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Estimating Time Series of Oregon Coastal Natural Coho Salmon Ocean Harvest Rates and Recruitment

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Introduction

Continuing low escapements of OCN coho salmon are causing concern among the fishing and conservation communities (Nehlsen et al. 1991). Effective recovery actions require that the cause or causes of the decline be accurately identified. One obstacle to correlating long-term changes in OCN abundance with possible factors affecting abundance has been the lack of a long-term data base calculated on a consistent basis.

Mullen (1981) compiled a historical time series of coho salmon landings. The earliest data come from cannery case pack records. These were segregated by species starting in 1892. Beginning in 1921 the State of Oregon imposed a tax on all salmon landings. Fish dealers were required to report their landings starting in 1923 (ODFW 1982). Recreational landings have been assessed since 1962 in California and 1970 in Oregon. Mullen (1981) compiled these disparate data sets for the time period from 1892 to 1960. Combined with recent landings data Figure 1 (taken from Figure II.C-1 of ODFW 1982) shows some important patterns. There were two major peaks in landings; approximately 1920-1940 and 1960-1980. Low landings prior to 1920 may have been due to the lack of reporting from ocean landings. However, the period of low landings between 1940 and 1960 probably reflects lower abundances. The effects of strong El Niños in 1900, 1925, 1940, and 1958 are evident in lower landings. Unfortunately, trends in stock size over a long time period cannot be inferred from this data set. Changes in reporting practices, shifts in the commercial fishery, the growth of the recreational fishery and the advent of dams and hatcheries on the Columbia River all obscure long-term trends. The contribution of Oregon coastal natural coho to this picture is impossible to discern.

Spawning ground surveys in coastal streams were initiated in 1950. This provided a direct measure of the abundance of OCN coho. However, spawning escapement is greatly influenced by harvest, especially in the ocean. In order to expand escapement estimates to population estimates the harvest rates need to be known. The data base currently used by ODFW (Table 1) uses overall OPI area harvest rates since 1970 and assumed harvest rates between 1950 and 1969 (Beidler et al. 1980). The assumed harvest rates prior to 1970 yield recruitment estimates that are not comparable with the more recent estimates and do not reflect true fluctuations in recruitment. In addition, a current study (Jacobs and Cooney 1991) is showing that actual spawning escapements are considerably lower than those traditionally calculated.

In an effort to construct a consistent data base for the time period 1952 to 1991 I used the same basic approach used by ODFW in their current data bases, but extended the time series backward from other data sources and making a few assumptions.

The data I used are presented in Table 2.

Data Sources and Assumptions

South of Cape Falcon Oregon Sport Landings: 1970 to 1991 from Oregon Historical Sport Landings Data Base. Prior to 1970 the sport landings were assumed to vary as a constant proportion of the troll landings. The proportion used, 0.26, was the mean of 1970 - 1979 landings.

South of Cape Falcon Oregon Troll Landings: 1952 to 1991 from Oregon Historical Troll Landings Data Base.

California Sport Landings: from 1962 to 1991 from California Historical Sport Landings Data Base. Prior to 1962 the sport landings were assumed to vary as a constant proportion of the troll landings. The proportion used, 0.14, was the mean of 1962 - 1971 landings.

California Troll Landings: 1952 to 1991 from California Historical Troll Landings Data Base.

North of Cape Falcon Oregon Sport Landings: 1970 to 1991 from Oregon Historical Sport Landings Data Base. Prior to 1970 the sport landings were assumed to vary as a constant proportion of the Washington Columbia River Area sport landings. The proportion used, 0.31, was the mean of 1970 - 1979 landings.

North of Cape Falcon Oregon Troll Landings: 1952 to 1991 from Oregon Historical Troll Landings Data Base.

Washington Columbia River Area Sport Landings: from 1952 to 1991 from Washington Historical Sport Landings Data Base.

Washington Troll Landings: 1952 to 1991 from Washington Historical Troll Landings Data Base.

OCN Rivers Spawning Escapement: 1952 to 1991 from ODFW Historical Table.

OCN Rivers Catch: 1970 to 1991 from ODFW Historical Table. Catch prior to 1970 was estimated from linear regression between OCN Rivers Spawning Escapement and OCN Rivers Catch from 1970 to 1991. The relationship was: OCN Rivers Catch = 0.565 + 0.028 * OCN Rivers Spawning Escapement, $r^2 = 0.391$.

OCN Lakes Spawning Escapement: 1960 to 1991. Escapement prior to 1960 was estimated from linear regression between OCN Rivers Escapement and OCN Lakes Spawning Escapement from 1960 to 1969 excluding 1964. The relationship was: OCN Lakes

Spawning Escapement = 1.446 + 0.0637 * OCN Rivers Spawning Escapement, r^2 = 0.696.

OCN Lakes Catch: 1960 to 1991. Catch prior to 1960 was assumed to be 1,000 per year, the average of 1960 to 1969 catch.

OCN Rivers Spawners * 0.33: Downward adjustment for over-expansion of spawning ground surveys. Thirty three per cent is a conservative estimate of what the actual factor may be. This is a very rough first cut at making an adjustment for this source of bias. More precise adjustments will be available following completion of the study by Jacobs and Cooney (1991).

OCN Ocean Escapement: OCN Rivers Catch + OCN Lakes Catch + OCN Lakes Spawning Escapement + OCN Rivers Spawners * 0.33.

Coastal Hatchery Escapement: Compile from department records from 1961 return year to present. The years 1952 to 1961 were estimated based on a linear regression of Coastal hatchery escapements vs. South of Cape Falcon troll landings from 1961 to 1970. The regression equations was Coastal Hatchery Escapement = 3.52 + 0.0456 * South of Cape Falcon Troll. r^2 = 0.785.

Escapement to the Columbia River: Coho runs entering the Columbia River, 1952 to 1991 from Status Report, 1992. Prior to 1970 the estimates include jacks.

Escapement to the Columbia River Ocean Area: Columbia River Ocean Escapement + Total North of Cape Falcon Catch.

Private Hatchery Catch: 1977 to 1991. From Jacobs, 1988. Catch reported is total OPI area, and broken out north and south of Cape Falcon (actually Oregon fisheries vs. Washington Columbia River fisheries). The assumption is that private hatchery coho are caught in a different pattern from other coho and therefore are subtracted from catch estimates before harvest rate calculations are made (estimates of private hatchery coho escapements are available, but are not included in the escapement estimates for this accounting).

Harvest Rates are catch/(catch+escapement).
OCN Recruits are Spawners/(1-Harvest Rate).

