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Evidences of Anthropogenic and Environmentally Driven Regime Shifts in Peruvian Pelagic Fisheries

by

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Regime shifts, …really!!?

It all started in San José, Costa Rica, 1983

WHY DO SOME PELAGIC FISHES HAVE WIDE FLUCTUATIONS IN THEIR NUMBERS? BIOLOGICAL BASIS OF FLUCTUATION FROM THE VIEWPOINT OF EVOLUTIONARY ECOLOGY

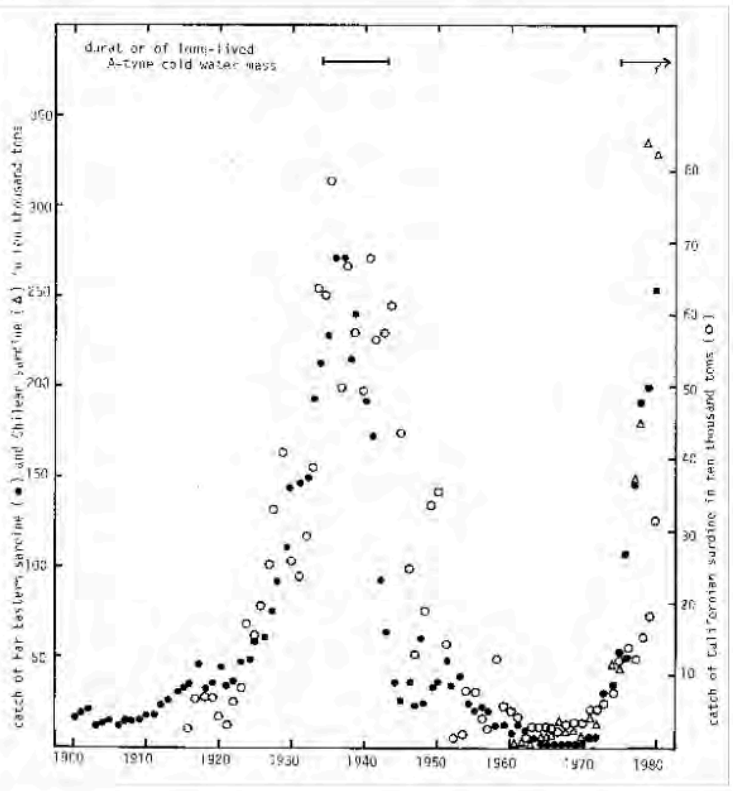
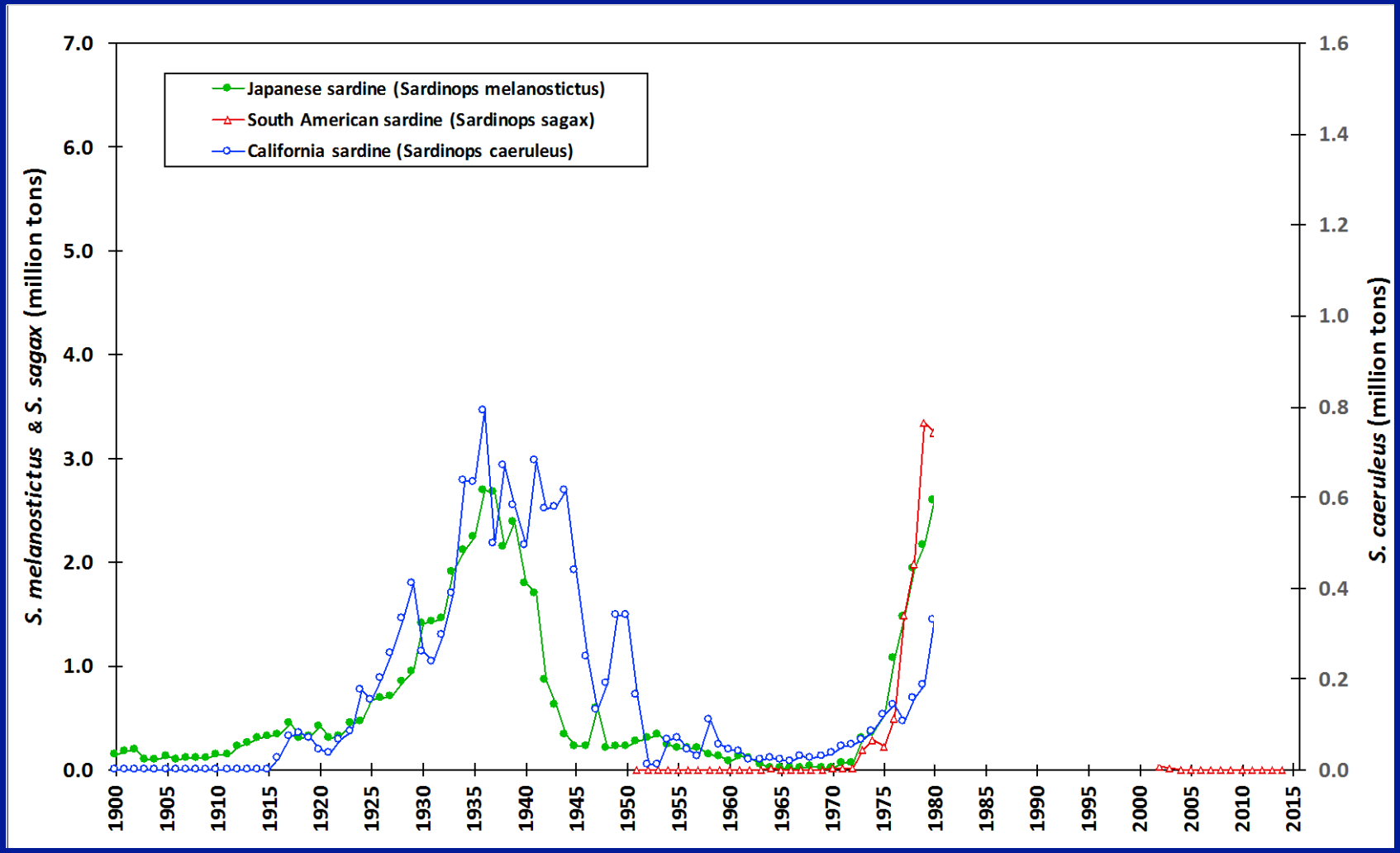


Fig. 1. Large-scale variations in catch of three species of sardine, Far Eastern, Californian and Chilean.

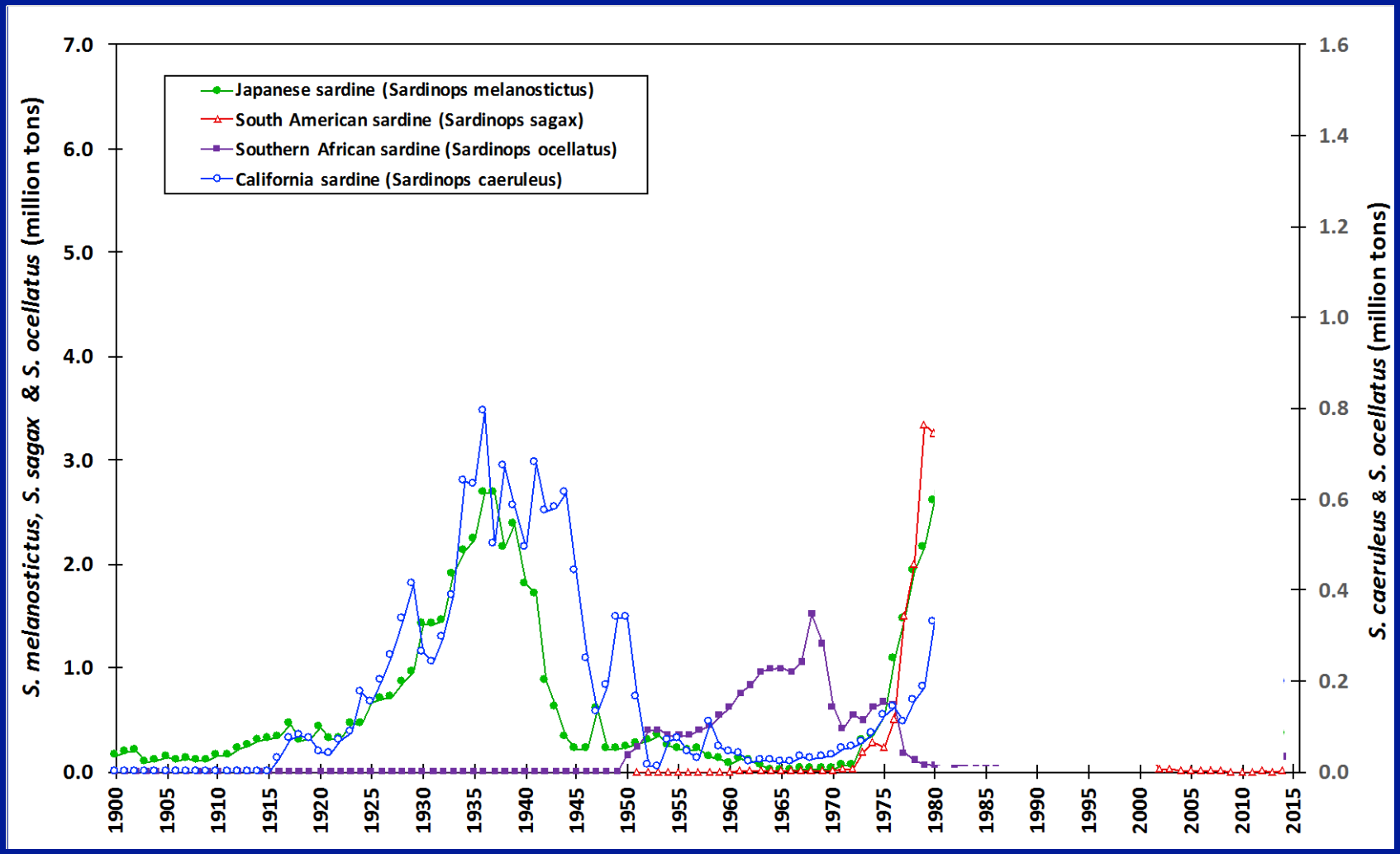
Paper presented by Prf. Tsuyoshi Kawasaki at the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources San José, Costa Rica, 18-29 April 1983

Three species of *Sardinops*, as presented by Kawasaki (1983)
San José, Costa Rica, 18-29 April 1983



Total annual landings of the three main species of the genus *Sardinops* in the Pacific Ocean: *S. caeruleus* in the NE Pacific (in blue), *S. melanostictus* in the NW Pacific (in green) and *S. sagax* in the SE Pacific (in red), years 1900-1980 (redrawn after Kawasaki, 1983)

Four species of *Sardinops*, after Kawasaki (1983)
San José, Costa Rica, 18-29 April 1983



