

**Document 1****CURRENT MANAGEMENT AND FISHERY-DEPENDENT SAMPLING  
OF THE U.S. PACIFIC SARDINE FISHERY**

Prepared for  
*WORKSHOP ON ENHANCING STOCK ASSESSMENTS OF PACIFIC SARDINE IN THE  
CALIFORNIA CURRENT THROUGH COOPERATIVE SURVEYS*  
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**Brief History of the West Coast Sardine Fishery**

The Pacific Sardine (*Sardinops sagax caerulea*) fishery was the largest in North America in the 1930s and 1940s with peak landings of over 700,000 metric tons in 1936 (Figure 1). The fishery developed in response to the demand for food during World War I and extended from southern California to British Columbia (Murphy, 1966). Sardine were used for either reduction to fishmeal and oil or canned for human consumption with a small portion taken for live bait (Frey 1971, Talbot 1973, Wolf et al. 2001).

Then in 1967, after approximately fifty years of fishing, a moratorium on fishing was imposed by the California Legislature. But, by the time the moratorium was imposed, most of the fisheries along the West Coast had collapsed, even in southern California. The recession of landings started from the north and moved southward, with sardine last landed in Canadian waters in the 1947-1948 season, in Oregon and Washington in the 1948-1949 season, and in San Francisco Bay in the 1951-1952 season (Murphy 1966, Radovich 1982). Landings persisted in Monterey and San Pedro until the early 1960s. During this time, management of the sardine resource was regulated by: 1) limits on the amount of sardines used for reduction, 2) case packing requirements (i.e., the number of cases of canned fish per ton of whole fish, and 3) restriction of the fishing season; however, total catch was not limited (Wolf et al. 2001).

From 1967 to 1973, the incidental take of sardines in other Coastal Pelagic Species (CPS) fisheries was limited to 15% by weight. However, liberal requirements to accommodate the use of these incidentally caught sardines and allowances for live and dead bait allowed several hundred tons of sardines to be taken per year (Wolf et al. 2001). In 1974, state legislation abolished the collection of sardine for dead bait and signaled the intent to replenish the resource. It also directed the California Department of Fish and Game (CDFG) to monitor the status of the sardine resource annually and provide for a directed fishery of 1,000 short tons when the spawning biomass had reached or exceeded 20,000 short tons (Wolf, 1992). Landings remained less than 50 metric tons per year. During the late 1970s sardines were rarely observed in any

fishery-independent surveys designed to target specific life stages including California Cooperative Oceanic Fisheries Investigation's (CalCOFI) egg and larval survey (Wolf 1992).

By the early 1980s, sardines were observed with increasing regularity in CPS fisheries such as Pacific mackerel (*Scomber japonicus*), and jack mackerel (*Trachurus symmetricus*) and in the live bait fishery for northern anchovy (*Engraulis mordax*) in southern California (Wolf 1992). On 1 January 1986, the first directed fishery in twenty years was prosecuted with a 1,000 short ton quota. Landings averaged about 150 tons per month and the fishery was closed on 11 July. Incidental landings after the directed fishery closed were 842 tons. Annual landings of sardines increased steadily in southern California and resumed in Monterey in 1984. For a complete discussion of quotas and incidental landings during the early recovery period in California, see Wolf (1992). Coastwide landings including Mexico and Canada averaged 52 tons in the 1970s, 5,290 tons in the 1980s, 72,614 tons in the 1990s, and 137,267 tons in 2000 through 2009. On 15 January 1999, a CDFG press release declared that the sardine resource was officially recovered since it had met the three criteria agreed upon by sardine researchers at an interagency workshop in 1983: 1) that the biomass exceeded one million tons, 2) that it occupy its historic range from Mexico to Canada, and 3) that all age classes were represented in the population.

