NOTES ON THE FISHES AND FISHERY OF THE LOWER EEL RIVER, HUMBOLDT COUNTY, CALIFORNIA[1]

by

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INTRODUCTION

During the season of 1950 a general survey was made of the fish populations and fishery of the lower Eel River. The study was designed to form an introduction to the problems of the lower river and consequently did not yield definitive data on any one facet. Responsibility for [illegible] the survey rests with both of the writers. De Witt carried out [illegible] of the field work during the period from June to September. Murphy continued the field work from October to February. The organization and preparation of this report was largely done by Murphy.

The report is organized into four sections. The first is a brief description of the study area; the second, a description of the fishery; the third, discussions of certain phases of the biology of the fishes entering the catch; the fourth, a brief discussion of the tidewater area.

DESCRIPTION OF THE STUDY AREA

The section of the Eel River from its confluence with the Van Duzen River to its mouth at the Pacific Ocean was selected for this study. Figure 1 is a detailed map of the area. The sections of the river above tidewater (upstream from Singley Pool) are typically gravel-bottomed and are composed of a series of medium gradient riffles and large, shallow pools. The upper reaches of the tidewater area (Dungan Pool to Singley Pool) resemble the upstream areas, but are subject to rises and falls with the tides. The lower section of the river (below Dungan Pool) presents a typical estuarine habitat with sloughs, mud flats, and finally the sand bar at the mouth. The bar was not observed to close during the study period.

Temperature records of the river were maintained at Fernbridge with a thermograph during the period June 11 to September 10. In addition, from time to time records were secured at other stations. These are presented in Tables 1 and 2. In order to determine the relative salinity of the tidewater areas, the specific gravity was measured at irregular intervals. These data are given in Table 3. Table 4 shows the runoff pattern for the lower Eel River.

Draft

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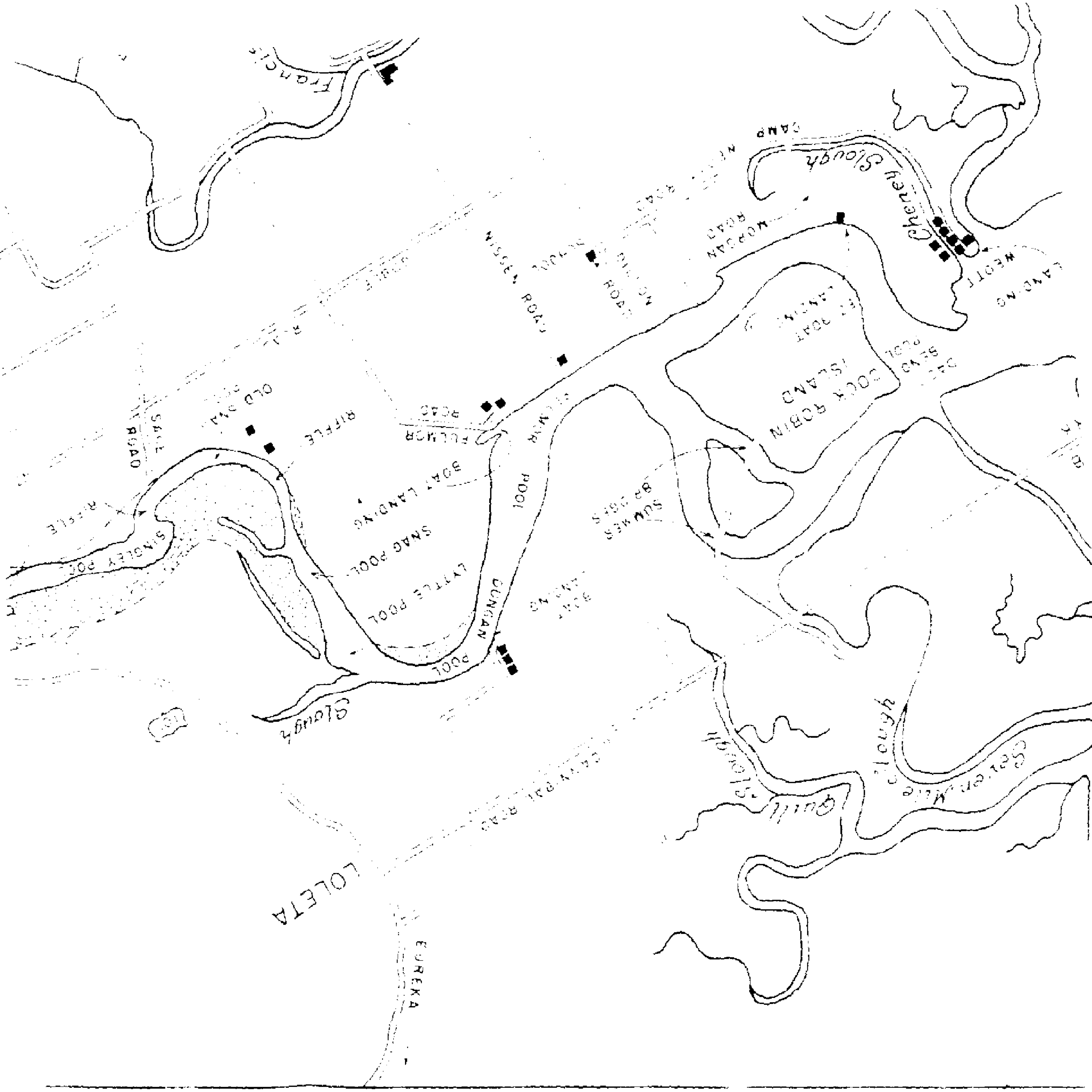
TABLE 1

Temperatures in Degrees Fahrenheit of Eel River at Fernbridge (Thermograph 1950)

Date	June Max.	June Min.	July Max.	July Min.	Aug. Max.	Aug. Min.	Sept. Max.	Sept. Min.
1			73	62	69	66	70	65
2			72	67	67	65	70	66
3			70	68	68	65	69	66
4			71	65	68	65	70	66
5			69	-	68	65	66	65
6			68	64	69	65	65	62
7			69	66	70	67	63	62
8			-	-	69	67	62	61
9			-	-	70	66	64	60
10			-	-	68	67	63	62
11	64		70	65	67	65		
12	63	59	71	66	65	64		
13	60	58	68	67	68	63		
14	59	58	69	65	72	68		
15	60	58	72	66	72	69		
16	59	59	72	67	71	70		
17	62	60	69	67	72	69		
18	63	62	69	66	71	69		
19	66	61	68	66	72	69		
20	64	62	70	67	72	69		
21	64	60	72	66	70	69		
22	63	59	72	66	70	66		
23	65	60	66	66	72	68		
24	68	62	68	65	72	69		
25	69	63	69	66	70	67		
26	70	64	66	65	71	68		
27	72	66	67	65	71	68		
28	73	68	69	64	71	68		
29	71	68	69	66	70	68		
30	71	67	70	66	69	64		
31			71	67	70	66		


Francis
Cheney Slough
CAMP
MORGAN ROAD
NISSEN ROAD
DILLON ROAD
COCK ROBIN ISLAND
BOAT LANDING
OLD SNAG
RIFFLE
FULMOR ROAD
SNAG POOL
LYTTLE POOL
DUNCAN POOL
SINGLEY POOL
Slough
LOLETA
EUREKA
Seven Mile Slough
Quill Slough