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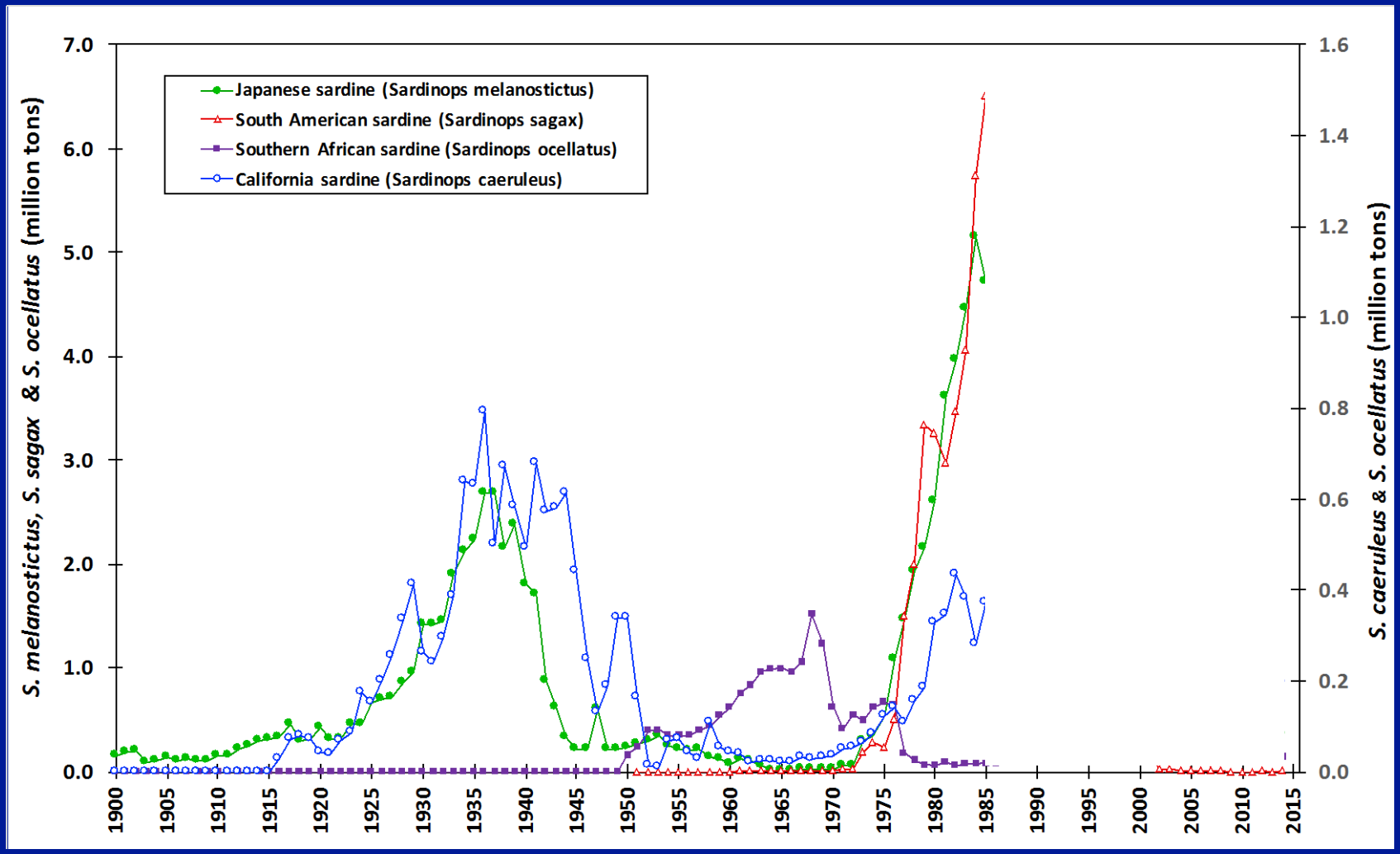
The same four species of *Sardinops* updated to 1985



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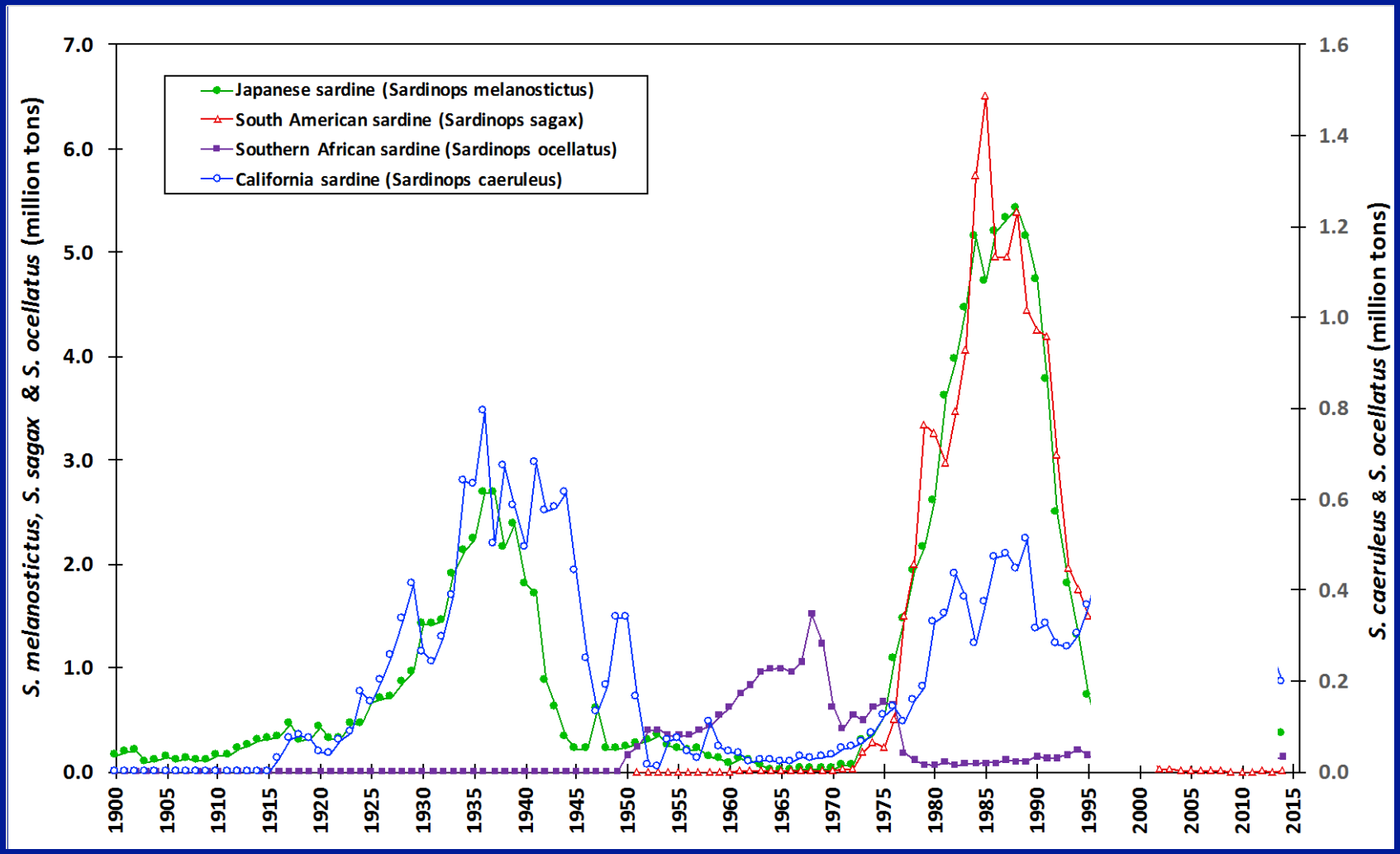
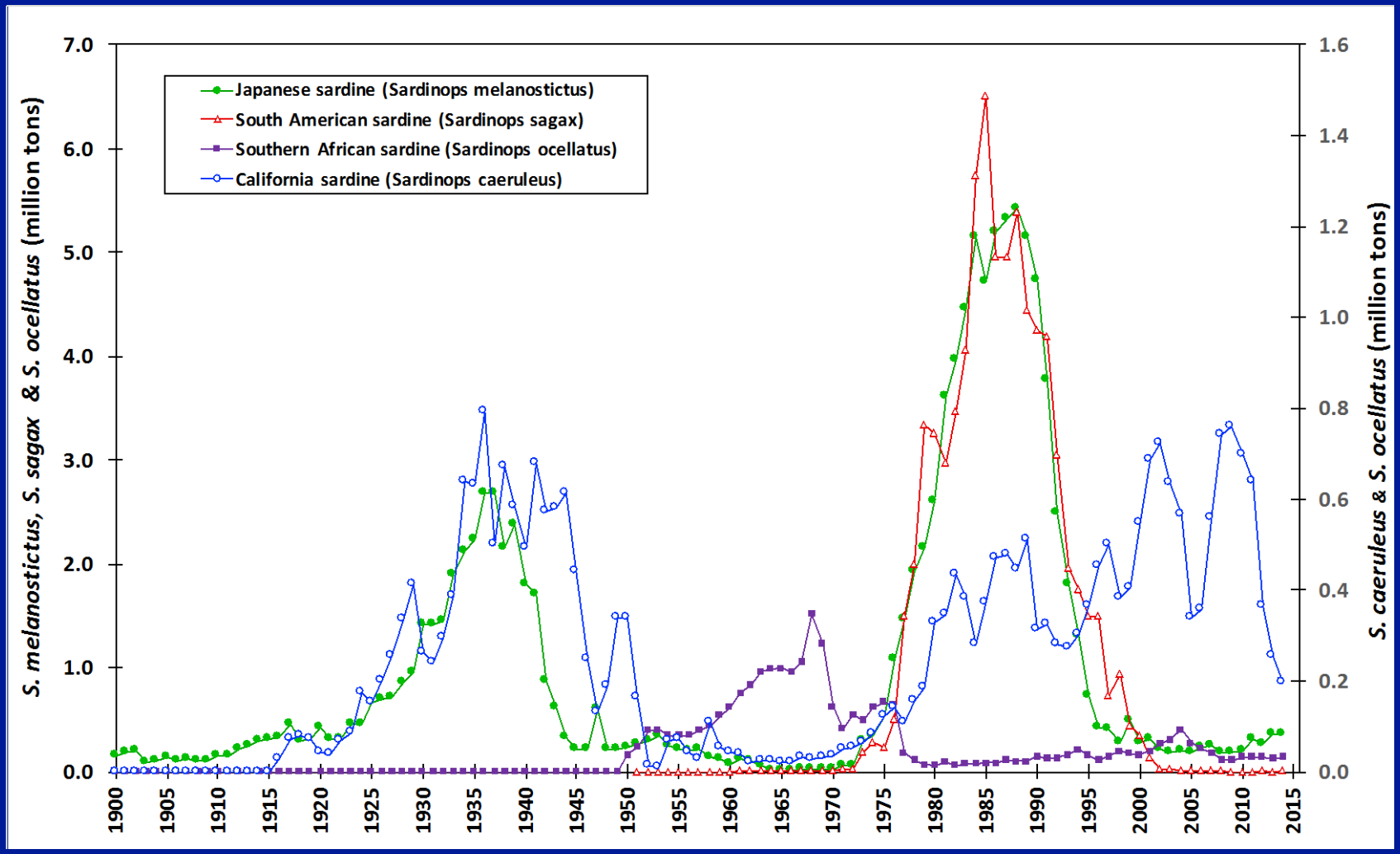
The same four species of *Sardinops* updated to 1995



