The Present Status of the Sardine and Tuna Fisheries of Venezuela

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Abstract

The sardine fishery is conducted by beach seining, and the annual catch has averaged about 40,000 tons over the past five years. Most of the catch is normally taken in the Gulf of Cariaco, which is an important spawning area. About 400 sets are made annually with an average catch per set of about 100 tons.

The specific components of the catch, seasonal migrations, dependence of school size on population density and new fishing methods are discussed.

From 2,000 to 3,500 tons of yellowfin and albacore tuna were caught annually by Venezuelan longliners from 1960-66. The fleet of about forty vessels sets an estimated 3.8 million hooks annually in the eastern Caribbean and western Atlantic. The average annual catch per 100 hooks is between 2 and 4 yellowfin and 0.4 and 1.4 albacore. Although the catch rate has declined during the past few years, the domestic price of over U.S. $ 400 per ton of gutter fish favors the continuance of fishing operations.

The possible differences between the two main fishing areas and the migrations between them, the effects of upwelling, the low radius of action of the fleet and new fishing methods are considered.

INTRODUCTION

THE PURPOSE of this report is to collate information about two pelagic resources that are important in Venezuelan fisheries. This information has been obtained from the fishery statistics of the past several years.

First we consider the beach-seine fishery for sardine, the yield from which has long been the mainstay of the national catch, occupying (since 1956) an average of 34%±5% by weight. Second, there is the longline tuna fishery, the annual catch of which has occupied since 1960 an average of about 2.5% of the total catch. In contrast to the sardine fishery which is relatively primitive, the tuna fishery is one of the more advanced in Venezuela (the shrimp fishery of the Gulf of Venezuela being the most advanced and industrialized).

For each fishery a brief description will be given, showing the catch and fishing effort and the relation between them, and an indication of the temporal and spatial distribution of effort.

Finally, some leading questions concerning these fisheries and their future are discussed.

THE SARDINE FISHERY

Method

Omitting some recent, preliminary attempts to catch sardines by purse-seining, the method of this fishery is the beach seine. This is a net of the lampara

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type with two wings and a bag. The total length is normally from 200 to 300 m and the depth of the wings is between 1 and 4 m. The net is set (a "calada") around any school that comes close enough to the beach, normally with the help of one or two small boats. Once the school is corralled, the wings are pulled by manpower up the beach and staked out. A fishing team consists of about 20 men and this team may work several nets, though only one at a time. In almost every set the whole school is caught; in less than 2% of the sets does any significant part of the school escape.

The catch is kept alive in the net, being transferred according to factory demand by small barge-like vessels, with an average capacity of about 8 tons. Fig. 1 shows the principal fishing areas and the locations of the sardine canneries.

Occasionally, a second set is made in the vicinity of a seine already staked to the beach. The catch of this second set is often passed to the first net, avoiding the need for staking the second net. This operation is called a "recalada"; it involves only a few percent of the total number of sets made in a year, and for most purposes can be ignored or averaged (by sharing the combined catch between the two nets). Rarely, a third set may be added to the first net.

Referring to single sets only, it has been shown that the time required to empty the net is variable. Using data from all the canneries between 1957 and 1963 it was found that about 8% of the nets were occupied in retaining the catch of the set more than 15 days and about 18% were occupied more than 10 days. The differences between canneries is, however, noticeable, the respective percentages for the best cannery being about 0.3% and 3%.

The Gulf of Cariaco, which is the principal fishing area, is about 56 km long, with a maximum width of 14 km and at its mouth is 3 km wide. The fishing teams which operate there maintain a system of lookouts from dawn till dusk. A similar lookout system covers much of the Santa Fe coast, whereas in other fishing areas it is less developed.

Species

At present the fishery is principally based on *Sardinella anchovia*. There is, however, a small and variable component of a second "type" present in the area which is larger and deeper bodied, though in other respects similar (Simpson, 1963). Its presence in the commercial catches of 1958 and 1959 was also noted during a study of the scales which showed that this second "type" had a different growth rate from that of *Sardinella anchovia* (Heald and Griffiths, 1967).

The taxonomy of the genus *Sardinella* in South America waters is rather incomplete, based mainly on small samples from Brazil and Trinidad, but none from Venezuela (Hildebrand, 1963).

The sardines in the commercial catches have a total length between about 11.5 cm and 29.0 cm and weigh between about 15 and 190 gm.

An overall length-weight equation was computed, using data from 1957 to 1963 (Griffiths and Simpson, MS). The sexes were combined since there was very little difference between their length-weight relationships. The allometric equation ($W=aL^b$) and its logarithmic transformation were used to express the relationship between length (cm) and weight (gm):

$$W=(0.00562)L^{3.136}$$

$$\log W=\log(0.00562) + 3.136 \log L.$$

This relationship is based on 48,230 sardines, in the length range 11.5-28.8 cm.

Catch and Fishing Effort

The annual catches since 1957 are shown in Table 1.

TABLE 1

THE TOTAL ANNUAL CATCH OF SARDINES IN VENEZUELA IN THOUSANDS OF METRIC TONS, 1957-1966

Year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Catch	23.7	31.0	30.7	30.6	23.4	32.3	35.3	42.1	43.8	39.1

The fishing effort, measured by the number of sets, is given in Table 2.

