SOUTHWEST FISHERIES CENTER

NATIONAL MARINE FISHERIES SERVICE
SOUTHWEST FISHERIES CENTER
P.O. BOX 271
LA JOLLA, CA 92038

SEPTEMBER 1986

TEMPORAL AND SPATIAL VARIATIONS IN THE NUMBERS OF FIRST-YEAR JUVENILE ROCKFISHES OFF NORTHERN CALIFORNIA

By

Edmund Hobson, Peter Adams,
James Chess, Daniel Howard,
and Wayne Samiere

ADMINISTRATIVE REPORT T-86-02

Southwest Fisheries Center Administrative Report T-86-02

Temporal and Spatial Variations in the Numbers of First-Year Juvenile Rockfishes off Northern California

Edmund Hobson

Peter Adams

James Chess

Daniel Howard

Wayne Samiere

Southwest Fisheries Center

National Marine Fisheries Service, NOAA

3150 Paradise Drive

Tiburon, CA 94920

June 1986

INTRODUCTION

The numbers of first-year juvenile rockfishes (Sebastes spp.) in coastal waters of northern California vary tremendously from year to year, and since 1983 the Groundfish Communities Investigation of the Tiburon Laboratory has attempted to measure this variation. In a coordinated effort with Tiburon's Groundfish Analysis Investigation, we have examined the possibility that the numbers of first-year juveniles might provide the means to predict the relative size of that year class when it enters the fishery years later. Because variation in year-class strength is the major problem facing managers of West Coast groundfishes, such predictive capability would have significant management potential. It is appropriate, therefore, that the two investigations at Tiburon bring to bear on the problem their distinctive proficiencies and viewpoints. An earlier report (Lenarz and Moreland 1985) incorporated some of the data used here, but much of the material we present resulted from work still in progress when that report was written.

The assessments have progressed three ways: 1) direct counts by underwater observers, 2) trawl samples taken from vessels, and 3) examination of gut contents of predators. Only the first two will be reported here, as analysis of the third, the predator gut contents, is incomplete. We plan to update these results annually so that estimates of year-class strength can be incorporated into management practices.

METHODS

NEARSHORE ASSESSMENTS

The nearshore assessments were made by three underwater observers using scuba at depths between 3 and 30 m nearshore at selected sites over approximately 100 km of the Sonoma and Mendocino County coasts. Emphasis was on the three species that predominated among the juveniles in the nearshore habitats: the yellowtail rockfish, Sebastes flavidus, the black rockfish, S. melanops, and the blue rockfish, S. mystinus. Others less frequently observed and not included in this report were the canary rockfish, S. pinniger, the shortbelly rockfish, S. jordani, the widow rockfish, S. entomelas, and the copper rockfish, S. caurinus. These species were assessed during the 7 months following transformation from their pelagic phases. After the first arrivals were noted--usually in May or June--counts were made every 2 to 3 weeks (weather permitting) until late fall. By that time no new arrivals were noted, and many that had arrived earlier had by then left the nearshore habitats for deeper water. Three sites in Mendocino County were monitored regularly, and other sites in Mendocino and Sonoma Counties judged representative of coastal habitats were sampled irregularly. At each station, two or three observers with writing slates recorded the species and number of juveniles counted during timed observation periods over haphazard courses. In this report the data are grouped into 1-minute periods. Although actual counts have been made only since 1983, estimates of relative abundance made since 1977 proved valuable in selecting study sites and designing sampling procedures. The earlier estimates also permitted anticipating the range of variation in numbers that could be expected.

OFFSHORE ASSESSMENTS

The offshore collections sampled pelagic juveniles, and so were made in June because experience had shown this to be their period of peak abundance in northern California. Samples were taken with a midwater trawl from David Starr Jordan, the fisheries research vessel of the Southwest Fisheries Center. For each collection the trawl (equipped with a 27-m headrope, and with 30 m of wire out) was hauled for 10 minutes at a speed of 5 kn. All collections were made at night, from 30 minutes after dark to 30 minutes before first light. The trawl fished over depths between 27 and 64 m at six sites (2 to 70 km from the mainland) in the Gulf of the Farallones. We replicated the 1983 and 1985 collections but bad weather prevented us from replicating the 1984 collections.