### **Current Management of the U.S. Sardine Fishery**

Federal management of the sardine resource in U.S. waters commenced with the Coastal Pelagic Species Fishery Management Plan (CPS FMP) which was implemented by the Pacific Fishery Management Council (PFMC) in January 2000. The CPS FMP was an expansion of the Northern Anchovy FMP to include other CPS which had been in place since 1978. It transferred management authority from CDFG to the National Marine Fisheries Service (NMFS) through the PFMC (PFMC 2010). Elements of the CPS FMP specific to sardine consisted of 1) fishery management areas, consisting of a limited entry zone and two subareas, 2) procedures for setting annual specifications including harvest guidelines (HG), quotas, and allocations, 3) provisions for closing directed fisheries when the directed portion of a HG or quota is taken, 4) a fishing season for sardine from 1 January through 31 December, 5) catch restrictions when the directed fishery for CPS is closed, and limited harvest of that species to an incidental limit, 6) a limited entry (LE) program, and 7) authorization for NMFS to issue exempted fishing permits for the harvest of CPS that otherwise would be prohibited (PFMC 1998). The 2000 sardine fishery opened on 1 January with a U.S. HG of 186,791 tons, based on a 1999 estimate of spawning biomass (Figure 2).

Initially the U.S. sardine resource was allocated both spatially and temporally with the LE fleet authorized to fish from the U.S. Mexican border to Point Arena, California (39° N latitude). Within that LE area, two subareas were divided at Point Piedras Blancas (35°40' N latitude). The southern subarea was allocated 66% of the HG and the northern subarea was allocated 33%. On 1 October, the remaining unused portion of the HG was reallocated 50% to each subarea. The area north of Point Arena was considered open access (PFMC 1998).

The 2009 CPS limited entry fleet consisted of 65 permits and 61 vessels (PFMC 2010). A capacity goal and transferability provisions established under CPS FMP Amendment 10 are based on calculated gross tonnage of individual vessels and is used to track total fleet capacity (PFMC 2010).

Pacific sardine was managed in Oregon as a developmental fishery from 1999 to 2005. A limited entry program run by Oregon Department of Fish and Wildlife was established in 2006 with 20 initial permits, but was later amended to include 26 permits. In 2009, 25 permits were issued, although only 20 permits were actively utilized in the fishery (PFMC 2010).

As Washington landings increased from 4,842 tons in 2000 to 14,894 tons in 2003, the Washington Department of Fish and Wildlife changed the sardine fishery designation from “trial” to “experimental.” This designation remained in place until July 2009 when Washington established its own limited entry program. A total of 16 permits were issued to qualifiers with a maximum number of permits set at 25 (PFMC 2010). Of the 16 permits, only six were active in the fishery. In addition, several vessels have permits in both Oregon and Washington (PFMC 2010).

In June 2005, the PFMC adopted a long-term allocation framework to apportion the annual Pacific sardine HG among the sectors of the sardine fishery. The seasonal allocation scheme provides the following allocation formula for the non-tribal share of the HG: 1) 1 January, 35% of the HG to be allocated coastwide, 2) 1 July, 40% of the HG, plus any portion not harvested from the initial allocation, to be reallocated coastwide, and 3) 15 September, the remaining 25% of the HG, plus any portion not harvested from earlier allocations, be reallocated coastwide (PFMC 2010). This allocation framework has remained in place through the 2010 fishing season with the expectation that it will be reassessed within the next year.

### **Description of the Current Sardine Fleet**

During the 1940s and 1950s, approximately 200 vessels participated in the Pacific sardine fishery. Today, a significant proportion of those vessels, mainly in California, are still an integral part of the fishery with an average age of 33 years for vessels in the limited entry fleet (PFMC 2010). In the 1980s, the number of vessels landing sardines in California ranged from two to 46 (Figure 3). In the 1990s, the number of vessels rose steadily from 75 in 1990 to 159 in 1999. In Oregon, as expansion of the sardine resource moved up the west coast, one vessel landed a small amount of sardines in 1998, with 4 making landings in 1999. Today, approximately the same number of vessels are landing sardines along the U.S. west coast as there were in the 1940s and 1950s.

The majority of current sardine landings made on the Pacific coast are done with roundhaul gear, primarily purse seines. Lampara gear was used prior to purse seines (Figure 4). In the 1990s purse seiners began converting to drum seines which are easier to deploy and retrieve (Figure 4). Many of the vessels fishing for sardines also fish for other CPS, including Pacific Mackerel, jack mackerel, northern anchovy, market squid (*Loligo [Doryteuthis] opalescens*), Pacific herring (*Clupea pallasii*), when available, or when there are market orders for these species (Figure 5). Pacific bonito (*Sarda chiliensis lineolata*), and bluefin tuna (*Thunnus thynnus*) are also caught on an opportunistic basis (PFMC 2010). In California, 55 purse seine vessels made landings of sardines in 2008, with nine of those vessels making 50% of the landings.