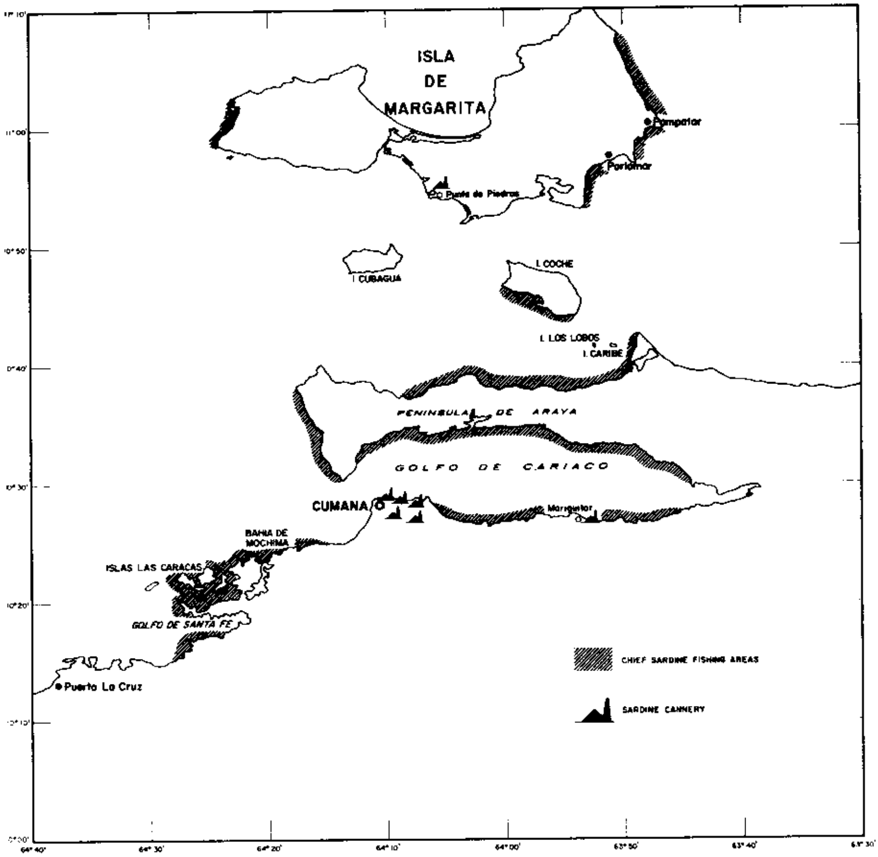

FIG. 1. The principal sardine fishing areas and the locations of the sardine canneries.

TABLE 2

THE NUMBER OF SINGLE AND MULTIPLE BEACH SEINE SETS AND THEIR TOTAL, 1957-1966

Year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
No. of single sets	244	232	251	315	266	273	333	369	301	353
No. multiple sets	20	15	9	14	14	15	20	48	14	23
TOTAL	264	247	260	329	280	288	353	417	315	376

These figures are comparatively reliable since they were obtained from the factories which record the arrivals of fish each day from specific seines. In recent years the proportion of seines owned and operated independently has increased, whereas in earlier years they were nearly all owned by, or contracted to, specific factories. This means that an independent seine fisherman may sell to more than one factory, though in general this would not be from the same set. Consequently, the statistical monitoring of this fishery has become more complicated. For this reason the number of multiple sets is less accurate after 1963.

From the previous years it can be seen that the percentage of multiple sets is on the average somewhat less than 6%. By computing the catch per set from the catches made by single sets only and the same index from global totals of catch and effort the above-mentioned discrepancy becomes apparent in recent years (Table 3).

TABLE 3

AVERAGE ANNUAL CATCH OF SARDINES (METRIC TONS) IN VENEZUELA, 1957-1966, COMPUTED FROM THE RESULTS OF SINGLE SETS ONLY AND FROM THOSE OF SINGLE AND MULITIPLE SETS (GLOBAL TOTALS OF CATCH AND EFFORT)

Year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Catch per set (single)	105	133	107	86	78	107	88	79	85	80
Catch per set (global)	90	126	119	93	84	112	100	100	139	104

Although the nets are of two main sizes no standardization of the unit of effort has been undertaken because there is no real difference in efficiency since the whole school is usually captured, irrespective of net size. The introduction of outboard motors to assist setting the seine produced a trend to larger nets.

The total catch and total effort, together with the two indices of apparent abundance (catch per set) described above are shown in Fig· 2. It can be seen that catch and effort have increased steadily during the last decade and that the catch per set has shown no pronounced tendency to decrease or increase. Further consideration is given later to the value of the catch per set as an index of apparent abundance for this resource.

The sardines are canned and the offal is converted to fish meal. Nearly all the canned sardines are destined for the Venezuelan market. Venezuela was the world's fourth largest producer of canned gilt sardines in 1963 and 1964 and the fifth in 1965 (FAO, 1964; 1965; 1966; Ministry of Agriculture, Venezuela, 1966), as shown in Table 4.

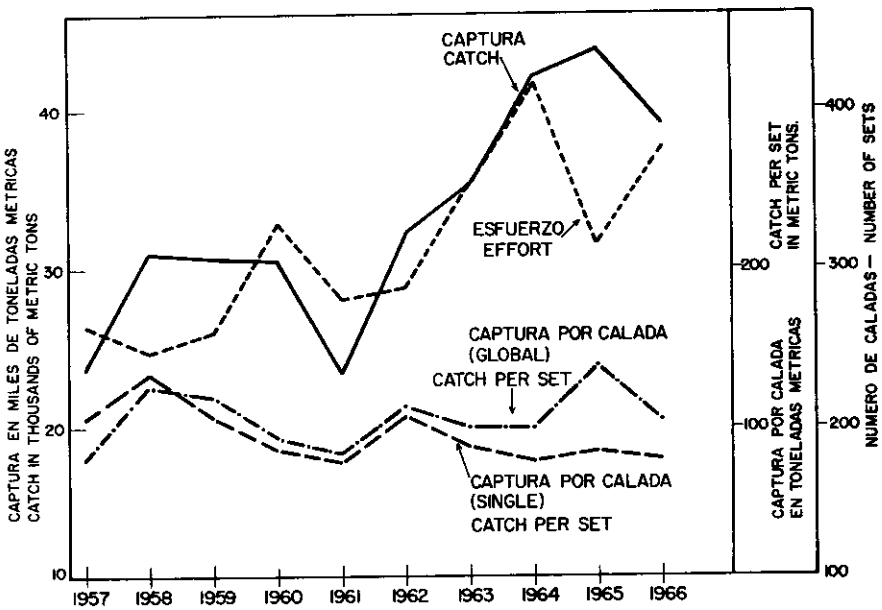

FIG. 2. Total annual catches, total effort (sets), catch per set computed from total catch and effort (single and multiple sets), and the catch per set computed from single sets only.

