General Aspects of the Biology and Ecology of the Anchovy *(Engraulis ringens)*

JORGE E. SANCHEZ R.
Director Técnico del Instituto del Mar del Perú
Lima, Perú

Abstract

The present work deals with the outstanding characteristics of the biology, ecology, and the fishery of the Peruvian anchovy, *Engraulis ringens*. This is one of the greatest fishery resources in the world, yielding an annual catch of about 9 million tons.

Life history studies have been made to determine spawning areas, growth rates, and ages of the fish. Reference is made to the characteristics of the environment and its connections with the behavior of adult fishes, their feeding, and principal predators and competitors.

The population characteristics, annual and seasonal changes of catch per unit of effort, abundance indices, and length frequencies have been studied in detail.

THIS REVIEW is based upon several years of joint research on the Peruvian anchovy conducted at the Instituto del Mar del Perú. Results of comprehensive life history, population dynamics, ecological, and behavioral studies are reported through June 1965.

The species has been identified as *Engraulis ringens* Jenyns, 1842, as redescribed by Hildebrand in 1946. In Peru it is called anchovy in the adult stage and peladilla in the juvenile stage. In Chile the common names are chicora, sardina bocona, sardina, anchoa, and anchoveta.

Variability

There are no subspecies of *Engraulis ringens*, but we have not determined whether there are subpopulations. Results proved that environmental factors cause some variability among the taxonomic characters of the anchovy, notably the vertebrae, otoliths, gill rakers, and morphometric features. Apparently the number of gill rakers increases exponentially with age. Specimens of 5 cm average 71 gill rakers, while those of 14 cm average 88.

Distribution

The anchovy is abundant off the coasts of Peru and Chile. According to Schweigger (1964), its geographical limits to the north are around Punta Aguja (5°50′S) and to the south at Lota (37°04′S).

The anchovy lives in the border of the relatively cold waters of the Peruvian coastal current, whose surface waters are characterized by being rich in nutrients and biologically highly productive. The largest concentrations of anchovies are found within 50 miles of the coast, but occasionally as far out as 100 miles. In spring and summer the greatest concentrations are near the coast but in winter the schools disperse and are generally in more distant waters. There is much variation in these distributional patterns.

Reproduction

The anchovy is heterosexual, without secondary external characteristics; cases of hermaphroditism are not known.

Some anchovies are mature at a total length of 12 cm. At this size they are approximately one year old. A rapid increase in the percentage of mature anchovies occurs at about 13 cm, and of the 13-14 cm size group 50% are mature.

The spawning season is long, between 6 and 8 months; it begins in August and ends in February or March. The limits of the spawning season are not strict, its beginning, its maximum, and its end vary according to weather and regional conditions from one year to another. In the northern and central zones of the Peruvian coasts, there are spawning peaks, one at the end of the winter and the other in summer. In the southern zone one peak occurs during the winter. Besides the seasonal peaks, sporadic spawning takes place all year round. The sequence of the sexual maturity for the Chimbote zone is shown in Fig. 1.

