RELATIVE ABUNDANCE OF FOUR SPECIES OF *SEBASTES* OFF CALIFORNIA AND BAJA CALIFORNIA

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ABSTRACT

Estimates of relative abundance of rockfish larvae were made for the area from San Francisco to southern Baja California. Over the 14 years studied, 30% of spawning occurred in February, 18% in January, 17% in March, and 12% in April. For the four identified species of rockfish larvae, peak spawning occurred in February (65%) for *S. jordani*; in January (45% and 40%, respectively) for *S. levis* and *S. paucispinis*; and in April (32%) for *S. macdonaldi*.

Half of the *S. jordani* larvae were taken within 10 nautical miles of land. About half of the other three species were taken within 20 nautical miles of land. *Sebastes* larvae were most abundant off San Francisco and Monterey and in the area of the Channel Islands off southern California, with the former area accounting for 53% of all larvae and the latter for 35%.

RESUMEN

Se estimó la abundancia relativa de larvas de *Sebastes* en el área entre San Francisco y el Sur de Baja California. Durante los 14 años de estudio, un 30% del desove ocurrió en febrero, un 18% en enero, un 17% en marzo, y un 12% en abril. Para las cuatro especies de larvas de *Sebastes* identificadas, el desove máximo se presentó en febrero (65%) para *S. jordani*, en enero (45% y 40%, respectivamente) para *S. levis* y *S. paucispinis*, y en abril (32%) para *S. macdonaldi*.

La mitad del número de larvas de *S. jordani* fue colectada dentro de las 10 millas náuticas desde la costa. Alrededor de un 50% de las otras tres especies fue colectado dentro de las 20 millas náuticas desde la costa. Las larvas de *Sebastes* fueron más abundantes frente a San Francisco y Monterey (53% del total de larvas), y en el área de las "Channel Islands" al Sur de California (35%).

INTRODUCTION

Hubbs et al. (1979) list 62 species of rockfish of the genus *Sebastes* occurring in the coastal waters of California. Some rockfishes are important to sport and commercial fisheries; others are too infrequently taken or do not grow large enough to significantly contribute to the fisheries.

Since 1950, CalCOFI members the National Marine Fisheries Service (U.S. Department of Commerce), its predecessor agency the Bureau of Commercial Fisheries, and Scripps Institution of Oceanography have furnished vessels to obtain biological, physical, and chemical samples over a pattern of stations off the coasts of California and Baja California (see inside back cover). The pattern was sampled monthly for the ten years from 1950 through 1959 and has been sampled intermittently since then.

Plankton are sampled at each station with a 1-m net. The larval fish taken in each net tow are identified and enumerated. In past years rockfish were identified to genus only. More recently (1977) Moser et al. described the larvae of 4 of the 62 species—*S. paucispinis* (bocaccio), *S. jordani* (shortbelly rockfish), *S. levis* (cow rockfish), and *S. macdonaldi* (Mexican rockfish).

Ahlstrom (1959) obtained information on the temperature and depth distribution of larval rockfish from a series of 17 vertical distribution net tows at 12 depths from 2 to 285 m. *Sebastes* larvae were taken at temperatures between 9.0° and 17.2°C, with the larger concentrations occurring at temperatures between 10.2° and 16.1°. Ahlstrom found that only nine rockfish larvae were taken below 100 meters (actually in the 122-89-m haul). The depth distribution follows a normal distribution (Figure 1), with a peak at about 40 m and a standard deviation of 21.6 m. However, distribution is probably determined to a considerable extent by the position of the thermocline. Ahlstrom also decided that there was no significant difference between the numbers of rockfish larvae taken in night and day net hauls. (For some species of fishes more larvae are taken in night hauls.)

This paper presents data based on the identification and enumeration of the larvae of four species of rockfish for 5 CalCOFI survey years and for all *Sebastes* larvae for 14 years. Although it is not yet possible to identify all sizes of larvae of most rockfish species, the results of this study provide a background for evaluating the potential use of larval surveys to study distribution and abundance. The larval data were provided by H. Geoffrey Moser, under whose direction

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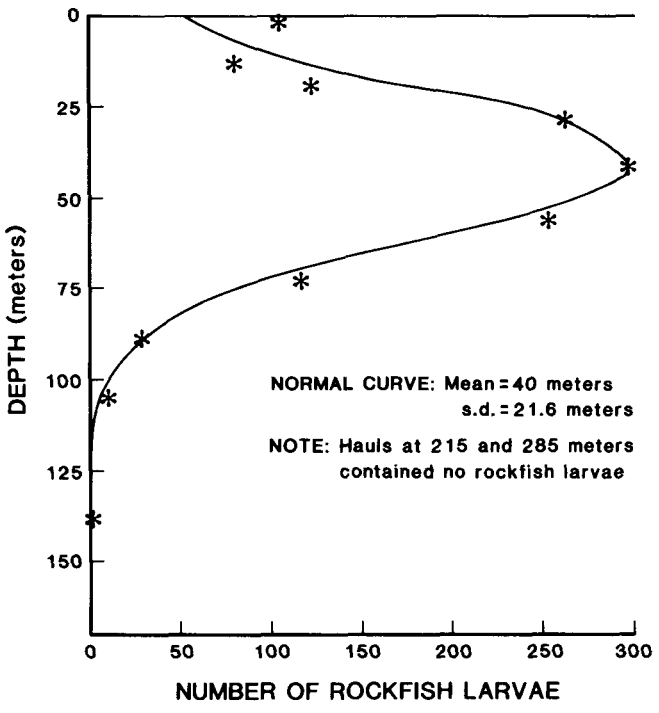

Figure 1. Depth distribution of rockfish larvae.

the four species of larval rockfishes were identified, counted, and measured by Elaine Sandknop with the assistance of Connie Fey and Susan D'Vincent.

MATERIALS AND METHODS

Sebastes larvae taken at each CalCOFI station for each survey cruise have been enumerated routinely each year. For this study, larvae of *S. paucispinis*, *S. jordani*, *S. levis*, and *S. macdonaldi* were identified, counted, and measured for each monthly survey for the years 1956, 1969, 1972, 1975; for *S. jordani* and *S. macdonaldi* 1966 was also included.

Routine CalCOFI plankton sampling methods and equipment have been described in detail by Ahlstrom (1948, 1953). The amount of water strained by the plankton net is measured so that the data may be converted to the numbers of organisms under one square meter of sea surface and therefore be comparable between stations.

The area included in this survey extended from the strip of ocean represented by CalCOFI line 60, just north of San Francisco Bay, to the strip represented by line 157, off the southern tip of Baja California (inside back cover). Coverage of the area north of line 60 was too spotty to be usable. The number of rockfish larvae taken at each station was expanded to give an abundance estimate for the area represented by that station. These estimates were combined to estimate the larval population present in the 40-nautical-mile-wide strip of ocean represented by each CalCOFI line. In some months no cruise was made, or some lines were omitted from the pattern. Estimates were calculated for these omissions based on the average percentages of larvae taken in those months or on those lines in the other years when they were sampled; i.e., if *X*% of the larvae were taken on a line or in a month when they were sampled, I assume that *X*% were present at similar times when they were not sampled. However, these omitted lines or months were generally outside the main spawning season and did not affect the estimates significantly. The estimates obtained are for the numbers of larvae in the area at the time of the cruise. No data are available that would allow us to interpolate between months in order to obtain more representative estimates of annual spawning.