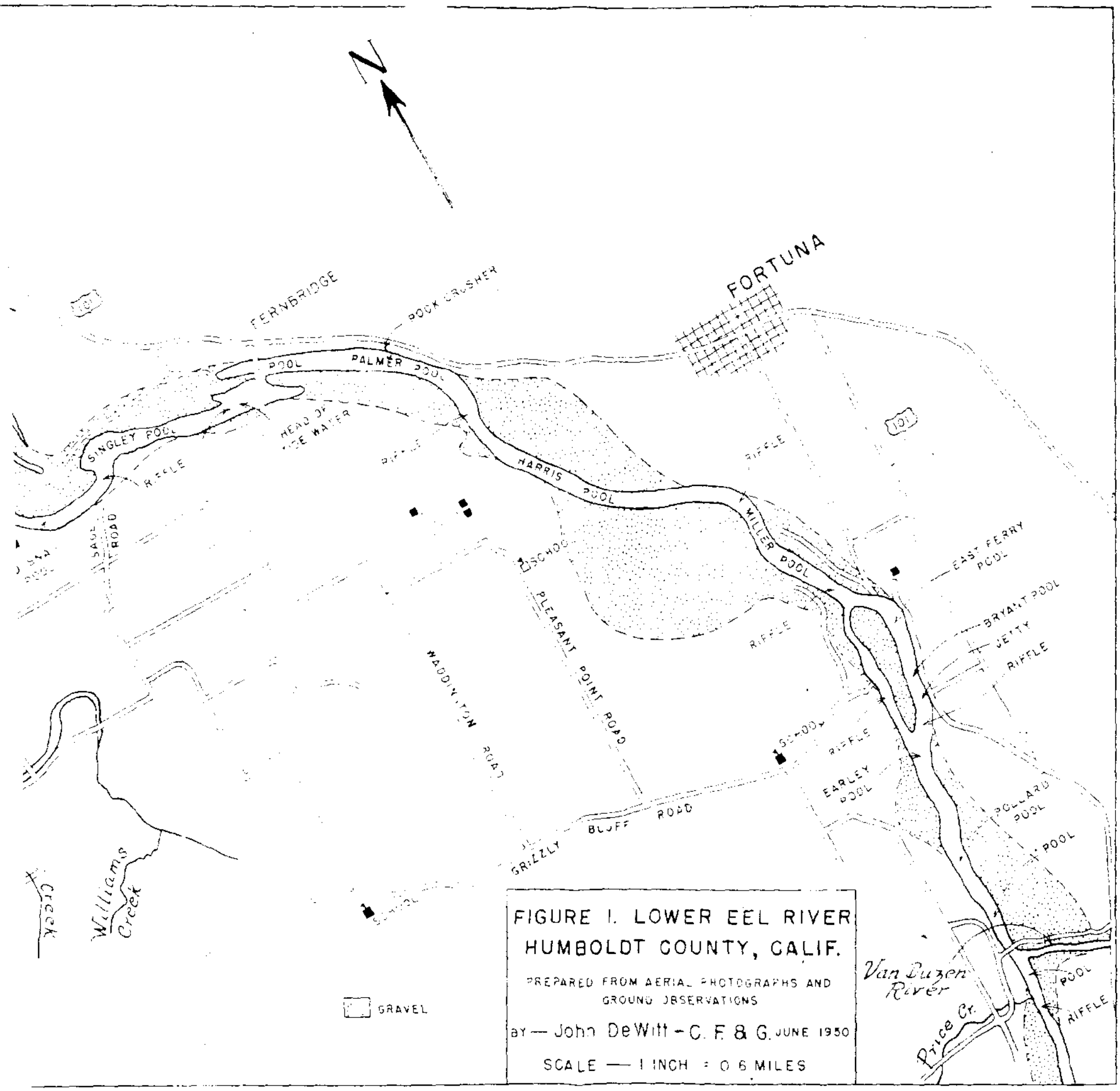


FIGURE 1. LOWER EEL RIVER
HUMBOLDT COUNTY, CALIF.

PREPARED FROM AERIAL PHOTOGRAPHS AND GROUND OBSERVATIONS

BY — John DeWitt — C. F. & G. JUNE 1950

SCALE — 1 INCH = 0.6 MILES

TABLE 2

Temperature Records,

Eel River and Van Duzen River (Mouth) 1950

Date	Time	Place	Temperature in degrees Fahrenheit Air	Water	Remarks
June 10	9:35 A	Eel River VD	61	63	Cloudy, cool
" "	9:45 A	Van Duzen R.	61	61	" "
" "	11:45 A	Weott Bay	56	59	In backwater of Bay
" "	12:05 P	Salt R. Bridge	56	58	Flow 100 g.p.m. (rough)
" "	12:45 P	Singley Pool	56	69	Water clear, green
June 11	11:30 A	Van Duzen R.	62	59	Cloudy, mild
" "	1:30 P	Singley Pool	58	62	Cloudy, cool
June 12	10:00 A	Singley Pool	54	61	" "
" "	4:00 P	Van Duzen R.	57	60	Cloudy, cool, water not too clear
" "	5:00 P	Singley Pool	54	59	Cloudy, cool
June 13	6:20 P	Van Duzen R.	54	57	Cloudy, cool, water muddy
June 17	10:00 A	Van Duzen R.	58	58	Cloudy, warm
" "	11:30 A	Fernbridge	56	60	" "
June 19	9:00 A	Van Duzen R.	57	57	Cloudy, mild
June 20	4:15 P	Van Duzen R.	58	60	Cloudy, cool, windy
" "	5:00 P	Fernbridge	57	63	" " "
June 22	2:30 P	Van Duzen R.	58	64	Partly cloudy, cool
June 24	10:40 A	Van Duzen R.	60	62	Partly cloudy, mild
June 25	6:00 P	Van Duzen R.	57	70	Clear, mild
June 28	10:20 A	Van Duzen R.	66	67	Clear, warm
" "	2:30 P	Dungan Pool	66	69	" "
June 29	10:30 A	Van Duzen R.	60	66	" "
July 2	1:00 P	Van Duzen R.	68	71	" "
July 3	11:30 A	Dungan Pool	65	66	" "
" "	12:30 A	Van Duzen R.	60	68	" "
July 8	1:00 P	Van Duzen R.	71	74	" "
July 9	9:30 A	Van Duzen R.	55	62	Cloudy, cool, misty
July 15	12:00 A	Van Duzen R.	65	72	Clear, warm
July 23	10:30 A	Van Duzen R.	60	64	Cloudy, mild
July 29	10:00 A	Van Duzen R.	60	65	Clear, warm
July 31	12:00 A	Van Duzen R.	67	73	" "
Aug. 5	3:30 P	Dungan Pool	65	67	Clear, warm, breezy
Aug. 6	2:00 P	Van Duzen R.	65	72	" " "
Aug. 20	1:30 P	Van Duzen R.	66	74	" " "

TABLE 3

Specific Gravity of Eel River Water at Several Tidewater Stations (1950)[1]

Date	Location	Time	Specific gravity[2]	Temp. in degrees Fahrenheit
June 24	North side Cock Robin I.	5:00 P	1.008	68
" "	South side Cock Robin I.	5:30 P	1.007	70
" "	Dungan Pool	3:00 P	1.003	65
June 28	Dungan Pool	3:30 P	1.005	64
July 3	Dungan Pool	8:45 A	1.006	63
July 8	Dungan Pool	12:00 N	1.005	67
July 9	Dungan Pool	11:00 A	1.005	66
" "	North side Cock Robin I.	12:00 N	1.018	64
" "	South side Cock Robin I.	1:00 P	1.012	69
" "	Crab Slough	1:30 P	1.029	66
July 10	Cheney Slough	3:15 P	1.028	63
" "	E Z Landing	3:30 P	1.008	65
July 11	Mouth Salt River	12:00 N	1.026	57
July 12	Mouth Eel River	12:15 N	1.030	59
July 16	Dungan Pool	3:30 P	1.014	69
Aug. 15	Dungan Pool	3:30 P	1.016	70

[1] Difference in tide between mouth and head of tide approximately 2 hours.