### **Fishery-Dependent Sampling Utilized in the Pacific Sardine Fishery**

All three states monitor the commercial sardine catch utilizing port sampling programs. The goals of the sampling program are to: 1) provide age from otoliths and length data to NMFS for Pacific sardine and Pacific mackerel for use in stock assessment modeling, 2) determine sex and maturity, 3) determine the species composition of the CPS catch, 4) determine by-catch and incidental catch, and 5) in California, estimate biological parameters necessary for management of market squid in accordance with the Market Squid Fishery Management Plan.

A multistage, stratified random sampling design is utilized for monitoring the purse seine fleet. Nearly all commercial catch arrives at the docks as boatloads, forming convenient clusters for sampling. Each selected cluster is sub-sampled and measurements taken on individual fish. Because an adequate sampling frame of clusters cannot be generated *a priori*, a selection process using random calendar days, stratified by month, is used instead. This sampling frame excludes holidays, weekends, and furlough days. The first boatload containing the species of interest on each of 12 random sample days per month or carryover days is sampled. A total of 25 fish are systematically sampled throughout each selected load. Finally, the sampling design stratifies the total catch by port complex (Monterey, Santa Barbara, and San Pedro) to account for possible regional differences.

Mandatory logbooks that record incidental catch including salmonids and other species have been collected in both Oregon and Washington since 2000. There is currently no logbook required for CPS finfish in California; however, a market squid logbook has been in place since 1999.

The research and data needs section of the 2010 Stock Assessment and Fishery Evaluation (SAFE), proposed implementation of a comprehensive CPS vessel logbook program for Washington, Oregon, and California vessels. The purpose of such a program would be to collect biological and stock assessment related data, and also vessel-trip-level fishery economic data (e.g., fuel cost and consumption, number of crew, cost of provisions) across all CPS fishery operations needed to evaluate economic success of the fishery (PFMC 2010).

### **The Effect of Harvest Constraints on the California Sardine Fishery in 2008 and 2009**

In 2008, the U.S. HG was set at 89,093 tons, a 42% decline from the 2007 HG of 152,564 tons (Figure 2). However in 2007, U.S. fisheries landed 127,764 tons of sardines, 43% larger than the projected 2008 HG setting the stage for landings to be constrained by management restrictions for the first time since the 1999 recovery declaration. In California, as well as the Pacific Northwest, the potential for early closures during the allocation periods resulted in a derby style fishery in which there was a race to catch sardines. Only California landings are presented here due to time limitations, although Oregon and Washington landings were reasonably similar since all three states were under the same harvest constraints.

During the first 2008 allocation period from 1 January through 30 June, only the California fishery was landing sardines since inclement weather and a later seasonal opening in Washington (1 April) usually preclude winter and spring fishing opportunities in the Pacific Northwest sectors. California fisheries averaged 240 tons/day and did not land sardines on weekends as is customary in California since market squid cannot be landed on weekends (Figure 6). The number of landings averaged 6.6 per day. The directed fishery allocation of 26,552 tons lasted

for 150 days and was closed on 29 May, over a month prior to the start of the second allocation period on 1 July.

At the start of the second allocation period, speculation that all the other fishery sectors were now competing for the allocation led to increased fishing intensity. The average catch per day doubled to 548 tons per day (Figure 6) and the number of landings increased to 16.2 per day. California fisheries were now landing on the weekends and two trips per day by vessels was not uncommon. The directed fishery allocation of 34,568 tons was fully utilized in 40 days, 36 days before the start of the next allocation.

By the start of the third allocation period on 15 September, fishing intensity had increased dramatically and fueled a frenzied atmosphere. The catch increased to 1,034 tons per day and the number of landings nearly doubled again averaging 26.3 per day (Figure 6). Some vessels were making three landings per day and processors were operating round the clock. The final directed fishery allocation of 19,066 tons lasted nine days. Overall, the amount of sardines landed per trip also significantly increased in each allocation period from 27.7 tons in the first period, 33.8 tons in the second period, and 39.3 tons in the last. The coastwide sardine fishery was only open for 199 days (55%) and closed 166 days (45%) in 2008.

