Sardines and Man

THE 1952-53 CATCH

In the last progress report, we forecast that the 1952-53 sardine season would be "very bleak." A better description would have been "catastrophic." The total sardine catch for the entire Pacific coast in the 1952-53 season fell to 15,000 tons, just one-tenth of the previous season's poor catch (see Fig. 15).

Most of the sardines were caught off Ensenada. Through the courtesy of processors canning sardines there, tonnages received at this port have been obtained for the calendar years 1949 through 1952. In this time interval the Mexican landings exceeded those of San Francisco and after 1950 those of Monterey also. Between 1951 and 1952 the Ensenada sardine catch declined from 21,330 tons to 9,620 tons. Yet in spite of a scarcity of sardines on the Mexican fishing grounds during the spring and early summer of 1952, the total catch for the year exceeded that for all California in the 1952-53 season.

The total catch for the four seasons during which the expanded research program has been in operation has shown great fluctuations. The tonnage landed in the 1949-50 season at California ports was about twice that of the previous season, the increase being most evident at San Francisco and Monterey. In the next season, 1950-51, the total landings again showed a slight increase, as a phenomenally successful catch off Southern California offset a serious decrease to the north. In 1951-52 practically no fish were taken on the Central California fishing grounds and the Southern California fishery showed a marked decline. Finally the entire fishery failed in 1952-53.

AGE COMPOSITION OF THE CATCH AND MORTALITY RATES

The presence or absence of sardines on the California fishing grounds depends on the history of each individual year class comprising the population: its abundance, its availability, and its rate of decline. During the seasons 1949-50 through 1952-53 the catch was made up almost entirely of fish two, three, and four years old (Fig. 16). For this time interval these age groups represent year classes spawned in 1946, 1947, and 1948. By 1951-52 the 1946 year class had almost disappeared from the catch, there were few of the 1947 year class left, and the 1948 year class had declined in numbers. By 1952-53 too few sardines of any age group were caught on the California grounds to support a fishery.

The contraction in the distribution of sardine is indicated in Figure 17, which shows the percentage of each year class from 1937 through 1948 caught in each of four areas along the coast. This figure shows how the fishing area has contracted: it does not show another factor of great importance that also is visible in the catch—a decrease in actual numbers arising by reason of a series of small year classes being present on the fishing grounds. As the figure indicates there is considerable variation with time not only in the spatial distribution of a given year class, but also between year classes. Differences in year-class origin as well as variations in behavior account for this.

What has been happening to the sardines is shown by data collected in the course of our young-fish surveys. Though, as the name indicates, these cruises are directed primarily toward an assessment of the status of the young-fish population, information on adult fish is also gathered. For each of the year classes now in the fishery mortality rates between the years 1950 and 1951 and again between 1951 and 1952 may be estimated from the survey data. These rates appear to have been extremely high.

TABLE 1
TOTAL MORTALITY RATES ESTIMATED FROM SURVEYS ALONG THE CALIFORNIA AND BAJA CALIFORNIA COASTS

	Percentage decline between	
Year class	*1950 and 1951*	*1951 and 1952*
1945 and older	90	100
1946	75	100
1947	70	90
1948	40	85
1949	25	80
1950	45	60
1951	--	50

Mortalities were higher during both time intervals among the older age groups subject to fishing as well as natural mortalities. All rates were higher between 1951 and 1952 than between 1950 and 1951 but this increase was most marked among the younger year classes reaching sizes suitable to the fishery.

At the present time (1953) sardines older than 1948 year class have all but disappeared from the California fishing grounds. Nor are these older fish present in Baja California waters. They may have originated from spawnings off California and never have been abundant in the southern waters or the southern representatives of these year classes may have moved northward and been caught in the California fishery. On the other hand, fish of the 1948 year class and younger age groups are now more abundant off Baja California than off California. These groups probably resulted largely from southern spawnings. The 1948 year class has made a material contribution to the California fishing grounds but no great numbers of the 1949 and 1950 groups have been caught. The success or failure of the fishery in the immediate future will be largely determined by the number of sardines that may move from the Baja California waters onto the California fishing grounds.

