SAMPLING FOR EGGS OF SARDINE AND OTHER FISHES IN THE COASTAL ZONE USING THE CALVET NET

ROBERT J. LAVENBERG, ANDREW E. JAHN, GERALD E. MCGOWEN, AND JAMES H. PETERSEN
Los Angeles County Museum of Natural History
Section of Fishes
900 Exposition Boulevard
Los Angeles, California 90007

ABSTRACT

In 1986, vertical tows for fish eggs (using the CalVET sampler) were taken at standard southern California monitoring stations, which range from Ormond Beach in the north to San Onofre in the south and represent the 8-, 15-, 22-, 36-, and 75-m contours. Data for six cruises in even months (120 tows in all) indicate the certain or very probable identification of eggs of at least 18 species or species complexes. *Engraulis mordax, Sardinops sagax, Genyonemus lineatus, Symphurus atricauda, Citharichthys* spp., *Seriphus politus,* and *Pleuronichthys verticalis* were (in descending order) most abundant. *Engraulis* and *Symphurus* were concentrated at the deepest stations, *Seriphus* at the shallowest, the other four at midshelf (15–36 m). The three flatfishes were about evenly distributed alongshore, but 73% to 100% of clupeoids and croakers were concentrated at our two central transects (Santa Monica Bay and Seal Beach). Only one *Paralichthys californicus* and six *Paralabrax* spp. eggs were taken.

RESUMEN

Durante 1986 se realizaron arrastres verticales con un muestreador CalVET para colectar muestras de huevos de peces en estaciones de monitoreo estándar en el Sur de California, las cuales cubren el area desde Ormond Beach en el norte hasta San Onofre en el sur a lo largo de las isóbatas de 8-, 15-, 22-, 36-, y 75-m. Los datos colectados en seis cruceros realizados durante meses pares (120 arrastres en total) permitieron identificar con certeza parcial o total al menos 18 especies o complejos de especies. *Engraulis mordax, Sardinops sagax, Genyonemus lineatus, Symphurus atricauda, Citharichthys* spp., *Seriphus politus,* y *Pleuronichthys verticalis* fueron, en orden decreciente, las más abundantes. *Engraulis* y *Symphurus* se concentraron en las estaciones más profundas, *Seriphus* en las menos profundas y las restantes cuatro sobre la plataforma (15–36 m). Los tres lenguados se distribuyeron uniformemente a lo largo de la costa, mientras que un 73%–100% de los clupeidos y sciaenidos se concentraron a lo largo de nuestras dos transectas centrales (Bahía de Santa Monica y Seal Beach). Un solo huevo de *Paralichthys californicus* y seis huevos de *Paralabrax* spp. fueron colectados.

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INTRODUCTION

Recently, much interest has focused on the apparent recovery of the Pacific sardine (*Sardinops sagax*) resource off California and on the use of egg survey data to monitor the stock (Wolf 1985; Wolf and Smith 1985, 1986). Wolf and Smith (1986) estimated that a spawning biomass of 20,000 short tons of sardine, given characteristic values of fecundity and egg production per unit area, would occupy an area of approximately 500 nautical miles^2, or 1,715 km^2. The total area of the continental shelf between Point Conception and the border with Mexico, out to a depth of 75 m, is about 2,800 km^2. The nearshore zone thus has the potential to harbor a substantial portion of the sardine spawning stock in its early stage of recovery.

Year-round collection of egg and larval data from the very nearshore zone showed an increase in sardine spawning beginning in 1982, with a seasonal peak in summer–fall that varied from the expected predominantly springtime pattern (Ahlstrom 1967; Lavenberg et al. 1986). Discussions with P. Smith of the National Marine Fisheries Service (NMFS) and P. Wolf, K. Mais, and R. Klingbeil of the California Department of Fish and Game (CDFG) pointed to the desirability of rapid intercalibration of offshore and nearshore sampling. Accordingly, we integrated the CalVET net, now standard in the NMFS/CDFG sardine egg surveys, into our coastal zone cruise schedule in 1986. This note presents data on sardine and other abundant taxa of which eggs could be identified.