Harvest rates and OCN Ocean Recruits were estimated three different ways:

(Method 1) OCN Ocean Escapement and all OPI area catch. This is essentially the traditional calculation for 1970 to 1991.

(Method 2) OCN Ocean Escapement with OCN River Spawners * 0.33 and all OPI area catch. This assumes that the overall OPI area harvest rate is equal to the OCN harvest rate and spawning escapements are overestimated by a factor of three.

(Method 3) OCN Ocean Escapement with River Spawners * 0.33, catch south of Cape Falcon, and Escapement to the Columbia River area. This assumes that landings south of Cape Falcon are more representative of harvest on OCN coho than landings off the mouth of the Columbia River.

For comparison, I have included the ODFW historical OCN data base from 1952 to 1991.

Discussion

The chief difference between methods (1) and (2) is the estimated number of OCN spawners. With the reduced spawner estimates calculated harvest rates are higher and OCN Ocean Recruit estimates are lower.

Method (3) raises some additional questions. We know generally that OCN coho are distributed further south than Columbia River coho. OCN coho contribute to the fisheries south of Cape Falcon at a higher rate later in the season. The hope has been that the higher contribution rate of Columbia River coho in the Columbia River Ocean Area fisheries is balanced by the higher contribution rate of OCN coho in the south of Cape Falcon fisheries. To the extent that this is true, harvest rate estimates from method (2) are probably more realistic than method (3). However, year to year changes in recruitment and harvest rate specifically on OCN coho are probably better determined by catch south of Cape Falcon as in method (3). **I expect that method (2) shows the general level of harvest rates while method (3) shows the patterns of interannual variation for harvest rate and escapement of OCN coho.**

The purpose of this analysis is to produce a consistent forty year data set of OCN recruitments for analysis of trends and correlation with environmental factors. Figure 2 shows the time series of ocean harvest rates from the three estimation methods. Generally these methods vary together, with method (2) producing the highest estimates and method (3) producing the lowest. A pronounced drop occurred in 1984 - 1986 followed by a rebound to previous levels. Figure 3 shows a five-year moving average of the harvest rates in Figure 2. The long term pattern is for high harvest rates in the 1950's with a drop in the late 50's and early 60's rising to a broad peak in the mid 70's.

Recruitment indices from the three methods are graphed in Figure 4. Method (1) is the most variable and method (3) the least variable. All methods show peaks of abundance in 1952, 1957, 1961, 1965,1971, 1976, and 1979. The drop in abundance in 1958 - 1960 is due to a strong El Niño. The effects of the 1983 El Niño are barely perceptible in this time series. All three methods show low and constant abundances since 1980. Smoothing the recruitment time series produces Figure 5. Method (1) would suggest that abundance has been stable until the mid 1970's and then dropped to a lower level. Methods (2) and (3) indicate a longer term decline, consistent with analysis by McGie (1981). All methods show peaks in the late 50's and early 70's, although differences are slight in method (3).

Examining method 3 by itself (Figure 6) allows expansion of the vertical axis so that differences show more clearly. The downward trend is clearly visible in the 1950's, followed by a levelling off in the 60's and 70's and an abrupt drop to a lower level in 1977. Stock size in 1952 (and 1951) was very high, and not representative of average stock levels during that period.

Literature Cited and Data Sources

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Historical Table of Oregon Coastal Natural River and Lake Coho Spawning Escapement, Freshwater Catch, and Estimated Adult Recruits, 1950-91. Contact Don Bodenmiller, OFDW, Marine Science Drive, Bldg. #3, Newport, Oregon 97365.

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Washington Historical Sport and Troll Landings Data Base. Contact Jane Banyard, WDF, PO Box 43150, Olympia. Washington 98504-3150.

Table 1. Estimated harvest rates and ocean recruitments for Oregon coastal natural coho

Return Year	ODFW Official Estimates		Method 1 Spawners * 1 Catch in OPI Area		Method 2 Spawners * 0.33 Catch In OPI Area		Method 3 Spawners * 0.33 Catch south of Cape Falcon	
	HR	Recruits	HR /a	Recruits	HR /b G.11 w/ mitoscohh	Recruits	HR /c	Recruits
52	0.60	1582.8	0.42 .45	1095.1	0.60 .63	670.2	0.46	494.6
53	0.60	428.5	0.67 .69	521.1	0.78 .80	346.9	0.59	182.4
54	0.60	499.3	0.62 .64	522.6	0.76 .78	367.6	0.58	205.1
55	0.60	481.8	0.62 .64	502.3	0.75	328.5	0.53	179.3
56	0.60	783.0	0.65 .66	882.8	0.78	616.9	0.55	301.2
57	0.60	952.3	0.65	1093.8	0.79	792.1	0.62	427.5
58	0.60	245.0	0.72	351.2	0.83	255.2	0.51	89.1
59	0.60	660.5	0.55	592.3	0.74	432.6	0.39	186.5
60	0.60	314.5	0.57	293.6	0.71	182.7	0.35	82.3
61	0.60	876.7	0.59	851.1	0.73	544.9	0.43	261.2
62	0.60	718.8	0.57	664.5	0.68	401.4	0.36	201.9
63	0.60	450.0	0.73	670.6	0.80	407.8	0.52	169.5
64	0.60	307.3	0.67	370.2	0.70	253.4	0.47	145.8
65	0.65	885.7	0.65	886.8	0.71	442.2	0.38	207.7
66	0.67	819.1	0.60	669.2	0.64	328.9	0.44	212.1
67	0.67	620.3	0.70	685.1	0.73	329.5	0.50	175.0
68	0.67	602.7	0.73	739.1	0.77	367.0	0.56	188.8
69	0.67	391.5	0.67	389.0	0.70	187.2	0.47	105.7
70	0.60	664.1	0.61	584.6	0.64	305.6	0.44	197.1
71	0.77	1450.7	0.77	1298.2	0.81	730.1	0.55	302.4
72	0.80	669.8	0.80	594.9	0.83	330.7	0.54	118.5
73	0.77	734.6	0.78	638.5	0.81	378.3	0.65	203.1
74	0.80	700.0	0.80	647.6	0.83	306.4	0.65	150.2
75	0.76	673.7	0.76	638.3	0.80	310.7	0.58	144.3
76	0.87	1288.5	0.87	1216.1	0.89	596.4	0.65	184.3
77	0.85	476.3	0.85	403.9	0.88	263.4	0.52	65.3
78	0.79	379.6	0.79	347.3	0.81	159.4	0.59	73.3
79	0.73	642.8	0.73	619.4	0.78	283.2	0.59	151.0
80	0.68	358.1	0.68	326.0	0.72	158.1	0.50	89.4
81	0.78	357.8	0.78	315.5	0.81	172.9	0.57	76.7
82	0.58	323.9	0.58	297.4	0.62	135.1	0.48	100.0
83	0.74	236.7	0.75	226.2	0.80	118.7	0.58	57.8
84	0.26	290.5	0.27	264.8	0.31	121.9	0.24	110.7
85	0.37	311.4	0.38	293.6	0.43	129.0	0.28	101.5
86	0.30	286.1	0.31	260.3	0.33	116.6	0.25	104.3
87	0.56	192.5	0.56	178.4	0.59	80.2	0.49	64.2
88	0.52	343.4	0.52	325.8	0.56	136.5	0.54	132.1
89	0.51	305.9	0.51	287.9	0.54	123.0	0.46	103.6
90	0.61	275.3	0.62	259.9	0.67	120.9	0.47	75.6
91	0.42	200.3	0.43 .43 .31	184.1	0.45	83.8	0.36	72.5
92								
93								

