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AFS 65 NEHALEM RIVER WINTER STEELHEAD STUDY

FINAL REPORT

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Prepared By: Walter Weber
Warren Knispel

Oregon Department of Fish and Wildlife
506 Mill Street, Portland, Oregon

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INTRODUCTION

The Nehalem and North Fork Nehalem rivers are the major tributaries of Nehalem Bay, an estuary on Oregon's north coast (Fig 1). The winter steelhead (*Salmo gairdneri*) and related fisheries of both streams have been the object of a study which began in 1972. Some data from creel surveys were available for the 1970-71 and 1971-72 steelhead seasons and have been used where appropriate.

The study was prompted by the apparent failure of hatchery-reared steelhead smolts to contribute in the Nehalem River sport catch at the rate similar to that observed on other coastal streams. There was also concern regarding the status of wild winter steelhead in the Nehalem River.

We did not feel that there were any particular problems with the fishery on the North Fork, but included it in the study because the steelhead catch card analysis had historically combined the catches from the two streams. We felt it desirable to compare our catch estimates with those obtained from catch card analysis. As it turned out, the fishery on the North Fork served an informative role as a control study stream.

Initial study objectives included the following:

1. Determine the total catch and angler effort.
2. Determine contribution of hatchery fish to catch and escapement.
3. Identify factors limiting contribution of hatchery fish.
4. Determine optimum time and release sites for hatchery smolts for the best return to the angler.
5. Determine the winter steelhead hatchery stock best suited for use in a fishery enhancement program.

As the study developed, obtaining life-history data on wild steelhead in the Nehalem River also became an important objective.

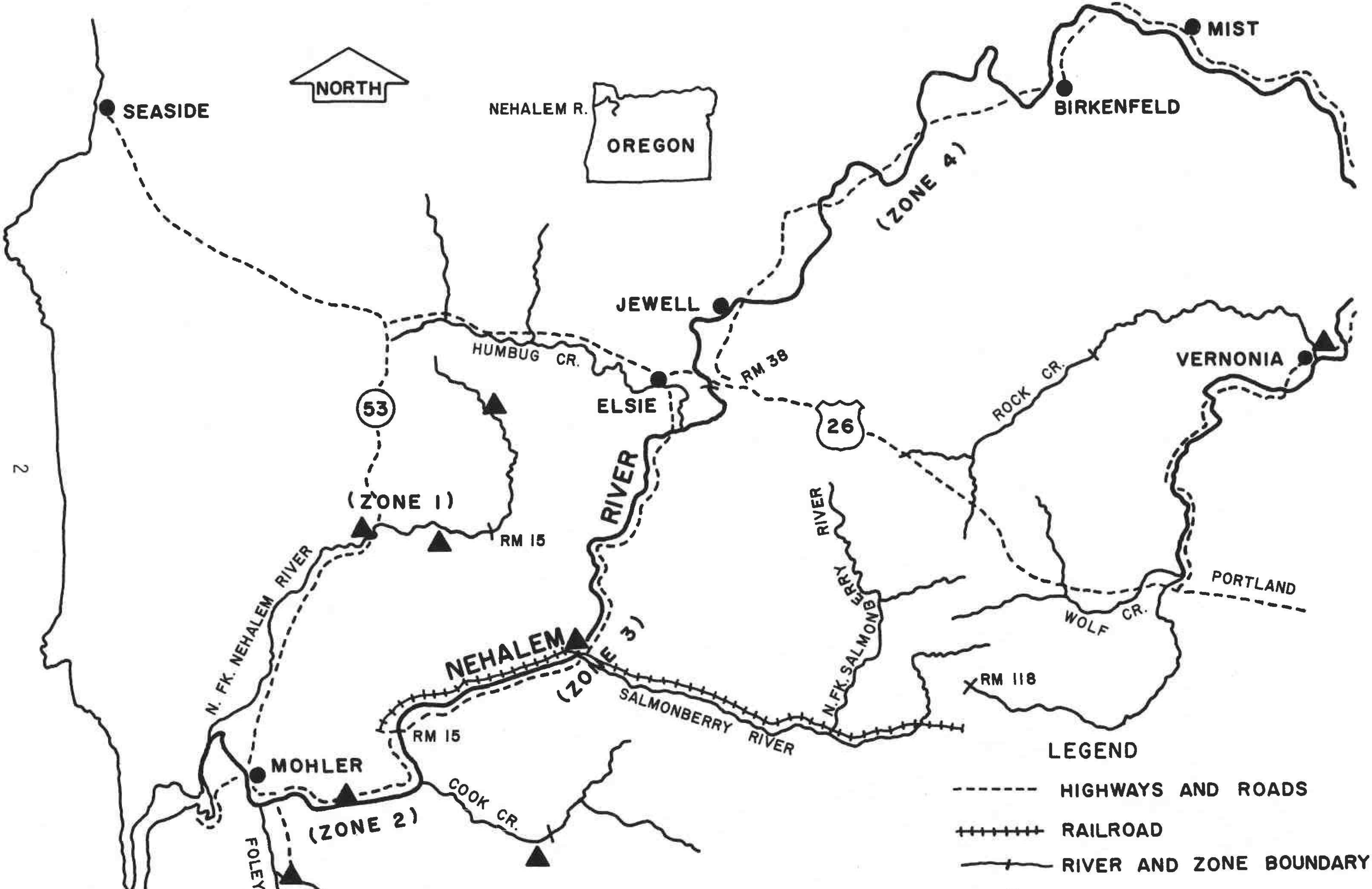

FIG. I. MAP OF NEHALEM RIVER SYSTEM
SCALE = 1" = 4 MILES

STUDY AREAS

Nehalem River

Physical Features

The watershed

The Nehalem is one of the longest rivers in Oregon, with a length of approximately 120 mi. It originates on the east side of the coast range, circles around the northern tip of the mountains before heading in a southwesterly direction towards the ocean. The drainage area contains over 700 mi a/ of streams. A general description follows:

River mile (RM)	Watershed type	Stream gradient
0-7	Pasture	Tidewater
7-39	Second growth forest	Moderate to steep
39-100	Pasture in flood plain; surrounding hills in second growth forest	Low
100-120	Second growth forest	Moderate

Over 60 tributaries drain the watershed. Their basins are mostly in second growth forest. Major tributaries are listed below:

Point of Entry into Nehalem River (RM)	Tributary
7	Foley Creek
13	Cook Creek
22	Salmonberry River
35	Humbug Creek
90	Rock Creek

a/ Metric equivalents to measurements used in this report are presented in Appendix A.

Much of the Nehalem watershed was burned in the 1933 "Tillamook Burn" fire (Kemp 1967). The Salmonberry River, Cook, Humbug, and Rock Creek drainages were extensively damaged as was the main stem from RM 12-42. Kemp also reported that a 1945 fire again damaged the Cook Creek and Salmonberry River basins. The heat, ash fall, and subsequent siltation undoubtedly had a serious impact on aquatic life. A long-time resident on the Salmonberry River described dead juvenile salmonids and adult chinook salmon following the 1933 fire (personal communication, Charley Johnson). The Trask and Wilson rivers, just south of the Nehalem, were more extensively damaged than the Nehalem in 1933 and 1945, and were also hit by a 1939 fire. We mention these streams, both presently hosting good winter steelhead runs, only to illustrate that apparently fire damage is not a current factor adversely affecting steelhead runs in the Nehalem River.

The forested portion of the Nehalem watershed is in better condition now than at any time since the 1939 fire, although some of the south slopes in the Cook Creek and Salmonberry River basins have never regained a forest cover.

Flows

A flow gauging station operated by the United States Geological Survey (U.S.G.S.) is located at RM 13.5. Table 1 presents average monthly flows for water years 1971-75. Maximum flows generally occurred in December or January and minimums in August or September. Extreme low summer flows rarely dropped below 50 cfs. Summer flows at RM 35.5 averaged about 60% of those at the gauge while those at RM 90.5 commonly were below 5 cfs and may have dropped below 2 cfs.

Water quality

Turbid water conditions adversely affect angling opportunities in the Nehalem River during much of the steelhead season. The more efficient drift fisherman is excluded at least 50% of the time by turbid water. Much of this time falls within the peak angling period in December and January. Once the stream becomes muddy it takes 4-6 days to clear sufficiently to allow participation by drift fishermen. Tributary streams open to angling are not seriously affected by turbidity.

Pollution sources are difficult to pinpoint but generally arise from the watershed between RM 40-100. A number of tributaries are contributors as is stream bank erosion along the main river. The dominant soil type is an erodable material known as Nehalem silt loam (U.S. Soil Conservation Service 1956). This soil type has a tendency to weep and slump when present in stream bank formations and stabilization is difficult.

Table 1. Mean monthly flows of the Nehalem River at RM 13.5, 1971-75.

Month	Flow (cfs) /a
January	9,940
February	5,052
March	6,023
April	3,006
May	1,149
June	519
July	260
August	135
September	231
October	582
November	4,107
December	8,348

/a Represents the 4-year average of the mean monthly flow as published in Water Resources Data for Oregon, U.S. Geological Survey (1971-75).

the main stem below RM 90 experiences summer water approaching 80 F, and 70 F temperatures are common. Warm air temperatures, low stream velocity and an exposed streambed are the contributing factors, particularly in the upper Nehalem Valley (RM 40-90). Tributary temperatures are considerably lower and seldom exceed 70 F.

Biological Features

Native fish fauna

Winter steelhead, cutthroat trout (Salmo clarki) and coho salmon (Oncorhynchus kisutch) are found distributed throughout the system. Fall chinook salmon (O. tshawytscha) are known to spawn up to about RM 42 but were reported spawning up as far as RM 105 in the 1930's (unpublished data, Oregon Department of Fish and Wildlife). A run of summer chinook was formerly abundant in July near the mouth of the Salmonberry River (personal communication, Charley Johnson). The "Tillamook Burn" fires possibly led to the demise of this run. Chum salmon (O. keta) are found up to RM 13 but are primarily confined to Foley Creek (RM 7).

The pacific lamprey (Lampetra tridentata) is abundant and the brook lamprey (Lampetra planeri) is present in unknown numbers. Sculpins (Cottid sp.) are common. An unusual Oregon coastal stream resident is the largescale sucker (Catostomus macrocheilus) which is found throughout the system. This fish is a common Willamette Valley species and its presence in the Nehalem may be related to this stream's point of origin (east side of coast range); the possibility of an introduction also exists.

Releases of hatchery fish

Releases of hatchery fish have been used to supplement native populations of cutthroat and winter steelhead trout. All of the salmon species are essentially wild since the closure of Foley Creek Hatchery in 1966.

The hatchery began operations in 1926 and was capable of raising 300,000 coho smolts (Oregon Fish Commission 1961). Limited numbers of chinook salmon were reared up to the early 1950's, and intermittent releases of steelhead were made between 1935 and 1961 (Oregon Fish Commission 1961).

Coho smolts and surplus adults from the North Nehalem stock were released in 1976 and 1977. Siletz River summer steelhead smolts were released in the Salmonberry River in 1966 and 1967, but few, if any, adult fish returned.

Cutthroat trout originating from the Alsea River have been released since, at least, the late 1940's to provide a spring trout fishery and to supplement the fall sea-run fishery. Annual releases in recent years varied from 11,000 to 16,000 legal-sized, 8- to 11-inch fish.

The Nehalem was one of the last major coastal streams to receive hatchery steelhead, and it was not until 1964 that a consistent stocking program began. Releases of steelhead smolts from 1964-77 are summarized in Table 2. Numbers releases ranged from 15,900 to 137,000. Prior to 1976

Table 2. Releases of winter steelhead smolts in the Nehalem and North Fork Nehalem rivers, 1964-77. /a

Year	Nehalem River /b	North Fork Nehelem /d
1964	50,900	14,000 /e
1965	71,900	10,000 /e
1966	76,900	10,100 /e
1967	50,500	41,400 /f
1968	100,100	34,700
1969	105,000	16,500
1970	137,000	43,400
1971	135,000	44,500
1972	116,800	42,700
1973	110,200	61,900
1974	104,500	22,700 /e
1975	75,000	54,500
1976	15,900 /c	39,800 /c
1977	115,900 /c	47,000 /c

/a Smolts were released in earlier years but on a limited and discontinuous basis.
/b Essentially all the smolts were Alsea River stock reared at Cedar Creek Hatchery, except for those released in 1976 and 1977.
/c Reared from eggs taken at North Nehalem Hatchery.
/d Reared from eggs taken at Big Creek Hatchery (Lower Columbia River) except as noted.
/e Alsea stock reared at Cedar Creek Hatchery.
/f 10,000 of the fish were as in /e, remainder as in /d.

all originated from Alsea River stock and nearly all were reared at Cedar Creek Hatchery. The Alsea Hatchery is located on the North Fork of the Alsea River and Cedar Creek Hatchery is on a tributary of the Nestucca River. The Alsea and Nestucca rivers are Oregon coastal streams entering the Pacific Ocean approximately 87 and 39 miles south of the Nehalem River, respectively. Liberations since 1975 were North Nehalem stock reared at the North Nehalem Hatchery.

Some earlier steelhead releases were made from the Foley Creek Hatchery between 1935 and 1961. Liberations from 1935-42 ranged from 10,000 to 249,000 fry. After 1942, 10,000 to 20,000 steelhead were stocked on an intermittent basis and, except for fingerlings stocked in 1960 and 1961, were fry (Oregon Fish Commission 1961). Most originated from the Nehalem River reared from eggs taken at Foley Creek. Because of their small size, it is doubtful if the fry survived in substantial numbers.

The Fishery

History of the winter steelhead fishery

Little information about the winter steelhead fishery is available prior to 1952. A number of "old-time" anglers of the Nehalem River were interviewed in an attempt to document the historical fishery. We recognized the pitfalls with this type of data, but in some cases it was the only information available. The interviewees were at times in conflict with each other, but most concluded that the period from 1971-72 through 1975-76 provided the worst steelhead angling in their memories. Several anglers reported excellent fishing between 1920 and 1940 despite a severely damaged watershed. One angler stated that he and a partner took 23 steelhead in 4 hours at RM 8 in 1938. Angling was reportedly good in the 1940's but declined in the 1950's although several fishermen noted increased success when commercial netting in the estuary ended in 1956.

The nets would take about 300 steelhead per year in November with the range being from 40-600. Except for the early season fishery it is doubtful that the commercial catch of steelhead had much impact on the sport fishery.

The Nehalem River was described in 1955 by Pacific Northwest Steelhead magazine as near the top of Oregon's 10 best steelhead streams. Several anglers reported an upsurge in fishing success in the 1960's while others thought the 1960's marked the beginning of a gradual decline.

Data from creel surveys preceding our study are available back to the 1952-53 season and are summarized in Tables 3 and 4. A long-term gradual decline is not indicated by the data. Average catch rate (hours per fish) was 28 during the period 1952-53 to 1960-61 and 17.7 from 1961-62 to 1969-70. The catch rate from the latter period was increased somewhat by the inclusion of information from a rather successful guide.

Table 3. Catch rates for winter steelhead on the Nehalem River, 1952-53 through 1960-61. /a

Year	Sample period	Sample size (fish)	Catch rate (hours/fish)	Comments
1952-53	Entire season	68	46.0	
1953-54	Nov-Feb	132	28.2	Boats took fish at rate of 9.5 h/fish
1954-55	Nov-Feb	191	31.2	
1955-56	Nov-Feb	205	15.6	
1956-57	Nov-Feb	97	31.6	
1957-58	Entire season	136	25.6	
1958-59	" "	167	23.6	Sample biased toward March fishery
1959-60	" "	115	21.3	
1960-61	" "	59	29.1	
Average			28.0	

/a From Fishery Reports, Oregon Game Commission, 1953-61.

Table 4. Catch rates for winter steelhead on the Nehalem River, 1961-62 through 1969-70. /a

Year	Sample period	Sample size (fish)	Catch rate (hours/fish)	Comments
1961-62	Entire season	266	15.9 (7.5) /b	27% of effort by boat guides
1962-63	" "	190	34.7 (9.2)	21% " " " " guides
1963-64	" "	115	21.3 (9.2)	12% " " " " guides
1964-65	" "	111	33.7 (6.7)	15% " " " " guides
1965-66	Dec-Mar	185	11.0 (4.1)	13% " " " " guides
1966-67	Dec-Mar	99	14.6 (9.4)	27% " " " " guides
1967-68	Dec-Mar	115	8.9 (4.7)	13% " " " " guides
1968-69	Entire season	162	8.7 (6.4)	29% " " " " guides
1969-70	Dec-Mar	134	10.7 (6.9)	24% " " " " guides
Average			17.7 (7.1)	

/a From Fishery Reports, Oregon Game Commission, 1962-70.
/b Figures in parentheses represent catch rate for fishermen in guided boats which are included in the total.

The above data were based on an intensive sampling effort that generally covered the entire steelhead season. Creel survey effort was selective and presumably the more favorable days were sampled; thus, these data may have a bias toward the more successful trips. Catch card data goes back to 1953 (Table 5) but the catch of steelhead from the North Fork Nehalem and Nehalem rivers were combined until 1973; as a result data analysis is difficult. Generally, North Fork Nehalem steelhead catches and angler interest have sharply increased since initiation of an extensive stocking program in 1967 (Table 2).

Nehalem River angling pressure has remained stable or perhaps decreased slightly in the last 20 yrs. A car count on a weekend day in mid-January 1958 recorded 164 vehicles. Peak counts in recent years seldom exceed 80 vehicles although a 1970-71 count totaled 126. The decline in angler use runs contrary to the greatly increased pressure observed on other coastal steelhead fisheries and Oregon salmon and steelhead fisheries generally in Oregon. Salmon and steelhead catch card sales have increased from 135,230 in 1958 (Oregon Game Commission 1959) to 406,542 in 1976 (Oregon Department of Fish and Wildlife 1977). The reduced angler interest in the Nehalem River is due to better angling success on other coastal streams, in some situations the result of hatchery programs. The intensive stocking programs on most coastal streams were initiated in the late 1960's.

Description of the fishery

The present as well as the historical steelhead fishery is primarily limited to RM 7-22. Over 95% of the angling pressure and catch occurs in this area. Anglers concentrate at several popular still fishing sites between RM 7 and RM 13 and at the mouth of the Salmonberry River (RM 22). The clear Salmonberry River allows the drift fishermen to participate even when the Nehalem is turbid.

Still fishing consists of casting a bait or lure into the water and waiting for an upstream migrating fish to take it (Fig. 2). Drift fishermen cast to selected areas and allow the current to drift their offering to a fish. The drift fisherman is normally more successful.

A number of trophy-sized steelhead over 18 lb. are taken each season. Most are caught below RM 22 or in the Salmonberry River.

Generally, poor success above RM 22 discourages angler use. From RM 35-85 brushy stream banks and poorly defined holding water further limit angler participation (Fig. 3). Although the stream is open its entire length and its fishability improves above RM 90 (Fig. 4) there is little effort above that point, again, probably because of poor success.

Drift-boat use is confined to the stream section between the head of tidewater (RM 7) and RM 14. As many as 24 boats a day have been observed in this section. From RM 14-22 dangerous boating water and poor vehicle access preclude the use of drift boats. A minor boat fishery (maximum 3 boats per day) exists near Vernonia (RM 90) but the remainder of the stream is ignored by the boat angler.

Table 5. Catch card summaries of steelhead catches from the Salmonberry, Nehalem, and North Fork Nehalem rivers, 1953-76.

	Catches /a				
Year	Salmonberry R.	Nehalem /b	Subtotal /b	N.Fk. Nehalem /b	Total
1953	290	3,804	-	-	4,094
1954	77	2,411	-	-	2,488
1955	556	3,221	-	-	3,777
1956	142	3,605	-	-	3,747
1957	64	2,274	-	-	2,338
1958	106	4,597	-	-	4,703
1959	153	3,955	-	-	4,108
1960	192	3,915	-	-	4,107
1961	354	3,849	-	-	4,203
1962	180	3,832	-	-	4,012
1963	90	3,552	-	-	3,642
1964	201	3,482	-	-	3,683
1965	71	2,731	-	-	2,802
1966	144	3,907	-	-	4,051
1967	196	2,806	-	-	3,002
1968	253	3,877	-	-	4,130
1969	134	3,929	-	-	4,063
1970	302	5,971	-	-	6,273
1971	364	4,633	-	-	4,997
1972	151	3,559	-	-	3,710
1973	117	3,161	3,278	2,959	6,237
1974	153	4,245	/c (915)/d	/c (2,036)/d	4,398 (2951)/d
1975	92	1,970	2,062 (1300)/d	3,249	5,311
1976	67	985	1,052	1,332	2,384

/a Corrected for nonresponse bias.
/b Nehalem and North Fork Nehalem catches not separated until 1973.
/c No separation in 1974 because of programming error.
/d Figures in parentheses are estimates determined by statistical creel surveys.

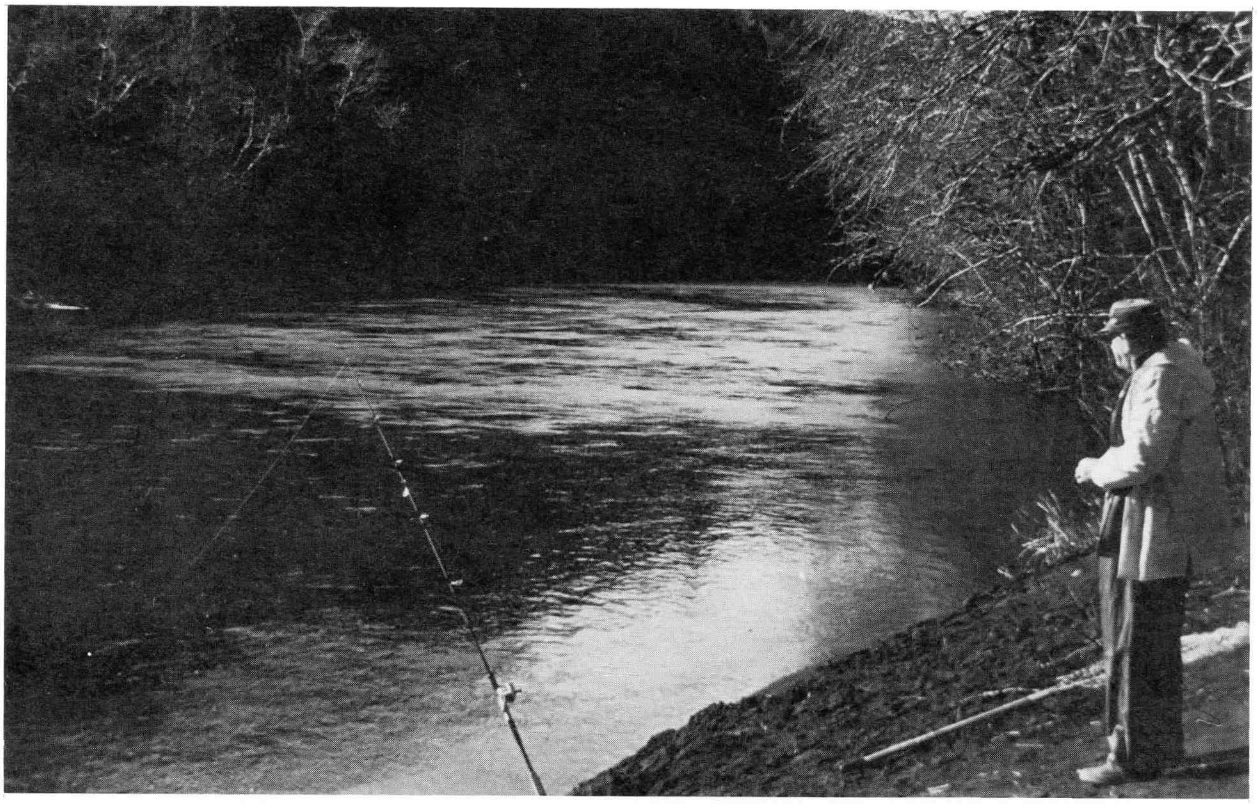

Fig. 2. Still fisherman on lower Nehalem River.