Although the stations on some lines were sampled much farther to sea than on others, I believe that most of the offshore distribution was sampled adequately. Half of the *S. paucispinis* and *S. macdonaldi* larvae were taken within 20 nautical miles of land, and half of the *S. jordani* larvae within 10 nautical miles of land (Table 1). *S. paucispinis* appears to have a somewhat more offshore distribution than the other larvae, while the distribution of *S. jordani* is more inshore. There were too few data to determine the offshore distribution of *S. levis*, but it appears to be similar to the other *Sebastes* larvae.

The numbers and percentages in the tables include several degrees of magnitude. Digits are retained in the larger numbers for purposes of alignment and do not imply great accuracy of these numbers.

RESULTS AND DISCUSSION

Estimates of larval rockfish abundance in the area represented by lines 60 through 137 (Table 2) range from 38×10^{12} in 1959 to 219×10^{12} in 1969 for the 14 years 1950-59, 1966, 1969, 1972, and 1975. The 14-year average abundance is 135×10^{12} larvae.

Because rockfishes are live bearers whose larvae develop within the ovaries and hatch at the time of spawning, and because most of the larvae taken were close to the hatching size, the occurrence of larvae should delimit the spawning season fairly well. For the 14 years 18% of the spawning occurred in January, 30% in February, 17% in March, and 12% in April.

In any given year, if the spawning was low in one of these four months, it tended to be low in the other three months, and, if high, it tended to be high in the other three months. Rank correlation of the amount of spawning in January, February, and March yielded correlation coefficients of 0.65 (January/February), 0.70 (January/March), and 0.78 (February/March). The correlation coefficient for a probability of 0.01 is 0.66. Correlations with April were less significant.

TABLE 1
Cumulative Percentage Distribution of Rockfish Larvae (Five-Year Average) Relative to Distance from Nearest Land for Each of Three Species Compared to Percent Distribution of All Species of Rockfish Larvae Less the Species Compared

Nautical miles from land	*Sebastes paucispinis*	All other rockfish	*Sebastes jordani*	All other rockfish	*Sebastes macdonaldi*	All other rockfish
0-10	29.3	63.7	56.9	65.6	43.9	46.5
0-20	50.4	76.6	68.2	76.7	56.5	65.6
0-30	56.9	85.4	93.3	83.1	69.7	85.0
0-40	74.4	90.1	97.0	88.5	81.2	89.2
0-50	85.8	95.2	99.1	94.2	83.3	92.9
0-100	97.6	98.5	99.9	98.2	100.0	96.4
0-150	99.1	99.2	100.0	99.2		98.1
0-200	100.0	99.8		99.7		100.0
0-250		100.0		100.0		

Total rockfish larvae include only larvae occurring in the same areas as species with which compared; i.e., no *S. paucispinis* larvae were taken south of line 113, no *S. jordani* south of line 120, no *S. macdonaldi* north of line 83. Also *S. paucispinis* was not identified in the 1966 samples.

The high correlations among the first three months indicate that the sampling program provided representative estimates of larval abundance, and that short-term random changes in larval abundance do not mask annual changes during the major spawning season. Years of low abundance estimates probably indicate low spawning effort and/or high early larval mortality, whereas years of high abundance estimates indicate

TABLE 2
Estimated Rockfish Larvae (Billions) for 14 Years

	Year							
Month	1950	1951	1952	1953	1954	1955	1956	1957
Jan.	14,622	12,109	9,707	17,284	26,355	29,950	24,018	36,519
Feb.	16,118	18,715	35,049	47,529	55,980	50,871	63,875	72,650
Mar.	12,999	15,931	23,730	19,506	22,583	15,951	37,967	31,048
Apr.	16,716	25,438	14,820	8,401	16,943	16,578	9,886	30,031
May	4,593	11,414	7,575	4,496	9,447	5,810	5,763	13,457
June	4.445	9,367	9,285	4,576	7,453	5,404	4,264	8,232
July	2,969	2,580	4,652	3,467	4,858	10,993	4,295	4,591
Aug.	3,149	3,418	1,600	2,768	2,791	2,698	5,683	490
Sept.	1,433	904	1,119	2,141	1,316	987	0	701
Oct.	1,093	781	2,086	6,098	1,536	1,709	2,121	1,185
Nov.	1,109	2,462	1,801	1,486	2,110	5,192	1,376	2,083
Dec.	2,310	1,853	3,248	5,115	3,708	2,766	8,929	8,954
Totals	81,556	104,972	114,672	122,867	155,080	148,909	168,177	209,941

	Year							
Month	1958	1959	1966	1969	1972	1975	Mean	Percent
Jan.	17,424	5,777	24,736	38,560	48,378	28,617	23,861	17.68
Feb.	21,297	8,863	27,401	77,687	30,567	46,245	40,918	30.32
Mar.	15,370	4,572	23,878	40,409	30,382	28,165	23,035	17.07
Apr.	7,235	6,569	20,845	25,792	16,617	16,573	16,603	12.30
May	9,583	4,226	8,812	9,156	12,110	5,129	7,969	5.90
June	4,161	2,274	8,003	7,578	5,484	5,469	6,143	4.55
July	3,765	2,205	6,075	6,363	4,886	3,252	4,639	3.44
Aug.	113	623	1,438	3,102	2,681	2,675	2,374	1.76
Sept.	477	554	2,196	2,809	1,966	1,961	1,326	0.98
Oct.	1,300	420	1,989	1,693	2,208	1,805	1,859	1.38
Nov.	376	542	474	3,755	2,620	3,241	2,045	1.51
Dec.	1,320	1,242	3,420	2,074	4,878	8,939	4,197	3.11
Totals	82,421	37,867	129,267	218,978	162,777	152,071	134,969	100.00

Estimates are for the area represented by CalCOFI lines 60 through 137 at the time the samples were taken.

TABLE 3
Rockfish Larvae 14-Year Annual Averages

CalCOFI line	Number (billions)	Percent
60	16,044	11.841
63	15,779	11.646
67	12,685	9.362
70	5,329	3.933
73	4,201	3.101
77	6,159	4.546
Total (60-77)	60,197	44.429
80	7,476	5.518
83	12,896	9.518
87	16,326	12.049
90	9,791	7.226
93	5,094	3.760
Total (80-93)	51,583	38.071
97	3,275	2.417
100	2,973	2.194
103	1,775	1.310
107	1,419	1.048
Total (97-107)	9,442	6.969
110	1,448	1.069
113	2,014	1.486
117	3,944	2.911
120	2,182	1.610
Total (110-120)	9,588	7.076
123	1,336	0.986
127	881	0.650
130	579	0.428
133	824	0.608
137	539	0.398
Total (123-137)	4,159	3.070
140	128	0.094
143	64	0.047
147	237	0.175
150	68	0.050
153	8	0.006
157	17	0.013
Total (140-157)	522	0.385
Total (60-157)	135,491	100.000

high spawning effort and/or low early mortality rather than random fluctuations resulting from inadequate sampling.