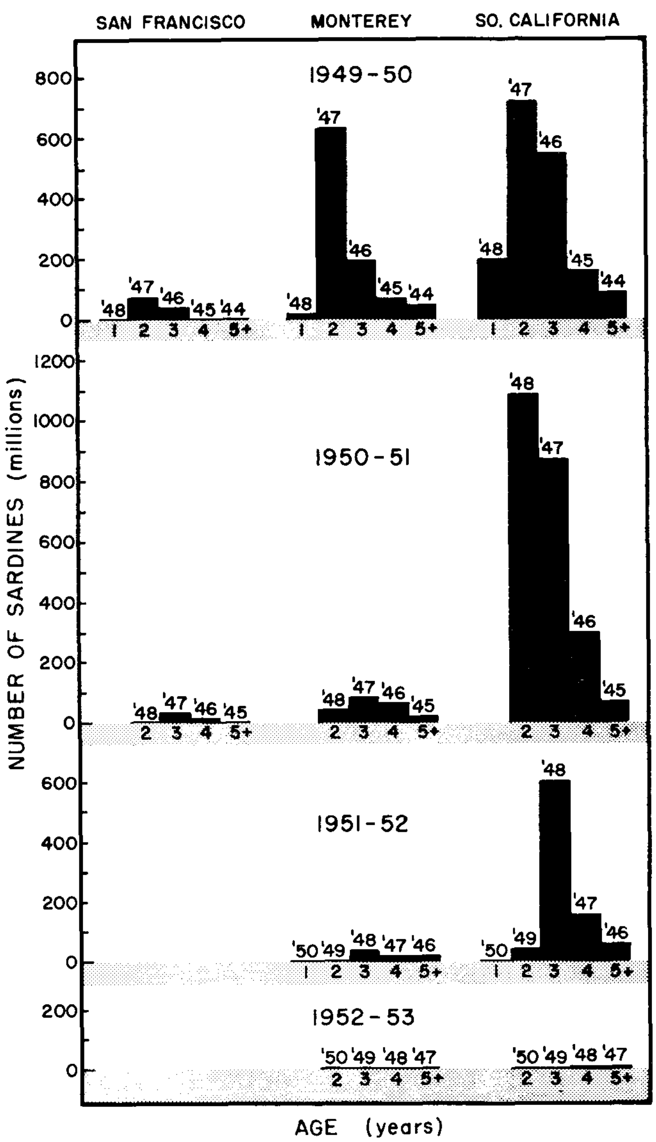
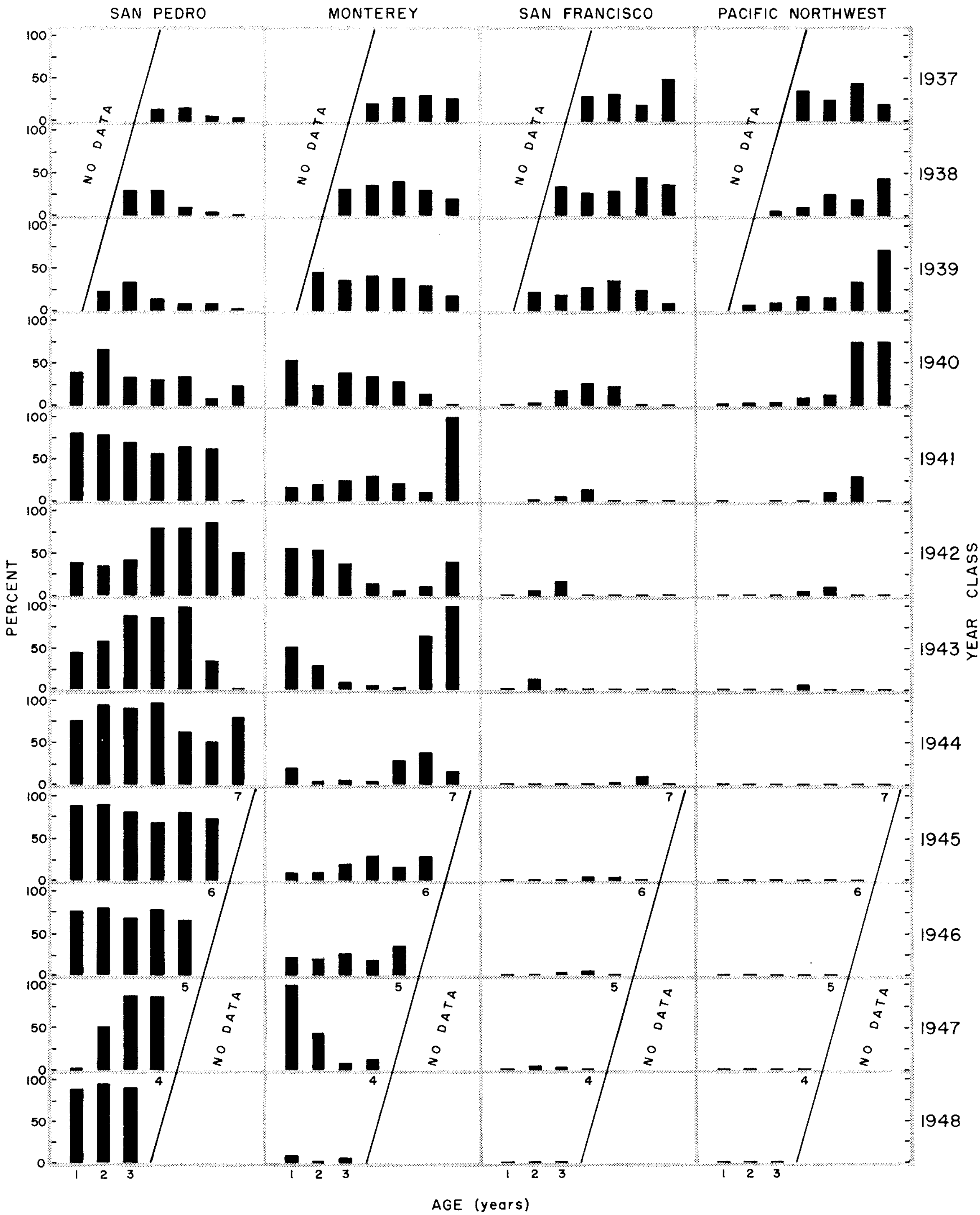