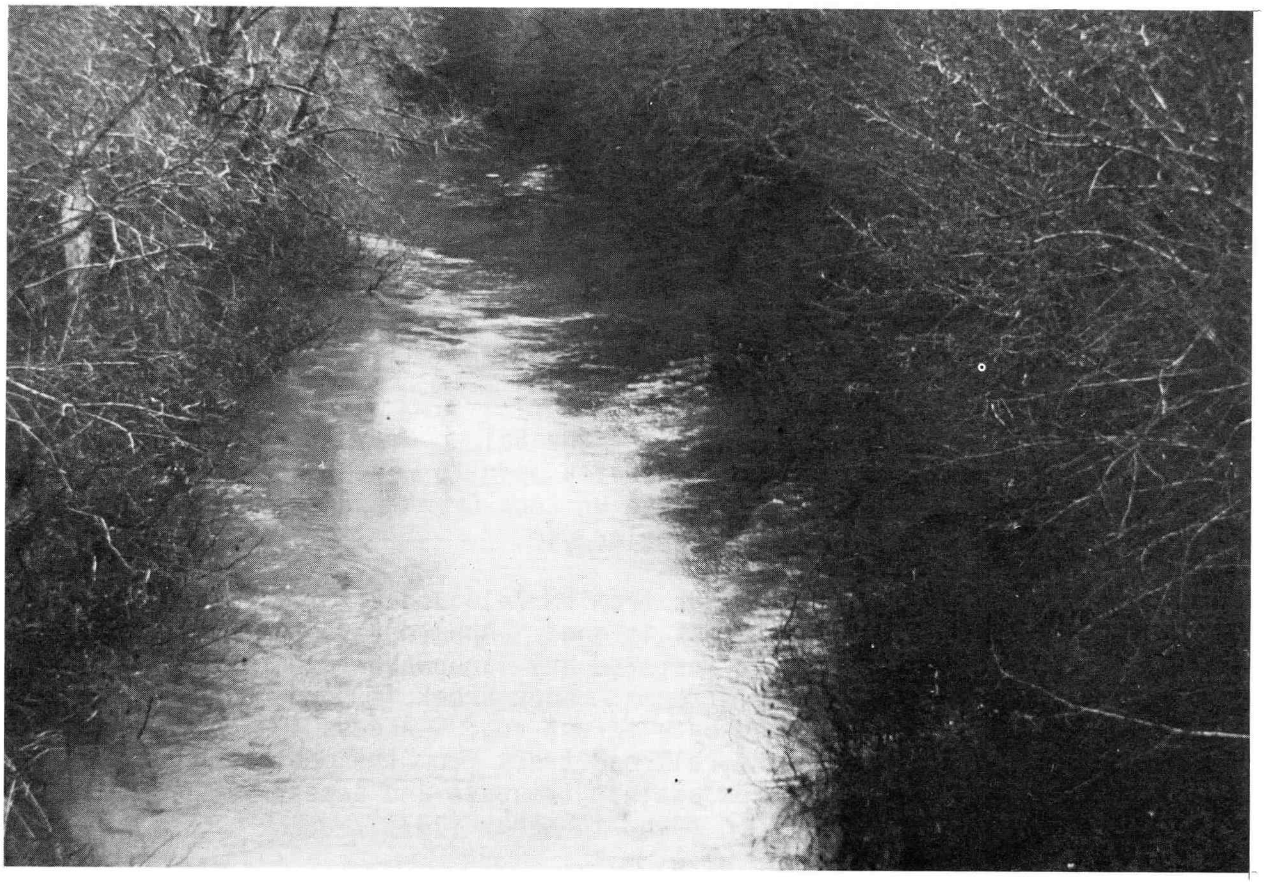

Fig. 3. Brushy stream bank - poor holding water.

Fig. 4. Character of stream showing more defined holding water.

The lower 5 mi of Cook Creek, all of the Salmonberry River, and the lower 15 mi of Rock Creek are presently open to winter steelhead angling. Angling effort is light to moderate on Cook Creek and the Salmonberry, but Rock Creek receives little angler use.

Although much of the stream bank from RM 7-14 and RM 32-112 is privately owned pastureland, angler access is good. Apparently, the relatively low angling pressure has not fostered any landowner-fisherman conflicts found on many other coastal streams. Cook Creek is bordered by state timberland and is paralleled by a forest road. Access to the Salmonberry is limited to walking up the railroad track from the mouth. Portions of Rock Creek are heavily posted against trespass and access may be limited. More details on access can be found in Weber (1971).

North Fork Nehalem River

Physical Features

The watershed

The stream originates about 12 miles east of the Pacific Ocean and flows 24 miles before entering the Nehalem River estuary at RM 3 (Fig. 1). The drainage area covers an estimated 90 square miles. The watershed can be generally classified as follows:

RM	Watershed type	Stream gradient
0-5	Pasture	Tidewater
5-15	Second growth forest	Steep
15-24	Second growth forest	Moderate to steep

The watershed is in good condition, although logging has been and will continue to be a major activity. Adverse effects are expected to be minimal. The "Tillamook Burn" of 1933 had only a limited effect on this basin (Kemp 1967).

Fifteen tributaries drain this system. Soapstone Creek (RM 10.5) and Little North Fork (RM 20) are the two largest.

Flows

There is no flow monitoring station on this stream. Sample measurements from RM 7 indicate that extreme low summer flows may drop below 15 cfs (Thompson and Fortune 1968). Peak discharge generally occurs in December or January.

Water quality

Prolonged periods of turbidity and high temperatures are not a problem. The stream clears rapidly, usually within 2 days, following a major freshet. Stream temperatures are recorded continuously at the North Nehalem Hatchery (RM 10) and seldom exceed 70 F (personal communication, Bill Nealeigh).

Biological Features

Native fish fauna

The fish fauna is similar to that found in the Nehalem River. Winter steelhead, cutthroat trout, and coho salmon are distributed throughout the system. Fall chinook salmon spawn in the main stem and in Soapstone (RM 10.5) and Gods Valley creeks (RM 13.5). Chum salmon are confined to the main stem up to RM 7 and in tributaries below that point. Cottids, lampreys and the largescale sucker are present.

Releases of hatchery fish

The North Nehalem Hatchery, completed in 1966, replaced the Foley Creek Hatchery. This station raises coho and chinook salmon along with winter steelhead.

Coho and chinook salmon reared at the Foley Creek Hatchery had been stocked since 1930 (Oregon Fish Commission 1961). Since 1966, releases have averaged about one million coho and 200,000 fall chinook smolts. No chinook were liberated in the 1972-74 period.

An annual steelhead stocking program began in 1964 and numbers released have ranged from 10,000 to 62,000 (Table 2). Alsea stock were used for 1964-66 smolt releases. In 1967, about 25% were Alsea fish and the remainder were reared at the North Nehalem station from eggs obtained at Big Creek Hatchery (lower Columbia River). Big Creek eggs continued to be used from 1968-75 except in 1974 when Alsea smolts were substituted. The 1976 smolts were the first release from eggs taken (early January 1975) at the North Nehalem Hatchery. This process was repeated in 1977 with the 1976 brood fish. Both the 1975 and 1976 broods were selected by size to exclude any of the 1973 brood Alsea stock. Scale readings from 86 steelhead entering the North Nehalem trap in 1977 indicated that the size criteria (we used 28 inches for female and 29 inches for males) accurately distinguished between 1+/2 and 1+/3 age fish (1+/2 = 1 fresh-water annulus and 2 summers at sea). All but one fish were hatchery reared. The scales were read by Nancy Peterson, Research and Development Section, Oregon Department of Fish and Wildlife.

Sea-run cutthroat trout originating from the Alsea River stock, and reared at Cedar Creek Hatchery, were released starting prior to the 1950's with recent annual average numbers at 3,500 fish. Liberations usually were in late May and again in June. The seasons for stocking were similar to those for the Nehalem River cutthroat program.

The Fishery

History of the winter steelhead fishery

Little background information is available prior to 1955. Limited creel data indicated an average catch rate of 15 hours per fish during the seasons from 1955-56 through 1964-65. The range was 9.3 h (1964-65) to 23+ h (1962-64).

Catch rates showed an improvement with the first returns from the stocking program in 1965-66. The average rate during the period 1965-66 through 1969-70 was 9.7 h per fish and ranged from 7.2 h (1968-69) to 11.9 h (1965-66).

Angling pressure has greatly increased since the 1950's. The hatchery program since 1966 has been a factor in attracting more anglers.

Description of the fishery

Virtually all the winter steelhead angling is by bank-drift fishermen. Drift-boat use is limited by dangerous water conditions and little still fishing is done. The fishery is concentrated in the vicinity of the hatchery and 3 miles of river above that point. On a peak weekend day up to 70 vehicles can be counted within ¼ mile of the hatchery. Private lands and lack of road access reduce angling opportunities below the hatchery. Above the hatchery, a logging road closely parallels the stream for much of its length up to RM 17. In 1977, the winter deadline was extended from RM 15.5 to 19; and this along with replacement of a bridge at RM 14 should provide increased angling opportunities in the upper river.

METHODS

Creel Surveys

Intensive creel surveys and angling pressure estimates were part of each year's program. The size of the study area made it necessary to divide it into four zones:

Zone 1 - North Fork Nehalem River, RM 0 to angling deadline at RM 15.5.
Zone 2 - Nehalem River, (RM 0-15) including open area of Cook Creek (RM 0-5).
Zone 3 - Nehalem River, (RM 15-38) including the Salmonberry River.
Zone 4 - Nehalem River, RM 38-118 including open area of Rock Creek (RM 0-15).

Angler surveys began November 16 and continued until the close of the winter fishing season March 31. An average of 3 days/wk were selected for sampling. Sample days were selected according to a stratified random sampling scheme. A typical day included vehicle counts in two zones and a creel check in a single zone.

Angling effort was measured by counting vehicles at 10 a.m. except in Zone 1 where anglers were more mobile and counts were made at 9 and 11 a.m. Only the new arrivals were recorded in the latter count. The tally was obtained by driving through each zone and recording license numbers. In a few places, where vehicles could not be seen from the road, an adjustment was made based on subsequent interviews with anglers that had been in those locations. We are satisfied that any resulting error was minor.

Daily angler effort estimates were made by zone on the main river at 10 a.m. and at 9 a.m. and 11 a.m. on the North Fork based on predicted river conditions, and angler success and effort observed the previous day (Fig. 1). Estimates were based on the same time frame as the counts. An automatic water level recording device activated by telephone provided Nehalem River water level information from the gauging station, and was useful in predicting water condition.

In those years when no statistical analyses of the data were made, pressure estimates were adjusted based on information obtained after the prediction was established. Statistical analysis procedures did not permit this choice. For example, if on Tuesday, a nonsurvey day, we estimated 20 vehicles and a count of 40 vehicles was made on Wednesday, we would adjust the Tuesday figure to 40 assuming that angling conditions, etc., were similar between the 2 days. Information obtained from anglers who had fished on the river the day before was also used as a basis for adjustments.

Creel survey efforts were concentrated in the preselected zone but data from other zones were included if collected in a random manner. Anglers that had completed their trip as well as incomplete anglers were interviewed. The two types were separated on the data forms.

A single roadside check station, situated so that a high percentage of departing fishermen would pass by, was set up after vehicle counts were completed. Explanatory notices describing the check station operation were placed on anglers' vehicles, and signs at the check station requested all anglers to stop.

License numbers of stopped vehicles were checked against the car count list to determine if they had previously been tabulated. For those that were not an inquiry established whether we had missed the vehicle or if it had arrived after the count. These late arrivals were segregated in the creel survey data for subsequent adjustment. The license number was also used as a check to see if some anglers were not stopping at the check station. In some instances such was the case and where possible these were flagged down. It was impossible to locate our check stations at a spot that required all anglers to pass when completed angling. If our car count indicated a number of vehicles in locations that would make it unlikely for them to pass the check station an attempt was made to interview them at streamside. Obviously, some anglers were not included in our creel survey program because of deliberately not stopping or because their travel route did not take them past the station; but we do not feel that such omissions had a significant effect on the validity of the creel data.

Anglers were also interviewed at roadside when encountered. On low pressure days, streamside angler surveys were the most practical method. On such days an attempt was made to contact all anglers, not just those at popular or easily accessible locations.

Exceptions to the general sampling design were as follows:

<u>1972-73</u>

(1) Zone 4 was not included in the program due to low angling pressure.
(2) Only 1 car count (10 a.m.) was made in Zone 1.
(3) Only completed anglers were interviewed.

<u>1973-74</u>

(1) March was eliminated from the Zone 1 sample program because of low angler use.
(2) Daily vehicle counts by a local resident in Zone 3 were used as partial pressure estimates in that zone. This provided a more accurate effort predication.

1974-75

(1) Zone 1 was excluded from the program in order to obtain better data on the Nehalem River.
(2) Zone 4 was excluded.
(3) Use of the local residents' vehicle count continued in Zone 3.

1975-76

(1) Zone 1 included to evaluate returns of marked steelhead originating from Alsea River stock.
(2) Zone 4 was again excluded.
(3) The local residents' Zone 3 car count information was available only through December.

Supplemental data were obtained during the 1970-71 and 1971-72 winter fishing seasons using a sampling program similar to the 1972-73 plan except that Zone 4 was included in 1970-71 and two Zone 1 car counts were made in 1971-72.

Creel data for the 1970-71, 1972-73, and 1975-76 seasons were statistically analyzed and an estimate of the catch (95% confidence limits) was calculated. This was accomplished by the Statistical Section of the former Oregon Game Commission under the direction of Warren Aney in 1970-71 and 1972-73, and in 1975-76 by the Biometrics Section of the Oregon Department of Fish and Wildlife by Russ Wayland and Ken Hall. Details of statistical models and techniques are included in the unpublished reports.

Work load did not permit statistical data interpretation in 1971-72, 1973-74, and 1974-75. In those years total angling effort was simply a summation of daily vehicle counts or estimates adjusted for late arriving anglers. The late arrival adjustment was calculated as shown in Appendix B. Adjusted total effort (Ea) was calculated for each two-week period and then multiplied by the periods observed--catch rate per vehicle--to produce an estimated catch. The catches by period that were totaled produced an estimate of the total catch (C).

An additional adjustment to C was made to reflect the inclusion of incomplete anglers in our creel data. This calculation is shown in Appendix B.

In 2 years, 1970-71 and 1975-76, where catch calculations were statistically made, we also estimated catch. Our figures were within the 95 confidence level of the statistical data.

Life-History Studies

Scale samples and length/weight data were obtained throughout the study from over 300 wild adult steelhead taken from the Nehalem River system, exclusive of the North Fork Nehalem. Scales were read by Fran Sumner and Nancy Peterson.

Nearly 1,200 angler-caught, hatchery and wild steelhead from the North Fork Nehalem and Nehalem River systems were classified as to sex. Jaw morphology distinguished males from females except for "jacks". The latter were generally sexed by visual inspection of the gonads. Selected anglers were issued logbooks which provided us with considerable information from the Nehalem River. Hatchery personnel at the North Nehalem Hatchery provided similar information on 1975-76 catches from the North Fork Nehalem. This was included along with observations made during creel surveys. Samples were obtained throughout the angling season and included only "prime" fish, as anglers tend to retain spent or ripe females and release males in a similar condition.

Rearing Area Surveys

The entire length of the main stem Nehalem, all of the major tributaries, and virtually all of those having any potential as summer rearing areas were sampled for juvenile steelhead. Objectives were to (1) locate important rearing areas, (2) identify characteristics of such, and (3) evaluate the rearing capacity of the system. The number of yearling (1+) steelhead captured or observed was used as a quantitative measure of rearing use. This standard was selected because we felt that a major limitation to Nehalem River steelhead production was the stream area capable of rearing steelhead to smolt size. The yearling fish, as opposed to 0+ fish, were also simpler to count, catch, and distinguish from similar-sized cutthroat trout (Fig. 10).

The sampling was done during the summer-fall low flow period. Such flows facilitated the inventory process, and streams not rearing 1+ steelhead during this critical time are assumed to contribute little to overall steelhead production.

Sampling techniques included snorkeling, electroshocking, seining, and angling.

Snorkel and mask were used in the main stem and larger tributaries. Poor visibility resulting from plankton blooms greatly lowered the usefulness of this technique in the main stem below RM 70. Given good conditions, underwater counts were consistently higher than those obtained by other methods.

Seines utilized ranged from a 5-foot, one-man seine to a 100-foot bag seine. Mesh size ranged from ¼ to ½ inch. The larger mesh did not capture 0+ steelhead or cutthroat trout.

A Smith-Root backpack shocker was used in electrofishing. Oregon's north coast streams have low conductivity and the unit was effective only on small streams with flows of less than 3 cfs where the fish would hide rather than try to avoid the shocker operator. Fly and bait angling were techniques used in all sample areas. For bait angling single egg hooks (size 12-14) baited with worm, crayfish flesh or caddis larvae were used. Fish, ranging in size from 2½-11 inches were taken by that method. Fly angling took only larger yearling steelhead and cutthroat trout. Fly angling was quicker than bait angling in sampling a given area, and hooking mortality was much less. Streams with good rearing potential were surveyed to locate any barriers blocking adult steelhead migrations. It was hoped that rearing capacity could be expanded by barrier removal or introduction of adult spawners.

Flows in a number of tributary streams were measured with a Gurley Meter. Others were estimated or, where available, we used measurements from other studies. An analysis of low flows was prepared from USGS records (1940-75) for the Nehalem River.

Spawning Ground Surveys

An extensive steelhead spawning survey was initiated in 1974 and continued in 1975 and 1976. A limited number of counts were conducted in 1973 and 1977. The North Fork Nehalem system was included in 1975 and 1976. With the exception of the Salmonberry River little historical data were available. The objectives were to (1) locate important spawning areas and identify characteristics of such, (2) determine if large numbers of hatchery fish were present, and (3) determine time of peak spawning.

The 1974 program included a wide range of stream types, many of which were selected at random. Most were checked only once in an attempt to satisfy our first objective. Four stream sections were surveyed up to four times to determine peak spawning periods.

In 1975 and 1976 observations were limited to those waters which appeared to have good spawning potential. Repeat surveys, usually three, but in some cases four, were made on most of the streams. Timing was planned to encompass the range of spawning activity. Redds were flagged with colored ribbon to prevent duplicate counting. A number of these were revisited periodically to determine duration of visibility.

An attempt was made to capture adult steelhead on the spawning grounds and identify adipose marked hatchery fish. Two-man teams, each man equipped with a large salmon dip net, would approach a spawning or resting fish from the front and rear and attempt to place a net in the most probable escape route (Fig. 10). This technique was successful in capturing fish in small (20 cfs or less) tributaries of the Siletz River (Weber and Fortune 1974).

Disease Studies

General

Some of the wild steelhead yearlings (1+) seined from the main stem Nehalem River in the late summer and early fall of 1974 were obviously in poor health as evidenced by low condition factor, fin erosion, and heavy black spotting on the ventral surface. A few fish in similar condition were also taken from upper Nehalem River tributaries, Oak Ranch Creek (RM 80), and Rock Creek (RM 90).

In mid-October 1974, wild yearling steelhead, coho salmon, and cutthroat trout were seined near RM 42. Samples of each were examined by James E. Sanders, ODFW, and found to be heavily infected with the metacercaria stage of the salmon poisoning fluke, Nanophyetus salmincola. The intensity of the infection indicated a probable effect on survival (personal communication, James E. Sanders).

An experiment to test the effects of the fluke and other disease on hatchery reared steelhead juveniles was designed using 3'x3'x3' live-boxes (Fig. 5). The boxes were weighted with rocks and placed on the stream bottom or buoyed and floated in place.

River level varied by as much as 5 feet during some test periods necessitating frequent moves of the submerged cages. Freshets severely buffeted the boxes on several occasions; but, except for one floating cage torn loose from its moorings, none were damaged or lost.

Mortalities and fish killed for samples were usually frozen and taken to Corvallis, Oregon, for analysis. The same procedure was followed for wild fish seined from the river although the 1974 specimens were delivered fresh and analyzed immediately. Freezing does not interfere with diagnosis of C. shasta or the fluke Nanophyetus salmincola (personal communication, James E. Sanders). Live samples were also tranferred to the Corvallis Fish Disease Laboratory.

1975 Tests

Winter steelhead post-smolts of Alsea River and Big Creek stocks were first exposed in mid-April 1975.

The Alsea fish were the same hatchery stock which had been utilized with apparently poor results in the Nehalem for a number of years while the Big Creek fish had been used successfully in the North Fork Nehalem. The stocking program is summarized in Table 2. Cutthroat trout (0+ age) of Alsea River stock were also tested in late summer 1975.

Test sites were established in the Nehalem River (RM 7-72), North Fork Nehalem River (RM 8-10), and the Salmonberry River (RM 0.1-0.5). The boxes were checked every 2 or 3 days and more frequently during high loss periods. At each visit water temperatures were taken and the fish fed to satiation with a nonmedicated pelletized food. Algae accumulations were removed with a long-handled brush and mortalities with a dip net. The net and brush were sterilized after each use with a 9 to 1 solution of water and household bleach.

Samples of wild fall chinook salmon, coho salmon, steelhead yearlings, and cutthroat trout were seined from the Nehalem River (RM 13-42) in late August and examined by Jim Sanders.

Briefly, results of the above tests indicated that Ceratomyxa shasta, a myxosporidian parasite, was a serious problem for live-boxed Alsea steelhead and cutthroat trout. The salmon poisoning fluke did not seriously affect live-boxed or seined fish.