/a OPI Area Catch / (OPI Area Catch + OCN Esc + Coastal Hatchery Esc + Columbia R. Esc.)

/b OPI Area Catch / (OPI Area Catch + OCN Esc * 0.33 + Coastal Hatchery Esc + Columbia R. Esc.)

/c South of Falcon Catch / (South of Falcon Catch + OCN Esc * 0.33 + Coastal Hatchery Esc +
+ Escapement to Columbia River Area)

Table 2. Data used for estimating harvest rates and recruitment of OCN coho.

Return Year	Catch South of Cape Falcon					Catch North of Cape Falcon					Oregon Coastal Natural Coho							Escapements to Cost			Private Hatchery		Total Catch - Private Hatchery	
	OR Sport /a	OR Troll	CA Sport /b	CA Troll	Total	OR Sport /c	OR Troll	WA CRspt	WA CRtrl	N of F Total	Rivers Spawn a	+	Catch /d b	Lakes Spawn /e c	Catch /f d	=	OCN Ocean Esc. /g e	Rivers Spawn *0.33 /h	OCN*0.33 Ocean Esc. /i	Coastal Hatchery /j	Col. R. Fresh Water /k	Col. R. Ocean Area /l	Total OPI	South of Falcon /m	North of Falcon /m	Total Catch S of F	Total Catch OPI Area
52	73.8	264.0	12.9	91.9	462.6	0.0	72.5	0.0	72.7	145.2	633.1		17.8	41.8	1.0		693.7	208.9	269.5	13.0	126.3	271.5	0.0	0.0	0.0	462.6	607.0
53	56.8	226.2	14.2	101.6	400.8	2.5	46.8	8.0	72.8	132.1	171.4		4.9	12.4	1.0		189.6	56.6	74.8	10.3	61.3	193.4	0.0	0.0	0.0	400.8	532.5
54	52.1	200.5	9.0	64.5	326.2	5.0	26.7	16.0	57.9	105.6	199.7		5.7	14.2	1.0		220.5	65.9	86.7	9.2	37.4	143.0	0.0	0.0	0.0	326.2	431.7
55	54.8	210.9	7.8	56.0	329.6	4.7	45.1	15.2	66.2	131.2	192.7		5.5	13.7	1.0		212.8	63.6	83.7	9.6	64.3	195.5	0.0	0.0	0.0	329.6	460.7
56	97.7	375.7	9.2	65.6	548.2	15.5	67.5	50.0	93.5	226.5	313.2		8.9	21.4	1.0		344.4	103.4	134.6	17.1	64.4	290.9	0.0	0.0	0.0	548.2	774.7
57	128.3	493.6	12.4	88.6	722.9	12.0	57.5	38.7	97.1	205.3	380.9		10.8	25.7	1.0		418.3	125.7	163.1	22.5	55.1	260.4	0.0	0.0	0.0	722.9	926.2
58	43.2	166.2	1.8	12.7	223.9	12.3	30.4	39.6	58.7	141.0	98.0		2.8	7.7	1.0		109.5	32.3	43.8	7.6	24.2	165.2	0.0	0.0	0.0	223.9	364.9
59	34.9	134.1	4.9	34.9	208.8	15.7	41.3	50.5	79.0	186.5	264.2		7.5	18.3	1.0		290.9	87.2	113.9	6.1	21.2	207.7	0.0	0.0	0.0	208.8	386.5
60	21.5	82.8	2.5	17.5	124.3	10.7	29.7	34.6	53.4	128.4	125.8		3.6	8.0	0.6		138.0	41.5	53.7	3.8	47.7	176.1	0.0	0.0	0.0	124.3	252.7
61	69.5	267.2	11.1	79.1	426.8	26.5	61.6	85.5	117.9	291.5	350.7		9.9	21.5	1.1		383.2	115.7	148.2	7.9	112.3	403.8	0.0	0.0	0.0	426.8	718.4
62	61.4	236.3	13.0	47.8	358.5	36.9	56.9	118.9	110.9	323.6	287.5		8.1	28.3	0.9		322.8	94.9	130.2	12.6	184.7	508.3	0.0	0.0	0.0	358.5	682.1
63	99.1	381.3	32.6	162.0	675.0	36.0	76.4	116.2	140.3	368.9	180.0		5.1	15.9	1.5		202.5	59.4	81.9	18.6	161.9	530.8	0.0	0.0	0.0	675.0	1044.0
64	123.3	474.1	39.6	247.3	884.3	41.6	84.0	134.1	157.1	416.8	122.9		3.5	32.0	0.6		159.0	40.6	76.7	33.8	453.9	870.7	0.0	0.0	0.0	884.3	1301.0
65	132.9	511.2	20.5	217.4	882.0	71.3	155.5	230.0	307.2	764.0	310.0		8.8	17.2	0.6		336.6	102.3	126.9	29.1	519.0	1283.0	0.0	0.0	0.0	882.0	1646.0
66	134.3	516.6	32.4	445.8	1129.1	44.8	129.5	144.5	194.5	513.3	270.3		7.7	20.7	1.5		300.2	89.2	119.1	26.6	785.9	1299.2	0.0	0.0	0.0	1129.1	1642.4
67	219.9	845.6	50.3	414.1	1529.9	77.4	158.4	249.8	242.6	728.2	204.7		5.8	14.3	0.5		225.3	67.8	88.2	42.8	684.2	1422.4	0.0	0.0	0.0	1529.9	2256.1
68	189.2	727.6	40.4	362.4	1319.6	53.6	97.6	172.8	185.7	509.9	196.9		5.6	10.8	1.6		216.9	65.6	83.7	32.8	423.9	933.8	0.0	0.0	0.0	1319.6	1629.4
69	132.3	508.9	28.2	193.3	862.7	51.2	48.4	165.2	163.1	427.9	129.2		3.7	9.4	0.8		142.9	42.6	56.3	35.6	463.4	891.3	0.0	0.0	0.0	862.7	1290.0