[2] A urinometer adjusted for 60 degrees Fahrenheit was used.

TABLE 4

Runoff Eel River at Scotia (8 Miles Above Van Duzen River) for 1947

Month	Discharge in acre-feet	Minimum discharge in second-feet[1]	Maximum discharge in second-feet
January	75,400	565	8,110
February	538,700	2,920	62,500
March	918,000	2,880	54,700
April	342,900	2,000	13,600
May	62,840	560	1,940
June	61,650	386	3,240
July	15,620	185	359
August	9,170	91	190
September	4,250	47	102
October	156,800	47	15,400
November	120,900	650	7,520
December	93,140	530	4,560
Extremes on record		10	345,000

[1]Average for 24 hour period.

THE FISHERY

The catch was sampled periodically during the study period. During the period May 27 (when the angling season opened) to August 30 the catch was sampled on one or more week-end days and on one or more week days. The checker started at the mouth of the Van Duzen River and worked downstream, sampling the catch. Catches were measured at random and scale samples were taken at random for all fish except "half-pounders". Special attention was given to this latter group, because of the lack of information on them.

The fishery is complex and difficult to present in an orderly fashion. A good starting point is to define the important groups of fishes entering the catch.

1. Trout - young steelhead rainbow trout that have not been to sea. These range from 4 to 8 inches in length. (Some resident fish and a few cutthroat trout may be included in this group.)

2. Half-pounders - young steelhead rainbow trout that have been to sea for a brief period, and have returned to fresh water. These fish are 9 to 17 inches in length and show no sign of sexual maturity.

3. Steelhead - adult steelhead rainbow trout that have spent a considerable period in the ocean and presumably will spawn without further periods of ocean life, or have completed one spawning. These are large fish ranging from 20 to 40 inches in length.

4. King salmon - adult king salmon that are in fresh water on their spawning run. (A very few downstream migrating king salmon are caught as "trout", but the number is so small that they can be ignored.)

5. Silver salmon - adult silver salmon on their spawning run. Only 4 juvenile silver salmon were observed in the "trout" catch, so it must be presumed that most yearling silver salmon had completed their downstream migration before angling commenced on May 27. The group of silver salmon in their first summer are too small to enter the "trout" catch and in addition do not frequent the main channel of the lower river. (Numerous seine hauls captured only one silver salmon fingerling.) These five groups represent the bulk of the catch. Other species are taken, particularly in the tidewater areas. These will be introduced as they enter the discussion.

Briefly, the fishery by months may be described as follows:

June-July (includes May 27-31) - Trout, steelhead.
August - Trout, half-pounders, king salmon, steelhead.
September - King salmon, half-pounders, trout, steelhead, silver salmon.
November-December - No fishing because of water conditions. Presumably king salmon, silver salmon, steelhead.
January-February - Steelhead.

Let us abandon the chronological approach for the moment and examine each of the individual fisheries that make up the whole. This is possible because an angler fishing for one group of fish generally catches only fish of that group. Table 5 summarizes the creel census data.

Trout fishing is responsible for the bulk of the effort during the period June to Agusut, inclusive. Trout were taken on flies, salmon eggs, other baits, and on small spinners. The size distribution of the catch is indicated in Table 6. The effort expended on trout fishing drops off considerably through July. In August large numbers of trout were again taken by anglers fishing for half-pounders, and in addition the catch per day increased over July, luring more anglers afield. (This is not apparent in Table 5 because the data on hours fished includes a considerable number of salmon anglers.) During September and October little effort was expended on trout, the bulk of them being caught incidentally with other species.

Half-pounder fishing began in August and continued through October. Some of these fish were taken by trout fishermen but the majority were captured by anglers fishing specifically for them with flies. It did not appear that more than 25 separate individuals regularly engaged in this fishery.

Steelhead fishing was practiced during the entire fishing season, dependent, of course, on water conditions. A few steelhead were present along the entire lower river during the summer months. The writers first noted them on June 20 in Pollard Pool and on June 10 in Dungan Pool (tidewater). Apparently only a few anglers were aware of the presence of these fish, and they were difficult to catch after the first hour of daylight. The first specimen seen caught was taken in July. Though there appeared to be a few steelhead in tidewater (Dungan Pool, etc.) at all times, practically none were taken by anglers until the heavy fishing for king salmon developed. In October what appeared to be the vanguard of the winter runs entered the catch, generally being taken by king salmon anglers. Due to unusually high water in November, December, January, and February, the steelhead catch was virtually zero. During most years the tempo of steelhead angling increases through November and reaches a peak in December.

Most steelhead are captured by shore fishermen, but some are taken by trolling in the larger pools.

The first king salmon to come to our attention was taken August 12 at Fernbridge. On August 13 a small king salmon was taken by Mr. Gerald Holman near the mouth of Howe Creek just above the study area. By August 25 many large king salmon could be seen rising in Dungan Pool and on August 27 the first was taken in that pool by an angler. From the latter part of August to the end of October (when rains terminated the fishery) trolling for salmon was intense from Dungan Pool to Fulmor Pool and bank fishing intense above Dungan Pool (large quantities of algae below Fulmor Pool make trolling difficult). Most of the troll-caught fish were taken on spinners and most of the bank-caught fish were taken on salmon eggs. However, the most interesting and at times the most successful method of taking salmon was with a fly. Boat fishermen sometimes troll a fly, and make good catches in tidewater. It is interesting to note that they usually insist

TABLE 5

Summary of Eel River Catch Records, 1950-51[1]

Month	Juvenile steelhead	Half-pound steelhead	Adult Steelhead	Juvenile king salmon	Adult king salmon	Juvenile silver salmon	Adult silver salmon	Number anglers	Number hours	Number days checked
June[2]	216			2		4		158	106	14
July	86							159	93	16
August	291	9	1		3			292	359	13
September	41	14	1		8			292	196	5
October	69	38	4		86			632	1,500	6
November					3		1	47	119	1
December										0
January										0
February										0

[1] Does not include anglers fishing for marine species at the mouth of Eel River.

[2] Includes May 27-31.