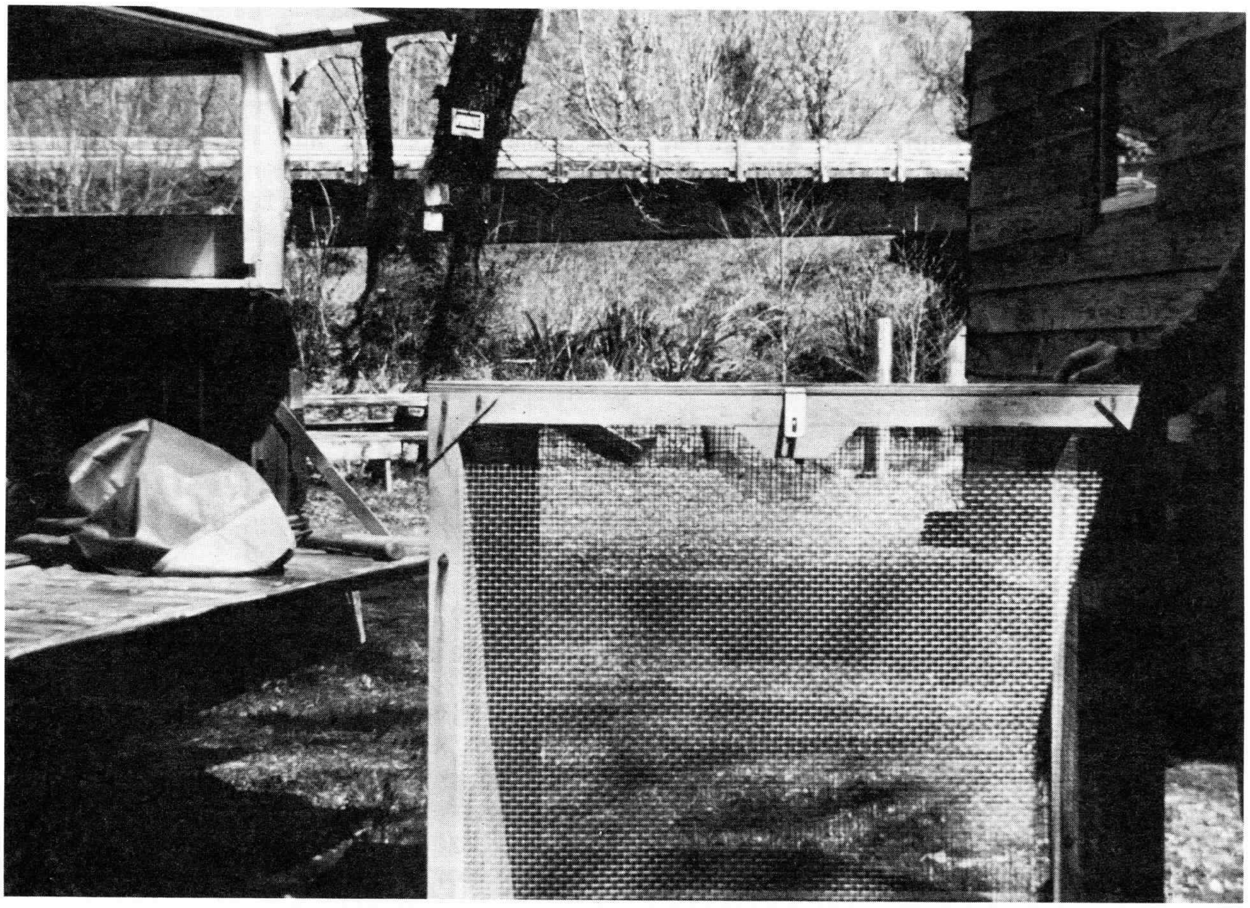

Fig. 5. Live-box used to hold test fish.

1976 Tests

These experiments were designed to (1) confirm or refute the preliminary results obtained in 1975, (2) determine if fish migrating out of the North Fork Nehalem into the Nehalem estuary were exposed to the parasite, (3) determine the infectious period for C. shasta, and (4) determine the susceptibility of North Nehalem stock steelhead. Big Creek and Alsea River hatchery-reared cutthroat trout (0+ age) were also exposed. North Fork Nehalem Hatchery coho were tested in the Nehalem estuary at RM 2.5 and in the Nehalem at RM 7. Wild steelhead yearlings (1+) from the Salmonberry River were exposed in the Nehalem River.

Procedures were similar to 1975 except that medicated food (3% TM-50) was used to reduce complications from bacterial disease. The medicated food provided no protection from C. shasta (personal communication, James E. Sanders). Continuous water temperature readings were obtained at two locations. Periodic salinity measurements with a hydrometer were made at the lowest live-box location (RM 2.5).

1977 Tests

The 1976 brood North Nehalem steelhead were retested as smolts. Big Creek smolts known to be resistant to C. shasta were used as the negative control. Legal-sized, hatchery-reared Big Creek and Alsea River cutthroat trout were exposed. Both experiments simulated expected exposures experienced by typical releases under Nehalem River stocking programs.

Coho salmon smolts, apparently released from the North Nehalem Hatchery in the upper Nehalem, were captured in the vicinity of the test boxes and held for exposure.

Experimental procedures were similar to 1975 except medicated food (3% TM-50) was again used but not on a continuous basis. Live-box locations were confined to the head of tidewater (RM 7-8) on the Nehalem River.

RESULTS AND DISCUSSION

Creel Surveys

Nehalem River Fishery

Table 6 summarizes six seasons of creel survey data. Zones 2, 3 and 4 are combined in this summary. Surveys included between 8.6% and 22.7% of the angler parties; this calculation was not made for the 1971-72 and 1972-73 seasons.

Angling effort

This was measured by vehicle numbers that seasonally ranged from 3,400 to 4,800 during the study years. Water conditions were the most important regulator of fishing effort. The lowest pressure was recorded in 1973-74 when numerous high water periods reduced angling opportunities. The 1974-75 season provided the best water conditions and the highest angling intensity.

Heaviest angler use and catch generally occurs from mid-December to mid-January. A smaller peak occurs in March and is stimulated by good water conditions and an unusually late run of steelhead (Fig. 6). Monthly breakdowns in angling pressure and catch for 1970-71 and 1973-74 through 1975-76 can be found in Weber (1971) and Weber and Knispel (1974, 1975, 1976).

Success rates and total catch

Angler success rates (hours per fish) ranged from 18.1 (1972-73) to 33.6 (1975-76) and averaged 24.2 angler hours per steelhead. Comprehensive surveys on three other coastal streams show catch rates ranging from 12.8 to 19.6 (Table 7). Average catch rate on the North Fork Nehalem was 12.0 (Table 11). Total catch varied from 817 (1973-74) to 2,005 (1970-71) and averaged 1,327 fish.

Hatchery contribution

The percentage of hatchery steelhead observed in the angler catch ranged from 5.3% (1974-75) to 45.9% (1975-76) and averaged 22.0%. The relatively high contribution in 1975-76 is due to a very low catch of wild fish combined with one of the best returns of hatchery fish. Estimated seasonal catch of hatchery fish ranged from 64 to 645. An extremely disappointing rate of return to the angler is indicated. This ranged from 0.1% (1973-74) to 0.4% (1972-73, 1975-76) and averaged only 0.22%. Table 7 shows hatchery contribution on the three other coastal streams ranged from 65 to 88% of the catch. More importantly, the rate of return to the angler on those streams ranged from 2.4 to 5.5% or from 6 to 11 times that observed on the Nehalem. The hatchery fish providing these returns were the same stock (Alsea) as used on the Nehalem River and, generally, size at and time of release as well as rearing conditions were similar.

Table 6. Summary of catch and effort statistics from the Nehalem River, 1970-71 through 1975-76.

Stocking Number	Stocking Year	Season of return	Est. angling effort (vehicles) /a	No. of fish observed	Estimated catch /c Wild	Estimated catch /c Hatchery	Estimated catch /c Total	Catch rate (hours/fish)	Percentage hatchery	Percentage hatchery return to the angler
					Nehalem					
105,500	1969	1970-71 /d	4,215(±497) /e	273	1,815	190	2,005(±466) /e	19.0	9.5	0.20
134,900	1970	1971-72 /d	3,940 /f	108	1,410	180	1,590 /f	20.7	11.3	0.13
138,600	1971	1972-73	3,781 /g	618 /b	820	645	1,465 /g	18.1	44.0	0.40
116,800	1972	1973-74	3,362 /g	305 /b	688	129	817 /g	27.7	15.8	0.10
110,200	1973	1974-75	4,776 /g	468 /b	1,151	64	1,215 /g	26.2	5.3	0.06
104,500	1974	1975-76	3,556(±519) /e	428 /b	472	401	873(±170) /e	33.6	45.9 /h	0.40 /h
Average			3,938	367	1,059	268	1,327	24.2	22.0	0.22

/a Does not include angling pressure above RM 38. Probably less than 150 vehicles per season. Can be corrected to approximate angler days by a factor of 1.75.
/b Includes fish reported on angler logbooks as well as those recorded in creel surveys.
/c Includes estimated catch above RM 38.
/d Supplemental data. Not part of study program.
/e Statistically computed. Figures in parentheses represent 95% confidence limits.
/f Statistically computed. No confidence limits set.
/g Computed by extrapolation without statistical analysis.
/h Only 87% of fish marked. Figures adjusted for unmarked hatchery fish.

Fig. 6. March steelhead catch.

Table 7. Contribution of hatchery-reared winter steelhead in other Oregon coastal streams.

	Alsea River /a		Wilson River /a		Siuslaw River /b
	1964-65	1965-66	1964-65	1965-66	1967-68
Stock	Alsea	Alsea	Alsea, Wilson	Alsea, Wilson	Alsea
Number released /c	150,000	152,000	120,000	112,000	88,000
Size at release	5.7-12.8	5.6-10.4	7.7	7.9	Approx. 8.0
Time at release	Feb-Apr	Feb-Apr	Apr-May	Apr	Apr-early May
Angler days	23,000	26,700	22,600	30,300	11,500
Catch					
Wild	1,009	828	2,867	1,792	1,460
Hatchery	3,586	6,117	5,618	6,193	2,711
Total	4,595	6,945	8,485	7,985	4,171
Catch/h	19.6	18.9	16.4	15.4	12.8
Percentage hatchery	78.0	88.1	66.2	77.6	65.0
Rate of return to the angler /d	2.4	4.0	4.7	5.5	3.1

/a From Wagner 1967.
/b From Hutchison 1970.
/c Release providing most of the hatchery contribution in year indicated.
/d Assumes that all hatchery fish caught were released as in /c.

Discussion

It is apparent, when comparing catch rate, percentage hatchery contribution, and percentage return to the fishery from the Nehalem River with similar statistics from other Oregon coastal streams (Table 7), that the fishery, in general, and the hatchery contribution, in particular, has been disappointing.

Although we would expect a somewhat lower success rate because of the high percentage of angler effort represented by the less efficient still fisherman, the relatively low angler pressure should partially compensate for this. Angler success in the last 3 yr of this study was particularly low.

The low percentage of hatchery contribution is partially due to the number of wild fish in the run, but the percentage of return to the fishery is the most significant statistic and suggests a small overall return or excessive escapement. Because of the Nehalem's size, turbid water conditions, and having less angling effort, we would not expect an exceptionally high rate of return. However, the Siuslaw River, a similar-sized stream with turbidity problems, produced a 3.1% return to the fishery with only 40% more effort (Table 7).

In addition a considerable portion of the Nehalem's fish returning in 1973-74 to 1975-76 were stocked into or adjacent to the mouths of Cook Creek and the Salmonberry River. Both are open to angling and provide considerable drift fishing opportunities but creel data shown in Table 8 indicates that angling was poor. Spawning ground surveys did not indicate any excessive escapement of wild or hatchery fish.

The percentage returns are even lower than indicated because of inclusion of marked fish that possibly strayed from other streams. The bias was probably greatest in low return years when identically marked fish were returning to the North Fork Nehalem River.

Hatchery steelhead returning to other coastal streams from 1970-71 through 1975-76 were all marked with an adipose fin clip (Ad) except in 1974-75 and 1975-76 when the number marked were reduced to 50%. Hatchery fish coming back to the North Fork Nehalem River were unmarked except those in 1974-75 and 1975-76 when returns from 14,000 and 11,350 Ad-marked smolts were expected, respectively. Table 9 provides stocking program details for fish returning to the Nehalem River during the period when the fishery was sampled. Except in 1974-75 and 1975-76, when most carried a unique mark, the Ad fin clip was also used on steelhead stocked in the Nehalem River.

Analysis of the 17 marked fish recorded in the 1974-75 creel census indicates that only 6 (35%) were from the uniquely marked 1973 release expected to return in 1974-75. One of the remainder was a one salt (jack) fish from the 1974 release while the rest were Ad-marked fish that were either strays or older fish from earlier releases. It is doubtful if many were from the 1973 accidental release of 3,750 Ad-marked fish into Foley Creek (RM 7). The contribution of strays in other years is not known.

Table 8. Winter steelhead creel census data from Nehalem River tributaries, 1973-74 through 1975-76.

Season	Cook Creek Anglers checked	Cook Creek Angler hours	Steelhead catch	Catch rate h/fish
1973-74	98	322	7	46.0
1974-75	65	148	3	49.3
1975-76	43	123	5	24.6
TOTAL	206	593	15	39.5
		Salmonberry River		
1973-74	24	84	2	42.0
1974-75	141	431	7	61.6
1975-76	65	194	5	38.8
TOTAL	230	709	14	50.7

Table 9. Nehalem River steelhead releases returning during the period 1970-71 through 1975-76.

Year: Release	Year: Primary return /a	Release location	Date of release	No. of fish	Mark	Size (fish/lb.)	Hatchery	Stock
1969	1970-71	Nehalem R. Mainstem RM 8	4/03	19,300	Ad	7.4	Cedar Cr.	Alsea
		Nehalem R. Mainstem RM 10.5	4/30	21,500	Ad	7.2	"	"
		In Salmonberry R. (RM 0.1) RM 22	4/29-30	25,500	Ad	7.2	"	"
		Nehalem R. Mainstem RM 34.5	4/28-29	17,500	Ad	7.2	"	"
		Mouth of Rock Cr. RM 90	4/29-30	13,300	LV-RV	6.1	Alsea	"
		Nehalem R. Mainstem RM 107	4/26	8,400	LV-RV	5.9	"	"
				105,500				
1970	1971-72	Nehalem R. Mainstem RM 10.5	4/22-23	30,600	Ad	6.4-6.7	Cedar Cr.	Alsea
		Mouth of Cook Creek RM 13	4/06-08	16,400	Ad	6.6-7.0	"	"
		In Cook Cr. (RM .5) RM 13	4/21	7,800	Ad	6.4	"	"
		In Salmonberry R. (RM 0.1) RM 22	4/06-09	42,100	Ad	6.5-7.0	"	"
		Nehalem R. Mainstem RM 34.5	4/22	10,400	Ad	6.7	"	"
		Mouth of Rock Cr. RM 90	4/20-21	27,600	Ad	6.4	"	"
				134,900				
1971	1972-73	Nehalem R. Mainstem RM 10.5-13.5	4/01	30,200	Ad	6.3	Cedar Cr.	Alsea
		Mouth of Cook Cr. RM 13	4/01	15,100	Ad	6.3	"	"
		In Cook Cr. (RM 5) RM 13	4/07-13	23,000	Ad	5.5-5.7	"	"
		In Salmonberry R. (RM 0.1) RM 22	3/30-4/06	38,500	Ad	5.7-5.9	"	"
		In Fishhawk Cr. (RM 3) RM 47	3/30	2,000	Ad	5.7	"	"
		Mouth of Rock Cr. RM 90	4/05-12	29,800	Ad-LP	5.5	"	"
				138,600				
1972	1973-74	In Cook Cr. (RM 5) RM 13	5/09-17	32,500	Ad	6.4-7.6	Roaring River	"
		In Salmonberry R. (RM 0.1) RM 22	5/04	30,800	Ad	5.5-5.6	Roaring River 16,700	"
							Cedar Creek 14,100	"
		In Humbug Cr. (RM 9) RM 35	5/05-08	16,700	Ad	5.5-5.8	Roaring River	"
		In Wolf Cr. (RM 4) RM 106.5	5/03	21,800	Ad-LP	6.0-6.3	Cedar Creek	"
		Mouth of Wolf Cr. RM 106.5	5/03	7,200	Ad-LP	6.0	"	"
		Mainstem Nehalem R. RM 107	5/02	7,800	Ad-LP	6.3	"	"
				116,800				
1973	1974-75	In East Foley Cr. (RM 0.3) RM 7	4/11	7,700	50% Ad	6.4	"	"
		Nehalem R. Mainstem RM 10.5	3/30-4/06	30,400	LV	6.2	"	"
		In Cook Cr. (RM 5) RM 13	4/06-12	17,600	LV	6.1	"	"
		In Salmonberry R. (RM 0.1) RM 22	4/13	32,500	RV	6.4	"	"
		Mouth of Rock Cr. RM 90	4/13	22,000	RV	6.4	"	"
				110,200				
1974	1975-76	Nehalem R. Mainstem R 10.5	3/27	20,000	Ad-LV	6.5	"	"
		Nehalem R. Mainstem RM 10.5	3/28	6,800	50% Ad	7.4	"	"
		Mouth of Cook Cr. RM 13	3/27	32,400	Ad-LV	6.2	"	"
		In Cook Cr. (RM 5) RM 13	3/28	20,300	50% Ad	7.4	"	"
		In Salmonberry R. (RM 0.1) RM 22	3/27	25,000	Ad-LV	6.1-6.5	"	"
				104,500				

/a Returning as 3-year-old fish (2 summers in saltwater).

A portion (21,700 to 36,800) of the smolts released in the upper Nehalem system (RM 90-107) in 1969, 1971 and 1972 were uniquely marked. There were no adults recovered from these groups in 1970-71 or 1973-74 but 9 fish were reported in 1972-73. Only light angling pressure occurs in that area and logbook data on 15 to 35 fish per season is about the only catch data obtained. It appears from these data that upriver releases may have returned at even lower rates than the others. Disease problems associated with an extended migration period may have reduced the survival rate. These problems will be discussed in a subsequent section.

In the absence of any other explanation and noting the successful programs on other coastal streams using the Alsea stock steelhead, a high differential mortality on all hatchery releases in the Nehalem River is suggested. Table 6 indicates that the rate of return in 1972-73 and 1975-76, while still disappointedly low at 0.4%, exceeded those of other years by a factor ranging from 2 to 7. The bulk of the hatchery fish returning in those 2 yr had two things in common distinguishing them from the others: (1) they were released earlier and (2) they were released into higher flows (Table 10). Correspondingly, the two poorest years (1973-74 and 1974-75) were from late smolt releases into very low flows. Although a perfect relationship is not evident (we would have expected a better return in 1971-72), a definite pattern appears to exist. The relationship by disease problems that will be discussed later.

The catch of wild fish varied from 472 (1975-76) to 1,815 (1970-71) and averaged 1,059 fish (Table 6). The wild run historically, as well as presently, supports the winter steelhead fishery. The magnitude of the fluctuations indicated above are seen in wild fish catches from other Oregon streams (Wagner 1967). Angling conditions are an obvious factor affecting catch of hatchery and wild fish. Of the two lowest seasonal catches, an unusual amount of turbid water certainly reduced angling opportunities in the 1973-74 season but excellent conditions prevailed in the 1975-76 season. Factors affecting run size, mainly ocean and freshwater survival, also have an obvious effect on catch. Life-history studies show that most Nehalem River wild fish spend 2 yr in fresh water and return during their second winter at sea. When analyzing U.S.G.S. flow records for conditions which may have influenced freshwater survival, we noted that broods returning in the three poorest catch years (1972-73, 1973-74, and 1975-76) all experienced major flooding during their second winter (U.S.G.S. 1969-75). Possibly such conditions could have resulted in high juvenile losses but we can only speculate that a relationship exists or that our observations are coincidental. Comments from other ODFW coastal biologists indicated lower than normal steelhead catches during the 1972-73 and 1975-76 seasons for unknown reasons (personal communication, Dave Heckeroth, John Fortune, James Hutchinson).

In the absence of any quantitative escapement data, it is difficult to speculate on total run size but this seems to be a question that demands an answer. Wagner (1967) with comprehensive catch and escapement data at hand noted that nearly 50% of the wild run was caught in the heavily fished Sandy River (Columbia River tributary). Catch of hatchery fish

Table 10. Relationship of release times and river flow at time of release to rate of return of winter steelhead stocked in the Nehalem River, 1970-71 to 1975-76.

Time of release	Winter of primary return	Rate of return to the fishery	Flows (cfs) during release period /a	Flows (cfs) for 7 days after release /a
Late April 1969	1970-71	0.20	1,590-1,780	1,260-1,590
Early to late April 1970	1971-72	0.13	1,410-5,040	2,910-4,100
Early to mid-April 1971	1972-73	0.40	3,110-12,500	2,370-4,920
Early May 1972	1973-74	0.10	1,190-1,980	925-1,110
Mid-April 1973	1974-75	0.06	910-1,560	843-2,470
Late March 1974	1975-76	0.40	2,410-7,160	7,540-11,500

/a Flow data obtained from gauge readings at RM 13.5 (U.S.G.S. 1969-1974).

exceeded 50% of the run and in one year 66% were taken. Wagner's data on catch/escapement ratios in a heavily fished coastal stream (Alsea River) also indicated that approximately 60% of the hatchery fish were caught. Based on an estimated 1.75 anglers per vehicle, Nehalem River angling pressure is about 1/3 of that noted by Wagner (1967) on the Alsea and Sandy rivers. The Nehalem catch rate (Table 6) is lower than the Alsea and comparable to the Sandy River (Wagner 1967). Nehalem River angler use is spread over a much larger system. Because of the above factors catch/escapement ratios are low. We speculate the catch to escapement ratio for hatchery fish would be 1:4 and for wild fish 1:9. Total run size would be calculated as follows:

	Average Catch (Table 6)	Escapement Factor	Escapement	Run Size
Hatchery Fish	268	4	1,072	1,340
Wild Fish	1,059	9	9,531	11,930
Total	1,327		10,603	13,270

North Fork Nehalem Fishery

Table 11 summarizes six seasons of creel data. Approximately 5 to 10% of the anglers were sampled in 1970-71, 1973-74, and 1975-76. A calculation of creel survey coverage was not made in 1971-72 and 1972-73. A statistical sampling program was not used in 1974-75 and although extensive creel data was obtained only catch rate and hatchery contribution were calculated.

Angling effort

Vehicle counts ranged from 941 (1972-73) to 2,744 (1973-74) and averaged 1,832. The 1974-75 season probably had greater pressure but an estimate was not made. Water conditions were the main regulator of angler use. The low angler use in 1972-73 was due to the nearly complete loss of December angling opportunities resulting from extremely cold weather and low flows followed by a major flood.

The hatchery run is early with some good angling by mid-November, it peaks in December and by mid-January most fish are dark or spent. Angling pressure follows the hatchery run and has greatly increased since hatchery construction in 1968. Although a good run of wild fish is present in late February and March, angler use is low and creel data difficult to obtain. A high percentage of the fish caught in February and March are of poor quality. Monthly breakdowns of creel data and angling effort for 1970-71, 1973-74, and 1975-76 can be found in Weber (1971) and Weber and Knispel (1974, 1976).

Success rates and total catch

Catch rates averaged 12.0 hours per steelhead taken and ranged from 7.8 to 14.4. This is considerably higher than that for the Nehalem (24.2) and also better than other coastal streams shown in Table 7. Total catch ranged from 414 to 1,627 fish and averaged 1,144 and for the last 3 yr has exceeded those from the Nehalem River.

Table 11. Summary of catch and effort statistics from the North Fork Nehalem River, 1970-71 through 1975-76.

Stocking Number	Stocking Year	Season of return	Est. angling effort (vehicles) /a	No. of fish observed	Estimated catch /c Wild	Estimated catch /c Hatchery	Estimated catch /c Total	Catch rate (hours/fish)	Percentage hatchery	Percentage hatchery return to the angler
16,500	1969	1970-71 /c	1,460(±178)/a	64	-	-	1,528(±353)/a	7.8	- /g	- /g
43,400	1970	1971-72 /c	1,680 /d	31	-	-	728 /d	14.4	- /g	- /g
44,500	1971	1972-73	941 /e	36	-	-	414 /e	12.7	- /g	- /g
42,700	1972	1973-74	2,744 /e	174	-	-	1,627 /e	13.2	- /g	- /g
62,000	1973	1974-75	- /f	138	-	-	- /f	10.8	25.2 /h	-
22,700	1974	1975-76	2,333(±357)/a	270	497	924	1,421(±398)/a	13.1	26.1 /i	2.04/j
Average			1,832	119	-	-	1,144	12.0	-	-

/a Statistically computed. Figures in parentheses represent 95% confidence limits.
/b Includes fish reported on angler and hatchery logbooks as well as those recorded by creel census.
/c Supplemental data. Not part of the study program.
/d Statistically computed. No confidence limits set.
/e Computed by extrapolation without statistical analysis.
/f No statistical sampling program.
/g None of fish marked.
/h Only 22.6% of fish marked. A sampling error is indicated.
/i Only a portion of hatchery fish marked. 1973 release 22.6%, 1974 releases 50% marked.
/j Return from 1974 release of Alsea stock only.