METHODS

The sampler used was the bongo-type PAIROVET version of the CalVET net (Smith et al. 1985), consisting of paired cylindrical-conical nets, each of 0.05-m^2 mouth opening, fitted with 150-μm

TABLE 1
Ranking of Taxa from CalVET Samples for 1986

	Sum	Frequency
1. *Engraulis mordax*	269	39
2. *Sardinops sagax*	170	27
3. *Genyonemus lineatus*	147	38
4. *Symphurus atricauda*	84	18
5. *Citharichthys* species	83	51
6. *Seriphus politus*	41	17
7. *Pleuronichthys verticalis*	33	20
8. *Pleuronichthys ritteri*	16	14
9. *Etrumeus teres*	15	7
10. *Sphyraena argentea*	10	5
11. *Synodus lucioceps*	8	7
12. *Paralabrax* species	6	2
13. *Leuroglossus stilbius*	3	1
14. *Paralichthys californicus*	1	1
15. *Merluccius productus*	1	1
16. *Ophidion scrippsae*	1	1
17. *Pleuronichthys coenosus*	1	1
18. *Pleuronichthys decurrens*	1	1
Subtotal	890	
Other designated types	51	
Unidentified eggs	1,015	
Total	1,956	

mesh netting in one side and 333-μm mesh in the other. The nets were towed vertically from a depth of 70 m, or from the bottom in shoaler waters, at a rate of 70 m min^{-1}. Cruises were in even-numbered months from February to December 1986. Across-shelf transects consisting of samples over the 8-, 15-, 22-, 36-, and 75-m contours were taken from north to south off Ormond Beach, Playa del Rey, Seal Beach, and San Onofre, all in the Southern California Bight (see Lavenberg et al. 1986). Samples were fixed at sea in buffered 5% seawater Formalin. Tows were made in the evening, principally between 1800 and 2200 hrs, and each tow was accompanied by a surface temperature reading.

The 20 paired samples from each cruise were sorted in the laboratory, and then all fish eggs were examined by an experienced technician. Although northern anchovy and Pacific sardine eggs can be readily identified, the eggs of relatively few other local species can yet be identified with absolute certainty. Published descriptions exist for about two-thirds of the taxa listed in Table 1, and an evolving system of designated types is gradually improving the state of fish-egg taxonomy. The identifications used in this report were all made with a high degree of confidence. Staging of sardine and anchovy eggs was done by the methods of Ahlstrom (1943) and Moser and Ahlstrom (1985).

After the fourth cruise, paired t-tests indicated no difference in capture by the two sides of the sampler for either anchovy eggs or all eggs combined. We have therefore added the counts from both nets, so that abundances tabulated here are eggs per 0.1 m^2.

RESULTS

On the six bimonthly cruises, 120 samples produced 1,956 eggs, about half of which were identified to 18 species or species complexes (Table 1). The patterns (places and months of capture) of abundance of the seven most abundant taxa are given in Table 2. Northern anchovy (*Engraulis mordax*) and white croaker (*Genyonemus lineatus*) displayed characteristic winter-spring seasonality; Pacific sardine (*Sardinops sagax*) and the sanddab complex (*Citharichthys* spp.) spawned essentially year-round; hornyhead turbot (*Pleuronichthys verticalis*) and queenfish (*Seriphus politus*) appeared in spring and summer; and California tonguefish (*Symphurus atricauda*) appeared in late summer-fall. Anchovy and tonguefish were most concentrated over the outer shelf, where the abundance of other species tapered off. All species except queenfish and sanddabs became less abundant at the 8-m contour.

An interesting feature of these data is the concentration at the two central transects of four of these species, particularly during their months of peak spawning (73%–100% of all eggs of anchovy, sardine, white croaker, and queenfish occurred at Playa del Rey and Seal Beach). The exceptions to this trend were, perhaps coincidentally, all flatfishes—*Symphurus, Citharichthys,* and *Pleuronichthys* (54%–60%). The extreme case of mid-bight concentration was Pacific sardine, which was not taken at all in the north (Ormond Beach) or south (San Onofre) in 1986.

These data allow some comparisons to the more offshore sardine work of CDFG. In this study, sardine eggs were always taken in a contiguous block of stations (Table 2), roughly representing from about 270 km^2 to 580 km^2 (Table 3). The total ocean area represented by the Playa del Rey and Seal Beach transects, 927 km^2, is roughly half the area estimated by Wolf and Smith (1986) to be occupied by a spawning population of 20,000 tons, the criterion biomass for opening a directed sardine fishery. Taking the comparison further, the average egg abundance at positive stations ranged from 1.4 to 7.2 eggs per 0.05 m^2. Since nearly all eggs were at least a day old (see below), the total count can be considered a crude minimum estimate of daily production (unless mortality was much less than normal); thus the range found here is similar to that used by Wolf and Smith (1.5 to 5 eggs per .05 m^2) in their inverse biomass estimate.