Spatial and Temporal Distribution of Catch and Effort

SPATIAL: The principal fishing areas are shown in Fig. 1. Traditionally, the focus of the fishery has been the Gulf of Cariaco where about 80% of the catch used to be taken (Simpson, 1963). In recent years there has been an expansion of the fishery to areas outside the Gulf that were only slightly fished before, or not all. Such areas are the Santa Fe coast, the west and north coasts of the Peninsula of Araya, around some of the small islands (e.g. Coche, Los Lobos, Caribe), between the mainland and the island of Margarita, and the southern and eastern coasts of the island of Margarita. Small quantities of sardine are taken for bait in the Gulf of Venezuela.

Since place names in the area are often the same for several different places, there is some error in the detailed groupings of the distribution of effort and catch. However, the following general observations may be made.

TABLE 4

THE TONNAGES (FRESH WEIGHT) OF SARDINES CANNED IN 1963, 1964 AND 1965 BY COUNTRY, WITH THEIR RANKS

	1963 Fresh weight canned, in thousands of metric tons	Rank	1964 Fresh weight canned, in thousands of metric tons	Rank	1965 Fresh weight canned, in thousands of metric tons	Rank
Algiers	0.2	16	0.9	15	—	(16)*
Argentina	5.3	10	7.8	9	9.2	9
Brazil	15.5	7	19.0	6	29.5	4
Chile	2.7	12	2.3	13	2.5	11
Colombia	0.3	15	0.3	16	0.4	14
France	19.0	5	21.0	5	—	(7)
Italy	1.6	13	2.4	12	2.5	12
Japan	4.5	11	4.6	10	3.8	10
Mexico	10.6	8	10.5	8	11.2	8
Morocco	30.6	2	41.9	3	43.8	3
Portugal	49.6	1	70.2	1	56.2	2
South Africa	7.7	9	1.8	14	1.3	13
Southwest Africa	29.1	3	64.0	2	63.0	1
Spain	17.3	6	16.9	7	18.9	6
Turkey	0.1	17	0.1	17	—	(17)*
United States	1.2	14	2.5	11	0.2	15
Venezuela	22.3	4	25.3	4	24.6	5
TOTAL	217.6		291.5		267.1	

*Ranks in parenthesis are assumed on basis of earlier annual catches since 1965 data were not available.

In the Gulf of Cariaco, more sets are made on the north side than on the south side. Upwelling, however, has been shown to be more pronounced in the southern and eastern parts of the Gulf (Gade, 1961 b; Griffiths and Simpson, 1967). On the west coast of the Peninsula of Araya, the southern part is generally more heavily fished. Along the Santa Fe coast, the more intensively fished areas are the Gulf of Santa Fe (in many ways a miniature of the Gulf of Cariaco), Isla Caracas and the Bay of Mochima. There has been a marked increase in fishing along the north coast of the Peninsula of Araya especially west of the island of Caribe, though also to the east, during the last two years.

Efforts are being made to improve the collection of the statistics by locating a given set within a suitable sub-area on a map, rather than by simply naming it.

TEMPORAL: Historically, most of the catch has been taken in the early months of the year, but occasionally this pattern shifts somewhat to the middle and sometimes the later months of the year. Table 5 shows the distribution of monthly catches expressed as ranks in each year.

It is apparent that variations from the "normal" are not clear-cut. A rank correlation test showed that there is no significant relationship between the average catch per set (school size) and the month; in effect, the school size is independent of the season, and, therefore, probably independent of stock abundance. The rank correlation coefficients for 1964, 1965 and the two years combined were − 0.306, + 0.434, and − 0.126, respectively.

TABLE 5

THE CATCH OF SARDINES IN VENEZUELA EXPRESSED IN TERMS OF THE RANK OF EACH MONTH IN EACH YEAR, 1957-1966. THE FIRST SIX MONTHS BY RANK IN EACH YEAR ARE IN LIGHTFACE

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1957	5	4	1	3	2	**7**	**9**	**8**	**11**	**12**	**10**	6
1958	**7**	5	3	4	1	2	**9**	**12**	**10**	**11**	6	**8**
1959	6	2	3	5	4	1	**8**	**7**	**11**	**12**	**10**	**9**
1960	6	1	2	**8**	**11**	3	5	**9**	**7**	4	**10**	**12**
1961	4	1	5	**9**	6	2	3	**11**	**8**	**7**	**10**	**12**
1962	6	2	1	5	3	4	**7**	**8**	**12**	**10**	**11**	**9**
1963	3	2	1	4	6	**8**	**10**	**12**	**11**	**9**	**7**	5
1964	1	2	4	**8**	**11**	**10**	**9**	**7**	**12**	5	6	3
1965	5	**9**	**11**	6	4	2	1	3	**10**	**7**	**8**	**12**
1966	1	5	6	**12**	4	**7**	2	3	**11**	**10**	**8**	**9**

The causes of annual variations in the peak fishing months, which are usually from January to April, are at present unknown, but certain pertinent facts may be mentioned.

The Gulf of Cariaco is an important sardine spawning area(Simpson, 1963; Simpson and González 1967). Although some spawning occurs throughout the year, the main spawning season is from December to April, and the peak spawning is usually during January and February. The highest monthly catches are usually taken during the main spawning season, and annual variations in the timing of peak spawning may be reflected in the timing of peak catches.

In the Gulf of Cariaco, upwelling is most intense from December to April, and is induced principally by the northeasterly component of the trade winds; these are strongest during the early months of the year and are weaker and more variable during the later months, often being replaced by winds from the northwest. Griffiths and Simpson (1967) have shown, at least for 1960 and 1961, that there can be significant annual differences in the intensity and duration of upwelling in the Gulf of Cariaco; these may also determine the availability and abundance of the sardine and the distribution of monthly catches.

Important Considerations of the Sardine Fishery

(1) It is now known that though most of the sardine catch is *Sardinella anchovia,* there is present a small proportion of a second type, whose degree of taxonomic differentiation is uncertain. It was also noted that there was a small component of the *Sardinella anchovia* whose growth rate departed somewhat from that of the majority.

This raises a question concerning a fairly common assertion: that the sardines, after spawning (and perhaps when the plankton declines in abundance), emigrate from the Gulf. Although nothing is known of the sardine migrations, it has been suggested that some portion of the spawning population remains in the Gulf and experiences different environmental conditions from those of the emigrants (Heald and Griffiths, 1967).