The pattern of landings in 2009 started out similar to 2008 but changed dramatically by the last allocation period. A total of 37,660 tons of sardines were landed in California ports. This represents a 35% decline from 2008 landings (57,800 tons) mainly due to a reduction of the HG to 66,932 tons. The directed fishery allocation for the first period was 23,006 mt. California fisheries averaged 397 tons per day, nearly twice the amount in 2008 for the same period (Figure 7). The fishery averaged 11.8 landings per day with each landing averaging 33.7 tons. During this period, fishermen fished harder than in 2008 because they thought that the allocation amount would be used as quickly as it was in the last allocation period in 2008. The first allocation period was closed after 51 days.

In the second allocation period, 28,559 tons were available starting 1 July. A total of 8,665 mt was landed prior to the fishery closing on 18 July. In southern California sardine landings started slower than expected because some vessels shifted to landing large loads of squid (Figure 8). There were also complaints about the difficulty in finding larger schools of sardines. Daily landings averaged 664.1 tons per day, over 100 tons higher than in 2008 for the same period (Figure 7). The fishery averaged 22 landings per day, double the first allocation period, and each landing averaged 30.2 tons.

The third allocation period opened on 15 September with 15,886 mt available for harvest, and was closed on 23 September. Daily landings dropped to 503.5 tons per day, over 150 tons lower than the second allocation period (Figure 7). The fishery averaged 15.5 landings per day, 25% lower than the second allocation period with each landing averaging 32.7 tons. Thus, the coastwide sardine fishery was only open for 78 days (21%) and closed 287 days (79%) in 2009.

A comparison between 2008 and 2009 landings indicate a doubling of effort and number of trips per day during the first allocation period in 2009 reduced the number of days allowed to fish by two-thirds (Figures 6 and 7). During the second allocation period in 2009, the number of trips per

day increased by approximately 25%, which led to a reduction in the number of fishing days. In the third allocation period, effort was shifted away from landing sardines to the more valuable squid (i.e., \$120 to \$150 per short ton for sardines versus \$500-\$700 per short ton for market squid). However, a 50% reduction in tons landed per day and a 25% reduction in the number of trips in 2009 did not extend the allocation period because fishing effort was high in Oregon and Washington.

Harvest constraints on the sardine fishery can have numerous negative effects besides limiting the amount of time vessels are allowed to fish. Production in processing plants becomes sporadic when the season is opened and closed which makes it difficult for employers to keep staff working. One suggestion brought up by the fishing industry to keep a longer, more continuous season in place would be to establish daily limits on how much sardine could be landed. This may help to extend the allocation period and reduce the derby effect.

Seasonal closures, besides limiting the fishery, also limit the amount of fishery-dependent data that can be collected throughout the year. It also underscores the need to adequately sample the sardine population for the biological information needed for stock assessments. In addition, there is currently only a limited amount of fishery-independent sampling which collects needed biological information (e.g., CalCOFI sampling of adults in midwater trawls). A review of current sampling design utilized for monitoring the purse seine fleet has been undertaken in order to maximize sampling efficiency for when the sardine fishery is open and determine if an adequate amount of biological information is being collected.

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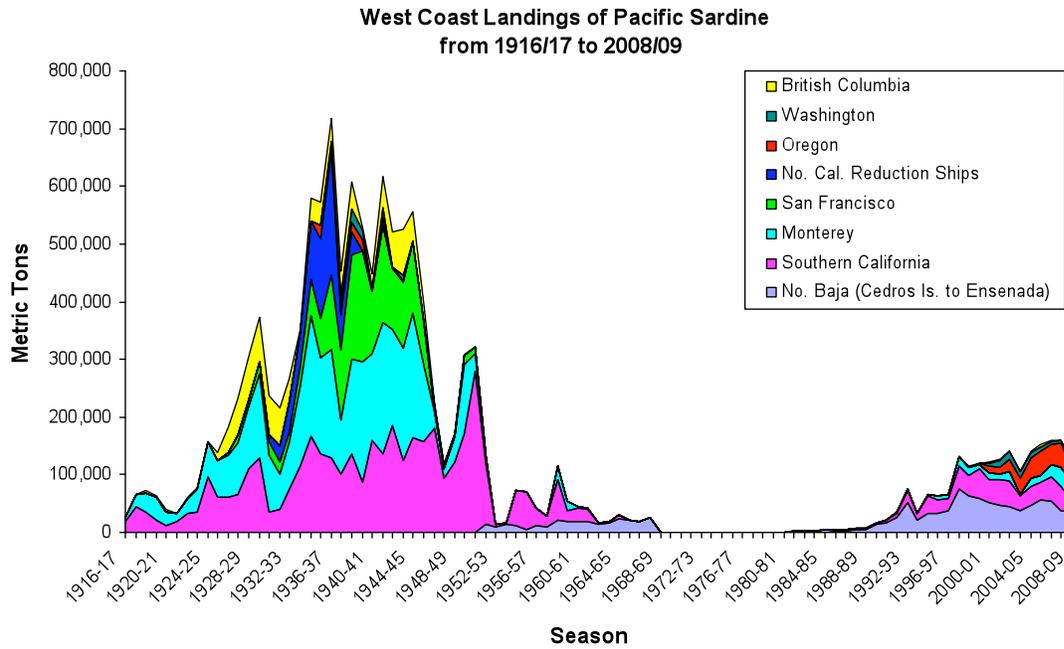


