Age Composition and Growth Rates from Coast-Wide Sampling Programs

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The California Current ecosystem has shown a large-scale change in physical structure resulting in warmer than average ocean temperatures since 1977. This shift has coincided with the return of the Pacific sardine to its historical northern range off British Columbia (B.C.). In southern California, growth of the sardine population allowed resumption of a limited fishery for the species in 1984. By 1993, Pacific sardine had appeared in significant numbers off B.C., while in 1994, sardine eggs were collected in abundance off Oregon (Bentley et. al. 1996). By the mid-1990's the presence of sardine off Oregon (OR) and Washington (WA) prompted those States to propose pilot fisheries. In California (CA), sardine had become one of the largest volume fisheries in the state.

Under the auspices of the Pacific States Marine Fisheries Commission, the California Department of Fish & Game (CDFG), Oregon Dept. of Fish & Wildlife (ODFW), and Washington Dept. of Fish & Wildlife (WDFW) coordinated a plan to collect biological data on sardine off of their respective coasts. The Canadian Department of Fisheries and Oceans (DFO) and Mexico's Instituto Nacional de la Pesca (INP) supplied additional samples. In California, sardine were obtained by sampling from the directed sardine fishery. Sardine were sampled by WDFW and ODFW from mid-water trawl or purse seine vessels. Due to the relative rarity of sardine as bycatch, most samples were obtained by directed fishing. In addition, the National Marine Fisheries Service, in conjunction with State and foreign government agencies, conducted coordinated sampling of sardine from Mexico to British Columbia in July 1998. Ages were determined from otoliths using the methods described by Yaremko (1996). Whole body condition factor (K) was calculated as $K = (W/L^3)*100$, where W = weight in grams, and L = length in centimeters. Age composition and mean size-at-age were compared to data from the historical fishery when biomass was in a state of steady decline (Phillips 1948).

There was an apparent latitudinal cline in sardine age composition for recent years. California sardine were generally younger than those taken to the north, with a mode of two years and range of zero to six. Southern California (San Pedro) sardine were even younger, dominated by one year old fish. To the north (OR, WA, B.C.), fish ranged in age from one to eight years, with age zero fish being virtually absent. Washington and B.C. sardine had an age mode of three years, with relatively more four, five, and six year old fish in the samples. Latitudinal differences were also apparent in the historical fishery, but sardine were generally older to the south and the north. The historical fishery off southern California was dominated by 3 year old fish, with a range of two to nine years. Sardine off the Pacific northwest had a mode of five years, and ranged two to twelve years of age. The absolute differences in age composition between the present day (younger) and historical (older) fisheries may be explained in part by the expected shift in relative age distributions in growing and declining populations. The current population is in a state of rapid growth, with more younger fish recruiting to the population, whereas the

population of the 1940s was undergoing a series of recruitment failures, resulting in a shift in relative abundance of older fish.

Size composition data suggest a gradient of increasing length-at-age from the south to north. For example, two, three, and four year-old fish are an average of 15 mm longer off of B.C. compared to southern California. The same trend was apparent in the historical fishery. Latitudinal differences in sardine size-at-age have been attributed to size-dependent migration rates, with longer fish swimming faster and traveling greater distances in their annual migrations. There was also an apparent cline of increasing condition factor (K) from south to north, with Mexico sardine having the lowest mean K value (1.27), and sardine off OR, WA, and B.C. ranging from K=1.4 to 1.52.

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