# CALIFORNIA WHITE SEABASS STOCK ASSESSMENT IN 2016


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## Stock Assessment Executive Summary for California White Seabass

### Modeling Approach

An integrated sex-specific statistical age-structured model with sex-specific growth estimated within the model was implemented using the stock assessment platform Stock Synthesis to assess white seabass (*Atractoscion nobilis*) from California, USA. Alternative model runs were conducted covering white seabass dynamics between 1889-2014 and 1969-2014. Owing to the lack of sex specific information in size composition data and the lack of age data, except conditional age at length, the same natural mortality and selectivity for females and males was used. The model is fit to several relative indices of abundance: Commercial Passenger Fishing Vessel (CPFV) historic (pre-1980), CPFV modern (post-1980), drift gillnet logbook catch-per-unit-effort (CPUE), set gillnet logbook CPUE, Hubbs SeaWorld Research Institute (HSWRI) gillnet CPUE and Power Plants Heat Treatment CPUE. The model is also fit to length composition data for hook and line, drift gillnet and set gillnet commercial fisheries. For the recreational sector the model was fit to lengths from CPFV observers (modern and historic) and lengths from a combined “other recreational” group. Length compositions from HSWRI gillnet surveys and Power Plants Heat Treatment were also fitted to the model. Conditional age at length from HSWRI was also fitted to the model.

### Catches

White seabass have been exploited for more than 125 years. The first quantitative records date back to 1889 (Figure a). Even if catches are combined at that time with Mexico, assuming that the California/Mexico share was similar to more reliable records post 1916, the total calculated catches around 1900s were in the same order as catches during the decade leading to this study. Alternative model runs were conducted covering white seabass dynamics between 1870-2014, 1889-2014 and 1969-2014 using alternative assumptions for initial catches (Figure b). An equilibrium catch was calculated prior to 1969 for each commercial fleet by distributing the average 1889-1968 catches among the commercial fleets present in 1969, proportional to landings in 1969, and estimated initial equilibrium fishing mortalities. An initial equilibrium catch was calculated for the CPFV in a similar way to the commercial, and also estimated its initial equilibrium fishing mortality.

*Figure a. Total landings in metric tons (mt) from 1889 to 2014 by fleets as defined in the stock assessment model: Commercial historical (HistCom), Hook and Line (HL), Drift Gillnet (Drift), Set Gillnet (Set), Historic Commercial Passenger Fishing Vessel (CPFV_H), Modern Commercial Passenger Fishing Vessel (CPFV_M), Other Recreational (OtherRec)*

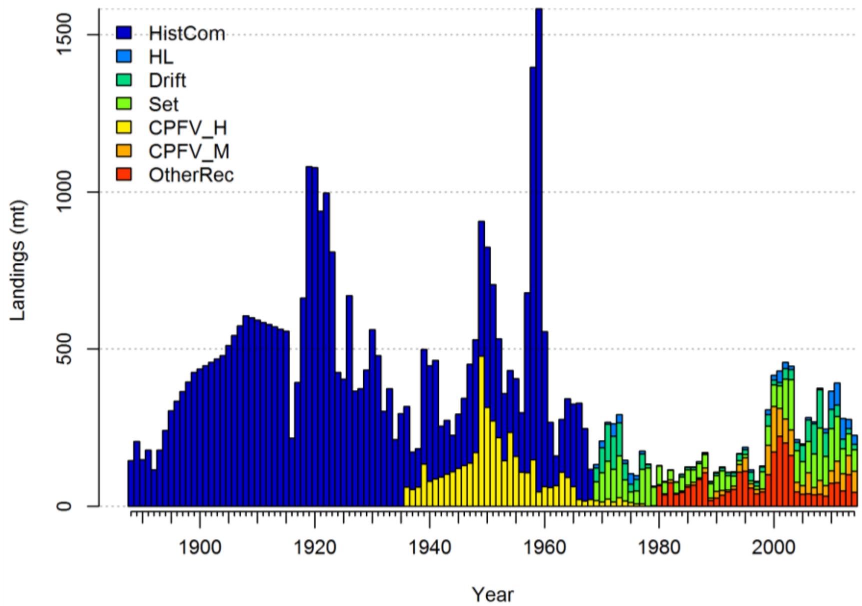
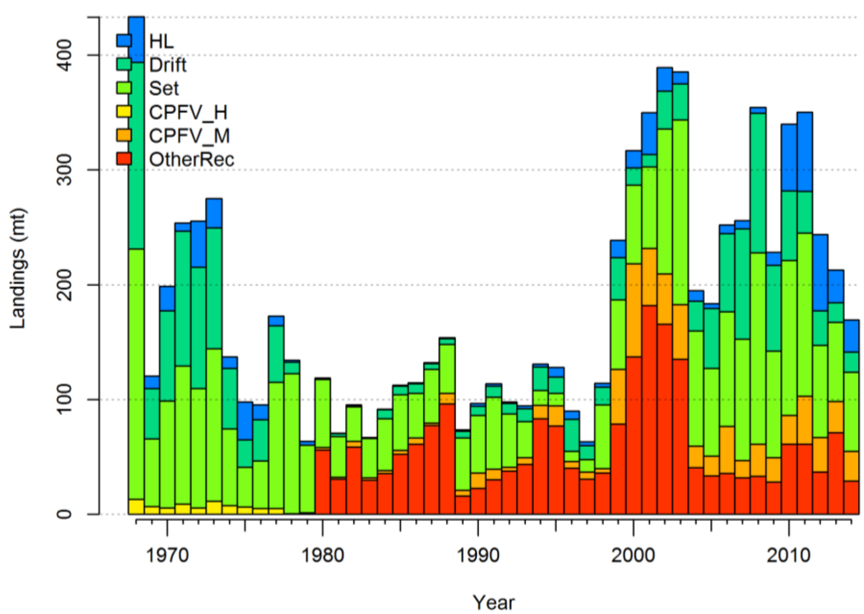



*Figure b. Total landings in metric tons (mt) from 1969 to 2014 by fleets as defined in the stock assessment model.*




## Results

The base model estimates of growth are consistent with external estimates from previous works. The selectivity estimates appear reasonable based on a priori examination of the size compositions for the different fisheries and surveys and examination of the fit to the length compositions by fleet aggregated throughout time. Fit to the length composition data was reasonably good, both when aggregated across years and less so on a year by year basis.

The base-case model estimates extremely low spawning biomass during the 1970s. This does not necessarily imply that biomass was that low, but could instead be indicative of a violation of the closed population assumption of the assessment. There is evidence of transboundary movements between US-Mexico, so it could be also indicative of changes in availability of the stock, with portions leaving the assessment area.

Under Pacific Fishery Management Council (PFMC) Groundfish management policy, if the current spawning biomass of a stock falls at or below 25% of the unexploited biomass, the stock is considered overfished. The base case model estimates white seabass female spawning biomass in 2015 at 569 mt (~95% asymptotic interval: 241- 896 mt) (Figure c). Virgin unfished female spawning biomass (*B0*) is estimated at *B0*: 2092 mt (~95% asymptotic interval: 1600 - 2584 mt). The base case model estimates 2015 depletion at 0.27 (~95% asymptotic interval: 0.16- 0.39). This level is below what would be a PFMC biomass target of 40% depletion, but above what would be a PFMC minimum stock size threshold of 25% biomass depletion. White seabass biomass is estimated to be decreasing over the last 9 years (Figure d). However, under California State guidelines (set in the white seabass fisheries management plan (CDFG, 2012)) white seabass would be considered overfished only if three conditions are met simultaneously: 1) total annual commercial catch of white seabass in pounds landed (from fish receipt data) for two consecutive years declines each year by 20% or greater from the prior five-year average of landings; 2) a 20% decline occurs in the number of fish and average size of fish (round weight) for the same two consecutive years for white seabass caught in the recreational fishery as determined from the best available data and 3) recruitment of juvenile white seabass declines each year by 30% or greater from the prior five-year average of recruitment as determined from the best available data.

Maximum Sustainable Yield (MSY) is estimated by this stock assessment at less than half of that reported by previous works and to occur at a relatively low fraction of the unexploited female spawning biomass. The base case model estimates a MSY of 307 mt (95% asymptotic CI: 238 - 376 mt), corresponding to a female spawning biomass ($B_{MSY}$) of 447 mt (340 - 554 mt) and to a depletion of 0.24. Estimated MSY depends on the size of fish caught, natural mortality (*M*), growth and the productivity shape of the spawning stock curve determined by steepness (*h*). There is uncertainty about many of the biological and fishing processes including the stock-recruitment relationship, natural mortality, growth, maturity, survival of discarded fish. MSY was estimated for a range of fixed values of *M* and *h*. Alternative values of MSY ranged between 294 and 475 mt for alternative values of *M* (Figure 7-2, top) and between 260 and 336 mt for alternative values of *h*.

Sensitivity analyses included a comparison of key model assumptions and were based on nested models including asymptotic vs. domed selectivity, alternative values of *M*, *h*, proportional vs. non-proportional relationship between indices of abundance and biomass and changes in catchability for commercial gillnets. Runs modelling dynamics between 1889 and 2014 (*Historical*), were conducted, contrasting with the base-case model 1969 to 2014 (*Modern*) time frame. Historical models were unstable and had convergence issues. Sensitivity analyses showed that the general results in terms of estimated population trajectories did not change markedly, although the estimated scale of the population showed some variability.

## Research Needs

Additional research on the CPFV datasets are needed, including information on CPFV trips that catch nothing, more information on targeted species from CPFV trips, and better analysis of spatial information on fishing effort and catch. Additional work on parsing out the (non-CPFV) recreational components of the data is needed. More information on mortality from other fisheries not targeting white seabass, but catching them as bycatch, is needed. Collection and processing of otoliths for estimating age compositions of the catch of different gears, including gender-specific age sampling of commercial and recreational fishery catches and discards would allow for alternative estimates of sex or age specific selectivity. The available maturity information for white seabass is very limited. Additional data should be collected on the relationship between fish size and maturity state. Age data should also be collected to determine maturity at size and/or age. The rationale behind the use of a minimum size limit is allowing the fish to spawn before being killed. Limited, more recent maturity information supports a size at maturity larger than the one used to provide the rational for the current minimum size limit. Given the current use of a minimum size limit, undersized white seabass caught by recreational and commercial fisheries are released or discarded. Collection of discard data, both regarding the amount, size/age/sex compositions and survival of discarded fish would allow the estimation of retention curves and better estimation of total mortality of the stock. In addition to exploring the effect of alternative size limits, it is recommended to explore impacts of alternative potential harvest strategies (including selectivity, alternative size limits and/or seasonal closures, total catch, etc.). Sampling and estimation of the relationship between fork length and total length of white seabass is needed to convert between the two data types. There is evidence of white seabass transboundary movements, both seasonal and inter annual, between Mexico and USA. Collaborative work between researchers of both countries is expected to increase understanding of white seabass dynamics under exploitation including: life history, history of catches, and interpretation of relative abundance indices in years where oceanographic conditions are suspected to affect distributional changes across the border. Timely updates to this stock assessment (the first for this species) are recommended given the large changes in estimated biomass, the ongoing 9-year decline in spawning biomass, current depletion levels and the lack of updated data up to the final year of the model for some of the indices used in the assessment.

*Figure c. Time series of estimated female spawning biomass with 95% asymptotic confidence intervals. The blue dot before the start of the time series is the estimated equilibrium virgin unfished female spawning biomass (B0) with 95% asymptotic confidence interval.*

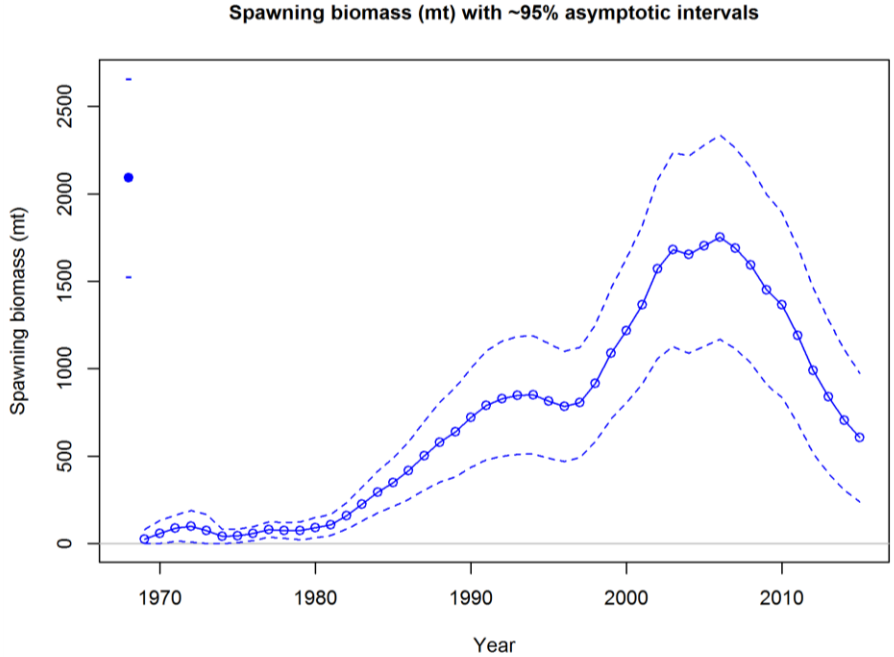



*Figure d. Estimated female spawning biomass depletion with 95% asymptotic confidence intervals.*

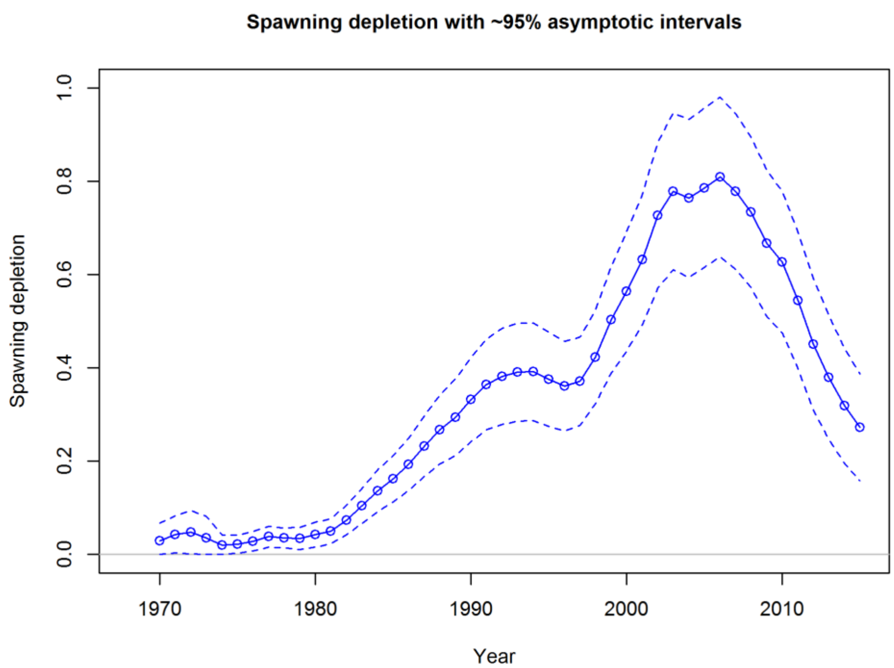


*Figure e. Time series of estimated age-0 recruits with 95% asymptotic confidence intervals. The blue dot before the start of the time series is the estimated equilibrium unfished average recruitment (R0) with 95% asymptotic confidence interval.*