FIGURE 16. In this figure we show a breakdown of the California catch for the past four seasons for each of three areas according to the age groups taken in the commercial catch. (We have no similar figures for the Mexican fishery.) As can be seen, the fishery for the first three seasons depended primarily on the two- and three-year-old fish. The insignificant 1952-53 catch came from the four- and five-year-old fish. For four seasons the California fishery has depended on fish spawned in 1948 and previously. There has been no significant contribution from the younger year classes, nor, as has been indicated in Figure 14, can we expect one from any year class in the fishery at the present time.

FIGURE 17. This rather complex graph documents an important aspect of the sardine situation. There has been a great contraction of the sardine population. For purposes of comparison, we assume that all the year classes from 1937 to 1948 were of the same numerical strength. Each bar in the graph represents the percentage of the total fish of a particular year class at a specific age that were caught at a single port. Thus, for example, if we add the percentages for the 1940 year class at three years of age for each of the four areas, we arrive at 100 percent. By eliminating variations in year-class strength, we emphasize the strong southward contraction of the fishery.


SAN PEDRO
MONTEREY
SAN FRANCISCO
PACIFIC NORTHWEST
PERCENT
YEAR CLASS
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
NO DATA
AGE (years)

AVAILABILITY ON THE FISHING GROUNDS

The data that we collect on the catch and the amount of effort spent to take the catch may be used to derive information on how much changes in fish distribution and behavior may affect the availability of the fish to the fisherman. They will not, of course, tell us why such changes take place, but they do constitute a record of those changes.

One method of estimating total population size also yields estimates of the fraction, or percentage, of the total population that is available to the California fishermen each season. The changes in this availability fraction from one season to the next are given in Figure 18. It is important to note that the availability fraction pertains not to the absolute *numbers* of fish on the fishing grounds, but rather to that *fraction* of the total number of fish which are on the fishing grounds, regardless of what the total number may be. The figures thus refer to the changes in that fraction from one season to the next.