Hatchery contribution

Table 12 provides smolt release statistics relating to steelhead returning during the creel survey period. Marked fish were available for evaluation only in the last two seasons and only a portion were marked. We feel that hatchery fish have made a large contribution to the run each year, but in the absence of a marking program, this is difficult to substantiate. In the 1973-74 season, 76% of the angler-caught steelhead examined had an eroded dorsal fin, an indicator of hatchery rearing; this technique tends to underestimate hatchery contribution. We examined 46 marked hatchery fish in 1975-76 but only 63% had an obvious dorsal fin deformity.

Although only 22.6% of the 1973 release were fin clipped, 25.2% of the 1974-75 catch were from this group, which suggests that 100% of the run was hatchery fish. A disproportionate amount of creel data were obtained at the North Nehalem Hatchery grounds, one of the stocking sites.

Finclipped fish represented 26.1% of the catch in 1975-76. Big Creek fish from the large (62,000) smolt liberations in 1973 made up a surprisingly high portion (54%) of the marked catch and were particularly dominant early in the season. These were returning as repeat spawners or had spent an extra year at sea. This group also provided a good return the previous season. The 1974 release of 22,700 smolts from Alsea stock made up the remainder of the marked fish. Both groups were identically marked and were distinguished by size. Those less than 28.8 inches in fork length were considered to be age 1/2 and originating from Alsea stock; larger fish were considered to be age 1/3 and from Big Creek stock. Using this guideline and noting that only a portion of the 1973 and 1974 releases were marked, a 65% hatchery contribution was calculated for 1975-76. Scale analysis of 1976-77 adult returns verified our size/age guideline. Of 86 fish between 23.6 and 28.8 inches all were age 1/2 except for one repeat spawner age 1/3.

Marked strays from the Nehalem River were observed each season in the North Fork catch. The 1975-76 season was the only time numbers were calculated with an estimated 60 to 70 fish caught. With smolts for the Nehalem River now being reared at the North Fork station the incidence of straying back to that system will probably increase.

Discussion

The high catch rate (10.8 hr/fish) in 1974-75 may have been biased by a tendency to sample when angling conditions were good. The relatively poor catch rate (13.2 h/fish) in 1973-74 is in opposition to the high total catch. Possible explanations would be: Angling effort was the highest recorded, and water conditions were such that high flows, although still allowing angling, permitted the runs to move in at an almost constant rate during the peak of the season. The usual situation is for a concentration of fish to move in following a freshet and provide a high rate of success for several days. High flows reduced drift fishing opportunities on many other coastal streams that year but the North Fork remained fishable most of the time. The resulting influx of anglers unfamiliar with the stream may have lowered success rates.

Table 12. North Fork Nehalem River steelhead releases returning during the period 1970-71 through 1975-76.

Year: Release	Year: Primary return /a	Release location	Date of release	No. of fish	Mark	Size (fish/lb)	Hatchery	Stock
1969	1970-71	Hatchery (RM 10)	4/29	9,300	None	7.0	No. Nehalem	Big Creek /b
		RM 14	4/29	7,100	None	7.0	"	"
				16,400				
1970	1971-72	Hatchery Site (RM 10)	4/16	21,700	None	8.0	"	"
		RM 13	4/15	21,700	None	8.0	"	"
				43,400				
1971	1972-73	Hatchery (RM 10)	4/26	11,200	None	6.9	"	"
		RM 13	4/26	20,700	None	6.9	"	"
		Hamlet Rd. (RM 20)	4/26	12,600	None	6.9	"	"
				44,500				
1972	1973-74	Hatchery (RM 10)	4/14	13,600	None	5.4	"	"
		RM 13	4/14	13,800	None	5.4	"	"
		Hamlet Rd. (RM 20)	4/14	15,300	None	5.4	"	"
				42,700				
1973	1974-75	Hatchery (RM 10)	4/18	14,000	Ad	5.5	"	"
		Hatchery (RM 10)	4/18	6,800	None	5.5	"	"
		RM 13	4/18	22,000	None	5.5	"	"
		Hamlet Rd. (RM 20)	4/18	19,100	None	5.5	"	"
				61,900				
1974	1975-76	Hatchery	4/08-4/09	22,700	Ad (50%)	7.5	Cedar Creek	Alsea

/a Returning as 3-year-old fish (1/2).
/b Eggs taken from fish returning to Big Creek Hatchery (Lower Columbia River).

It is probable that the total catch in 1975-76 is overestimated by several hundred fish because of a bias created by sampling only 2 days, both of which were productive, in December 1975; a period which produced 64% of the total catch. Catch card estimates (Table 13) also suggest that the angler survey overestimated the catch.

The highest catch and angling pressure probably occurred in 1974-75 when no statistical sampling program was in operation. The high stocking rate and high percentage of marked fish in the catch indicated excellent returns. Creel surveys while not expandable, indicated high angling effort.

We were particularly interested in monitoring the 1975-76 return of the fish originating from Alsea River smolts released in 1974. Disease problems in the Nehalem River are apparently the cause of poor returns from that stock. Fish migrating out of the North Fork share about 8 mi of estuary with those released in the main river and the disease is known to be present in at least the upper end of the estuary. The calculated return of 2.0% to the fishery is much better than that noted for the Nehalem (Table 6) but below returns from other streams (Table 7). Adverse effects from exposure to disease organisms may be a possibility. Total run size estimation was complicated by the absence of escapement data and lack of historical wild/hatchery fish catch ratios.

We feel hatchery and wild fish catch/escapement ratios differ widely on the North Fork of the Nehalem River. Angler effort concentrates in the vicinity of the hatchery and is heaviest during the peak of the hatchery run. Access limitations result in wild fish being exposed to heavy pressure only as they pass through about a 4-mi section adjacent to the hatchery. Also, the late run of wild stocks is subjected to little angling pressure, but, unlike the Nehalem, water conditions permit the more efficient drift fisherman to pursue his quarry most of the season. Assuming that the 1975-76 wild/hatchery fish ratio of 35/65 is typical of most years we would calculate the average run size as follows:

	Average catch (Table 11)	Escapement factor	Escapement	Run size
Hatchery fish	744	2	1,488	2,232
Wild Fish	400	3	1,200	1,600
Total	1,144		2,688	3,832

The steelhead fishery on the North Fork meets our present management objectives. Catch rate is good and hatchery contribution from the Big Creek stock has apparently been excellent. A disease control policy resulted in a ban on moving eggs or fish out of the Columbia River system. Thus, the 1976 brood were reared from eggs taken at the North Nehalem Hatchery trap rather than eggs from the Big Creek Hatchery. Scale analysis indicated that only hatchery fish entered the trap so essentially we will be maintaining the same stock. First returns came back in 1977-78 but were unmarked and not evaluated from the egg-take.

Table 13. Comparison of steelhead catch estimates derived from catch card data and from the Nehalem and North Fork Nehalem creel survey program.

	Catch card	Creel survey	Percentage (catch card/creel survey)
Nehalem River			
Nov. 1973	90	18	500
Dec. 1973	592	283	209
Calendar Year 1975	2,040	1,300	156
TOTAL	2,722	1,601	170
North Fork Nehalem			
Nov. 1973	362	167	216
Dec. 1973	1,565	704	222
Nov. 1975	334	177	189
Dec. 1975	897	1,131	79
TOTAL	3,158	2,179	145
Combined			
Jan. 1971	1,674	815	205
Feb. 1971	1,111	552	201
Mar. 1971	530	431	123
Jan. 1974	1,651	663	249
Feb. 1974	729	409	178
Mar. 1974	331	200	166
TOTAL	6,026	3,070	196

Comparison of Creel Survey Data and Catch Card Estimates

The ODFW uses the salmon-steelhead catch card to estimate the annual catch of salmon and steelhead in Oregon. The return of catch cards is essentially voluntary and only averaged about 20% during our study period. As successful anglers are more likely to return cards, the data have been corrected for nonresponse bias as described by Hicks and Calvin (1964). In addition to total catch, an estimate by stream for each month is prepared, although it is recognized that the precision decreases as the estimates are refined.

The catch estimates for individual streams are widely used as trend data. Until 1974, catch estimates for the Nehalem and North Fork were combined (Table 5). Catch estimates from our creel surveys are compared with those from the catch card in Table 13. With one exception the card estimates are considerably higher, usually over 150% of our figure. The exception is probably due to a sampling error caused by basing our estimates on limited data. Table 13 was presented to support the contention that catch card information on a stream-by-stream basis should only be used for showing trends.

Life-History Studies

Age

Table 14 summarizes scale analysis data obtained from 328 wild, angler-caught Nehalem River steelhead. Samples were gathered in 4 study years but the 1974-75 data is probably most representative. In other years there was some tendency to bias the sample by selecting unusually small or large fish. Ten different life-history patterns were observed excluding repeat spawners. The most common (68.6%) was 2/2, 2 years in freshwater and 2 summers at sea (2-salts). Studies of other wild Oregon coastal stocks also noted 2/2 was the most common pattern. Hutchison (1970) found 59% of 174 wild Siuslaw River fish had a 2/2 life-history. Summer (1946) reported 55.6% of a commercially gillnetted sample (800 fish) from Tillamook Bay were age 2/2. Burt (unpublished data) studying 1,221 Alsea River trap- and angler-caught fish noted that 52% were 2/2; the next most common pattern was 2/3 (21%).

The 2/3 pattern was also the second most frequently observed history (7.9%) in our sample. Few fish which had spent only 1 year in fresh water were noted by any of the above studies. It is possible the 1/2 samples shown in Table 14 may be unmarked hatchery strays, probably from the North Fork Nehalem.

Repeat spawners made up 10.4% of our sample. Maher and Larkin (1954) noted 5.3% in British Columbia's Chilliwack River. The Alsea River study revealed 10.9% of the combined sample of hatchery and wild fish were in this category (Burt, unpublished data). Burt's samples were taken from a 3-year period, and between years the percentage ranged from 3 to 17%. Hutchison (1970) reported 14% repeat spawners from the Siuslaw River.

Table 14. Age of wild winter steelhead from the Nehalem River, 1970-71 and 1973-74 to 1975-76.[a/]

Year	No. of Fish	1/2	2/1	2/2	2/3	3/2	Other	Jacks	Repeat Spawners
1970-71	92(100)[b/]	6(6.5)	10(10.9)	58(63.0)	4(4.3)	11(12.0)	3(9.8)	12(13.0)	6(6.5)
1973-74[c/]	45(100)	1(2.2)	6(13.3)	18(40.0)	7(15.5)	4(8.9)	9(20.0)	10(22.2)	3(6.7)
1974-75	174(100)	9(5.2)	4(2.3)	144(82.8)	7(4.0)	5(2.9)	5(2.9)	5(2.9)	22(12.6)
1975-76[d/]	17(100)	0(0)	3(17.6)	5(29.4)	8(47.1)	0(0)	1(5.9)	2(11.8)	3(17.6)
TOTAL	328(100)	16(4.9)	23(7.0)	225(68.6)	26(7.9)	20(6.1)	18(5.5)	29(8.9)	34(10.4)

a/ Repeat spawners included in the category reflecting their age in year of initial return.
b/ Percentages in parenthesis.
c/ Sample based in favor of smaller fish.
d/ Sample based in favor of larger fish.

About 8.9% of the Nehalem River catch that was sampled consisted of 1-salts or fish spending only 1 summer at sea. These "jacks" are usually less than 20 inches in length. Table 14 shows that 23, or 79% of the jack scale samples, revealed a 2/1 life-history; the remainder were 3/1.

As jacks could be easily identified by size, our creel data provides a more representative sample than does Table 14. Between sample years jack percentage in the Nehalem River catch ranged from 2 to 8% and in the North Fork averaged only about 1% with the range from 0 to 2.3%. Although contrary to our expectations it appears the catch by still fishermen is selective toward jacks when compared to the drift fishery. The North Fork Nehalem does not have a "still fishery" and jack catches are low, whereas most Nehalem River jacks are taken by still fishermen using salmon or steelhead roe, a popular bait for all forms of steelhead angling. However, the still fisherman uses much larger bait; and it would appear that the smaller baits of the drifter would more readily take the smaller fish.

Wagner (1967) reported jacks made up 6% of the hatchery run. His data included both angler and trap catches, and he did not feel the fishery selected for or against them. Burt (unpublished data) in an earlier Alsea River study noted 4% of the wild run and 8% of the hatchery run were jacks. Hutchison (1970) analyzed 6 consecutive seasons on the Siuslaw River and found jacks representing from 2 to 16% of the wild run and 0.3-33% of the hatchery run. He felt a good return of jacks predicted a good run of 2-salt fish the following year.

Some interesting individual life-history patterns were revealed by the scale analysis. Two females, 35.5 and 38.0 inches in length, were in their 8th year and on a 5th consecutive spawning migration. The only fish with 4 uninterrupted ocean years (2/4) was also the largest, a 40-inch male.

Sex Ratios

Classification of 1,199 angler-caught steelhead from the Nehalem and North Fork Nehalem rivers is shown in Table 15. The fish were classified over a 4-year period and included hatchery and wild fish. The totals of all samples were virtually equal with female/male ratios of 1.04. Between years there were some wide variations in both streams with ratios ranging from about 0.7 to 1.5. These variations were probably the result of disproportionate sampling during the run. Males appear to dominate the early portion of the run, but this was not consistent between streams or seasons. Of 27 Nehalem River fish classified during late November 1974, all but 1 were males. That year North Fork Nehalem males outnumbered females 51 to 43 from mid-November to mid-December.

Jacks were primarily maturing males with only 3 of 33 (9.1%) being females. Hutchison (1970) noted a similar ratio (16% females) in 25 fish observed on the Siuslaw River, but he found many males to be

Table 15. Sex ratios of angler-caught winter steelhead from the Nehalem and North Fork Nehalem Rivers, 1973-74 to 1976-77.

	Nehalem R.		N.Fk. Nehalem		Total	
	Females	Males	Females	Males	Females	Males
1973-74 Migratory Season						
No. of Fish[a/]	57	39	63	70	120	109
Female/Male ratio	1.46		0.90		1.10	
1974-75 Migratory Season						
No. of Fish[a/]	137	123	47	31	184	154
Female/Male ratio	1.11		1.52		1.19	
1975-76 Migratory Season						
No. of Fish[a/]	104	145	109	94	213	239
Female/Male ratio	0.72		1.16		0.89	
1976-77 Migratory Season						
No. of Fish[a/]	81	64	14	21	95	85
Female/Male ratio	1.27		0.67		1.12	
All Years						
No. of Fish[a/]	379	371	233	216	612	587
Female/Male ratio	1.02		1.08		1.04	

a/ Includes jacks.

immature. He also noted even sex ratios in a 100-fish sample of 2-salt fish. Classification of 468 angler-caught Chilliwack River steelhead indicated a strong preponderance of females (ratio of 1.4) (Maher and Larkin 1954). Their data were taken throughout 4 different seasons.

Rearing Area Surveys

Main Stem Nehalem River

Sample sites were selected along virtually the entire length of the river from RM 14 upstream to the headwaters. Efforts were directed at riffle areas that appeared to be good steelhead rearing habitat. Seining was the main sampling technique as poor visibility limited snorkel observations to sections above RM 42. In some areas bait angling preceded sampling by seining and snorkeling.

Seining at 15 sites between RM 14 and 34 in late summer of 1974 and 1975 produced no steelhead, 50 fall chinook salmon smolts, 24 cutthroat trout up to 9 inches in length, 8 coho salmon juveniles, and an 18-inch sucker. Between 2 and 15 net hauls were made at each site. Angling took the only steelhead, a yearling (1+), and two cutthroat trout.

The riffle areas between RM 42-43 were seined in 1974 and 1975 and 24 steelhead (age 1+), 7 steelhead (0+), 12 cutthroat trout to 8 inches FL, 21 coho salmon juveniles, and 2 juvenile suckers were captured. Angling took three cutthroat. It was interesting to note that the chinook salmon and steelhead were apparently unable to share the same rearing areas.

Snorkel observations at five pool/riffle sites between RM 60 and 75 recorded five steelhead (1+) and four juvenile coho salmon. Hook and line took two cutthroat trout to 9 inches FL. Five sites between RM 82 and 108 were snorkeled in 1973 and 8 steelhead (0+), 1 steelhead (1+), 42 coho salmon, and 5 cutthroat trout were enumerated. Most fish observed were at the two upper sites near RM 108. A 1974 underwater count of three riffle/pool sequences at RM 101 found 17 steelhead (0+), 11 steelhead (1+), 12 coho salmon, 1 adult sucker, and numerous juvenile suckers.

This section's riffles are the better appearing steelhead rearing areas in the upper river. In 1975 10 riffle/pool areas, totaling 240 yards and located between RM 72 and 105, were snorkeled. A total of 19 steelhead (0+), 3 steelhead (1+), and about 150 coho salmon were observed. Again, most of the fish were found in the RM 101 area.

Bait angling surveys beginning at RM 105 and extending into the headwaters at RM 117 recorded between 0 and 5 steelhead (1+)/100 yards. Good numbers of coho salmon and cutthroat trout were also noted.

Low summer flows in the main stem survey areas were estimated to be as follows:

RM 14	100 cfs
RM 35	50 cfs
RM 70	10 cfs
RM 90	3 cfs

Tributaries

All tributaries which appeared to have significant steelhead rearing potential were surveyed; the larger streams are listed in Table 16. Data shown are from our measurements or estimates or from Thompson and Fortune (1968).

Bait angling surveys in 1974 and 1975 of five sections of Foley Creek revealed steelhead populations (1+) of 6-14/100 yards. Good numbers of cutthroat trout (4 to 7/100 yards) and coho salmon were also present.

Cook Creek was sampled 3 consecutive years (1974-76). Fly angling indicated high populations in upper portions (above RM 5) with counts of 10-50/100 yards. Below RM 5 good populations were noted in 1976, but angling and snorkel surveys in 1974 and 1975 showed very low numbers. Coho and cutthroat were not abundant at any location. Small trout (0+), probably steelhead, were plentiful in all areas.

Two sections of Lost Creek inventoried in 1974 by fly angling produced 10 fish/100 yards. Few cutthroat or coho were observed. The Salmonberry River is the largest (flow) tributary. Rearing populations were sampled in 1974-76. Sites were located between RM 0.5 and 8.5 and one to four areas were surveyed each year. Fly angling recorded populations ranging from 1-32 fish/100 yards. Snorkel observations indicated angling was enumerating ¼ to ½ of the fish present. Yearling (1+) steelhead were generally evenly distributed along the river length but some areas of apparently suitable habitat contained few fish (1 fish/100 yards).

A single, 1974 inventory by fly angling of the South Fork Salmonberry recorded 20 fish/100 yards. Extensive surveys of the North Fork Salmonberry indicated very high steelhead populations with counts ranging from 21-100 fish/100 yards. Cutthroat and coho populations were low throughout the Salmonberry system.

Gonad examination of North Fork Salmonberry steelhead (5½-9 inches FL) revealed that 12 out of 30 (40%) were maturing, including several females. The percentage increased as an impassable falls at RM 5 was approached. A resident rainbow trout population exists above the falls and the high incidence of maturing fish probably results from these moving downstream. Internal examination of 25 fish 5-8 inches FL from the main stem Salmonberry found only 1 mature fish.

A hook and line survey of four Cronin Creek study areas in 1975 documented steelhead populations of 1-6/100 yards. Coho were abundant but few cutthroat were seen.

Table 16. Larger tributaries of the Nehalem River system surveyed for juvenile steelhead.

Name	Point of entry into Nehalem R.	Estimated length [a/]	Low flow (cfs) [c/]	Gradient [b/]
Foley Cr.	7	7	1-12	M
Cook Cr.	13	10	2-13	H
Lost Cr.	14	4	1-3	H
Salmonberry R.	22	22	4-30	H
Cronin Cr.	25	5	1-4	H
Humbug Cr.	35	15	1-6	M
Buster Cr.	44	5	1-2	M
Fishhawk Cr. #1	47	13	2-5	M
Fishhawk Cr. #2	66	9	1-6	M
Oak Ranch Cr.	80	4	1-2	M
Rock Cr.	90	32	2-12	M
Wolf Cr.	107	7	1-2	M

a/ Area, including tributaries, suitable for rearing yearling steelhead. Conversion to metric, 1 mile=1.6093 km.

b/ H= High = pool/riffle ratio less than 40/60; M= Moderate = pool/riffle ratio more than 40/60 but less than 70/30 at summer flows.

c/ 1 cfs = 28.32 ℓ/sec.

Snorkel observations at two Humbug Creek sites revealed low salmonid populations and no yearling steelhead in 1974. Angling at two different locations took several cutthroat trout but no steelhead in 1976. Hook and line sampling of two tributaries, West Humbug Creek (one section) and East Hambug Creek (two sections), produced steelhead counts of 6 fish/100 yards and no fish in 350 yards, respectively. Coho salmon and cutthroat trout were abundant in both tributaries.

Bait angling in two sections of Buster Creek in 1974 and 1975 indicated less than 1 fish/100 yards. The 1975 test was repeated using a backpack shocker, and a count of 2 fish/100 yards was recorded. An abundance of coho and a good population (5 fish/100 yards) of cutthroat was noted.

Bait angling in up to five sections of Fishhawk Creek #1 in 1974-76 produced few steelhead in any of the 3 years. A 1975 check of one section with a backpack shocker found no steelhead. Cutthroat and coho were plentiful in most sections. Fishhawk Creek #2 was not surveyed.

A single 1974 Oak Ranch Creek survey using bait angling and a backpack shocker indicated good populations at 6 fish/100 yards. Coho and cutthroat were in abundance. This is the first stream above Humbug Creek (RM 35) with a good steelhead rearing population.

The Rock Creek system contains the most stream miles of steelhead rearing habitat. Extensive angling and snorkeling observations were made in 1974-76. Between five and seven sections scattered the length of the system were surveyed each year. Bait angling in 1974 produced catches of 0-5 steelhead/100 yards with most sections showing less than 2 steelhead/100 yards. Snorkeling observations in 1975 noted only an average of 1 fish/100 yards, while angling in the uppermost section produced no steelhead. A 1976 snorkeling survey covering 0.9 miles in five different plots observed fewer than 2 steelhead/100 yards. Young of the year (0+) steelhead or cutthroat were not abundant in any area. A good population of legal-sized cutthroat was apparent. Bait angling surveys of several sections of Wolf Creek noted populations of 2-5 steelhead/100 yards. Coho were numerous but few cutthroat were taken.

Although the watershed contains approximately 510 miles of fish production streams, only about 43 miles or 8% rear steelhead yearlings in good numbers. Most rearing is concentrated in four tributaries of the lower Nehalem: Foley, Cook, and Lost creeks and the Salmonberry River. Because of high populations and stream length, Cook Creek and the Salmonberry River are the most important steelhead production areas.

Another 90 miles or 18% rear low numbers of steelhead yearlings. Most are in the upper main stem Nehalem River (18 miles), Rock Creek, and Wolf Creek.