The 14-year average number of larvae by CalCOFI line (Table 3) shows high abundance levels in the San Francisco-Monterey area (lines 60-67). These lines account for 33% of the larvae found in the main survey area (30 lines, 60-157). Sparse data for the six lines north of line 60 (lines 40-57) indicate a population equal to about 75% of the population in the area represented by the six lines 60-77, with about a third of

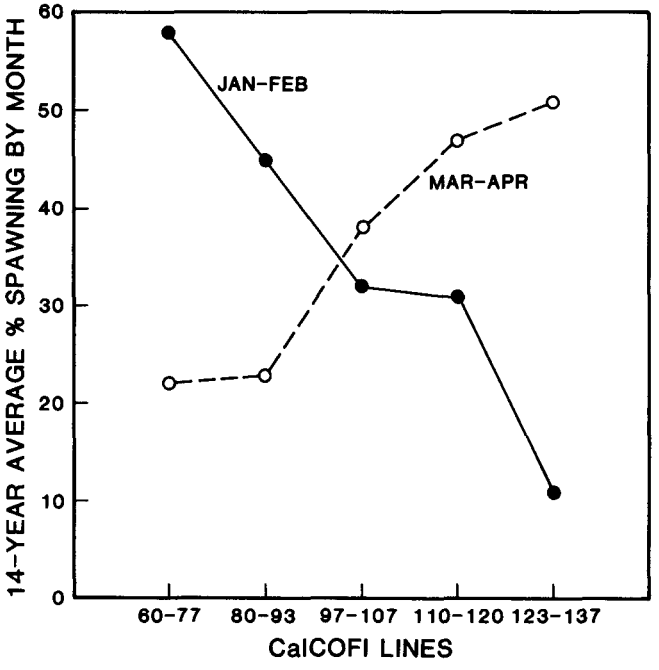

Figure 2. Percent of total year's rockfish spawning occurring in January/February and March/April for five areas as measured by larvae (14-year average).

these larvae found on line 57. Along the exposed coast south of Monterey (line 70) the larval abundance decreases to Point Conception (line 80). In the Channel Islands area (lines 83-90) larval abundance again increases. These three lines account for 29% of the larvae found in the main survey area. The number of larvae continues to decrease southward to line 157 with one smaller increase in the area around and north of Punta Eugenia and Cedros Island (lines 113-120).

The spawning season appears to be later farther south (Figure 2). April is the peak spawning month off Mexico (lines 97-137). This area accounts for only 17½% of the total average yearly production of rockfish larvae, in contrast to 82½% for U.S. waters (lines 60-93), which tends to mask this seasonal phenomenon (Table 3). The increase in late spawning in the more southern areas is probably due to increased proportions of late-spawning species of rockfishes like the Mexican rockfish and the subgenus *Sebastomus* (Chen 1971), which become relatively more abundant in the rockfishes' southern range.

Estimates of the numbers of all rockfishes, *S. jordani*, and *S. macdonaldi* were calculated by month and line for 1956, 1966, 1972, and 1975, and of *S. paucispinis* and *S. levis* for 1956, 1969, 1972, and 1975[1]. A summary of the estimated larval abundance by year and month (Table 4) shows that the seasonal distribution of all rockfish larvae for the 5 selected

[1]Tables to be issued as an administrative report of the Southwest Fisheries Center.

TABLE 4
Estimated Larvae (Billions) from CalCOFI Lines 60-137 (60-157 for *Sebastes macdonaldi*) for All Rockfish, and Four Species of Rockfish

Month	Year						
All RF	1956	1966	1969	1972	1975	Mean	Percent
Jan.	24,018	24,736	38,560	48,378	28,617	32,862	19.766
Feb.	63,875	27,401	77,687	30,567	46,245	49,155	29.566
Mar.	37,967	23,878	40,409	30,382	28,165	32,160	19.344
Apr.	9,886	20,845	25,792	16,617	16,573	17,943	10.792
May	5,763	8,812	9,156	12,110	5,129	8,194	4.929
June	4,264	8,003	7,578	5,484	5,469	6,160	3.705
July	4,295	6,075	6,363	4,886	3,252	4,974	2.992
Aug.	5,683	1,438	3,102	2,681	2,675	3,116	1.874
Sept.	0	2,196	2,809	1,966	1,961	1,786	1.075
Oct.	2,121	1,989	1,693	2,208	1,805	1,963	1.181
Nov.	1,376	474	3,755	2,620	3,241	2,298	1.379
Dec.	8,929	3,420	2,074	4,878	8,939	5,648	3.397
Totals	168,177	129,267	218,978	162,777	152,071	166,254	100.000
S. paucispinis							
Jan.	548		2,651	3,966	2,050	2,304	40.131
Feb.	351		2,934	1,615	1,693	1,648	28.713
Mar.	514		1,374	1,388	952	1,057	18.413
Apr.	65		462	333	235	274	4.769
May	17		170	304	82	143	2.495
June	17		20	17	24	20	0.340
July	0		0	0	0	0	0.000
Aug.	0		0	0	0	0	0.000
Sept.	0		0	0	0	0	0.000
Oct.	0		0	13	6	5	0.083
Nov.	0		12	12	19	11	0.187
Dec.	133		168	341	476	280	4.869
Totals	1,645		7,791	7,989	5,537	5,742	100.000
S. jordani							
Jan.	1,611	2,761	1,611	3,551	2,160	2,339	13.564
Feb.	14,300	8,118	20,932	2,426	10,590	11,273	65.378
Mar.	2,962	2,017	4,186	2,541	2,419	2,825	16.383
Apr.	492	667	1,183	364	666	674	3.911
May	23	0	113	310	46	98	0.571
June	0	0	9	1	3	3	0.015
July	0	0	4	0	0	1	0.005
Aug.	0	0	23	11	21	11	0.064
Sept.	0	0	0	0	0	0	0.000
Oct.	0	0	0	0	0	0	0.000
Nov.	0	0	17	11	66	19	0.109
Dec.	0	0	0	0	0	0	0.000
Totals	19,388	13,563	28,078	9,215	15,971	17,243	100.000
S. levis							
Jan.	40		56	214	574	221	45.473
Feb.	0		170	53	164	97	19.908
Mar.	0		93	118	144	89	18.261
Apr.	8		119	7	139	68	14.043
May	0		15	7	0	6	1.132
June	0		0	0	0	0	0.000
July	0		23	0	0	6	1.183
Aug.	0		0	0	0	0	0.000
Sept.	0	0		0	0	0	0.000
Oct.	0	0		0	0	0	0.000
Nov.	0		0	0	0	0	0.000
Dec.	0	0		0	0	0	0.000
Totals	48		476	399	1,021	487	100.000

(Table 4 continued on next page)

TABLE 4 (continued)

Month	Year						
	1956	1966	1969	1972	1975	Mean	Percent
S. macdonaldi							
Jan.	268	36	86	35	167	118	10.432
Feb.	279	437	637	125	153	326	28.740
Mar.	67	473	298	750	7	319	28.106
Apr.	17	979	172	459	162	358	31.524
May	17	0	6	7	2	6	0.564
June	0	0	0	0	0	0	0.000
July	0	0	0	0	0	0	0.000
Aug.	0	0	0	0	0	0	0.000
Sept.	0	0	0	0	0	0	0.000
Oct.	0	0	0	0	0	0	0.000
Nov.	0	10	0	3	0	3	0.299
Dec.	0	0	18	5	0	5	0.405
Totals	648	1,935	1,217	1,384	491	1,135	100.000

years is not much different from the 14-year average of which it is a part (Table 2). However, the 5 years were among the years of higher abundance estimates. The mean abundance index was 166×10^{12} compared to 135×10^{12} for the 14-year average.

For the 5 years in which individual species were enumerated, 30% of all rockfish larvae were taken in February, 20% in January, 19% in March, and 11% in April (Figure 3). *S. jordani*, which accounted for 10.4% of all rockfish larvae, was most abundant in February in 4 of 5 years; an average of 65% of the larvae was taken in this month. January, February, and March accounted for 95% of the larvae of this species. The larvae of *S. paucispinis* were most abundant in January, when 40% of the estimated annual number was found. In January, February, and March—the months of heaviest spawning—87% of the annual larval population of this species was present. *S. paucispinis* was about one-third as abundant as *S. jordani*. *S. levis* also appears to be an earlier-spawning species, with 45% of the spawning taking place in January. In January, February, and March 84% of the larvae were taken. *S. levis* larvae were only 1/35 as abundant as *S. jordani* larvae. *S. macdonaldi* appeared to be a later-spawning species, with 32% of the spawning occurring in April. About 89% of the total larvae were taken in February, March, and April. *S. macdonaldi* larvae were about 1/15 as abundant as *S. jordani* larvae.