So far no one can say exactly why some fish are unavailable, where they are when they are unavailable, or why the degree of availability varies with time. Several explanations can be suggested: differences in schooling behavior in any given area (recent results of the young-fish surveys indicate that there may actually be a size or age difference in schooling behavior and that this explains why the small, young fish are ordinarily not represented in the catch in proportion to their true abundance in the ocean); inshore and offshore movements; north and south movements (for which there is considerable evidence from tagging); up and down movements; and so on.

Some data have been collected within the last few years which will yield information on north and south movements. In this case we may consider fish which are south of the International Boundary as unavailable to the California fishermen. Of course, any particular fish may move so that it is at one time north of the Boundary, then south of it, then north, etc. But while it is south of the Boundary, it is unavailable to the California fishermen. It was suggested in the last progress report that one source of variation in the San Pedro catch could be the existence of a "southern" group of sardines which moved onto the California grounds in varying amounts in different seasons. The data mentioned bear on this.

Collections of sardine eggs can also be used to estimate the total number of spawning fish and, also, the geographic distribution of these fish during the spawning season. The young-fish surveys yield information as well on the distribution of adults within the time and place of the survey. Comparison of these two independent sources of information shows a net northward movement of fish between spring and fall (Fig. 19). (Our data are so arranged that it has been easier to show the percentages north and south of

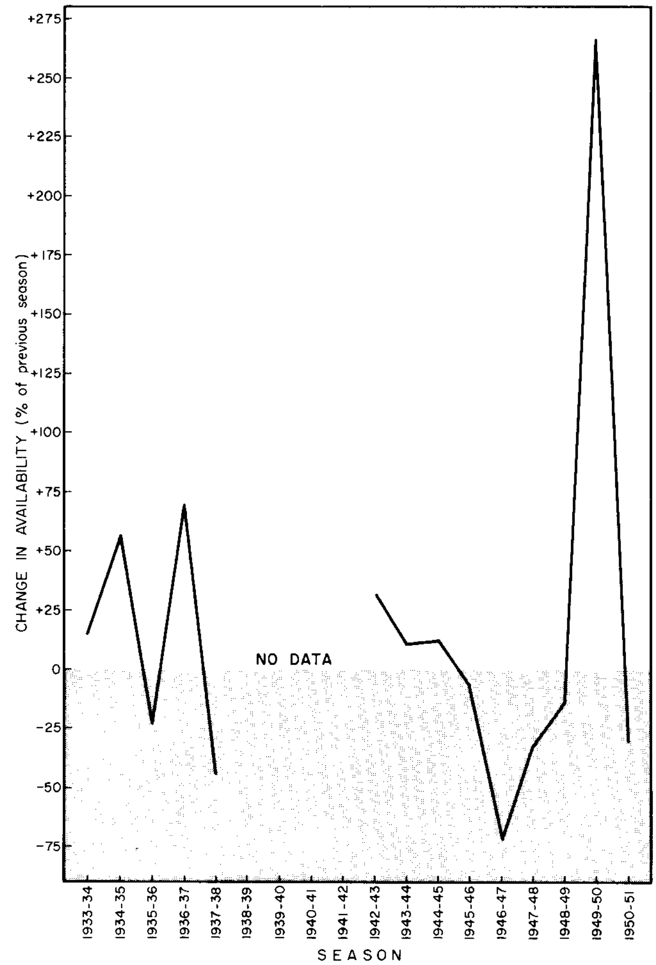
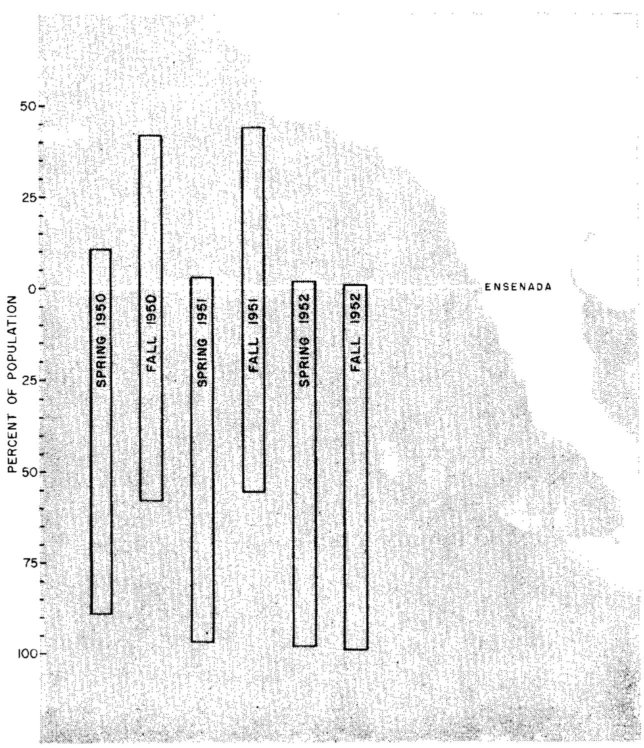