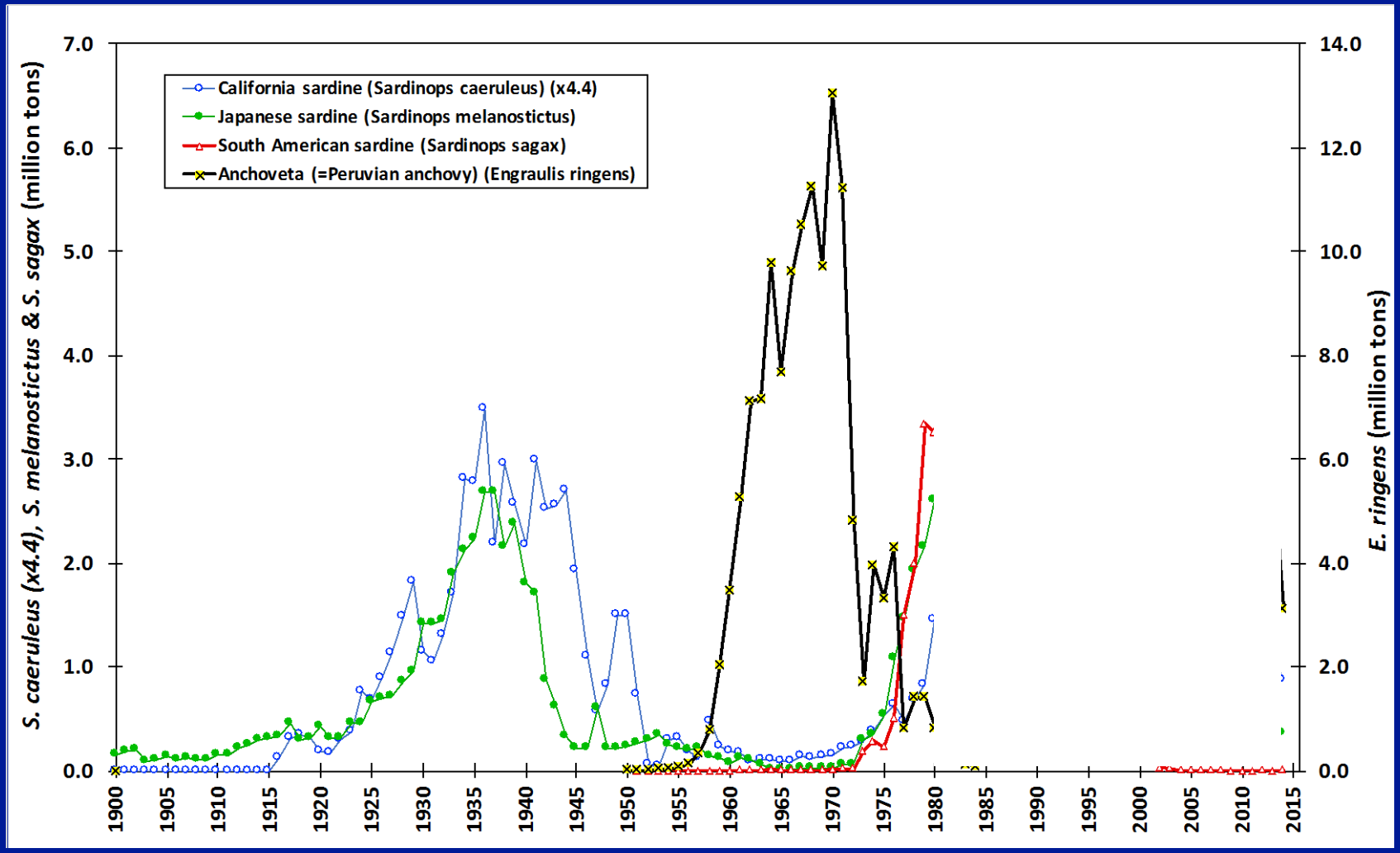
Total annual landings of the four main species of the genus *Sardinops*: *S. cauruleus* in the NE Pacific (in blue), *S. melanostictus* in the NW Pacific (in green), *S. sagax* in the SE Pacific (in red) and *S. ocellatus* in the SE Atlantic (in purple), years 1900-1995 (updated after Kawasaki, 1983)

The same four species of *Sardinops* updated to 2015



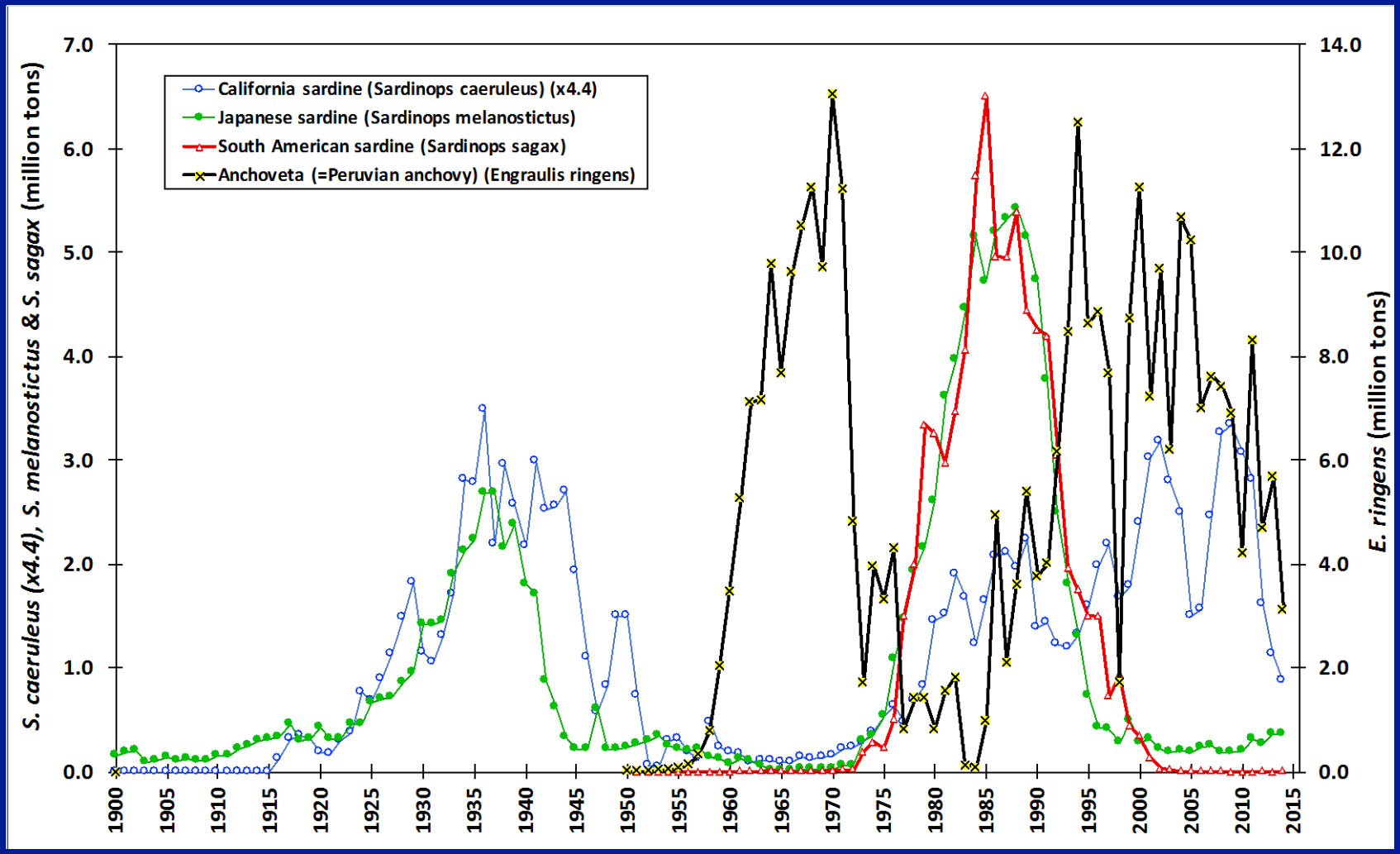
Total annual landings of the four main species of the genus *Sardinops*: *S. caeruleus* in the NE Pacific (in blue), *S. melanostictus* in the NW Pacific (in green), *S. sagax* in the SE Pacific (in red) and *S. ocellatus* in the SE Atlantic (in purple), years 1900-2015 (updated after Kawasaki, 1983)

Anchoveta and the three main species of *Sardinops in the Pacific Ocean* after Kawasaki (1983), San José, Costa Rica, 18-29 April 1983



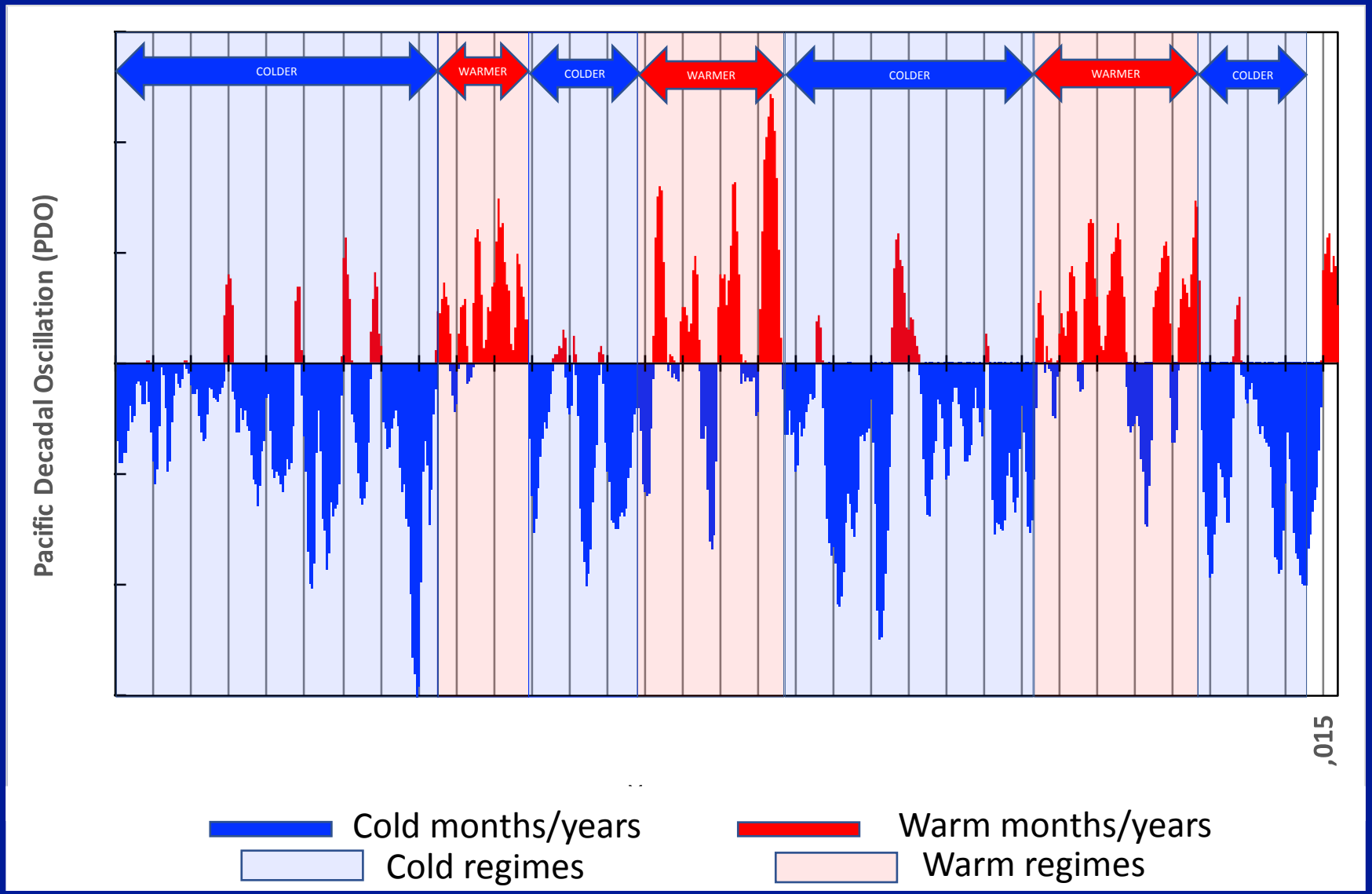
Total annual landings of anchoveta, *Engraulis ringens* (in grey) and the three main species of the genus *Sardinops* in the Pacific Ocean: *S. cauruleus* (in blue), *S. melanostictus* (in green) and *S. sagax* (in red), years 1900-1980. (after Kawasaki, 1983)