RESULTS

NEARSHORE ASSESSMENTS

Counts made by the three underwater observers were pooled, since differences between them were insignificant (paired t-test: pair 1, $n = 12$, $p = 0.54$; pair 2, $n = 8$, $p = 0.57$; pair 3, $n = 33$, $p = 0.11$)

Annual Variation

Although the assessments made prior to 1983 were estimates of relative abundance, rather than counts, it was clear even from casual observations that there were fewer first-year juveniles in 1983 than in any other year since observations began in 1977. It was also clear that the numbers counted in 1985 were similar in magnitude to the exceptionally high numbers of 1977. The great variation in numbers between 1983 and 1985, however, was based on S. flavidus and S. mystinus--the numbers of S. melanops varied little (Tables 1 and 2).

TABLE 1.--Mean number (standard error in parentheses) of first-year juveniles counted/minute during the same 4-week period each year (early August-early September) in Mendocino, 1983-1985.

Species	1983 n = 36		1984 n = 57		1985 n = 50	
S. flavidus	0.000	(0.000)	6.584	(2.287)	115.600	(21.255)
S. mystinus	0.267	(0.091)	1.490	(0.295)	70.560	(15.320)
S. melanops	0.411	(0.143)	0.309	(0.084)	4.340	(1.537)
Total	0.678	(0.189)	8.382	(2.329)	190.500	(29.821)

TABLE 2.--One way analysis of variance in numbers of juvenile rockfish counted/minute, 1984-1985, in Mendocino during the same 4-week period, early August-early September. Data were transformed $ln(x + 0.001)$.

		F (probability)			
Source	*d.f.*	S. flavidus	S. melanops	S. mystinus	Total
Year	2	66.57	0.19	46.24	53.06
		(< 0.001)	(0.82)	(< 0.001)	(< 0.001)
Error	140				

Seasonal Variation

Changes in the numbers of first-year juveniles during the 7 months following their initial appearance nearshore were documented with counts made at one Mendocino station from May to November 1985 (Table 3). After arriving in the nearshore habitats in late May, their numbers continued to increase for about a month, then began a gradual decline. The decline continued at least through August despite a continued influx of additional juveniles. Then in October, in an exodus that had been noted in previous years, the juvenile S. flavidus abruptly left the nearshore habitat, presumably for the more offshore habitats of their adults. The juvenile S. melanops and S. mystinus, on the other hand, remained in the nearshore habitats, also occupied by their adults.

Areal Variation

In a comparison between numbers of first-year juveniles counted on the Mendocino and Sonoma coasts in August of 1984 and 1985, numbers were generally higher in Sonoma--the only exception being S. flavidus in 1984 (Table 4). But a two-way analysis of variance (Table 5) indicated that the differences between the species are not significant at the 5% level, even though the total numbers are significant at the 3% level. This analysis, which integrated both annual and areal differences, also indicated that in Sonoma, as in Mendocino, the numbers of S. flavidus and S. mystinus varied significantly from year to year, while the numbers of S. melanops did not. Finally, the analysis indicated that the pattern was the same in both areas in both years.

TABLE 3.--Mean number of juveniles counted/minute at one Mendocino site, May to November, 1985.

Species	May n = 45	Jun n = 52	Jul n = 79	Aug n = 50	Nov[1/] n = 51
S. flavidus	148.44	232.77	191.54	115.60	5.33
S. mystinus	74.69	102.35	103.16	70.56	76.29
S. melanops	4.07	3.00	6.32	4.34	1.14
Total	227.20	338.12	301.02	190.50	82.76

[1/] Counts may have been somewhat inflated by exceptionally clear water that increased underwater visibility by about 30%.