A knowledge of regional migrations is required for planning the best fishing strategy. There have been reports of a shortage of sardines for over a decade now, yet the catch has increased from 23,700 (1957) to 43,800 tons (1965), and the amount of effort (number of sets) increased from 264 to 397, respectively. The reported shortages may be strictly seasonal and due to the migrational pattern.

(2) If there are two species in the commercial catch then techniques for studying a mixed fishery would have to be developed and applied.

(3) Catch per unit of effort is commonly used as an index of average apparent abundance, and the catch per set is provisionally considered to be the index for this fishery. In most of the sets the whole school is captured, (Simpson, 1963), so that, in effect, school size becomes the index of abundance. However, the most important factors governing school size are not known. As real abundance declines, school size may remain independent of stock density and provide a false measure of apparent abundance. Under the passive conditions of this fishery, the total catch or total effort may be a better index; the latter would be especially useful if the frequency with which schools approached the shore depended on stock abundance. Individual school size shows a wide variation in which about 60% weigh less than 100 metric tons and about 92% weigh less than 200 tons (Simpson, 1963). From 1957 to 1961 the frequency distributions of school size showed little change. It is premature to conclude from these data that school size is independent of stock abundance, but this seems likely at present stock levels.

(4) It is important to determine the relationship, if any, between the duration and intensity of the upwelling season and the success of the corresponding year class. By determining the contribution of each year class to the fishery it may become possible to predict future abundance from present oceanographic conditions.

(5) The present fishery though using a primitive method is in some respects a comparatively efficient one. According to Schneider and de León (1961) the

average annual catch per man approaches 200 metric tons. Using this fishing method the only practicable means to increase the catch substantially would be to fish the resource throughout a greater extent of its distribution along the coast. Nevertheless, the same sort of limitation subsequently presents itself. Although there is some experimental purse-seining to exploit the sardine when offshore, the results have been modest. This may be partially due to inexperience with this method, but it may also be due to the behavior of the sardine schools which are often diffuse and rather deep when offshore. It may be necessary to introduce purse-seining using lights to concentrate the sardines.

(6) Nothing is known of the population structure of the sardine in Venezuela, though it occurs both in eastern and western Venezuela. Seasonal upwelling also occurs along the western coast of the Gulf of Venezuela (Zeigler, 1964). The problem of determining whether more than one population exists should be resolved by using tagging and the more advanced biochemical and serological techniques, as well as morphometric and meristic analyses.

THE TUNA FISHERY

Method

The Venezuelan tuna fishery is little more than a decade old. Until now all the fishing has been done by longline of the Japanese type, though some locally made and designed equipment has been introduced. The Japanese longline basket contains about 270 meters of mainline with, usually, 5 hooks set about 40 m apart.

Most of the Venezuelan vessels engaged in this fishery were converted from fishing for groupers and snappers by bottom line. They are all too small for high-seas longlining, having an overall length of less than 20 m. Such vessels have a maximum gear capacity of about 120 baskets. Many of them still engage in bottom longlining when circumstances warrant.

There are about 50 vessels operating from Venezuelan ports on a full or part-time basis. Among these are three comparatively small vessels (by Japanese standards) that were originally designed as longliners and were brought from Japan. The largest has a fishing capacity of about 400 baskets and the other two of about 260.

Fishing trips last from 2 to 3 weeks for most of the vessels, though the largest vessels may take a month or more. The fish-hold capacities range from about 5 to 150 tons.

The preferred bait is the gilt sardine *(Sardinella anchovia)* that abounds in eastern Venezuela and is comparatively cheap (about U.S. $20 per ton). It is carried to the fishing grounds in ice chips.

Species

The most important species is the yellowfin, *Thunnus albacares,* followed by the albacore, *T. alalunga.* Small amounts of bigeye, *T. obesus,* are taken. Occasionally bluefin, *T. thynnus,* or blackfin, *T. altanticus,* may be caught. The longliners catch marlins *(Makaira),* swordfish *(Xiphias),* sharks and other species incidentially. The average weight of the predominant size-class of yellowfin in the commercial catch is about 56 kilos, and that of the albacore is about 21 kilos.

Using the allometric equation the length-weight relationship of the yellowfin tuna on an arithmetic and logarithmic basis was:

$$W = (0.00000374)\ L^{3.353}$$
$$\log W = \log(0.00000374)) + 3.353 \log L$$
(111 individuals in the length range 80-153 cms)

The data showed no obvious difference between the sexes, which were therefore combined.

Catch and Fishing Effort

The total annual landings of all tuna species caught by Venezuelan vessels since 1960 are given in Table 6.

TABLE 6

THE TOTAL ANNUAL LANDINGS OF TUNA IN THOUSANDS OF METRIC TONS BY VENEZUELAN VESSELS SINCE 1960.

Year	1960	1961	1962	1963	1964	1965	1966
Catch	2.06	2.01	3.54	3.09	1.94	1.83	2.14

About 65% of the catch is landed in eastern Venezuelan ports, the balance in La Guaira, central Venezuela. Most of the catch landed at the eastern ports (Cumaná, Marigüitar) is canned, the offal being converted to meal. That landed at La Guaira is mostly sold as fresh fish in the metropolitan area.

The best data on fishing effort were obtained for the period 1960-1963 from three Japanese vessels operated by a Venezuelan-Japanese company. Most of what is known of the fishery at the level of the operational fishing unit is based on these limited but excellent data (Griffiths and Nemoto, 1967). An attempt was made to institute the use of logbooks by the whole fleet, but the lack of personnel prevented the fulfillment of the early promise of this program.

Almost all the catch is landed in ports in eastern Venezuela or in La Guaira, the port of Caracas. The price for gutted fish on the dock ex-vessel is now about U.S. $470 per metric ton, regardless of species. Roughly 70% of the catch is made up of yellowfin, about 20% of albacore, and the rest by other tunas, marlins and sharks.

Table 7 shows the effort by the three above-mentioned vessels from 1960 to 1963.

TABLE 7

NUMBER OF HOOKS FISHED BY THREE VENEZUELAN-JAPANESE VESSELS IN EACH OF THE YEARS SHOWN

Year	1960	1961	1962	1963
No. of hooks fished	545,450	627,120	677,940	690,225

It should be noted that the largest of these three vessels did not begin fishing till mid-1961. Thus it becomes clear that their total effort is fairly constant from year to year, averaging slightly less than 700 thousand hooks.