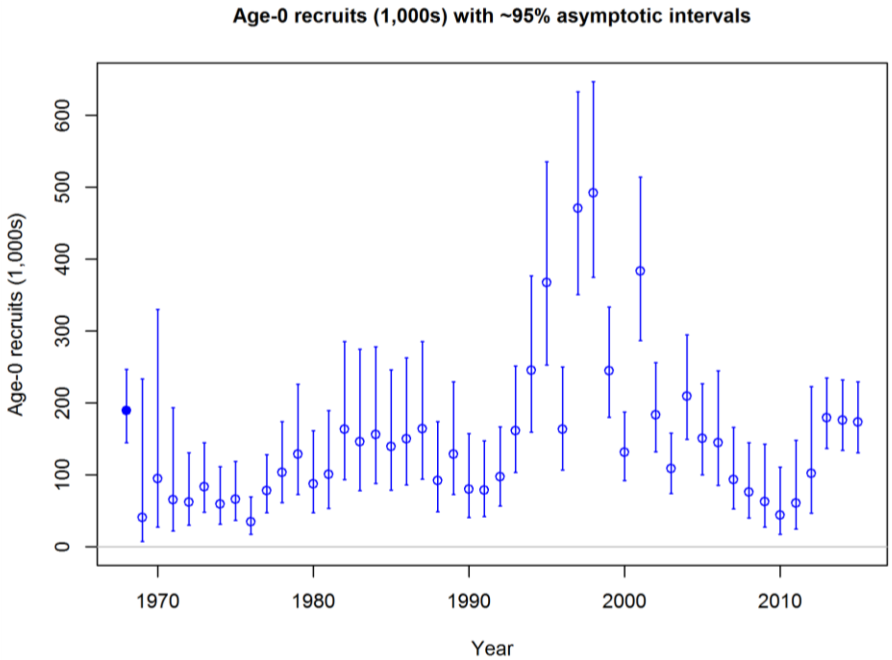
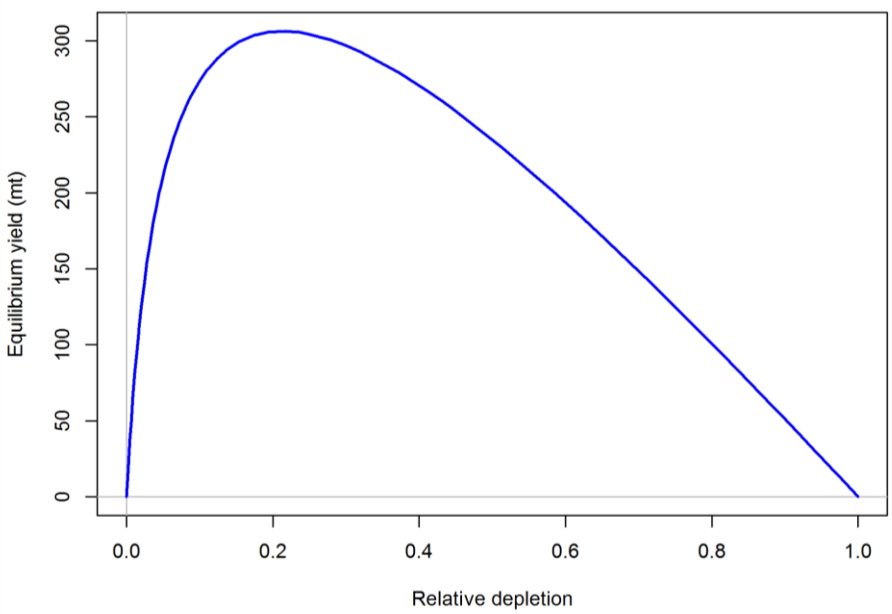



*Figure f. Equilibrium yield (metric tons) curve versus relative depletion.*



# 1. Stock Assessment Team

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# 2. Introduction

The white seabass (*Atractoscion nobilis*), previously known as *Cynoscion nobilis*, is the largest member of the croaker family (Sciaenidae) found along the US West Coast. The species was first described in 1860 by W. O. Ayres (Thomas, 1968; Skogsberg, 1939). The maximum weight is over 80 pounds (36 kg) and greater than 4 feet long, while an average fish from the commercial fishery is typically between 20 (9 kg) and 40 pounds (18 kg) (Young, 1979).

White seabass have been harvested by humans for thousands of years. The otoliths were used by coastal Indians as lucky stones and the fish itself was consumed (Young, 1973). The modern commercial fishery dates back to at least the 1880s and the recreational fishery dates back over 130 years (Vojkovich and Reed, 1983). Historically, the majority of the catch of white seabass was landed further north; in 1889 nearly 75% of the catch was landed in San Francisco (Skogsberg, 1939). However, by the 1920s, the majority of the catch (>80%) was being landed in Southern California, and presently most of the catch is from south of Point Conception. This shift in catch coincides with a shift in the bulk of the human population being located in San Francisco to further south, in Los Angeles, over the same fifty years (Skogsberg, 1939). However, it has been claimed that most likely a combination of changing hydrographic conditions and overfishing also played a role in the disappearance of white seabass from the northern extent of its range (Skogsberg, 1939).

The commercial catch of white seabass has been conducted with gillnets (both set and drift), round haul nets, lampara nets, purse seine nets, and some hook and line. Purse seining was often done at night as the schools of white seabass were easy to locate from their disturbance of bioluminescent organisms, creating an intense glow as the school was startled by a boat (Skogsberg, 1939). After 1924 purse seins were used less and less, as they were no longer economically feasible (Young, 1973). The use of purse seines was restricted in 1939 due to their effectiveness of targeting aggregations of white seabass at night (Skogsberg, 1939; Vojkovich and Reed, 1983). Historically, much of the Mexican-caught white seabass was taken by purse seiners (Skogsberg, 1939), and a considerable but unknown amount of white seabass are still harvested by purse seine in Mexico. The sea-bass fishery of central California had declined before more effective purse seine methods had become highly developed in California (Skogsberg, 1939).

Recreational (sport) fishermen primarily fish by hook and line. Other species that they may target when fishing for white seabass include barracuda, kelp bass, and yellowtail (Skogsberg, 1939). Some free-divers also use spears to target white seabass. The commercial and recreational fisheries overlap spatially (Young, 1973).

# 3. Management History

As of the 2015-2016 Season, the recreational fishery for white seabass (*Atractoscion nobilis*) remains open year-round. The daily bag and possession limit is three fish except that only one fish may be taken in waters south of Point Conception between March 15 and June 15. The minimum size limit is 28 inches (71 cm) total length or 20 inches alternate length (California Department of Fish and Wildlife (CDFW) website, http://www.dfg.ca.gov/marine/mapregs5.asp#seabass, May 24, 2015). Current management of the commercial fishery includes: mandatory logs for the CPFV fleet; all commercial fishermen who take white seabass south of Point Arguello are required to purchase the Ocean Enhancement Stamp; size and season limits. In the commercial fishery, south of the line extending west from Point Conception, white seabass may not be taken for commercial purposes between March 15 and June 15 (inclusive). The minimum size limit is 28 inches in length from the tip of the lower jaw to the end of the longer lobe of the tail. In the commercial fishery when white seabass is taken incidental to gill and trammel net fishing on trips lasting one calendar day, they are allowed to possess one white seabass not less than 28 inches in length; however, this fish may not be transferred to another vessel. If the trip lasts more than one calendar day, they can still only have one fish not less than 28 inches. White seabass may be taken by gill or trammel nets with meshes of a minimum length of six inches, however, during the period from June 16 to March 14, inclusive, not more than 20 percent by number of a load of fish may be white seabass 28 inches or more in total length, up to a maximum of 10 white seabass per load, if taken in gillnets or trammel nets with meshes from 3 1/2 to 6 inches in length.

Vojkovich and Reed (1983) provided a table of regulations, which CDFW updates in Table 4-1 of the White Seabass Fishery Management Plan (2002) (here Table 3-1). The White Seabass Fishery Management Plan Annual Reviews were searched for additional updates to management regulations.

*Table 3-1. History of regulations for White Seabass in the state of California. Modified from California Department of Fish and Game (now California Department of Fish and Wildlife) White Seabass Fishery Management Plan 2002, which was adapted from Vojkovich and Reed 1983.*

| Date | Season | Size Limit | Bag Limit | Gear/Area Restrictions | Special Conditions |
|---|---|---|---|---|---|
| 1931-33<br><br>(Commercial license required) | July 1- April 30 | Commercial: >28”; no more than 5 fish <28” | None | No nets within 4-mile radius of San Juan Pt., Orange Co.; bait nets only in Santa Monica Bay. | 5 fish any size with hook & line, but may not be sold |
| 1933-35<br><br>(same) | Hook & line all year | Same | May 1- June 30 (5 per day- hook & line) | Same | After Oct. 25, 1933, no fish may be sold from May 1- June 30. |
| 1935-37<br><br>(same) | No net fishing May 1- Aug 31 | Same | May 1- Aug 31 500 lbs/person; 2500 lbs/boat | No nets in any Orange Co. waters (later rescinded) | Same |
| 1937-39<br><br>(Commercial license same.<br><br>Sportfishing | Same | Commercial and Sportfish: >28”; no more than 5 fish <28” | Sportfish: 15/day for anyone on sportfish boat | Same | Sport-caught fish may not be sold |

| | | | | | |
|---|---|---|---|---|---|
| license required- White seabass officially considered a "game fish" under the Anglers License Act, which make it a misdemeanor for any person over 18 years of age to take, catch, or kill any "game fish" for any purpose other than profit, without first purchasing a license.) | | | | | |
| 1939-41<br><br>(same) | Year round net fishing allowed | Same | Same | No purse seines. Gillnet mesh >3 ½" | Same |
| 1941-49<br><br>(same) | Same | Same | Same | Same | Same |
| 1949-53<br><br>(same) | Same | Same | Sportfish: 10/day | Same | Same |
| 1953-57<br><br>(same) | Same | Same | Commercial: 1000 lbs/person/day; 5000 lbs/boat/day | Same | Same |
| 1957-71<br><br>(same) | Same | Sportfish: 2 fish <28" | Sportfish: 10/day | Same | Same |
| 1971-73<br><br>(same) | Same | Commercial and Sportfish: No fish <28" | Same | Same | Same |
| 1973-78<br><br>(same) | Same | Commercial and Sportfish: One fish <28" | Same | Same | Same |
| 1978<br><br>(same) | Same | Com'l and Sport: No fish <28" | Same | Same | Same |
| 1980-81<br><br>(same) | Season closed Mar 15-Jun 15 (commercial) | Same | Sportfish: 3/day/person | Same | Logs required<br><br>Permits required |
| 1982<br><br>(same) | Same | Same | Same | Area closures for nets with mesh less than 6" | Permits no longer required<br><br>US Fishing vessels no longer able to fish in |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Mexican waters under Mexico's Foreign Fishery Act. In order to fish in Mexico a fish business has to have 51% Mexican ownership. |
| 1984<br><br>(same) | Same | Same | Sportfish: 1 white seabass during closed season (March 15 – Jun 15) south of Point Conception | Same | Same |
| 1994<br><br>(same) | Same | Same | Same | No Gill or trammel nets allowed 0-3 miles from shore along the mainland, or within 1 mile or waters less than 70 fathoms deep at the offshore islands from Point Arguello, Santa Barbara County to the United States- Mexico Border, and in waters less than 35 fathoms deep from Point Fermin, Los Angeles County to the south jetty Newport Harbor, Orange County. | Same |
| 2000<br><br>(same) | Same | Same | Commercial: 1 fish during closed season | Same | Same |
| 2002<br><br>(same) | Same | Same | Same | No gill or trammel nets allowed in waters less than 70 fathoms deep from Point Reyes, Marin Co, to Point Arguello, Santa Barbara Co. | Same |
| 2009<br><br>(same) | Same | Same | Same | Same | Before start of 2009-2010 season CDFW distributed brochure to recreational fishers aiming to increase compliance of no fish less than 28" |

Commercial catch is reconstructed from 1889 using catch from commercial landings receipts and historic records (Figure 3-1). The present day commercial catch is dominated by 3 gear types: hook and line, drift net, and set net. There is some commercial fishing by other means but this is lumped in with set net for the purpose of this assessment. Recreational catch is reconstructed from 1936 using CPFV logbook data from the historical record (1936 to 1979) and the modern record (1980 to 2014). Additional recreational fishing catch comes from the RecFIN database, using all mode of fishing other than CPFV. Looking at the recreational catch along with recreational management regulations (Figure 3-2), some instances of catch decreasing after certain regulations are evident (e.g., requiring a permit to fish in Mexico).

*Figure 3-1. Plot of commercial catch from historic database, hook and line, drift net, and set net combined with all other means for white seabass in the state of California. Overlaid are key management regulations for the commercial fishery.*

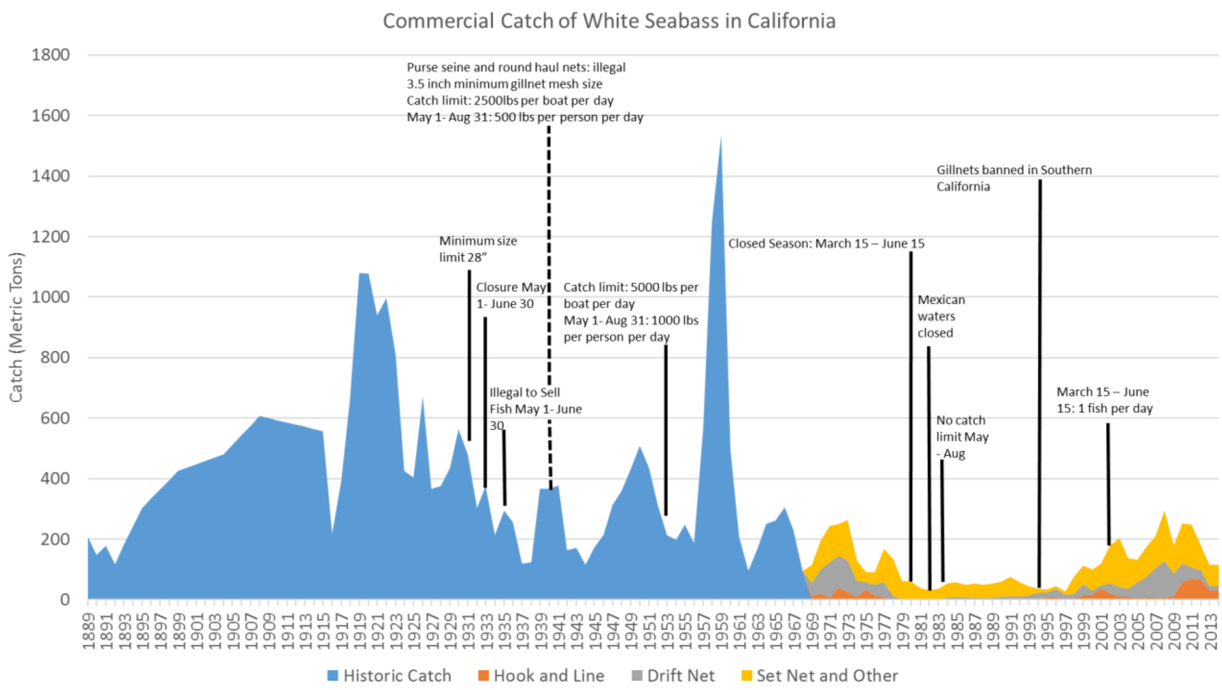
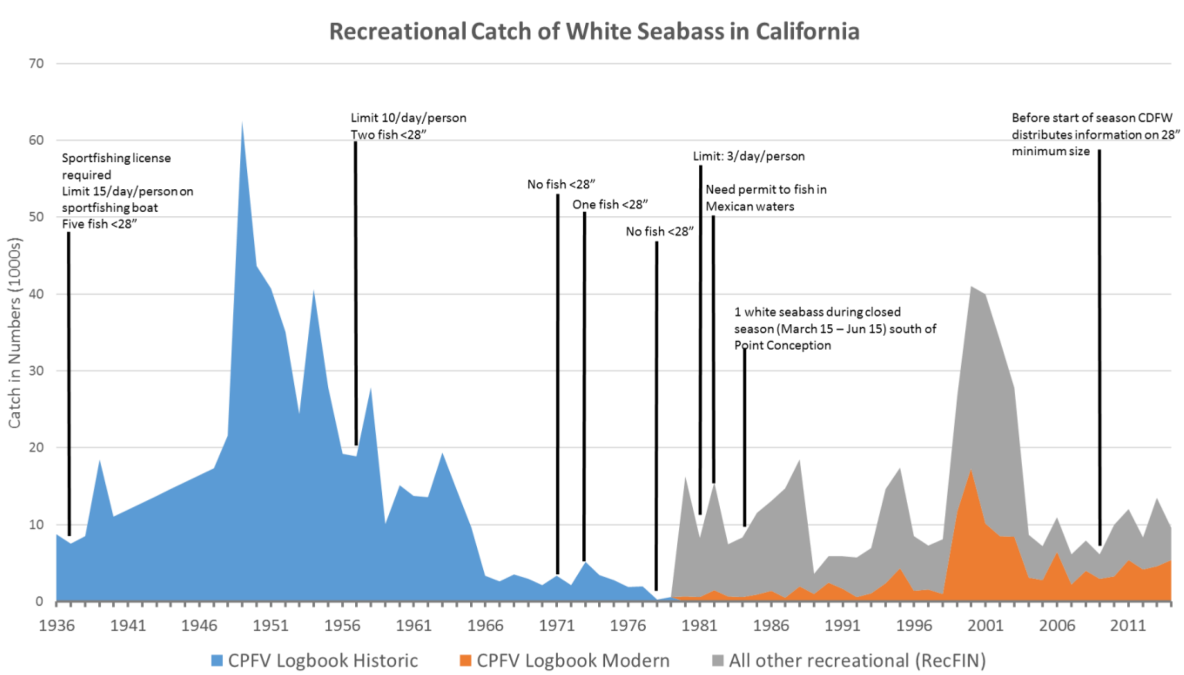



