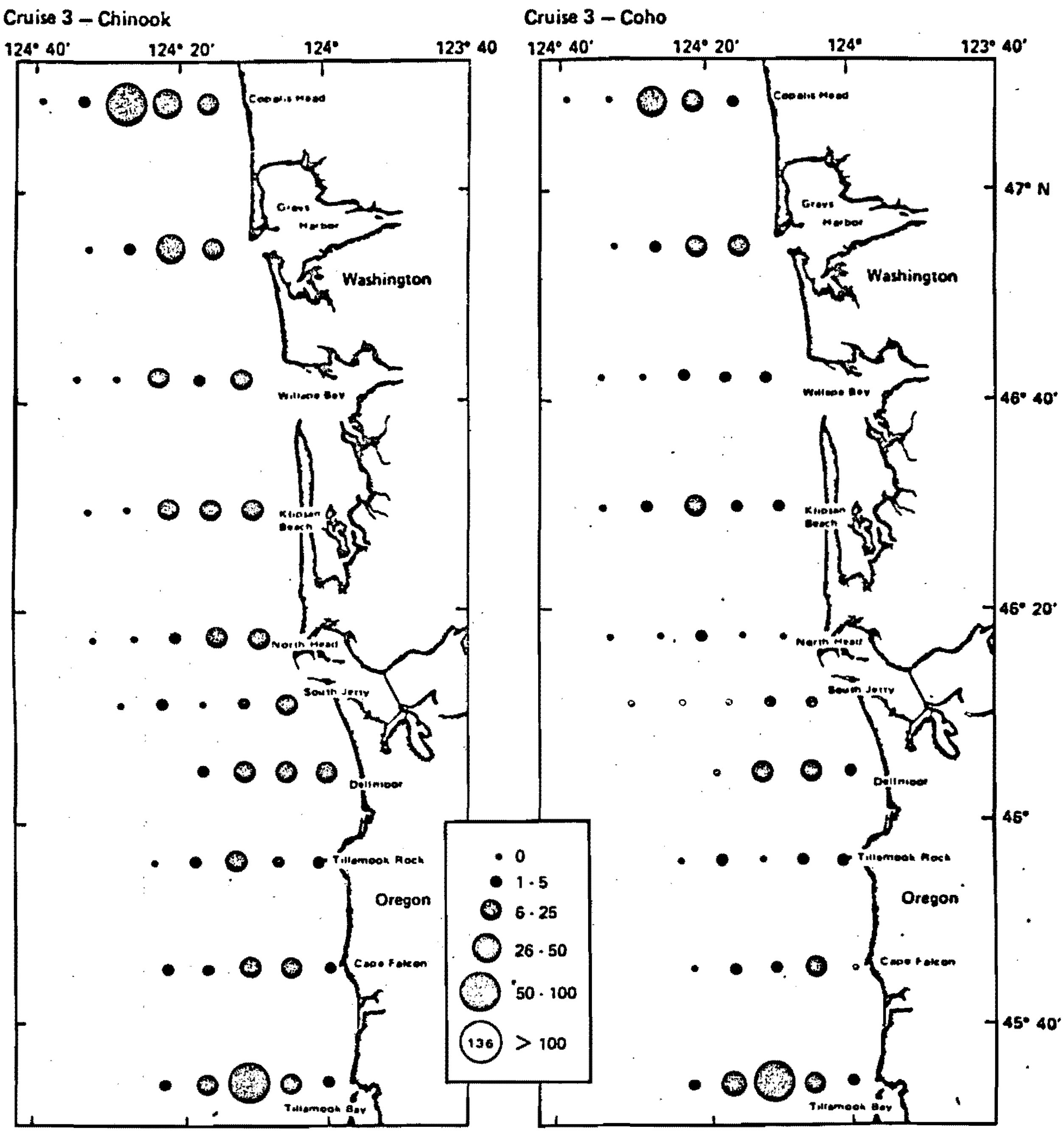

Figure 4.--Relative abundances of juvenile chinook and coho salmon taken by purse seine, 28 August-8 September, 1980.

to indicate the relationship between catches of juvenile coho and chinook salmon in the sampling area (T4). The abundance of each species varied similarly between sampling stations.