Anchoveta and the three main species of *Sardinops in the Pacific Ocean*
Updated to 2015



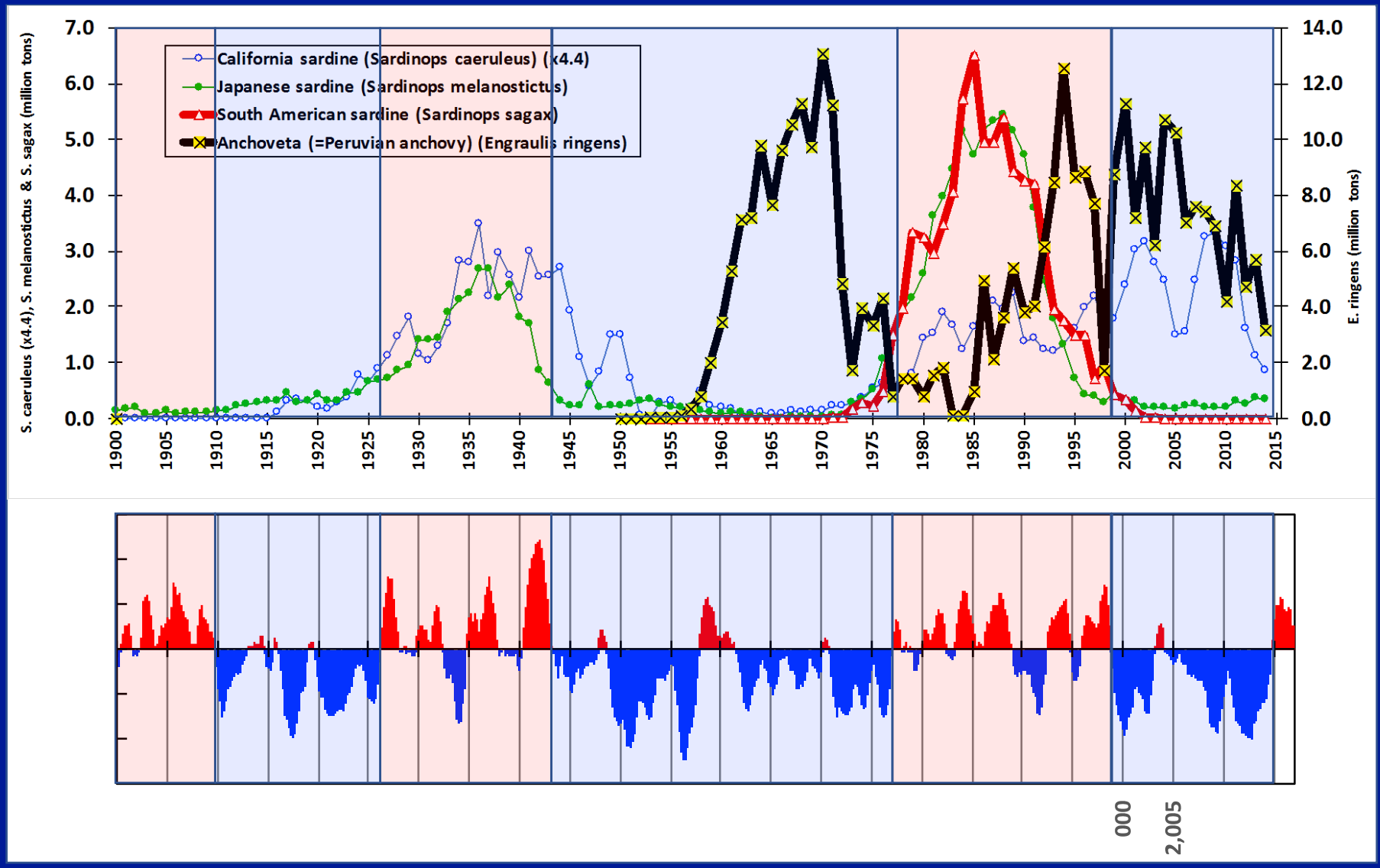
Total annual landings of anchoveta, *Engraulis ringens* (in grey) and the three main species of the genus *Sardinops* in the Pacific Ocean: *S. cauruleus* (in blue), *S. melanostictus* (in green) and *S. sagax* (in red), years 1900-2015. (after Kawasaki, 1983)

The Pacific Decadal Oscillation (PDO)



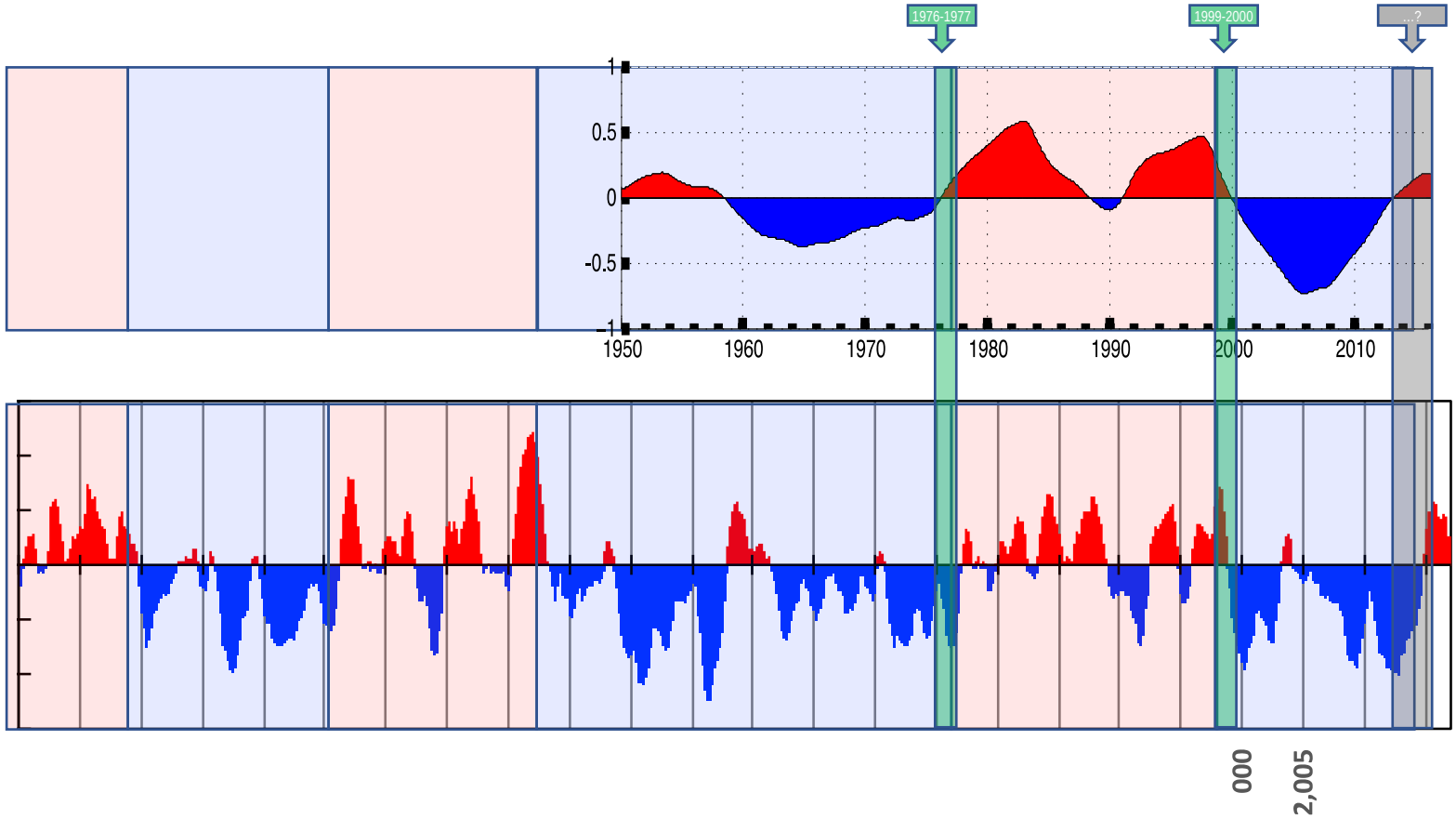
Twelve-month moving average of the Pacific Decadal Oscillation with indication of predominantly cold and warm groups of years or regimes, January 1855 - January 2017 (monthly data from NOAA)

Anchoveta, sardines and the PDO in the Pacific Ocean



Annual landings of anchoveta and the three main species of the genus *Sardinops* in the Pacific Ocean and the Pacific Decadal Oscilation (PDO), years 1900-2015

The Pacific Decadal Oscillation (PDO) and the more local Peruvian Oscillation Index (POI)



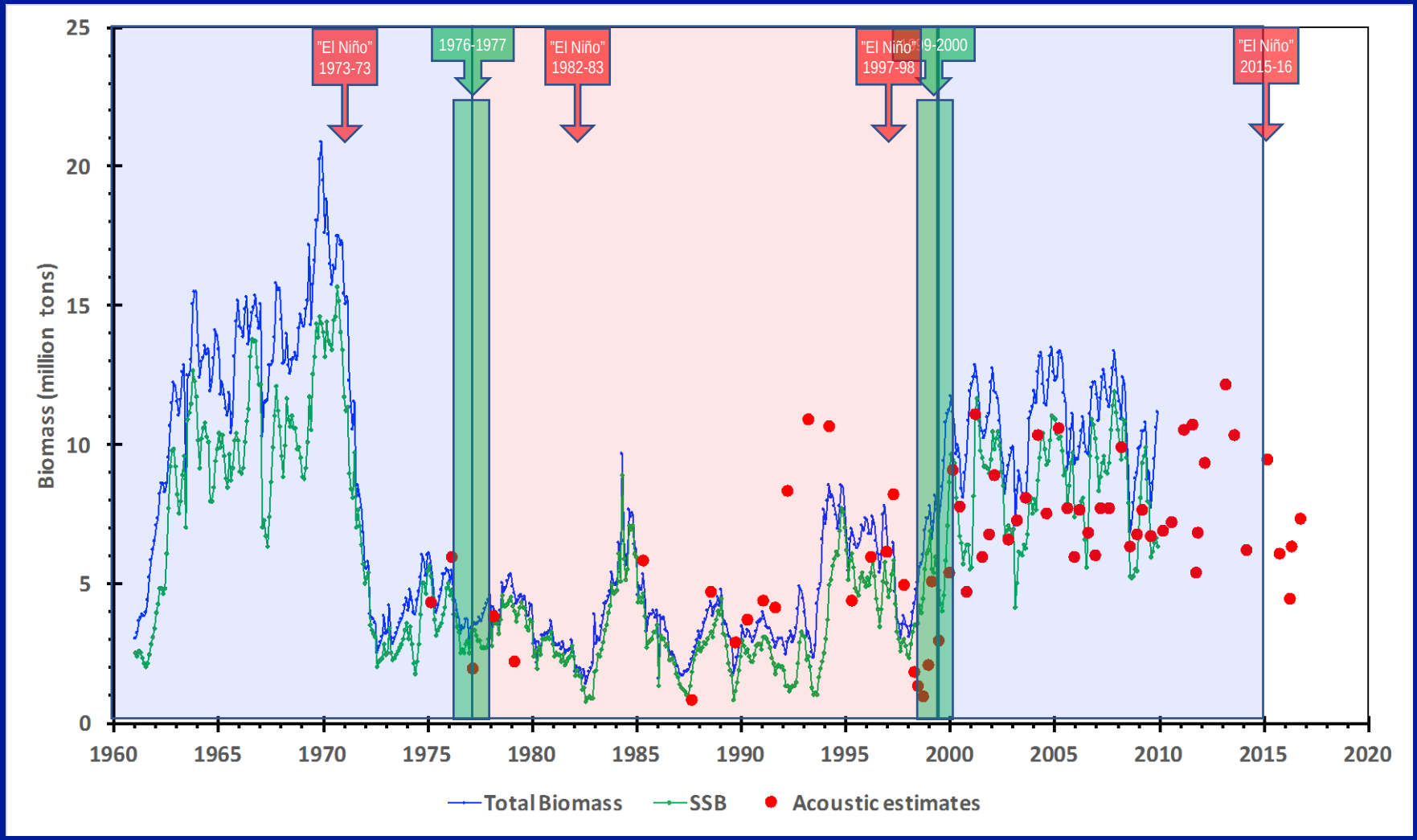
The Peruvian Oscillation Index (POI), years 1950-2016 (top panel) and the Pacific Decadal Oscillation (PDO), years 1900-2016 (bottom panel)

Regime shifts in the main Peruvian fisheries

…environmental or men induced?

