AN ATTEMPT TO ESTIMATE ANNUAL SPAWNING INTENSITY OF THE ANCHOVY (*ENGRAULIS RINGENS* JENYNS) BY MEANS OF REGIONAL EGG AND LARVAL SURVEYS DURING 1961–1964

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INTRODUCTION

From the beginning of our investigations in August 1961, until June 1964, we have covered three anchovy spawning cycles. During this period we have collected quantitative samples with the Hensen net at 1,422 localities in northern Peruvian waters. A description of eggs and larvae of the Peruvian anchovy was published in 1963 (Einarsson and Rojas de Mendiola), and a preliminary description of the frequency and distribution of eggs and larvae was presented at the "Primer Seminario Latinoamericano sobre el Océano Pacífico Oriental" (Einarsson, Rojas de Mendiola, and Santander, in press). The present paper carries this analysis a step further and describes the yearly areal variations in spawning intensity, as well as the variations within the whole northern region from Callao to Punta Aguja, the main fishing area now under exploitation.

For the purpose of this analysis we use only samples taken during the spawning season from August of one year to March of the next. The total number of stations occupied during the three spawning cycles was 847. Of these, 185 were occupied during 1961–62, 317 during 1962–63, and 345 during 1963–64.

The number of eggs and larvae are calculated as number per square meter of surface in a column 50 meters deep. As in our previous study the average values are given in two ways; firstly, as average values per station, which reflect the spawning intensity within the area as a whole, and secondly, as average values per positive station which reflect the spawning intensity within the boundaries of the spawning area. The material is in many ways faulty, due to uneven timing of cruises and also because all areas have not been investigated on every cruise. In spite of this we find this analysis worthwhile, and the results seem to tally with other kinds of evidence, derived from an entirely different approach.

ANNUAL AREAL VARIATIONS IN SPAWNING INTENSITY

We have divided the Peruvian coastal waters latitudinally into 2° areas from north to south as seen in Figure 1. In this evaluation only areas B-E come under consideration, since anchovy spawning does not occur in area A and our material is insufficient as regards the more southern areas. The material is graphically presented in Figure 2.

The areas fall clearly into two groups, B and C constituting one, D and E the other (Figure 3). In the first group the spawning intensity has been on a high level during the three spawning cycles, the period 1962–63 yielding the highest values, especially in the average per positive station. This means that the spawning was intensive but confined to restricted zones. Only area B shows this maximum also in the average values per station, during the said period, while area C shows declining values from the first to the third spawning cycle.

Areas D and E show a rather marked decline in the values during the two latter spawning cycles, especially in the numbers per station, and we must conclude that during the latter two cycles the spawning was both of lesser intensity and geographically less extensive.

While the values were fairly similar in all areas during the first spawning cycle, the last two cycles show values which sharply decrease from north to south.