The distribution of steelhead was comparatively restricted. On Cruise 1, more than 90% were captured 15 to 32 km offshore between Klipsan Beach and Grays Harbor, Washington (F5). Abundance varied greatly between cruises. Only eight steelhead were caught on Cruise 2 and none on Cruise 3.

Effect of Direction of Set on Salmonid Catches

On Cruise 1, almost the entire catch of steelhead, 80% of the chinook salmon, and 76% of the coho salmon were taken in sets made toward the south (F6). There was no correlation on Cruises 2 and 3 between direction of seine set and abundance of salmonids caught, nor a correlation with marked fish captured.

Size Characteristics

Steelhead averaged 212 mm in fork length on Cruise 1 with no or too few recoveries on the later cruises to estimate growth (F7).

Coho salmon fork length averaged 172 mm on Cruise 1, 170 mm on Cruise 2, and 268 mm on Cruise 3 (F7). There was a 55% increase in the size of fish captured between mid-July and early September.

Chinook salmon fork length averaged 166 mm on Cruise 1, 190 mm on Cruise 2, and 273 mm on Cruise 3 (F7). Two distinct size classes were observed in the area between Willapa Bay and Copalis Head on Cruises 2 and 3. The smaller fish averaged 162 mm (35) and 177 mm (45); and the larger fish averaged 246 mm (25) and 288 mm (135) on Cruises 2 and 3, respectively. Marked spring chinook salmon were captured only on Cruise 1, so it was assumed that few spring chinook salmon were represented in the

Table 4.--Spearman rank correlations (Rs) indicating relationships between juvenile chinook and coho salmon catches on Cruises 1-3.

Cruise	Number of observations	RS	Level of significance (P)
1	35	0.51	<0.005
2	39	0.73	<0.005
3	48	0.76	<0.001