Figure 1. Coastwide historical landings of Pacific sardine (metric tons) by season (June –May) 1916-1917 through 1967-1968 from Radovich (1982), 1968 -2009 from PacFIN, Hill et al. 2009.

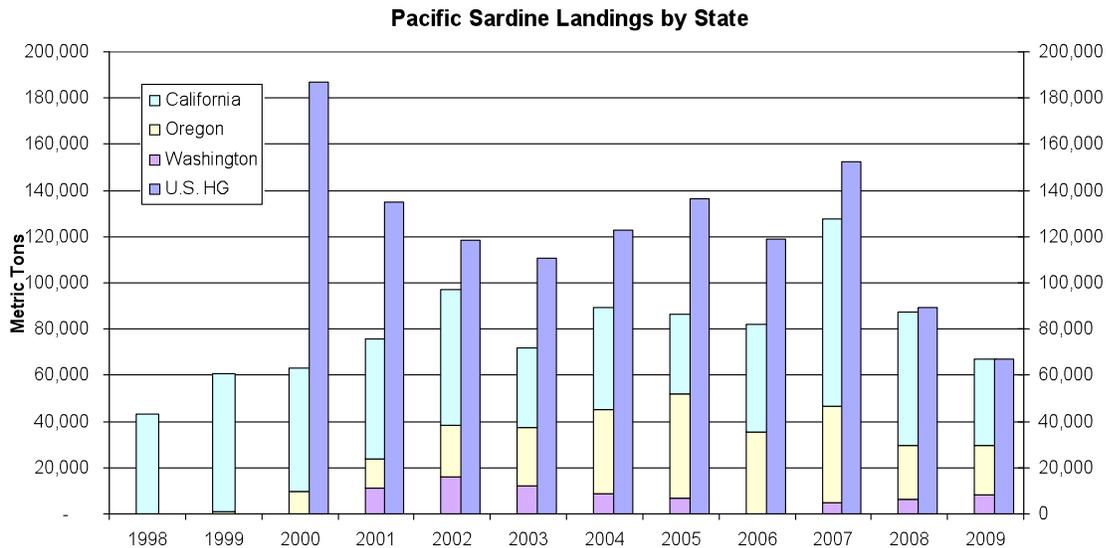


Figure 2. Annual landing of Pacific sardine by state compared to the U.S. harvest guideline from 1998-2009 (from Hill et al. 2009).