TABLE 6

Anglers' Catch of Steelhead, Lower Eel River, 1950

Fork length	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
4.0	2	3	6	1					
4.5	21	5	17	1					
5.0	44	25	31		1	2nd yr. stream life			
5.5	33	17	60	3	1				
6.0	31	9	31	3	1				
6.5	3	1	14	1	1				
7.0		1	6	1	1		TROUT		
7.5			4	1					
8.0		1	1	2					
8.5		1			1	1 yr. stream - part 2nd yr.			
9.0				1		est., then upstream			
9.5			1	1	4				
10.0			1	2	2	2 yrs. stream			
10.5			5	2	3	1 yr. ocean			
11.0			8	2	2				
11.5			5	4	3				
12.0			1	2	5				
12.5			1	2			HALF-POUNDERS		
13.0			2		1				
13.5				1	2				
14.0									
14.5									
15.0			1						
15.5					1	1 yr. stream, estuary, 1 ocean			
16.0				1					
16.5					1		LARGE HALF-POUNDERS		
17.0					2				
17.5									
18.0									
18.5									
19.0									
19.5									
20.0									
21					1				
22									
23			2		1				
24									
25			1				STEELHEAD		
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									

on using a fly rod and reel when trolling a fly, a practice that usually results in losing the fish. It is claimed that this is more sporting, to which we subscribe, but then why not use a fly rod when trolling a spinner?

Fly casting for salmon centered around Bryant, Miller, and Pollard pools and was indulged in by not more than 50 to 60 different anglers. They usually fished a heavy red fly, allowing it to sink. They were phenomenally successful, at least in hooking fish. For example, on September 17, Murphy spent 1-1/2 hours at Bryant Pool. Twelve anglers were fly casting. During that period someone had a fish on at all times, and at times 3 or 4 of them were engaging a fish. One angler hooked 21 salmon that afternoon and landed and released 6. Another hooked 11 and landed none. The fish hooked ranged from 5 to 35 pounds but most of those landed were between 5 to 20 pounds. One angler reported landing a 43-pound fish after an hour and forty-five minute battle.

Angling for silver salmon was negligible during the season under study. A few were taken during the latter part of October, but during November and December, when the bulk of the run passes the lower river, water conditions made fishing impossible.

A special type of fishery exists in the lower estuary. It is a fishery for marine species and will receive only passing attention in this report. Ocean perch, tomcod, starry flounder, and sculpins constituted the bulk of the sport catch in the lower estuary. Most of the fishing took place from the boat landing at the mouth of Salt River, although some boat fishing occurred in the channel near the entrance of the estuary. From the anglers' standpoint the most consistently dependable species was the pile perch. Late in June, however, a heavy run of tomcod appeared and remained in that area between the boat landing and the ocean. According to the reports of anglers, this run was the first to have occurred in the estuary for three to five years. Angler success was very high; the usual daily catch was one or two water bucketfuls. These fish abruptly disappeared from the catch during the first week in August. During the peak of the run 10 to 20 anglers could be found on the boat landing almost any day of the week. Before and after the run, the fishing effort was much lighter.

In presenting any fishery it is always of interest to attempt a quantitative description. Such data as total catch are invaluable to the manager. The catch data procured in this study were summarized in Table 5. They represent bank fishermen only and so are relatively valueless in estimating, for instance, the king salmon catch, since large numbers of these fish are caught from boats. They can be used to estimate the trout catch. An estimate of the June, July, and August trout catch was derived as follows. Working through a section systematically, we sampled probably not more than one-half the anglers using the area that day, and we sampled during approximately one-half the fishing days. The average angler day was roughly 4 hours in length (not enough anglers were contacted at the end of their fishing day to establish this definitely.) Therefore, multiplying the number of anglers seen by 4, assuming a 4-hour fishing day, and using the catch per hour for each month (derived from the data in Table 4), we obtained the following estimated catch of trout for each month.

June	-	5,000
July	-	2,500
August	-	3,800
Total	-	11,300

The number of trout taken during September and October was insignificant and would add little to the estimated 11,300.

Angling effort for half-pounders and king salmon from the bank followed such an erratic pattern that our limited sampling gives no basis for even a rough estimate of the total catch. Effort fluctuated wildly as reports of favorable or unfavorable fishing were received. On week days masses of anglers would fish the river for an hour or two before going to work. For instance, at one pool 112 cars were counted at 6 a.m. on a week day in September. At 8:30 a.m. there were only 8 anglers fishing this pool. Anglers generally, even on week ends, started fishing early (when fishing was best.) Most, after catching a fish or two, would leave. Then, with the exception of the first pool or two contacted, we found ourselves interviewing a residue of unsuccessful anglers. In contrast, trout fishing tends to be relatively stable both in terms of weekly effort and distribution of effort throughout the day. A sampling procedure could be established that would furnish the basis of a quantitative estimate of the half-pounder and salmon catch, but greater effort would be required than we were able to devote, and perhaps the results would not justify the effort.

THE FISHES

The following fresh-water and anadromous fishes were detected or have been noted by other observers in the study area. Some of them are discussed in the sections to follow.

1. Entosphenus tridentatus (Gairdner). Pacific Lamprey.
2. Acipenser medirostris Ayres. Green Sturgeon.
3. Alosa sapidissima (Wilson). American Shad.
4. Oncorhynchus kisutch (Walbaum). Silver Salmon.
5. Oncorhynchus tshawytscha (Walbaum). King Salmon.
6. Salmo clarkii clarkii Richardson. Coast Cutthroat Trout.
7. Salmo gairdnerii gairdnerii Richardson. Steelhead Rainbow Trout.
8. Catostomus humboldtianus Snyder. Humboldt Sucker.
9. Ameiurus nebulosus nebulosus (Le Sueur). Northern Brown Bullhead.
10. Lepomis cyanellus Rafinesque. Green Sunfish.
11. Cottus sp.? Sculpin.
12. Gasterosteus aculeatus Linné. Three-spined Stickleback.

Pacific Lamprey

Larvae of the Pacific lamprey were present in the lower river during the period June to September. Some of them were migrating downstream, judging by their sporadic capture in fyke nets at Bryant Pool. On July 31 a spent lamprey was captured in a fyke net at Bryant Pool. In this connection it is of interest to note that lampreys at Sweasey Dam on the Mad River were seen ascending the fishway in July.

Green Sturgeon

On June 25 and 28, 1950 several large sturgeon (up to 5 feet in length) were seen jumping in Dungan Pool. None were noted later in the season. On July 17 a dead green sturgeon 5.4 inches in length was taken near the mouth of the Van Duzen River. This specimen was badly decomposed and identification is not certain. On July 29, a 4.1 inch green sturgeon was taken in a fyke net at Bryant Pool.

King Salmon

The spawning run. In 1950 the spawning run of king salmon entered the Eel River in August. The first fish were taken in the sport fishery on August 12 and 15. From August until October increasing numbers of salmon entered the lower river. Some pushed upstream, apparently in response to slight rises in the river induced by mild fall rains. On October 6, 1950 the first king salmon appeared at Benbow Dam, on the South Fork of Eel River near Garberville. Heavy rains occurred in the Eel basin the last week in October. During and after these rains the king salmon migrated rapidly upstream. During the week of October 29 to November 4, 4,258 king salmon passed the Benbow Dam fishway. From then until January 27, 1951, when the last king salmon passed Benbow Dam, salmon were probably passing the lower river, but because of high, muddy water practically none were caught in the sport fishery.