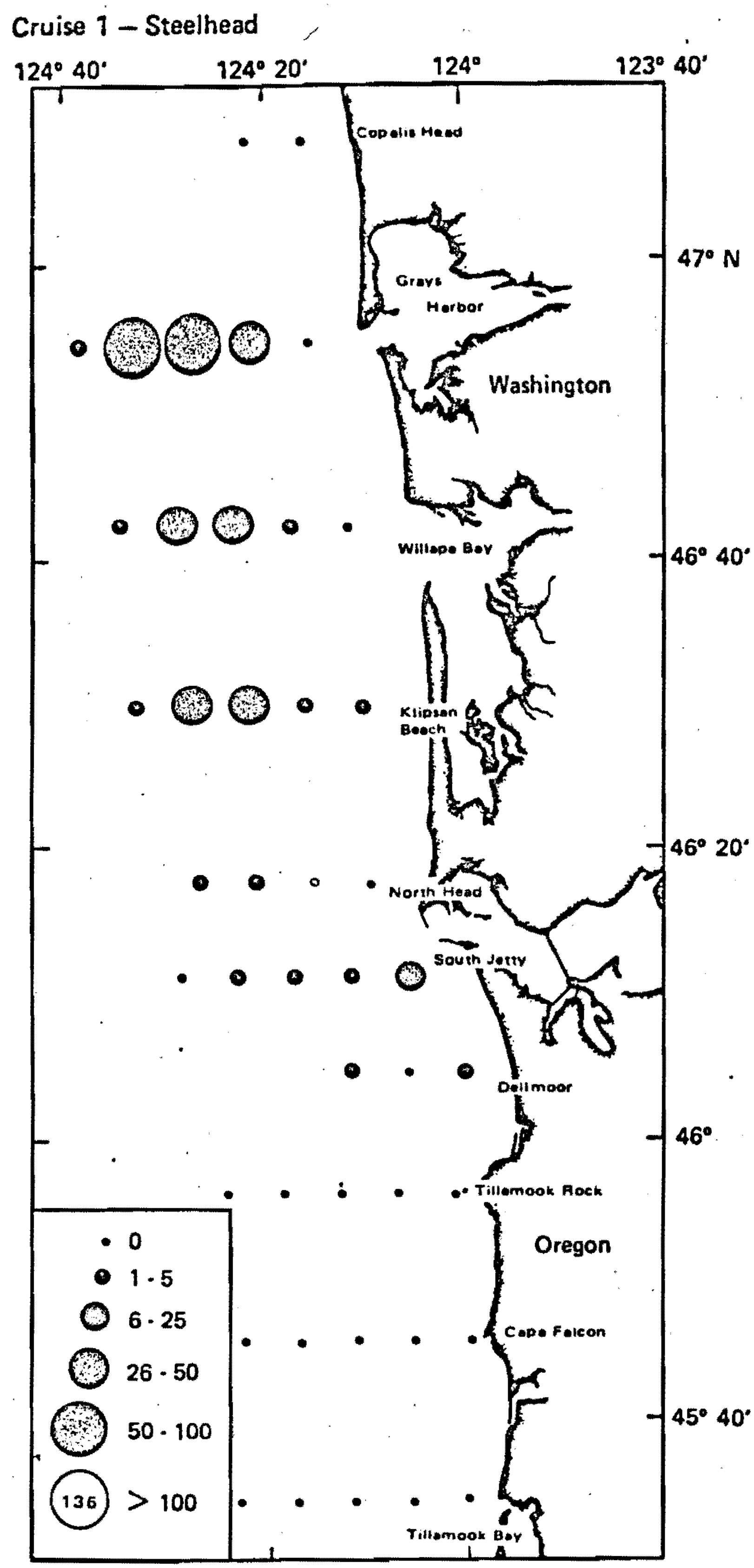

Figure 5.—Relative abundances of juvenile steelhead taken by purse seine, 27 May-7 June, 1980.