70	190.9	901.0	14.6	182.9	1289.4	66.5	100.5	203.2	205.5	575.7	228.7		12.5	20.8	1.0		263.0	75.5	109.8	40.4	895.1	1470.8	0.0	0.0	0.0	1289.4	1865.1
71	229.1	1361.0	67.4	442.1	2099.6	82.6	129.1	302.6	487.9	1002.2	293.2		7.4	30.6	0.8		332.2	96.8	135.8	28.3	544.4	1546.8	0.0	0.0	0.0	2099.6	3101.8
72	151.9	760.9	44.6	158.0	1115.4	96.5	63.7	240.6	218.3	619.1	116.9		5.0	10.8	0.6		133.3	38.6	55.0	13.0	277.9	897.0	0.0	0.0	0.0	1115.4	1734.5
73	194.2	763.8	31.6	348.1	1337.7	37.9	31.7	158.4	107.7	335.7	143.5		4.7	18.8	0.5		167.5	47.4	71.4	26.4	291.2	628.9	0.0	0.0	0.0	1337.7	1673.4
74	216.4	1093.0	76.6	655.9	2043.9	96.1	44.2	245.7	186.0	572.0	126.4		4.2	6.9	0.4		137.9	41.7	59.2	35.6	460.9	1032.9	0.0	0.0	0.0	2043.9	2615.9
75	209.7	614.6	21.2	204.0	1049.5	42.5	42.8	168.2	160.2	413.7	153.0		3.9	6.1	0.7		163.7	50.5	61.2	5.2	292.4	706.1	0.0	0.0	0.0	1049.5	1463.2
76	384.6	1650.3	57.9	621.8	2714.6	116.7	176.7	371.9	326.1	991.4	156.8		6.5	5.3	0.2		168.8	51.7	63.7	42.7	337.1	1326.5	0.0	0.0	0.0	2714.6	3706.0
77	147.8	372.9	14.2	45.2	580.1	47.5	73.2	183.0	99.0	402.7	61.0		4.4	6.8	0.2		72.4	20.1	31.5	7.5	93.5	496.2	8.2	7.4	0.8	572.7	974.8
78	200.0	555.4	41.2	315.8	1112.4	59.8	56.2	198.8	91.2	406.0	72.2		1.3	4.5	0.2		78.2	23.8	29.8	7.8	307.0	713.0	21.5	18.9	2.6	1063.5	1496.9
79	142.8	654.0	21.3	184.4	1002.5	38.0	48.7	123.3	112.6	322.6	167.0		0.4	6.8	0.0		174.2	55.1	62.3	25.5	274.6	587.2	40.3	28.0	12.3	974.5	1284.6
80	270.2	350.7	21.2	49.8	691.9	55.6	23.5	154.5	55.1	288.7	104.2		3.6	6.5	0.3		114.6	34.4	44.8	25.5	299.7	568.4	44.2	35.6	8.4	656.1	936.4
81	145.5	567.7	10.6	83.9	807.7	54.3	41.9	118.6	77.0	291.8	70.5		2.8	6.5	0.7		80.5	23.3	33.3	24.1	170.2	462.0	144.6	129.4	15.1	676.3	954.5
82	139.6	519.4	26.7	91.9	777.6	35.5	24.1	83.3	44.1	187.0	124.7		3.1	7.2	0.4		135.4	41.2	51.9	19.7	453.2	640.2	122.2	116.1	6.0	661.5	842.5
83	109.7	321.5	27.2	59.9	518.3	37.2	4.9	85.6	18.4	146.1	55.5		1.1	4.3	0.4		61.3	18.3	24.1	10.2	100.6	246.7	135.2	125.4	9.8	392.9	529.2
84	112.4	17.5	19.0	47.0	195.9	10.9	13.9	23.3	6.6	54.7	194.0		4.8	13.5	1.5		213.8	64.0	83.8	30.6	414.0	468.7	10.2	8.8	1.4	167.1	240.4
85	151.5	105.8	15.8	11.0	284.1	31.0	18.3	68.7	14.3	132.3	183.4		4.7	7.8	0.3		196.2	60.5	73.3	25.7	365.7	496.0	63.3	54.7	8.6	229.4	353.1
86	174.6	472.2	18.7	36.4	702.1	36.9	45.8	67.7	45.6	196.0	179.0		7.0	11.8	0.5		198.3	59.1	78.4	39.4	1530.0	1726.0	94.9	91.0	3.9	611.1	803.2
87	152.1	375.1	47.3	43.7	618.2	25.3	7.6	54.3	10.8	98.0	78.3		2.5	4.2	0.1		85.1	25.6	32.6	35.2	306.9	404.9	170.0	160.7	9.4	457.5	545.2
88	216.4	735.1	34.7	51.0	1037.2	9.8	0.0	21.8	0.0	31.6	155.0		3.3	5.8	0.4		164.5	51.2	60.7	45.4	665.8	897.4	103.7	91.3	12.4	945.9	955.1
89	236.0	514.7	49.6	41.9	844.2	34.4	21.1	82.3	16.0	153.8	139.7		4.8	4.8	0.6		149.9	46.1	56.3	43.0	702.3	856.1	48.0	42.2	5.8	802.0	950.0
90	162.4	155.5	51.6	60.9	430.4	36.1	10.6	87.9	21.5	156.3	99.8		2.3	4.4	0.3		106.8	32.9	39.9	16.9	196.6	352.9	72.9	64.2	8.7	366.2	513.8
91	219.7	295.9	69.1	83.9	668.6	39.4	26.7	75.2	14.7	156.0	104.7		6.6	4.4	0.7		116.4	34.6	45.3	41.5	895.7	1051.7	25.3	22.3	3.0	646.3	799.2

/a Catch prior to 1970 assumed to vary as a constant proportion of the troll catch. Proportion is average of 1970-1979 sport/troll catch = 0.26.

/b Catch prior to 1962 is a constant proportion of troll catch. Proportion is mean 1962-1971 sport/troll catch = 0.14.

/c Catch prior to 1970 is a constant proportion of the Washington Columbia River Area sport catch. Proportion is mean 1970-1979 OR Sport/WA CRspt = 0.31.