The Pacific Marine Fisheries Commission has been conducting an extensive program of king and silver salmon tagging in the offshore waters of Washington, Oregon, and California. Of 97 king salmon examined in the sport catch, one tag was recovered. This fish was tagged on June 14, 1950, four miles SW of Point Reyes. It was captured on October 8, 1950 in the Eel River near the mouth of the Van Duzen River. A report of the capture of a salmon tagged off Oregon was heard. One other tagged fish was supposedly taken in the South Fork of Eel River near Garberville. It is of interest to note that no tagged fish were noted among the 14,357 king salmon and 12,050 silver salmon counted over Benbow Dam.

The size range of Eel River king salmon is indicated in Table 7. The size distributions indicated in Table 7 are not representative of the run. The sport catch is biased for two reasons. It represents the early part of the run only, and anglers, though they may hook fish at random, are more successful at landing the smaller fish. Most of the sample at Benbow Dam was taken on December 5, 1950, and is therefore not representative.

Downstream migration. Considerable effort was devoted to ascertaining the population of juvenile king salmon in the lower river. Seining was carried out at several points in June, July, and August. Measurements of a sample of each catch was given in Table 8. No seining was done in September. In mid-October seining captured no king salmon, so it must be presumed that they had migrated out of the river.

Fyke nets were fished in July and August to ascertain any downstream migration. These were unsuccessful except for one catch, shown in Table 8. (As will be shown later there is other evidence for downstream migration in July and August.) The fyke net used had a mouth 3' x 4' and was

TABLE 7

Anglers' Catch of King Salmon, Lower Eel River (September-October, 1950) and Sample Measured at Benbow Dam, South Fork of Eel River

Fork length in inches	Lower Eel River	Benbow Dam
17	2	
18	6	
19	9	1
20	7	5
21	13	2
22	3	3
23	5	1
24	3	0
25	0	2
26	3	1
27	1	2
28	4	1
29	6	1
30	4	3
31	5	1
32	5	1
33	3	7
34	1	3
35	4	5
36	3	4
37	1	1
38	1	1
39		2
40		2
41		2

TABLE 8

Seine Samples, Lower Eel River King Salmon, 1950
(30' x 6' x 1/4" mesh)

Fork Length in inches	Mouth Van Duzen River June 22	Eel River at Fernbridge June 24	Van Duzen River near mouth July 24	Eel River at mouth Van Duzen River July 19	Bryant Pool Fyke net July 24	Eel River at mouth Van Duzen River August 15	Van Duzen River near mouth August 15	Eel River at Fernbridge August 15
1.5								
1.6								
1.7								
1.8	1	1	1					
1.9	2							
2.0	3		1					
2.1	3		1		1			
2.2	1	1	2	2	1			
2.3	2		3		2			1
2.4	1	1	3	2	2			
2.5	4	4	5		3			
2.6	2	6	5	3	6		11	
2.7	4	6	4	5	5		1	
2.8	5	9	4	7	6	1		2
2.9	5	6	15	10	7	1	1	3
3.0	10	10	11	3	8	1		2
3.1	11	13	13	2	6			3
3.2	9	19	11	4	9			5
3.3	7	13	10	2	4			7
3.4	1	5	9		1			
3.5	2	2	2		1			3
3.6								4
3.7	1							1
3.8		1						
3.9								
4.0								1
4.1								
4.2								
4.3								
4.4								
4.5								
4.6								
4.7								

made of 1/2" square webbing. It was fished in varying locations day and night. It is possible that clear water precluded good catches in the day time. This would not be true at night. However, the fish in the river were large (Table 8) and far from being at the mercy of the moderately swift current in the riffles. The shock waves produced by the action of the current on the net may have warned the young salmon in time to by-pass the net.

Evidence available establishing downstream migration in July, August, and September may be summarized as follows:

1. On numerous occasions in locations favorable to direct observation schools of fingerling king salmon could be seen drifting downstream.

2. King salmon fingerlings were abundant in tidewater throughout the summer. They were also very abundant at the very mouth of the river.

3. The size frequencies shown in Table 8 changed very little through the season. They are evidence for growth and/or migration of the smaller size classes. They are strong evidence for migration of the larger size classes.

4. In 1939 Shapovalov (1940) studied the downstream migration of king salmon at Benbow Dam. He installed a trap in the fishway and released a known number of marked fish above the dam. From the ratio of marked to unmarked fish the total migration was estimated to be from 2 to 3 million fish. Migrants were taken from April 1 to July 9, 1939, but the bulk of the migrants passed the dam during the period June 1 to June 28. Benbow Dam is 60 miles upstream from the study area.

5. Our seining through the season, though impossible to place on quantitative terms, seemed to indicate a decline in the abundance of king salmon fingerlings. In late June and early July they were present in incredible numbers, then gradually declined as the season progressed, until they could not be detected in October.

6. On July 18, 1950 king salmon were seined from a riffle, marked by clipping the top of the caudal fin, and released on the riffle. Two hours later the area was re-seined. Fifty fingerling salmon were recovered, none of them marked. A few yards below the sample area 10 salmon were netted, 3 of them marked, and one marked salmon was recovered 90 yards below the marking area. This behavior, indicating migration, was in contrast to that of young steelhead. This latter species was marked and recovered in the sample area, and no marked fish were recovered below.

We may summarize the available evidence as follows. Downstream migrating king salmon pass the lower river during July, August, and September as fingerlings averaging around 3 inches in length. No sign of yearling migrants was detected.

Size of downstream migration. Writers such as Rutter (1903), Rich (1920), and Clark (1929) have recorded king salmon migrating to sea in such streams as the Sacramento and Columbia Rivers as newly risen fry. Rutter recovered such fry in the Sacramento Delta and Rich (1920) noted their presence near the mouth of the Columbia River. These fry and those that enter at larger sizes, up to one year, develop into adults with the so-called ocean-type scale nuclei. King salmon spending a full year in fresh water give rise to the so-called stream nuclei. Studies of scales from adults by Rich (1925), Clark (1929), and Snyder (1931) classify the adults as having either ocean-type nuclei or stream-type nuclei. From their photographs of scales it appears that most of their ocean-type nuclei fish actually went through a considerable period of fresh-water growth (though less than a year). In view of this a statement such as, "The above description is of salmon scales that have ocean-type nuclei (the young migrating to the ocean soon after they are able to swim)." Clark (1929) is somewhat misleading. It appears that the so-called ocean-type nucleus can best be defined as a nucleus indicating the fish went to sea during its first year of life. From the appearance of the scales illustrated by these writers it appears that either few salmon go to sea as soon as they can swim, or those that do, do not survive.

Returning to the Eel River, we note that there is as yet no evidence of seaward migration immediately after rising from the gravel. The migration at Benbow Dam did not occur until the summer following hatching. Any such apparent migration detected by netting should be viewed with skepticism, as it would appear difficult to distinguish between the incidental downstream movement of relatively helpless newly risen fry and actual deliberate migration. This would be particularly true if it were known that spawning redds existed immediately above the sampling station.

The length frequencies given in Table 8 are thought to represent the size of most Eel River king salmon when they enter the ocean. As a check on this, scale samples from 93 adult sport-caught salmon from the lower river were examined. The length of the fish at the apparent end of their fresh-water life was calculated. (Scales were projected and calculations made with a nomograph.) The results of this study are given in Table 9. As a check on the validity of the interpretations, scales from fingerling Eel River salmon were studied. The number of circuli on a 2.5 inch migrant was compared with the number of circuli in the stream section of an adult that apparently went to sea at 2.5 inches, etc. These data are shown in Table 10. They indicate that the interpretations of the adult scales are essentially correct.