The remaining 450 miles do not provide suitable habitat for yearling steelhead. The main stem Nehalem below RM 100 provides little rearing. Many of the smaller streams which enter directly into the Nehalem provide spawning habitat and rear some steelhead (0+). However, without suitable area to complete their freshwater cycle, it appears these fish make little contribution to adult steelhead production.

Surveys indicate little potential to extend any of the productive areas through barrier removal. About 3.0 miles of the North Fork Salmonberry are blocked by several falls but fish passage improvements are impractical. Present management of the Salmonberry system as a wild steelhead stream precludes stocking of fry or surplus adults.

Characteristics of the most productive rearing streams include high gradient (60% riffle or greater), cool water temperatures, flows not less than 3 cfs, and low interspecific competition. The Salmonberry River and Cook Creek have all four features (Fig. 7). Lost Creek has less flow but meets the other three criteria. Foley Creek has a moderate gradient and contains good populations of other salmonids, but its size evidently permits it to also carry a good steelhead population.

Areas that were rearing some yearling steelhead generally had average low flows of 1-5 cfs, moderate gradient (40-60% riffle area), cool water temperatures, and were rearing good coho and cutthroat populations. Several of these such as Buster Creek and Fishhawk Creek #1 received heavy steelhead spawning use.

Waters providing little steelhead rearing were smaller or had low gradients. Most held good populations of coho and some contained cutthroat trout.

There were several notable exceptions to the above classification system. The main stem Nehalem from RM 34 to 100 has adequate flows (3-50 cfs) and light interspecific competition but a very low gradient with less than 10% riffle area. The isolated riffle areas (Fig. 8) appear capable of supporting a good number of steelhead yearlings, but production is generally low. Water temperatures in the high 70's and a bedrock stream bottom are limiting factors. From RM 34 to the head of tidewater (RM 8) it provides high flows (50-100 cfs), moderate gradient (40% riffle), and productive boulder and rubble stream bottom and appears to offer excellent steelhead rearing conditions (Fig. 9). While summer water temperatures reach the mid-70's F, they are cooler than those recorded upstream. Despite the apparently favorable habitat, there is virtually no steelhead production. Disease may be a limiting factor and will be discussed in a following section. Competition with fall chinook salmon is another possibility as our observations indicate the two species were not sharing main stem rearing areas.

The lower 29 miles of Rock Creek were supporting few yearling steelhead, yet had good flows (up to 12 cfs) and met the other criteria of productive rearing waters. It appears capable of much higher steelhead production but for reasons unknown to us does not.

Despite its size and large number of tributaries, it is obvious the Nehalem River drainage has a paucity of high quality steelhead rearing areas. Lack of such and the apparent failure of some areas to produce up to their potential greatly restrict wild steelhead production.

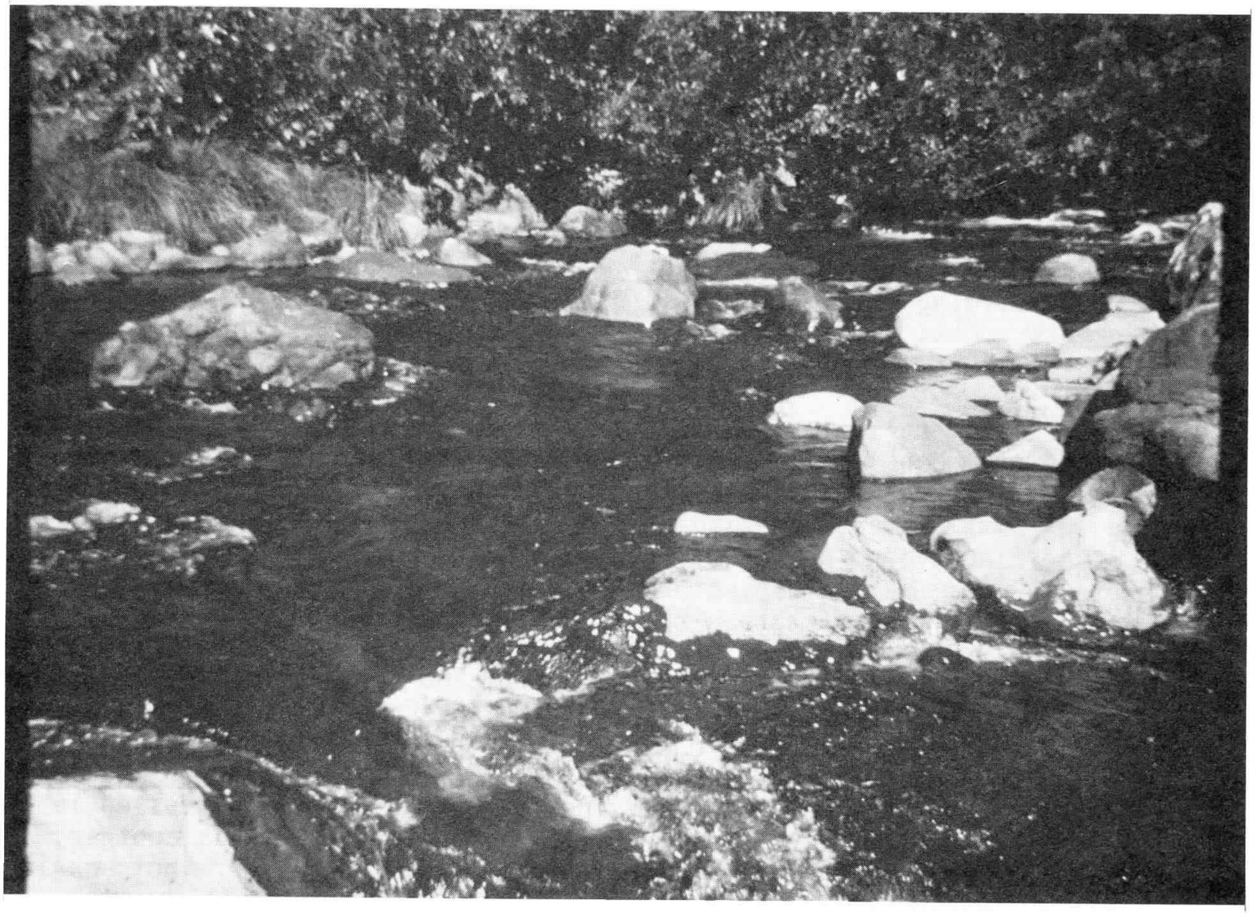

Fig. 7. Ideal rearing area in Salmonberry River.

Fig. 8. Isolated riffle areas in upper Nehalem River, RM 42.

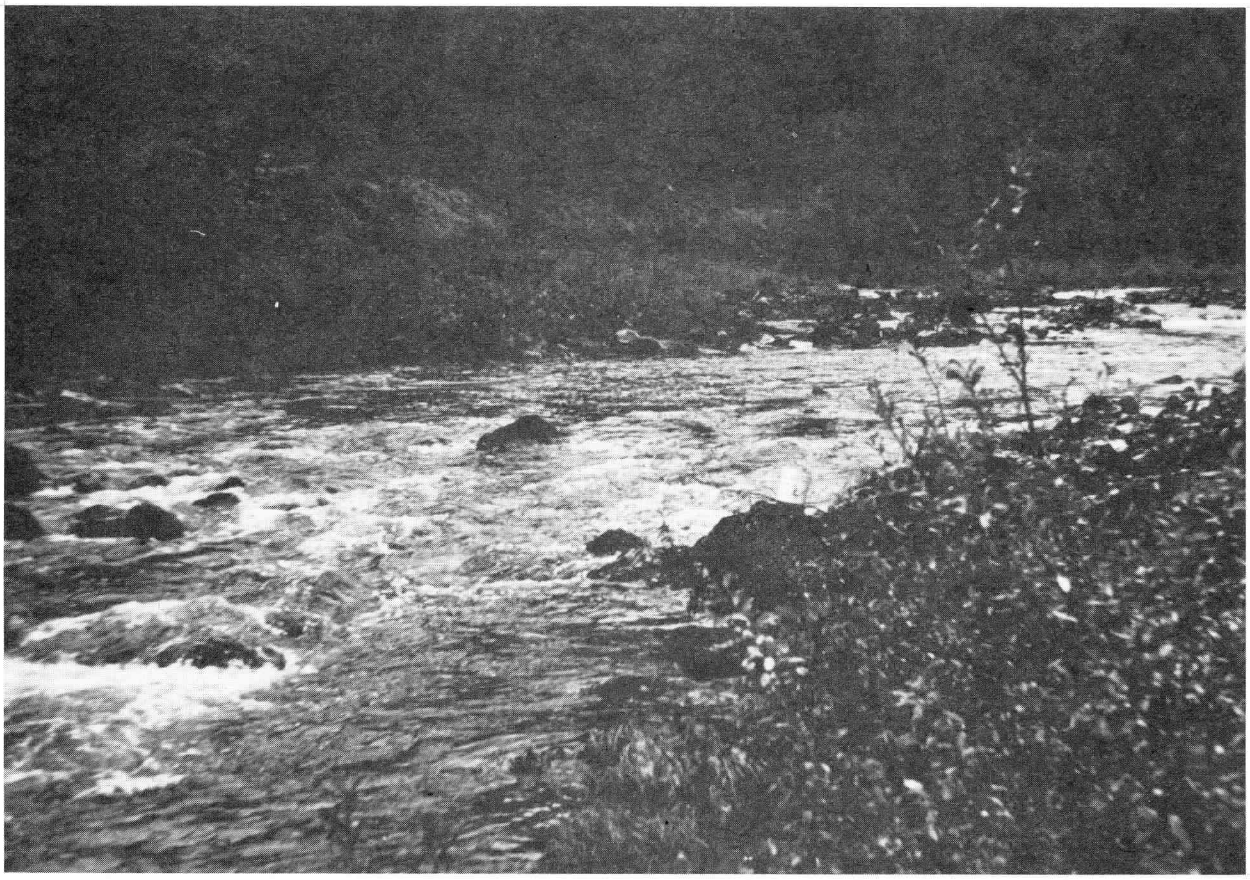

Fig. 9. Good rearing areas in lower Nehalem River, RM 20.

Study area selection. Snorkel observations of some of the larger tributaries indicated that adjacent sections of apparently similar habitat exhibited wide variances in salmonid populations. Steelhead yearling hook and line counts along a 1-mile section of the Salmonberry River ranged from 1-24 fish/100 yards. We have observed similar variances in other Oregon coastal streams.

We have also observed considerable annual variation in population density of a sample area. Several sections of Cook Creek were practically devoid of steelhead yearlings 1 year yet had a good population the next.

It is important to select an area large enough to smooth out such variations. Rearing studies should also be based on more than 1 year's observations.

North Fork Nehalem River

Studies were limited to noting potential rearing areas blocked by impassable falls or barriers. Anadromous fish passage to 4 miles of Grassy Lake Creek (RM 7) and 2 miles of Fall Creek is blocked. Both streams contain cutthroat trout, and Fall Creek has been stocked periodically with surplus adult coho salmon. Recent liberations in Grassy Lake Creek consist of a 1977 release of 54,000 steelhead fry and a 1976 stocking of about 20 adult coho.

At present it is impractical to provide fish passage over the barriers but additional steelhead rearing capacity could be obtained by placing fry or adults above the barriers. Grassy Lake Creek has adequate flow (low flow 2-6 cfs), cool water, and high gradient and appears to offer considerable steelhead production potential.

Fall Creek is smaller (1-2 cfs), has good water quality, and has a moderate gradient. Although capable of supporting some steelhead rearing, it appears to be a better coho stream and should be managed as such.

Steelhead stocking may depress native cutthroat populations but these fish presently attract little angler interest. However, emigrants may contribute to highly desirable sea-run cutthroat runs.

Spawning Ground Surveys

General

Spawning ground surveys recorded redds and fish. We felt valid counts could be obtained for both. Our marking study indicated that, in the absence of major freshets, redds remained visible for at least 1 month. The lighter color of freshly disturbed gravel remained visible for 2-3 weeks and the depression and tailing pile could be seen for a longer period. A major freshet would obliterate all redds. Stream channel stability and substrate size also influenced the duration of visibility.

Steelhead, when on the spawning grounds, were usually visible and could be counted. Few fish were noted actually hiding under cutbanks, roots, etc. Weber also noted this to be true in extensive Siletz River surveys. Fresh fish holding in larger tributaries usually will seek cover and would be an exception to the above observations.

Stream surveys can provide a reasonable, albeit conservative, estimate of steelhead spawning use. Redd counts are a superior measurement over fish observations because of the fish's transitory nature. We feel that most steelhead, particularly the females, leave the stream shortly after spawning. Many surveys located numerous fresh redds but few fish, and then they were mostly males. Our observations are not in agreement with those of Moring and Lantz (1975) who trapped all adult steelhead moving up or down a small, Oregon coastal stream. They found an average of 34 days was spent in the spawning stream. A disadvantage of using redd counts is that they are more or less an index instead of an escapement estimate unless one can somehow relate redd numbers to fish numbers. A female steelhead may construct more than one redd, and a single male may spawn with more than one female.

To obtain valid estimates, surveys must encompass the entire spawning period and should be done at least once a month. Survey design should include sections of both large and small streams to smooth out use fluctuations resulting from flow variations. The fish tend to use the smaller streams in high flow periods and the larger waters during low flows.

Nehalem River

Spawning areas. Little historical information was available, thus the main thrust of the 1974 program was the location of spawning areas. Sections of most large tributaries as well as a number of randomly selected small streams were surveyed. Stream size (spawning period flow) varied from 2 to 225 cfs with most being in the 15-100 cfs range. Most surveys were completed during the expected peak spawning period (late February to early April).

A total of 46.5 mi in 65 different stream sections was surveyed (Table 17). The watershed was divided for analytical purposes into four sections based on watershed characteristics. Fish and redd counts were comparable in the lower, middle, and headwater sections with 1.5-2.6 fish/mile and 10.2-11.3 redds/mile recorded. Only .5 fish and 4.3 redds/mile were observed in the upper section (RM 74-106) with virtually all activity noted in a single major tributary. This area represents 50% of the Nehalem watershed.

Heaviest spawning use was in larger (at least 30 cfs), high gradient (at least 50% riffle) streams. Weber and Fortune (1974) found considerable winter steelhead spawning in Siletz River tributaries with flows less than 10 cfs.

Nearly all the tributaries in the upper section are small with low gradients and silted streambeds. Summer rearing studies indicated little steelhead use of these smaller streams. Rock Creek, a major tributary entering at RM 90, provides an abundance of excellent spawning

Table 17. Summary of winter steelhead spawning ground surveys, Nehalem River system, 1974.

Section		Fish		Redds	
Description and length	Survey miles	No. counted	Fish/mile[a]	No. Counted	Redds/mile[a]
Lower Nehalem, RM 0 to 22 includes Cook Cr. and Salmonberry R.	16.95	45	2.7	175	10.3
Middle Nehalem, RM 22 to 47	15.75	24	1.5	178	11.3
Upper Nehalem, RM 47 to 106 includes Rock Cr.	8.00	4	0.5	34	4.3
Headwaters RM 106 to 118	5.80	12	2.1	59	10.2
TOTALS:	46.50	85	1.8	446	9.6

a/ Conversion to metric system. One mile = 1.6093 km.

habitat. All of the fish and all but one redd observed in the upper section were found in 3.65 miles of Rock Creek surveys. Some spawning occurs in the main stem Nehalem within this section but high flows and limited gravel preclude extensive use. High flows and turbid water made main stem observations difficult.

The 1975 and 1976 studies concentrated on those areas known or thought to be good spawning habitat. Multiple surveys further defined relative importance of each spawning area and accurately identified peak use periods. The Salmonberry River was the only area surveyed in 1977.

The 1975 surveys included 15.6 miles on 31 different stream sections (Table 18). The 1976 studies involved 12.2 miles of 24 areas (Table 19). Other locations were sampled but dropped from inclusion in Tables 16 and 17 when they were found to be unimportant as steelhead spawning areas. Caution should be used in comparing Tables 18 and 19 CUMULATIVE fish and redd counts with those shown on Table 17 or similar data from other studies. The typical reported spawning inventory consists of peak counts or only a single census while Tables 18 and 19 show the TOTALS from multiple observations. The different number of inventories between stream sections reflects different spawning period lengths and should not materially bias cumulative totals between streams unless so reported. Generally, the indicated figures, for redd counts at least, accurately reflect total spawning activity in the study sections.

With one exception, 1976 redd counts were consistently at least 50-75% below 1975 indicating a considerably lower escapement. The exception, Cook Creek, had a 1976 increase of 25% because of large 1974 smolt releases. There were also obvious variances from year to year between different sections of the same stream that could usually be explained by flow regime differences.

Our redd counts were generally lower than those reported by Weber and Fortune (1974) on four Siletz River (Oregon coastal) tributaries. These streams were only surveyed twice but cumulative totals averaged 57 redds/mile.

Table 20 lists the most extensively used waters and approximate miles of spawning habitat. Foley, Cook, and Rock creeks along with Salmonberry River receive the heaviest use with the latter two being the most important because of their length. Some of these streams such as Rock, Fishhawk #1, Buster, and Humbug creeks have good escapements but as discussed earlier provide little rearing.

The Salmonberry River, because of its size, is the most important steelhead production stream, but the fishery has been disappointing in recent years. Spawning escapement and fish rearing is out of proportion to the catch when compared to other streams. The possibility exists that most of the adult steelhead enter the Salmonberry River after the angling season closes. Salmonberry River creel survey (Table 8) indicated poor angling from 1973-74 through 1975-76. Catch

Table 18. Cumulative spawning ground counts for North Fork Nehalem and Nehalem River systems, 1975.

Stream	RM of entry into Nehalem	No. of sections surveyed	Survey length (miles) b/	No. of surveys	Survey period	Approx. spawning flows c/	Cumulative a/ b/ Redds/ mile	Fish/ mile	Peak spawning period
N. Fk. Nehalem	RM 3	3	1.5	3	02/07-04/16	20-125 cfs	108.0	24.7	Early April
Foley Cr.	RM 8	2	1.3	3	02/27-04/08	15-60 cfs	56.9	13.1	Mid-March
Middle Cook Cr.	RM 13	1	0.5	3	02/05-04/08	150 cfs	54.0	24.0	Early April
Upper Cook Cr.	RM 13	1	0.5	2	02/24-03/31	75 cfs	18.0	12.0	Early March
E. Fk. Cook Cr.	RM 13	1	0.5	4	02/05-04/08	40 cfs	80.0 d/	44.0 d/	Late March
Salmonberry R.	RM 22	4	2.5	2	02/06/-05/09	150-300 cfs	86.4	47.6	Mid-April
N.Fk. Salmonberry	RM 22	3	0.8	2	03/07-05/13	150 cfs	118.7 d/	125.0 d/	Late April
Cronin Cr.	RM 25	2	0.75	3	02/05-03/25	15-60 cfs	5.3	0	Inconclusive
Humbug Cr.	RM 35	2	0.75	3	02/05-04/10	15-60 cfs	38.7	0	Early March
W.Fk. Humbug Cr.	RM 35	2	1.2	2	03/05-03/25	35 cfs	11.7	4.2	Late Feb.
Buster Cr.	RM 44	3	1.2	1	03/24-04/13	25-100 cfs	21.7	5.0	Inconclusive
Fishhawk Cr. #1	RM 47	2	1.1	2	03/05-04/01	15-60 cfs	18.2	0	Late Feb.
Rock Cr.	RM 90	1	0.5	3	02/04-04/13	60-100 cfs	52.0	2.0	Late March
Upper Rock Cr.	RM 90	3	1.9	2	02/05-03/26	30-50 cfs	27.4	0.5	Var. by Sec.
Wolf Cr.	RM 107	3	1.6	3	02/05-04/13	25-75 cfs	21.9	0	Early March
Upper Nehalem R.	RM 109	1	0.5	3	02/04-04/13	50 cfs	30.0	6.0	Early March

a/ Sum of each survey's counts/length of the survey area.
b/ Conversion to metric. One mile = 1/6093 km.
c/ Conversion to metric. One cfs = 28.32 liters per sec.
d/ Survey ended at partial barrier, fish concentrated.

Table 19. Cumulative spawning ground counts for North Fork Nehalem and Nehalem River systems, 1976.

Stream	Point of entry (RM)[b/] into Nehalem	No. of sections surveyed	Survey length[b/] (miles)	No. of surveys	Survey period	Approx. spawning flows (cfs)[d/]	Cumulative count[a/] [b/] Redds/ mile	Cumulative count Fish/ mile	Peak spawning period
N. Fk. Nehalem	3	4	1.5	3	02/05-04/08	30-150	71.3	11.3	Early April
Foley Creek	8	2	1.2	3	02/19-04/16	30-60	30.8	9.2	Late March
Cook Creek	13	2	1.0	4	02/01-04/25	15-150	120.0 [c/]	30.0 [c/]	Early March & mid-April
E. Fk. Cook Creek	13	1	0.5	3	02/04-04/03	35-45	68.0 [e/]	50.0 [e/]	Mid-March
Salmonberry River	22	1	3.0	4	02/03-05/07	150-250	55.0	20.0	Early May
Humbug Creek	35	3	1.25	2-3	02/21-04/08	15-100	20.8	2.4	Late February
Buster Creek	44	2	1.0	2	03/02-04/08	40-125	11	3.0	Late March
Fishhawk #1	47	1	0.5	2	03/02-04/08	35-70	8	0	Late March
Fishhawk #2	66	2	0.5	1	03/06-04/08	55-60	16	0	Late March
Rock Creek	90	3	1.8	2-3	02/23-04/08	35-150	36.1	7.8	Early March
Wolf Creek	107	2	1.2	2	02/23-04/02	30-65	5.0	4.2	Late March
Upper Nehalem R.	109	1	0.3	2	02/23-04/02	30-65	0	2	Inconclusive

a/ Sum of each survey's counts/length of survey area.
b/ Conversion to metric. One mile = 1.6093 km.
c/ Returns from heavy stock influenced count.
d/ Conversion to metric. One cfs = 28.32 liters per sec.
e/ Survey ended at partial barrier, fish concentrated.

Table 20. Major steelhead spawning systems in the Nehalem River watershed.

Stream	Point of entry into Nehalem [a]	Approx. no. of stream miles available [a]
	HEAVY USE	
Foley Cr.	RM 8	10
Cook Cr.	RM 13	13
Salmonberry R.	RM 22	24
Rock Cr.	RM 90	35
	MODERATE USE	
Humbug Cr.	RM 35	16
Buster Cr.	RM 44	6
Fishhawk #1	RM 47	8
Fishhawk #2	RM 66	11
Wolf Cr.	RM 107	8
Main stem Nehalem River	RM 100 upstream	16

a/ Conversion to metric. One mile = 1.6093 km.

card data indicate the last 5 years (1972-76) produced less fish than any preceding period. Catch card and angler reports suggest a more successful fishery, particularly early in the season, until the beginning of the 1970's.

Spawning surveys (Table 21) show at least the late portion of recent escapements is comparable to earlier counts. They also document the apparent unexplained paucity of steelhead during the angling season.

Timing. Redd construction was observed as early as late January and continued well into May on the Salmonberry River. Analysis of creel spawning survey data in Tables 18 and 19 indicates that peak spawning periods by stream ranged from late February to early May with most streams showing a peak sometime in March. Hatchery returns have been low so essentially we are reporting wild steelhead behavior. An exception would be the early March 1976 peak observed on Cook Creek where hatchery fish made up much of the population. Late activity was associated with larger streams in the lower watershed, mainly Cook Creek and the Salmonberry River. The Salmonberry population is particularly unique in that spawning extended well into May and it was not until mid-April that much activity at all was noted. April and May observations recorded at least 13 and up to 48 redds/mile. Prior to our study, counts had been made in April and May and no information is available on earlier activity.