Studies on egg diameters suggest that the anchovy can spawn more than

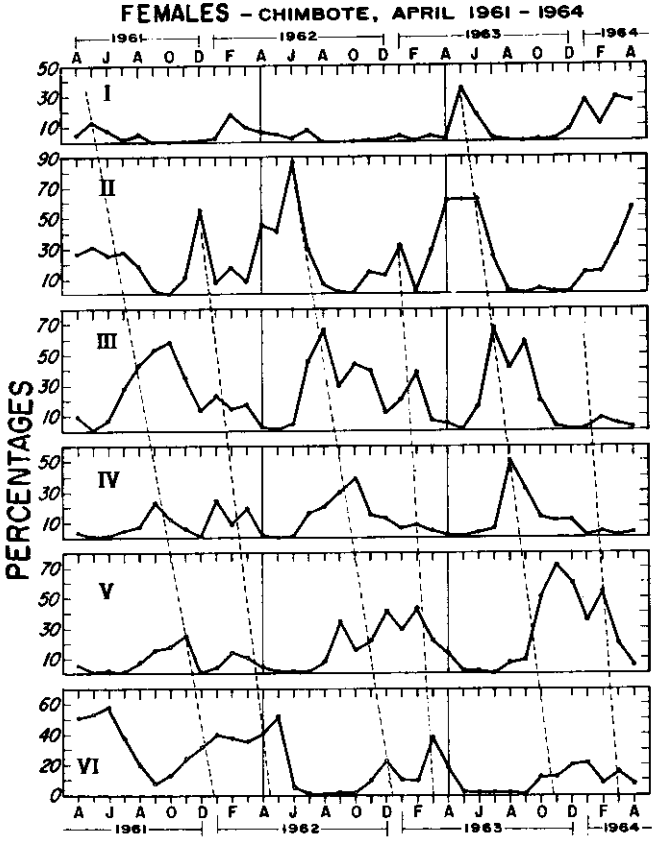

FIG. 1. Monthly percentages of mature females in the Chimbote area, April 1961-April 1964. (from Einarsson et al., in press).

once within the same season. If this is the case, the long spawning season could be the result of two combined circumstances: series of spawning individuals within the spawning season, and the fractional spawnings by them. Minãno (1958) has found that anchovies of 12 cm would yield approximately 9,000 eggs and those of 17 cm about 24,000.

It has been established that the anchovy spawns along the Peruvian coast from 6° southwards. The largest concentrations of eggs and larvae have been found near the coast, although spawning areas beyond 100 miles have been located (Fig. 2).

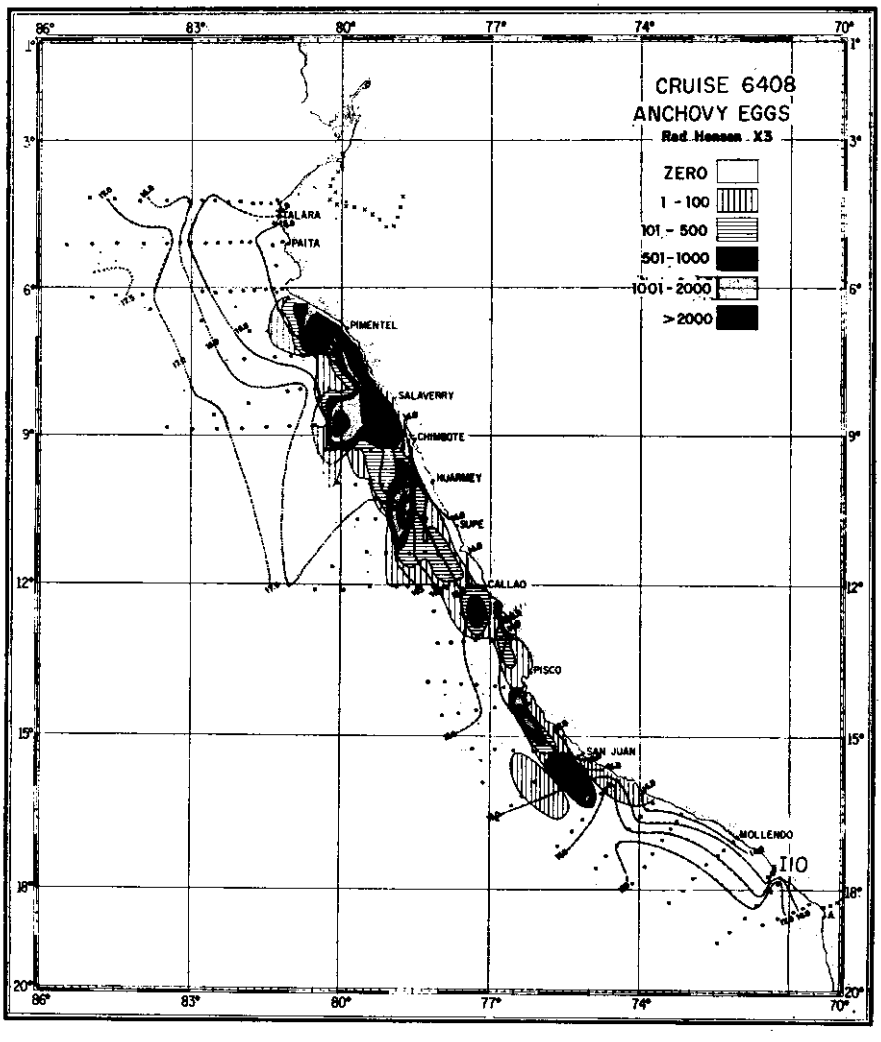

FIG. 2. Spawning areas off the Peruvian coast (from August 1964).

