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Lecture Notes

Part 1

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PERUVIAN ANCHOVY FISHERY: FACTORS AFFECTING THE RESOURCE

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Introduction

The Peruvian anchovy fishery is constituted by the species *Engraulis ringens* (Engraulididae: Clupeiformes) and is locally known as 'anchoveta peruvana'. The species distribution extends from northern Peru to central Chile (5^0S – 25^0S. Lat.) along the west coast of South American. A marine coastal species distributed within 30 km off the coast. These fishes are seen in huge shoals mainly in surface waters and during day time may descend down to 50 m.

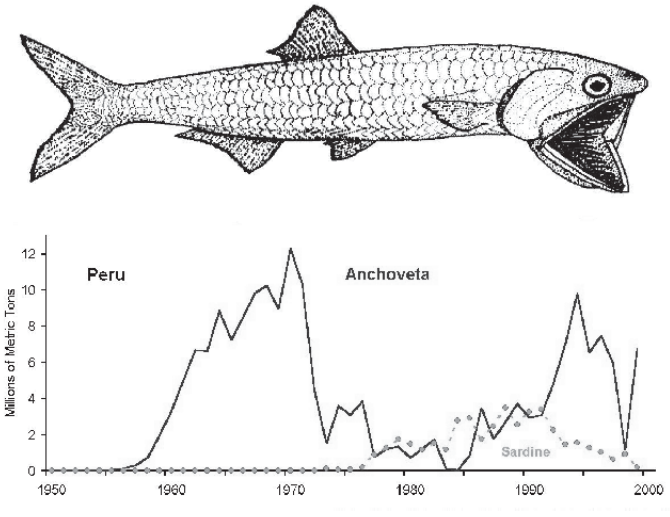
Bionomics

The anchovy is a very efficient filter feeder. The early larvae (apterolarvae) consume phytoplankton, late larvae (pterolarvae) and juveniles mainly feed on small zooplankton. The adults are entirely phytophagous, more than 90% of the diet

consisting of diatoms. The species breeds throughout the year along the Peru coast with two peaks. The first peak is shown during the southern summer in January -February and the major one during late winter in August– September. The absolute fecundity ranges from 10,000 to 20,000 for the fish length range of 10 to 15 cm. The longevity is three years and the growth potential is around 20 cm. The growth is 8.0 cm Standard Length in six months, 10.5 cm SL in 12 months and 12.0 cm SL in 18 months. The interesting aspect is that the fish is recruited to the fishery at around 8.0 cm SL from the sixth month onwards. Three fishery stocks are identified, one off Peru and two off Chile. The Peru stock is the most productive.

Hydrography

The southeast Pacific FAO fishing region constitutes the west coast of South America along the coasts of Ecuador, Columbia, Peru and Chile. Off the coasts of Peru and northern Chile lies one of the richest marine environments on earth – the Peruvian upwelling region – a typical west coast upwelling zone. This is the region of the cold Peru or Humboldt Current. The Peru Current carries cool, nutrient rich



waters to the north. The upwelling caused by the offshore drift of the surface waters (due to the trade winds and the Coriolis force) brings the cool (10 – 22^{0}C) nutrient rich waters of the Peru Current to the surface. These waters are rich in phosphates and nitrates. This is the cause of an enormous growth of phytoplankton (up to more than 500 mg C/m^2/day) and subsequent zooplankton growth. This area supports huge populations of small cool-water pelagics like the Peruvian anchovy and the South American pilchard (*Sardinops sagax*). From December to February, the warm tropical water shifts southwards along the coasts of Ecuador and Columbia and extends in a small strip, along the coast of Peru (El Viejo). In certain abnormal years the water that is upwelled is much warmer and hence low in nutrients due to heavy warm-water incursion. As a result there is a sharp reduction in the primary production and plankton biomass. This phenomenon of unusually strong warm-water incursion is known as El Nino (the boy child – Christ child as the phenomenon occurs during Christmas time). More recently it has come to be referred to as the El Nino Southern Oscillation (ENSO) event. Hence the inter-annual productivity varies greatly and with this the catches of the small pelagic resources namely the Peruvian anchovy. Also these fishes migrate southwards and to the deeper waters during ENSO times.