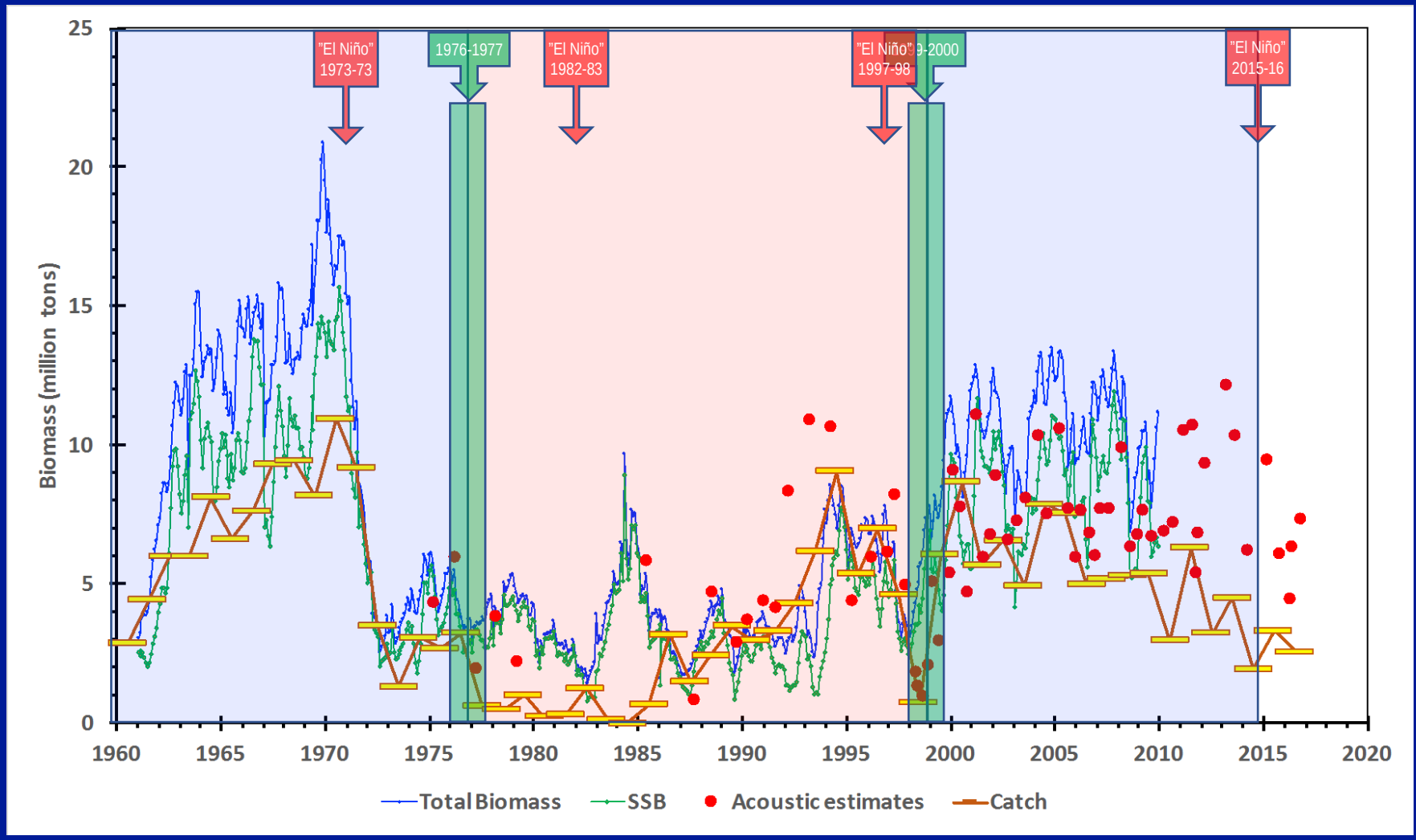
Anchoveta (*Engraulis ringens*)

Peruvian anchoveta biomass



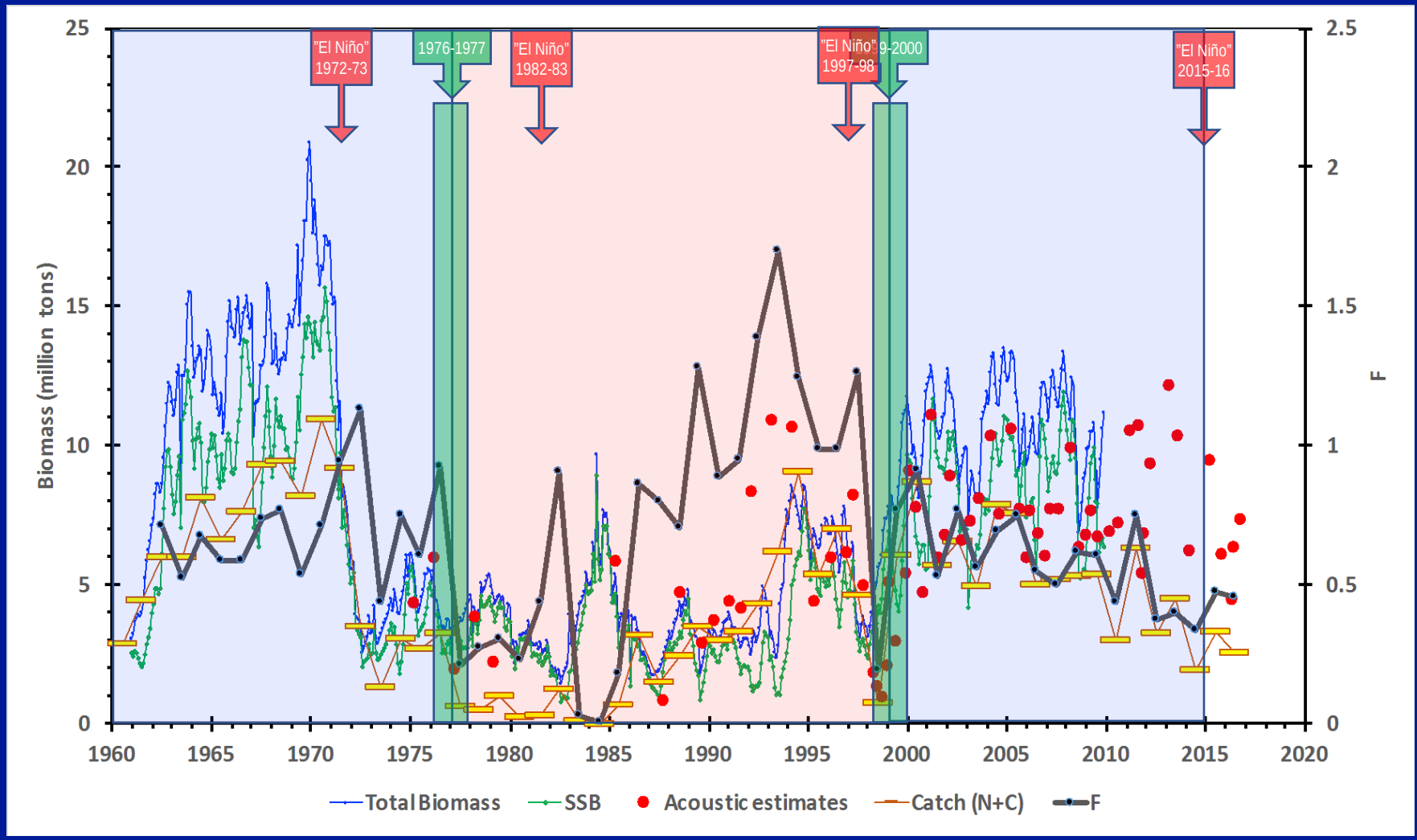
Biomass of Peruvian anchoveta, estimated by a length structured model (blue line=total biomass, green line=spawning stock biomass) and through acoustic surveys (red dots), years 1960-2016

Peruvian anchoveta catch and biomass



Annual catch and biomass of Peruvian anchoveta. Biomass estimated by a length structured model (blue line=total biomass, green line=spawning stock biomass) and through acoustic surveys (red dots). Years 1960-2016