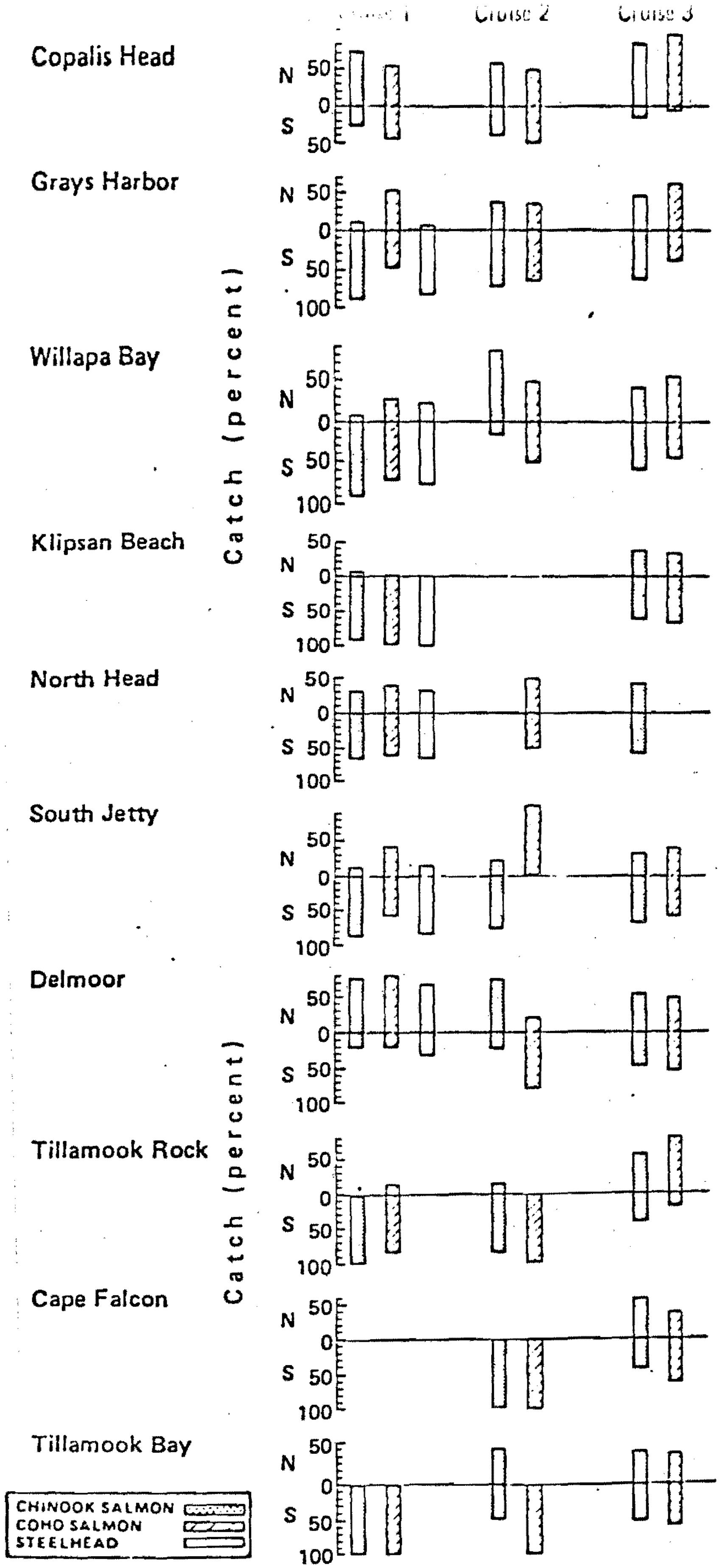

Figure 6.--Distribution of catch between north-facing and south-facing

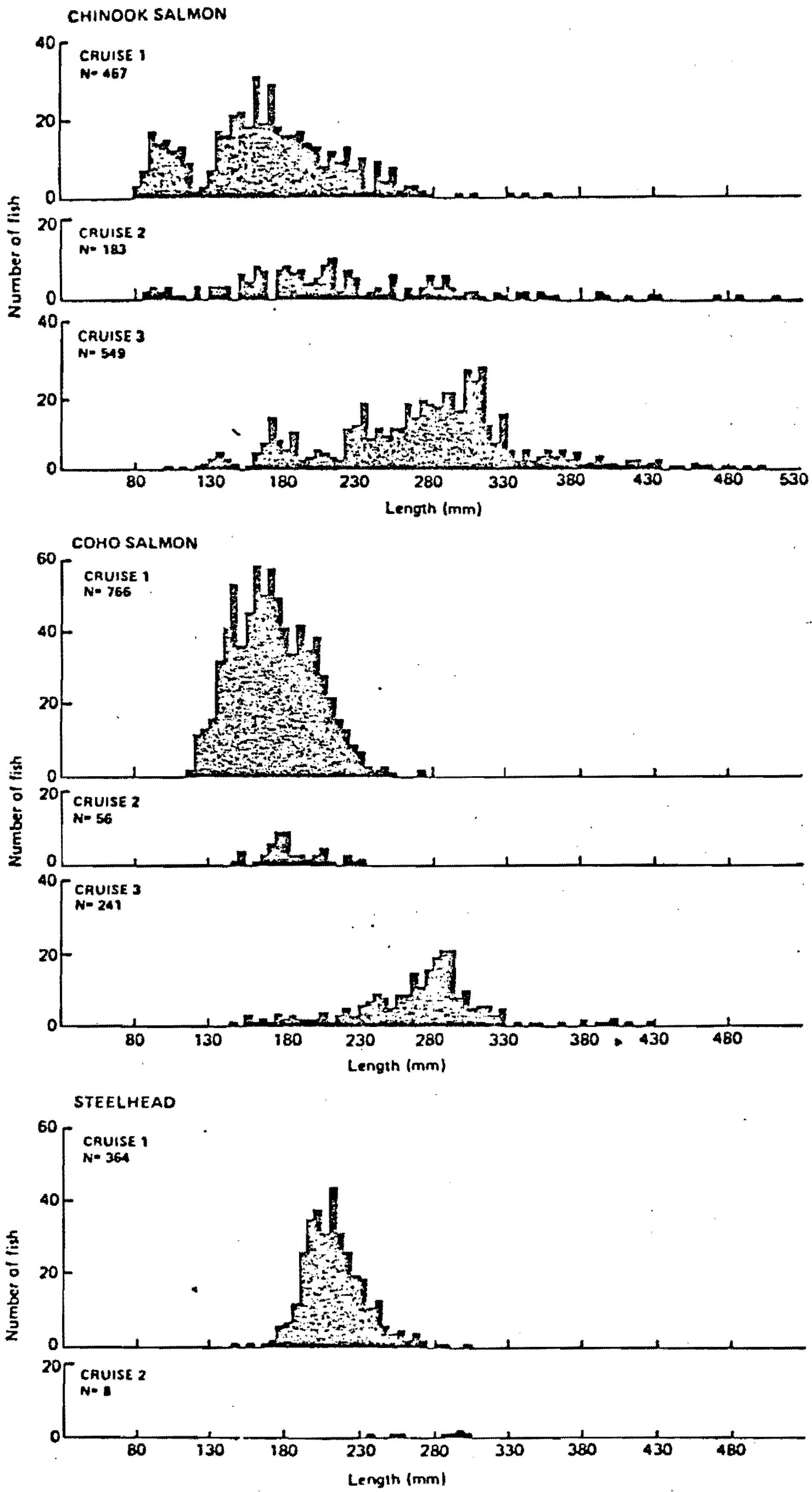

Figure 7.--Length distribution of juvenile salmonids captured by purse

catches from Cruises 2 and 3. The size of subyearling Columbia River chinook salmon entering the estuary and ocean in the spring from the brood of the previous fall ranged from 70 to 110 mm. Thus the length of chinook salmon recaptured on Cruise 3 represented the growth these fish attained in 5 to 6 months.

DISCUSSION

Distribution and Abundance

In the study area, from Tillamook Bay to Copalis Head and 36 to 38 km offshore, numerous juvenile salmonids were caught at the first 4 stations (28-30 km offshore) of each transect. Few fish were taken at Station 5 (36-38 km offshore) of any transect. Other researchers in the northern N.E. Pacific, Godfrey et al. (1975), Major et al. (1978) and Hart (1980) also found juvenile salmonids more concentrated close inshore but with some fish caught as far as 480 km offshore. In the northern N.W. Pacific, Birman (1969) reported concentrations of juvenile salmonids close to shore in the Sea of Okhotsk until August-September. Andrievskaya (1968, 1970) reported juvenile coho salmon from nearshore to 960 km offshore in the Sea of Okhotsk and the Bering Sea.

Although more than 2,700 juvenile salmonids were caught on the three cruises, not enough marked fish were captured to determine the relative abundance or distribution of any particular stock, with the possible exception of those from the Washougal Hatchery. This was due in part to the timing of the cruises and the effort necessary to sample a large enough area to determine general overall fish distribution. In the process of determining distribution, much effort was expended in sampling some distance offshore where no fish