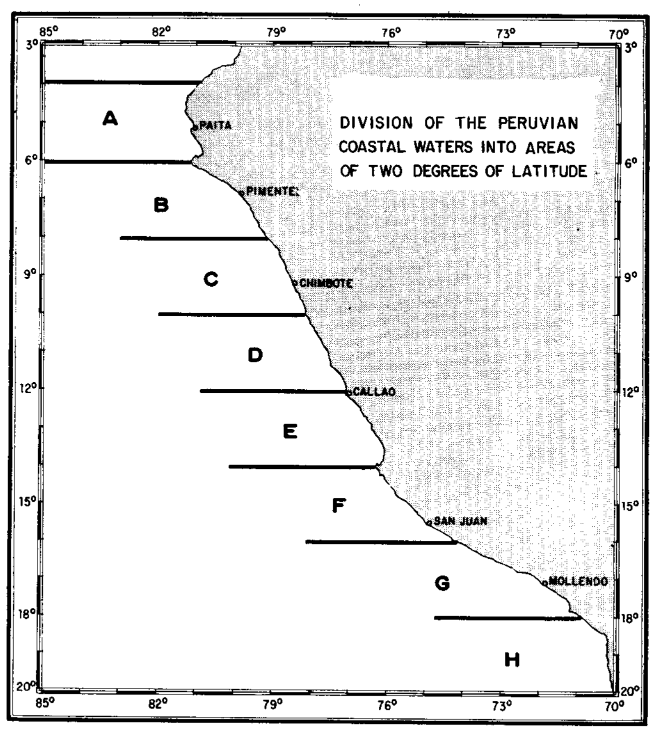
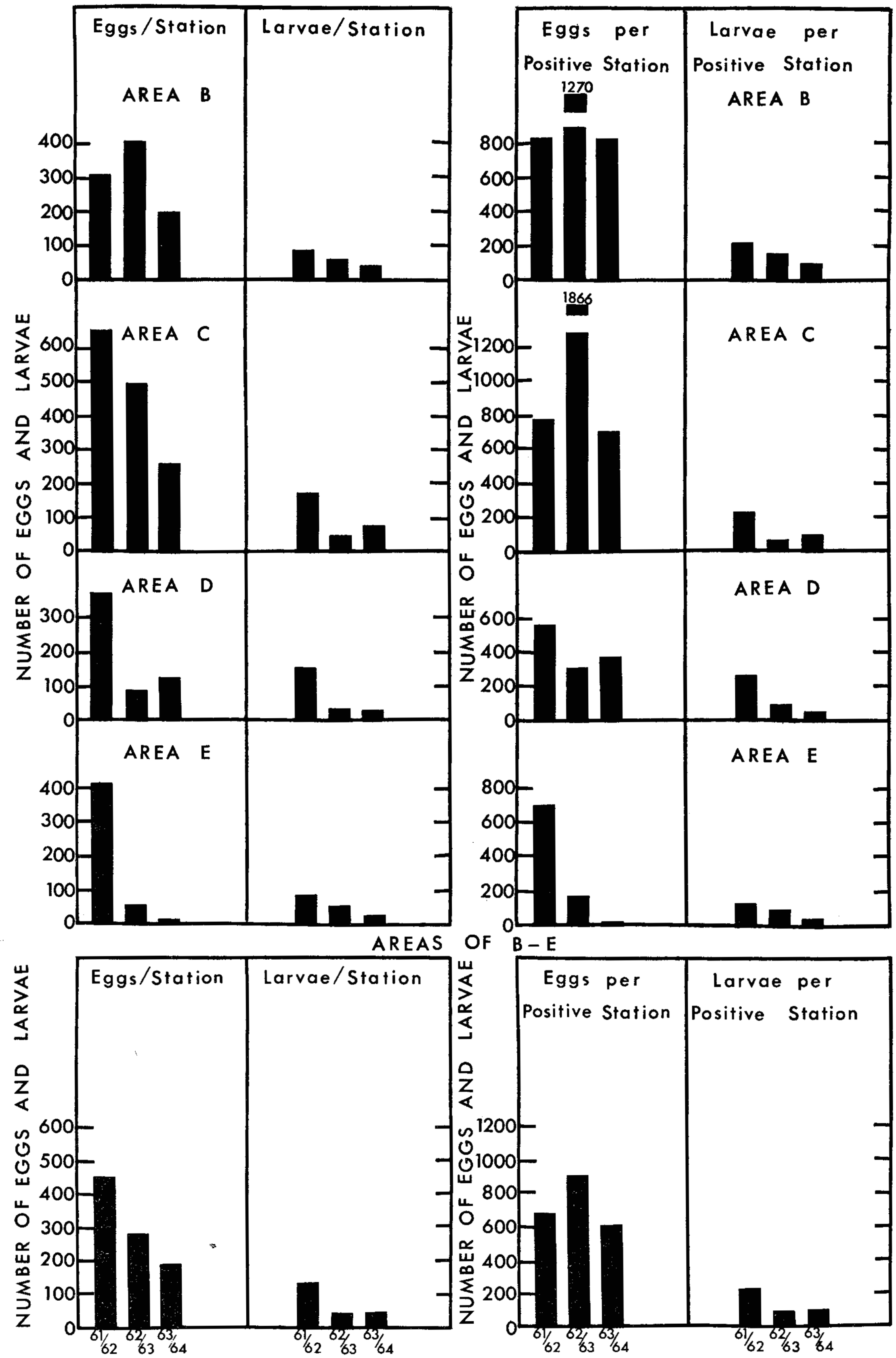


FIGURE 1.



Eggs/Station
Larvae/Station
Eggs per Positive Station
Larvae per Positive Station
AREA B
AREA C
AREA D
AREA E
1270
1866
NUMBER OF EGGS AND LARVAE
AREAS OF B–E
61/62
62/63
63/64

FIGURE 2.