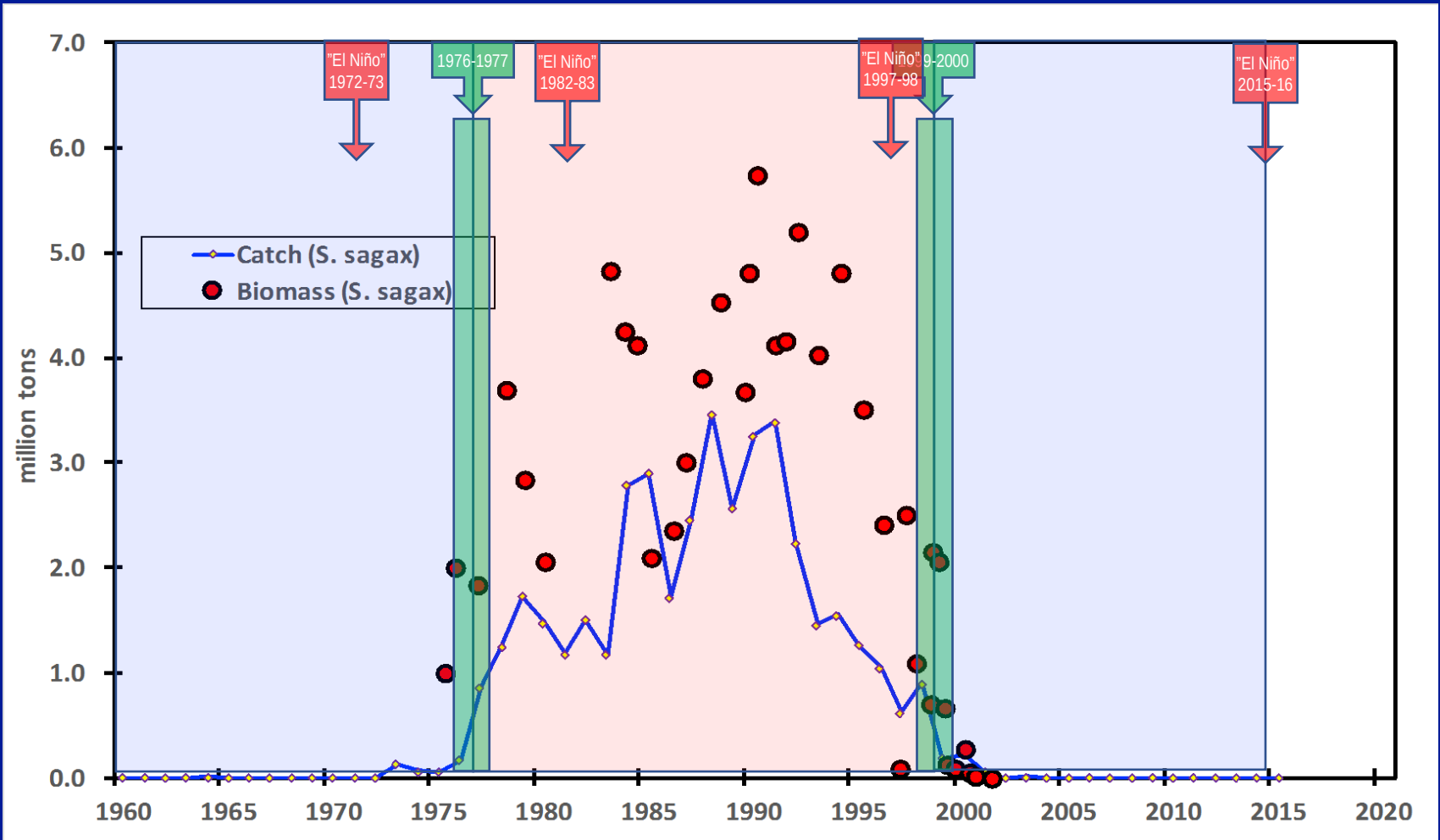
Anchoveta catch, biomass and fishing mortality



Annual catch, fishing mortality (F) and biomass of Peruvian anchoveta. Biomass estimated by a length structured model (blue line=total biomass, green line=spawning stock biomass) and acoustic surveys (red dots). Years 1960-2016

Sardine (*Sardinops sagax*)

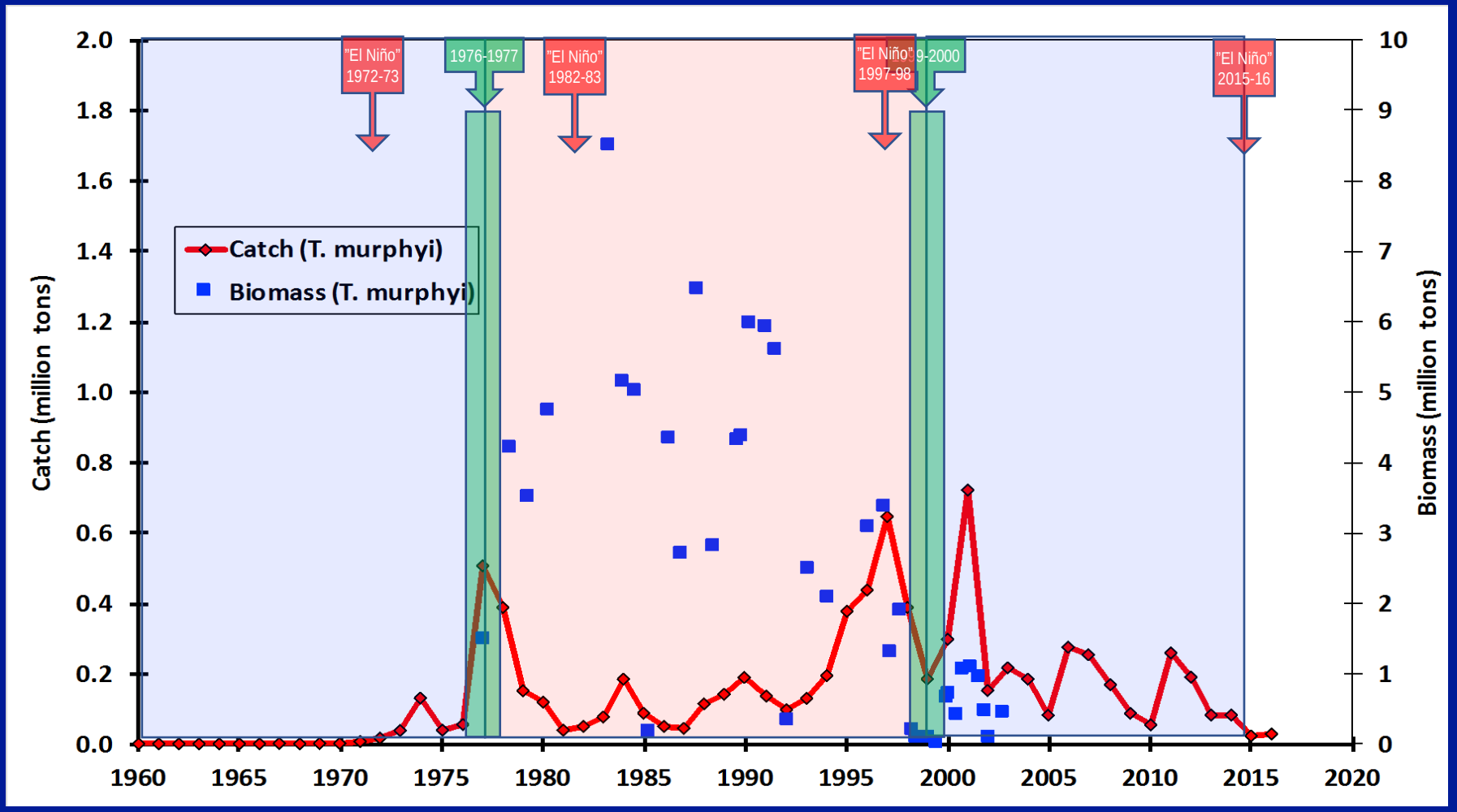
Sardine catch and biomass



Annual catch (years 1960-2016) and biomass estimates (by acoustics, years 1975-2000) of the Peruvian stock of sardine (*Sardinops sagax*)

Jack mackerel (*Trachurus murphyi*)

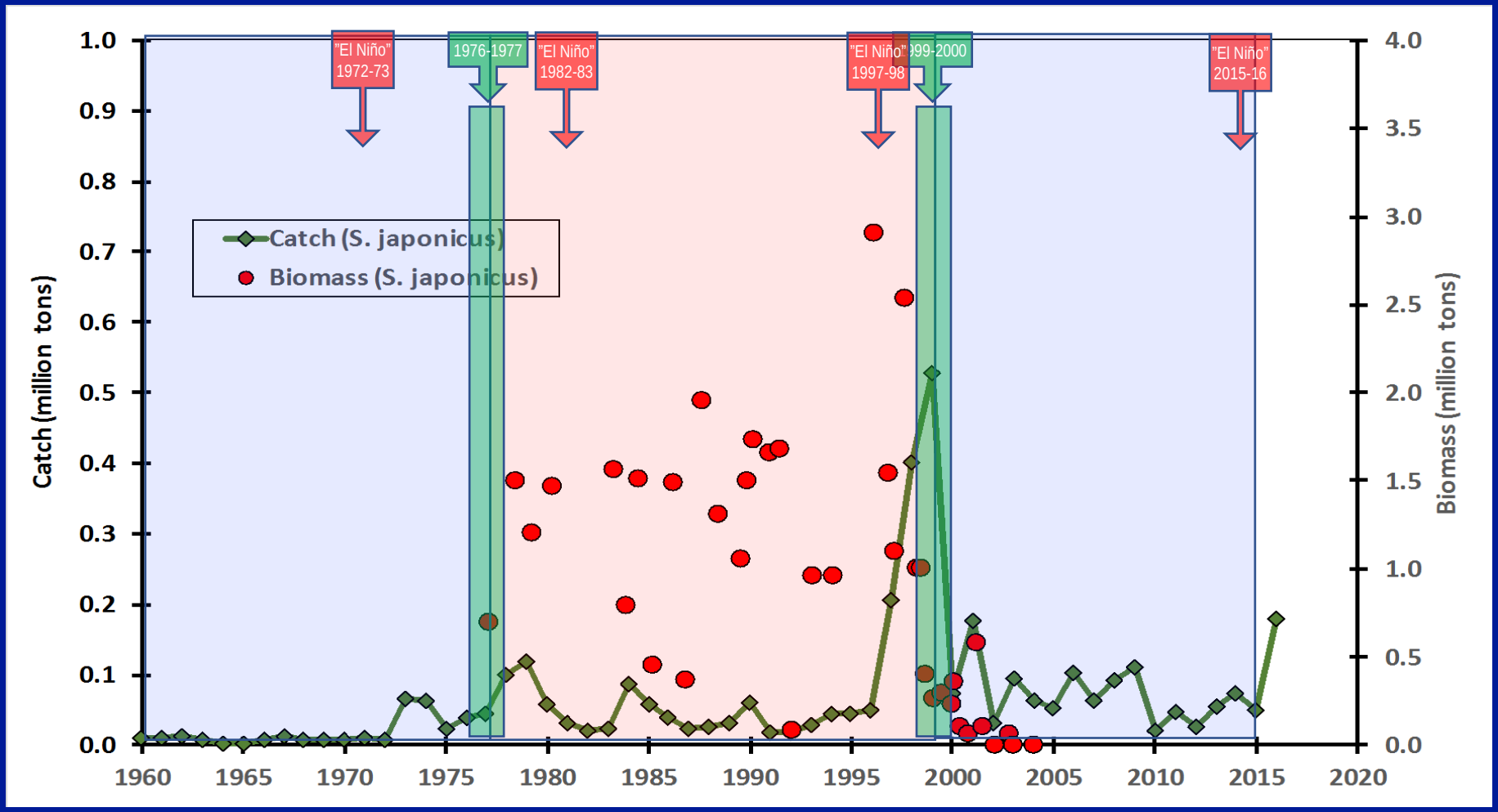
Jack mackerel catch and biomass



Annual catch (years 1960-2016) and biomass estimates (by acoustics, years 1977-2011) of the Peruvian stock of Jack mackerel (*Trachurus murphyi)*

Mackerel (*Scomber japonicus*)