The possibility exists that early spawning fish could be using the system above our survey areas. However, a March 24, 1977, inventory of 1.2 miles of excellent headwater habitat recorded only 6.7 redds/ mile.

Further, confirming the lack of early activity were observations at a partial barrier on the North Fork Salmonberry River. It is the major tributary of the Salmonberry River and enters at RM 8. Prior to mid-April few fish could be seen below the falls and little, if any, indication of fish or spawning above. Later observations showed large numbers of fish congregated below the falls and by late April good numbers were upstream. Passage at the falls is difficult as indicated by a mid-April observation of 62 unsuccessful attempts to jump the falls in one 5-minute period. Passage may be somewhat related to low flow conditions, but in 1977 low water prevailed throughout the spawning period and no fish or redds were noted upstream until late April. Possibly the late-run fish are uniquely adapted to navigate the barrier.

The poor angler success in Salmonberry River may be because most of the fish enter the river after the season closes. Angler interest is relatively low in March and, even if available, the fish would receive only light angling pressure. However, we feel that these steelhead make an important contribution to the Nehalem fishery in March.

Table 21. Salmonberry River winter steelhead spawning ground counts, 1953-77.

Year	Date of survey	Miles of river surveyed[a/]	Number		Number per mile	
			Fish	Redds	Fish	Redds
1953	Mid-April	8.0	238	-	29.8	-
1957	Mid-April	7.0	134	-	19.1	-
1958	Early April	8.0	142	-	17.8	-
1959	Unknown	6.0	70	-	11.7	-
1960	Early May	6.0	40	-	6.7	-
1961	Early April	3.0	26	-	8.7	-
1962	Early April	3.0	31	-	10.3	-
1973	Early April	3.0	37	76	12.3	25.3
1974	Mid-April	3.0	17	54	5.7	18.0
1975	Early February	2.7	1	4	0.4	1.5
	Mid-March	3.8	17	9	4.5	2.4
	Mid-April	3.8	93	186	24.5	48.9
	Early May	.75	3	14	4.0	18.7
1976	Early February	3.0	1	5	0.3	1.7
	Early March	3.0	10	10	3.3	3.3
	Early April	3.0	32	40	10.7	13.3
	Early May	3.0	17	110	5.7	36.7
1977	Mid-February	2.5	6	13	2.4	5.2
	Late March	2.5	8	6	3.2	2.4
	Late April	3.0	29	73	9.7	24.3

a/ One mile = 1.6093 km.

An unusual number of trophy-sized fish in the 20-lb class were noted in the April and May surveys in Salmonberry. Between 5 and 10 were observed each trip and most were dark males which appeared to have been in the river a considerable time. In the authors' experience on other Oregon coastal streams, including extensive surveys on the Siletz River (Weber and Fortune 1974), such large steelhead were rarely, if ever, observed.

Hatchery fish. Capture attempts were concentrated in those streams where returning fish were expected from smolt releases. The relatively large flow associated with the preferred spawning areas frustrated our dip-net capture techniques (Fig. 10). Weber and Fortune (1974) experienced greater success on smaller tributaries of the Siletz River.

Only 12 fish were captured in 1974 including 4 from West Humbug Creek where returns from a 1972 liberation of 16,700 smolts were expected. Two were marked and this, along with unusually high counts, indicated some returns. None of the 5 fish captured in Wolf Creek were hatchery stock although 29,000 smolts had been released. One of the four fish captured in other streams was a hatchery fish. In 1975 none of the 8 steelhead captured or closely observed in Cook Creek were marked although returns were expected from a 1973 release of 17,600. Overall spawning survey observations provided no indication that the low 1975-76 hatchery fish return to the fishery was compensated for by excessive escapement.

Returns from a 1974 release of 52,700 smolts in or adjacent to the mouth of Cook Creek had a definite influence on 1976 Cook Creek spawning ground counts. It was the only tributary stocked and the only stream surveyed that had increased numbers over 1975. Ten of the 14 fish captured were hatchery fish. Their presence reflects the heavier stocking and a better rate of return than 1975. Rate of return in 1975-76 excluded that of the previous year by a factor of seven (Table 6).

This should not be construed as a breakthrough in obtaining a successful return. Even a poor 1% return from 52,700 smolts would have created a very obvious run of about 500 fish. Spawning surveys indicated an increase, but angling success remained relatively poor (Table 8) at 24.6 hours/fish.

North Fork Nehalem River

Spawning areas. Surveys were conducted on the North Nehalem watershed in 1975 and 1976. All important areas were not included but three sections of excellent habitat, totaling 1.5 miles, were counted three times each year between early February and early to mid-April. Two main stem sections were at RM 15 and 17. Either Sweet Home Creek or Fall Creek, tributaries entering at RM 15 and 16.5, represented the other

Fig. 10. Dip-net capture of steelhead in spawning area.

section. Spawning period flows ranged from an estimated 75-150 cfs at RM 15 to 20-40 cfs in Sweet Home Creek. Other suspected important spawning areas include Soapstone Creek, Gods Valley Creek, and the Little North Fork. The main stem furnishes suitable habitat for most of its length above RM 5. Considerable April spawning occurs in the lower main stem (RM 5-10). There was no historical data available. Cumulative 1975 counts totaled 108 redds and 24.7 fish/mile (Table 18). The 1976 numbers were considerably lower at 71.3 redds and 11.3 fish/mile (Table 19).

The greatest decline (50%) was noted in the early census and certainly reflects a 63% reduction in 1974 hatchery releases. Presumably most of the early spawners are of hatchery origin. A drop in the 1976 wild fish escapement was also noted in Nehalem River surveys. Cumulative totals for both years are conservative in that considerable spawning occurs well before and after our survey period. January freshets obliterated early redds in both years and a considerable amount of superimposition was noted.

Timing. Spawning begins in December and extends into late April. The hatchery stock (Big Creek) is an early spawning fish and is responsible for much of the early spawning activity. The egg-taking operations at the North Nehalem Hatchery begin in mid-January as they have since its beginning. Peak natural spawning takes place in early April and presumably is mainly wild fish. A secondary peak occurs in early February and represents mainly hatchery fish activity.

Hatchery fish. Hatchery contribution to the fishery has been good and we felt no need to evaluate hatchery escapement. Overall escapement is adequate, and a harvestable surplus presently exists.

Disease Studies

Tests Conducted in 1975

Experiment 1 - Alsea and North Nehalem steelhead. In mid-April 1975, 50 Alsea stock (coastal) steelhead smolts at a size of 7.3 fish/lb from Cedar Creek Hatchery and 50 Big Creek stock (lower Columbia River) smolts at a size of 6.7/lb from the North Nehalem Hatchery were placed in each of 12 live-boxes at the sites listed below:

Site No.	Location
1	Nehalem R. - Head of Tide RM 7
2	Nehalem R. - Head of Tide RM 7.5
3	Nehalem R. RM 19
4	Nehalem R. RM 21
5	Salmonberry R. RM 0.1 Trib. to Nehalem at RM 22
6	Salmonberry R. RM 0.5 Trib. to Nehalem at RM 22
7	Nehalem R. RM 34
8	Nehalem R. RM 34
9	Nehalem R. RM 42
10	Nehalem R. RM 42
11	N.F. Nehalem R. RM 8 Trib. to Nehalem at RM 3
12	N.F. Nehalem R. RM 10 Trib. to Nehalem at RM 3

All boxes were placed on the streambed except #1 which was floating.

Samples of fish from each lot on April 30 and May 19 were killed, examined, and found to be free of diseases and parasites. Frozen samples of an occasional mortality were examined and were also disease free. The fish appeared healthy until June 10 when the first substantial mortalities occurred and within 3-5 days high losses were experienced. The losses were in all main stem Nehalem boxes except the uppermost ones at RM 42. Of the 215 identifiable mortalities occurring between June 10 and June 16, 158 (73%) were Alsea fish. Few of this group survived beyond June 16. The Big Creek fish began to show increased losses on June 16 and by July 7 most of them were dead.

The fish live-boxed at RM 42 eventually suffered nearly 100% mortalities but the mortality pattern differed. Heavy losses were first observed June 16 and continued at a gradual rate, taking about equal numbers of each stock until only a few survivors remained by July 23.

Fish held in the Salmonberry and North Fork Nehalem rivers experienced little loss and the test was terminated on August 1. There was a noticeable decline in body condition during the 107-day experiment.

Maximum Nehalem River water temperatures were in the high 40's and low 50's through the first week in May and rose to the mid-50's by midmonth. Temperatures reached the 60's in late May and remained above 60 until the experiment was terminated. Maximum temperature recorded was 72 F in late July. Temperatures in the North Fork Nehalem and Salmonberry rivers were nearly identical but were usually 2-7 F lower than those recorded in the Nehalem River. Peak temperatures were in the high 60's.

Table 22 presents the results from the pathologist's examination of sacrificed fish and natural mortalities. Only smolts taken from the boxes after June 9 are included. Mortalities examined included frozen or fresh specimens. Only those losses obtained within approximately 24 hours after death were retained for examination.

A high percentage of the Alsea River stock live-boxed between RM 7 and 34 of the main stem Nehalem were found to be infected with the myxosporidian parasite, <u>Ceratomyxa shasta</u>. Infections were found in 40 of 44 fish (90.9%) examined. This parasite is known to cause heavy mortalities in salmonids, and juvenile steelhead are very susceptible (Sanders, Fryer, and Gould 1970).

The Big Creek stock had a much lower incidence of <u>C. shasta</u> with only 16% or 13 of 79 fish infected. The presence of <u>C. shasta</u> has been documented in the Columbia River but it was not thought to be present in Oregon coastal streams except in isolated instances (Sanders et al. 1970). They reported finding a high incidence in adult coho salmon from the Nehalem River but speculated that the fish had become infected when they strayed into the Columbia River estuary.

Table 22. Experiment 1. Incidence of *Ceratomyxa shasta* and *Aeromonas salmonicida* (Furunculosis) in two hatchery stocks of winter steelhead live-boxed in the Nehalem, Salmonberry, and North Fork Nehalem rivers, 1975.

Live-box no.	Live-box location	Infected with Certomyxa shasta		Infected with Aeromonas salmonicida	
		Big Creek stock	Alsea River stock	Big Creek stock	Alsea River stock
1	Nehalem R. (RM 7)	5/20 1/	14/14 1/	1/5 1/	2/6 1/
2	Nehalem R. (RM 8)	4/16	6/6	0/3	0/1
3	Nehalem R. (RM 19)	2/18	6/6	0/9	0/5
4	Nehalem R. (RM 21)	1/12	9/11	0/5	3/5
8	Nehalem R. (RM 34)	1/13	5/7	2/4	-
TOTAL NEHALEM R. (RM 7-34)		13/79	40/44	3/26	5/17
10	Nehalem R. (RM 42)	0/9	0/8	2/4	0/5
5	Salmonberry River (RM 0.4)	0/5	0/5	0/5	0/5
11	N. Fk. Nehalem R. (RM 8)	0/10	0/10	2/5	1/5

1/ Number of fish infected with *C. shasta* or *A. salmonicida* over total number of fish examined for each disease.

The infection rate variance between the two stocks is thought to be the result of a genetic resistance in the Big Creek stock evolving from a historical exposure to the disease. It is likely that the Alsea River stock has never been exposed. Sanders et al. (1970) examined 28 adult steelhead from Alsea River and found no incidence of C. shasta. The Oregon Wildlife Commission (1975) determined a coastal race of summer steelhead (Siletz River) to be much more susceptible than three Columbia River stocks.

Significant mortalities did not occur in our experiment until 56 days after the tests began. C. shasta requires an incubation period which is inversely related to water temperatures (Udey et al. 1975). Water temperatures reached the 60's about 10 days prior to the onset of heavy losses. The warmer water accelerated the loss but an exposed, susceptible fish would eventually be affected even if the water remained cold (Udey et al. 1975). The disease organism is difficult to identify until late in the incubation period. (Udey et al. 1975).

Although the Big Creek smolts eventually suffered mortalities approximating 100%, it is thought that most of them died from a bacterial disease, Aeromonas salmonicida, commonly referred to as furunculosis (James E. Sanders, personal communication). The warmer water temperatures triggered the onset of this disease and explains why the Big Creek stock began to die at about the same time the Alsea River stock was suffering heavy losses from C. shasta. The live-boxed fish in the Willamette River study, that were resistant to C. shasta, also suffered heavy losses from furunculosis despite the use of antibiotics in their diet. Our experimental steelhead were stressed by snout injuries, limited food, and high water temperatures. Stressed fish are known to be more susceptible to furunculosis.

Table 22 does not indicate a high incidence but relatively few fish tested for this disease were mortalities. If more losses had been examined, the incidence of furunculosis probably would have been much higher.

The complete absence of C. shasta from RM 42, the uppermost site, is noted in Table 22. Similar situations have been reported from other areas. In the Deschutes River the disease is not found above the mouth of the Little Deschutes River, and in the Columbia it is absent above the Deschutes (Sanders et al. 1970). In the Willamette River experiment live-boxed fish were infected only up as far as the mouth of the Marys River, yet tests in that system did not isolate C. shasta (personal communication, James E. Sanders, 1975). There may be a relationship between the complete absence of wild juvenile steelhead in the Nehalem below RM 42 and the presence of C. shasta. Juvenile steelhead were present at RM 42 and above.

Both stocks experienced heavy losses at the RM 42 site. Furunculosis was considered the main causative agent (James E. Sanders, personal communication). Some of the fish were also infected with Nanophyetus salmincola, the salmon poisoning trematode. The dark, hemorrhagic spotting caused by the parasite was not noticed until early July after much of the mortality had already taken place.

C. shasta was not found in any of the test fish from the Salmonberry and North Fork Nehalem rivers despite a 107-day exposure period and water temperatures conducive to the development of the disease. Losses among these fish were light throughout the duration of the study. Some furunculosis was found in the North Fork fish but was not detected in the Salmonberry River samples.

Experiment 2 - Alsea River cutthroat at RM 71 site. Some cutthroat stocks suffered heavy losses from C. shasta when exposed in the Willamette River (Zinn et al. 1976). We were concerned that Alsea stock cutthroat which are released each year in the Nehalem may also be affected by the disease. We also wanted to confirm the absence of C. shasta at RM 42 and above.

Fifty Alsea 0+ juvenile cutthroat (67.5 fish/lb) were placed in live-boxes at RM 34, 42, and 71 on August 13, 1975. Losses were heavy at all three sites but C. shasta infections were found only in fish from RM 34. A high percentage (61.9%) were infected. The other loss factors were not diagnosed but probably were bacterial diseases promoted by the live-box environment and warm water. Maximum water temperatures ranged from 58 to 71 F and averaged 65 F. Table 23 summarizes the test results.

Tests Conducted in 1976

Experiment 3 - determination of C. shasta infectious period. This study was designed to determine the degree of exposure experienced by steelhead released at different times within the normal liberation period (late March to early May). Beginning March 15, 1976, 20 Alsea stock smolts (7.4/lb) were live-boxed at RM 7, exposed for 7 days, transferred to the Corvallis fish disease lab, and held in 64 F disease-free water. This process was repeated at weekly intervals with the last group exposed on May 11. The fish were not fed while in the river but received daily satiation feedings at the laboratory.

Table 24 indicates C. shasta first became infectious during the week of April 7-14 in 1976. The incidence of infection remained at a low level for another week, then sharply increased, and by late April was 91%.

Water temperatures remained below 50 F and averaged about 46 F until the first week of May then exceeded 50 F and averaged about 55 F until the test was terminated May 18.

In Willamette River experiments, the appearance of the disease varied 2-3 weeks from year to year but generally seemed directly related to water temperatures (Jim Sanders, personal communication, 1976). Udey et al. (1975) found juvenile rainbow could be infected at temperatures as low as 44 F and mortality was independent of water temperatures. They did note, however, that time from exposure to death was temperature dependent.

If 1976 was a typical year as to timing of the appearance of C. shasta, steelhead smolt liberations in most years were made into waters already infectious with the disease.

Table 23. Experiment 2. Incidence of *Ceratomyxa shasta* in Alsea stock cutthroat trout live-boxed at three locations in the Nehalem River, August 13 to September 18, 1975.

Live-box location	Number of Fish						Percentage infected
	Exposed	Adjusted a/	Mortalities	Sacrificed	Survivors	Examined b/	
RM 34	48	42	27	6	9 c/	21	61.9
RM 42	50	38	12	10	16	16	0
RM 71	50	31	14	8	9	14	0

a/ Number of fish surviving after 2 weeks of exposure.
b/ Includes both mortalities and sacrificed fish.
c/ Terminated on September 4.

Table 24. Experiment 3. Determination of the time of appearance in the Nehalem River of the infectious stage of *Ceratomyxa shasta*, 1976.

Exposure period	No. of fish[a/] Exposed	No. of fish[a/] Adjusted b/	No. of fish infected *C. shasta*	Percentage infected *C. shasta*
March 15-24	16	16	0	0
March 24-31	10	6	0	0
March 31-April 7	18	11	0	0
April 7-14	21	21	2	10
April 14-21	19	19	1	5
April 21-28	18	11	10	91
April 28-May 5	17	11	10	91
May 5-11	25	24	23	96
May 11-18	15	15	14	93

a/ Alsea winter steelhead (7-10/lb) from Cedar Creek Hatchery were used in these experiments. The fish were exposed in the main stem Nehalem River at RM 7.

b/ Only fish surviving past the period in which *C. shasta* could be isolated are included. Some of the losses were from nitrogen gas bubble disease contacted at the laboratory.

Experiment 4 - 1975-brood smolts from the Alsea and North Nehalem rivers. On May 24, 1976, 50 Alsea (4.8/lb) and 50 North Nehalem stock (6.0/lb) winter steelhead post-smolts were placed in each of two floating live-boxes at RM 7. Fifty Alsea fish were also tested at RM 18. A thermograph installed at RM 7 provided continuous water temperature readings during most of the test.

This experiment essentially duplicated some of our 1975 work and was performed to verify that the 1975 results were not the result of some unusual circumstances. A major variation was that the North Fork fish were not reared from eggs taken at the Big Creek Hatchery but were obtained from adult fish trapped at the North Nehalem Hatchery and spawned in late January 1975.

As in the past year, the Alsea stock suffered heavy losses from C. shasta. The loss probably would have approximated 100% except for the early termination of the experiment at RM 18. Table 25 details the results of this test. North Nehalem fish also had a high infection rate (72.8%) and suffered heavy losses (48%). Nearly all the Alsea fish were dead by July 2 while 52% of the North Fork fish survived up to July 13 when the experiment was terminated. The surviving fish were still feeding and active on that date. Six of the North Fork survivors were sacrificed and examined. One of the fish was heavily infected and two had light infections. The 52% survival of this group after a 50-day exposure is indicative of some resistance, but the North Fork stock held at the same site in 1975 experienced only a 25% infection rate. If it is assumed that all of the 1976 mortalities were due to C. shasta (all nine examined were), an infection rate of 89% is indicated. The higher incidence this year is difficult to explain. The 1975 test fish were reared from eggs of a resistant stock (Big Creek) while the 1976 fish were reared from eggs taken from adults returning to the holding pond at North Nehalem Hatchery. It is believed that these adults were returnees from Big Creek smolts released at the hatchery site. The fish entered the holding pond on their own even though they had the option to proceed upstream. If anything, the 1976 fish should have shown less infection and mortality. They were live-boxed only 50 days compared to 83 days for the 1975 group and fed medicated (3% TM 50) feed to reduce bacterial infections and related stress. The 1975 test fish did not receive medicated feed and suffered heavy losses from bacterial diseases (Weber and Knispel 1975). Most of the 1975 mortalities occurred after the normal incubation period for C. shasta had passed. Water temperatures were generally similar both years. In 1976 they ranged from 50 to 59 F until June 18 and from then until termination from 58 to 65 F.

Experiment 5 - estuary exposure. Fifty Alsea (4.8/lb) and 50 North Nehalem stock (6.0/lb) post-smolts were live-boxed in the Nehalem estuary at RM 2.5 or 0.5 mile below the mouth of the North Fork Nehalem. Exposure began on May 24 and a thermograph provided continuous water temperature data from May 26 to July 1. The purpose of this study was to determine how far downstream into the estuary C. shasta occurs and if fish emigrating from the North Fork Nehalem are exposed.

Table 25. Experiments 4 and 5. Results of exposing two stocks of winter steelhead (1975 brood) in the Nehalem River, May 24 to July 13, 1976.

Stock	Live-box location	Number of fish				Percentage positive for *C. shasta*	
				Examined			
		Exposed[a]	Mortalities	Mortalities	Survivors	Mortalities	Survivors
EXPERIMENT 4							
Alsea	RM 7	100	100	47	0	100.0%	-
North Nehalem	RM 7	92	44	9	11[b/c]	100.0%	72.8
Alsea	RM 18	40	27	12	13[d]	100.0%	100.0
EXPERIMENT 5							
Alsea	Estuary, ½-mile below mouth of North Fork	50	50	15	0[c]	100.0%	-
North Nehalem	Same	50	11	4	6[c]	100.0%	0.0

a/ Exposed on May 24.
b/ Five of survivors were sacrificed on July 8.
c/ Experiment terminated on July 13.
d/ Experiment terminated on June 29.

It was determined that C. shasta is present at high levels as far downstream as the upper end of the estuary. Data presented in Table 25 indicate the Alsea steelhead experienced nearly 100% mortality from the disease while North Nehalem stock experienced only 22% mortality. Six of the 39 surviving North Nehalem fish were tested at the end of the exposure period and found to be disease free. The mortality rate difference of the North Nehalem stock between Experiments 4 and 5 seems to indicate that the disease is at a reduced level in the estuary but still capable of causing heavy infections in a susceptible stock. Water temperatures were similar to those recorded in Experiment 4. Hydrometer measurements indicated very low surface salinity occasionally during low flows and high tides. Greater levels may have been reached during the highest tides but no measurements were obtained at those times.

Experiment 6 - North Fork Nehalem coho. The North Nehalem coho stock are descendants from two broods (1964 and 1965) taken from Foley Creek (lower Nehalem River) and the 1966 brood transferred in from the Trask Hatchery. The Trask stock is a coastal form never known to have been exposed to C. shasta. We would expect this fish to be susceptible while those from Foley Creek should be resistant.

Moring and Lantz (1975) noted that over 90% of the adult fish returning to an Oregon coastal stream were age 1/2 so the genetic integrity of the three broods should have been essentially maintained over the years. The Trask fish would be represented in the 1969, 1972, and 1975 broods.

On May 20, 1976, 50 1974-brood coho post-smolts (14.8/lb) from the North Nehalem Hatchery were placed in two live-boxes at RM 8 and in a box in the estuary adjacent to Experiment 5. Daily maximum water temperatures ranged from 50 to 59 F until June 18 and from then until termination were 58-65 F.

Table 26 indicates that fish at both sites suffered heavy losses and that all natural mortalities, sacrificed samples, and survivors were infected with C. shasta. No difference in infection rates was noted between sites, even though Experiments 4 and 5 had shown that the potentially resistant North Nehalem steelhead suffered lower infections at the estuary site. We were surprised that this brood of coho was not more resistant considering its Foley Creek background.