Anchovy eggs are pelagic and have an elongate shape, almost transparent and colorless; they do not have oil globules. Their sizes vary, for the biggest axis from 1.19 to 1.60 mm and for the smaller between 0.57 to 0.80 mm.

Vital Cycle, Age, and Growth

The anchovy matures rapidly. At less than one year of age it can spawn, and it does not seem to exceed 3 years of age. These characteristics are common to anchovies from other seas of the world.

When the larvae reach about 4.5 mm, they lose the vitelline bag and the mouth becomes functional.

Jordán (1959) analyzing length frequencies, ovary development, presence of eggs in the plankton samples, and the young fishes found in the stomachs of birds, suggested that anchovies of 5 to 7 cm are 4 or 5 months old; from 11 to 12 cm, 1 year; from 13 to 14 cm, 2 years; and from 15 to 17 cm, more than 3 years.

The results obtained by reading of otoliths show that anchovies enter the commercial fishery at about 6 months of age, with a size of approximately 8-9 cm, and attain approximately 12 to 13 cm when they are 1 year old. This will give a growth rate slightly higher than that obtained from the distribution of lengths.

The monthly increase in size in the group 9 to 13 cm is over 0.5 cm between October and May and less than half of this during June to September. This seasonal growth cycle, with a decrease during the winter, could be explained by a phytoplanktonic production considerably smaller in the winter season than during the rest of the year.

The largest specimens found off the Peruvian coast have attained 18 cm.

No important difference has been observed in the length of the males and females.

Food

The Peruvian anchovies are principally phytoplankton feeders. According to Rojas de Mendiola (1958), 98% of the diet is diatoms and only 2% dinoflagellates and other organisms. The zooplankton represented by copepods, euphausids, fish eggs, etc. constituted less than 1%.

In confinement, they adapt themselves very well to other types of living food, and it has been confirmed that each anchovy eats between 2 and 3 gr *Arthemia salina* per day. However, the weights of the contents in the stomach of the anchovies examined by Rojas de Mendiola (1958) fluctuated between 0.01 and 1.62 gr per unit with temporary changes in quality and quantity. The month of greatest ingestion is October.

Changes in Sizes and Abundance

The analysis of the data regarding sizes of anchovies captured during the initial phase of the exploitation of the stock in 1954 to 1955 did not show any tendencies to consistent changes, while the length-abundance curve for the years 1961 to 1964 shows changes in the composition of the stock as a consequence of variations in recruitment and mortality. These curves show for the ports of Chimbote, Callao, and Ilo a decline in the abundance of adult fishes from 13 to 16 cm in size (Fig. 3).