TABLE 2
Counts (Eggs per 0.1 m^2) of the Seven Most Numerous Egg Taxa

	Engraulis mordax					*Sardinops sagax*					*Genyonemus lineatus*					*Symphurus atricauda*					*Citharichthys* spp.					*Seriphus politus*					*Pleuronichthys verticalis*				
Depth (m)	8	15	22	36	75	8	15	22	36	75	8	15	22	36	75	8	15	22	36	75	8	15	22	36	75	8	15	22	36	75	8	15	22	36	75
February																																			
Ormond Beach	–	–	1	6	6	–	–	–	–	–	1	–	–	1	1						1	1	–	–	–	–	–	1	–	–	–	–	–	–	–
Playa del Rey	–	1	–	7	14	–	1	2	3	–	–	–	1	3	–	none taken					–	2	4	–	–	–	–	–	–	–	–	–	–	4	–
Seal Beach	1	5	4	28	105	–	–	2	7	–	3	7	37	26	–						–	1	3	5	–	–	–	–	–	–	–	–	1	–	–
San Onofre	–	–	–	–	–	–	–	–	–	–	1	2	3	1	1						–	1	2	1	–	–	–	–	–	–	–	–	–	–	–
April																																			
Ormond Beach	–	–	22	4	–	–	–	–	–	–	–	–	–	–	–						–	1	1	2	–	–	1	1	2	–	–	–	–	–	–
Playa del Rey	1	6	2	–	–	3	15	27	–	–	–	4	3	–	–	none taken					3	1	–	–	–	4	5	5	1	–	–	1	1	–	–
Seal Beach	–	–	1	2	3	–	13	14	–	–	1	2	–	–	–						1	1	–	1	–	3	–	–	–	–	–	–	2	–	–
San Onofre	2	–	1	1	1	–	–	–	–	–	–	5	1	–	–						2	1	–	–	–	3	2	–	–	–	–	2	–	–	–
June																																			
Ormond Beach	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–						2	–	–	–	–	–	–	–	–	1	–	3	4	1	1
Playa del Rey	1	2	10	–	–	–	–	–	–	–	–	–	–	–	–	none taken					–	–	–	–	–	–	–	1	–	–	–	–	–	1	–
Seal Beach	5	1	–	–	–	–	3	7	2	1	1	–	–	–	–						–	–	–	–	–	4	3	3	–	–	–	–	2	–	–
San Onofre	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–						–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
August																																			
Ormond Beach						–	–	–	–	–						–	–	–	1	–	–	2	–	1	–	–	–	–	–	–	–	–	–	–	–
Playa del Rey	none taken					–	–	–	–	–	none taken					–	–	1	11	3	–	1	–	1	1	1	–	–	–	–	–	1	2	–	–
Seal Beach						1	2	3	28	1						1	–	2	4	3	3	–	1	1	–	–	–	–	–	–	–	1	–	1	1
San Onofre						–	–	–	–	–						–	–	–	–	–	1	2	–	3	–	–	–	–	–	–	–	–	–	–	–
October																																			
Ormond Beach	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	14	2	1	1	–	–						–	1	–	–	–
Playa del Rey	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	1	11	2	4	1	1	–	none taken					–	–	–	–	–
Seal Beach	–	–	–	–	2	–	1	6	10	1	–	–	4	1	–	1	1	–	2	5	1	1	1	2	–						–	–	–	–	–
San Onofre	–	–	–	–	–	–	–	–	–	–	1	2	2	2	1	–	–	–	1	17	2	–	–	–	–						–	2	–	–	–
December																																			
Ormond Beach	–	2	1	–	–	–	–	–	–	–	–	1	3	1	–						–	2	–	–	–										
Playa del Rey	–	–	–	2	–	–	–	–	–	–	–	1	–	2	–	none taken					–	1	–	1	–	none taken					none taken				
Seal Beach	–	7	5	–	–	–	3	3	8	3	–	–	12	4	–						2	–	2	1	–										
San Onofre	1	1	2	2	–	–	–	–	–	–	–	2	1	–	–						–	–	–	1	–										
	11	25	49	53	131	4	38	64	58	6	8	26	67	43	3	2	1	3	25	53	22	23	16	21	1	15	11	11	3	1	0	12	12	7	2

Column totals show overall abundance at the five depth contours.