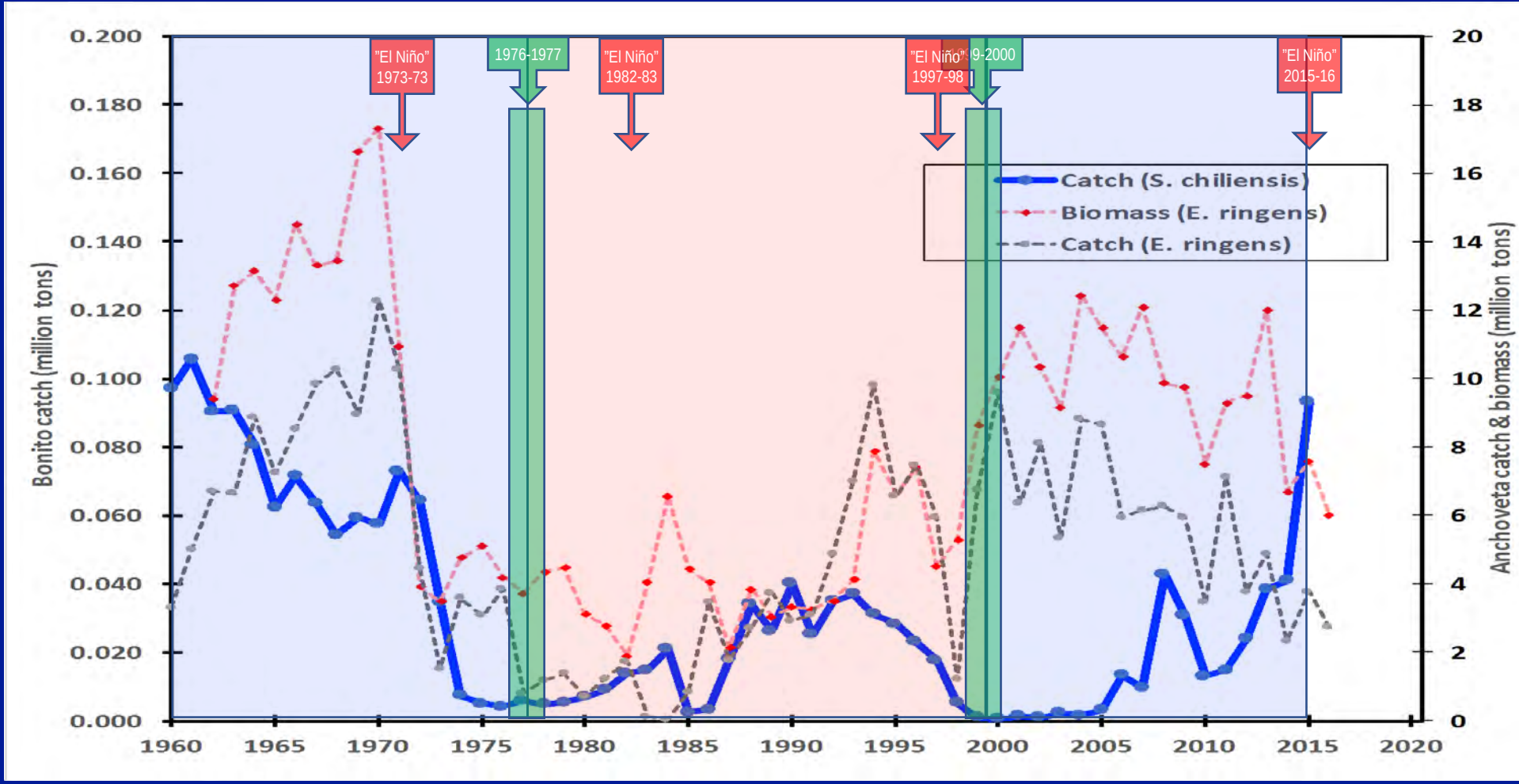
Mackerel catch and biomass



Annual catch (years 1960-2016) and biomass estimates (by acoustics, years 1977-2011) of the Peruvian stock of mackerel (*Scomber japonicus*)

Bonito (*Sarda chiliensis*)

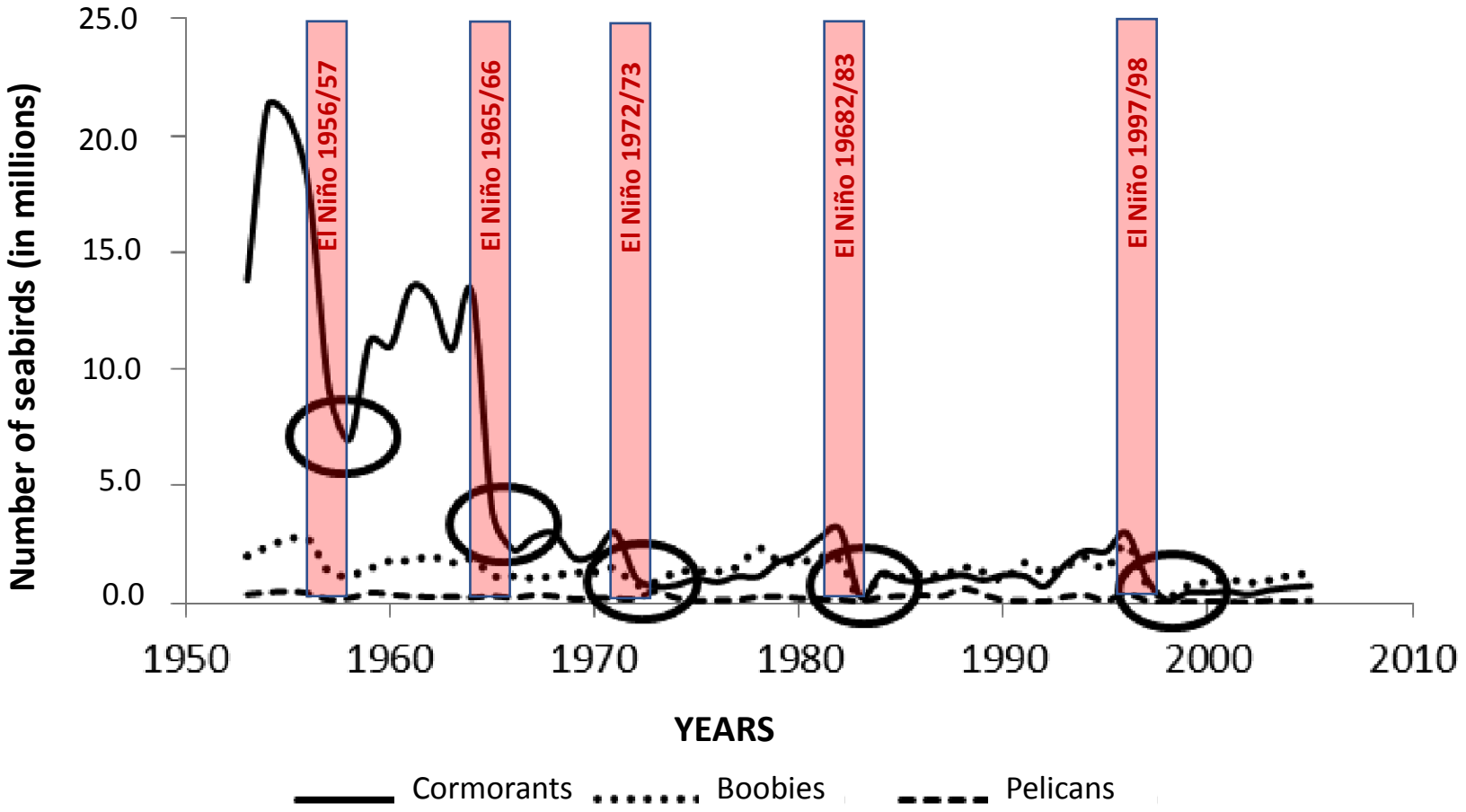
Bonito catch and anchoveta catch and biomass



Annual catch of bonito (*Sarda chiliensis*), years 1960-2016, and catch and biomass of anchoveta (*Engraulis ringens*), years 1960-2016

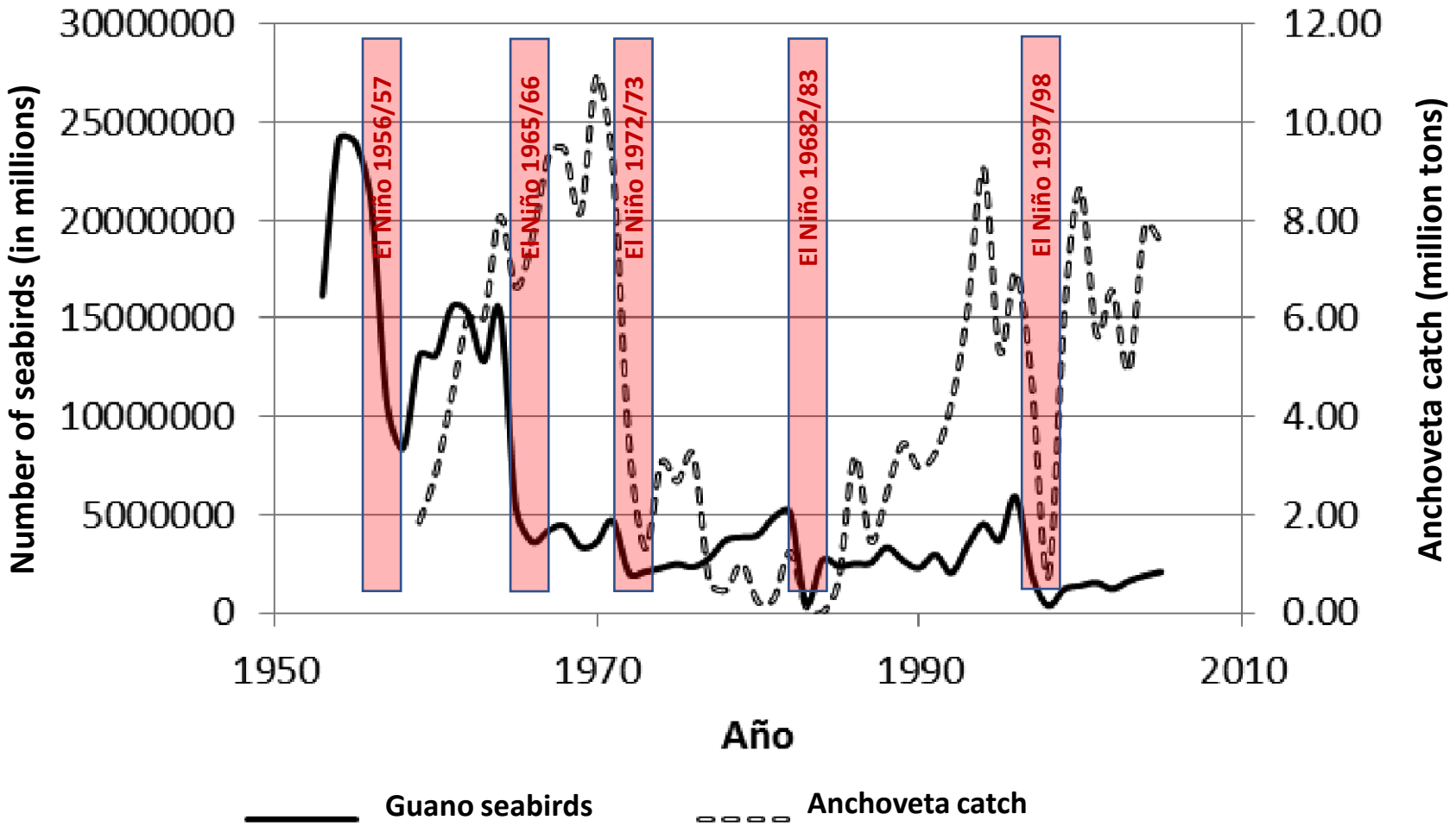
Guano seabirds

Guano seabird population



Population of cormorants (*Phalacrocorax bougainvillii*), boobies (*Sula variegata*) and pelicans (*Pelecanus thagus*) along the Peruvian coast, 1953-2005. Redrawn from Goya et al (in press)