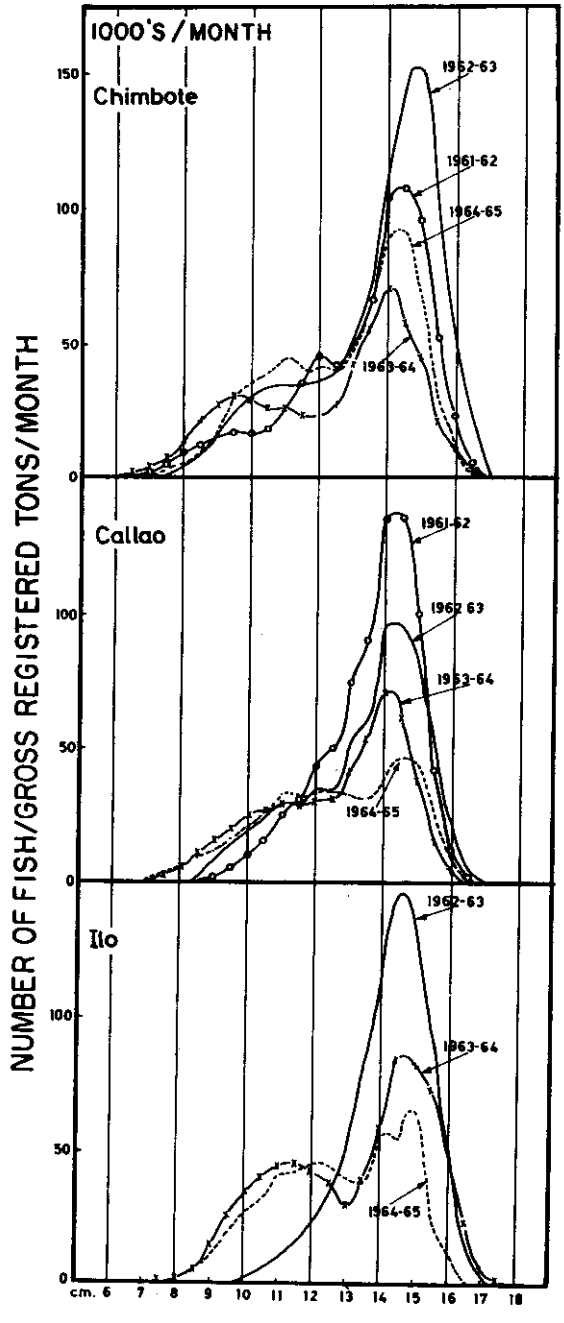

FIG. 3. Length frequency-abundance curves for various ports (from Boerema and Saetersdal, in press).

The abundance of the recruits used to be greatest between January and July with a maximum generally in May and sometimes in April. However, there are some variations in years and ports.

It has been established that recruitment decreased from 1961 to 1962 with a subsequent diminishing in 1963. In 1964 recruitment was high, followed by an increase in the abundance of adults during the season 1964-1965.

Dynamics

Greatest fluctuations in adult anchovy stocks are caused by variations in larval survival. Boerema and Saetersdal (1965) indicated that in the last 4 years the fishing mortality has been increasing as follows: 1961, 0.39; 1962, 0.54; and 1963/64, 0.70.

The decrease in the average size of fish in the commercial catch and information from the number of rings on the otoliths also suggest that the increase in the total mortaliy in recent years has reached a rather high level.

The theoretical relationship between effort and the total production, as well as the production by unit of effort under conditions that could be applied to the anchovy stock has been presented by Boerema and Saetersdal (1965). According to them the present effort is producing the maximum catch.

The same idea has been stated by Schaefer (1965) and Murphy (1965). In their analyses of the Peruvian anchovy fishery, they have suggested that the average annual maximum production should be under 7½ million tons.

Habitat

The Peruvian coastal current with its environment properties and the complex biological community that it contains, constitute an eco-system of which the anchovy is an important part. This biological community begins with an exuberant and varied planktonic vegetation that maintains small animals of the zooplankton and principally the anchovy. In turn the anchovy constitutes the fundamental food of greater animals, like cephalopods, fishes. birds, and mammals, as well as raw material for the great industry that has been established by men.

The general characteristics of the Peruvian coastal current according to Schweigger (1964) can be summarized in this way: average sea temperature 20C for the summer and 16C for the winter. The salinity varies from south to north from 34.8 parts per thousand (‰) to 35.10‰. The prevailing winds vary from south to southwest with the strength of 2-3 to 5-6 on the Beaufort scale. According to Wyrtki (1965) the currents will be of 0.2 to 0.3 knots along the coast, reaching 0.5 to 0.7 knots when its waters are part of the south Equatorial current.

The greatest concentrations of phosphates in the surface waters are near the coast (within 50 miles) with values greater than 1.5 μg atoms per liter, while the greatest concentrations of oxygen are found far from the coast with values higher than 5 ml/L according to Guillén (1964). The layer with greatest oxygen content, between 1.0 to a maximum of 7.0 ml/L is confined to the upper level of 20 to 40 m with a sudden decrease in greater depths.

Occasionally, warm fronts of tropical characteristics occur, changing the normal conditions of the region. A warm front with rains invades the coast and mists disappear. This is the phenomenon referred to as "El Niño" which is the most notable natural change in this part of the ocean. It has destructive effects on the sea fauna, and causes the death of millions of "guano" birds due to a lack of food. Fish and other dead organisms are washed ashore, and the

industry suffers from shortages of fish.