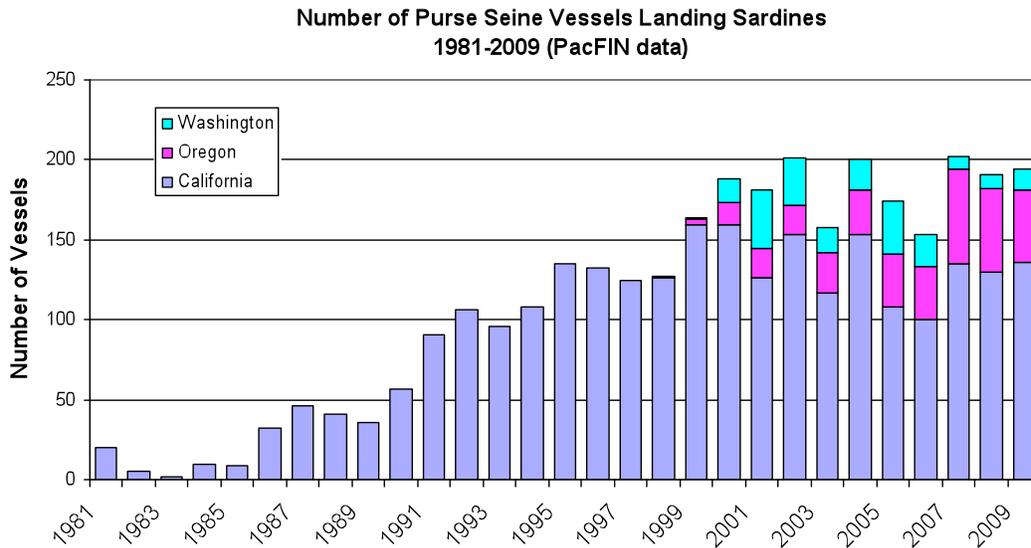


Figure 3. Number of vessels landing Pacific sardine along the U.S. west coast from 1981-2009 (data from PacFIN).

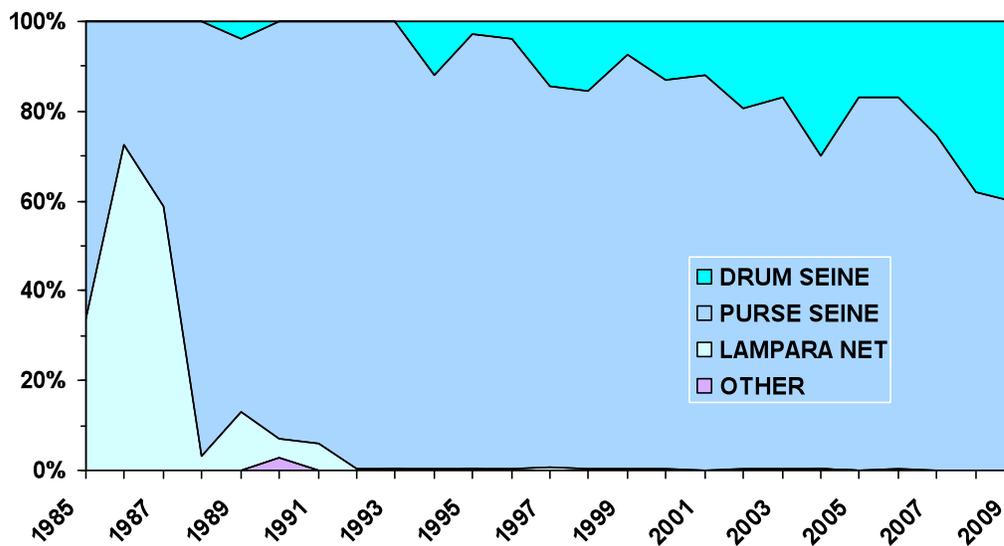


Figure 4. Percentage of gear type used to land Pacific sardines in California from 1985 to 2009 (data from the California Fisheries Information System - CFIS).