Several pattern types were detected in the central regions of the scales. Since the total number examined (93) is small and the sample is not representative of the entire run, no attempt was made to treat the patterns numerically. Possible interpretations of these patterns are:

1. One year fresh-water - ocean (one doubtful individual).
2. Part-year fresh-water - estuary - ocean.
3. Part-year fresh-water - ocean.

In conclusion, we feel safe in stating that either all or nearly all Eel River king salmon leave fresh water during the summer following hatching or survival of variants from this pattern is negligible.

TABLE 9

Calculated Length of Sport-Caught King Salmon
at End of Fresh-water Growth

Fork length in inches	Number
2.4	5
2.5	3
2.6	2
2.7	4
2.8	7
2.9	4
3.0	10
3.1	4
3.2	5
3.3	3
3.4	7
3.5	10
3.6	3
3.7	6
3.8	5
3.9	1
4.0	2
4.1	2
4.2	2
4.3	1
4.4	0
4.5	0
4.6	1
4.7	
4.8	
4.9	1

TABLE 10

Circuli Counts of Fingerling King Salmon and Fresh-Water Growth Sections of Scales of Adult King Salmon

	Circuli				Circuli		
Length fingerling[1]	Scale 1	Scale 2	Scale 3	Length adult at end fresh-water growth[2]	Scale 1	Scale 2	Scale 3
2.4	9	8	8	2.4	6	11	10
				2.4	8	9	
				2.4	12	11	9
				2.4	10	12	12
3.0	12	11	12	3.0	13	12	12
				3.0	12	13	
				3.0	11	14	12
				3.0	14	14	13
3.5	15	14	13	3.6	13	13	
				3.6	14	15	13
				3.6	14	14	
3.7	18	17	17	3.7	18	17	21
				3.7	17	17	
				3.7	17	18	17
3.9	17	19	19	3.9	19		
				4.0	22		

[1]Fork length in inches.

[2]Calculated.

It is not known how long the young salmon remain in the estuary (from direct observation.) Large numbers of fingerlings were noted during the summer both in the estuary and at the mouth of the estuary. Those at the mouth appeared to be moving to sea. Anglers do not take 5, 6, and 7-inch salmon in the estuary, and though we regard this as poor evidence it does appear that the bulk of the young salmon do not tarry long in the estuary.

Tables 8 and 9 give us clues that artifically propagated king salmon to be stocked in the Eel River should be planted at a size of at least 3.5 inches fork length, It appears from Table 8 that the average size of the seaward migrants is considerably less than the average size at migration of the surviving adults. This may be explained on the basis of poorer survival of the smaller migrants. This poorer survival probably takes place in the ocean phase, since the migrants sampled (Table 8) were near the mouth of the river, and we detected no direct predation on young salmon in the lower river.

Coast Cutthroat Trout

Two specimens of the cutthroat were collected from tidewater of the Eel River. These were sport-caught fish. One other was detected in the sport catch but was not preserved, These tidewater specimens were quite silvery and had only faint evidence of the cutthroat mark. Data on these tidewater specimens are as follows. (Identification of these specimens was confirmed by Carl L. Hubbs).

1. June 28, 1950 - Dungan Pool, 8.7 inches fork length.
2. August 5, 1950 - Snag Pool, 9.8 inches fork length.
3. August 29, 1950 - Old Snag Pool, 9.5 inches fork length.

Frank H. Sumner of the Oregon Game Commission examined scale samples from these fish. He concludes from their scale pattern and the fish lengths that they had not been to sea.

Cutthroat were found to be abundant in streams tributary to Salt River and thence Eel River, On January 30, 1951 specimens from 3 to 8 inches in length were collected from the following streams tributary to Salt River:

Russ Creek
Reas Creek
Francis Creek
Williams Creek

Representatives of each of the collections will be deposited in collections of the California Academy of Sciences.

These specimens represent definitive records of the cutthroat in the Eel River system, though anglers have reported the species in past years. The most recent survey of the genus Salmo (Miller 1950) lists Mad River in Humboldt County as the southernmost range of the cutthroat. Earlier, Jordan (1907), in a popular account of the trout and salmon of the Pacific Coast, listed Salmo clarkii as appearing in Eel River, California. This may represent a typographical error, since Jordan, Evermann, and Clark (1930) give the southern end of the range as Elk River, Humboldt County, California. Snyder (1940) states: "They have been recorded from Eel River, but examples from that stream have never come to the writer's notice. Considerable seining there has not caught any young of the species." He may have been referring to the record of Jordan (1907).

Steelhead

In the Eel River system there are at least two races of steelhead. The first is the spring-run race that enters fresh water in April and May and remains in the stream, gradually ripening through the summer and fall and spawning during the following season. Concentrations of these fish are to be found during the summer in the headwaters of the Van Duzen River and Middle Fork of Eel River. The second race enters the river in the fall and winter and spawns during that season. In addition to these two runs, fish called half-pounders enter the river in late summer.

During the study period, the young of these races were abundant in the lower river. They were sampled from time to time by seining. Random samples of the seine catches were measured. These data are given in Table 11. They seem to fall into two size groups that probably represent age classes. The smaller class, delimited above the heavy line (Table 11), probably represents fish of the year. The average size of this group increases with passage of time. The larger size class is poorly represented in the seine samples, probably because of their ability to elude capture in the open river. This size class is probably composed of fish in their second year of stream life.

Second-year fish are the group sampled by the sport fishery (see Table 6). These samples from the sport fishery give some indication of growth as the season progresses. However, scale samples from the larger classes (8.0-9.0 inches) that entered the catch later in the season indicate that they spent the first part of their second year in the estuary and then moved upstream again.

An attempt was made to ascertain the population of steelhead of the year in a limited area of water. A stretch including riffles and pools (slow current) located just above the mouth of the Van Duzen River, was chosen. The stream section was 265 yards long and averaged 30 yards in width. On July 18 in the early afternoon 360 steelhead of the year were seined and marked by clipping the upper lobe of the caudal fin. In the late afternoon the same area was re-seined, the numbers of marked and unmarked fish noted, and all fish captured marked by clipping the lower lobe of the caudal fin. On July 19 the area was re-seined and the numbers of marked and unmarked fish were noted. The data for all seining are given in Table 12.

From the data in Table 12 we can make four estimates of the population of fish of the year.