Assuming an average of 100 baskets for the remaining vessels of the fleet, with an average number of 40 vessels as of 1963 and an average of 300 baskets for the 3 vessels for which the data are accurate, and given the round number of 700 thousand hooks fished per year by these 3, the approximate total annual effort by the Venezuelan fleet is about 3 million 800 thousand.

The catch per hundred hooks is used as the index of abundance. The data from the Venezuelan-Japanese vessels permit this to be expressed in terms of numbers of fish. The much less adequate data from the main fleet permit only an approximation in terms of weight per hundred hooks. The better data, which locate the fishing effort within 1-degree rectangles, allow two different indices of abundance to be calculated: one being unweighted by the number of 1-degree rectangles fished and calculated simply as the ratio of the total catch to the total effort; the other being weighted by the dispersion of the fishing effort and calculated as the average catch per 100 hooks for all the rectangles fished. Algebraically they are:

Unweighted index of apparent abundance

$$= \frac{\Sigma C}{\Sigma E} \text{ and}$$

Weighted index of apparent abundance

$$= \frac{\Sigma \frac{C}{E}}{n}, \text{ where } \Sigma \text{ means sum over}$$

all 1-degree rectangles, of which there are n. These indices were computed quarterly and annually. They are linearly related and their ratio (unweighted to weighted) is a measure of how well the fleet concentrates its fishing effort on densities of fish higher than the average overall density of the resource; in other words, it measures the fleet's fish-finding ability.

The lack of complete effort data oblige us to use the small amount of the better data to measure the average catch per unit of effort (100 hooks). Nevertheless, it is known that the so-called Japanese vessels were not the most successful vessels, though they were above the average. The small boats probably fish as well as the larger vessels *when they find the fish*. One of their basic limitations is their small radius of action, which limits the accessibility of the fish; this matter will be discussed later.

Table 8 shows the average annual catch of yellowfin and albacore taken per hundred hooks set from 1960 to 1963. Both weighted and unweighted indices are given where data permit. A declining trend in total numbers caught per 100 hooks is shown.

Approximate average weights per 100 hooks for both species combined are available, but are based only on a small sample of the fleet and on crude effort data for 1964 and 1965. However, the sample does include the Venezuelan-Japanese vessels' data. The average annual catch per 100 hooks (unweighted index) by the Venezuelan fleet as a whole for 1964 and 1965 was 86 and 73 kg respectively. The corresponding values for the Venezuelan-Japanese vessels were 99 (1964) and 68 (1965). The fleet averages were only slightly changed by omitting the data from the latter vessels.

Although the data are incomplete it is apparent that there is a real decrease with time in the average catch per unit of effort (Fig. 3).

TABLE 8

THE AVERAGE ANNUAL CATCH PER 100 HOOKS IN TERMS OF NUMBERS OF YELLOWFIN, ALBACORE AND OF BOTH SPECIES, AND IN TERMS OF WEIGHT IN KILOGRAMS OF BOTH SPECIES COMBINED, FROM 1960 TO 1963, BASED ON DATA FROM THREE VENEZUELAN-JAPANESE VESSELS

Year		1960	1961	1962	1963
Number of fish per 100 hooks	Yellowfin				
	unweighted	3.55	4.25	3.92	3.46
	weighted	3.26	2.71	3.34	2.87
	Albacore				
	unweighted	1.42	0.83	0.84	0.41
	weighted	1.36	0.75	0.81	0.48
	Both				
	unweighted	4.97	5.08	4.76	3.87
	weighted	4.62	3.46	4.14	3.37
Weight in kilograms per 100 hooks	Both unweighted	196	158	170	140

Fig. 4 shows the distribution of fishing effort in thousands of hooks set by the three Venezuelan-Japanese vessels from 1960 to 1963, except for some occasional fishing in mid-Atlantic (east of 45°W), to the north of Puerto Rico (20°-24°N), and to the west of 75°W, off Panama. The remainder of the fleet usually must confine its fishing to the boundary of the fishing area illustrated in Fig. 4 nearest to the Venezuelan coast, owing to the limited radius of action of these vessels. The top twenty 1-degree rectangles, ranked in terms of total fishing effort both for the Caribbean and the Atlantic, have been outlined in Fig. 4.

No marked seasonal or annual patterns were demonstrated by the quarterly charts of effort distribution, though there are shifts between the Caribbean and the Atlantic which do not appear to follow any pattern.

Figs. 5 and 6 show the distributions of average numbers of yellowfin and albacore, respectively, caught per 100 hooks during the same four-year period. The data show that albacore catches tend to be higher in the Atlantic than in the Caribbean and those of yellowfin the opposite. However, Griffiths and Nemoto (1967) showed that such a situation may be occasionally reversed. Again the top twenty 1-degree rectangles, ranked by catch rates, are outlined in both fishing areas.

Although these data only suggest it, the yellowfin in the Caribbean appeared to have a two-year cycle of abundance (the average quarterly catch per 100 hooks tended to show peak values every other year), whereas in the Atlantic for which the data were fewer, the cycle was probably annual. The albacore abundance appeared to be annual in both fishing areas. Some data from the Brazilian tuna fishery (Rodrigues Lima and Wise, 1962) support the view of an annual cycle of abundance for western Atlantic yellowfin, but show no definite periodicity for the Atlantic albacore. None of these cycles of abun-