Fishery

The sediment core studies have shown that the Peruvian anchovy dominated the Central Peru coasts for more than 2000 years. From 1840s the major industry along the Peru coast has been the mining of bird droppings – 'Guano' from the rocky islands, for use as fertiliser. Large populations of the fish eating guano birds like cormorants (*Phalacrocorax bougaivilli*), boobies (*Sula variegata*) and pelicans (*Pelicanus thagus*) are characteristic of the upwelling zones. Nearly 20 - 30 million birds have been estimated to roost along the 'Bird Islands' of Peru and Chile coasts before the start of the fishing industry.

After the Second World War a small Peruvian anchovy fishery started, mainly for export as canned fish. The high oil content and hence less palatability coupled with the huge demand for an alternate cheap protein source (fish-meal) for the giant poultry and pig industry of the developed world kick-started a highly successful anchovy fishery. In 1949, seven fish meal plants started in Peru. The fish landings increased to an average of 1.0 million tonnes (m t) per year during 1955 – 1959. Anchovy trawlers and purse-seiners locally known as 'Bolicheras' are the crafts used for the fishery. From around 100 vessels and 30 fish-meal plants in 1954-'55, the industry grew to around 2000 vessels and 175 plants in 1968-69. This was the boom period for the now 'Industrial Fishery'. The fishery peaked at 13.0 m t in 1970. Many scientists unofficially peg the landings at 15.0 m t in 1970. Southeast Pacific area ranked first among the Pacific fishing areas. The total biomass was estimated to be 23.0 m t in 1970 and around 9.0 to14.0 m t in 1971.

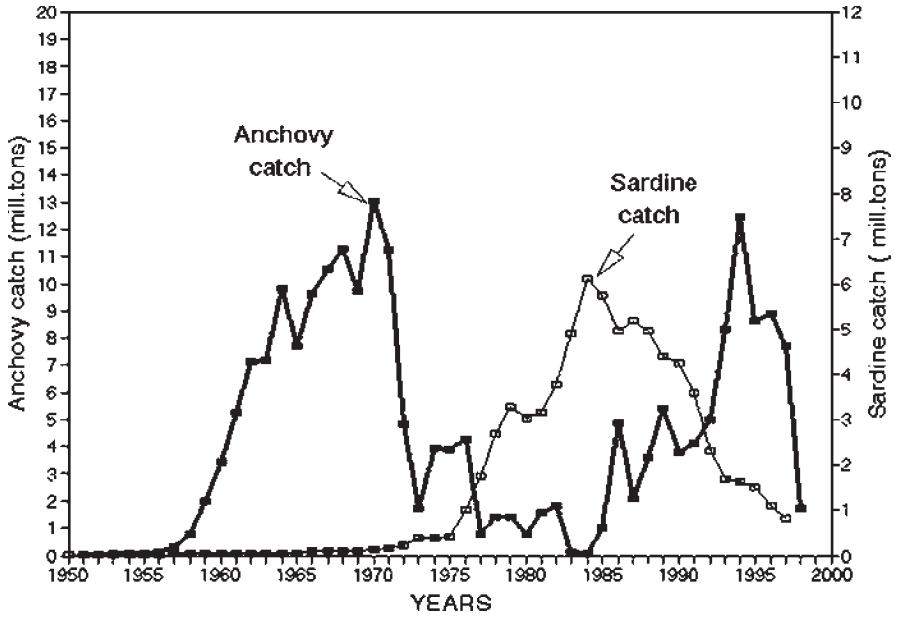
The climate-dependent dynamics of Peruvian anchovy is affected by strong El Nino events. The 1972-'73 ENSO event led to the drastic decrease in the anchovy landings. The catches dropped to around 2.0 – 4.0 m t. After the 1975-'76 event, the landings further decreased to 1.0 – 2.0 m t. The landings further crashed to 1.0 m t after the 1977-'78 event. The 1982-'83 ENSO, the severest of them all led to an all time low of 0.5 – 0.1 m t catches in 1983 and 1984 with a total biomass of less than a million tons. The environmental conditions stabilised after this. Thus after a protracted period (1974 to 1985) of highly fluctuating low landings the fishery started to recover. In 1986 it exploded back to 5.0 m t. The fishery fluctuated between 2.0 to 5.0 m t till it reached a peak in 1994 (12.0 m t). The strong ENSO event of 1996-'97 led to a collapse in 1998 (1.8 m t), the fishery coming back strongly the next year with a catch of 8.7 m t, the year-class strength being independent of the parental population.