TABLE 11

Seine Samples, Lower Eel River Steelhead, 1950
(30' x 6' x 1/4" square mesh)

Fork length in inches	Mouth Van Duzen River (fresh) June 22	Eel River at Fernbridge, June 24	Van Duzen River near mouth, June 24	Van Duzen River at mouth, July 19	Van Duzen River near mouth, July 18	Eel River at mouth Van Duzen River, August 15	Van Duzen River near mouth, August 15	Eel River at Fernbridge, August 15
1.3			1					
1.4								
1.5					1			
1.6	2		1		1		1	
1.7		1	2					
1.8	1	2	3				2	
1.9	1	1	1	1	1		2	
2.0	5	5		2		1	2	
2.1	4	5	2	3	1	1	6	
2.2	2	5	1			3	1	1
2.3	5	3		8	1	3	7	
2.4		4		1	3	4	4	
2.5	2	2		1	7	4	3	1
2.6	1	4		1	7	5	6	1
2.7	1	1		6	3	6	4	3
2.8		3		5	3	4	1	
2.9		3		3	4	6		1
3.0		2		6	6	6	4	
3.1		4		11	4	5	2	1
3.2	1			10	2	3	2	3
3.3				7	2	4	1	4
3.4		1	1	1	1	3	1	5
3.5		1	1	3	1	1		2
3.6				2		3		3
3.7								3
3.8			2			1		2
3.9					1			1
4.0			2	1	1	1		1
4.1			1					2
4.2								
4.3			1					
4.4								
4.5			3					
4.6			4					
4.7	1	3	2					
4.8			4					
4.9			2					1
5.0			1					
5.1			4					
5.2			1					
5.3								1

TABLE 12

Results of Seining and Marking Experiment on Steelhead of the Year

Date	Total number captured	Number clipped upper lobe	Number clipped lower lobe	Number marked upper lobe	Number marked lower lobe
July 18 a	360	360			
July 18 b	309		309	87	
July 19	139			29	27

1. (July 18) $\frac{309}{87} \times 360 = 1,280$ (Dorsal mark)

2. (July 19) $\frac{139}{56} \times 669 = 1,660$ (Both marks combined)

3. (July 19, dorsal mark) $\frac{139}{29} \times 360 = 1,730$

4. (July 19, ventral mark) $\frac{139}{27} \times 309 = 1,590$

5. Mean of 1 - 4 $= 1,565$

Some factors that might mitigate the estimates are the following: (1) Downstream migration of marked and unmarked fish. Presumably these would be replaced by unmarked fish from stream sections above the study area. This would make the estimate too high. That this was not serious is indicated by the two estimates made on successive days, based on fish marked by clipping the dorsal lobe of the caudal fin. In addition, seining immediately below the study areas on both days captured no marked fish. (2) Differential mortality of marked fish. This would raise the estimate, but, as in the case of the factor just discussed, does not appear to be serious. (3) Failure to sample all the population or failure of the marked fish to mingle at random with the unmarked population. This would lower the estimate. We were unable to seine the west bank of the study area because of water depth (up to 5 feet), and we do not know if the fish on both sides of the stream intermingle over such a short period. This source of error might be serious.

The sample area was about 2 acres in area. The estimated 1,565 fish of the year averaged about 3 inches in length, or 6 per ounce. (See Table 11 for measurements of samples taken near the study area on July 18 and 19.) At this rate there were about 17 pounds of fish of the year per acre of stream. The weight of the yearling population possibly equalled this, making a total of about 34 pounds of juvenile steelhead per acre of stream. This cannot be regarded as the standing crop, since no estimate was obtained of the abundant but downstream migrating (at this time) king salmon, the abundant stickleback population (frequently seined by the hundreds with the steelhead), or the sucker population. A rough guess would place the total fish population at something like 100 pounds to the acre.

If is of interest to note that while fish of the year in the river weighed about 6 to the ounce, steelhead of the year in the Prairie Creek Hatchery at the same time weighed 20-40 to the ounce.

The next class of steelhead to be considered is the half-pounder. It was first reported on by Snyder (1925). He surmised, "....the half-pounder is a young steelhead, approximately three years old, which has entered the river on its first nuptial migration." We are in agreement with the first half of the statement, but do not believe that the bulk of the fish are on a spawning migration.

The size distribution of the half-pounder catch is shown in Table 6. There appear to be two size classes of these fish. Nearly all of the smaller fish have spent two seasons in fresh water and one season in the ocean. Table 13 details the history of the half-pounders from which scales

TABLE 13

Classification of Half-pounders and Steelhead by Life History Type

Class	Number	Years in stream	Years in estuary	Years in ocean
Half-pounder	39	2	0	1
	1	1	0	1
	1	1	1	1
	1	1	1/2	1/2
	2	2	1/2	1/2
	1	4	0	0
Large half-pounders	2	1	1	1
	1	2	0	1
Steelhead	3	2	0	2[1]
	1	1	0	3[2]

[1]One spawned at age 3.

[2]Half-pounder migration at age 2 or spawn. Spawn at age 3.

were procured. From Table 13 it can be seen that at least some of the larger group appear to have spent their second year in the estuary. Some of the smaller group of half-pounders (Table 6) had formed a second winter check before ocean type growth commenced. Others had not, so it can be surmised that these latter fish had migrated to the ocean during the winter. It should be pointed out that the scale interpretations summarized in Table 12 are not supported by fish of known life history, e.g., marked fish. For this reason, some of the interpretations, particularly those involving the estuarine life, must be regarded as provisional.

Snyder (1925) stated that the half-pounders were "present in the lower reaches of the river from the first of October until about the middle of November....." During the current study the first half-pounders were noted in early August. Anglers report that they usually appear in July. Snyder thought that these fish were on a nuptial migration. Eighteen specimens were sexed in the field during 1950. Both males and females were found. None of them showed any sign of maturing. Eight were preserved and carefully examined. The two females in this group had eggs only 1/5 millimeter in diameter, and the males showed no sign of development. In contrast, small spring-run steelhead (16 inches in length) from the Van Duzen River taken even earlier in the season were also green, but the eggs were well formed and the total mass was the size of a man's thumb. We must conclude that the half-pounder is not on a spawning migration, although we did not make a laboratory examination of any of the "large half-pounders." (Table 6).

Judging from angling experience the half-pounder disappears during December. Whether they have returned to sea or have distributed themselves over the entire drainage is not known.

It is of interest to note that angling for juvenile steelhead declined as the summer progressed, indicating that the bulk of the downstream migrants do not remain for a long period in the estuary. These data are reinforced by the small number of half-pounders evidencing apparent estuarine growth on their scales.

Heavy rains and the resultant high and roily water virtually precluded a fishery on the runs of steelhead entering the lower river from November to February, so we have no data on these fish.

As stated in earlier sections, some steelhead were present in the lower river during the period May 27 to September 1. These could be either spent fish, spring-run steelhead, or precursors of the fall and winter migration. We obtained scale samples from three of these fish in August. One was a virgin fish that had spent 2 years in fresh water and two seasons in the ocean. One spent one year in fresh water, one in the ocean, after which it either spawned or migrated upstream as a half-pounder 11.9 inches in length, spent another season in the ocean, spawned, returned to the ocean, and returned to the lower river. The third spent two years in fresh water, one in the ocean, spawned, returned to the ocean, and returned to fresh water. (For the size of these fish see Table 6.) The fact that two of these fish show a short period of ocean growth after spawning at age 3 indicates that they had returned to fresh water following a brief post-spawning period, and since they appeared in the river so early, they can be considered to be spring-run fish.

AVIAN PREDATION IN THE RIVER

Field observations indicate that roughly the following numbers of avian predators were present on the river from the vicinity of the mouth of the Van Duzen River to Old Snag Pool during the summer. (Conditions in the estuary will be discussed in later sections.)