The distribution of all rockfish larvae by line for the 5 years (Table 5; Figure 4) is not much different from the distribution for the 14 years (Table 3).

The distribution of *S. jordani* larvae by line and year (Table 6) indicates concentrations in the San Francisco-Monterey area (lines 60-67), where 53% of the 5-year mean of the number of larvae occurred, and in the Channel Islands area (lines 83-90), where 35% of the larvae were found. No larvae were taken south of line 120 (Cedros Island). No data are available for the area north of line 60.

S. paucispinis larvae appear to follow all rockfish larvae in distribution by line within their range (Table 7). They were most abundant in the Channel Islands

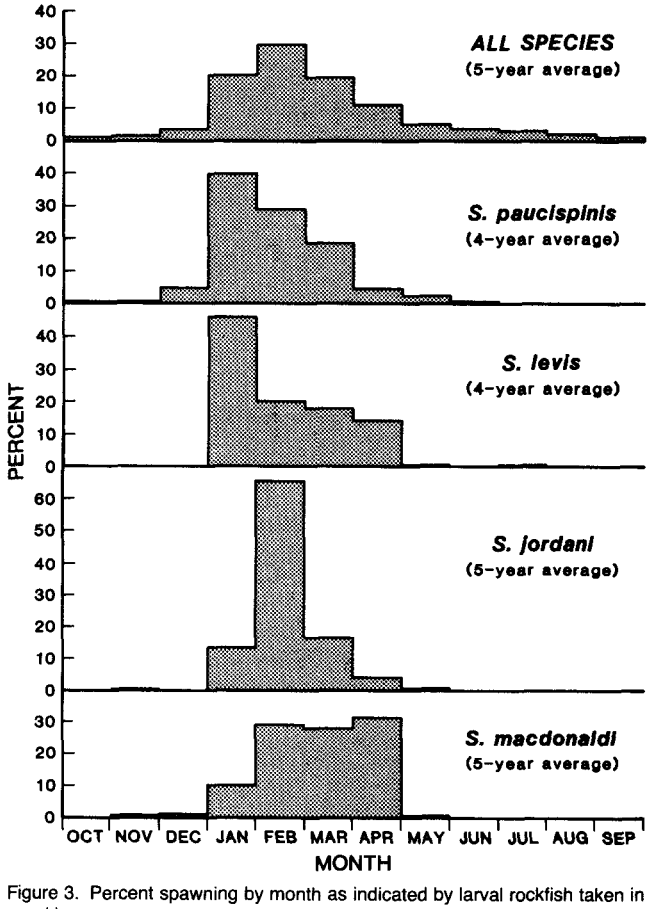

Figure 3. Percent spawning by month as indicated by larval rockfish taken in net tows.

TABLE 5
Percent Distribution of Rockfish Larvae by CalCOFI Line

	Year					
Line	1956	1966	1969	1972	1975	Average
60	13.240	12.455	14.933	11.926	10.560	12.816
63	11.490	12.303	14.494	6.569	11.926	11.524
67	9.944	12.232	10.361	6.752	8.439	9.509
70	4.065	5.449	4.660	4.840	4.496	4.668
73	2.879	3.170	3.098	2,869	4.421	3.262
77	4.369	5.615	4.543	8.468	3.481	5.249
60-77	45.987	51.224	52.089	41.424	43.323	47.028
80	3.213	4.578	4.710	10.494	4.644	5.507
83	7.070	10.832	11.112	14.634	13.469	11.372
87	11.556	11.068	11.713	10.566	15.135	11.983
90	8.945	5.354	8.845	9.741	7.834	8.312
93	1.978	3.027	2.502	3.441	2.976	2.748
80-93	32.762	34.859	38.882	48.876	44.058	39.922
97	0.824	1.901	0.966	2.118	1.603	1.425
100	2.520	2.849	1.226	1.352	1.631	1.839
103	1.738	0.673	0.649	0.750	1.365	1.024
107	1.993	0.952	0.832	0.419	0.775	0.994
97-107	7.075	6.375	3.673	4.639	5.374	5.282
110	1.486	1.176	0.992	0.515	0.975	1.024
113	1.148	1.036	0.778	0.549	0.874	0.866
117	4.479	2.321	1.283	1.240	2.123	2.236
120	3.689	0.860	0.844	0.800	1.500	1.533
110-120	10.802	5.393	3.897	3.104	5.472	5.659
123	1.013	1.137	0.636	0.937	0.545	0.833
127	0.930	0.383	0.255	0.413	0.537	0.494
130	0.228	0.112	0.093	0.077	0.179	0.136
133	0.568	0.230	0.226	0.270	0.187	0.297
137	0.501	0.142	0.156	0.143	0.189	0.227
123-137	3.240	2.004	1.366	1.840	1.637	1.987
140	0.065	0.073	0.045	0.055	0.069	0.060
143	0.041	0.041	0.028	0.033	0.045	0.036
147	0.000	0.000	0.000	0.000	0.000	0.000
150	0.009	0.009	0.006	0.010	0.006	0.008
153	0.008	0.011	0.006	0.007	0.008	0.008
157	0.011	0.011	0.008	0.012	0.008	0.010
140-157	0.134	0.145	0.093	0.117	0.136	0.122
60-157	100.000	100.000	100.000	100.000	100.000	100.000

area off southern California, and north to Point Conception. Nineteen percent of the larvae occurred in the area represented by line 83, and 53% in the area represented by lines 80-90. The peak on lines 60-67 is less marked than for all rockfish, and there are no data for the area to the north.

The distribution of *S. levis* (Table 8) appears to be restricted primarily to southern California. Miller and Lea (1972) give the range of this species as from Mendocino County (line 50) to Ranger Bank (line 117). Most larvae—86%—were taken on lines 83-90. Only 7% occurred in the area represented by the six lines north of Point Conception.

S. macdonaldi (Table 9) has the most southerly distribution of the four species. No larvae were taken from Point Conception (line 80) north. Ninety-seven percent of the larvae were spread over the area represented by the 10 lines 110-140, with 37% occurring along line 117. A second apparent peak was found south of Point Eugenia along line 123. The population decreased to line 143 (Magdalena Bay area), and no larvae were taken to the south.