Factors affecting the resource

The question was whether it was over fishing or environmental changes or a combination of both which led to the repeated collapse of the anchovy fishery.

Environmental conditions

Drastic reduction in primary production and plankton biomass due to the El Nino events had a major impact on the biology of the Peruvian anchovy. The following causes are attributed:



a) Larvae fail to survive and get recruited to the fishery due to lack of phytoplankton food. The resultant drop in catches is felt immediately because the anchovies are recruited when six months old.

b) The adults could have starved to death for lack of diatom blooms. The interesting feature of the 1975-'76 ENSO was the bloom of *Gymnodinium splendens* leading to unfavourable food conditions and adult mortality.

c) The anchovy is a cool water species concentrated in the low temperature zones (16 - 18^{0}C) of the Peruvian upwelling area. During the ENSO years the shoals remain in the cool pockets within the upwelling zone. The temperatures may go up to 28 – 29^0 C. When these cool pockets are over-ridden by the warm waters as in the 1982 – '83 ENSO, the fishes die *en masse.* The other alternative is for the shoals to migrate to cooler deeper waters (below 100 m) or to the southern Peruvian or Chilean coasts. In the deeper waters the low productivity will not sustain such huge populations leading to mass mortality. In the southern waters the established South American pilchard populations heavily compete with migrating anchovies again leading to large scale mortality.

Overfishing

Vulnerability to these harsh environmental conditions may have been enhanced by the heavy fishing pressure of the late 1960s up to 1970. In fact studies have shown that even before the impact of 1972-'73 ENSO, there was a recruitment collapse in the stocks, the total biomass estimated to be 9 – 14 m t in 1971. In 1966 the Maximum Sustainable Yield (MSY) was estimated to be 8.0 m t, which was revised as 9.5 m t in 1970.

Predation and Competition

Another interesting aspect is the heavy predation on the anchovy populations by the guano birds. Nearly 80 – 95% of their diet consists of the anchovies. So the huge bird populations (estimates as high as 30 million) before the industrial fishery has now dwindled to as low as 5 million, mainly due to the fluctuations in the anchovy populations. Another major predator is the Chilean jack mackerel (*Trachurus murphyi*), whose population increases during the El Nino years due to enhanced spawning success. During El Nino years other predators like the yellowfin tuna, dolphinfish and Chilean bonito migrate southward to the

anchovy domain. So the trophic dynamics is greatly affected by these events. Competition with the South American pilchard especially when the anchovies migrate southwards is another major factor. The pilchard populations are not much affected by the El Nino. The inverse relationship between the two tandem fisheries can be clearly seen in the figure. After the 1972-'73 ENSO, the pilchard stock began to increase and an important fishery developed over the next 15 years coinciding with the decline and rebuild of the anchovy fishery.

Management

In 1963, the Instituto del Mar del Peru (IMARPE) was established with a strong FAO backing to study the fishery and to advise the Government. In 1965 a five-day week fishing was established. In 1966 three months of closed season (veda) was put in place during January to March. Catch quotas were fixed as per the MSY levels (8.0 – 9.5 m t). So a second closed season was envisaged after around six months fishing when the quota would be taken. But many of these measures were hard to implement. It is now estimated that only less than 1500 vessels are required to catch around 10 m t of anchovies.

The Peruvian anchovy fishery is one example to understand how the climate and environment influence the fisheries. Another interesting parallel is the story of a warm-water species (*Sardinops melanosticta* – Japanese pilchard) and the impact of cool-water incursion into its domain in the Northwest Pacific fishing area.