The Anchovy in the Eco-system

Although the anchovy normally lives in the waters of the Peruvian coastal current, between 14C and 21C, during the warming periods in the years 1957, 1963, and 1965, schools were found at the surface where temperatures were from 24C to 26C. In the Institute, it has been possible to keep anchovies in aquariums for experimental purposes for 8 months. There they tolerated temperatures up to 27C and salinities up to 42.89‰. The European anchovy *E. encrasicholus* lives under more extreme conditions, resisting temperatures of 6C to 29C and salinities of 35 to 41.55‰.

The anchovy has been recorded in depths of 10 to 20 m, although from echo traces, they may be found in 80 m. A limiting factor for a greater depth could be a shortage of dissolved oxygen which characterizes the water layers at 40 m. The most important natural predators are the "guano birds" (guanays, piqueros, and pelicanus) that each year catch 2 to 3 million tons and the "bonito" which eat at least 1 million tons.

Fishery

The Peruvian anchovy catch of around 9 million tons, in 1964 represented almost 18% of the total world production. Processing this catch are 169 reduction plants along the coast. The largest concentration is from Chimbote to Callao, with a production of 1.5 million tons of fishmeal. This industry supplies work to more than 200,000 persons.

The Peruvian fishing fleet at the end of 1964 totaled more than 1,800 vessels and is growing in number, total loading capacity, and storeroom capacity, as can be seen in the following table:

Year	No. of Vessels	Total loading capacity	Storeroom capacity per vessel
1959	433	25,638 M.T.	59.2 M.T.
1960	700	51,620 "	72.8 "
1961	878	68,730 "	78.3 "
1962	1,096	99,000 "	90.3 "
1963	1,756	176,000 "	100.0 "
1964	1,846	192,000 "	104.0 "

The principal fishing zone in Peru is between Callao and Chimbote, actually known as the first fishing ports of the world. Generally, fishing is limited to trips lasting one day. The vessels leave the port between 02:00 and 03:00 A.M. and return in the afternoon.

The coastal distribution of the anchovy, especially in the summer, permits fishing between 20 to 50 miles off the coast and in depths from the surface to 20 m. During the winter the schools generally spread out and are found deeper.

Fishing Season and Density Changes

The best fishing season is in spring and summer, these are the months of October to February, with the height of the season being 3 months of this period. A secondary season is in the autumn, between March and June, and the season of very low fishing is from July to September.

The mechanism of these regular changes in the apparent abundance, at least in the region between Callao and Chimbote, could be explained as a result of variations in the environment and/or by changes in the total abundance of the stock. However, it is also true that the indices of abundance have decreased since 1963 in these ports due to the fishing effort (Fig. 4).