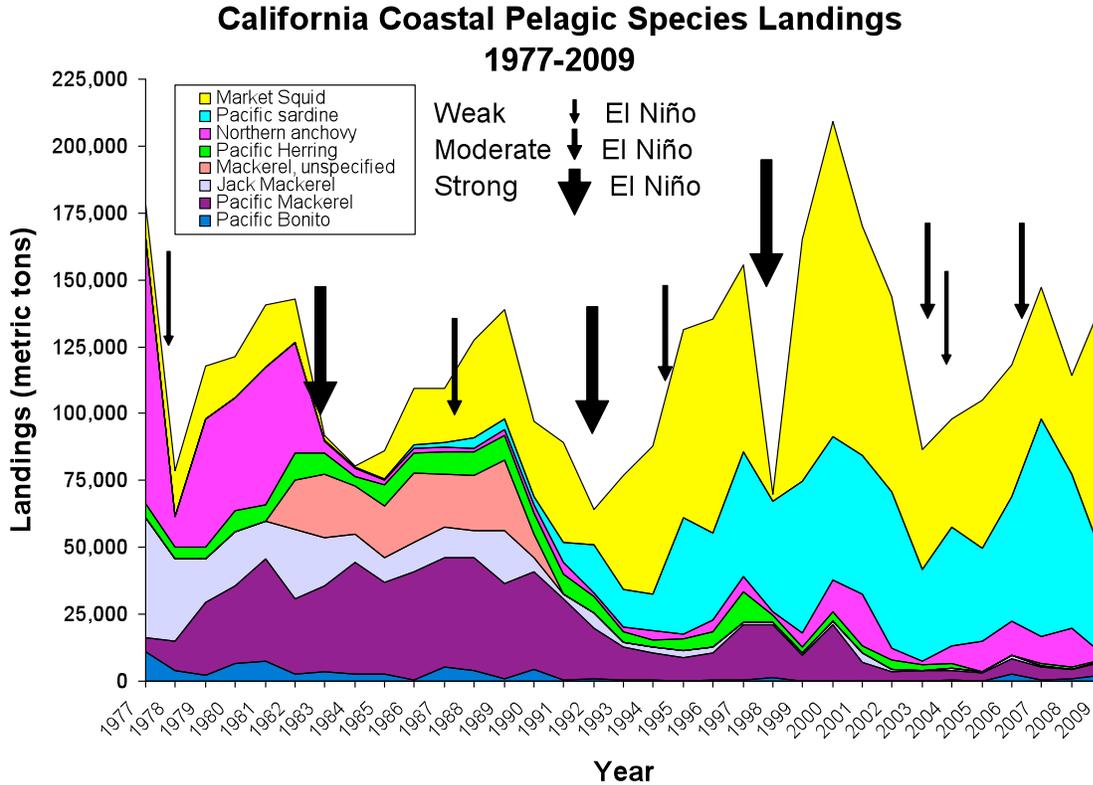


Figure 5. California coastal pelagic species landings from 1977 to 2009 (CFIS) with arrows indicating timing and magnitude ENSO events (see NOAA <http://www.cpc.noaa.gov/products/precip/CWlink/MJO/enso.shtml>).

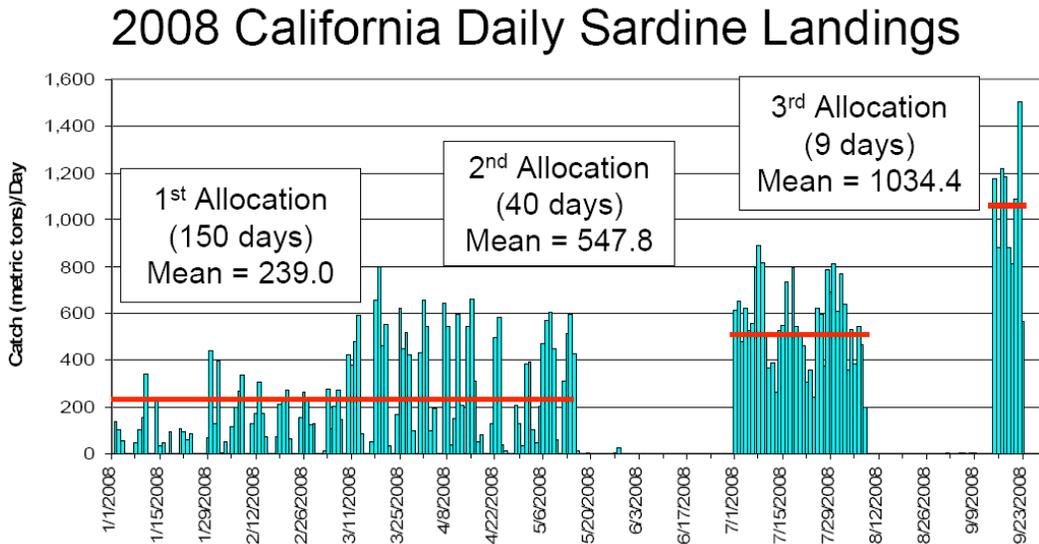


Figure 6. Daily landings (metric tons per day) of Pacific sardines in California for 2008 (CFIS). Red lines represent the average daily landings per allocation period.