FIGURE 18. The factor of availability varies from season to season, sometimes operating to increase the expected catch, sometimes to decrease it. In this figure we have charted estimates of the changes in availability from one season to the next for two periods. The table shows, for example, that the fraction of the population available to the fishermen in 1934-35 was 56 percent greater than in 1933-34; that in 1935-36 it was 23 percent less than in 1934-35; and so on. It is important to note that these estimates do not pertain to the absolute numbers of fish on the fishing grounds, but rather to that portion of the total number on the fishing grounds regardless of what the total may be. So far, no one can say exactly why some fish are unavailable, where they are when they are unavailable, or why the degree of availability varies with time.

FIGURE 19. California sardine fishing stops at the International Border between the United States and Mexico. Information from two separate sources locates the bulk of the adult sardine population south of the border at all times of the year. (In this chart we have arbitrarily displaced the border to Ensenada to avoid some complex and rather unproductive reworking of the data.) Each bar represents the entire population, regardless of its numerical size. The egg surveys show that during the spring and early summer months, most of the spawning fish are south of Ensenada. The young-fish surveys, which also yield information on the distribution of adult sardines, also locate the majority of the sardines south of Ensenada, though the proportions have sharply changed, indicating a net northward movement in the summer and early fall months. A possible explanation lies in the existence of separate, but mingling, subgroups in the sardine population, with one centered off Baja California (the "southern fish" of last year's progress report), another off Southern California.



Ensenada, rather than the International Boundary. The few miles between the Boundary and Ensenada are unlikely to cause any major distortion of the information.)

In 1950, only 11 percent of the spawning fish were north of Ensenada in the spring, but by fall 39 percent of all adults were north of Ensenada, a net northward movement of about 28 percent of the adult population. In 1951 the net northward movement was about 25 percent and 1952 there was a slight net southward movement.

The reasons for movements of sardines, such as that demonstrated above, are not known. This is unfortunate, for they would be of great value in the understanding of the behavior and distribution of the population and their effects on the catch.

A NEW METHOD OF ATTACKING THE PROBLEM OF SUBGROUPS

Much of our evidence leads us to believe that the sardine population along the coast consists of several local populations that may mingle to a small or large extent. Last year we described some of the evidence for this theory. This year we can say a little more about a new technique, borrowed from geneticists, that may eventually clear up this matter.

The technique is paper partition chromatography. The genetic constitution of an organism is known to affect its biochemical makeup. The technique requires that one treat a bit of tissue (we are using muscle) with chemical solvents. The tissue is placed on a sheet of filter paper and allowed to dry. The edge of the paper is immersed in a solvent; with the paper acting as if it were a wick, the solvent dissolves out various components of the muscle tissue and carries them along the sheet. When the process is stopped it is found, by application of ultra-violet light or special indicators, that the substances are distributed in a linear series of spots, each spot being a definite chemical compound (see Fig. 20). The pattern of spots formed is characteristic of the species. It is hoped that further research will yield patterns representative of subgroups.

Obviously if sardines carry such a "built-in" tag, a number of interesting questions can be answered, but wholly reliable and significant information is unlikely to emerge from the use of this technique until we have had time to determine its limitations.