*Figure 3-2. Plot of recreational catch from historic CPFV logbook, modern CPFV logbook, and RecFin data for white seabass in the state of California. Overlaid are key management regulations for the recreational fishery.*



# 4. Data and Biological Characteristics

## 4.1. Catch Data Types

The catch data comes from the commercial and recreational fleets. For the recreational fishery, there is catch from CPFV logbooks (broken into a historical and modern datasets), CPFV observers (2 datasets, one from the 1970s and one from 1980s), and RecFIN data which includes a subsample of CPFV data.  RecFIN data represents a subsample of recreational fishing in California and an expansion algorithm is applied to that data to generate total catch. Data sources representing the commercial fleets come from gillnet logbooks (which include set and drift gillnets) and commercial landings receipt data. Gillnet observer data were also considered for this assessment but were not used because there was essentially no data on white seabass in this data file.

The state of California, specifically CDFW, has designated fishing zones for California, a block of roughly 10 nautical miles by 10 nautical miles, herein referred to as ‘fishing blocks’ or ‘blocks’.  The blocks start in Washington (100-level) and then move into northern California (200-level) and become higher in number to the south (Figure 4.1-1, Figure 4.1-2, and Figure 4.1-3).  This report refers to blocks at the100-level resolution between 600-800, which represents southern California.  For instance, both block 141 and 199 are in the 100 block.  Blocks in the 900-level are located in Mexico. Blocks numbered 3028 are outside of California state waters in the US and blocks numbered 3900 are 5km offshore of Mexico, in Mexican federal waters.

*Figure 4.1-1. Northern California fisheries chart from CDFW.*

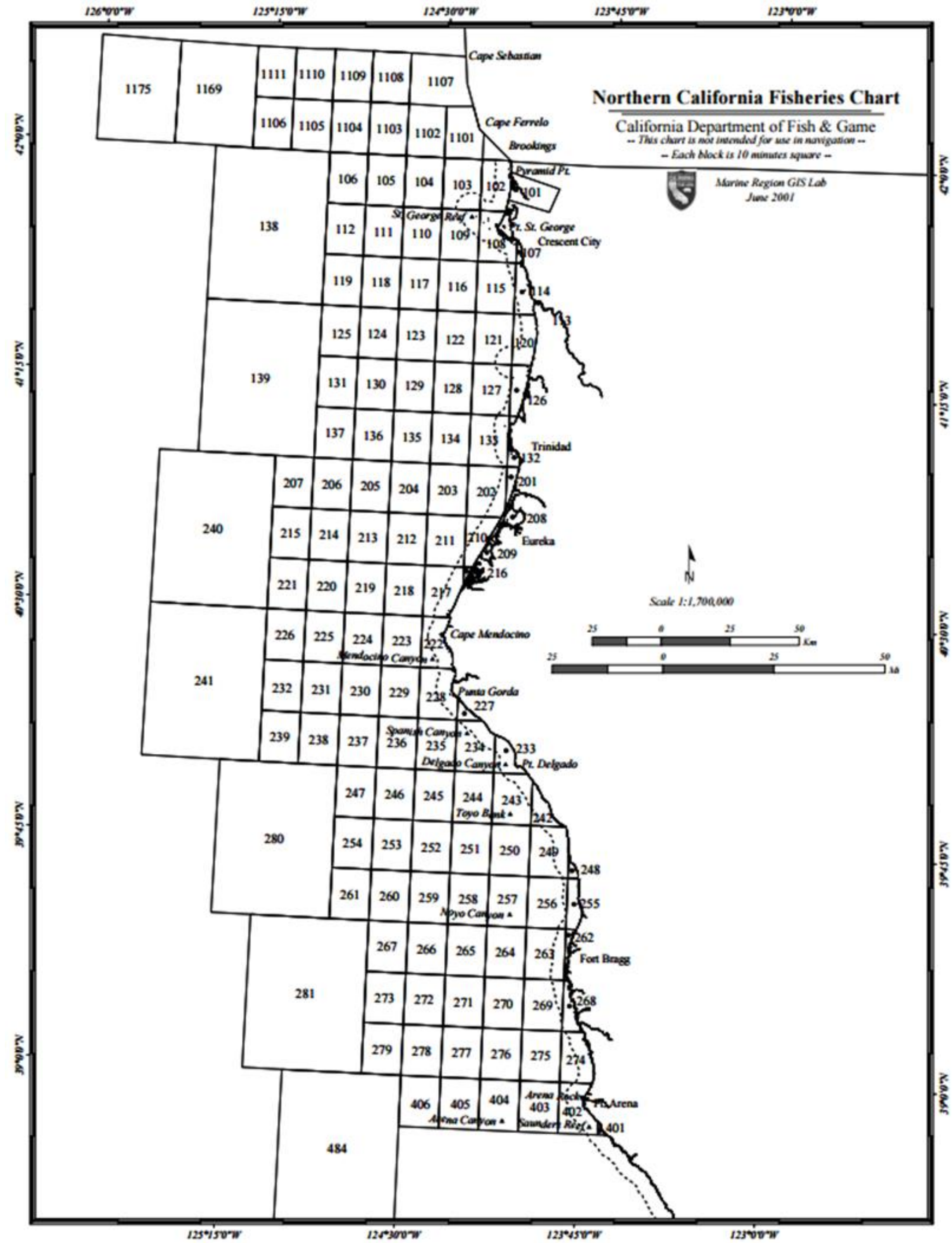


*Figure 4.1-2. Central California fisheries chart from CDFW.*

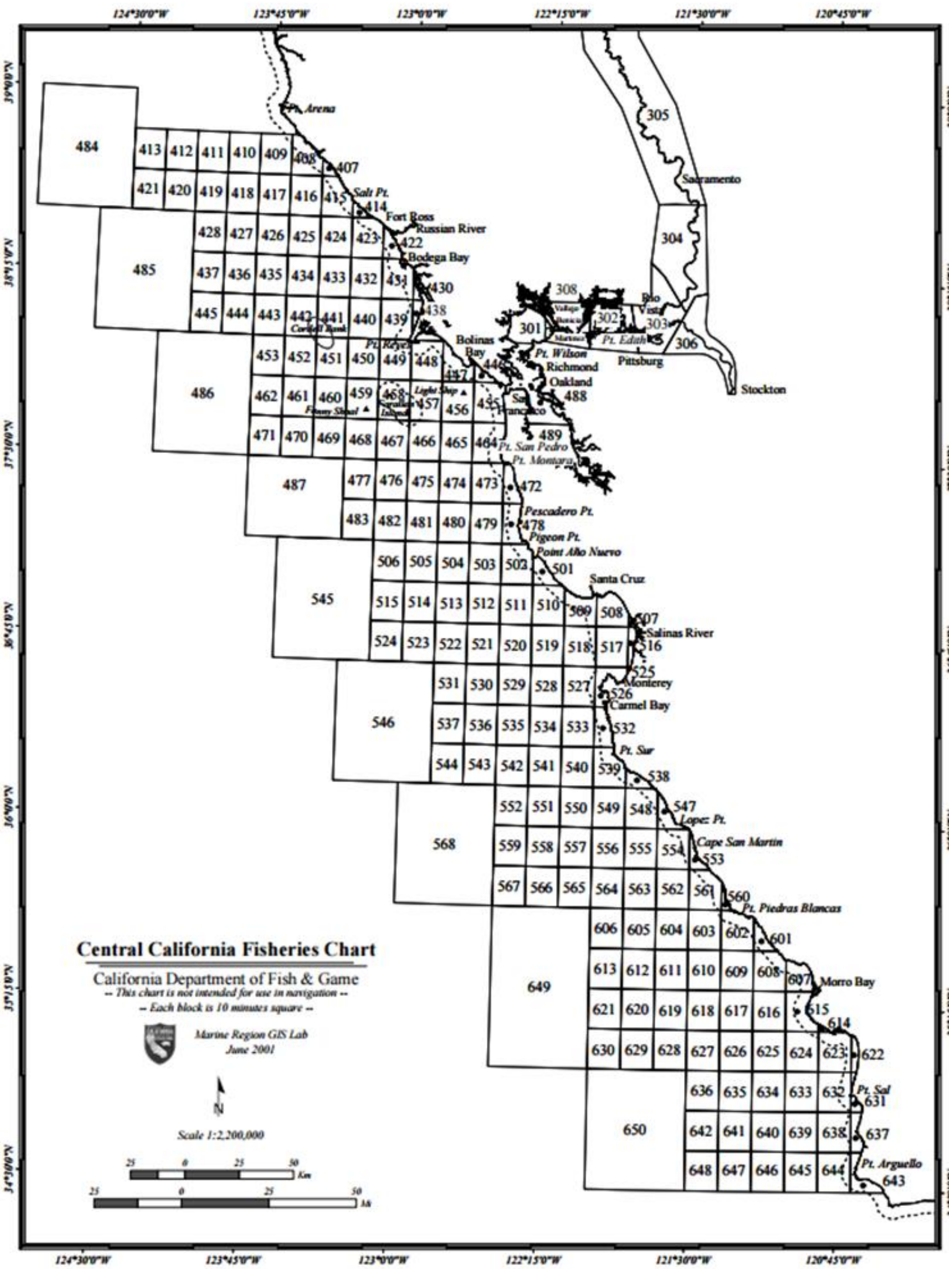
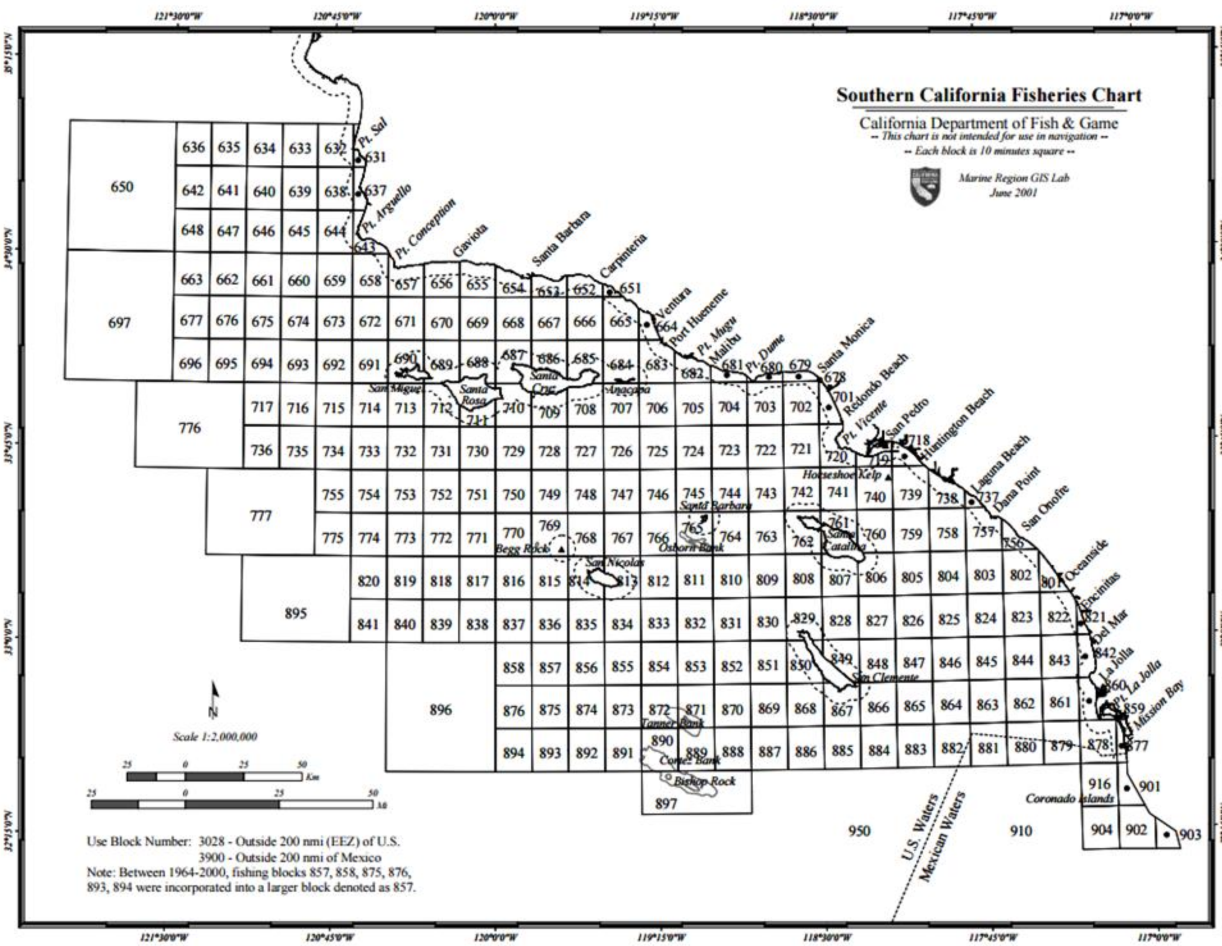