Experiment 7 - wild steelhead from the Nehalem River. To test the C. shasta resistance qualities of native Nehalem River steelhead, 14 yearlings (4-7 in FL) were captured by fly angling in the Salmonberry River in late May 1976 and subsequently live-boxed at RM 19. Alsea stock post-smolts (4.8/lb) in an adjacent box served as a control group. After a 14-day exposure, the 12 surviving wild fish and 10 of the control fish were transferred to the Corvallis laboratory.

This experiment was duplicated on June 18, 1976, with 16 wild Salmonberry yearlings. The fish were exposed for 20 days and the 7 surviving wild fish and 10 of the control were transferred to the laboratory.

Table 26. Experiment 6. Results of exposing North Nehalem Hatchery coho salmon in the Nehalem River, May 26 to July 13, 1976.

Live-box	Number of fish					Percentage infected with C. shasta	
				Examined			
location	Exposed	Mortalities	Sacrificed	Mortalities	Survivors/sacrificed	Mortalities	Survivors/killed
RM 8	100	83	11[a]	14	17[a]	100.0%	100.0
Estuary, RM 2.5	50	43	5[b]	11	7[b]	100.0	100.0

a/ Eleven fish killed between 6/27 and 6/29. Test terminated on 7/6.
b/ Five fish killed on 7/6.

Table 27. Experiment 7. Susceptibility of wild juvenile steelhead exposed to *Ceratomyxa shasta* in the Nehalem River, 1976.

Stock	Exposure period	Number of fish			Percentage infected
		Exposed	Adjusted[a]	Infected with C. Shasta	
		Exposure A			
Alsea (Control)	5-24 to 6-9	10	10	9	90
Wild (Salmonberry)	5-26 to 6-9	16	12	4	33
		Exposure B			
Alsea (Control)	6-20 to 7-8	11	11	11	100
Wild (Salmonberry)	6-18 to 7-8	16	7	5	71

a/ Adjusted figures indicates number of surviving fish taken to Corvallis Fish Disease Laboratory for holding.

Continuous water temperature data were obtained from a thermograph located at RM 7. Although we attempted to feed the fish every 2 or 3 days with a medicated (3% TM 50) pellet the wild steelhead were never observed feeding although food remained in the box and may have been eaten later. Table 27 indicates that wild native steelhead yearlings offered considerable resistance to C. shasta but still suffered some losses in two live-box exposure tests. The control, susceptible Alsea stock steelhead, suffered high losses in both exposures. The wild fish had a 33% infection rate during the early exposure but it rose to 71% on the subsequent test. The first exposure was 14 days (5/24-6/9) with water temperatures in the low 50's F. The second exposure lasted 20 days (6/18-7/8) and temperatures averaged 10-12 F higher. The warmer water temperatures undoubtedly stressed both wild and control fish to a greater degree. In addition, furunculosis, Aeromonas salmonicida, was found in five of the seven wild fish in the second exposure but was not isolated from the control. This is a common disease when a stressed and injured fish is subjected to water temperatures such as those recorded during the exposure period. The hooking injury incurred when the wild fish were captured undoubtedly made them more susceptible to both C. shasta and bacterial diseases (James E. Sanders, personal communication). The wild fish losses (9 of 16) prior to transfer were probably due to bacterial disease as the short holding period precludes C. shasta from being a mortality cause. The control fish readily accepted the medicated pellets and obtained some protection from bacterial diseases.

Experiment 8 - 1976-brood cutthroat from Big Creek and steelhead from Alsea, North Nehalem rivers. On July 27, 1976, 50 1976-brood Big Creek cutthroat trout (200/lb) Alsea steelhead (250/lb) and North Nehalem steelhead (130/lb) were placed in three floating pens in the Nehalem River (RM 7.5). Because of their small size, it was necessary to hold the fish in perforated 3-gallon plastic buckets suspended from the pen roof. We were hoping the Big Creek cutthroat would be C. shasta resistant and could be used in Nehalem River management programs as a substitute for the susceptible Alsea cutthroat. We were also disappointed in the showing of the 1975-brood North Nehalem steelhead (Experiment 4) and wanted to evaluate the 1976 brood as soon as possible. The Alsea steelhead were used as the control.

After a 6-day exposure period, 30 of each North Nehalem steelhead and Big Creek cutthroat were transferred to the Corvallis laboratory. All but three Alsea fish had escaped but these were also transferred. Maximum water temperatures were in the high 60's. Table 28 indicates all groups suffered a high incidence of C. shasta infection. The North Nehalem steelhead's lack of resistance (100% incidence) was particularly disappointing. We also felt the Big Creek cutthroat would be more resistant but this stock had suffered a 50% infection when tested in the Willamette River (Jim Golden, ODFW, personal communication) while his Alsea cutthroat trout control showed a 100% incidence. Our fish suffered heavy losses (24 fish) within 10 days after transfer. Bacterial diseases were presumably the cause as C. shasta requires a longer incubation period (James Sanders, personal communication).

Table 27. Experiment 7. Susceptibility of wild juvenile steelhead exposed to Ceratomyxa shasta in the Nehalem River, 1976.

Stock	Exposure period	Number of fish: Exposed	Adjusted[a/]	Infected with C. Shasta	Percentage infected
		Exposure A			
Alsea (Control)	5-24 to 6-9	10	10	9	90
Wild (Salmonberry)	5-26 to 6-9	16	12	4	33
		Exposure B			
Alsea (Control)	6-20 to 7-8	11	11	11	100
Wild (Salmonberry)	6-18 to 7-8	16	7	5	71

a/ Adjusted figures indicates number of surviving fish taken to Corvallis Fish Disease Laboratory for holding.

Table 28. Experiment 8. Susceptibility of 1976-brood North Nehalem winter steelhead and 1976-brood Big Creek cutthroat trout to *Ceratomyxa shasta* in the Nehalem River, 1976.

Stock	Exposure period	Number of fish: Start	Number of fish: Adjusted[a]	Number of fish: Infected with *Ceratomyxa shasta*	Percentage infected[b]
Alsea winter steelhead - 1976 brood (control)	7-27 to 8-2-76	3	3	3	100.0
North Nehalem winter steelhead - 1976 brood	7-27 to 8-2-76	30	28	28	100.0
Big Creek cutthroat - 1976 brood	7-27 to 8-2-76	30	6	5	83.3

a/ Excludes fish which died prior to the required incubation period for *C. shasta*. Mortalities prior to August 12 were not considered to be from *C. shasta*.

b/ Test terminated on August 31. There were no surviving fish.

Sanders noted other researchers had documented that even resistant fish could be overwhelmed by the disease if highly stressed. It is possible the warm water temperatures, live-box environment, snout abrasions, and disease problems produced such a stress level.

The North Nehalem steelhead and Big Creek cutthroat left in the boxes died within 15 days of exposure. Again, the short incubation period precludes C. shasta as the causative agent.

Experiment 9 - 1976-brood steelhead from Alsea and North Fork Nehalem rivers. This test duplicated Experiment 8 except that no Big Creek cutthroat were involved. On September 16-17, 20 1976-brood Alsea steelhead (50/lb) and 20 1976-brood North Nehalem fish (26/lb) were placed in two floating boxes at RM 7, exposed until September 30, and then transferred to the Corvallis laboratory. Again, both groups suffered 100% loss from C. shasta. Water temperatures were cooler than those in Experiment 8 with maximum temperatures averaging 64 F and the fish were larger. The North Nehalem fish still gave no indication of C. shasta resistance. Possibly, the time of exposure and their small size produced an exaggerated infection rate in the North Nehalem fish in both Experiments 8 and 9.

Experiment 10 - seasonal presence of infectious C. shasta. As far as steelhead stocking is concerned, it is more or less academic whether the disease persists through the fall and winter months, but this becomes relevant when fall releases of fall chinook salmon are discussed. Subyearling 1976-brood Alsea steelhead (30/lb) were first exposed on September 30, 1976, and the last group was exposed on December 22, 1976. This test was conducted identically to Experiment 3. Table 29 indicates infections remained high through November 10-24 and then fell off sharply but still persisted well into December. The sharp decrease in the infection rate can be correlated with a decrease in water temperatures beginning on November 26. A low of 37 F was recorded on December 2. Another cold spell during the December 22-January 7 exposure may have eliminated the disease incidence. Water temperatures fell to 34 F on January 7, 1977. Udey et al. (1975) reported that rainbow trout (Salmo gairdneri) exposed to C. shasta at 39 F suffered no losses, and no mortality was found in coho salmon exposed at 44 F. They also noted that mortality rates were independent of water temperature above 39 F in rainbow trout but increased with increasing temperature for coho salmon.

Tests Conducted in 1977

Experiment 11 - 1976-brood steelhead smolts from North Nehalem River. The 1976-brood North Nehalem stock had shown poor resistance to C. shasta when tested as fingerlings in late July 1976 (Experiment 8) and mid-September 1976 (Experiment 9). The 1977 test was designed to simulate the exposure faced by a typical smolt release. On April 3, 1977, 81 1976-brood Alsea (7.0/lb) and 70 North Nehalem smolts (7.6/lb) were placed in each of two floating live-boxes at RM 7. Sixty-two Big Creek smolts (6.6./lb) were exposed at RM 8 on April 10. The Alsea fish served as a positive control. The Big Creek steelhead, known to be C. shasta resistant, served as the negative control. On April 18, samples

Table 29. Experiment 10. Presence of infectious *Ceratomyxa shasta* in the Nehalem River, September 30, 1976-January 7, 1977.

Date of exposure	Average daily maximum water temperatures a/	No. of fish exposed b/	No. of fish infected with *C. shasta*	Percentage infected
Sept. 30-Oct. 14	58 F (15.5 C)	17	15	88
Oct. 14-29	52 F (11.1 C)	16	14	88
Oct. 29-Nov. 10	51 F (10.5 C)	20	18	90
Nov. 10-24	48 F (8.9 C)	18	18	100
Nov. 24-Dec. 9	42 F (5.6 C)	20	4	20
Dec. 9-22	44 F (6.6 C)	19	2	11
Dec. 22-Jan. 7, 1977	41 F (5.0 C)	20	0	0

a/ Centigrade temperature in parentheses.
b/ Test fish were 1976-brood Alsea stock steelhead.

from each group were transferred to the Corvallis laboratory. A similar move was also made May 11. Maximum daily water temperatures averaged about 49 F from April 3 to 18 and 52 F from April 19 to May 11. Results are shown in Table 30 and indicate a high degree of resistance for the North Nehalem stock and the Big Creek control group. The Alsea fish suffered losses approaching 100%. The fish transferred May 11 experienced 100% mortalities but C. shasta was diagnosed only in the Alsea fish. Bacterial gill disease was responsible for the complete loss in the other stocks.

We continued to monitor the remaining live-boxed fish and sacrificed 10 from each group on June 7. The Alsea stock had high losses beginning in early June, and within 2 weeks all were dead. In the other two groups loss began in mid-June and continued until the experiment's termination June 23 (Big Creek fish) and July 5 (North Nehalem fish). There were 11 Big Creek survivors and 17 North Nehalem survivors. Table 31 summarizes the results of the pathologist's examination of mortalities and sacrified fish . All Alsea stock were infected with C. shasta. Exclusive of these sacrificed, about 49% of the North Fork fish survived the experiment but 70% of those were infected as were most of the mortalities examined (83%). However, only 10% of the sacrificed fish tested positive for C. shasta.

The Big Creek stock appeared to show stronger resistance but were held 12 days less. Although only 41% survived the test, none were heavily infected and only two had light infections. Two (20%) sacrificed fish tested positive and of the two mortalities examined one had a light C. shasta infection. Average maximum daily water temperatures since May 11 were estimated to be as follows:

May 12-June 4	53 F
June 5-June 20	58 F
June 21-July 5	65 F

The higher losses experienced by the fish left in the boxes is related to the longer exposure and warmer water temperatures at a time of year when the river is known to be more infective.

Experiment 12 - coho smolts captured from North Nehalem River. In early March 1977 approximately 104,000 coho smolts (1975-brood) at 16/lb were liberated into the upper Nehalem system near RM 90 and 50,000 into Foley Creek a tributary entering the Nehalem at RM 7.5. These fish were mainly Alsea stock transferred to North Nehalem Hatchery as eggs to compensate for the poor return of 1972-brood Trask stock. Alsea coho are known to be susceptible to C. shasta (Zinn et al. 1977), but we felt the early release date would allow them to emigrate prior to the disease onset. North Nehalem coho from the 1974 brood which should have offered some disease resistance suffered heavy losses in Experiment 6.

Table 30. Experiment 11. Susceptibility of three hatchery stocks of 1976-brood steelhead smolts exposed to *Ceratomyxa shasta* in the Nehalem River, April-May 1977, and then held in parasite-free water.

Stock	Exposure period [a]	No. fish tested	No. of fish infected with *C. shasta*/no. of fish			Percentage infected with *C. shasta*		
			Mortalities	Survivors	Total	Mortalities	Survivors	Total
Alsea	April 3-18	12	11/12	None	11/12	91.7	None	91.7
North Nehalem	April 3-18	13	1/3	1/10 [b]	2/13	33.3	10.0	15.4
Big Creek	April 10-18	11	0/1	1/10 [b]	1/11	0	10.0	9.1
Alsea	April 3-May 11	12	12/12	None [c]	12/12	100.0	None	100.0
North Nehalem	April 3-May 11	12	0/12	None [c]	0/12	0	None	0
Big Creek	April 10-May 11	14	0/14	None [c]	0/14	0	None	0

a/ After exposure the fish were brought to the Fish Disease Laboratory in Corvallis and held in 64 F water.
b/ Terminated May 31.
c/ Terminated May 26 following losses caused by gill disease and/or *C. shasta*.

Table 31. Experiment 12. Susceptibility of three hatchery stocks of 1976-brood steelhead smolts exposed to *Ceratomyxa shasta* in the Nehalem River, April-July 1977.

Stock	Number of fish					Number of fish examined Percentage infected in parentheses		
	Exposed	Adjusted a/	Mortalities	Sacrificed b/	Survivors	Mortalities	Sacrificed	Survivors
Alsea	81	43	33	10	0	13 (100.0%)	10 (100.0%)	None
North Nehalem	70	45	18	10	17 c/	6 (83.3%)	10 (10.0%)	10 (70.0%)
Big Creek	62	37	16	10	11 d/	2 (50.0%)	10 (20.0%)	11 (18.2%)

a/ Total exposed less fish transferred to laboratory and 14 Alsea fish lost due to hauling stress.
b/ Killed June 7.
c/ Experiment terminated July 5.
d/ Experiment terminated June 23.

In mid-April, large numbers of coho smolts were observed in the vicinity of Experiment 11 live-boxes at RM 7-8. These fish readily accepted the pelletized food and were presumed to be the hatchery smolts released in March. Ed Cummings, ODFW biologist, analyzed scales taken from several of the fish and they appeared to exhibit a hatchery growth pattern. Coho were abundant in the live-box vicinity until mid-May.

On April 22, 25 of these fish were captured, using dip nets or hook and line, and placed in a floating box at RM 8. They were held until May 11 and then transferred to the Corvallis Fish Disease Laboratory. The fish were placed in a common tank with Experiment 11 steelhead which contacted bacterial gill disease. The coho suffered 100% mortality and 9 of the 11 fish were positive for C. shasta although bacterial gill disease may have caused some losses. Ten of the remaining live-boxed coho were sacrificed June 7 and the test terminated. All 10 were infected with C. shasta.

Experiment 13 - Cutthroat smolts from Alsea River and Big Creek. Although the Alsea and Big Creek cutthroat had been tested previously and found to be susceptible to C. shasta (Experiments 2 and 8), we felt they should be exposed at a time and size that simulated normal stocking practices. Cutthroat smolts are typically released in late May just prior to the trout season.

In mid-May, 35 smolts from each stock were placed in separate cages at RM 7 and 8. The Big Creek fish were about 10.0/lb while the Alsea stock were considerably larger at 2.7/lb. On June 7, 12 from each group were transferred to the Corvallis laboratory. Maximum daily water temperatures during the 21-day exposure averaged 54 F. The Alsea fish suffered 100% mortality by June 30. Five (42%) of the Big Creek fish survived until July 15 when the laboratory test ended. All survivors were free of C. shasta but six of the seven mortalities were infected.

All the remaining live-boxed Alsea fish were dead by June 27 and 9 of 10 examined had C. shasta. Many of these developed serious Saprolegnia infections, probably from handling injuries. Thirteen (56%) of the Big Creek cutthroat remained alive until experiment termination on July 5. None of the mortalities were examined but eight of the survivors were infected with C. shasta.

Salmon Poisoning Fluke Infections

The fluke, Nanophyetus salmincola, noted in 1974 as a serious problem in wild Nehalem River salmonids, did not produce heavy infections in any live-boxed test fish examined. Both groups of Experiment 1 steelhead at RM 42 were obviously infected but examination indicated it was not a serious problem (James E. Sanders, personal communication). These fish were live-boxed for approximately 3 months and held later into the summer than most other experimental fish. Other test fish were infected but never at a problem level. Milliman and Knapp (1970) citing Bender (unpublished data) reported infections were first observed from several Oregon coastal streams in mid-April and then increased rapidly by early July. The fluke is not a problem for hatchery reared steelhead smolts but may affect native salmonids. However, tests completed on four cutthroat trout, two steelhead yearlings, three fall chinook smolts (0+), and six coho juveniles (0+) seined from the Nehalem River (RM 8-42) September 9, 1977, indicated only one steelhead yearling from RM 42 to be heavily diseased (5,000+ metacercaries). All others were infected but only at light levels (46-582 metacercariae). Survival problems at levels far below those seen in our 1974 sample and in the one steelhead noted above were reported by Milliman and Knapp (1970) and Butler and Milliman (1971). However, they were working with much smaller fish (1.0-2.4 in).

Discussion

Our results indicate C. shasta is responsible for the poor returns of Alsea stock steelhead. High disease levels were noted from the upper estuary (RM 2.5) upstream to RM 37. It is not known how far down into the estuary the disease continues. Tests in the Columbia River estuary and in a laboratory indicate salinity levels in excess of 10% eliminate the infection (James E. Sanders, personal communication).

The abrupt disease disappearance between RM 37 and 42 is a similar situation to that on other streams. C. shasta is found in the Columbia River and several major tributaries including the Cowlitz, Willamette, and Deschutes rivers (Sanders et al. 1970; Oregon Wildlife Commission 1975). It is absent from the Columbia above the Deschutes River mouth and is not present in the Deschutes above its confluence with the infectious Little Deschutes River (Sanders et al. 1970). C. shasta disappears from the Willamette immediately above the Marys River but in this case the tributary is not infectious. Humbug Creek, a major Nehalem River tributary, enters just above the uppermost known infectious site (RM 37) but has not been tested. Why only certain areas of a stream are infectious is not understood but evidently the disease is not transmitted by fish.

Indigenous salmonid stocks thrive in the infected areas and are apparently resistant to C. shasta. The Nehalem is the only known coastal stream infected, and as a result coastal stocks have had no exposure or opportunity to develop a resistance to C. shasta. Our studies and those of Zenn et al. (1977) and Oregon Wildlife Commission (1975) indicate the variability in resistance between stocks from C. shasta infected areas and those from disease-free waters. We are hopeful the North Nehalem winter steelhead stock with its Columbia River background will provide the resistant qualities needed.

There is some indication the wild Nehalem River steelhead are adversely affected by C. shasta. Experiment 7 indicated considerable resistance but the complete absence of steelhead from the infected river section is otherwise unexplained. An interesting theory suggests continued stocking of susceptible hatchery stocks can increase the disease level to a point where even resistant stocks can be overwhelmed (James E. Sanders, personal communication).

Our 1976 testing indicated the river to be highly infectious from late April to late November. Light infection levels were documented in early April and into late December.

Our data are based on only 1 year's testing and there may be some variation between years. There were several weeks' variation in the fall infectious period noted in Willamette River tests (James E. Sanders, personal communication). Probable variables are water temperature and flows. High flows would dilute the number of infective units and may reduce the incidence and seriousness of the disease. Unusually low flows prevailed during our 1976 work and may have exaggerated the length of the infectious period. Stocking data (Table 9) indicate that most steelhead releases were probably made into waters already infected with C. shasta. Table 10 indicates a relationship between stocking date and river flows at time of release to the rate of return. Generally, the earlier the liberation and the higher the flows the better the rate of return. The timing of the C. shasta onset is the factor that explains this relationship. If our 1976 data is at all typical, it indicates that the 1969 and 1972 smolts were released at a time when live-boxed fish suffered a 90% infection rate. We do not know how long the smolts remain in the stream but would expect the infection rate to increase in proportion to the length of time in the river. If we assume higher flows tend to accelerate smolt emigration, higher flows should also reduce the incidence by diluting the infective units.

The duration of the C. shasta infectious period precludes the use of susceptible stocks. Sanders et al. (1970) noted that--in addition to steelhead--coho salmon, fall and spring chinook salmon, and cutthroat trout were susceptible. They felt juvenile fish were more susceptible than adults. Their findings are in agreement with our test results involving coho and cutthroat trout. Zinn et al. (1977) also noted chum salmon and rainbow trout to be highly susceptible.

Nehalem and North Fork Nehalem cutthroat trout management has been to stock legal-sized fish about 3/lb in late May and June to provide a "put and take fishery" with the survivors returning in late summer or early fall as sea-run fish. Considering the high infection levels present when these fish are in the river and their high susceptibility, it is doubtful that there is any contribution to the sea-run fishery. The Big Creek cutthroat offers some resistance but ODFW stocking policy does not permit transfer of stocks between the Columbia River system and coastal streams.

The native Nehalem River cutthroat is apparently resistant with good numbers rearing in the infected area even during peak infection periods. Two moribund fish taken from RM 7 and 35 were found to be heavily infected but fish seined in 1977 samples taken between RM 7 and 42 were free of the disease. Trout stocked in the North Fork Nehalem are exposed to C. shasta as they emigrate into the estuary. Although exposed to a somewhat lower infection level we presume they also suffer heavy losses.

The native Nehalem (Foley Creek) line of North Nehalem coho stock was found to be highly susceptible to C. shasta (Experiment 6). We assumed native fish would offer more resistance but Sanders et al. (1970) found 10 and 32% infection levels in 1965 and 1966 returns to Foley Creek Hatchery. Our testing period (late May to mid-July) may have resulted in a higher than normal exposure.

Coho smolts typically emigrate in late spring (March-May) according to Lorz and McPherson (1976) and Moring and Lantz (1975). An early March release of Alsea coho smolts in the upper Nehalem River (RM 66-114) was still moving through the RM 7 area in early May.

Adult coho returns to North Nehalem Hatchery from both the Nehalem and Trask lines have generally been adequate. The Trask stock has not been tested but because of its coastal background we presume it is susceptible. Coho liberations have been made between early March and mid-April and apparently the fish move through the estuary prior to the time the disease becomes a serious problem.

Returns have ranged from 0.05 to 3.10% but are difficult to compare because in some years all fish were trapped and in others trapping ceased when an adequate egg supply was obtained. Average return from the two lines of Nehalem stock (1964 and 1965 broods) are two to three times that of the Trask line (1966 brood). Variations in trapping programs and ocean survival may be an explanation but differences in susceptibility to C. shasta also could be a factor.

In 1975 adult returns from the 1972 brood (Trask River line) were too low (.02% and 80 females) to supply egg-take needs; and 1,100,000 Alsea stock eggs were transferred in, reared, and released in 1977. Live-box exposure simulating natural emigration indicated these fish to be susceptible (Experiment 12). Zenn et al. (1977) also found this stock to be susceptible but their loss percentage was only 42%. The Alsea fish will return in 1978. Jack returns in 1977 were the lowest ever recorded and may indicate heavy 1977 smolt C. shasta losses.