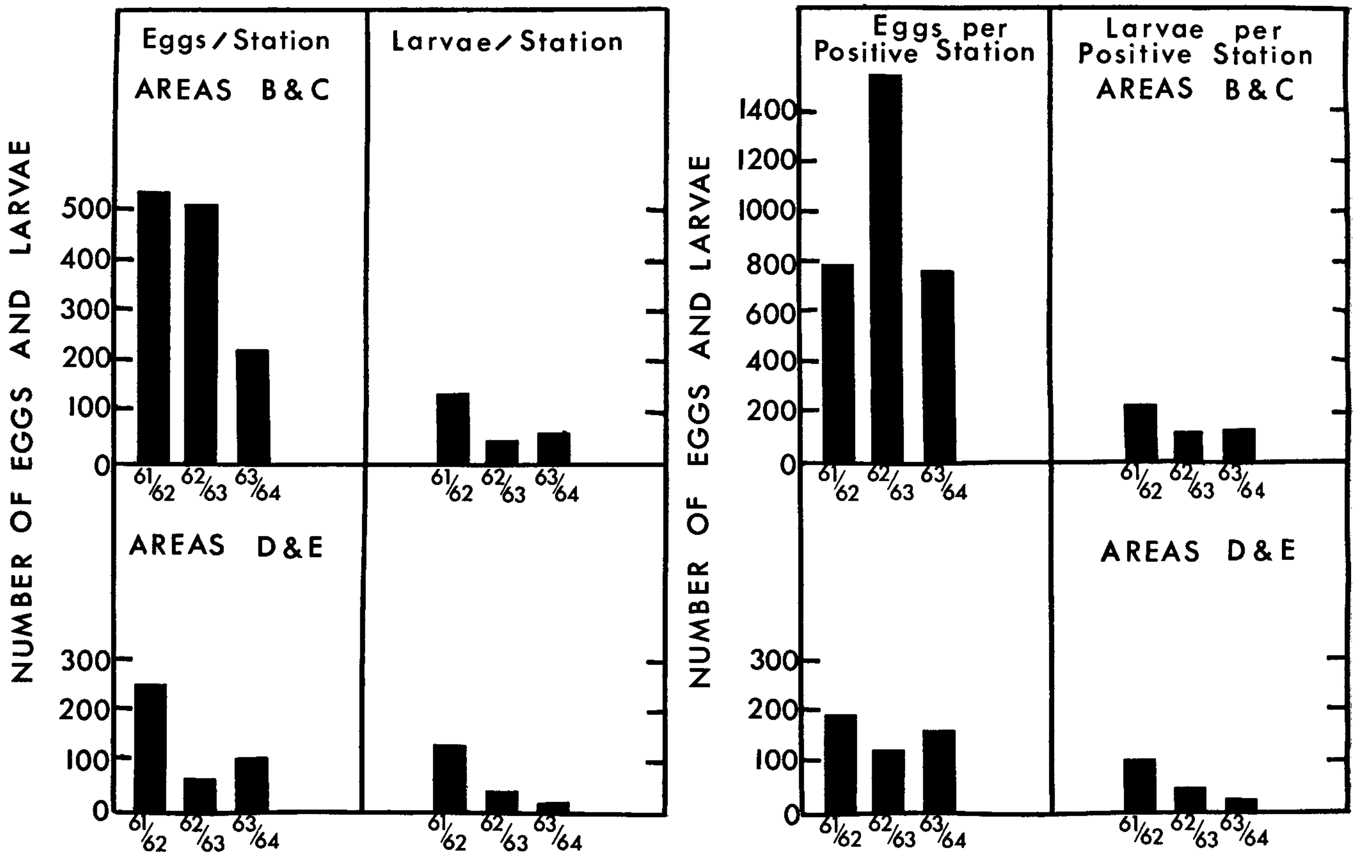


FIGURE 3.

TABLE 1

AVERAGE NUMBERS OF EGGS PER STATION AND PER POSITIVE STATION IN AREAS B–E, DURING THREE SPAWNING CYCLES (1961–1964)

Spawning Cycle	Total Number of Eggs	Average per Positive Station	Number of Positive Stations	Number of Stations	Average per Stations	Percent of Positive Stations
1961–62						
August 1961	37,407	634	59	93	402	63
October 1961	4,692	1,173	4	4	1,173	100
December 1961	345	57	6	10	34	60
January 1962	6,546	2,182	3	13	504	23
February 1962	34,695	708	49	65	534	75
	83,685	691	121	185	452	65
1962–63						
October 1962	3,045	132	23	66	46	35
November 1962	56,745	1,113	51	136	417	37
January 1963	549	137	4	19	29	21
February 1963	26,001	1,444	18	96	271	19
	86,340	899	96	317	272	30
1963–64						
August 1963	23,793	580	41	112	212	37
October 1963	16,431	747	22	91	181	24
November 1963	16,767	798	21	55	305	38
February 1964	8,340	363	23	87	96	26
	65,331	610	107	345	189	31

TABLE 2

AVERAGE NUMBERS OF LARVAE PER STATION AND PER POSITIVE STATION IN AREAS B–E, DURING THREE SPAWNING CYCLES (1961–1964)

Spawning Cycle	Total Number of Larvae	Average per Positive Station	Number of Positive Stations	Number of Stations	Average per Stations	Percent of Positive Stations
1961–62						
August 1961	13,101	234	56	93	141	60
October 1961	1,338	669	2	4	334	50
December 1961	327	54	6	10	33	60
January 1962	1,674	239	7	13	129	54
February 1962	8,583	232	37	65	132	57
	25,023	232	108	185	135	58
1962–63						
October 1962	417	13	32	66	6	48
November 1962	3,150	57	55	136	23	40
January 1963	129	21	6	19	7	32
February 1963	10,089	202	50	96	105	52
	13,785	96	143	317	43	45
1963–64						
August 1963	6,285	108	58	112	56	52
October 1963	5,154	99	52	91	57	57
November 1963	2,727	160	17	55	50	31
February 1964	1,464	49	30	87	17	34
	15,630	99	157	345	45	46