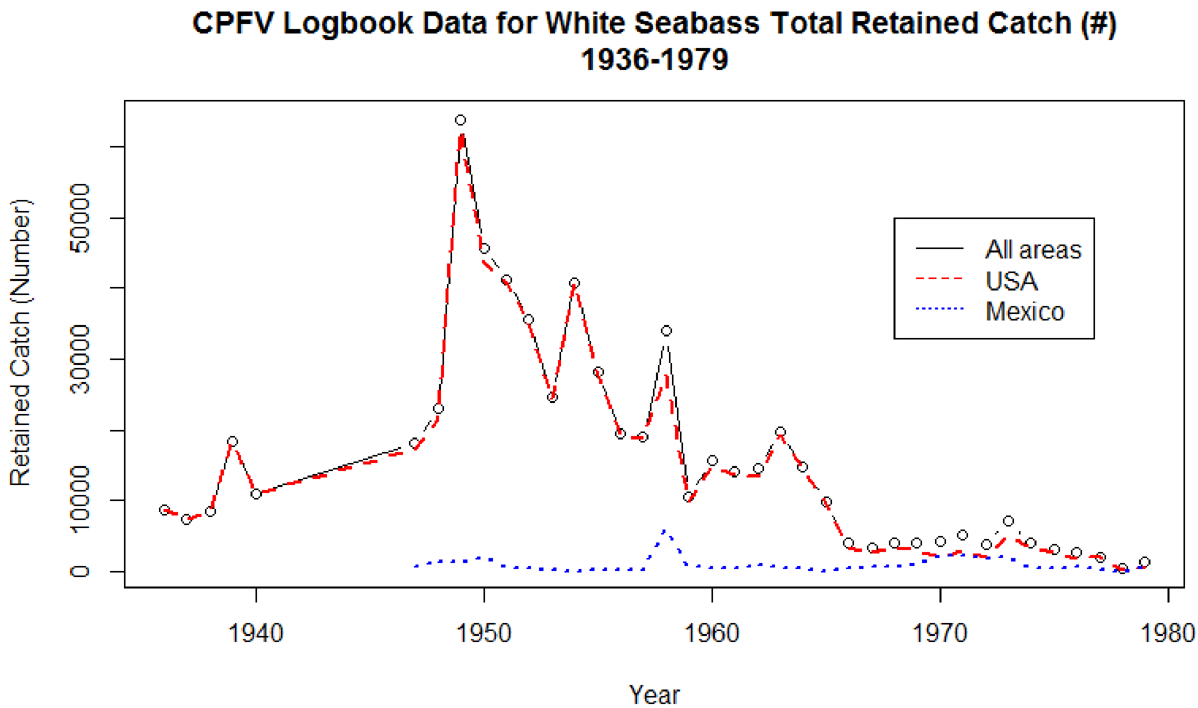
*Figure 4.1-3. Southern California fisheries chart from CDFW.*




## 4.1.1. Catch from CPFV Logbook Data

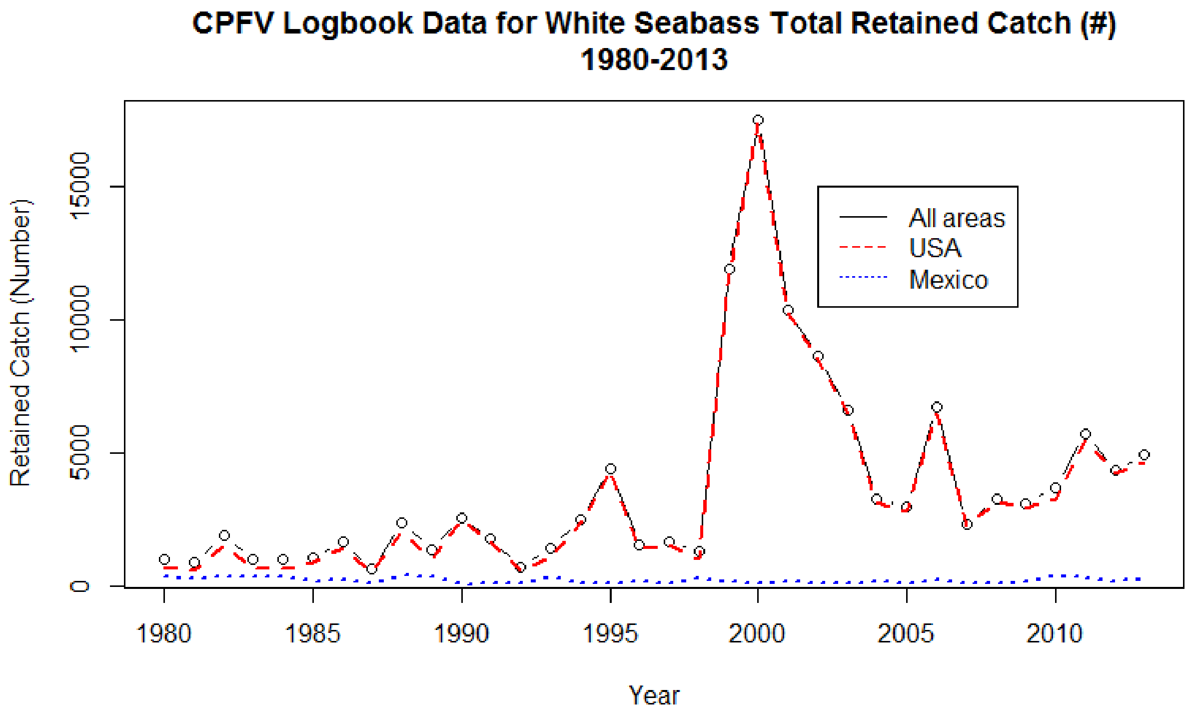
CPFV logbook data was provided by the CDFW. Logbook data has been required from the CPFV fleet by CDFW since 1936 (Figure 4.1.1-1). Skippers from the boat provide the data including which fishing block they targeted, date of fishing, and numbers caught. The data is divided into two time ranges, historical from 1936 to 1979, and the more recent dataset, referred to here as 'modern CPFV', covering the years 1980-2013 (Figure 4.1.1-2). The effort data is compiled in a different manner for the two time periods. For the historical CPFV logbook data the effort is tabulated by month each year on a fishing block basis. The catch for the historical CPFV logbook data is tabulated per species by month each year on a fishing block basis. The modern CPFV logbook data is tabulated on a trip and species basis, so if a given trip catches ten different species there will be ten corresponding rows in the dataset. A detailed description and discussion of the CPFV logbook data can be found in Hill and Schneider, 1999 (SIO Reference Series No. 99-19).

*Figure 4.1.1-1. Catch in number of fish retained from CPFV logbook data for 1936 to 1979. This data includes catch from Mexico and the US, with lines for US only, Mexico only, and both given in the graph.*




The historical and modern CPFV datasets were analyzed independently when creating indices of abundance. Additionally, one continuous time series (1936 to 2013) was created by collapsing the modern data by block, month, and year so that all effort was summed up at this level and catch was tabulated on a per species basis at this resolution. Prior to collapsing the data, any rows missing any piece of the information were removed. The effort is tabulated by taking the minutes fished on the trip multiplied by the number of anglers).

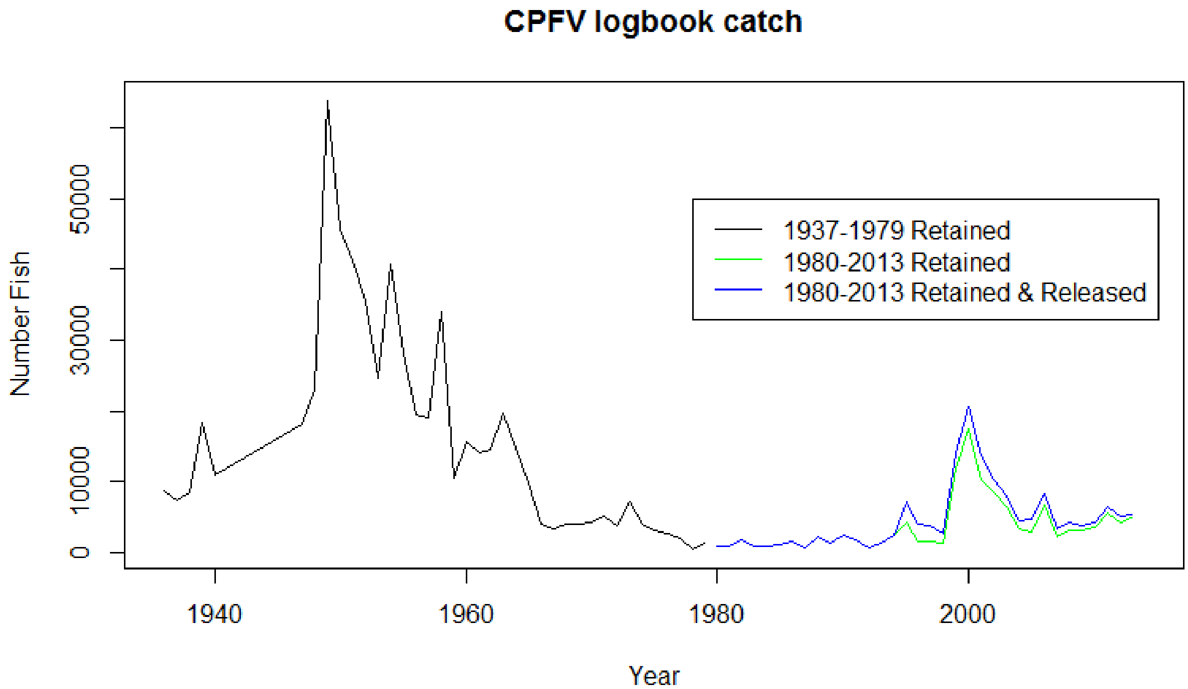
*Figure 4.1.1-2. Catch in number of fish retained from CPFV logbook data for 1980 to 2013. This data includes catch from Mexico and the US, with lines for US only, Mexico only, and both given in the graph.*




The modern CPFV dataset has records of 'Number Kept' and 'Number Released', as well as to a lesser extent, the 'Number Lost to Sea Lions'. Number caught refers to the 'Number Kept', or number retained (Figure 4.1.1.-3). The 'Number Released' is treated as discards and was analyzed separately as discards.

In the modern CPFV data there were records in which the 'Number Kept' field was left blank. Sometimes these records were the only record for that trip and other times there were other records from the same trip. It could not be determined what these blank records represented and as such they were removed from all further data analysis. The modern CPFV data do not have any records in which nothing was caught at all for the entire trip from any species (a true zero). It is unclear if this is due to the nature of the data recording, a transcribing/data entry error, or some other cause.

*Figure 4.1.1-3. Catch in number of fish retained from CPFV logbook data for 1936 to 2013. This data includes catch from Mexico and the USA. For data from 1980 to 2013 there is also information on number of fish released.*




### 4.1.2. Catch from CPFV Observer Data

Creel and onboard observer data was collected for parts of the 1970s and 1980s. The purpose of the respective studies was different, but they have been merged by CDFW since then. The data from the 1970's covered years 1975-1979 and were compiled by Rob Collins and Steve Crooke, California Department of Fish and Game (CDFG). The 1970s data was never published in a scientific report. These samples from the 1970s come from observers being on board CPFV and open charter trips that took place on the weekend and weekdays. There is no information on discards or releases in the 1970s data, just information on catch, or what is assumed to be number kept (Table 4.1.2-1).

*Table 4.1.2-1. Total catch (assumed to be retained catch) reported in the 1970's CPFV observer dataset.*

| Year | Total Catch Recorded |
|---|---|
| 1976 | 69 |
| 1977 | 84 |
| 1978 | 65 |

The data from the 1980's covered the years 1986-1989 and were compiled by Ray Alley and David Ono, CDFG, and resulted in the publication of CDFG Administrative Report (No. 90-2, May 1991). All samples from the 1980s came from observers on CPFV trips (excluding open and charter trips) during weekdays.  The 1980s data includes information on total catch, total retained, and total released (Table 4.1.2-2).

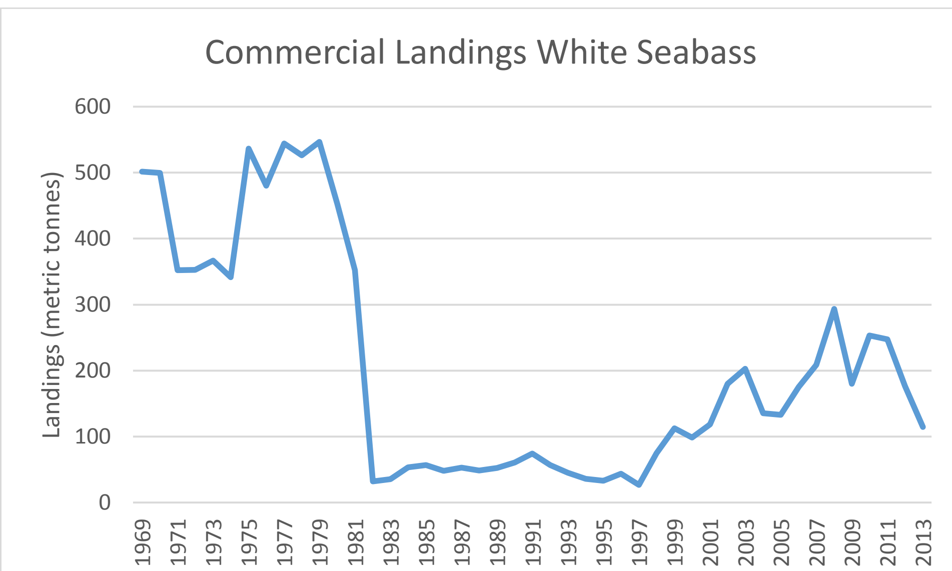
*Table 4.1.2-2. Total catch (retained and released), total number retained, total number released from the 1980's CPFV observer dataset.*

| Year | Total Catch Recorded | Total Catch Retained | Total Released |
|---|---|---|---|
| 1986 | 179 | 64 | 115 |
| 1987 | 160 | 16 | 144 |
| 1988 | 129 | 44 | 85 |
| 1989 | 123 | 48 | 75 |

### 4.1.3. Catch from Commercial Landings Data

CDFW provided catch data in the form of commercial landings for white seabass for this assessment. The data cover the time span 1969 to 2013 (Figure 4.1.3-1). The data are given in landings in converted pounds. There is no associated effort information for this dataset other than landings, so it is not possible to construct a relative index of abundance from these data. These data were only used as input for total landings (retained catch) in the model.  These data contained duplicate records, so a unique ID was created using 'serial..', 'converted.lbs', and 'unit.price'.  Using this new unique ID, 52 duplicates were removed from the dataset.

*Figure 4.1.3-1. Plot of commercial landings of white seabass through time.*




were used for: canned human food; non-canned human food; personal consumption; seized loads of fish; seized landing receipts; and some with no use code given (Table 4.1.3-1).

*Table 4.1.3-1. Use code type and total weight, in metric tons from the converted pounds variable, from commercial landings data for white seabass.*

| Use Code | Total Weight (metric tons) |
|---|---:|
| Human food (canned) | 100.65 |
| Human food (not canned) | 8260.04 |

| | |
|---|---|
| Seized load of fish | 2.16 |
| Personal Consumption | 35.80 |
| Seized Landing Receipt | 0.72 |
| NA | 1.03 |

Forty different gear codes appear in the commercial landings dataset (Table 4.1.3-2).