As with cutthroat trout, resistant coastal hatchery stocks are not available. The wild Nehalem River coho is probably resistant to C. shasta despite the findings of Experiment 6. Wild coho seined from RM 7 to 42 in 1977 were not infected. A 1978 test involving 14 fish taken from Cronin Creek (RM 24) and exposed for 12 days (May 10-22) in the Nehalem was inconclusive due to losses from bacterial gill disease. Examination of the one survivor produced no evidence of the disease. Most gill disease losses occurred 5-6 days previous to the initial C. shasta mortalities in the Alsea cutthroat control group and if infected should also have shown some sign of C. shasta but did not (James E. Sanders, personal communication).

Chinook salmon are not stocked in the Nehalem River but are periodically released in the North Fork Nehalem. Susceptible fall chinook could be released in late fall or early winter and escape excessive mortality but infection rates of returning adults would be high unless late run (December) stocks were used. Survival of progeny would be poor as nearly all of the rearing observed was within the diseased area at a time of high infection potential. Susceptible coastal fall chinook (Trask River) have been used in the North Fork Nehalem River with some degree of success. They were released at varying times from June to October. We would presume that fish emigrating from the North Fork Nehalem prior to November would be exposed to high infection levels. The wild Nehalem River chinook is apparently resistant and would be the best stock to utilize in both rivers.

There are no native spring chinook salmon in the Nehalem system and without locating a resistant coastal stock or obtaining approval to bring in resistant Columbia River system stock the presence of C. shasta precludes any spring chinook run development.

Chum salmon are not presently stocked in the Nehalem or North Fork Nehalem rivers. Susceptible stocks could be utilized with little exposure if released prior to April and they quickly emigrated. Adults would be returning at a time (late fall to early winter) when infection levels would be low and water temperatures would extend the incubation period of C. shasta well beyond spawning time. Wild chum salmon are available in Foley Creek (RM 7 to Nehalem River) and would be the best choice for brood stock development.

Mortality and infection rates determined by our tests were undoubtedly exaggerated by our live-box testing procedures. The incidence and intensity of C. shasta infections are increased by stress (James E. Sanders, personal communication). Overcrowding, inadequate food, snout injuries, and diseases were sources of stress in our experiment. However, in the absence of C. shasta, fish were held in several boxes as long as 107 days with little loss (Experiment 1).

SUMMARY

Investigation of the winter steelhead fisheries of the Nehalem and North Fork Nehalem rivers was initiated in December 1970 and continued into 1977. The two streams share a common estuary but hatchery programs used different stocks. Alsea (Oregon coastal) stock was used in the Nehalem, and fish originating from Big Creek (lower Columbia River) were released in the North Fork. Studies centered on (1) evaluation of hatchery returns and (2) determination of the cause of suspected poor returns to the Nehalem River.

Six years of intensive creel surveys provided data on the catch of wild and hatchery fish including age and sex ratios. Extensive rearing and spawning surveys were conducted. Disease studies involved live-boxing experiments with steelhead, coho, and cutthroat.

Creel Surveys - Nehalem River

Six seasons of data provided an average catch rate of 24.2 hours per steelhead with hatchery (Alsea stock) contribution averaging 22.0%. Percentage return of adults to the angler from smolts stocked averaged only 0.22%. All three rates are lower than those noted on other Oregon coastal streams.

Creel Surveys - North Fork Nehalem River

Catch rates averaged 12.0 hours per fish over the 6-year study. Only two releases of partially marked smolts were made. Evaluation of these two groups indicated a high rate of contribution to the fishery and a good rate of return. Hatchery stocks were primarily Big Creek stock (Columbia River). The management program here has produced a highly successful steelhead fishery.

Comparison of Creel Survey Data and Catch Card Estimates

Catch estimates derived from angler catch cards consistently exceeded our estimates by at least 150%.

Life-History Studies - Age

Only wild fish (328) from the Nehalem River were studied. The most common age classification was 2/2 (68.6%) and the next most common was 2/3 (7.9%). Other work on Oregon coastal steelhead indicated similar age composition. Repeat spawners made up 10.4% of our sample. Two females were in their 8th year and were on their 5th consecutive spawning migration. The largest fish, a male 40.0 in FL, had spent 4 uninterrupted years at sea.

Life-History Studies - Sex Ratios

Sex ratios of 1,199 angler-caught steelhead from the Nehalem and North Fork Nehalem rivers were virtually 1 (male): 1 (female) when combined. There was considerable variation between seasons and rivers but no consistent pattern. Most (90.9%) of the "jacks" (age N/1) were maturing males.

Rearing Area Surveys

Investigations were confined to the Nehalem River system and findings indicated that although it is a large watershed containing approximately 510 miles of fish-producing streams only about 43 miles or 8% were rearing substantial numbers of steelhead. Most of the rearing is confined to four tributaries in the lower 22 miles of the 118-mile main stem length. Several areas which appeared to offer excellent steelhead habitat were rearing low numbers or no steelhead at all. Disease problems may be a factor in the lower 35 miles of the main stem. Characteristics of the more productive rearing areas as measured during summer low flow periods include a high gradient (60% riffle or better), cool water, flows greater than 3 cfs, and low interspecific competition.

Spawning Ground Surveys - Nehalem River

Surveys included sections of nearly all important spawning areas. These areas were surveyed at least twice and up to four times throughout the spawning season. Cumulative redd counts were used as a measurement standard. A marking study indicated that, in the absence of major freshets, redds remain visible for at least 30 days.

Steelhead spawning use was well distributed throughout the system except in the watershed area between RM 47 and 106. Heaviest use was noted in waters with flows in excess of 30 cfs and a high gradient. Tributaries between RM 47 and 106 were primarily small streams with low gradients. Considerable activity was seen in a number of streams which were found to be rearing few juvenile fish. With little main stem rearing observed we question whether fish spawning in these streams are contributing to adult steelhead production.

Spawning activity was first observed in late January and on one stream continued well into May. Late spawning populations were associated with the larger streams in the lower 22 miles of the watershed. Most streams showed peak spawning activity sometime in March. An unusual number of trophy-sized fish were observed in April and May surveys on the Salmonberry River.

An excessive hatchery fish escapement that would explain the poor return to the fishery was not documented. Most fish observed were wild although in several cases hatchery steelhead were present in large numbers.

Although many spawning areas are underutilized, escapement appears adequate in view of the apparent limited rearing capacity.

Spawning Ground Surveys - North Fork Nehalem River

Three excellent stream sections were used as survey sites. Each was surveyed three times during the spawning period. Spawning began in December and extended into late April. Peak activity occurred in early

April and most of the fish observed were assumed to be wild fish. A secondary peak occurs in early February and is believed related to predominantly hatchery fish activity. Escapement is more than adequate, and considerable redd superimposition was observed.

Disease Studies

Pathologist's examination of wild steelhead, cutthroat trout, and coho salmon seined from the Nehalem River at RM 42 indicated a high incidence of infestation by the salmon poisoning fluke, Nanophyetus salmincola. Levels were believed to be extensive enough to affect survival. Hatchery salmonids used in live-box tests and native fish seined from the river in subsequent years did not exhibit serious infections. The initial observation appears to have been an anomaly.

Live-box tests did document the presence of the myxosporidian parasite, Ceratomyxa shasta, in the main stem Nehalem River from RM 2.5 to 35. It is not known how far down into the estuary below RM 2.5 the disease extends but upstream it disappears somewhere between RM 35 and 42. C. shasta was not found in the Salmonberry or North Fork Nehalem rivers but fish emigrating from these streams, as well as other tributaries, are exposed as they migrate down the main stem. One year of testing indicated the river to be highly infectious from mid-April to mid-November. We found the Alsea stock steelhead, the fish used in the Nehalem stocking program, to be highly susceptible to C. shasta. Exposed fish suffered heavy losses and exhibited infection rates of 90-100%. Smolts were generally released into waters already infectious and were further exposed during emigration. This disease is apparently the cause of the poor steelhead returns to the Nehalem River.

Alsea stock cutthroat trout have been released annually in the North Fork and Nehalem rivers and were also found to be highly susceptible. They were stocked at a time and location where they were subjected to a heavy exposure. Test fish suffered high losses, and infection rates ranged from 60 to 90%. Stocked fish survived long enough to provide a "put and take" fishery but it is doubtful if many returned as sea-run cutthroat. Big Creek stock cutthroat were more resistant but still suffered heavy losses and had infection rates of about 50%.

Two broods of North Nehalem stock coho salmon, 1974 and 1975, were tested and losses approximated 100%. The 1974 brood were 3rd generation descendants of native Nehalem River coho and we expected them to be C. shasta resistant. The 1975 brood were 3rd generation descendants of Trask stock and were expected to be susceptible. Returns to the North Nehalem Hatchery from these two brood lines, as well as a third line of native Nehalem River fish, have generally been adequate; but it does not appear that these stocks can be used in the Nehalem River. There is some evidence to indicate returns from the Trask brood line have been less successful than those from native Nehalem River stock.

Wild winter steelhead taken from a Nehalem River tributary were quite resistant with a 33% infection rate. However, the complete lack of steelhead rearing in the infected river section suggests that *C. shasta* may be more detrimental to native stocks than our tests indicate.

Big Creek stock, which formed the basis of the North Fork Nehalem steelhead stocking program through the 1974 brood, was found to be highly resistant, with *C. shasta* infection rates ranging from 9 to 16%. Beginning in 1975, eggs were taken from adults returning to North Nehalem Hatchery. These adults were essentially Big Creek stock but the resulting 1975-brood smolts suffered moderate losses and an 85% infection rate. In a less severe but more realistic test the 1976 brood suffered low losses and only a 15.4% infection rate. We found that even the more resistant stocks suffered heavy infections if subjected to a highly stressed situation but are hopeful the North Nehalem stock can be successfully used in the Nehalem River.

RECOMMENDATIONS

The Nehalem River as one of Oregon's largest coastal streams has the potential to provide winter steelhead angling opportunities along over 100 miles of main stem and approximately 35 miles of tributaries. While other Oregon steelhead streams are intensely fished and angling pressure is rapidly increasing, effort on the Nehalem is generally light and has actually declined in the last 25 years. Increased Nehalem River angling opportunities would relieve fishing pressure on other waters.

Other Oregon coastal streams have greatly benefited from successful steelhead hatchery programs while disease problems have prevented the Nehalem from realizing such benefits. The development of a successful, _Ceratomyxa shasta_ resistant stock should receive a high priority in Oregon's steelhead management program. Turbid water conditions during much of the steelhead angling season also reduces the Nehalem River steelhead fishery potential. Although the turbidity is essentially of a nonpoint nature, good land-use practices are needed to minimize turbidity levels. Angler use of the clearer tributary streams should be maximized to provide additional angling opportunities.

Although most of the Nehalem watershed's 510 or so stream miles are unsuitable for steelhead production, other valuable salmonids such as cutthroat trout, coho salmon, and chinook salmon use this habitat. These species would also benefit from supplemental hatchery stocking but suitable, disease resistant stocks are not available for use in either the Nehalem or North Fork Nehalem rivers. Development of these should have a high priority. Warm summer water temperatures and low flows reduce rearing potentials for all salmonids in the main stem Nehalem River. Domestic water withdrawals, particularly from tributaries in the upper Nehalem River valley, aggravate this situation and should be limited. The need for shade-producing, streamside buffer strips is critical where clear-cut logging is considered.

More specific recommendations are listed below.

Study Procedures

Studies of this nature should be preceded by an adequate literature search. Such a procedure may have drawn a relationship between the documented presence of _C. shasta_ in Nehalem River adult coho and the poor returns of hatchery steelhead. Several years of trial and error efforts possibly could have been avoided.

General Stocking Guidelines - Nehalem River

Liberations of fish susceptible to _C. shasta_ should be discontinued. A possibility exists that the presence of susceptible fish could increase disease levels thereby causing problems for resistant native stocks. The absence of juvenile native steelhead from the infected portion of the river suggests this may have happened. Another case in point is the apparent susceptibility of North Nehalem Hatchery coho which were originally derived from native Nehalem fish.

Steelhead

Over 100,000 marked, North Nehalem steelhead smolts were released in the Nehalem River in 1977 and 1978. These fish are expected to be resistant to C. shasta but returns should be evaluated by 1978-79 and 1979-80 creel census programs. A program similar to the one utilized in this study should be adequate. Releases of at least 100,000 North Nehalem stock smolts should continue during the evaluation.

If the North Nehalem fish does not produce adequate returns, permission to use the Big Creek stock should be obtained. Our tests indicate this fish to be very resistant to C. shasta. Native Nehalem River stocks offer another possibility. They would be difficlt, but not impossible, to obtain. Weir construction or capture of adults on the spawning grounds would be required.

It is important that liberations be made before disease levels become high as even resistant stocks can be overwhelmed by intense exposures. We suggest March 31 as a target release date with due consideration to smolting characteristics.

Releases should initially be confined between RM 12 and 35 where an established fishery exists. Three tributaries within this section--Cook Creek, Salmonberry River, and Humbug Creek--offer steelhead angling potential. Adequate stocking would increase angling opportunities, particularly during periods of main stem turbidity. Cook Creek and the Salmonberry River are presently open to winter fishing but only Cook Creek is being stocked.

The Salmonberry is presently managed as a wild steelhead stream. It is the most important wild steelhead rearing area in the system and has a good run of unique, late spawning fish plus an unusual number of trophy-sized fish. We concur with the genetic protection of these fish. However, our study indicated the December and January run which formerly provided considerable angling is, for reasons unknown, at a depressed level. If this run fails to reestablish itself after 5 or 6 years, we suggest that an early-run hatchery stock could be utilized and still retain the genetic integrity of the late-run native race. Humbug Creek is presently closed to winter angling to protect a large run of November spawning chinook salmon. A December opening would protect the salmon and provide angling opportunities along 5 stream miles. Oregon Department of Fish and Wildlife (ODFW) owned land provides bank access along 1 mile of this section. If a successful fishery is developed in the lower Nehalem watershed, stocking efforts could then move upstream with additional smolts and hopefully develop a fishery in areas that presently have none. Approximately 65 miles of main stem suitable for steelhead angling lie above RM 35. Brushy stream banks and poorly defined holding water will tend to discourage anglers in much of this section but increased steelhead numbers would offer incentive for the pioneering angler.

Tributaries which could provide steelhead angling opportunities include Buster Creek, Walker Creek, and Rock Creek. The former two are quite small and presently closed to winter angling but could provide fishing in the lower 2 miles or so. Virtually all access along lower Walker

Creek is controlled by the ODFW. Rock Creek is open to winter angling in the lower 10 miles but receives only light use. Additional water could be opened if desirable. Enhancement programs above RM 60 should consider use of local native stocks to provide a better quality fish for upriver fishermen. North Nehalem and Big Creek stocks are short-run fish and would tend to ripen prior to reaching release sites.

Rock Creek provides approximately 20 miles of prime rearing area but juvenile steelhead populations are low despite a good spawning escapement. Rearing populations should continue to be monitored and, if the discrepancy persists, causes should be investigated. Removal of a partial barrier on the North Fork Salmonberry (Fig. 11) has been considered and would allow unimpeded access to approximately 3.5 stream miles. Passage is apparently limited to low flow periods during late April and early May and is difficult even then. Escapement above the falls is adequate and rearing populations are extremely high. The falls may act to preserve the genetic integrity of a small, unique race of steelhead. We recommend against fish passage improvement.

Cutthroat Trout

The Alsea cutthroat trout is highly susceptible to *C. shasta* and should not be used in the Nehalem River system. A possible exception would be Rock Creek where a "put and take" fishery effectively harvests this fish. Historically, cutthroat have been used in the lower Nehalem River but only a small percentage are taken. The fish apparently disperse rapidly in the larger river, and angling pressure is light except for established stocking sites. The possibility of increased disease levels arising from stocking susceptible fish has been discussed earlier.

From a practical standpoint the only suitable sea-run stock available to use is the wild Nehalem River cutthroat. It appears to be resistant to *C. shasta* and is abundant during warm-water periods in the infected river section. A limited 1978 test involving three wild cutthroat from Cronin Creek (RM 24) indicated complete resistance after a 12-day exposure (May 10-22). The control, Alsea cutthroat smolts, suffered 100% loss from *C. shasta*.

Between 40 and 50 sea-run fish were seined or caught by hook and line from the Nehalem and North Fork Nehalem rivers in late summer 1977. They were held and spawned at Cedar Creek Hatchery. Scale analysis indicated that those sampled appeared to be wild fish, and their survival indicates *C. shasta* resistance. About 3,000 fingerlings are being reared for future brood stock. Considerably more eggs were taken but hatching success was low due to unequal maturation of sexes.

An additional 100 sea-run fish should be seined from the Nehalem River in 1978. An ideal seining site exists at RM 13 where cooler Cook Creek water attracts and concentrates the fish. If maturation problems again develop, the use of a stimulant such as gonadotropin should be considered. The fish presently being reared should be tested for *C. shasta* resistance in May and again in June 1979 if the May test shows disease resistance.

Fig. 11. North Fork Salmonberry Falls.

Stocking, location, and timing would be flexible if all tests produced desired results.

Coho Salmon

At present no coastal coho stock is known to be resistant to C. shasta. Columbia River fish should be, but ODFW stocking policy precludes transfer of these fish to a coastal river. We are uncertain if coho escapement is adequate but feel supplemental stocking would probably be a benefit. Presuming the wild Nehalem River coho to be C. shasta resistant, this stock should be developed at the North Nehalem Hatchery for use in both streams.

Capture of brood stock may be difficult, but an existing fishway on Fishhawk Creek #2 offers a possible trap site. Weir construction or capturing adults on the spawning grounds are more difficult alternatives.

Fall Chinook Salmon

In recent times chinook salmon have not been stocked in the Nehalem River. As with coho, we are unaware of any coastal stocks resistant to C. shasta and are uncertain whether supplemental stocking is needed. Releases of susceptible fall chinook smolts could produce successful returns if liberated in late fall but progeny would suffer heavy losses as juveniles. This program is not recommended.

Good native populations were noted rearing in highly infected areas so presumably this fish is disease resistant. If it becomes desirable to release fall chinook, the wild Nehalem fish should be a good brood stock. Spawning adults in Humbug Creek offer a difficult but possible egg source.

General Stocking Guidelines - North Fork Nehalem River

Salmonid emigrants may face high levels of C. shasta upon reaching the Nehalem estuary. Accordingly, susceptible stocks should not be used if at all possible.

Steelhead

The present North Nehalem stock should produce good returns. We recommend a creel survey program be established for the 1978-79 and 1979-80 season. Considerable adult straying from North Nehalem fish reared at that facility and released in the Nehalem River may occur and also needs study. The straying incidence should be reflected in future stocking allocations between the two streams.

Fish returning to North Nehalem Hatchery will also be used as the brood stock for the Nehalem River. It would be desirable to expose North Nehalem smolt releases to low C. shasta levels. Such exposure would remove susceptible individuals from the gene pool and prevent dilution of the resistant trait. We recommend an April 15 release date with due consideration to smolting characteristics. Low intensity exposure should not result in much loss if the fish are at all resistant. It would be a good practice to test the smolts about every 3 years to determine if resistance has declined.

A 25-foot falls near the mouth of Grassy Lake Creek prevents anadromous fish use of approximately 4 stream miles which appears to be excellent steelhead rearing habitat. Laddering costs are prohibitive but excess brood stock could be easily transported several miles and released above the barrier. Surplus fry could also be stocked but release sites are limited and adults would provide better distribution. Returning steelhead would tend to concentrate near the creek mouth and attract increased angler use in that area. A good population of wild cutthroat trout is presently found above the barrier. Legal-sized fish (8 inches) are available but attract few anglers. Steelhead releases would probably depress the cutthroat population but it could be reestablished, if desired, by stopping adult steelhead releases.

Cutthroat Trout

Alsea cutthroat provide a generally successful opening weekend "put and take" fishery. Catch rates are high. This program could be continued until a *C. shasta* resistant replacement stock is developed. Additional releases have also been made after opening weekend but harvest rates are low, and emigrating fish are exposed to high disease levels in the Nehalem River estuary. We recommend discontinuance of the later releases until a suitable stock is available.

Coho Salmon

Adults returning to North Nehalem Hatchery in 1978 are mainly Alsea stock brought in as eggs in 1975 when 2nd generation Trask River fish failed to return in adequate numbers. Returns in 1979 and 1980 will be 4th generation native Nehalem River stock transferred from the old Foley Creek Hatchery.

Nehalem stock returns have generally been adequate but tests in the Nehalem estuary 0.5 miles below the North Fork confluence produced nearly 100% mortalities from *C. shasta*. The experiment was conducted in late May and may have resulted in higher exposures than a typical smolt encounters. A more realistic test simulating natural exposure indicated the Alsea coho are highly susceptible. Jack returns in 1977 were the lowest ever recorded at the hatchery and may indicate that this stock experienced considerable loss while emigrating through the estuary.

Accordingly, 1978 would be an excellent year to initiate hatchery brood stock replacement. Hopefully a stock can be developed that will be *C. shasta* resistant and ideally suited for use also in the Nehalem River. The native Nehalem stock is the logical choice. Techniques and problems associated with capturing adults were discussed earlier. Complete replacement of hatchery brood stocks would require adult captures in 1979 and 1980.

Chinook Salmon

Releases of Trask stock fall chinook have been made since 1967 but returns have not been evaluated. Release times range from June to December. The Trask fall chinook is highly susceptible to *C. shasta* and we would expect heavy losses of smolts moving through the Nehalem River estuary from May through September.

Fall release dates may allow a susceptible stock to emigrate unexposed to *C. shasta*. The native Nehalem River fall chinook appears to be highly resistant to *C. shasta*. Development of this fish as a hatchery brood stock would permit utilization in the Nehalem River as well. Procurement of wild Nehalem River fall chinook eggs was discussed earlier.

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Personnel at the ODFW North Nehalem and Cedar Creek hatcheries cooperated by providing marked fish and various samples for disease testing. North Nehalem people also recorded steelhead catch data. Both stations assisted in holding captured cutthroat brood stock. We are indebted to Ralph Swan, Harry Wagner, and Ken Hall for reviewing the manuscript draft.

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Appendix A. Simplified Conversion Tables

Temperature =
Degrees centigrade = $\frac{5}{9}$ (degrees Fahrenheit +40) -40

Weight =
1 pound = 0.4535 kilograms

Flow =
1 cubic foot/sec = 28.32 liters/sec

Distance =
1 inch = 2.54 centimeters
1 foot = 0.3048 meters
1 yard = 0.9144 meters
1 mile = 1.6093 kilometers

Appendix B. Calculation of Adjustments Used in the Nonstatistical Methematical Expansion of Angling Effort Estimates and Creel Survey Data

Angling effort adjustment for late-arriving angler parties.

$$A = \frac{X + \frac{Z}{Y} + Z}{Z}$$

Where X = number of late arriving parties surveyed
Y = number of parties included in car count surveyed
Z = number of vehicles (parties) in car count

"A" was then multiplied by estimated total angling effort (E) to arrive at adjusted angling effort (Ea).

Catch per party adjustment to reflect inclusion of incomplete parties in our surve

$$B = \frac{r + S}{r + (S \times \frac{M}{N})}$$

Where M = average hours per angler - incomplete anglers
N = average hours per angler - complete anglers
R = seasonal total of complete angler hours
S = seasonal total of incomplete angler hours

"B" was then multiplied by estimated seasonal catch (C) to arrive at adjusted total catch (Ca).