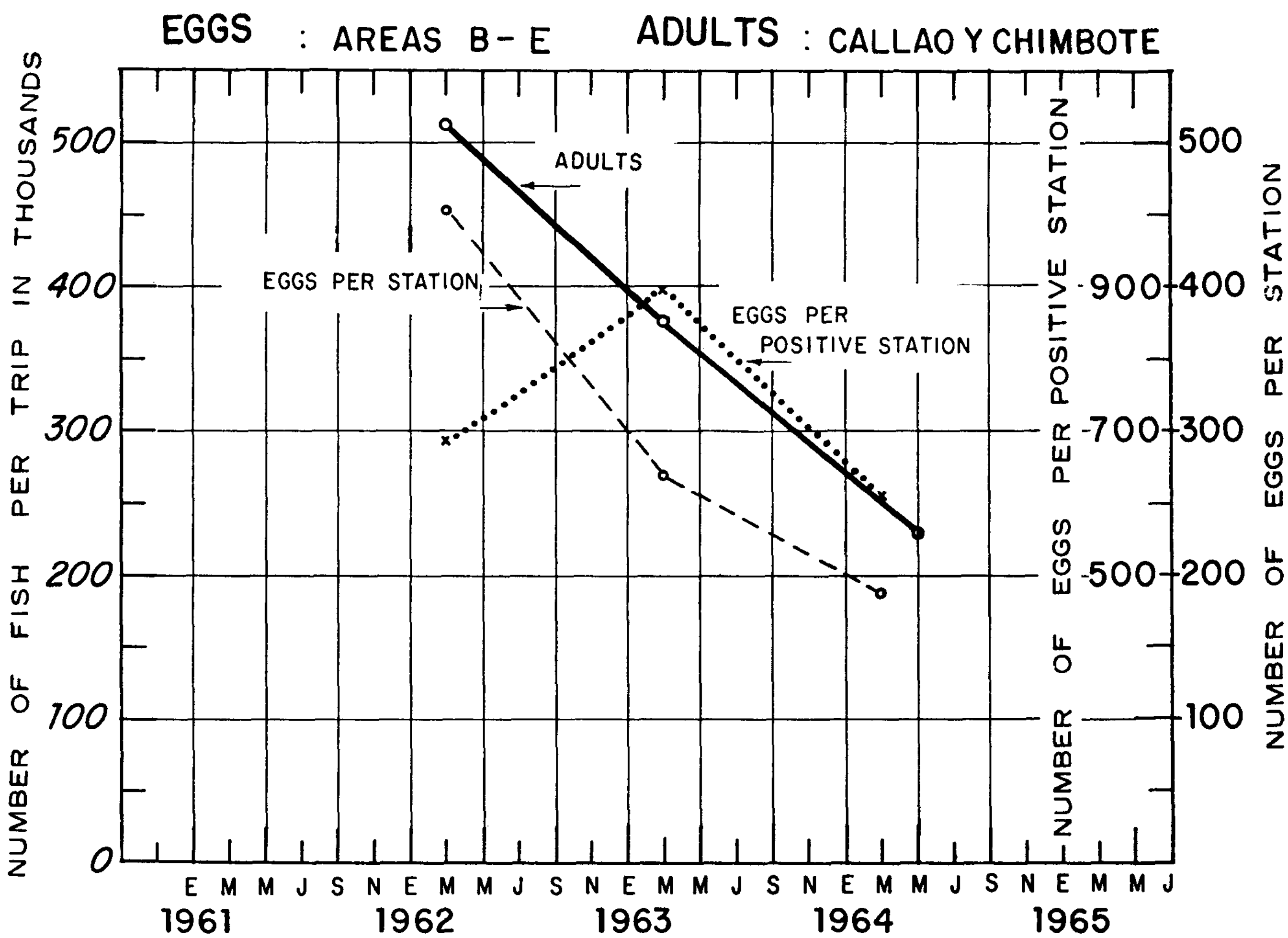


FIGURE 4.

ANNUAL REGIONAL VARIATIONS IN SPAWNING INTENSITY

The material has been summed up for the whole region in Tables 1 and 2, and graphically presented in the lower part of Figure 2.

The evidence shows that the spawning intensity in the region as a whole, measured by number of eggs per station, has been declining during the three spawning cycles and during 1963–64 was less than half of that observed during 1961–62. The average numbers per positive station indicate that there was a concentrated spawning effort during the 1962–63 cycle. We have demonstrated that this happened only in areas B and C.

A COMPARISON BETWEEN SPAWNING INTENSITY AND ABUNDANCE OF ADULTS

In their recent contribution on the present status of the Peruvian stock of anchovy, Saetersdal, Valdivia, Tsukayama and Alegre (this volume) draw attention to the reduced abundance of big adult fish from 1962 to 1964. In their Figure 7 they show the abundance of the adult fish as the mean value of the months of November through May each year, the abundance being measured in numbers of adult fish per trip. In Figure 4 we have compared these data with the spawning intensity during the corresponding period, as measured by the average number of eggs per station for the whole northern region. The abundance of adults refers to data from Chimbote and Callao combined, and should thus be comparable. There is a striking similarity in the rate of decline.

A COMPARISON BETWEEN SPAWNING INTENSITY AND RECRUITMENT

The relation between spawning intensity and recruitment is much more complex than the relation discussed in the preceding paragraph. So far we know nothing about egg mortalities and their causes, larval mortalities, larval drift and the subsequent fate of the young individual until it enters the fishery at a size of about 8 cm. This phase in the life history of the anchovy is still shrouded in mystery and the need to fill this gap in our knowledge, is imperative.