/d Catch prior to 1970 is from linear regression of 1970-1990 catch on OCN Rivers Spawn. OCN Rivers Catch = 0.565 + 0.028*OCN Rivers Spawn, r-squared = 0.391.

/e Escapement prior to 1960 is from linear regression of 1960-1969 escapement on OCN Rivers Spawn. 1964 was excluded. Regression is OCN Lakes Spawn = 1.446 + 0.0637*OCN Rivers Spawn. r-squared = 0.696.

/f Catch prior to 1960 is average of 1960-1969.

/g OCN Rivers Spawn + Rivers Catch + Lakes Spawn + Lakes Catch

/h Rivers Spawn * 0.33 spawning expansion bias. A crude first cut.

/i Rivers Spawn * 0.33 + Rivers Catch + Lakes Spawn + Lakes Catch.

/j Coastal Hatchery Escapement from 1952-1960 estimated from regression. CHEsc= 3.52 + 0.0456 * S of Falcon Troll(1961-1970). r-square= 0.785.

/k Includes minimum estimate of adult + jacks, 1952-1969, Adults only 1970-1991.

/l Columbia River Area Catch + Columbia River Ocean Escapement.

/m Private Hatchery Catch North of Cape Falcon for 1988 - 91 = 0.12 * Total Private Hatchery.

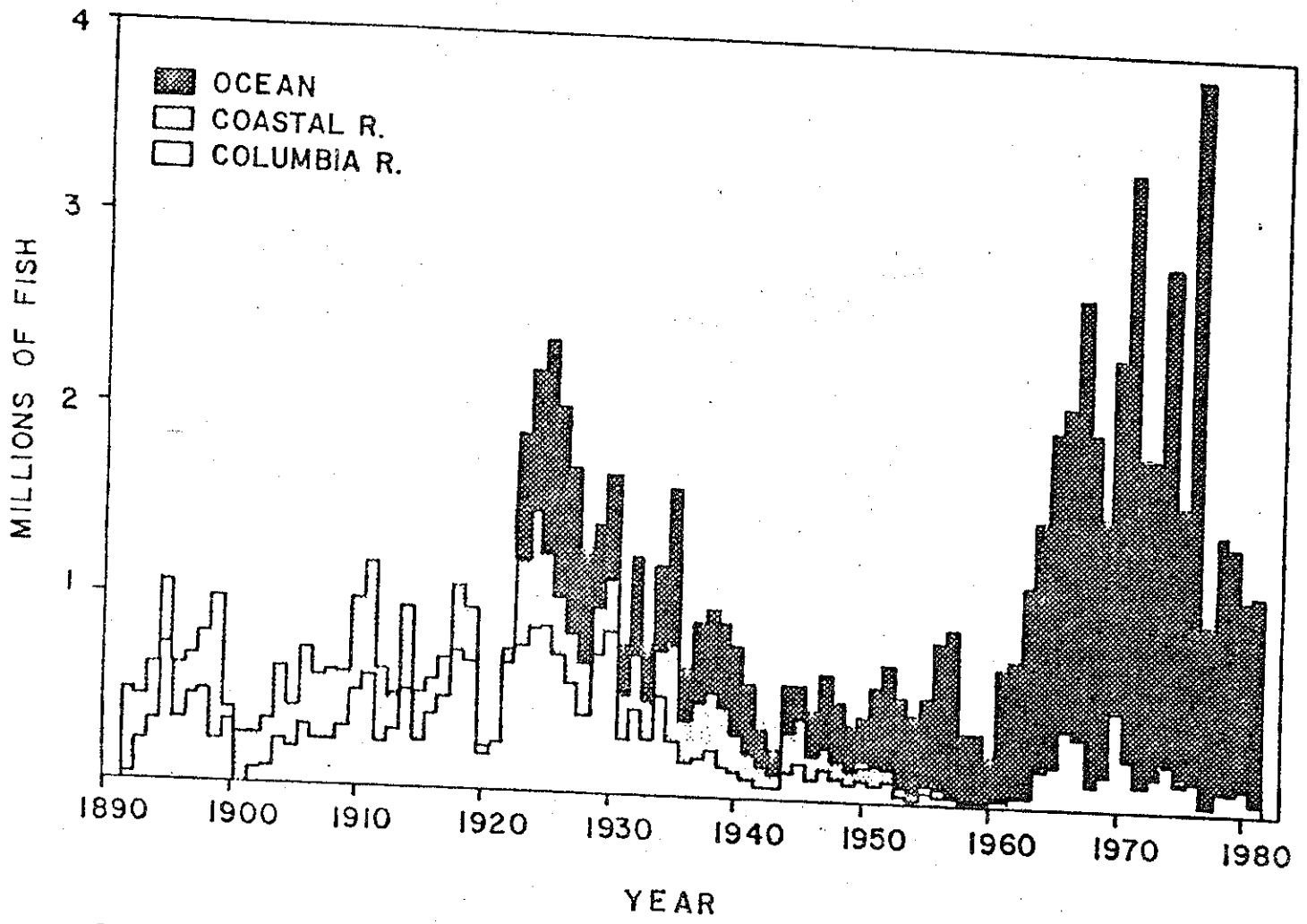

Figure 1.

Fig. II.C-1. Numbers of coho salmon landed in the Oregon Production Index (OPI) area and Columbia River, 1892-1981..