TABLE 4.--Mean number (standard error in parentheses) of first-year juveniles counted/minute during the same periods over 2 years in two different areas.

Species	Mendocino				Sonoma			
	8/84 n = 57		8/85 n = 50		8/84 n = 37		8/85 n = 84	
S. flavidus	6.58	(2.29)	115.60	(21.26)	4.39	(1.48)	135.17	(26.00)
S. mystinus	1.49	(0.30)	70.56	(15.32)	4.89	(1.29)	117.63	(19.50)
S. melanops	0.31	(0.08)	4.34	(1.54)	1.63	(0.52)	4.40	(1.17)
Total	8.38	(2.33)	190.50	(29.76)	10.91	(2.12)	257.20	(35.38)

TABLE 5.--Two-way analysis of variance in numbers of juvenile rockfishes counted/minute: Area--Sonoma vs. Mendocino; Year--1984 vs. 1985. Data were transformed $ln(x + 0.001)$.

Source	*d.f.*	*F* (probability)			
		S. flavidus	S. mystinus	S. melanops	Total
Area	1	1.30	1.28	1.85	4.58
		(0.26)	(0.26)	(0.18)	(0.03)
Year	1	91.14	81.45	0.24	4.80
		(< 0.001)	(< 0.001)	(0.62)	(< 0.001)
Area × year	1	0.02	1.51	0.44	0.02
		(0.90)	(0.22)	(0.50)	(0.88)
Error	224				

OFFSHORE ASSESSMENTS

The first-year juveniles sampled offshore by trawl in June of 1983, 1984, and 1985 (Table 6) occurred in essentially the same pattern as did their nearshore counterparts, described above. The year-to-year differences were even greater, however, with the numbers taken ranging from zero in 1983 to thousands per tow in 1985. The widow rockfish, S. entomelas, and the shortbelly rockfish, S. jordani, numerically dominated and also showed the greatest differences between 1984 and 1985. Annual differences were also significant for S. flavidus, S. goodei, S. mystinus, and S. paucispinis, but not for S. pinniger and S. saxicola (Table 7). Significantly, in the three species prominent both nearshore and offshore--S. flavidus, S. mystinus, and S. melanops--the proportions of the 3-year total taken each year were essentially the same in both regions (Table 8).

DISCUSSION

The variation in numbers of first-year juvenile Sebastes spp. from year to year probably is related to changes in the environment. Sebastes spp. bear live young that spend their first months as pelagic larvae (Moser 1967), and these could be expected to respond strongly to favorable or unfavorable environmental circumstances. Furthermore, because time of spawning varies among the species (Wyllie Echeverria in press), the highly changeable conditions that prevail in this region--both seasonally and from year to year--can be expected to affect the various species differently. This may be why the numbers of S. flavidus, S. mystinus, S. entomelas, and S. jordani varied greatly from 1983 to 1985, but the numbers of S. melanops, S. pinniger, and S. saxicola did not. The uniformly low numbers in 1983 probably reflect an unfavorable impact

TABLE 6.--Mean number (standard error in parentheses) of first-year juveniles collected in trawl, June 1983-1985.

Species	1983 n = 12		1984 n = 6		1985 n = 12	
S. entomelas	0	--	0.778	(0.53)	1090.00	(366.62)
S. flavidus[1/]	0	--	3.78	(2.22)	58.0	(25.06)
S. hopkinsi	0	--	0	--	98.7	(68.70)
S. goodei	0	--	0.667	(0.46)	31.2	(11.89)
S. jordani	0	--	1.89	(1.36)	6280.0	(2254.55)
S. melanops[1/]	0	--	0	--	2.87	(1.43)
S. mystinus[1/]	0	--	0.556	(0.54)	174.0	(64.95)
S. paucispinis	0	--	0.111	(0.13)	8.70	(3.84)
S. pinniger	0	--	0.778	(0.44)	3.17	(1.25)
S. saxicola	0	--	0.222	(0.18)	4.01	(2.04)

[1/] Also a major species inshore

TABLE 7.--One-way analysis of variance in numbers of first-year juvenile rockfishes collected in 10-minute trawls in the Gulf of the Farallones: 1984 vs. 1985. Data were transformed $ln(x + 1.00)$.