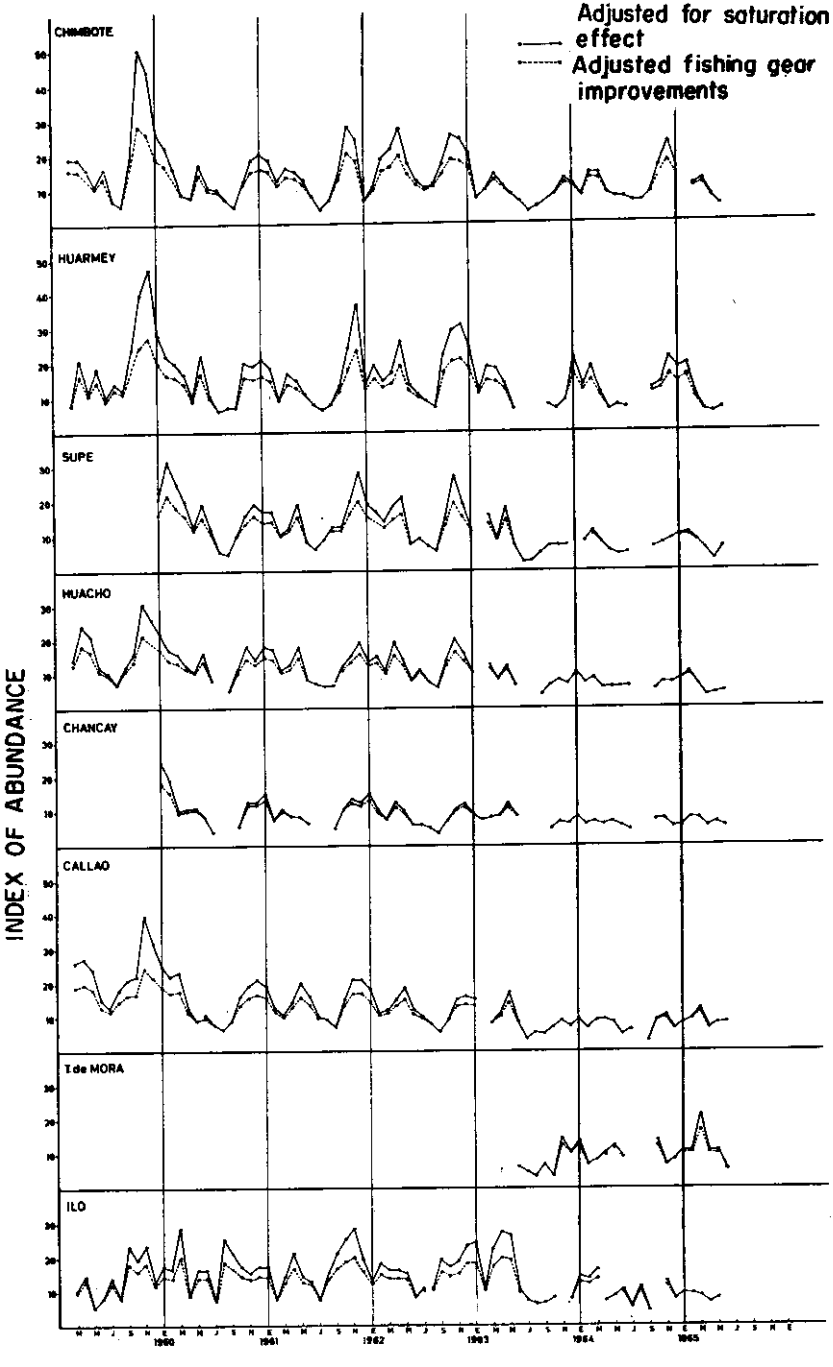

FIG. 4. Variations in the indices of anchovy abundance adjusted for the saturation effect indicate a clear decline in abundance since 1963, in the principal fishing ports. This decline is most evident in the central area.

Catch and Effort

The initial development of the anchovy fishery goes back to 1950. In 1953, 49 small vessels were operating. During the following years, the effort was so great that in 1964 1,846 bolicheras were operating.

The number of vessels increased about fivefold bebtween 1959-1964 when exploitation began on an industrial scale. Paralleling the increase in the number of vessels, was a marked increase in their sizes and net tonnages. The net tonnage for all the fleet increased almost tenfold from 1959 to 1964.

The sizes of the nets also increased with the increase in size of vessels and to a certain extent, even for boats of the same sizes. The average increase in nets was from 20 to 30 fathoms from 1959 to 1962. It has been proven that this corresponds to an increase of 4 to 5 tons of average catch per trip, which represents something like 10% of the average catch on regular vessels.

The introduction of new and better auxiliary fishing equipment aided in producing greater catches, especially during the years since 1962. These were