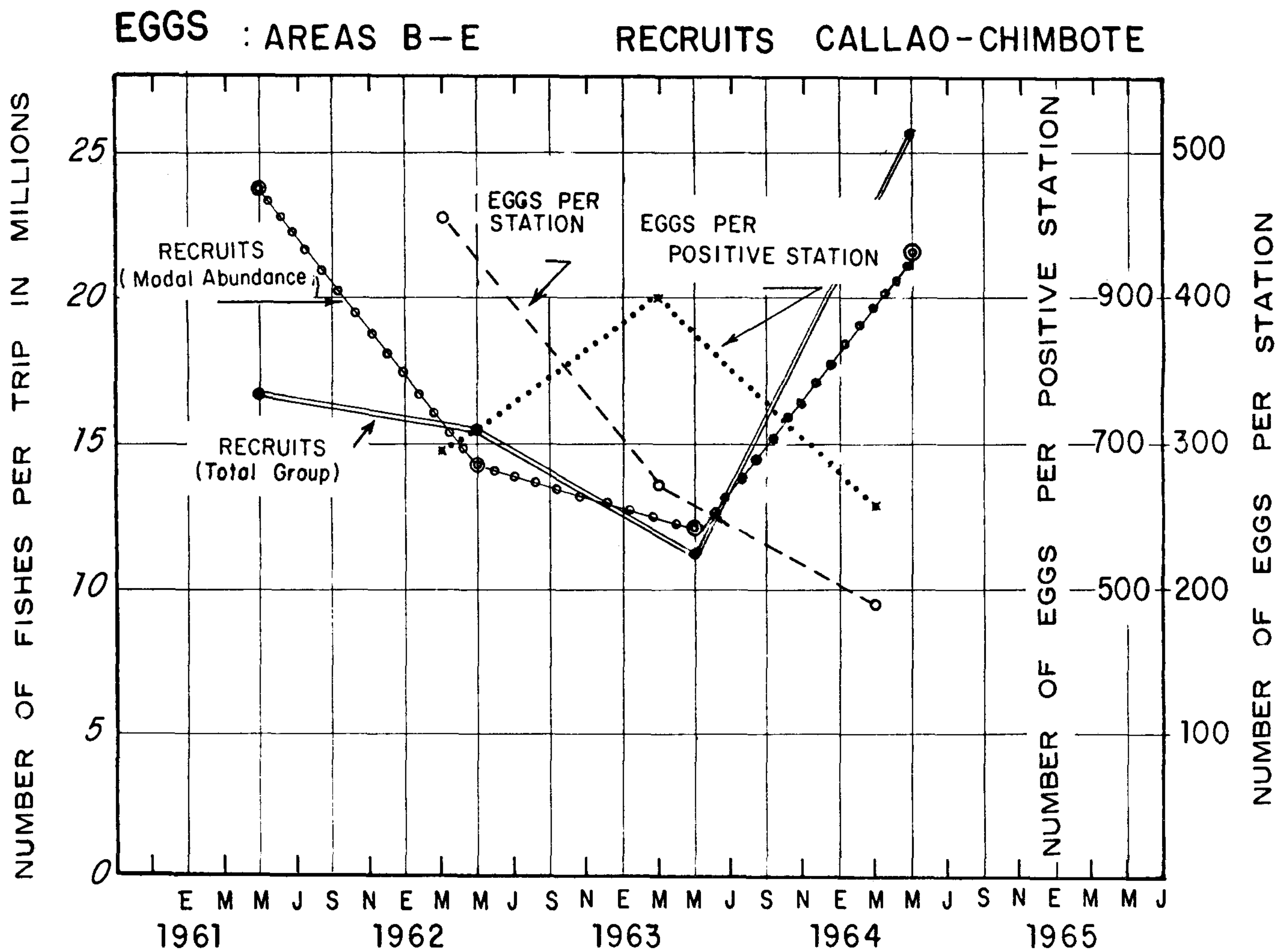


FIGURE 5.

In their paper, Saetersdal, Valdivia, Tsukayama and Alegre (this volume) have measured the abundance of the recruitment groups 1961 through 1964 in two different ways: first the modal abundance, expressed as average values for the highest modal abundance during the recruitment period, and second the estimated total number caught per unit of effort, as measured by number of recruits per trip. They found the decline in the abundance of adult fish parallel to that occurring in the abundance of recruits up till the season November 1963 to May 1964. However, in 1964, they found a very strong recruit group appearing in the fishery.

In Figure 5 we have compared the recruit abundance with the spawning intensity, as measured by egg numbers per station and per positive station for the region as a whole. The new strong recruit group did not at any rate originate through a widespread spawning, as shown by the low number of eggs per station. But it is quite possible that a strong