Because most sampling was done during evening (1800–2200 hrs) and because *Engraulis* and *Sardinops* both spawn at night (Ahlstrom 1943; Hunter and Macewicz 1980), there was a 24-hr pulse in the age structure of these species, with most specimens being at least a day old at the time of capture (Figures 1 and 2). (In April, over half of the anchovy eggs were taken at Ormond Beach, where the temperature was only 15°C, accounting for the somewhat younger calculated age.) Age-stage relationships have not been worked out for other abundant species.

Finally, it is apparent from the frequency-of-occurrence and overall abundance data (Table 1) that the sampler used in this study, specifically designed for use in northern anchovy egg production work, is ill-suited to studies on certain other important species: for instance, the bass complex *Paralabrax* occurred in only two samples (six eggs), and California halibut (*Paralichthys californicus*) in only one.

DISCUSSION

The temporal spawning pattern of Pacific sardine, with peaks in April and August, was similar in 1986 to the pattern previously reported and discussed for the years 1978–84 (Brewer and Smith 1982; Lavenberg et al. 1986), except that the spring peak appeared to be the stronger of the two in 1986. Ahlstrom (1967) noted that an August peak was generally found only off central Baja California and represented a southern subpopulation. The greater abundance in April 1986 may signal a return to the expected pattern for a northern stock.

Perhaps important from a management perspective was the consistent appearance of sardine eggs in waters 36 m deep or shallower, particularly off

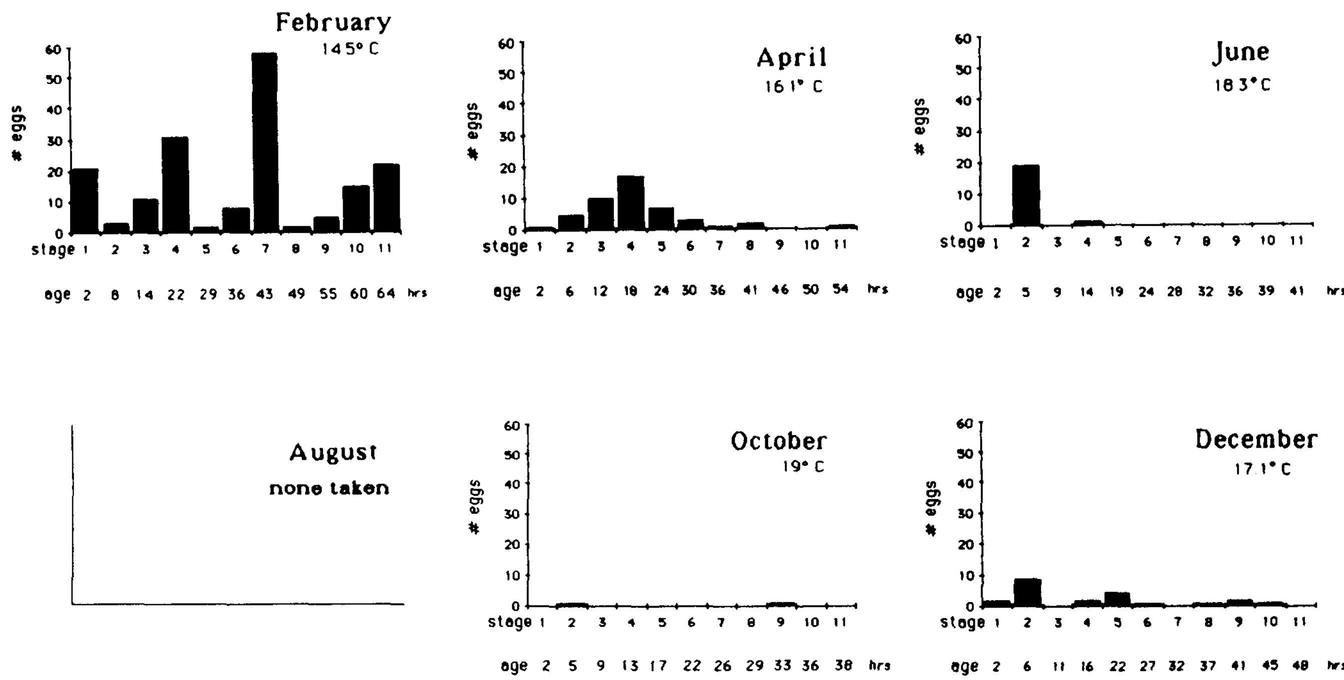

Figure 1. Estimated age in hours of *Engraulis mordax* eggs, based on bightwide mean surface temperature, by the method of Lo (1985).