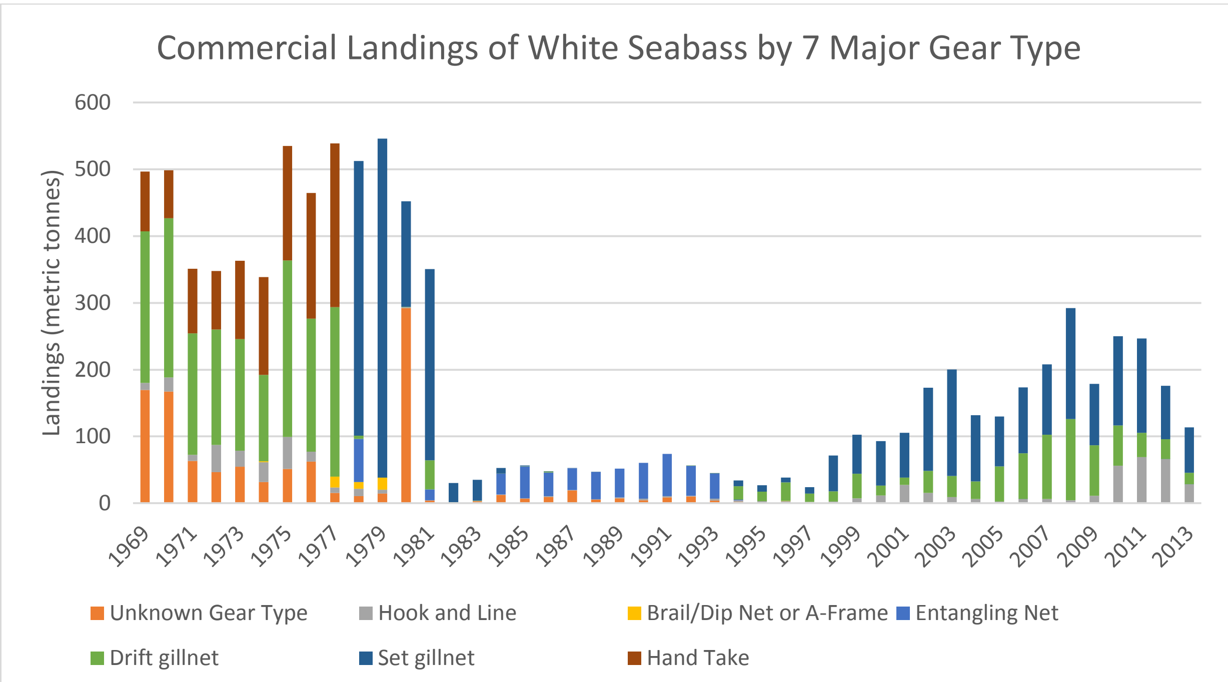
*Table 4.1.3-2. Gear code type and total weight, in metric tons from the converted pounds variable, from commercial landings data for white seabass.*

| Gear Type | Total Weight (mt) |
|---|---|
| Unknown | 1078.59 |
| Hook and line | 576.55 |
| Live bait | 1.47 |
| Vertical hook and line | 1.66 |
| Mooching in salmon fishery | 0.02 |
| Set longline | 41.49 |
| Jig/bait in albacore fishery | 3.57 |
| Trolling in albacore fishery | 3.95 |
| Trolling in groundfish or other fishery | 0.51 |
| Trolling in salmon fishery | 4.57 |
| Spear | 0.10 |
| Harpoon/spear | 14.24 |
| Diving/hooks in sea urchin fishery | 0.00 |
| Cast net | 0.03 |
| Diving | 0.08 |
| Entrapping | 0.84 |
| Fish trap | 0.04 |
| Prawn trap | 0.01 |
| Crab or lobster trap | 2.04 |
| Danish/ Scottish seine | 1.45 |
| Brail/dip net or a-frame | 46.18 |
| Selective flatfish trawl or small footrope | 0.03 |
| Trawl- footrope less than 8 inches in diameter | 9.95 |
| Trawl-footrope greater than 8 inches in diameter | 0.36 |
| Trawl net | 3.97 |
| Midwater net | 0.58 |
| Beam trawl | 0.39 |
| Bottom trawl | 11.32 |
| Balloon trawl | 0.00 |
| Single-rigged trawl | 2.93 |
| Double-rigged trawl | 0.01 |
| Entangling nets | 512.96 |
| Trammel net | 27.54 |

| | |
|---|---|
| Drift gillnet | 2685.36 |
| Set gillnet | 3056.53 |
| Encircling nets | 0.38 |
| Purse seine | 6.58 |
| Lampara net | 1.23 |
| Gear type 75 | 0.02 |
| Net | 1210.03 |

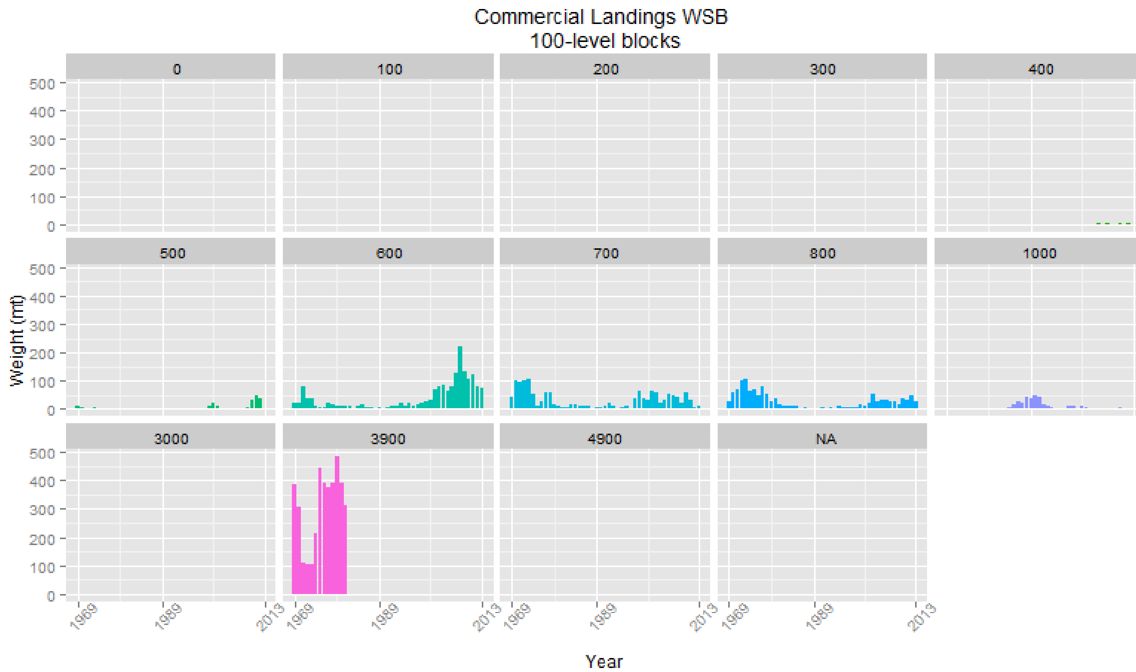
The gear types that landed the greatest amount of weight in the entire time period from 1979 to 2013 include unknown gear type; hook and line; brail/dip net or a-frame; entangling net; drift gillnet; set gillnet; and net (Figure 4.1.3-2).

*Figure 4.1.3-2. Commercial landings, in metric tons from the converted pounds variable, for white seabass shown for gear types that catch more than 45.36 metric tons (100,000 pounds) in the entire time series, 1979-2013.*




group blocks 600, 700, 800, and 3900 (Figure 4.1.3-3). The 3900 level blocks are from 200 nautical miles outside the Mexican coastline. Blocks in the 1000s are located in Oregon.

*Figure 4.1.3-3. Bar plot showing commercial landings, in metric tons from the converted pounds variable, summarized by 100 level blocks.*




## 4.1.4. Catch from Gillnet Logbook Data

At the time of the assessment, gillnet logbook data were available from the period 1981 to 2013 (Figure 4.1.4-1). However, as the records from the year 2012 were incomplete, the assessment only uses data from 1981 to 2011. The gillnet logbook data contains information (listed here by variable name from the dataset itself) on net type (drift, set, or other), hours soaked, target species, depth, length, mesh, hours soaked, fish caught, numbers, catch weight, and CDFW block. Not every record had catch weight or hours soaked. There were 25,366 records with no weight listed and 1,196 records with no numbers listed. For the gillnet logbook data, catch refers to retained catch, as there is no information on discards. In the gillnet logbook dataset, not every record had catch weight, so analysis was done using numbers rather than biomass. For each record it is unclear if 'catch weight' represents the entire catch or if it is a fraction of catch. Using the 'catch weight' and 'numbers' variables to try and find the average weight of white seabass caught resulted in unreasonable average weights (both too large and too small). It is unclear if 'catch weight' is meant to be the total weight of the catch, or the weight of a subsample of the catch and then what fraction of the catch is captured by the variable 'numbers'. As such, the record of total weight reported caught each year is not representative of the entire catch, and there is no information on what fraction of the total catch the weight does represent (Figure 4.1.4-2). Of the 29,078 records of white seabass (including those from part of the year 2012), 17,949 occurred when targeting white seabass. The 2nd highest catch of white seabass occurred when targeting California halibut, at 8,440 records of white seabass catch. No other target fishery had more than 1,000 records of white seabass catch. When barracuda was listed as the target species there were 825 records of white seabass catch and when angel shark was listed as the target species there were 443 records of white seabass catch.

*Figure 4.1.4-1. White seabass catch, in number, from 1981-2012 in the gillnet logbook dataset. Catch from all gillnet records indicating they caught white seabass shown with black line and catch from gillnet logbook entries indicated they targeting white seabass are shown in blue.*

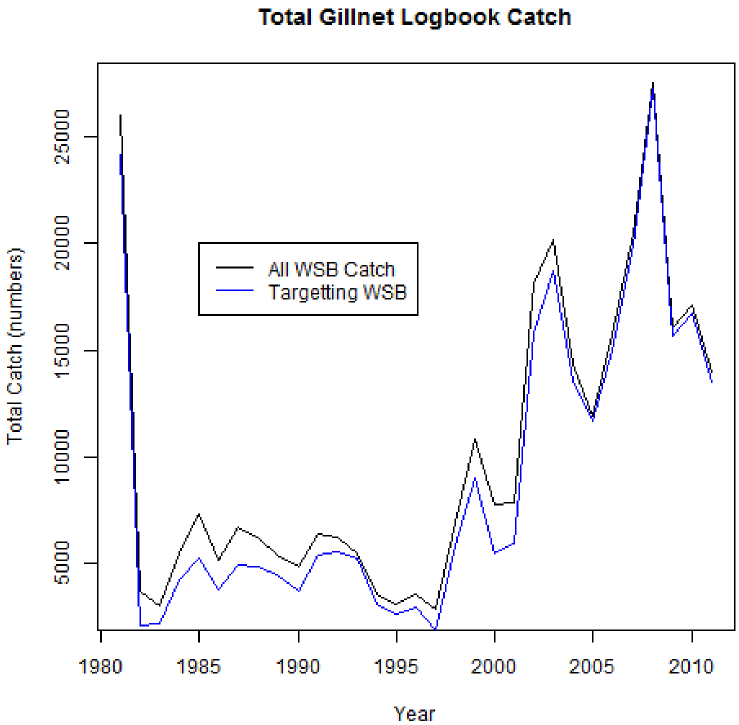
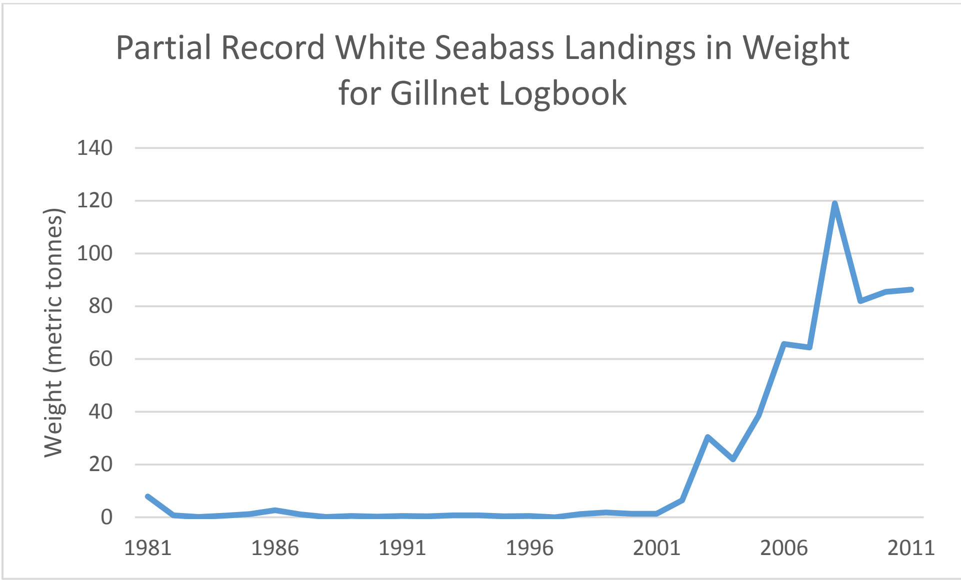



*Figure 4.1.4-2. Catch of white seabass in weight from the gillnet logbook data for 1981 to 2011. Note that the records for weight are incomplete. It is unknown what percentage of the yearly catch is represented by these weights.*



Both the total number of boats and permits were at the highest value in 1985, after which there was an immediate decline (Figure 4.1.4-3 and Figure 4.1.4-4). The decline in number of boats and permits stabilized by the year 1990 and has been approximately the same ever since.

*Figure 4.1.4-3. Plot of number of permits catching white seabass from the commercial gillnet logbooks. Number of total permits catching white seabass is shown in block and total number of permits catching white seabass indicating they were targeting white seabass is shown in blue.*

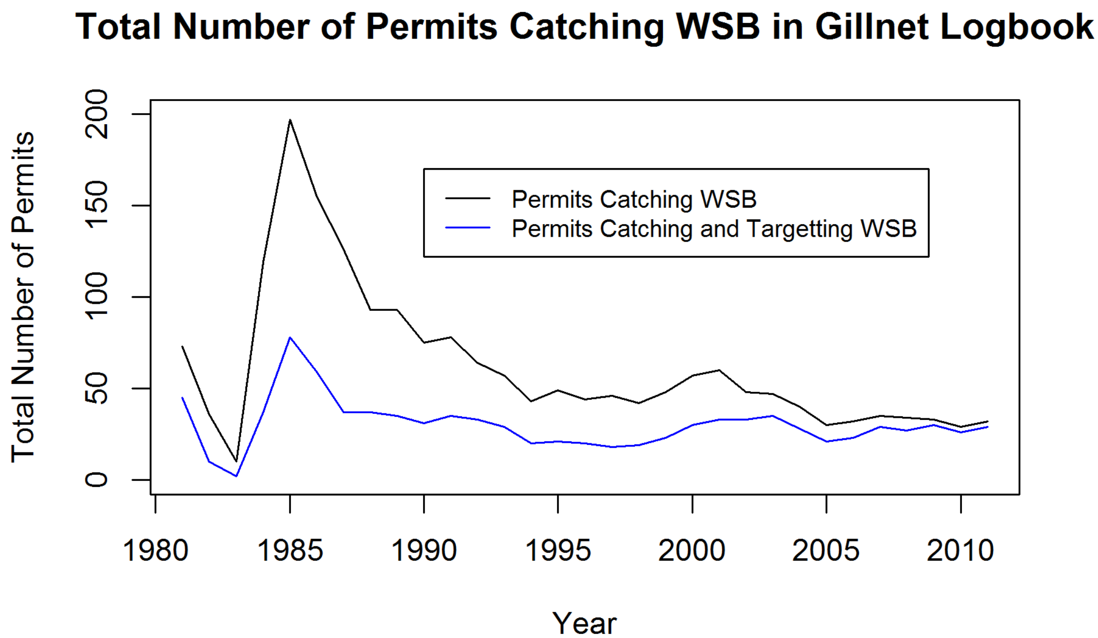
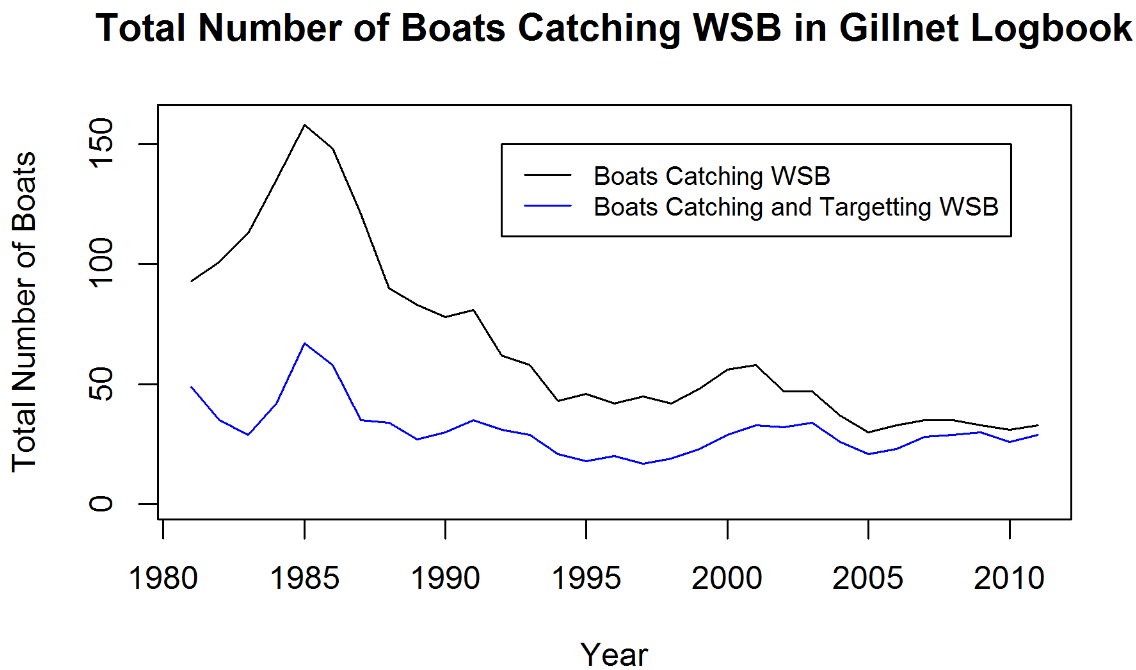