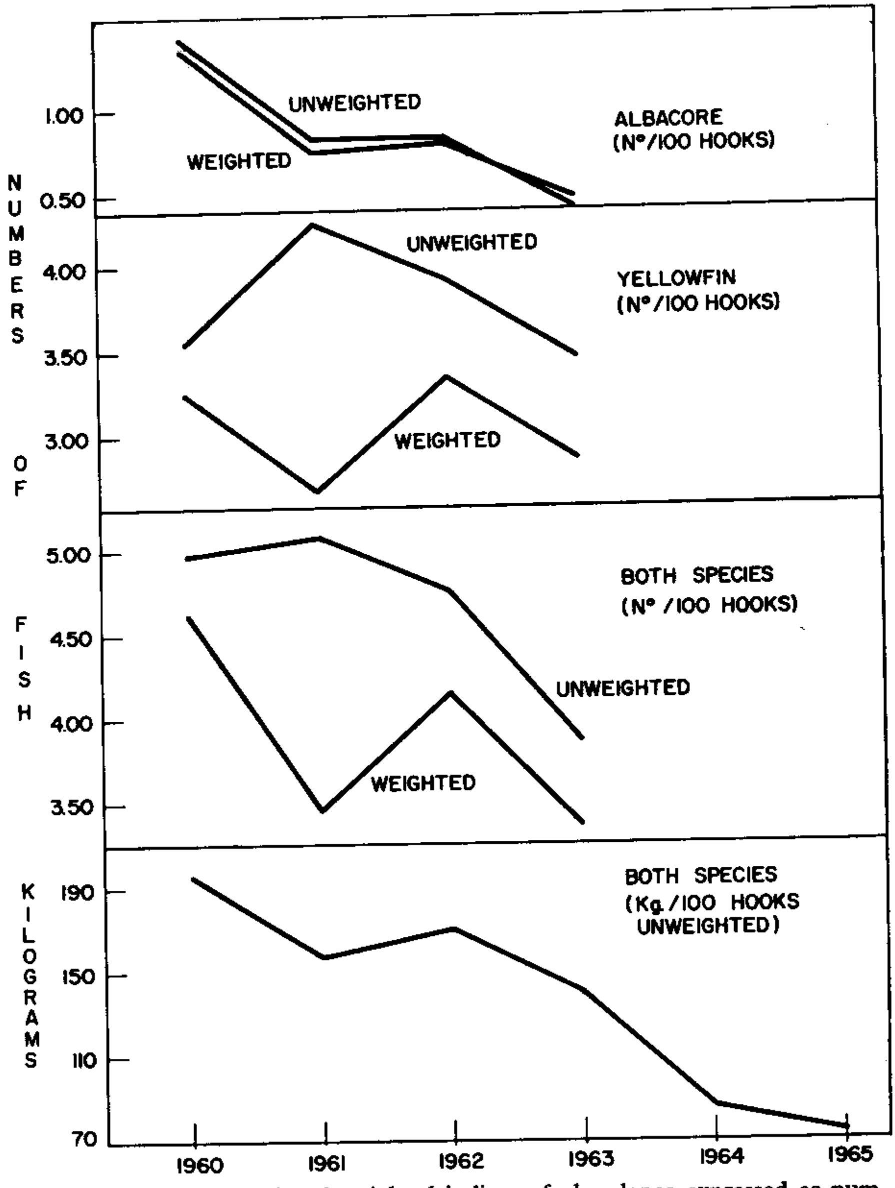

FIG. 3. The unweighted and weighted indices of abundance expressed as numbers of fish per 100 hooks for albacore, yellowfin and both species combined, and the unweighted index expressed as kilograms per 100 hooks for both species combined (see also Table 8).

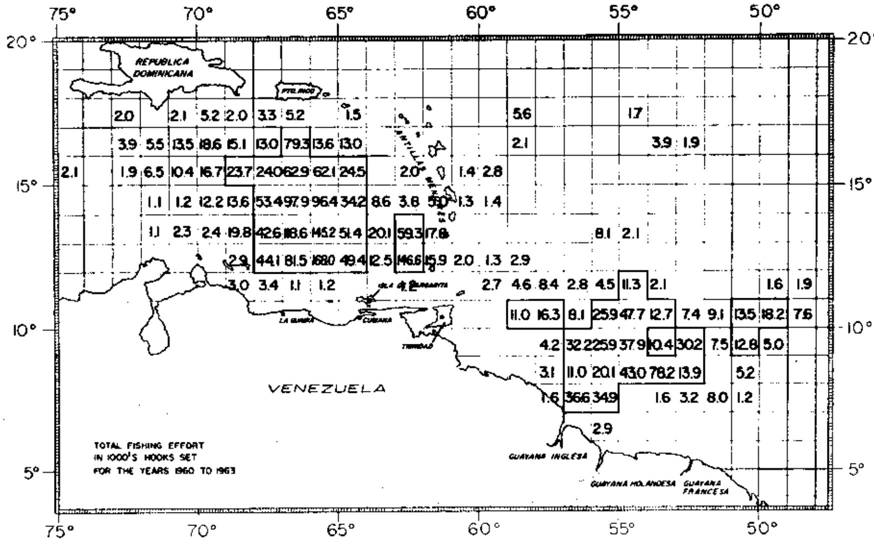

FIG. 4. Distribution of fishing effort in thousands of hooks set by the three Venezuelan-Japanese vessels from 1960 to 1963.

dance closely follows the calendar, but by ranking the quarterly unweighted averages given by Griffiths and Nemoto (1967) and accumulating frequencies for the first two ranks (i.e. two highest) and for the last two, the following generalized conclusions emerge:

In the Caribbean the yellowfin showed no seasonal changes in abundance, notwithstanding the above-mentioned periodicity, whereas the albacore tended to be more abundant in the first and last quarters.

In the Atlantic, the yellowfin were generally more abundant in the second and third quarters, whereas the albacore were generally most abundant in the third and fourth quarters. The data are summarized in Table 9.

These results are not fundamentally altered by using weighted averages, which is to be expected, since the two types of average are linearly related.

Although the data are not adequate to permit definite conclusions, there is an indication that the peak of albacore abundance in the Atlantic precedes the peak of its abundance in the Caribbean. This may mean that the albacore migrate seasonally from the Atlantic to the Caribbean. There is no similar indication for the yellowfin. Griffiths and Nemoto (1967) showed, by means of the index of concentration of fishing effort mentioned earlier, that the longliners have no significant overall ability to concentrate on greater than average fish densities. Presumably this is mainly due to the fact that the tunas accessible to this gear are not generally seen at the surface and that the vessels do not have equipment to detect them at subsurface depths. Similar findings were made by Suda and Schaefer (1965) for the Japanese longline fishery in the Pacific Ocean.

At present too little is known to allow more than quite tentative conclusions, but enough is known to prompt many questions concerning this resource. Some of these are now outlined.