Osprey - 4 or 5
American Merganser - 8 breeding pairs (10 to 15 to a brood)
Western Belted Kingfisher - 8 pairs
Anthony's Green Heron - 16
Black-crowned Night Heron - 4
Great Blue Heron - 8
American Bittern - 3

Elson (1950), working with Atlantic salmon in New Brunswick, found that eliminating 3 or 4 broods of mergansers and as many kingfishers on an 11-mile stretch of the Pollett River, New Brunswick, gave a fivefold increase in the number of 2 and 3-year old downstream migrants resulting from the same plant of hatchery fish of the year. He found that 270,000 fingerlings resulted in 24,000 2 and 3-year smolts with bird control and 4,300 smolts without bird control. Roughly speaking, the birds accounted for 20,000 downstream migrants.

The table presented at the start of this section indicated that there were somewhat more avian predators in the study section of the Eel River than in Elson's (1950) study area. It should also be pointed out that the streams Elson studied contained species of fish, such as suckers, other than salmonids, as does the lower Eel River. If the avian predators in the lower Eel account for 20,000 downstream migrant salmonids, of the second year age class, they are doing twice as much damage to the salmonid population as the summer trout fishermen. The problem appears to be one calling for prompt, careful inquiry.

THE ESTUARY

The estuary of Eel River is characterized by narrow channels and swift tidal currents. Most of the bottom is composed of sand or a sand and mud mixture. There is little aquatic bottom plant growth present. Inflowing tidal currents cool the lower end of the estuary in the summer. Temperatures ranging from 50 to 60° F. were common near the entrance, but this cooling effect was not carried far upstream.

The estuary is shallow and if anglers' reports may be considered, it is gradually becoming more so. The greatest depth found was just inside the entrance, the depth being 30 feet at low tide. Most of the soundings were at depths of less than 15 feet.

Euryhaline conditions were carried upstream to about Dungan Pool. (See Table 3 for the specific gravity at the various stations.) The species of fish collected or observed in this zone included:

1. Sardinops caerulea (Girard), Pacific Sardine.
2. Clupea pallasii Cuvier and Valenciennes, Pacific Herring.
3. Alosa sapidissima (Wilson), American Shad.
4. Osmerid, unidentified.
5. Atherinops affinis, Top Smelt.
6. Microgadus proximus (Girard), Tomcod.
7. Cymatogaster aggregata Gibbons, Shiner Perch.
8. Damalichthys vacca Girard, Pile Perch.
9. Leptocottus armatus Girard, Staghorn Sculpin.
10. Platichthys stellatus (Pallas), Starry Flounder.
11. Syngnathus griseo-lineatus Ayres, Pipefish.

The sardines seemed to be quite common as far upstream as Dungan Pool. Sample catches were made with a one-inch square mesh gill net set near the bottom. On one occasion several were caught in water having a density of 1.003 on an out-going tide.

Beginning in July, many small schools (50 to 200 fish) of smelt were observed moving slowly along just beneath the surface. Throughout the remainder of the summer the smelt were very common in every area observed from Dungan Pool to near the mouth of the river.

What appeared to be the mating of Cymatogaster aggregatus was observed in Dungan Pool on July 15 to 16. The activity occurred in the late afternoon in water of a density of about 1.014 and at a temperature of 69° F. on an out-going tide. A pair of fish would be located just above a submerged plant or limb a few feet from the bank. The female was content to remain almost motionless, while the male engaged in erratic movements around, under, and over the female. Several pairs were captured and the males were caused to discharge their sexual products with very slight pressure to the anal region.

Adult shad reportedly spawn on the riffles upstream in the vicinity of Bryant Pool. Collections were made only of a few small immature individuals in tidewater.

Young steelhead of the 5 to 7-inch class were very abundant in the upper tidewater areas from May until about July 15, when angler-success declined notably and fewer fish were observed. Few steelhead of this size class were observed or caught below the E-Z boat landing at any time during the study period.

King salmon from about 3 to 4 inches in length were abundant throughout the tidewater area in the main channel of the river. None were seen in the sloughs and backwaters that border the main channel. In Dungan Pool they were most commonly observed swimming slowly, either upstream or downstream, in compact schools of 50 to 100 fish. However, near the entrance of the estuary they appeared to be only very loosely associated into schools. Two small king salmon were taken with a wet fly fished directly in the entrance. Many others were observed rising to the surface in the same area.

Predators were numerous in the entire tidewater area. The most abundant avian predators were pelicans, cormorants, and seagulls. Osprey were commonly seen, usually 3 or 4 different individuals in an afternoon.

None of these birds were actually seen to feed upon salmonid fishes. Species observed being caught by pelicans or cormorants included starry flounder and smelt.

Seals were first noticed in the estuary in the first week of August. A few individuals were seen at Dungan Pool a few days later. On one occasion 8 seals were observed hunting in the area immediately inside the estuary entrance.

With the possible exception of ocean perch, flounder, and salmonids, few carnivorous fish that would constitute a serious predation problem seemed to be present. The smooth, sandy and muddy estuary bottom very likely precludes the presence of notably carnivorous rock-inhabiting forms, such as ling cod and rockfish. It seems unlikely, then, that piscine predation is a very serious factor in estuarian mortality of salmon and steelhead fingerlings migrating to the ocean, though avian predation may be a problem. However, it is possible that the estuary life of young salmon and steelhead may be an important or even critical stage. It is conceivable that important competition between these young fish and the many plankton-feeding fishes may exist.

SUMMARY

A general survey of the fishes and fishery of the Eel River from the mouth of the Van Duzen River to the Pacific Ocean was made during the 1950-51 season.

A brief description of the area and of certain chemical and physical data is given. The river fishery during the summer is for trout (juvenile steelhead); during the fall for half-pounders (small sea-run steelhead) and adult king salmon; during the fall and winter for silver salmon and steelhead. Summer trout fishermen caught about 11,000 juvenile steelhead, about 5 inches long, during the season. A fishery for such marine species as ocean perch and tomcod exists in the lower estuary.

The fresh-water and anadromous species found in the river are listed. The marine species detected in the estuary are also listed.

Larvae of the Pacific lamprey were present in the lower river during the period June-September. Some were migrating downstream during this period. Adult lamprey were found in the river during the summer.

Young green sturgeon were found in the river and large sturgeon were seen jumping in tidewater.

Adult king salmon entered the river from August to December. Fingerlings of the previous year were migrating downstream during the period June-September. In October the river was devoid of young king salmon. Most returning adults migrated to sea in the summer following hatching, at a length of 2.7-4.0 inches.

Specimens of cutthroat trout were taken in tidewater, and cutthroat were collected in tributaries of the Salt River, a tributary of the lower Eel River.

In one test area in July it was estimated that there were 8 pounds of 3-inch fish of the year per acre of stream bottom. The trout fishery preyed on juvenile steelhead in their second summer of stream life. The half-pounders, largely steelhead that had spent 2 years in the stream and part of one year in the ocean, entered the river in August. They were apparently not on a nuptial migration. Some spring-run adult steelhead were present in the river during the following winter. Observations are lacking on the fall and winter runs of steelhead, because of unfavorable run-off.

A possibly serious bird predation problem is pointed out.

In the estuary a variety of marine fishes was found. Some can be regarded as competitors with trout and salmon for food, but no important fish predators were detected. Avian predation in the estuary may be a source of serious mortality.

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