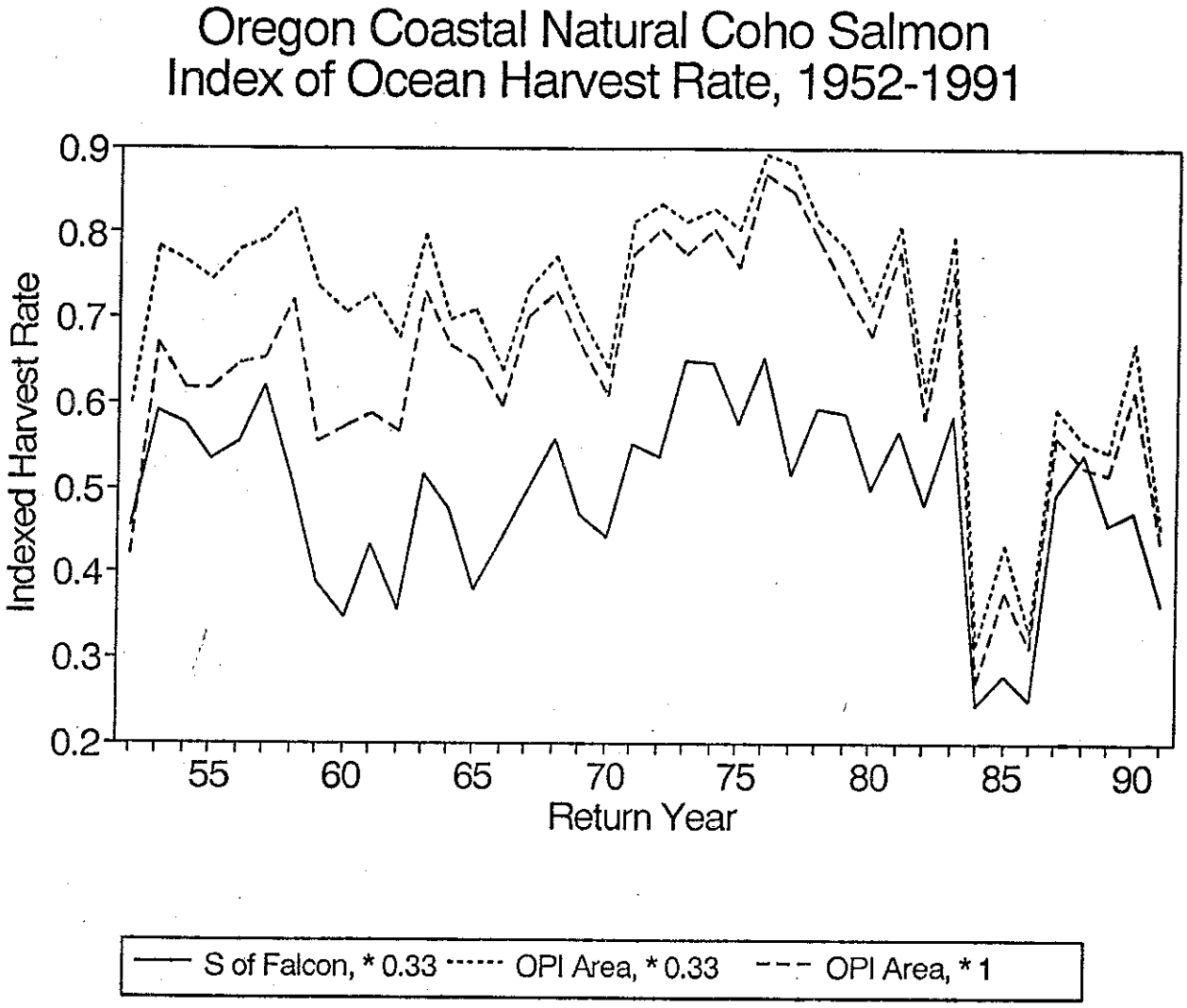
Oregon Coastal Natural Coho Salmon
Index of Ocean Harvest Rate, 1952-1991
Indexed Harvest Rate
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
55
60
65
70
75
80
85
90
Return Year
S of Falcon, * 0.33
OPI Area, * 0.33
OPI Area, * 1

Figure 2.

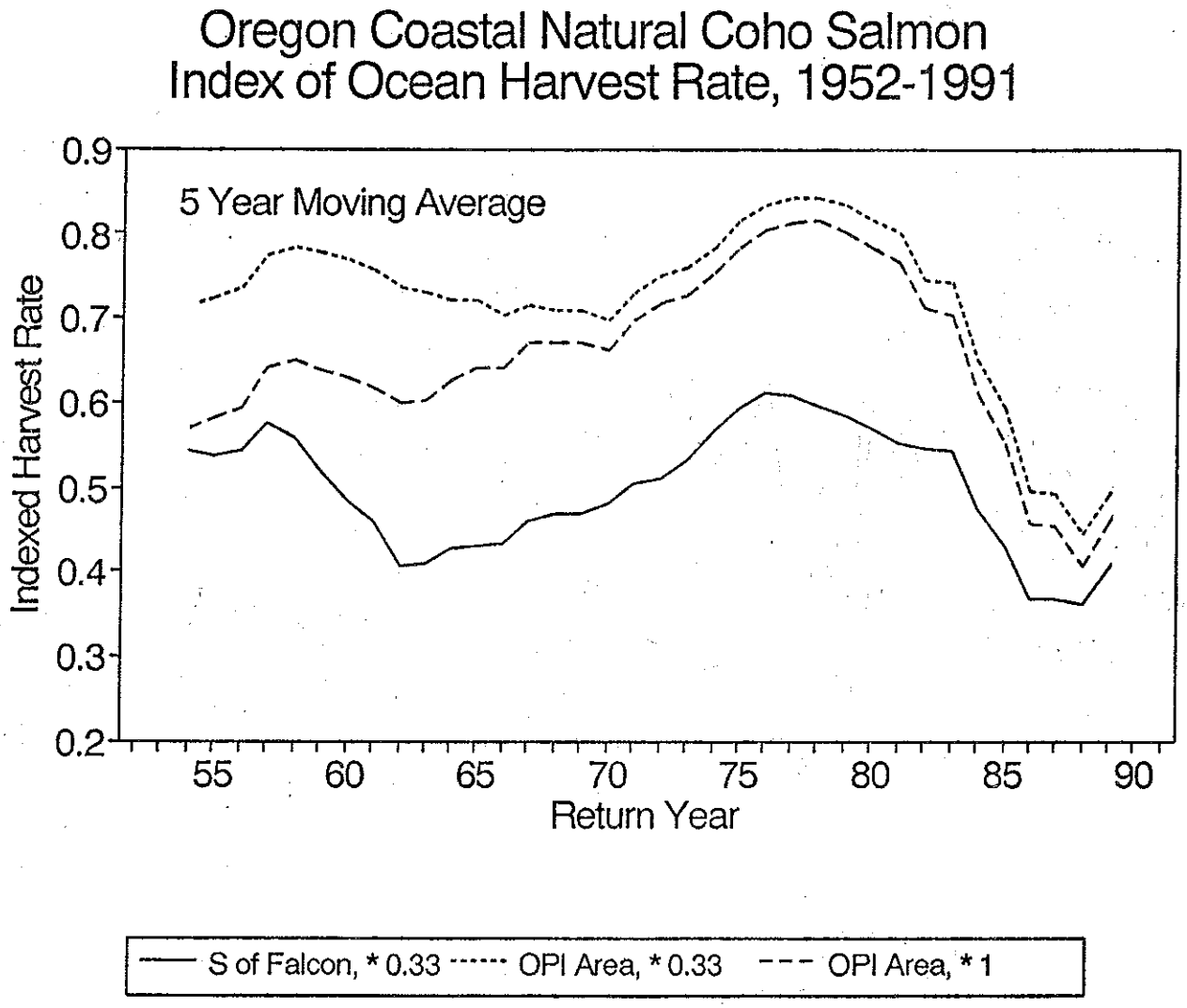
Oregon Coastal Natural Coho Salmon
Index of Ocean Harvest Rate, 1952-1991
5 Year Moving Average
Indexed Harvest Rate
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
55
60
65
70
75
80
85
90
Return Year
S of Falcon, * 0.33
OPI Area, * 0.33
OPI Area, * 1

Figure 3.