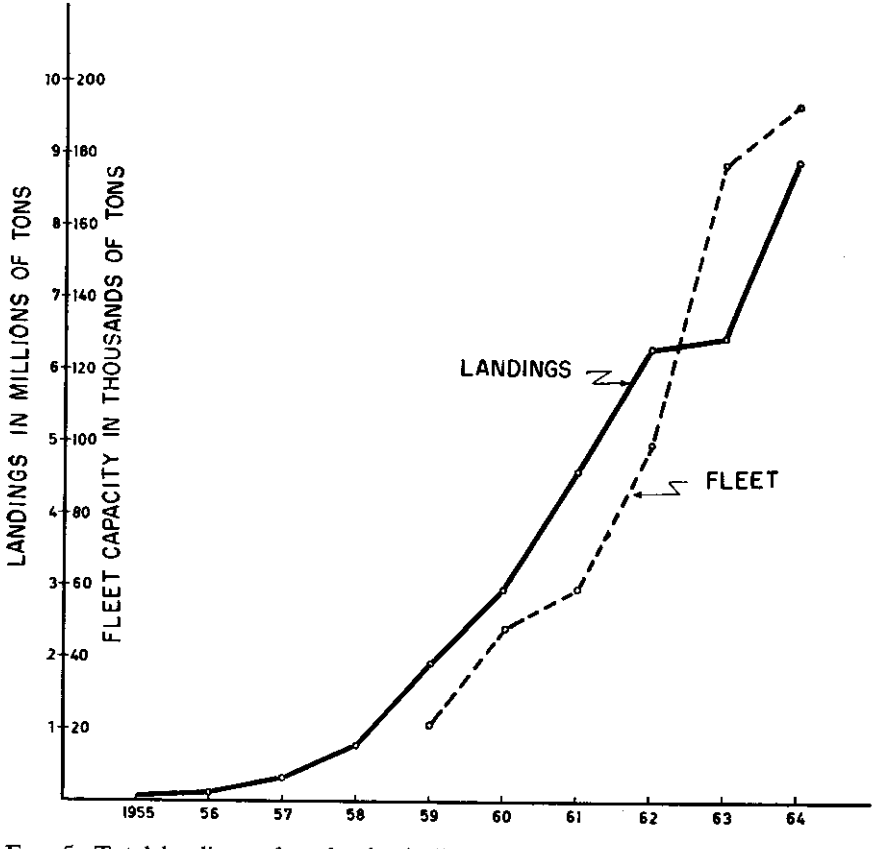

FIG. 5. Total landings of anchovies in Peru, during 1955-1964 compared with the estimated total capacity of the fishing fleet from 1959-1964.

the installation of acoustic equipment for the detection of schools, a considerable number of poles for the gathering of the nets, and the installation of fish pumps to load the fish into the hold of the vessels.

These improvements in the fishing craft have improved the efficiency of the total fleet by 18% when comparing 1959 with 1965.

An effect that reduces, under certain circumstances, the volume of fishing is the saturation phenomenon. This occurs when the vessels are full and the capacity of the unloading systems and of the plants are exceeded.

The rapid increase of the Peruvian anchovy fishery is shown by the fact that in 1954 only 40,000 tons were caught, but 10 years later in 1964, the catch surpassed 8,800,000 tons, an increase greater than 200 times.

The curve of the fishing volumes in Fig. 5 is self-explanatory and additional comments regarding the growth of the anchovy fishing industry are not necessary.

REFERENCES

BOEREMA, L. K. AND G. SAETERSDAL
1965. Informe sobre los efectos d ela pesca en el recurso peruano de la anchoveta.

GUILLEN, O.
1964. (a) Distribución del contenido de fosfatos en la región de la Corriente del Perú. Inf. Inst. Inv. Recur. Mar., Callao, 28: 1-12.

HILDEBRAND, S.
1946. A descriptive catalog of the shore fishes of Peru. Smithson. Inst. U.S. Nat. Mus. Bull. 189, 530 p.

JORDAN, R.
1959. Observaciones sobre la biología de la anchoveta *(Engraulis ringens* J.) de la zona pesquera de Huacho. Bol. Cía. Adm. Guano, *35* (11): 1-22 p.

MIÑANO, J.
1958. Algunas observaciones relacionadas con la anchoveta peruana *(Engraulis ringens)* y su fecundidad. Bol. Cía. Adm. Guano *34* (2 y 3): 9-16, 11-24 p.

MURPHY, G.
1965. Preliminary analysis of the population dynamics of the Peruvian anchovy. Informe presentado al IMARPE; 21 p.

ROJAS DE MENDIOLA, B.
1958. Breve estudio sobre la variación cualitativa anual del plancton superficial de la Bahía de Chimbote. Bol. Cía. Adm. Guano *24* (12): 7-17 p.

SCHAEFER, M. B.
1965. Análisis adicional de las relaciones entre el esfuerzo de la captura por unidad de esfuerzo y la captura total de la anchoveta peruana, *E. ringens,* basado en datos para los años 1961-1965. Informe presentado al IMARPE; 7 p. 5 gráf.

SCHWEIGGER, E.
1964. El litoral peruano. Segunda edición auspiciada por la Univ. Nac. "Federico Villarreal." Lima, 414 p.

WYRTKI, K.
1965. Surface currents of the eastern tropical Pacific Ocean. Inter-Amer. Trop. Tuna Comm. Bull., *9* (5): 271-294 (Inglés) 295-304 (Español).