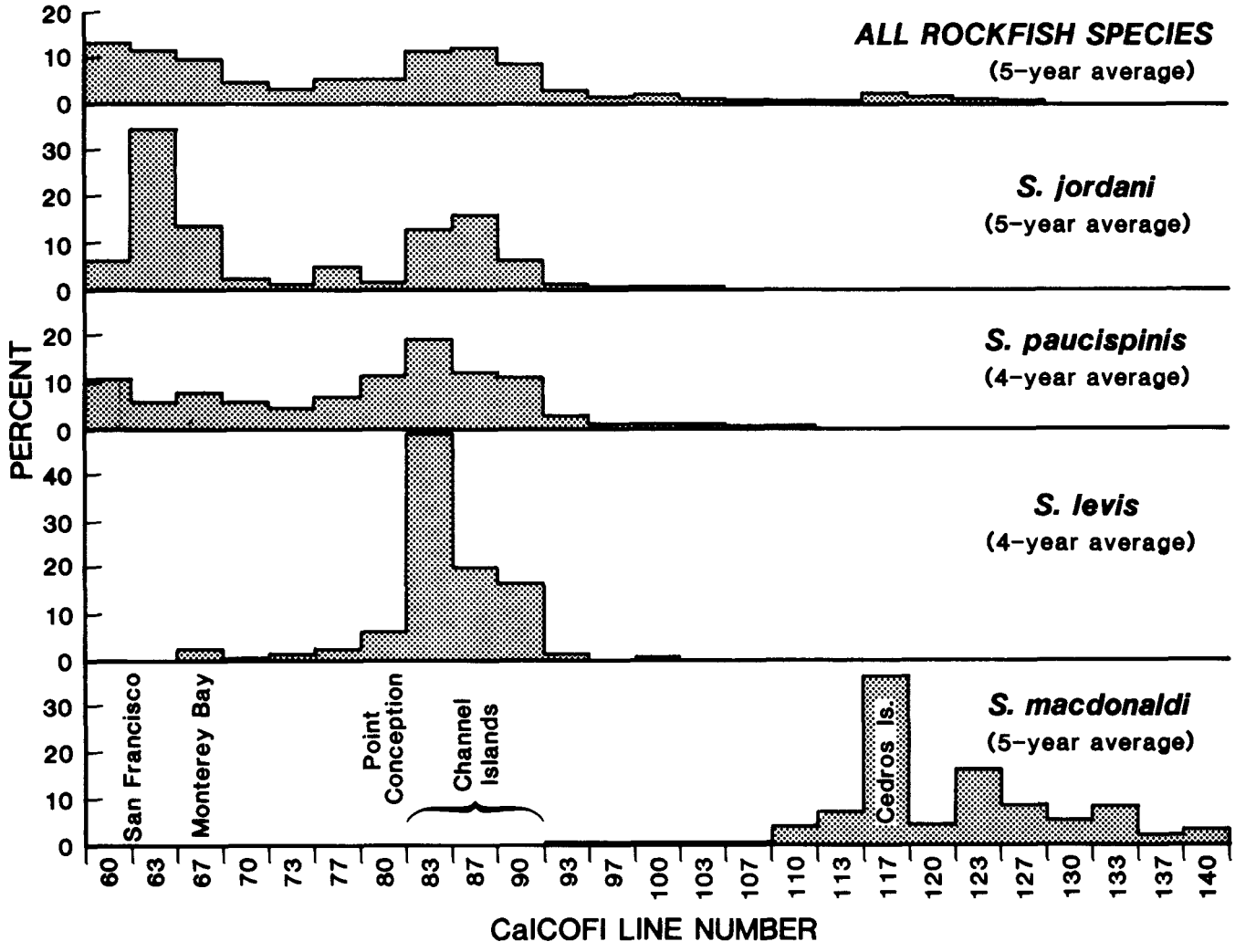

Figure 4. Larval rockfish percent distribution by CalCOFI line.

S. jordani, the most abundant of the four identified species, accounted for 10.4% of all rockfish larvae taken on lines 60-137 (Table 10). It was most abundant between San Francisco and Monterey (lines 63 and 67), where *S. jordani* was 23.4% of all rockfish larvae, and in the Channel Islands (lines 83 and 87), where it was 12.9% of all larvae. *S. paucispinis* accounted for 3.27% of all rockfish larvae. Its distribution was disproportionately high between the abundance peaks of all rockfish larvae. In this area (lines 70-80) it accounted for 5.0% of all rockfish larvae. *S. levis* was the least abundant of the four species, constituting only 0.28% of all rockfishes. It was most abundant in the Channel Islands area, where it accounted for 0.73% of the larvae on the three lines 83-90. *S. macdonaldi* larvae amounted to 0.68% of the total rockfish larvae. They were most abundant on line 117, where they equalled 11.14% of all rockfish larvae. However, smaller numbers of *S. macdonaldi* to the south of this area constituted a larger portion of the population (up to 27.8% on line 130) as numbers of other species decreased rapidly.

Length compositions (Tables 11-14) for *S. jordani* and *S. paucispinis* show an apparent increase in the percent of larger larvae as the season progresses; this is not apparent for the two less-abundant species. However, most of the larvae for all four species are smaller, more recently hatched larvae.

Moser et al. (1977) give the size of newly hatched *S. paucispinis* and *S. macdonaldi* as 4.5 mm, *S. levis* as 5.0 mm, and *S. jordani* as 5.4 mm. About 87% of *S. jordani*, 78% of *S. paucispinis*, 83% of *S. macdonaldi*, and 70% of *S. levis* were within 1 mm of the size of newly hatched larvae (Figure 5). This indicates that, unless rockfish larvae have exceptionally slow growth, a large portion of captured larvae were spawned during the month of capture. The decrease in numbers of longer larvae indicates a very high mortality combined

TABLE 6
Percent Distribution of *Sebastes jordani* Larvae by CalCOFI Line

	Year					
Line	1956	1966	1969	1972	1975	Average
60	5.875	5.190	5.805	6.989	6.906	6.055
63	35.976	30.229	38.977	22.398	36.535	34.701
67	12.554	16.560	12.925	6.424	12.949	12.723
70	1.547	2.625	2.148	3.039	1.703	2.100
73	0.928	0.509	1.079	0.846	2.285	1.154
77	4.513	5.766	4.861	4.775	3.995	4.756
60-77	61.393	60.879	65.795	44.471	64.373	61.489
80	0.423	0.819	2.799	1.357	1.903	1.633
83	12.111	15.483	8.594	26.088	12.316	13.028
87	18.207	17.105	15.468	11.915	15.879	16.038
90	5.555	4.394	6.336	14.704	3.970	6.311
93	0.753	0.605	0.641	1.020	0.488	0.673
80-93	37.049	38.406	33.838	55.084	34.556	37.683
97	0.031	0.288	0.103	0.141	0.507	0.195
100	0.676	0.383	0.185	0.108	0.338	0.347
103	0.660	0.015	0.018	0.000	0.163	0.187
107	0.000	0.000	0.025	0.011	0.013	0.011
97-107	1.367	0.686	0.331	0.260	1.021	0.740
110	0.191	0.000	0.000	0.000	0.050	0.052
113	0.000	0.000	0.000	0.000	0.000	0.000
117	0.000	0.029	0.032	0.185	0.000	0.035
120	0.000	0.000	0.004	0.000	0.000	0.001
110-120	0.191	0.029	0.036	0.185	0.050	0.088
123-157	0.000	0.000	0.000	0.000	0.000	0.000
60-157	100.000	100.000	100.000	100.000	100.000	100.000

with increasing ability to dodge the net as the larvae develop and grow. The decrease also may be affected by differences in growth rates among the species.