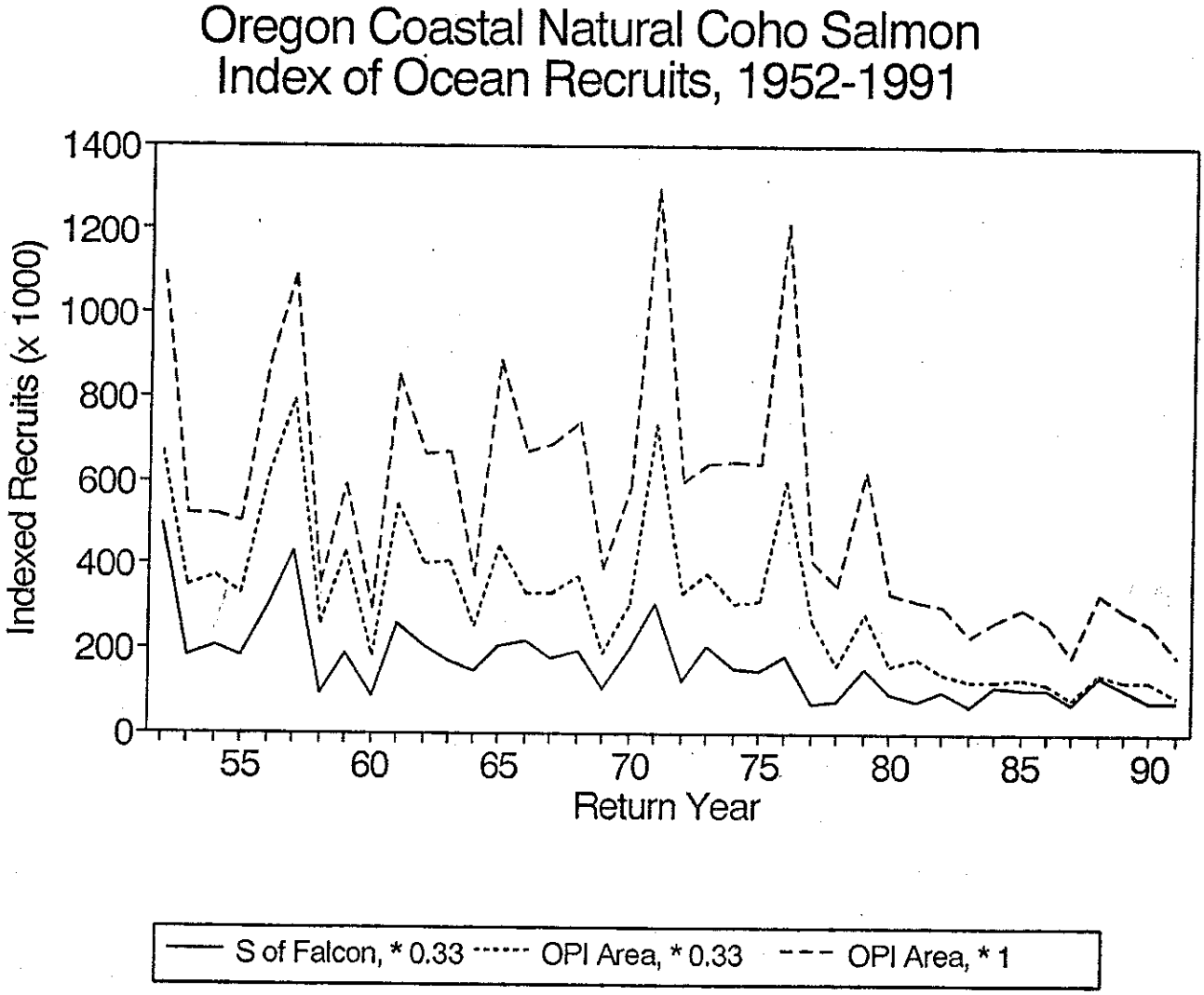
Oregon Coastal Natural Coho Salmon
Index of Ocean Recruits, 1952-1991
Indexed Recruits (x 1000)
1400
1200
1000
800
600
400
200
0
55
60
65
70
75
80
85
90
Return Year
S of Falcon, * 0.33
OPI Area, * 0.33
OPI Area, * 1

Figure 4.