*Figure 4.1.4-4. Plot of number of boats catching white seabass from the commercial gillnet logbooks. Number of total boats catching white seabass is shown in block and number of boats catching white seabass indicating they were targeting white seabass is shown in blue.*




## 4.1.5. Catch from Gillnet Observer Data

CDFW provided a folder called gillnet observer data to support the assessment. However the datasets contained in the folder lacked metadata. Additionally, the two read.me.txt files contained in the folder (one readme file was from CDFW and the other contained hand notations by Marija Vojkovich) provided conflicting and incomplete documentation regarding the data. None of these data were used in the assessment.

Within this folder, one dataset (GNM8398.MBD) covers 1983 to 1989 gillnet catch observations including sex and length. However, documentation could not be found for this dataset for field definitions. Another dataset (TAGREC2.MDB) had records from the 1986 to 1987 CDFW gillnet tagging program, but only 25 records of white seabass exist from this dataset. This data was not used as no metadata was available. There was also a dataset representing the catch of a single vessel in 1987 and 1988. There were only 35 records of white seabass from this dataset. Many of the other datasets in the folder did not contain any records of white seabass.

## 4.1.6. Catch from MRFSS/CRFS Data

CDFW contracts the Pacific States Marine Fisheries Commission (PSMFC) to collect and manage survey data on recreational fisheries. PSMFC runs the Recreational Fisheries Information Network (RecFIN) where the survey data on California recreational fisheries is stored (website: [http://www.RecFIN.org/](http://www.RecFIN.org/)) along with other federal and state fishing data.

Contemporary data comes from the California Recreational Fisheries Survey (CRFS) which replaced the prior survey, Marine Recreational Fisheries Statistical Survey (MRFSS), in 2004. Estimates of catch and effort from the CRFS data are derived from seven sampling and estimation methods: primary private boat sites (each site sampled 8 days per month); secondary private boat sites (sites sampled in roving clusters 3 days each month); private boats at night and at private access sites; CPFVs (party/charter boats); beach and bank fishing; man made structure fishing; and an effort only telephone survey based on angler licenses. MRFSS ran from 1980 to 2003 and CRFS data is used from 2004 to 2012 in this assessment.

Details on the major differences between the MRFSS and CRFS survey can be found in Porter and Crooke (2004). Some of the improvements include: (1) CRFS has six geographic regions for California instead of the two under MRFSS; (2) Effort estimates for all fishing modes except CPFV and beach/bank anglers come from direct field counts instead of telephone surveys under MRFSS; (3) CPFV estimates use direct sampling of 10% of all skippers, started in 2001 under MRFSS; (4) MRFSS data was used for estimates of catch and effort under two-month periods and the CRFS data is used for monthly estimates; (5) CRFS has higher field sampling rates than MRFSS; (6) CRFS tabulates catch and effort estimates by trip type and mode (see below) whereas MRFSS did mode only; (7) a phone survey is used for difficult effort estimates for some modes; and (8) the MRFSS phone survey was stopped in 2004. The phone survey of CRFS is conducted by CIC Research, Inc.

The four modes of fishing in CRFS include: private and rental boats, CPFVs, man-made structures, and beaches/banks. There are seven trip-types are: anything; coastal pelagic and coastal migratory species; highly migratory species; nearshore hard bottom, kelp beds, and shelf/slope hard and soft bottom; shore and nearshore soft bottom; salmonids; other anadromous species (non-salmonid); and invertebrates. According to detailed descriptions of these categories, white seabass are considered in the trip type categories nearshore hard bottom, kelp beds, shelf/slope, hard, soft bottom and any (California Department of Fish and Game, 2011). CPFV data appears in the RecFIN database as party boats. When referring to data from RecFIN, the term party boat will be used to indicate CPFV trips.

Data from RecFIN was provided to us by Kathryn Crane (CDFW) including trips catching barracuda, croakers, sea basses, and jacks. The RecFIN data included Type 1 (Angler Information), Type 2 (Reported Catch), Type 3 (Examined Catch), and Type 3d (Sampler Examined Discards). All of the Type 3d data came from CPFV discards. Data in the Type 1, Type 2, and Type 3 datasets came from man-made structure, beach/banks, CPFV, or private/rental boats, with the majority being from private/rental boats and then from CPFV boats. Details on how the catch and effort data collected are expanded into final estimates can be found in the California Department of Fish and Game, California Recreational Fisheries Survey Methods (2011).

## 4.2. Survey Data Types

All survey data on white seabass comes from Southern California. Survey data types include: California Cooperative Fisheries Institute (CalCOFI) data; Ocean Resources Enhancement Hatchery Program Gillnet Survey data (OREHP from Hubbs Sea World Research Institute and from California State University of Northridge); power plant impingement and associated trawl data; and from water treatment plants.

### 4.2.1. CalCOFI Survey

Data from the California Cooperative Fisheries Institute (CalCOFI) was accessed via the internet at NOAA ERDDAP site [http://coastwatch.pfeg.noaa.gov/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=calcofi]. There is no data on fish counts for white seabass. There are 8 records of tows that were positive for white seabass eggs, with all records from 2004 and 2005. There are 59 records of tows positive for white seabass larvae and they cover the time period 1965 to 2011. Due to the small amount of data for white seabass found in the CalCOFI data, these data was not included in the assessment.

### 4.2.2. Ocean Resources Enhancement Hatchery Program Gillnet Survey (CSUN/HSWRI)

Ocean Resources Enhancement and Hatchery Program (OREHP) funds gillnet surveys for juvenile white seabass in Southern California. Two surveys were conducted. The California State University of Northridge (CSUN) survey (data provided by Dr. Larry G. Allen, Southern California Marine Institute) covered the northern two-thirds of the Southern California Bight from Newport Beach to Santa Barbara including Catalina Island (Figure 4.2.2-1). The Hubbs-Sea World Research Institute (HSWRI) survey (data provided by Michael A. Shane, HSWRI) covered the stations south to the US-Mexico border (Figure 4.2.2-2). Details of the CSUN and HSWRI gillnet sampling program can be found in Allen and Franklin 1992, Allen et al., 2001, and Allen et al., 2007. The gillnets were set overnight and floated with the lead lines about 1 meter above the bottom. HSWRI has been deploying multiple-mesh gillnets since 1988, but the mesh sizes and panel lengths in the nets varied until June 1992 when the nets were standardized. The CSUN dataset runs from 1995 to 2007 and the HSWRI dataset includes 1988-1994, 1996-2008, and 2012 to 2014. Each survey has associated length composition data that can be used to estimate a selectivity curve to determine the component of the population it relates to.

*Figure 4.2.2-1. Catch in terms of number and weight (grams) from the gillnet survey operated by CSUN for 1995 to 2007. Note, that not all fish have associated weights, so the catch by weight under-reports the total biomass caught in the survey.*

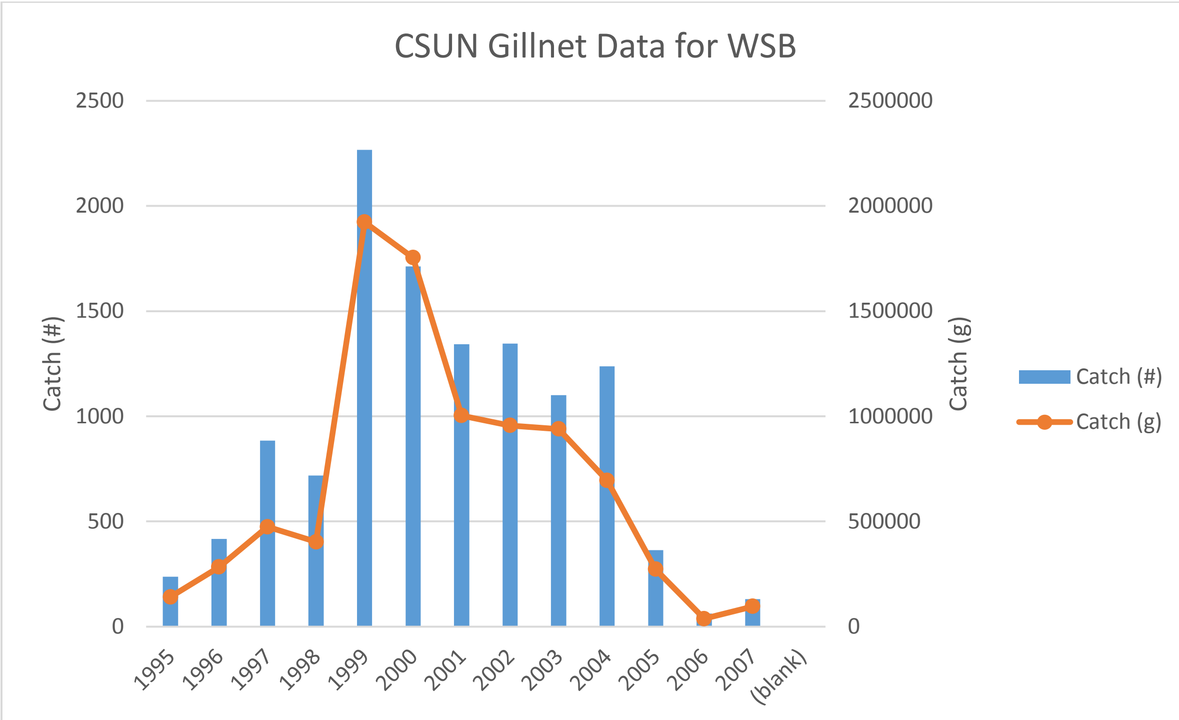
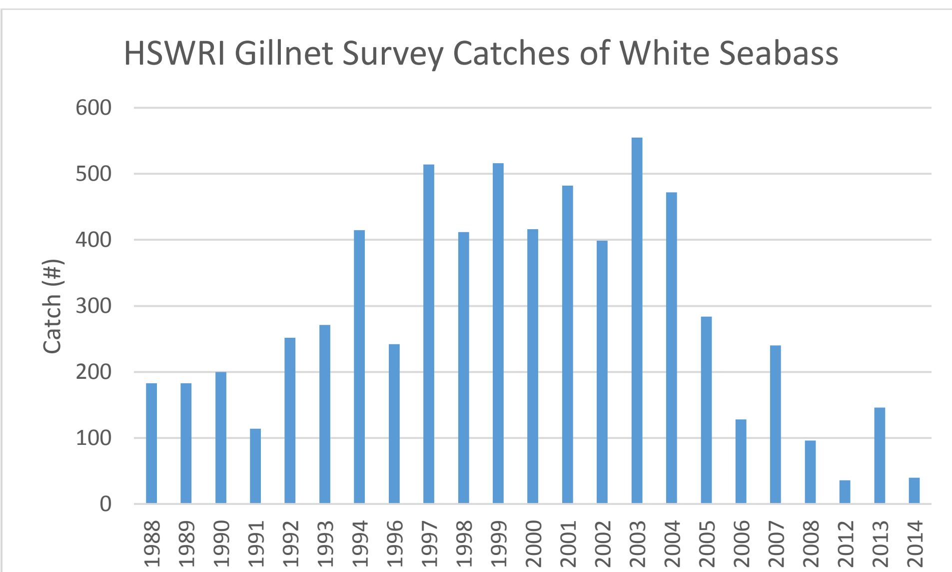



*Figure 4.2.2-2. Catch from HSWRI gillnet survey of juvenile white seabass.*




For both datasets, CSUN and HSWRI, the effort data was calculated using the amount of time between when the net went down and time the net was pulled up.

### 4.2.3. Power Plant Impingement and Associated Trawl Data

Data from six power plants were provided by MBC Applied Environmental Sciences and Southern California Edison (Figure 4.2.3-1). The six power plants represented in the data are Ormond Beach (OBGS), Scattergood (SGS), El Segundo (ESGS), Redondo Beach (RBGS), Huntington Beach (HBGS), and San Onofre (SONGS). Two types of impingement data were collected, called 'heat treatment' (HT) and 'fish chase' (FC) (Figure 4.2.3-2). The 'fish chase' data comes from only units 2 and 3 of the SONGS power plant. Further details on the two impingement types can be found in Miller et al. (2011). The power plant data, FC and HT, were used primarily for length information and to create various indices of relative abundance.