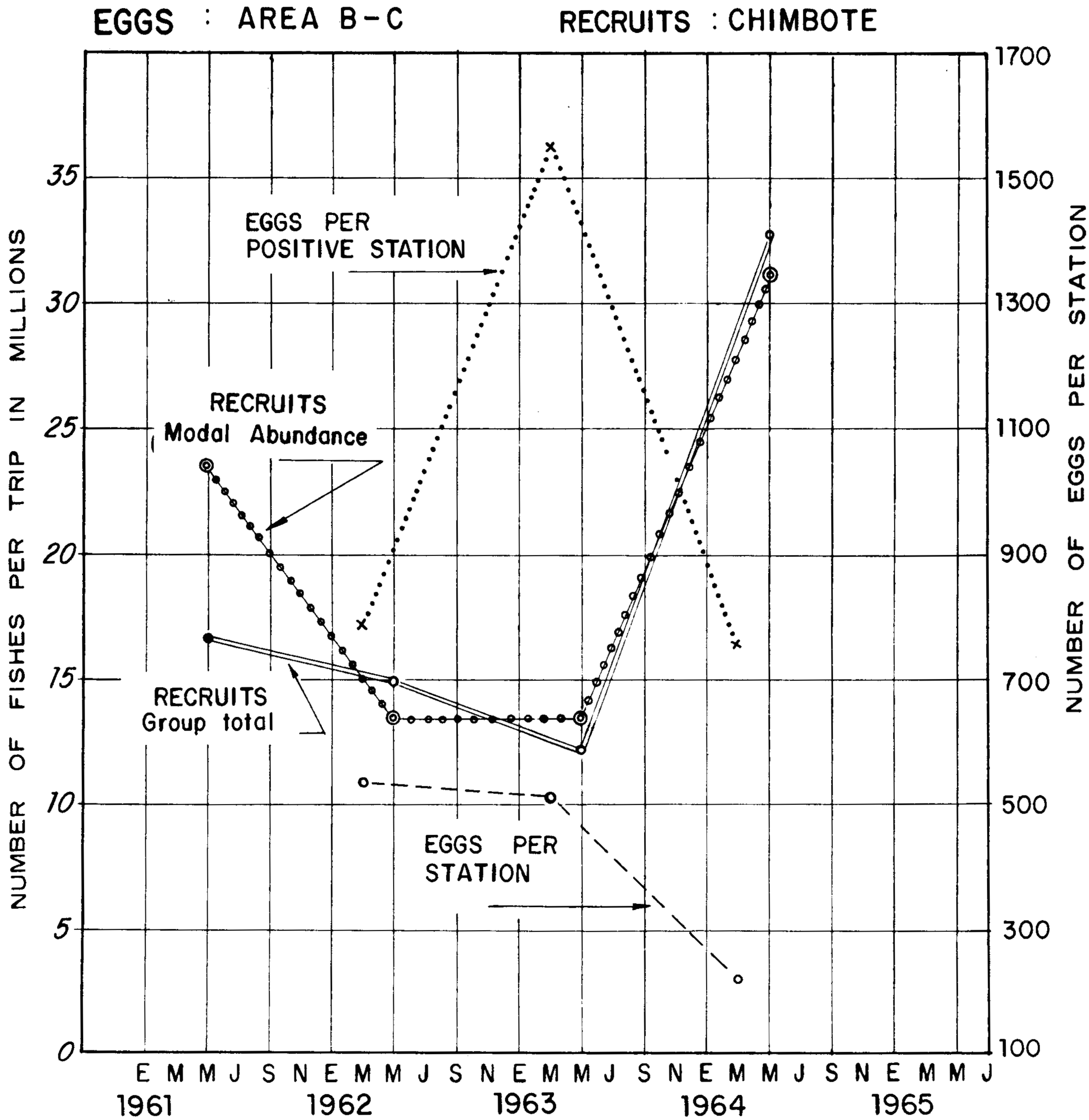


FIGURE 6.

recruit group originates through intensive and concentrated spawning and subsequent favorable conditions for survival. Ahlstrom (1959, p. 203) thought first that a widespread spawning of the California sardine favored greater survival and bigger recruitment, but a closer analysis of later data led him to doubt this conclusion.

It was stated that a strong recruit group could originate from an intense but geographically restricted spawning. This, however, did not occur as a result of the intensive spawning observed in areas B and C during 1962–63. The resulting group was poor according to the abundance estimates shown in Figure 6. On the other hand the low egg numbers in 1963–64 gave rise to an estimated rich recruit group. Evidently more effort is needed to tie up biological facts and oceanographic evidence.

The best conformity between egg numbers and recruitment strength was found in areas D and E as shown in Figure 7. Here the trend follows the same pattern both as regards eggs and recruits.

FREQUENCY OF LARVAE

It must be borne in mind that the Hensen net is very selective as to larval sizes caught. Only the youngest stages (less than 10 mm in length) are effectively retained by the net. We still lack experimental evidence as to incubation time and the rate of larval growth, but presumably the incubation time is shorter than the growth time of larval stages effectively retained. Until this time factor has been studied the numbers of eggs and larvae are not directly comparable, but if larval growth represents a longer time the numbers of larvae are maximal numbers in comparison, and we can conclude that

TABLE 3

PERCENTAGES OF ANCHOVY LARVAE VERSUS EGGS IN THE HENSEN NET HAULS 1961–1964

	Percent of larvae per positive Station	Percent of larvae per Station
Winter	28	32
Spring	10	13
Summer	22	29
Autumn	37	33
Average percent	20	25