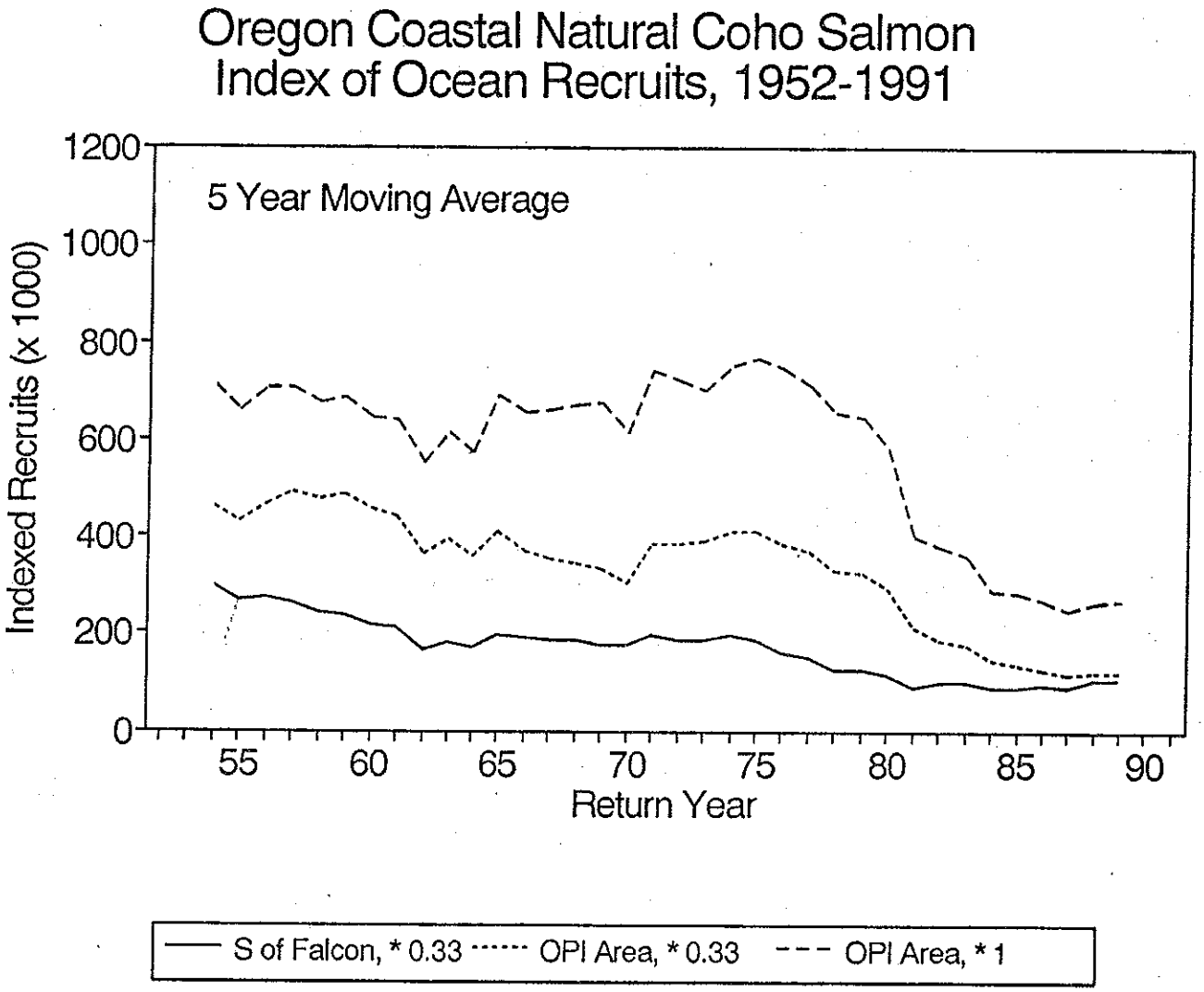
Oregon Coastal Natural Coho Salmon
Index of Ocean Recruits, 1952-1991
5 Year Moving Average
Indexed Recruits (x 1000)
1200
1000
800
600
400
200
0
55
60
65
70
75
80
85
90
Return Year
S of Falcon, * 0.33
OPI Area, * 0.33
OPI Area, * 1

Figure 5.

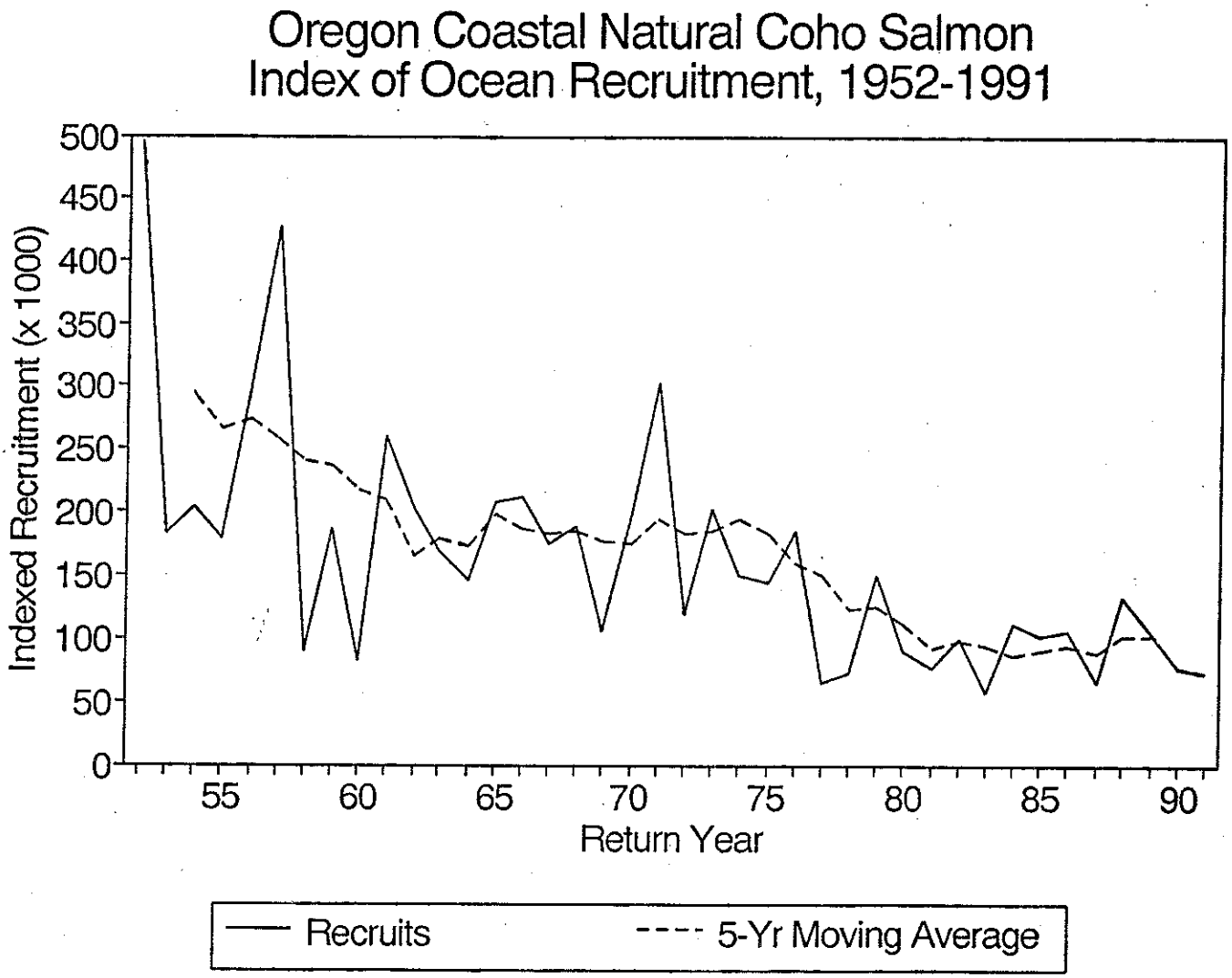
Oregon Coastal Natural Coho Salmon
Index of Ocean Recruitment, 1952-1991
Indexed Recruitment (x 1000)
500
450
400
350
300
250
200
150
100
50
0
55
60
65
70
75
80
85
90
Return Year
Recruits
5-Yr Moving Average

Figure 6.