*Figure 4.2.3-1.Map of location of five power plants included in study by MBC Applied Environmental Sciences and Southern California Edison summarized in Miller et al. (2011). The five power plants represented in the map (from North to South) are Ormond Beach (OBGS), El Segundo (ESGS), Redondo Beach (RBGS), Huntington Beach (HBGS), and San Onofre (SONGS). The Scattergood (SGS) power plant is not represented in the map but it is just north of ESGS (on the scale of this map they would appear on top of one another).*

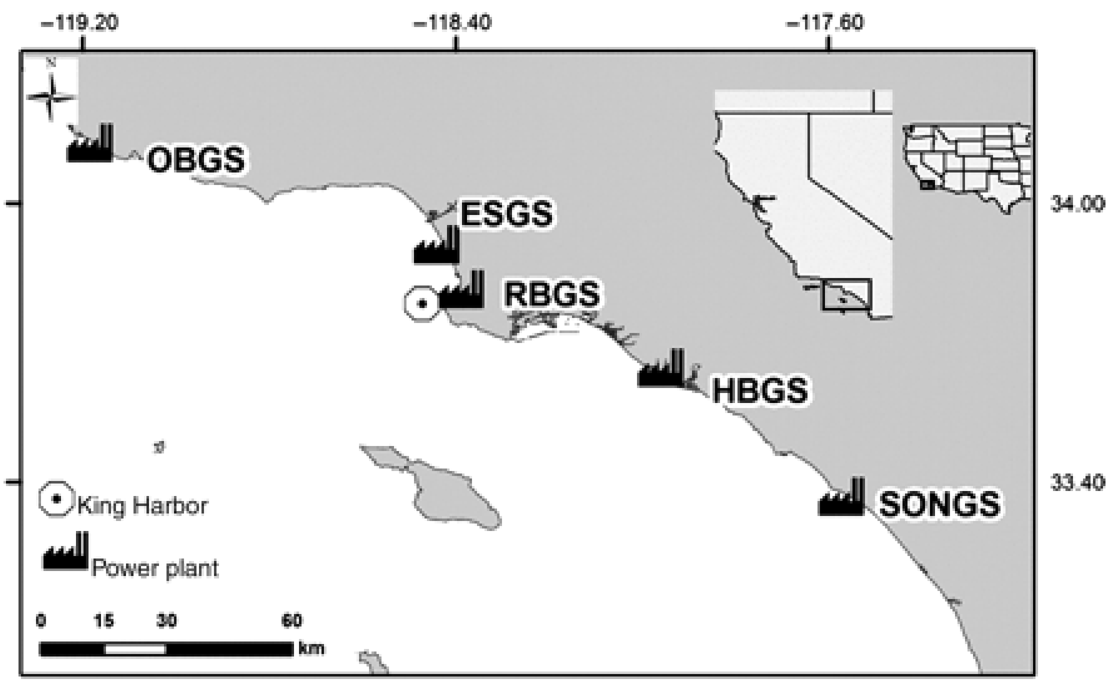
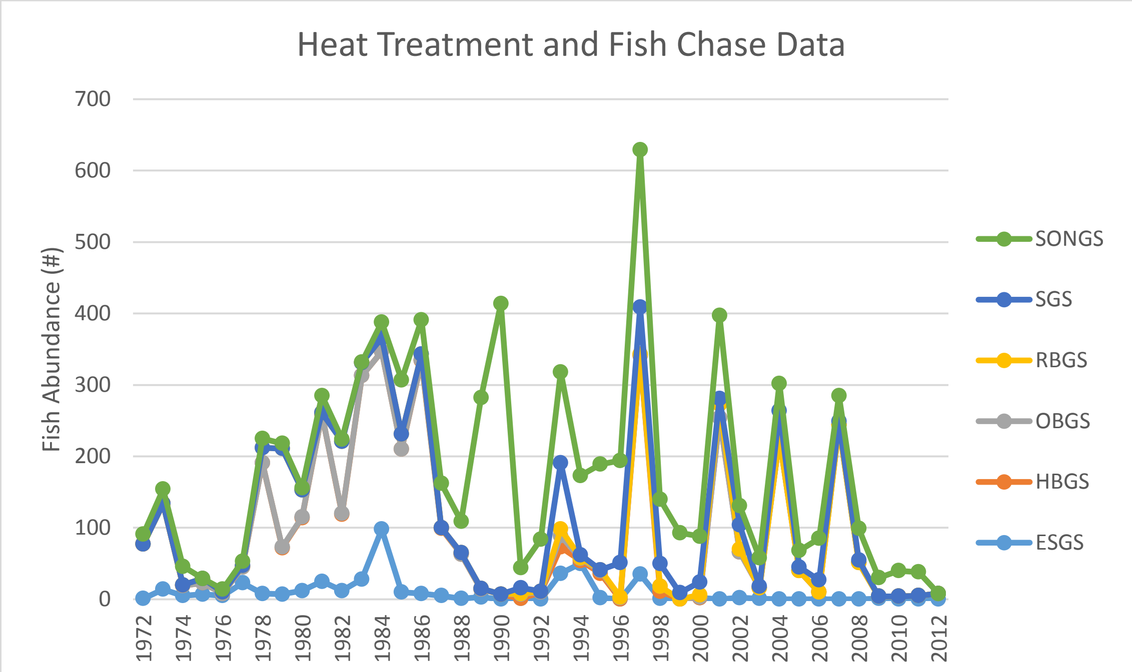
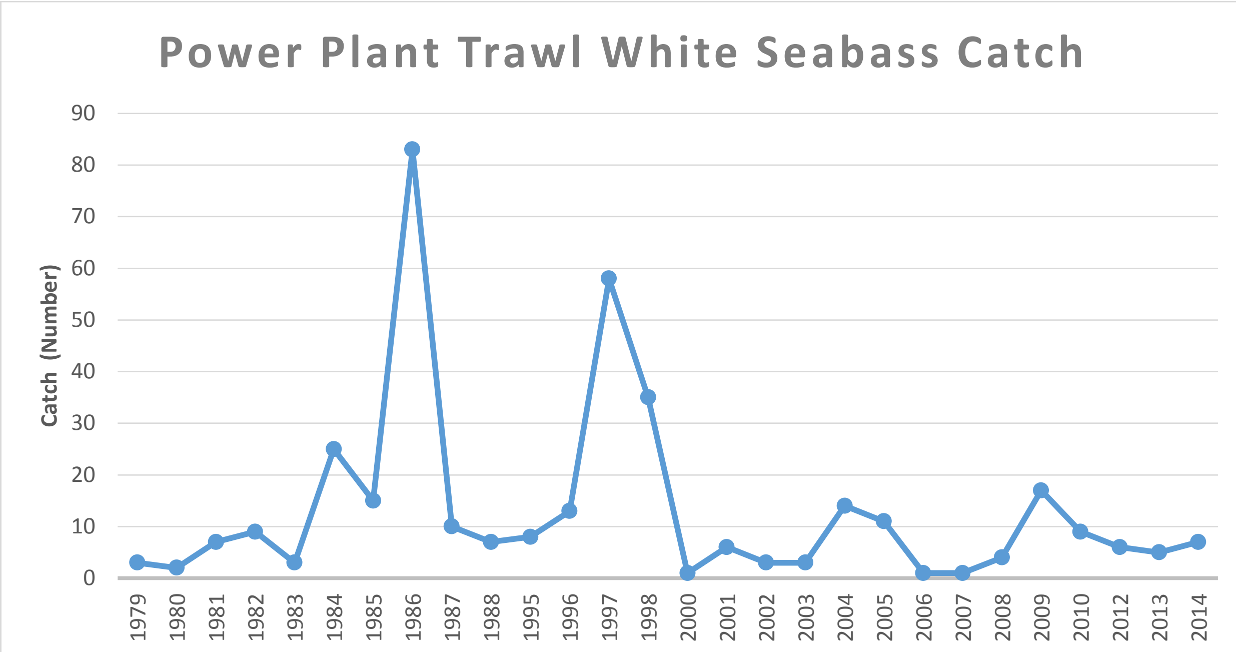


*Figure 4.2.3-2. Summary of total catch in numbers from heat treatment and fish chase data from the power plant.*




Another type of data collected came from trawl surveys (Figure 4.2.3-3). Trawl surveys were conducted from 1978 to 1988 and then again from 1995 to 2015. More details on the trawl surveys can be found in Miller et al. 2011. There were only 27 lengths for white seabass from the trawl survey and they were from the time span 2010-2014. All 27 fish were less than 16cm in total length. Since this assessment only uses data going to 2014, lengths from the trawl survey were not included in this analysis. In the trawl survey database there are 153 records of white seabass (representing a total of 366 fish), but the data contains records of effort for the trawls since 2010. As a result, the trawl survey data was not used to create a CPUE index. The trawl survey data was not used in any way for the rest of this analysis.

*Figure 4.2.3-3. Summary of total catch in terms of numbers for the power plant trawl survey.*




### 4.2.4. Sanitation District Data

Sanitation districts that have coastal access were emailed based on a list from the California Association of Sanitation Agencies (http://www.casaweb.org/about/member-agencies) and none of the districts reported having any white seabass data.

## 4.3. Growth

Several studies exist to date on white seabass growth, based on length frequency, otolith and scale analyses of fish sampled mainly in southern California waters. Some of these studies have been published (Clark, 1930; Thomas, 1968; Donohoe, 1997; Williams et al., 2007; Hervas et al., 2010; Romo-Curiel et al., 2015) while others remain in unpublished form (CDFG, 2002; HSWRI, Mike Shane pers. comm.). In addition, some of the studies focused on juveniles (Donohoe, 1997) or hatchery fish (Hervas et al., 2010) and therefore they will not be discussed further.

Clark (1930) inferred age and its relationship to length based on length frequency data from a limited number of individuals (n=78, 45 males and 33 females). The first study to estimate growth based on age estimation from analysis of fish scales was performed by Thomas (1968). Scales were found to be difficult to read beyond age 13 and showed great variability. With these caveats, Thomas (1968) estimated that length at age infinity (*Linf*) was 146.5 cm, and that a 71.1 cm (28 in.) white seabass (the minimum legal size in California) was around five years old and weighted about 3 kg (7 lb.). Thomas (1968) age estimates based on scales were later shown to underestimate age by subsequent studies using otoliths (CDFG, 2002; Williams et al., 2007). CDFG (2002) estimated growth based on otolith ageing and found a maximum age of 27 years of age, *Linf* = 136.6 cm total length (TL) and $K = 0.156$ yr$^{-1}$. Fish of 71.1 cm TL (the current minimum size limit in California) were estimated to be around three years old. The CDFG (2002) data consisted of mainly smaller individuals and examined a limited number of samples from age classes seven and older. Williams et al. (2007) found that growth rates during the first 4 years of life were significantly and positively correlated with mean SST and suggested that higher temperatures appeared to have a positive effect on growth rates of White Seabass juveniles from Southern California. Romo-Curiel et al. (2015) estimated white seabass growth based on otolith analysis of fish aged 0 to 28 years of age from southern California to southern Baja California (Mexico). They found no significant differences in growth across the study area with *Linf* around 141 cm (140.84 to 141.2) TL and *K* around 0.18 $yr^{-1}$ (0.17-0.19). Estimates for the pooled data were *Linf*=141.79 cm TL and *K*=0.17 $yr^{-1}$.

Thomas (1968) produced a length-weight relationship for white seabass:

$$W(kg) = 0.000015491*TL(cm)^{2.9216}$$

However, only mature fish of both sexes were used in Thomas' calculations and the sample size was relatively small (n = 153). A larger dataset obtained from PIER (Pfleger Institute of Environmental Research, Scott Aalbers, pers. com.) for white seabass was used to estimate an alternative relationship resulting in the following parameters:

$$W(kg) = 0.000007447*TL(cm)^{3.0335}$$

During the stock assessment review (see White Seabass (*Atractoscion nobilis*) 2016 Stock Assessment Review Panel Report) we manually digitized Thomas (1968) data and found that observations were closely aligned with the more recent samples (see below dataset provided by PIER), suggesting that there was either an error in the estimation process used by Thomas (1968) or a typo in the reported parameters. In either case, it appears that the length-weight relationship has remained stable over time (Figure 4.3-2).

*Figure 4.3-1. Length-weight relationship for white seabass in California. Fits based on relationship found by Thomas (1968; dashed line) and by analysis of data provided by PIER (solid line).*

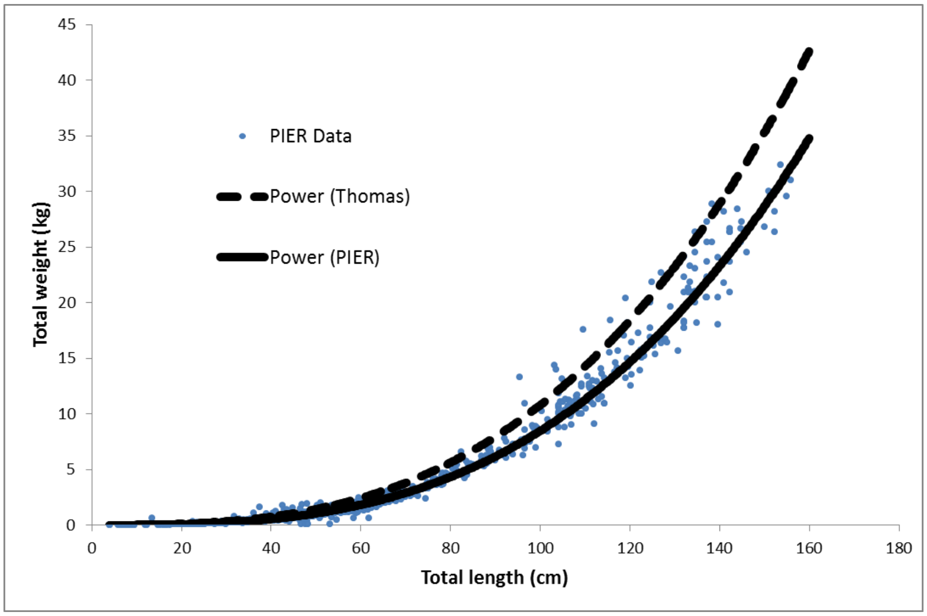
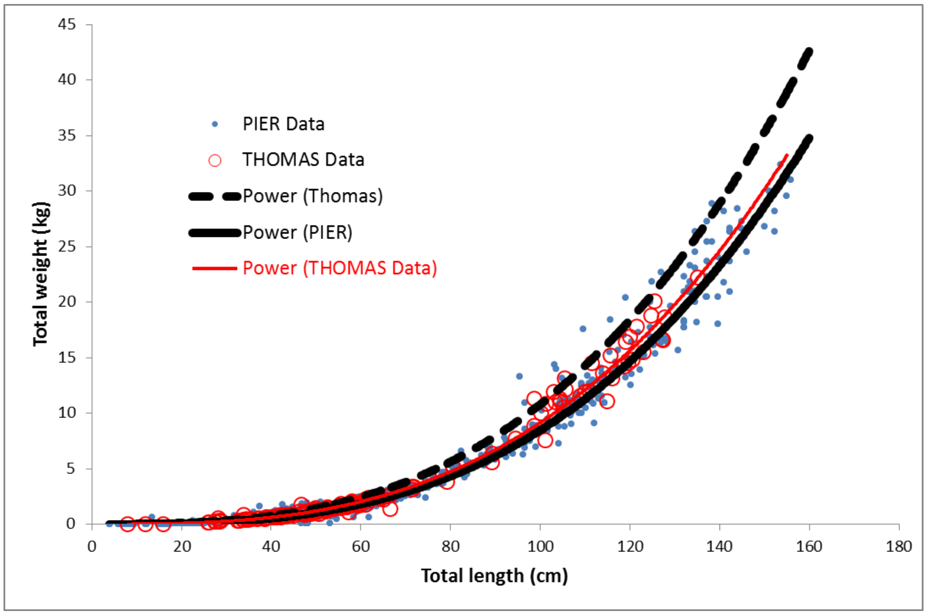



*Figure 4.3-2. Length-weight relationship for white seabass in California. Fits based on relationship found by Thomas (1968; dashed line) and by analysis of data provided by PIER (solid black line). Open red circles are digitized data from Thomas (1968) and fit to that data (thin red line).*



## 4.4. Variation of length-at-age

The variation of length at age is an important component of stock assessment models fitting to size composition data, particularly in the absence of age composition data. Two datasets were available to evaluate the variation of length at age, a dataset by Romo-Curiel et al. (2015) and unpublished data provided by Mike Shane (HSWRI). A relationship between the coefficient of variation (CV) of length at age and the mean length at age was found. Males and females show a similar relationship between the CV and the mean length-at-age (Figure 4.4.1). Separate linear regressions were fit by sex for the HSWRI sex specific data (Figure 4.4.1), for the combined sex data (Figure 4.4.2) from Romo-Curiel et al. (2015) and for the combined HSWRI and Romo-Curiel et al. (2015) data (Figure 4.4.3). Ages with less than 5 fish are left out of the regressions. These relationships can be used to determine the parameters of the Stock Synthesis model to represent variation in length at age.