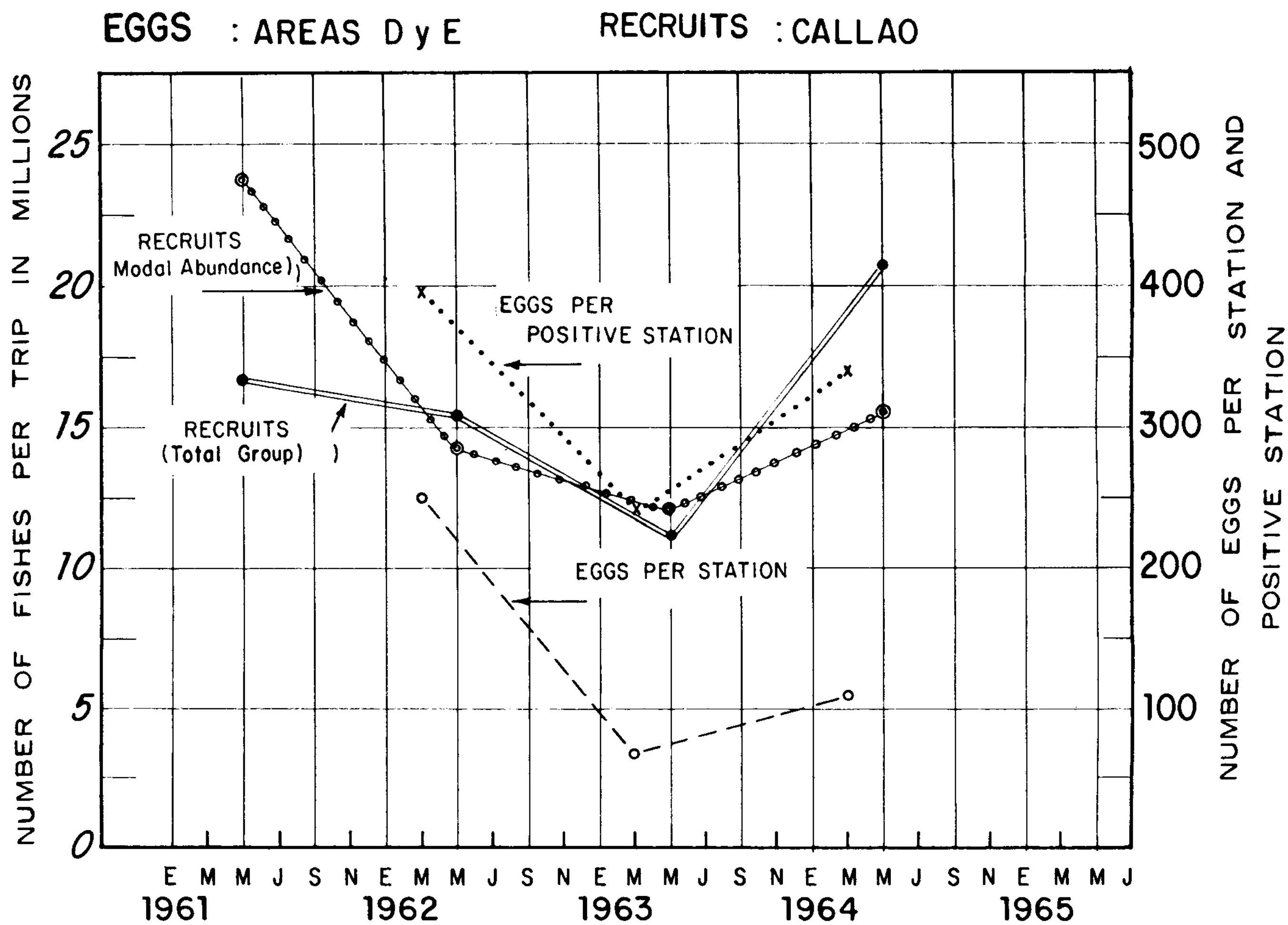


FIGURE 7.

mortality during the initial growth phase is not lower than that indicated by direct comparison between egg and larval number.

Adding up the whole material we find the percentage values of larvae versus eggs as shown in Table 3, the material being divided according to seasons.

The higher percentages of larvae per station reflects the effect of dispersal. The larval frequencies are much lower during the spring months. In fact the difference is so great that it must reflect higher egg mortalities during these months.

In Figure 8 we have shown graphically the larval percentages according to spawning cycles for the different areas. It will be seen that areas B and C follow the same trend with the lowest values during the 1962–63 cycle. It was shown above that a concentrated spawning effort occurred in these areas during this spawning cycle and it seems that this resulted in increased egg mortalities. It will be noted that the recruitment estimates and the percentage frequencies of larvae in these two areas follow the same pattern.

During the two latter spawning cycles area E shows a quite different trend with very high larval percentages and this is also true for area D during the 1962–63 cycle. We ascribe these phenomena to a low spawning intensity within the area, coupled

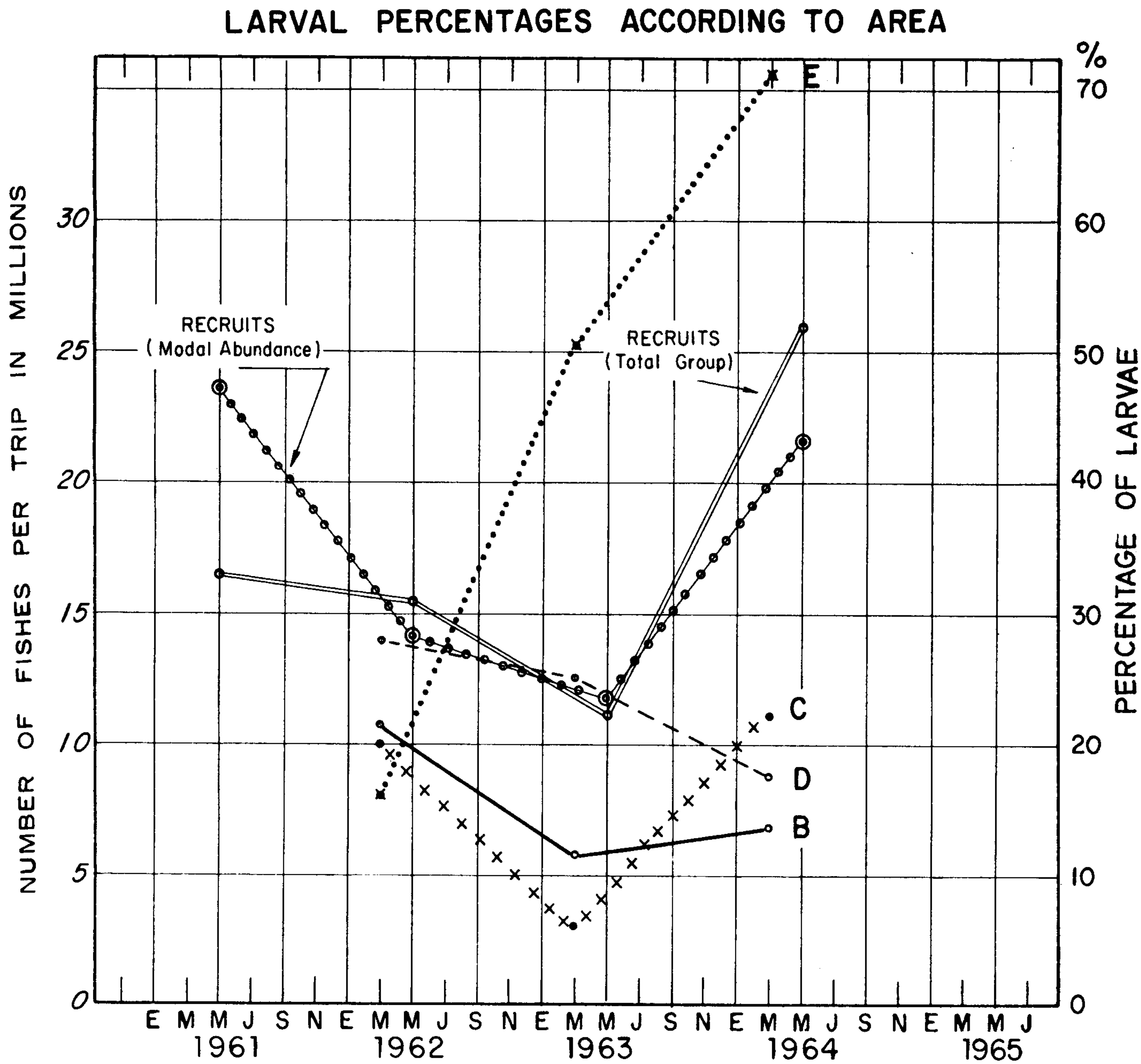


FIGURE 8.