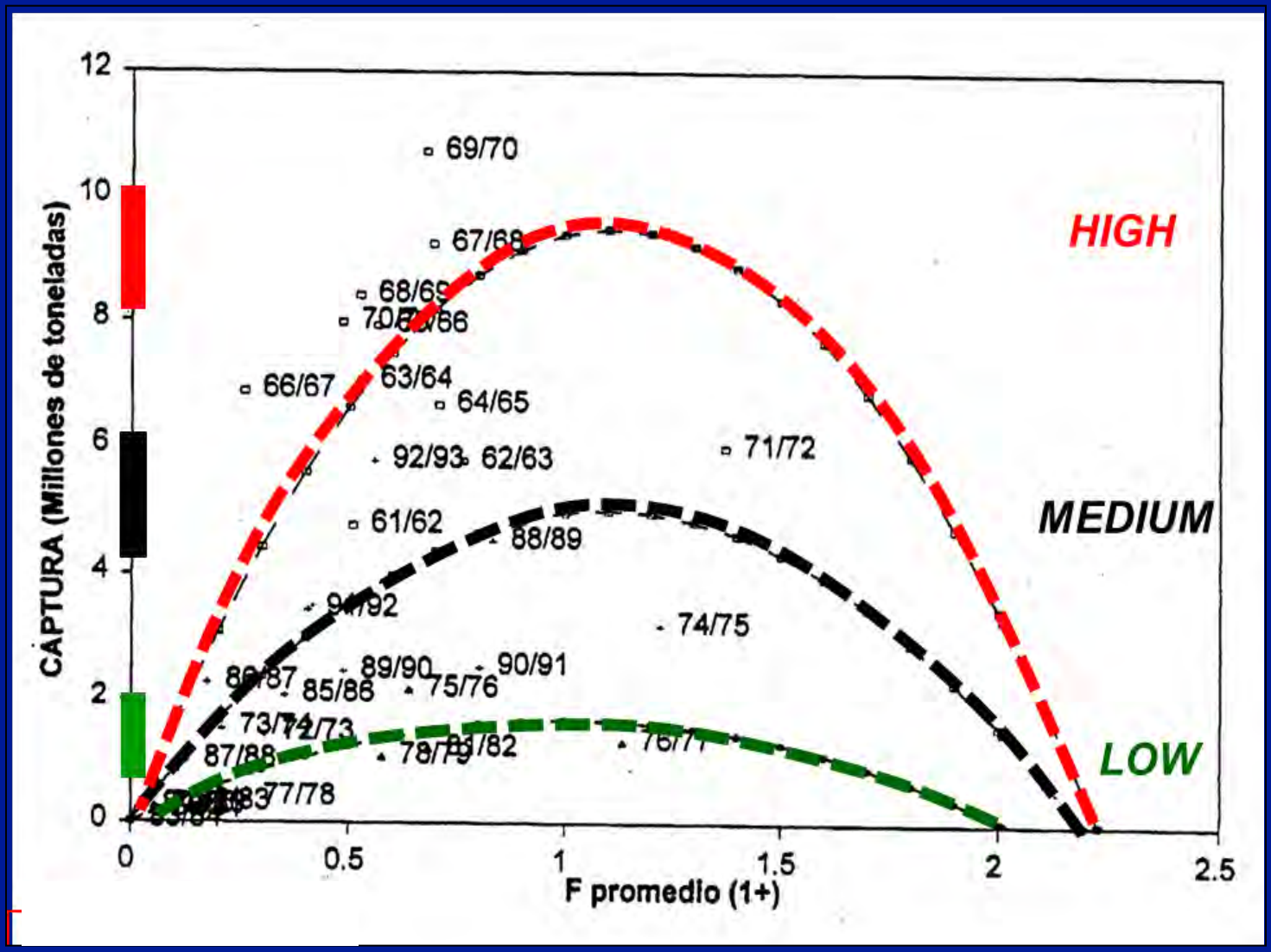
Guano seabird population and anchoveta catches



Guano seabirds population and catches of anchoveta along the Peruvian coast, 1953-2005. Redrawn from Goya et al (in press)

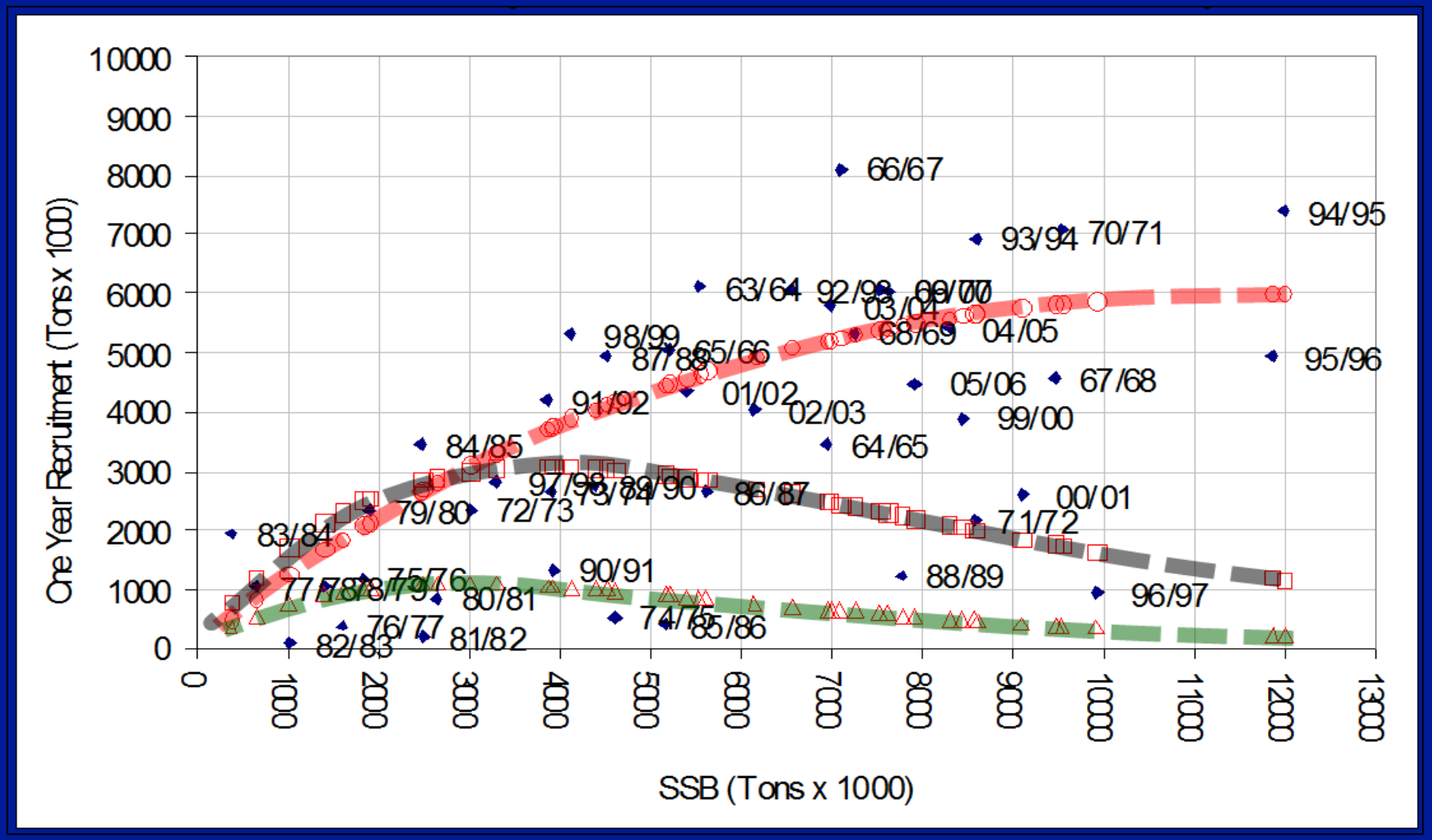
How is this applied in the provision of advice for fisheries management in Peru?

Surplus production and anchoveta regimes



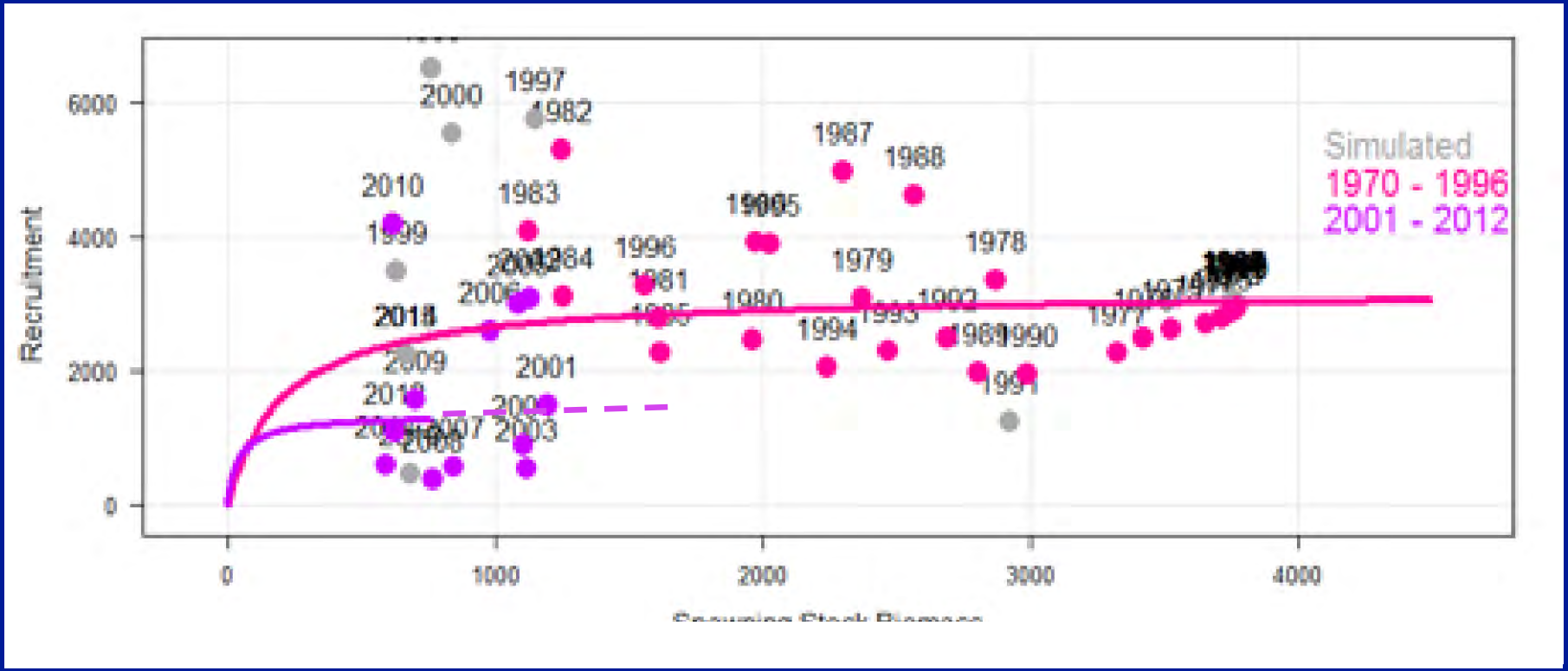
Surplus production curves for three possible anchoveta population regimes (Csirke et al, 1996)

Stock-Recruitment curves and anchoveta regimes



Stock-Recruitment curves for three possible anchoveta population regimes (after Csirke , 1980)

Stock-Recruitment curves and anchoveta regimes



Stock-Recruitment curves for two possible population regimes in the Peruvian jack mackerel stock (IMARPE-PRODUCE, 2016)

Thanks…!

Costa Rica, 1983

Participants in the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources San José, Costa Rica, 18-29 April 1983