### 2009 California Daily Sardine landings

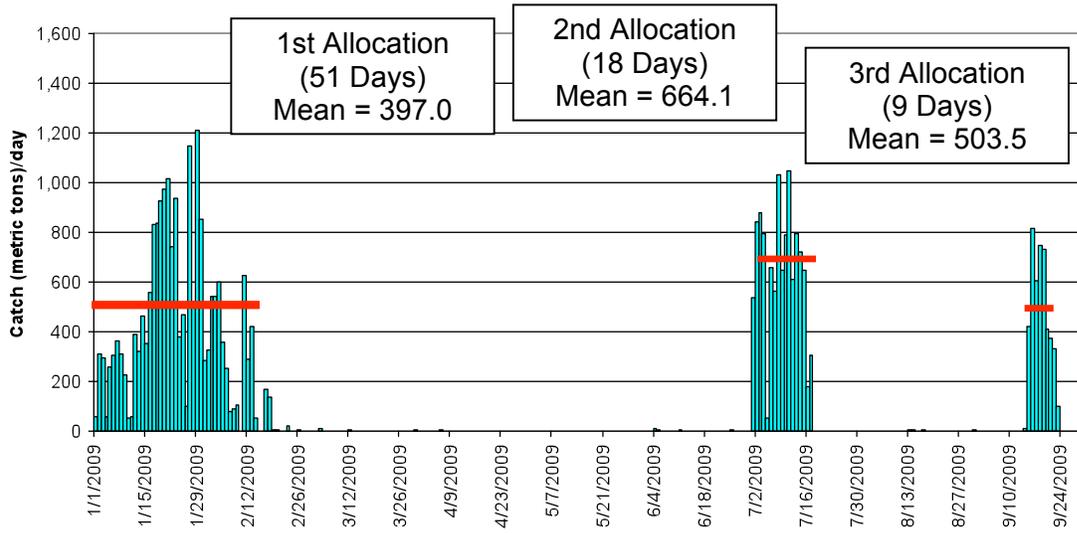


Figure 7. Daily landings (metric tons per day) of Pacific sardines in California for 2009 (CFIS). Red lines represent the average daily landings per allocation period.

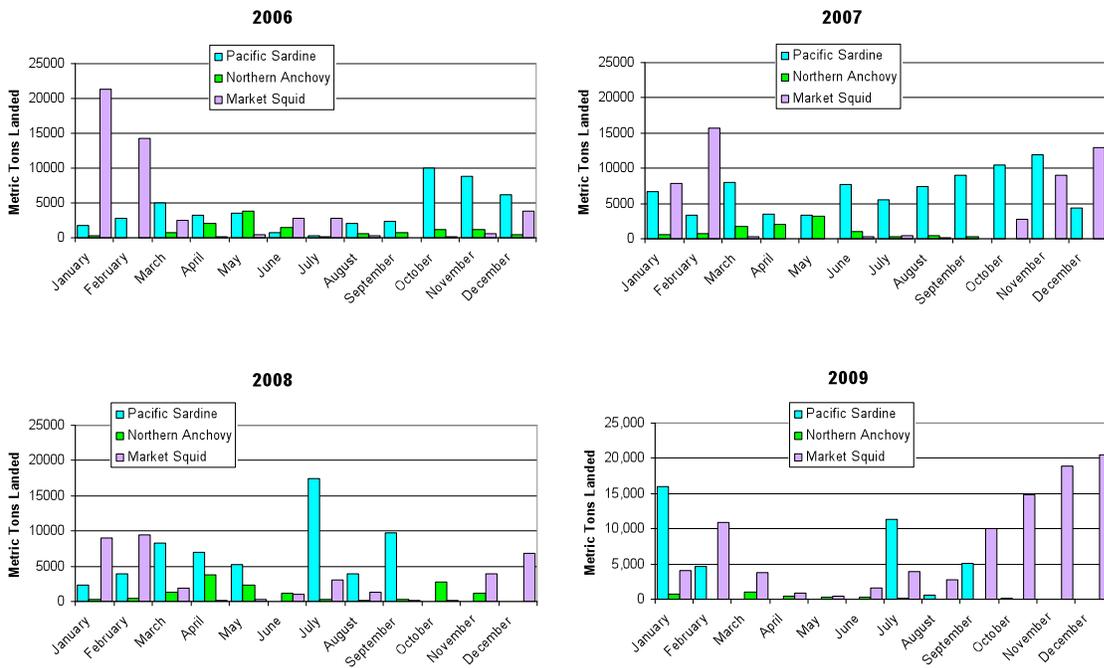


Figure 8. Monthly landings (metric tons) of coastal pelagic species in California by year from 2006 to 2009 (CFIS).