Exponential equations fitted to the data by transforming catches to logarithms and then using standard least squares regression techniques indicate a 61%

TABLE 7
Percent Distribution of *Sebastes paucispinis* Larvae by CalCOFI Line

	Year						Year				
Line	1956	1969	1972	1975	Average	Line	1956	1969	1972	1975	Average
60	12.462	9.703	15.296	5.261	10.774	97	1.155	0.500	2.028	0.958	1.189
63	6.079	8.895	1.940	6.003	5.575	100	2.371	0.488	1.027	0.651	0.849
67	7.355	12.091	3.980	5.985	7.456	103	0.425	0.257	0.851	1.537	0.784
70	5.836	4.698	5.232	7.304	5.618	107	0.000	0.051	0.225	0.036	0.104
73	4.924	4.646	2.616	7.431	4.629	97-107	3.951	1.296	4.131	3.182	2.926
77	6.809	5.776	8.512	5.496	6.733						
60-77	43.465	45.809	37.576	37.480	40.785	110	0.182	0.039	0.188	0.307	0.166
						113	0.730	0.000	0.000	0.000	0.052
80	8.632	9.986	12.467	13.560	11.611	117	0.000	0.000	0.000	0.000	0.000
83	12.644	19.073	21.430	17.158	18.966	120	0.000	0.000	0.000	0.000	0.000
87	14.347	11.693	9.751	14.211	11.811	110-120	0.912	0.039	0.188	0.307	0.218
90	14.225	9.126	10.802	12.746	10.944						
93	1.824	2.978	3.655	1.356	2.739	123-157	0.000	0.000	0.000	0.000	0.000
80-93	51.672	52.856	58.105	59.031	56.071	60-157	100.000	100.000	100.000	100.000	100.000

TABLE 8
Percent Distribution of *Sebastes levis* Larvae by CalCOFI Line

Line	Year					Line	Year				
	1956	1969	1972	1975	Average		1956	1969	1972	1975	Average
60	0.000	0.000	0.000	0.000	0.000	97	0.000	0.000	0.000	0.000	0.000
63	0.000	0.000	0.000	0.000	0.000	100	0.000	1.260	0.000	0.000	0.310
67	2.083	6.513	0.000	1.371	2.377	103	0.000	0.000	0.000	0.000	0.000
70	2.083	1.681	0.000	0.000	0.465	107	0.000	0.000	0.000	0.000	0.000
73	2.083	0.630	0.000	2.057	1.292	97-107	0.000	1.260	0.000	0.000	0.310
77	2.084	5.252	6.154	0.000	2.584						
60-77	8.333	14.076	6.154	3.428	6.718	110	0.000	0.000	0.000	0.000	0.000
						113	0.000	0.000	0.000	0.000	0.000
80	0.000	8.824	7.436	4.799	6.202	117	0.000	0.630	0.000	0.000	0.155
83	0.000	22.689	40.769	66.993	49.147	120	0.000	0.000	0.000	0.000	0.000
87	39.583	27.731	31.282	11.460	20.155	110-120	0.000	0.630	0.000	0.000	0.155
90	52.084	21.639	14.359	13.320	16.538						
93	0.000	3.151	0.000	0.000	0.775	123-152	0.000	0.000	0.000	0.000	0.000
80-93	91.667	84.034	93.846	96.572	92.817	60-157	100.000	100.000	100.000	100.000	100.000

TABLE 9
Percent Distribution of *Sebastes macdonaldi* Larvae by CalCOFI Line

Line	Year					
	1956	1966	1969	1972	1975	Average
60-77	0.000	0.000	0.000	0.000	0.000	0.000
80	0.000	0.000	0.000	0.000	0.000	0.000
83	0.000	0.000	1.479	0.361	0.000	0.405
87	0.000	0.000	0.000	0.000	0.000	0.000
90	0.000	0.000	0.000	0.000	0.000	0.000
93	0.000	0.413	0.000	0.000	0.000	0.141
80-93	0.000	0.413	1.479	0.361	0.000	0.5464
97	0.000	0.310	0.000	0.145	0.204	0.159
100	0.000	0.052	0.740	0.361	0.204	0.282
103	2.932	0.000	0.000	0.000	0.407	0.370
107	0.000	0.000	2.136	0.289	0.611	0.581
97-107	2.932	0.362	2.876	0.795	1.426	1.392
110	9.722	2.791	4.601	1.300	7.943	4.053
113	2.469	5.530	7.560	6.142	24.236	7.384
117	12.191	50.749	25.301	40.607	27.902	36.546
120	6.019	2.635	5.423	5.997	1.222	4.317
110-120	30.401	61.705	43.385	54.046	61.303	52.300
123	35.494	11.576	19.392	13.512	10.998	16.405
127	4.938	7.804	15.366	4.552	12.831	8.740
130	17.901	4.238	2.711	4.046	5.499	5.533
133	0.000	7.338	7.231	16.257	2.037	8.194
137	2.624	2.016	3.205	2.023	1.629	2.309
123-137	60.957	32.972	47.905	40.390	32.994	41.181
140	4.321	3.876	3.287	3.396	3.055	3.612
143	1.389	0.672	1.068	1.012	1.222	0.969
147	0.000	0.000	0.000	0.000	0.000	0.000
150	0.000	0.000	0.000	0.000	0.000	0.000
153	0.000	0.000	0.000	0.000	0.000	0.000
157	0.000	0.000	0.000	0.000	0.000	0.000
140-157	5.710	4.548	4.355	4.408	4.277	4.581
60-157	100.000	100.000	100.000	100.000	100.000	100.000

TABLE 10
Estimated Mean Numbers of Rockfish (for 1956, 1966, 1969, 1972, 1975) and Percent Each Species Is of All Rockfish

Line	5-year average					4-year average				
	All rockfish	*S. jordani*		*S. macdonaldi*		All rockfish	*S. paucispinis*		*S. levis*	
	No.	No.	%	No.	%	No.	No.	%	No.	%
60	21,333	1,004	4.89	0	0.00	22,636	619	2.73	0	0.00
63	19,182	5,984	31.19	0	0.00	19,996	320	1.60	0	0.00
67	15,829	2,194	13.86	0	0.00	15,827	428	2.70	12	0.07
70	7,770	362	4.66	0	0.00	7,948	322	4.06	2	0.03
73	5,430	199	3.67	0	0.00	5,762	266	4.61	6	0.11
77	8,737	820	9.39	0	0.00	9,104	386	4.25	13	0.14
Total	78,281	10,603	13.54	0	0.00	81,273	2,341	2.88	33	0.04
80	9,167	282	3.07	0	0.00	9,977	667	6.68	30	0.30
83	18,929	2,247	11.87	5	0.02	20,155	1,089	5.40	238	1.18
87	19,945	2,765	13.87	0	0.00	21,350	678	3.18	98	0.46
90	13,836	1,088	7.87	0	0.00	15,563	628	3.39	80	0.51
93	4,575	116	2.54	2	0.04	4,739	157	3.32	4	0.08
Total	66,452	6,498	9.78	7	0.01	71,784	3,219	4.48	449	0.63
97	2,372	34	1.42	2	0.08	2,349	68	2.91	0	0.00
100	3,061	60	1.95	3	0.11	2,905	49	1.68	2	0.05
103	1,704	32	1.89	4	0.25	1,912	45	2.35	0	0.00
107	1,655	2	0.12	7	0.40	1,761	6	0.34	0	0.00
Total	8,792	128	1.45	16	0.18	8,927	168	1.88	2	0.02
110	1,704	9	0.53	46	2.70	1,750	10	0.54	0	0.00
113	1,441	0	0.00	84	5.82	1,466	3	0.21	0	0.00
117	3,723	6	0.16	415	11.14	3,902	0	0.00	3	0.08
120	2,553	+	0.01	49	1.92	2,913	0	0.00	0	0.00
Total	9,421	15	0.16	594	6.30	10,031	13	0.13	3	0.03
123	1,386	0	0.00	186	13.44	1,365	0	0.00	0	0.00
127	822	0	0.00	99	12.06	904	0	0.00	0	0.00
130	226	0	0.00	63	27.79	246	0	0.00	0	0.00
133	495	0	0.00	93	18.80	544	0	0.00	0	0.00
137	378	0	0.00	26	6.93	427	0	0.00	0	0.00
Total	3,307	0	0.00	467	14.13	3,486	0	0.00	0	0.00
140-157	203	0	0.00	52	25.59	207	0	0.00	0	0.00
All lines	166,457	17,243	10.36	1,135	0.68	175,708	5,740	3.27	486	0.28

decrease in numbers with each mm of length growth for *S. jordani*. The decrease is 58% for *S. macdonaldi*, 54% for *S. levis*, and 43% for *S. paucispinis*. *S. jordani* is a small species and may have slower-growing larvae. *S. paucispinis* grows more rapidly than other rockfish later in life and may also have faster-growing larvae. The differences in decrease in numbers of larvae may reflect these growth differences rather than temporal mortality.