TABLE 9

GROUPED FREQUENCIES OF RANKS OF AVERAGE QUARTERLY CATCHES PER 100 HOOKS FOR YELLOWFIN AND ALBACORE TAKEN BY VENEZUELAN-JAPANESE LONGLINERS OPERATING FROM VENEZUELAN PORTS FROM 1960 TO 1963 (DATA FROM GRIFFITHS AND NEMOTO, 1967). THE UNWEIGHTED INDICES WERE USED AND THE HIGHEST VALUES WERE GIVEN HIGHEST RANK

	YELLOWFIN				ALBACORE			
CARIBBEAN								
Ranks	Quarter 1st	2nd	3rd	4th	Quarter 1st	2nd	3rd	4th
1 and 2	2	2	2	2	4	1	0	3
3 and 4	2	2	2	2	0	3	4	1
ATLANTIC								
1 and 2	1	3	3	1	1	1	3	3
3 and 4	3	1	1	3	3	3	1	1

Important Considerations of the Tuna Fishery.

(1) Certain differences in fishing success were observed between the Caribbean and the Atlantic fishing areas (separated by the Lesser Antilles). These were found for both species but in different respects: the periodicity in the abundance of yellowfin differed between the two regions and the seasonal abundance of albacore also differed between the two regions. Can it be inferred from this that there are separate stocks of both species in the two regions?

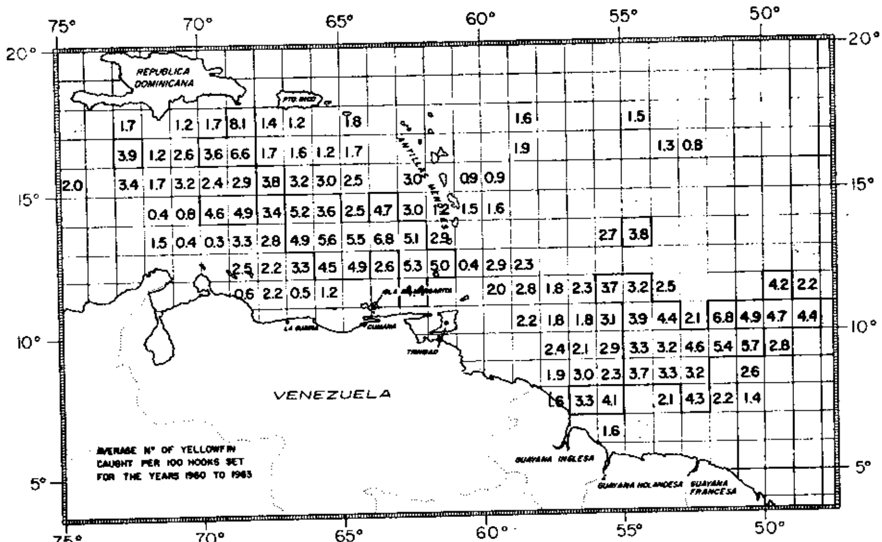

FIG. 5. Distribution of average numbers of yellowfin caught per one hundred hooks by the three Venezuelan-Japanese vessels from 1960 to 1963.

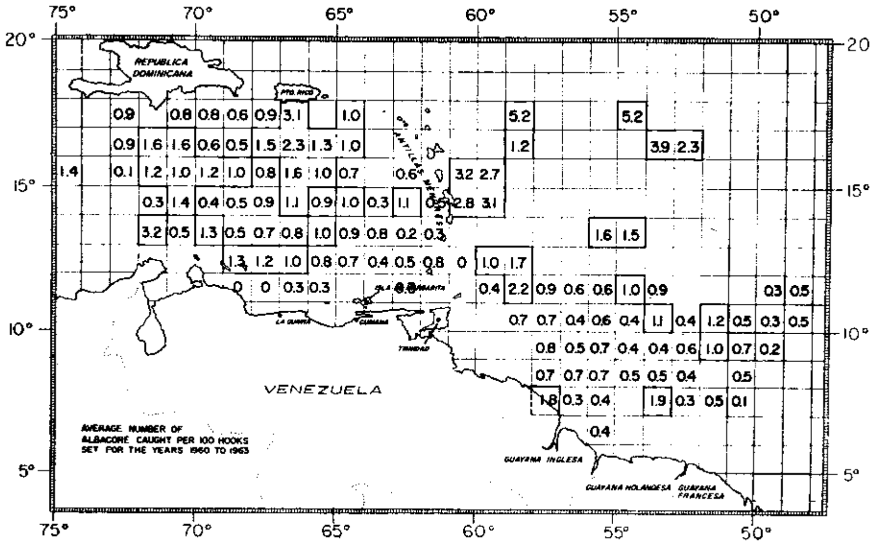

FIG. 6. Distribution of average numbers of albacore caught per one hundred hooks by the three Venezuelan-Japanese vessels from 1960 to 1963.

(2) If both species have common stocks in the two regions it is necessary to determine their migrational patterns as a basis for the best fishing strategy. There seems to be little likelihood at present that these patterns could be obtained from fisheries statistical data, since it was found that the Venezuelan-Japanese vessels had no significant ability to concentrate their effort on densities of fish greater than the average density in the fishery area.

(3) If the two species do not have common stocks, considering the comparatively heavy exploitation of the Atlantic stocks (Shiohama, Myojin and Sakamoto, 1965), it would clearly be preferable to concentrate on developing the exploitation of the Caribbean stocks.

(4) In either of the possibilities presented in points 2 and 3 the definition of spawning areas and seasons for both species is of considerable importance.

(5) Most of the Venezuelan vessels, as distinct from the Venezuelan-Japanese vessels, have a limited radius of action, so that their success is mainly determined by the accessibility of the fish. There is periodical upwelling along the northeastern coast of Venezuela (Gade, 1961a; Ljoen and Herrera, 1965). Coastal sea-surface temperatures may become as low as 20°C. It is not known at present whether this upwelling decreases the availability of tuna near the Venezuelan coast, and this possibility requires investigation. Nevertheless, there are other good reasons for improving the characteristics of the Venezuelan tuna vessels.

(6) Tuna boat captains while registering low catches on their longline sometimes observe numerous schools of young tuna, including skipjack, at the sea-surface. These tunas are, of course, not taken by the longliners. This suggests that other methods such as pole and line or purse-seining should be tried on an experimental basis.