		F (probability)							
Source	*d.f.*	S. entomelas	S. flavidus	S. goodei	S. jordani	S. mystinus	S. paucispinis	S. pinniger	S. saxicola
Year	1	48.63	9.82	7.96	43.28	33.70	8.77	1.68	3.13
		(< 0.001)	(0.005)	(0.01)	(< 0.001)	(< 0.001)	(0.008)	(0.21)	(0.09)
Error	20								

TABLE 8.--Number of juveniles taken each year as a proportion of the total number taken during all 3 years.

Species	1983	1984	1985
Nearshore			
S. flavidus	0.006	0.037	0.957
S. mystinus	0.003	0.014	0.983
S. melanops	0.080	0.059	0.861
Offshore			
S. flavidus	0.000	0.064	0.987
S. mystinus	0.000	0.003	0.997
S. melanops	0.000	0.000	1.000

of El Niño conditions that prevailed throughout that year, whereas the exceptionally high numbers of certain species present in 1985 may have resulted when critical early life-history stages of these species happened to coincide with unusually favorable conditions during that particular year. As for the species whose juveniles were relatively sparse in all three of the years monitored, their critical early life-history stages may have coincided with less favorable conditions during those times, or it may be simply that our study sites were not properly located to sample them effectively. Obviously, there is need for continued observations in coming years to obtain data that would support or reject these possibilities.

The changing numbers of juveniles during the season may create problems of producing a predictive index of year-class strength. The offshore assessments are most effective when juveniles late in their pelagic stages are most numerous, and this is a problem in that the timing of this period, which varies by a month or more from year to year and from species to species, cannot be predicted with reasonable certainty when the required research vessel must be scheduled. There is also question whether the numbers present early in the season do in fact offer the best opportunities to predict the size of future year classes. This concern is based on the impact of predators on these numbers. The nearshore assessments, which benefit from a flexible schedule and opportunity for unlimited temporal coverage, have suggested that predation may be greater when the juveniles are more numerous. In years of extreme abundance, such as 1985, the juveniles become the primary food of many predators, including some that do not consider them prey in more typical times. In 1985, rockfish juveniles 1) dominated the gut contents of several predatory species currently studied at the Tiburon Laboratory, 2) were regurgitated in large numbers from the fishes caught by fishermen all along

the northern California coast, and 3) were the major prey of marine birds under study by researchers at the Point Reyes Bird Observatory (Ainley[1/]). Although this predation took a heavy toll, the losses were to some extent offset by continued recruitment that lasted until at least late August. The resulting gradual decline (Table 3) would have been much steeper without the continued influx of additional juveniles. So because the loss to predators appears to vary proportionally with the relative numbers of juveniles present, the future size of that year class may be best estimated from the numbers present at the end of the recruitment season.

[1/] D. Ainley, Point Reyes Bird Observatory, 4990 State Route 1, Stinson Beach, CA 94970, pers. commun. December 1985.

REFERENCES

Lenarz, W. H., and S. L. Moreland.

1985. Progress report on rockfish recruitment studies at the Tiburon Laboratory. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Admin. Rep. T-85-02. Tiburon, CA 92930.

Moser, H. G.

1967. Reproduction and development of Sebastodes paucispinis and comparison with other rockfishes off southern California. Copeia 4:773-797.

Wyllie Echeverria, T.

In press. Maturity and seasonality of 34 species of rockfish (genus Sebastes) off central and northern California. Fish. Bull., U.S.