The larval abundance estimates yield interesting data on relative numbers of larvae by year, month, and area of the four species in relation to all larvae and to each other. But we need additional data in order to estimate the total numbers of larvae produced each year and, from that, the biomass of the spawning population. The two most important missing elements are the growth of larvae with time and temperature, and larval mortality. With these data we could interpolate for between-cruise estimates and obtain a rough estimate of the total annual production for each identified species. In order to convert larval data to adult biomass we need data on species size at maturity, ratio of adult females to males, number of larvae produced per unit weight of females per spawning, and number of spawnings per year. According to Phillips (1964), a few *S. jordani* mature at 6″ total length (152 mm, 31 g), age 2; 50% at 6½″ (165 mm, 30 g), age 3. They attain a maximum size of 12″ (306 mm, 275 g) and age of 10 years. A few *S. paucispinis* spawn at 14″ TL (356 mm, 456 g), age 3; 50% mature at 16¼″ (413 mm, 723 g),

TABLE 11
Number and Percent of *Sebastes paucispinis* by Size and Month*

Length (mm)	Number (billions)										
	Jan.	Feb.	Mar.	Apr.	May	June	Oct.	Nov.	Dec.	Total	Percent
2.0	10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7	0.19
2.5	40.2	20.5	0.0	0.0	0.0	0.0	0.0	0.0	13.4	74.1	1.30
3.0	96.3	5.8	5.4	14.6	4.3	0.0	0.0	0.0	49.2	175.6	3.08
3.5	291.7	38.1	21.9	19.4	8.6	0.0	0.0	0.0	35.8	415.5	7.28
4.0	696.0	278.3	137.0	43.7	4.3	5.9	3.1	0.0	53.7	1,222.0	21.40
4.5	422.9	389.8	230.1	48.6	8.6	0.0	3.1	4.3	49.2	1,156.6	20.26
5.0	275.7	383.8	246.6	29.1	8.6	5.9	0.0	4.3	17.9	971.9	17.02
5.5	165.9	140.7	71.3	19.4	0.0	0.0	0.0	0.0	8.9	406.2	7.11
6.0	101.7	149.4	60.3	9.7	17.2	0.0	0.0	0.0	8.9	347.2	6.08
6.5	45.5	43.9	60.3	4.9	12.9	0.0	0.0	0.0	0.0	167.5	2.93
7.0	56.2	88.0	43.9	9.7	4.3	0.0	0.0	0.0	0.0	202.1	3.54
7.5	34.8	26.4	21.9	4.9	8.6	0.0	0.0	0.0	0.0	96.6	1.69
8.0	16.0	79.1	27.4	4.9	0.0	0.0	0.0	0.0	0.0	127.4	2.23
8.5	21.4	35.2	21.9	14.6	8.6	0.0	0.0	0.0	4.5	106.2	1.86
9.0	13.5	29.4	16.4	4.9	4.3	0.0	0.0	0.0	4.5	73.0	1.28
9.5	5.3	8.7	5.4	0.0	0.0	0.0	0.0	0.0	0.0	19.4	0.34
10.0	16.0	11.7	5.4	0.0	4.3	0.0	0.0	0.0	4.5	41.9	0.73
10.5	0.0	3.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.15
11.0	5.3	3.0	11.0	0.0	4.3	0.0	0.0	0.0	0.0	23.6	0.41
11.5	2.8	5.8	5.4	0.0	4.3	0.0	0.0	0.0	0.0	18.3	0.32
12.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.05
12.5	0.0	0.0	0.0	4.9	4.3	0.0	0.0	0.0	0.0	9.2	0.16
13.0	0.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.10
13.5	0.0	3.0	0.0	9.7	0.0	0.0	0.0	0.0	0.0	12.7	0.22
14.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.05
14.5 — 16.0	0.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.10
16.0 — 18.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	4.3	0.07
18.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.05
Total	2,320.7	1,749.6	1,007.8	243.0	111.8	11.8	6.2	8.6	250.5	5,710.0	100.00
Percent	40.645	30.637	17.654	4.253	1.958	0.206	0.108	0.152	4/387		100.00

*Average data for all years.

TABLE 12
Number and Percent of *Sebastes levis* by Size and Month*

Length (mm)	Number (billions)								
	Jan.	Feb.	Mar.	Apr.	May	July	Dec.	Total	Percent
4.0	45.7	0.0	5.5	0.0	0.0	0.0	4.0	55.2	11.19
4.5	35.5	3.2	13.8	21.8	0.6	0.0	0.0	75.0	15.21
5.0	35.5	9.6	30.4	10.9	0.0	0.0	3.9	90.5	18.35
5.5	20.3	6.4	16.6	5.5	0.0	0.0	0.0	48.8	9.90
6.0	25.4	16.1	13.8	16.4	0.0	5.9	0.0	77.6	15.73
6.5	20.3	28.9	8.3	0.0	0.0	0.0	3.9	61.5	12.46
7.0	10.2	6.4	2.8	0.0	0.6	0.0	0.0	19.9	4.04
7.5	20.3	3.2	5.5	10.9	0.0	0.0	0.0	40.0	8.11
8.0	15.2	3.2	0.0	0.0	0.6	0.0	0.0	19.0	3.86
8.5 — 10.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.6	0.12
	5.1	0.0	0.0	0.0	0.0	0.0	0.0	5.1	1.03
Total	233.5	77.1	96.8	65.5	2.3	5.9	11.8	493.1	100.00
Percent	47.36	15.64	19.64	13.29	0.47	1.20	2.40		100.00

*Average data for all years.

TABLE 13
Number and Percent of *Sebastes macdonaldi* by Size and Month*

Length (mm)	Number (billions)								
	Jan.	Feb.	Mar.	Apr.	May	Nov.	Dec.	Total	Percent
3.5	0.0	0.0	0.0	8.6	0.0	0.0	0.0	8.6	0.74
4.0	22.5	22.1	68.6	86.4	1.1	0.0	0.0	200.7	17.19
4.5	28.9	119.3	103.0	83.5	2.7	2.4	0.0	339.8	29.11
5.0	33.7	68.5	76.6	103.6	0.2	2.4	0.0	285.0	24.42
5.5	20.9	68.5	10.6	31.7	0.2	0.0	0.0	131.9	11.29
6.0	4.8	37.6	7.9	40.3	0.4	0.0	0.0	91.0	7.79
6.5	0.0	8.8	13.2	2.9	0.0	0.0	0.0	24.9	2.14
7.0	6.4	6.6	5.3	2.9	0.0	0.0	0.0	21.2	1.82
7.5	0.0	13.3	0.0	2.9	0.0	0.0	0.0	16.2	1.38
8.0	1.6	6.6	0.0	5.7	0.5	0.0	0.0	14.4	1.24
8.5	0.0	2.2	0.0	5.7	0.0	0.0	0.0	7.9	0.68
9.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	2.2	0.19
9.5	0.0	4.4	0.0	5.7	0.0	0.0	4.5	14.6	1.26
10.0	0.0	2.2	0.0	0.0	0.5	0.0	0.0	2.7	0.23
10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
11.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	2.9	0.25
12.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.01
14.5	0.0	0.0	0.0	2.9	0.0	0.0	0.0	2.9	0.25
15.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.01
Total	118.8	362.3	285.2	385.7	6.0	4.8	4.5	1,167.3	100.00
Percent	10.18	31.03	24.44	33.04	0.50	0.42	0.39		100.00