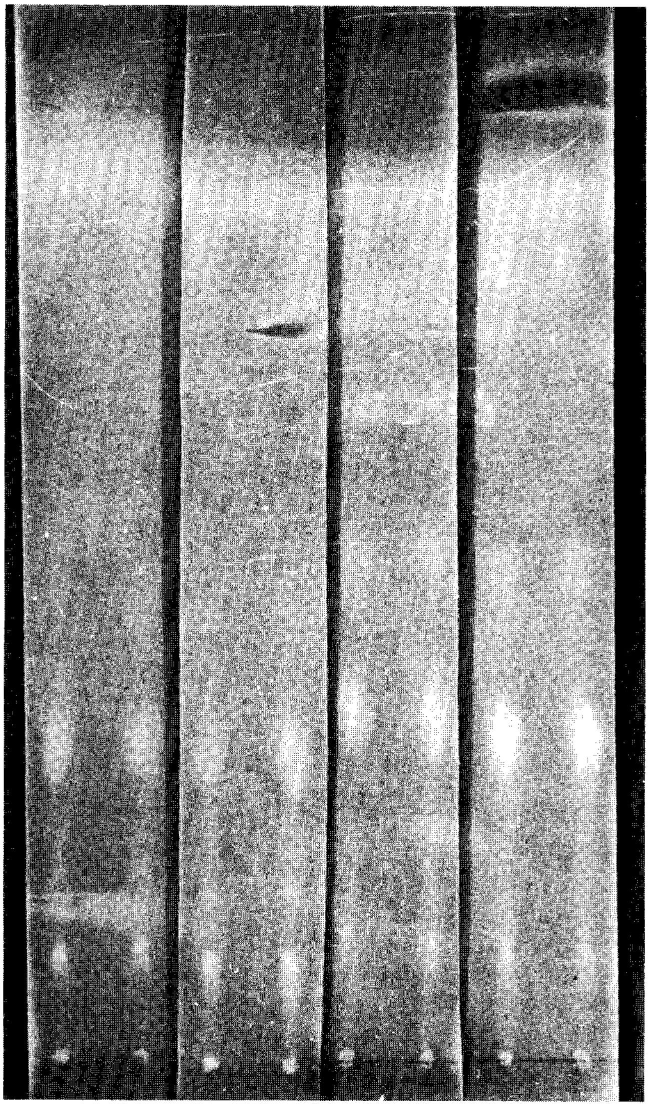


FIGURE 20. Recent experiments indicate that sardines, like other living creatures, may carry a "built-in" tag. The technique of paper partition chromatography is being tried on an experimental basis on Pacific sardines to see if it offers a means for the study of such problems as migration and subgroups. A bit of dried muscle tissue on a sheet of filter paper is treated with chemical solvents, which dissolve out various components of the tissue and carry them along the sheet. When the process is stopped it is found, by application of ultra-violet light or special indicators, that the substances are distributed in a linear series of spots, each spot being a definite chemical compound. The pattern of spots formed is characteristic of the species. Here we show two chromatograms each from sardines from (left to right) Punta Blanca, Lagoon Head, Morro Hermoso, and Punta Abreojos. Variations in the patterns may point to slight but significant differences between sardines from different environments.

SUMMARY: THE STATUS OF THE ADULT SARDINE POPULATION, 1 JULY 1953

1. In the past four years we have witnessed a decrease in numbers of sardines of all sizes on the California fishing grounds, and a maintenance, but no marked increase, in the numbers in Baja California waters south of Ensenada.
2. By 1952-53, too few sardines of any age group remained on the California grounds to support a fishery.
3. A contraction of the area in which the sardines are caught has been paralleled by a series of poor year classes.
4. Between 1951 and 1952, estimated mortality rates increased greatly over the preceding year's estimate.
5. The success or failure of the fishery in the immediate future will be largely determined by the number of sardines that may move from the Baja California waters onto the fishing grounds.
6. There is evidence for a vastly increased availability in the 1949-50 season, with a declining availability since then.
7. Estimates of population size have yielded information that indicates a variable net northward movement from Baja California to Southern California of sardines in the fall, and this variability accounted in part for the failure of the 1952-53 season.
8. A new technique has been introduced for the study of the problem of subgroups.