Seal Beach. Although the total area of shallow habitat used by spawning sardine appeared smaller than the critical area (1,715 km² for 20,000 tons spawning biomass) estimated by Wolf and Smith (1986), it constituted a substantial fraction of it. Egg abundance within this shallow area is indistinguishable from that obtained offshore (Wolf, pers. comm.). The consistent appearance of eggs off Seal Beach, along with the observation that the abundance at 75 m was generally less than that

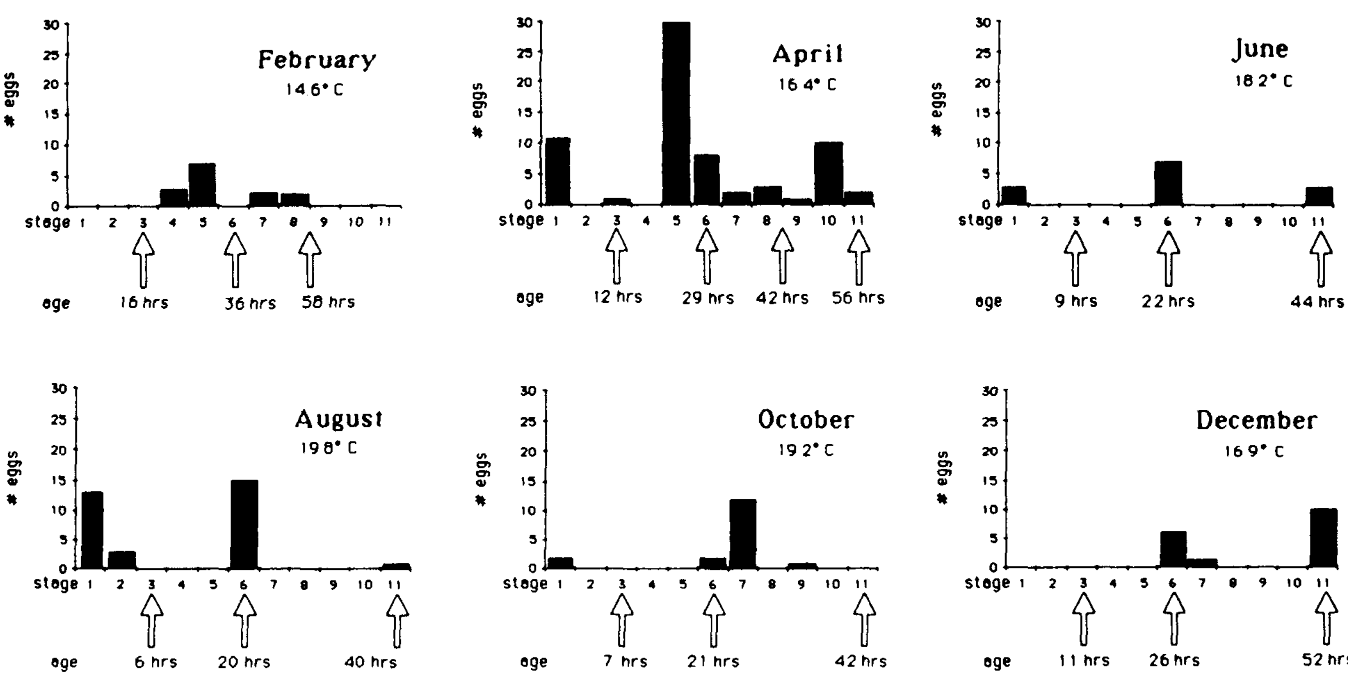

Figure 2. Estimated age in hours of *Sardinops sagax* eggs, based on mean surface temperature at the Playa del Rey and Seal Beach transects, by the temperature-development relations of Ahlstrom (1943).

TABLE 3
Subareas, in km², of the Continental Shelf Represented by Collecting Stations at the Two Central Transects

	Depth (m)					
Transect	0–8	8–15	15–22	22–36	36–75	Total
Playa del Rey	31	35	36	60	185	347
Seal Beach	67	79	91	163	180	580
Total						927

From Lavenberg et al. 1986, Table 4.

between 15 and 36 m, further suggests the importance of this continental shelf locality to a contracted sardine population.

The small numbers of Pacific halibut and bass eggs prove (not unexpectedly) that the techniques used here were inadequate for monitoring these resources. It is obvious that both gear and survey design should be tailored to the spawning habits of these important fishes.

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