TABLE 14
Number and Percent of *Sebastes jordani* by Size and Month*

Length (mm)	Number (billions)										
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Nov.	Total	Percent
4.0	28.8	0.0	3.6	0.0	4.3	0.0	0.0	0.0	7.3	44.0	0.25
4.5	558.9	210.7	114.7	13.0	0.0	0.0	0.0	0.0	2.5	899.8	5.18
5.0	862.6	2,935.5	696.0	123.3	12.9	0.0	0.4	11.2	7.3	4,649.2	26.77
5.5	592.7	3,080.6	721.3	100.6	21.4	0.0	0.4	11.2	2.4	4,530.6	26.09
6.0	222.5	2,177.7	351.6	220.7	12.9	0.0	0.0	0.0	2.4	2,987.8	17.20
6.5	73.0	1,846.0	157.8	58.4	8.6	0.0	0.0	0.0	0.0	2,143.8	12.35
7.0	45.9	738.2	136.4	42.2	0.0	0.0	0.0	0.0	0.0	962.7	5.54
7.5	20.3	322.5	86.0	42.2	0.0	0.0	0.0	0.0	0.0	471.0	2.71
8.0	8.5	115.2	75.4	32.5	8.6	0.0	0.0	0.0	0.0	240.2	1.38
8.5	5.1	49.5	43.1	22.7	0.0	0.0	0.0	0.0	0.0	120.4	0.69
9.0	0.0	28.8	64.6	19.5	4.3	0.0	0.0	0.0	0.0	117.2	0.67
9.5	0.0	2.9	43.1	13.0	0.0	0.0	0.0	0.0	0.0	59.0	0.34
10.0	0.0	2.9	43.1	16.2	0.0	0.0	0.0	0.0	0.0	62.2	0.36
10.5	0.0	0.0	25.1	3.3	0.0	0.0	0.0	0.0	0.0	28.4	0.16
11.0	0.0	2.9	17.8	3.3	0.0	0.0	0.0	0.0	0.0	24.0	0.14
11.5	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	4.3	0.03
12.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.02
12.5	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	3.3	0.02
13.0	0.0	2.9	0.0	3.3	0.0	0.0	0.0	0.0	0.0	6.2	0.04
13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	3.0	0.02
21.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	3.3	0.02
24.5	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	3.3	0.02
Total	2,418.3	11,516.3	2,583.2	724.1	77.3	3.0	0.8	22.4	21.9	17,367.3	100.00
Percent	13.925	66.310	14.875	4.168	0.444	0.017	0.005	0.129	0.127		100.00

*Average data for all years.

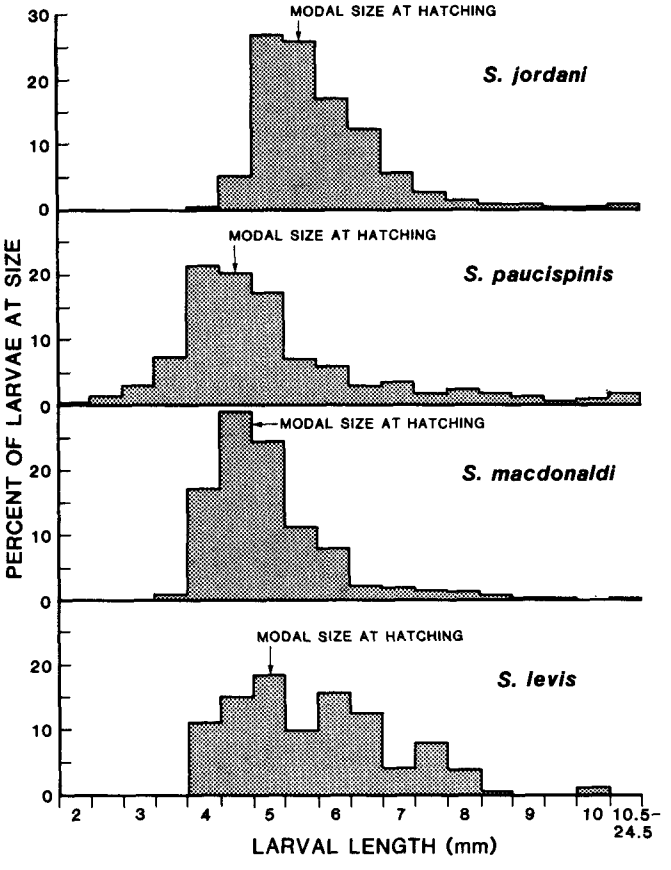

Figure 5. Percent length distribution of larval rockfish.

age 4. They live to a maximum age of 30 years and attain a maximum size of 34" (864 mm, 7096 g).

Phillips (1964) also gives fecundity data for these two species. Both show an increase in relative as well as absolute fecundity with increasing size of fish. Based on ten specimens of *S. jordani* weighing 46 to 275 g, a 50-g fish should produce an average of 115 eggs (larvae) per gram of spawning female fish, while a 275-g fish should produce 139 eggs/g. For *S. paucispinis* (based on 24 specimens weighing 560 to 5000 g) the relative fecundity was 200 eggs/g for a 550-g fish and 434 eggs/g for a 5000-g fish.

The average fecundity for Phillips' *S. Jordani* sample was 134 eggs/g, and for his *S. paucispinis* sample 339 eggs/g. A sample of 13 *S. paucispinis* from Fortymile Bank off southern California (MacGregor 1970) had an average fecundity of 211 eggs/g. These fish were smaller than Phillips' sample from the Monterey area.

We believe that rockfish spawn twice a year (Moser 1967; MacGregor 1970). Based on the ten specimens of *S. jordani*, this would mean that 268 larvae represent one gram of spawning female (if we discount larval mortality for present purposes); 610 larvae represent one gram of spawning female *S. paucispinis* (based on the combined total of 37 fish). The average number of *S. paucispinis* larvae found in the survey area for the four years was 5.7 trillion, with about three times as many *S. jordani*, 17.2 trillion. Based on the difference in relative fecundity, and assuming equal larval mortality rates, the spawning biomass of *S. jordani* should be about seven times larger than that of *S. paucispinis*.

In estimating the population of larvae present in the survey area, I have used a very small sampled area expanded to a population estimate for a very large area. I do not know how accurate this expansion is. However, the larval data are more consistent within years and among years than for egg and larval data of other species that have been studied in the CalCOFI area. As mentioned earlier, in years when rockfish larvae are more abundant, they tend to be abundant throughout the area and spawning season; when less abundant, they are consistently less abundant throughout the area and season. This would indicate that years of low larval abundance are truly years of scarcity, and years of high larval abundance are truly years of greater spawning success, and that these changes in abundance are not the result of erratic distribution.

Although the total production of *Sebastes* larvae varies from year to year, the numbers of larvae taken on each line remain proportionally similar both for all larvae and for the more abundant identified species. Both the season and area of spawning remained remarkably stable for the four species for the 4 or 5 years of the survey and for all species for the 14 years of data. However, all species do not have good spawning years at the same time. The second best year for *S. jordani* (1956) produced the smallest number of larvae for the other three species, and the year of smallest *S. jordani* larval production (1972) was the best or second best for the other three species.

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