(7) The declining catch rates over the past several years may have one or more possible causes. If the tuna stocks of the eastern Atlantic are common

to the western Atlantic and the Caribbean Sea, the catch rates may have been depressed by the comparatively heavy fishing, largely by Japanese vessels, in the Atlantic Ocean. Or the declining abundance may be due to a normal cyclical change in the tuna populations, which would have occurred irrespective of the fishing effort. These and other possible causes require study.

(8) Venezuelan vessels are not equipped with echo-sounders and sonar for fish detection, nor do they use bathythermographs to find the thermocline depth to determine (on the basis of experience) the optimum hook depth, which would probably increase the catch rate appreciably. It is often noticed that hooks in certain locations in each longline (basket) tend to catch either more fish than the rest, or more of one species than another (Kataoka, 1957), yet so far as is known most of the Venezuelan longliners do not attempt to make hook depths approximately uniform.

(9) Despite an inadequate fleet and declining catch rates the Venezuelan tuna fishery has made moderate progress. This is largely due to a high price for the tuna. In 1960 the price per metric ton for gutted fish ex-vessel was U.S. $276 for all tuna species. This price remained steady till 1963 when it rose abruptly to U.S. $330. It has risen steadily ever since and in 1966 was U.S. $471. The demand outstrips supply, partly because importation is not normally allowed, and will probably continue to do so; thus high prices seem to be assured. While the trend to higher prices continues to protect existing operations it will delay improvements in fleet efficiency. The matter requires further consideration.

LITERATURE CITED

FAO
1964. 1963 Yearbook of Fishery Statistics. Rome, Italy.

FAO
1965. 1964 Yearbook of Fishery Statistics. Rome, Italy.

FAO
1966. 1965 Yearbook of Fishery Statistics. Rome, Italy.

GADE, H. G.
1961a. On some oceanographic observations in the southeastern Caribbean Sea and the adjacent Atlantic Ocean with special reference to the influence of the Orinoco River. Bol. Inst. Oceanogr., Univ. de Oriente, Venezuela, *1* (2): 287-342.

GADE, H. G.
1961b. Further hydrographic observations in the Gulf of Cariaco, Venezuela. The circulation and water exchange. Bol. Inst. Oceanogr., Univ. de Oriente, Venezuela, *1* (2): 359-395.

GRIFFITHS, R. C. AND T. NEMOTO
1967. A preliminary study of the fishery for yellowfin and albacore tuna in the Caribbean Sea and western Atlantic Ocean by longliners from Venezuela. Ministerio de Agricultura y Cría de Venezuela, Investigaciones Pesqueras, Serie Recursos y Explotación Pesqueros, *1* (6): 209-274.

GRIFFITHS, R. C. AND J. G. SIMPSON
1967. The temperature structure of the Gulf of Cariaco from August 1959 till August 1961. Ministerio de Agricultura y Cría de Venezuela, Investigaciones Pesqueras, Serie Recursos y Explotación Pesqueros, *1* (4): 117-169.

GRIFFITHS, R. C. AND J. G. SIMPSON
(MS.) The length-weight relationship of the sardine, *Sardinella anchovia,* in Venezuela.

HEALD, E. J. AND R. C. GRIFFITHS
1967. La determinación, por medio de la lectura le escamas, de la edad de la sardina, *Sardinella anchovia,* del Golfo de Cariaco, Venezuela Oriental. Ministerio de Agricultura y Cría de Venezuela, Investigaciones Pesqueras, Serie Recursos y Explotación Pesqueros, *1* (10): 373-446.

HILDEBRAND, S. F.
1963. In: Fishes of the western North Atlantic. Part III by H. B. Bigelow *et al.* Sears Foundation for Marine Research, New Haven, U.S.A., 1963, 630 p.

KATAOKA, A.
1957. In: Fisheries Resources, edited by I. Kubo. Fisheries University of Tokyo, 307 p.

LJOEN, R. AND L. R. HERRERA
1965. Some oceanographic conditions of the coastal waters of eastern Venezuela. Bol. Inst. Oceanogr., Univ. de Oriente, Venezuela, *4* (1): 7-50.

MINISTERIO DE AGRICULTURA Y CRIA DE VENEZUELA
1966. Anuario Estadístico Agropecuario 1965. Caracas, Venezuela, 631 p.

RODRIGUES LIMA, F. AND J. P. WISE
1962. A first examination of the abundance and distribution of yellowfin and albacore tuna in the western tropical Atlantic, 1957 to 1961. In: Proceedings of the World Scientific Meeting on the Biology of Tunas and Related Species, Food and Agriculture Organization of the United Nations, Experience Paper 29:8 p.

SCHNEIDER, J. B. AND A. DE LEON
1961. El mercadeo del pescado de mar con referencia especial al abastecimiento en Caracas. Ministerio de Agricultura y Cría de Venezuela, División de Economía Agrícola, 126 p.

SHIOHAMA, T., M. MYOJIN AND H. SAKAMOTO
1965. The catch statistic data for the Japanese tuna long-line fishery in the Atlantic Ocean and some simple considerations on it. Nankai Reg. Fish. Res. Lab., Rep. 21: 131 p.

SIMPSON, J. G.
1963. Report to the Venezuelan government on the development of the Marine Fisheries Research Program. Food and Agriculture Organization, Rome, Italy, E.P.T.A. Report 1606, 61 p.

SIMPSON, J. G. AND G. GONZALEZ
1967. Some aspects of the early life history and environment of the sardine, *Sardinella anchovia,* in eastern Venezuela. Ministerio de Agricultura y Cría de Venezuela, Investigaciones Pesqueras, Serie Recursos y Explotación Pesqueros. *1* (2): 37-93.

SUDA, A. AND M. B. SCHAEFER
1965. General review of the Japanese tuna long-line fishery in the eastern tropical Pacific Ocean 1956-1962. Bull. Inter-Amer. Trop. Tuna Comm. *9* (6): 307-462.

ZEIGLER, J. M.
1964. The hydrography and sediments of the Gulf of Venezuela. Limnol. and Oceanogr., *9* (3): 397-411.