were located. Had sampling been conducted more intensively in areas where large fish abundances were found, the number of marked fish captured would likely have been considerably greater. In addition, the median date of passage for yearling chinook salmon and steelhead in the Columbia River estuary at River Kilometer (RKm) 75 (upper estuary sampling station, Jones Beach) was 11 May and the average travel time between Jones Beach and rkm 16 (lower estuary sampling station) was 2 days. Thus entry of the median fish of these two species into the ocean was probably prior to 15 May. As Cruise 1 was not begun until the end of May, many of the marked fish of these species may already have moved out of the sampling area. On the basis of the distribution found for steelhead, this would seem to be a particularly strong possibility.

Approximately 1.7 million marked coho salmon were released into the Columbia River in 1980, and of these, approximately 35% were released from the Washougal Hatchery. The marked Washougal Hatchery fish were from Cowlitz Hatchery (WDF) stock fish. They were captured over the entire sampling area and their marks accounted for 58% of the total marked fish recaptures. This greater proportion of marks recaptured from one hatchery and the distribution found may relate to a behavioral characteristic of the Cowlitz Hatchery stock. The largest catches in the ocean fishery of adult coho salmon of Columbia River origin have been off northern California to southern Oregon. The exception to this has been adult coho salmon of late run Cowlitz Hatchery stock. The adult tag returns from the ocean fishery for these fish have indicated their distribution to be primarily in the area between Tillamook Bay, Oregon, and Grays Harbor, Washington (R. Lincoln, Washington Dept. of Fisheries (WDF), Olympia, Washington, personal communication).