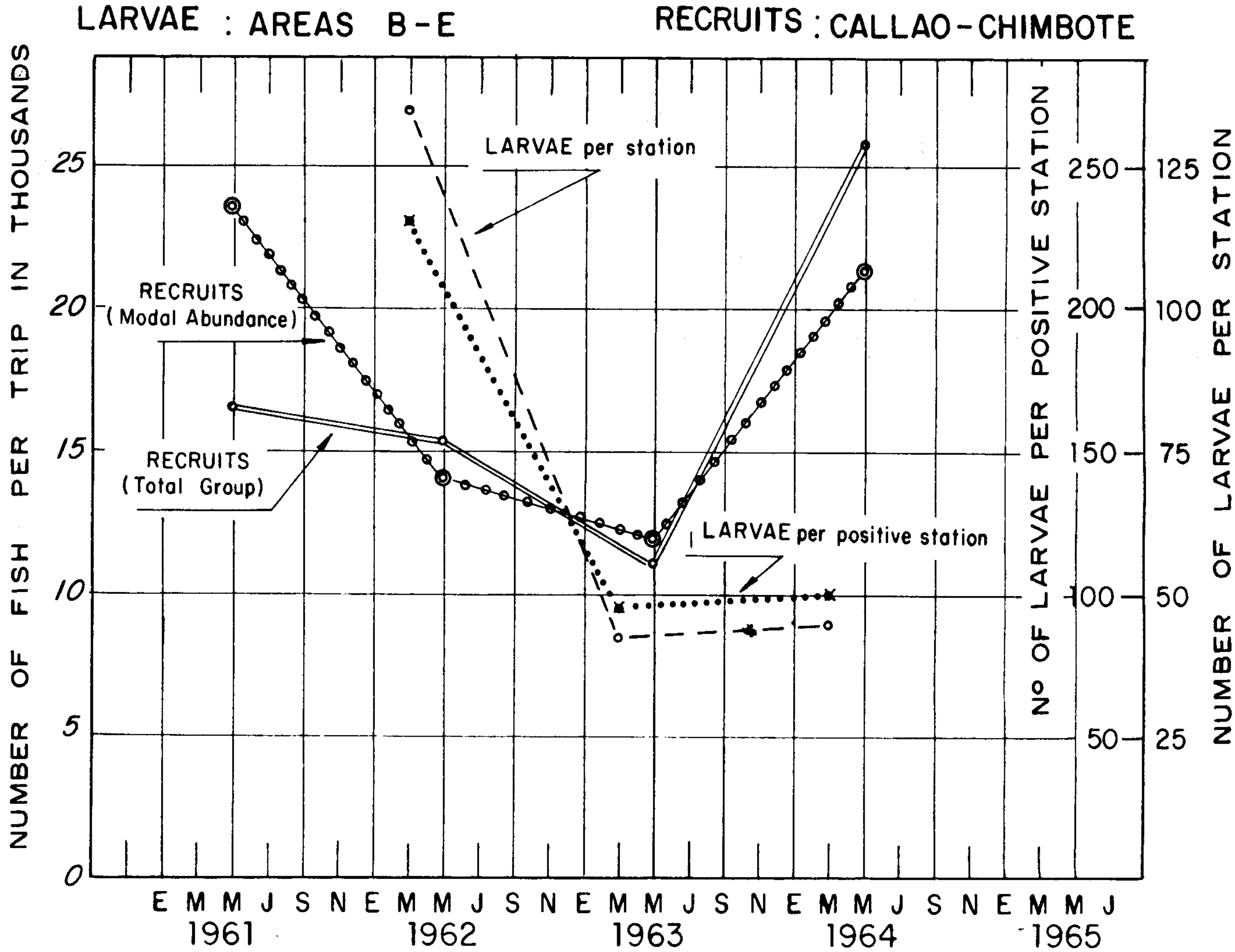


FIGURE 9.

with larval drift into the area from a spawning center lying to the south, the coastal current displacing the larval stock northwards from the spawning center. This could be verified as regards area D during 1962–63, but observational data are not sufficient from area F to establish this conclusion.

A COMPARISON BETWEEN LARVAL ABUNDANCE AND RECRUITMENT

We can presume that a closer relationship exists between larval abundance and recruitment strength than between spawning intensity and recruitment strength. However, our conclusions are limited by the fact that we have only been able to examine the abundance of the earliest stages in the growth of

In Figure 9 the number of larvae and recruit abundance are compared for the region as a whole. The highest numbers of larvae were found during the 1961–62 spawning cycle, but the resulting recruit group was not outstanding. The big recruit group appearing in 1964 seems not to have been derived from a rich larval stock in the region as a whole.

The evidence suggests that during the three spawning cycles larval abundance was highest during 1961–62, there was a big decline during 1962–63 and then a substantial increase during 1963–64, but not up to the 1961–62 level. Roughly this sequence reflects what has happened in recruitment, but the series of observation is too short to afford firm conclusions.

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