Migration Patterns and Growth

A northerly migration of steelhead from the Columbia River was readily apparent from the catch distribution and direction of seine set. In addition, these fish were caught slightly farther offshore than the chinook and coho salmon. During the intensive sampling for juvenile salmonids between 1960 and 1969, Hartt et al. (1966, 1967a, 1967b, 1970, and 1972) found considerably fewer steelhead than salmon in the nearshore areas. Further evidence of an offshore and northerly migration has been provided by recaptures of two marked juvenile steelhead. On 14 July 1980, a marked steelhead released on the Pahsimeroi River, Idaho, between 7 and 17 April 1980, was recovered 1,050 km west of the Queen Charlotte Islands in the Gulf of Alaska by a Japanese research vessel (W. Pearcy, Oregon State University, Corvallis, Oregon, personal communication). This was a distance of 1,700 km from the Columbia River mouth. Also a steelhead marked off Kodiak Island, Alaska, in September 1958 was caught by a sportsman in the Alsea River in southern Oregon 17 months later (Hartt 1980). These two tag recoveries indicated extensive migration of steelhead from the Columbia River and Oregon.

A northerly migration was also indicated for spring chinook salmon. Marked spring chinook salmon of Columbia River origin were caught only on south-facing seine sets, were found almost exclusively from the Columbia River mouth to the north, and were captured only on Cruise 1. Additional evidence for a northerly migration has been that in all marking off the Washington coast by the WDF of small chinook salmon that have spent only one winter in the ocean, none have returned to hatcheries as spring chinook salmon (R. Lincoln, WDF, Olympia, Washington, personal communication). If all spring chinook salmon migrated north, then the average length of the chinook salmon found on Cruise 3 represented the size attained by subyearlings in 5 to 6 months. One 271-mm marked fall chinook salmon (subyearling) was captured on 31 August 1980. It was from a group with an average length of 80-90 mm at release on 1 June 1980, indicating a potential for growth of 1.9 mm per day. This was considerably higher than the 1.32 mm/day growth found by Healey (1980) in small (44-115 mm) chinook salmon from the Nanaimo, Vancouver Island, estuary. Comparatively few small chinook salmon (<130 mm) were found in the sampling area as contrasted to the large catches (6,669) in shallow (less than 9 m) nearshore waters during NMFS purse seining operations from 1978 to 1980 (Dawley et al. 1981). In the shallow waters, the small chinook salmon accounted for 99% of the catch. As few small chinook salmon (<130 mm) were found in the deeper waters (>30 m) and less than 1% of total salmonid catch in shallow (<9 m) waters were greater than 130 mm, it appears that movement of fish into the sampling area was dependent upon size.

The decline in coho salmon abundance on Cruise 2 may have been related to migration. Hartt (1980) tagged a large number of juvenile coho salmon in July and August off the coast of Vancouver Island and southeastern Alaska. Many returned to the Columbia River as adults. Many adult coho salmon from the Columbia River, as previously discussed, are caught in the southern Oregon and northern California fisheries. In addition, migration out of the study area by the early stocks reaching the ocean and replacement by others would account for the apparent lack of growth of coho salmon between Cruise 1 and 2. This apparent lack of growth was also reported for coho salmon in British Columbia by Phillips and Barraclough (1978). They found a relatively small increase in mean lengths between May and July, with June coho salmon often smaller than those of the other two months. There was no discussion of possible reasons for the apparent lack of growth.

Although migration out of the sampling area was likely the prime factor affecting the abundance of salmonids on Cruise 2, a contributing factor in the lower catches may have been related to water temperatures. During sampling for juvenile coho salmon in the North Pacific Ocean, Godfrey et al. (1975) caught the largest number of fish in waters between 8° and 12°C (range 3°-16°C). Surface water temperatures on Cruise 2 averaged 15.2°C (T3) which was above those normally associated with salmonids. Some juveniles may have resided deeper in the water column to avoid the warmer water and thus were not as susceptible to the purse seine as those closer to the surface.

Results of the 1980 cruises are promising. General distribution patterns of juvenile salmonids were defined and mark recaptures provided indications of migration by various stocks of fish. More intensive sampling in areas and at times when fish are most abundant will be necessary to ascertain whether or not enough marked fish can be recaptured to determine relative differences in survival to the ocean between stocks of fish.

Acknowledgements

This study was funded by the Pacific Northwest Regional Commission and to National Marine Fisheries Service.

Particular thanks 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 ocean.

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