*Figure 4.4-1. The coefficient of variation (CV) of length at age plotted against mean total length (cm) with separate linear regressions applied to male and female data. The data is restricted to the ages with more than five samples. Data provided by HSWRI.*

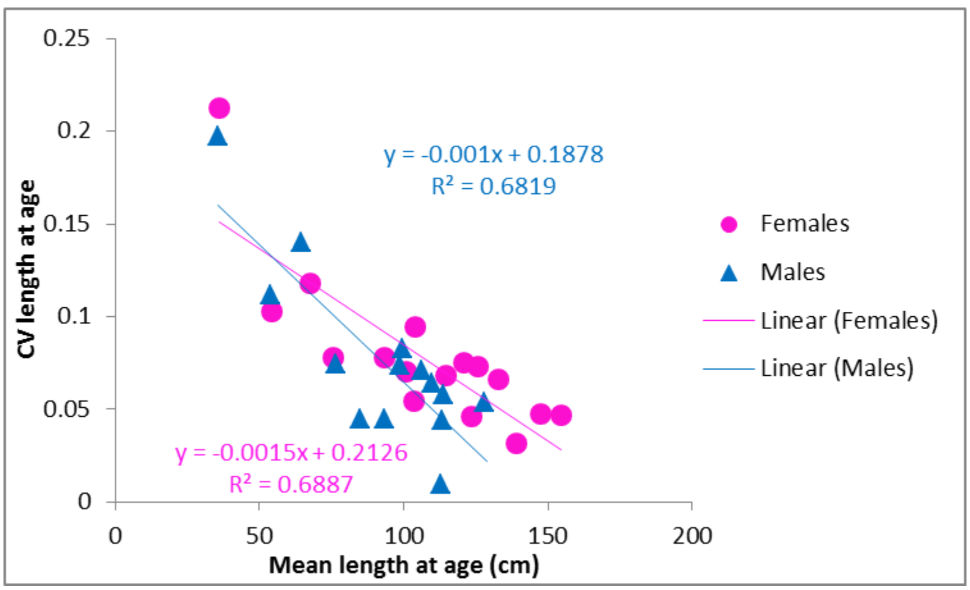


*Figure 4.4-2. The coefficient of variation (CV) of length at age plotted against mean total length (cm) with separate linear regressions applied to male and female data provided by HSWRI, and to the combined sex data provided by Romo-Curiel et al. (2015). The data is restricted to the ages with more than five samples.*

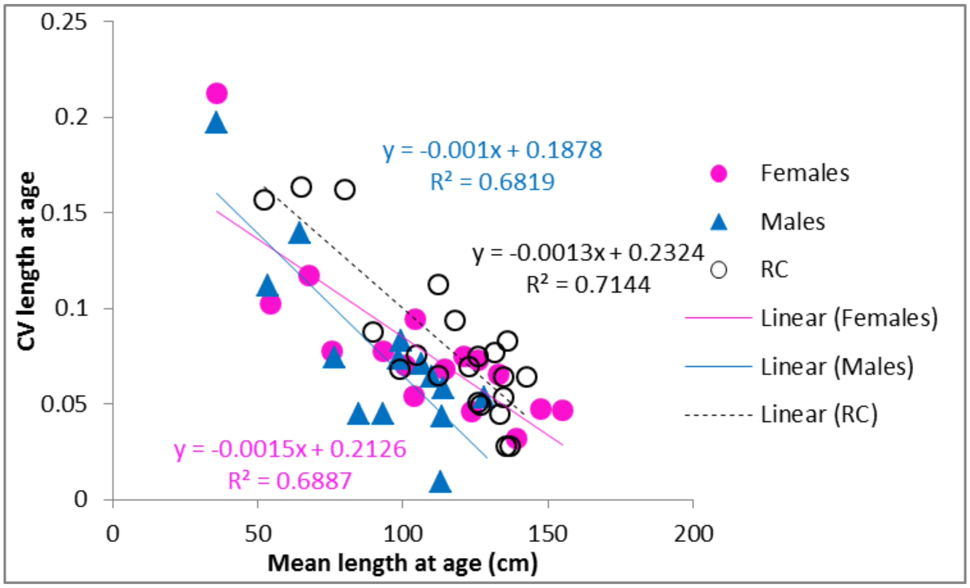
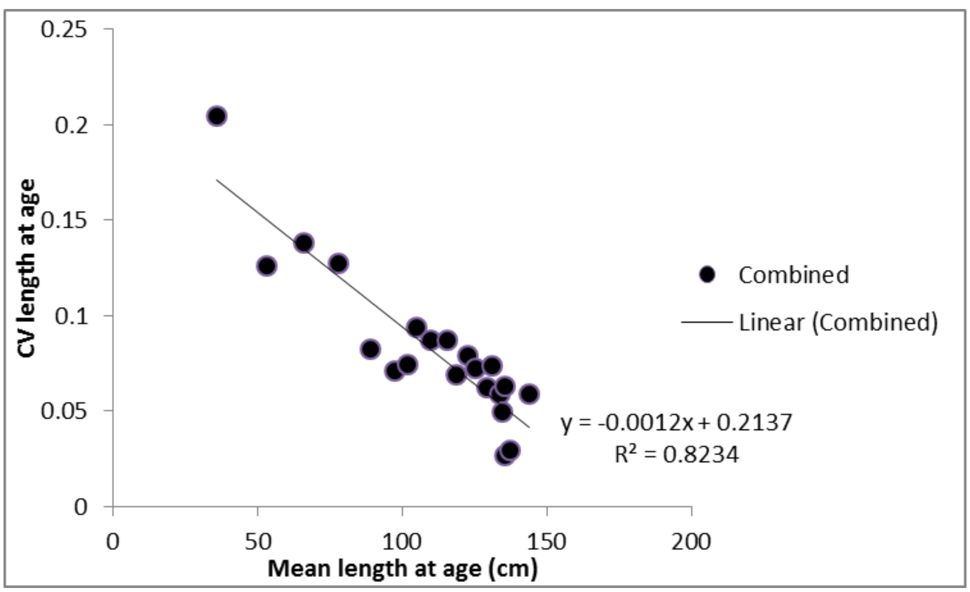



*Figure 4.4-3. The coefficient of variation (CV) of length at age plotted against mean total length (cm) with a linear regression applied to combined sex data from HSWRI and Romo-Curiel et al. (2015). The data is restricted to the ages with more than five samples.*




## 4.5. Environment and Ecosystem Role

The diet of white seabass consists primarily of squid, sardines, anchovies, other small fishes and a small amount of pelagic red swimming crabs when available (Young 1973). As prey, white seabass are eaten by other fish and sea lions. It is not known how varying levels of white seabass exploitation would impact this food chain. There may also be competition between white seabass and other species since they are often caught with other migratory species that have similar food habits, such as Pacific Bonito (*Sarda chiliensis lineolata*) and Yellowtail Jack (*Seriola lalandi*). It is not known how these species interact with white seabass, and how the removal of white seabass from the ecosystem would affect these relationships (CDFG 2002).

In years of warmer sea surface temperatures, the spatial distribution of white seabass shifts northward, up to San Francisco Bay (Young 1973). White seabass catches were unusually high in 1958 and 1959 and this has been attributed to abnormally warm sea surface temperature (Maxwell 1977). Adults may also become more common near outer edges of kelp beds during warmer summer months and El Niño years (Dayton et al., 1998). Juveniles grow significantly faster during warm periods (Williams et al., 2007). It is unclear if warm periods of longer duration would have the same positive effect on juvenile growth or if juvenile growth could be adversely affected via lower primary production caused by lower nutrient levels, lower concentrations of oxygen, and stress from increased metabolism.

El Niño events are expected to affect white seabass habitat and prey. Juvenile and adult white seabass are associated with kelp beds, which tend to be adversely affected by anomalously warm water (CDFG 2002). The reduction or loss of kelp habitat potentially impacts white seabass by reducing shelter and prey. During El Niño events two key white seabass prey items, anchovies (Fiedler 1984) and market squid (CDFG 1999) were not present, or were greatly reduced, in the Southern California Bight. However, other prey items such as sardines increase in abundance during El Niño (CDFC 2002).

### 4.6. Sex ratio

There is very little information on the sex ratio of white seabass. However, there is indication of temporal and spatial segregation by sex. Aalbers and Sepulveda (2015) found that 77% of recaptured individuals from tags deployed during the spawning season (March-July) were identified as female.

### 4.7. Spatial distribution and stock structure

White seabass are distributed over the continental shelf from Alaska to Baja California, Mexico (Thomas, 1968), with the center of the population typically south of Point Conception to Ballenas Bay, Baja California, Mexico (Young, 1973). It has been suggested that the spatial distribution of the population shifts with changes in sea surface temperatures and other factors (Skogsberg, 1939; Young, 1973; Maxwel, 1977; CDFG, 2002), however fishery-independent information on movement and stock structure is limited. More information on recent tagging work by PIER can be found in the next section (4.8. Movement).

There is no evidence of stock structure between the Pacific coast of California (USA) and Baja California (Mexico). DNA collected between 1990 and 1995 in the USA and Mexico suggested the potential for local spawning groups within the Southern California Bight (Franklin, 1997), indicating a genetically distinct group in the Gulf of California. Romo-Curiel et al. (2015)

investigated individual (otolith increments) and population somatic growth trajectories and suggested growth to be similar across the study range. However Romo-Curiel (2015) identified that white seabass reared in southern Baja California grow at a faster rate in the first year of life, a characteristic likely explained by the warmer water temperatures of the region. More recent findings by Romo-Curiel et al. (2016) on otolith microchemistry also identified differences in δ18O values between Southern California and Southern Baja California (above and below Punta Eugenia 27°N) which further suggests the potential of two discrete subpopulations along the Pacific coast. Additional studies are needed to fully elucidate white seabass stock structure in this region.

## 4.8. Movement

Early work to evaluate movement patterns of juvenile white seabass through conventional tagging programs in the mid-1970s were ineffective because of limited tag deployments and no reported tag recoveries (Maxwell, 1977). Recent work done by PIER using archival tags have shown that adult white seabass have marked seasonal movements both in vertical and horizontal planes (Aalbers and Sepulveda, 2015). They found that white seabass moved seasonally in a north and westerly direction from July to September, as sea-surface temperatures (SSTs) increased throughout Southern California. A vertical distributional shift toward the surface as water temperatures increase during the spring and summer months contributes to heightened vulnerability to fishing during the spawning season (Aalbers and Sepulveda, 2015). They also found individual fish moving more than 500 km from their initial point of release, although recoveries happened at smaller distances from the point of release, suggesting white seabass maintain an affinity for distinct sites or habitats that are revisited annually for feeding or spawning (Aalbers and Sepulveda, 2015). More recent findings from warmer water periods suggest that white seabass can extend their horizontal range as far as the Canadian border when sea surface temperatures are within the preferred range for this species (12-18°C; 54-64°F Aalbers and Sepulveda, in preparation). Widespread horizontal movements during the spawning season are consistent with recent data that indicate limited residency periods at distinct spawning sites along the southern coast of California (Aalbers and Sepulveda, 2012). Aalbers and Sepulveda (2015) also found evidence of transboundary movement as 3 out of 41 white seabass tagged in California were recaptured in Mexican waters.

## 4.9. Maturity

The only published study on white seabass maturity is by Clark (1930). In Clark's owns words: "…the data are very inadequate and they are presented here only as a rough guide for protective legislation for the white sea bass". The dataset consisted of 78 fish sampled in the late 1920s, 33 females and 45 males with 8 and 23 maturing fish respectively (Table 4.9-1). Clark (1930) found that 50% of the males over 60 cm in length (TL) were mature, but that 50% of the females had not yet matured at 70 cm (TL). Her conclusion was that females began maturing at 60.7 cm (24 inches) and all white seabass are mature at 80 cm (31.5 inches) TL. Although no fish were aged in Clark (1930), the study suggests that males mature at age 2 and females at age 3, based on interpretation of modes in size compositions. Maxwell (1977) also attempted to evaluate size at maturity for white seabass but was limited in sample availability and any data that may have resulted from that project is not available. However, Maxwell (1977) noted that in light of growth information available at the time of its study, based on ages from scales from Thomas, (1968), white seabass would be expected to have spawned at least once at age 6, rather than at 3 years of age.

*Table 4.9-1 Number and fraction of male and female white seabass maturing by fish total length (cm).Digitized from Clark (1930.)*

| | **Number** | | | | **Fraction Maturing** | |
|---|---|---|---|---|---|---|
| | **Males** | | **Females** | | **Males** | **Females** |
| **TL (cm)** | **Immature** | **Maturing** | **Immature** | **Maturing** | | |
| 23 | 1 | | | | 0 | |
| 26 | 1 | | | | 0 | |
| 27 | 1 | | | | 0 | |
| 38 | 1 | | | | 0 | |
| 40 | 2 | | | | 0 | |
| 41 | 1 | | 1 | | 0 | 0 |
| 42 | | | 4 | | | 0 |
| 43 | 1 | | 1 | | 0 | 0 |
| 44 | | | 2 | | | 0 |
| 45 | 1 | | 1 | | 0 | 0 |
| 46 | 2 | | 2 | | 0 | 0 |
| 48 | 3 | | | | 0 | |
| 49 | | | 2 | | | 0 |
| 50 | 1 | 1 | 3 | | 0.5 | 0 |
| 51 | | 1 | | | 1 | |
| 52 | | | 1 | | | 0 |
| 53 | | 1 | | | 1 | |
| 54 | 1 | | | | 0 | |
| 55 | | | 1 | | | 0 |
| 56 | | 1 | | | 1 | |
| 57 | 1 | | 1 | | 0 | 0 |
| 58 | 1 | 1 | | | 0.5 | |
| 59 | | 1 | | | 1 | |
| 60 | | 1 | | 1 | 1 | 1 |
| 61 | 1 | 1 | 3 | | 0.5 | 0 |
| 62 | 2 | 2 | | | 0.5 | |
| 63 | 1 | 1 | 1 | | 0.5 | 0 |
| 64 | | 1 | | 1 | 1 | 1 |
| 65 | | 2 | 1 | | 1 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 70 | | 1 | | | 1 | |
| 72 | | 1 | | | 1 | |
| 73 | | | 1 | | | 0 |
| 74 | | 2 | | | 1 | |
| 75 | | 2 | | | 1 | |
| 76 | | 1 | | | 1 | |
| 79 | | | | 1 | | 1 |
| 80 | | | | 1 | | 1 |
| 85 | | | | 1 | | 1 |
| 86 | | | | 1 | | 1 |
| 90 | | 1 | | | 1 | |
| 99 | | 1 | | | 1 | |
| 100+ | | | | 2 | | 1 |
| **Total** | **22** | **23** | **25** | **8** | | |

A recent program by PIER resulted in the collection of 77 female and 20 male white seabass between 2007 and 2015 to evaluate maturity state by fish size and sex (Scott Aalbers, pers. comm.).

Maturity at size for each sex, and separately for the Clark (1930) and PIER datasets was modeled. Here, maturity at length *l* is shown calculated using a logistic function:

$$Mat_l = \frac{1}{1 + e^{slope(l - L_{50\%})}}$$

where "*slope*" is the slope of the maturity logistic function, and "$L_{50\%}$" is the length-at-50%-maturity. Figure 4.9-1 shows the fit to Clark (1930) data and Figure 4.9-2 shows the fit to PIER data, Table 4.9-2 shows the logistic function coefficients.

*Table 4.9-2. Parameters of logistic models for proportion mature at length for male and female white seabass fitted to data from Clark (1930) and PIER. L50% is the length at 50% maturity.*

| Clark (1930) | *slope* | $L_{50\%}$ |
|---|---|---|
| Females | -0.2081 | 69.33 |
| Males | -0.1983 | 56.57 |
| | | |
| PIER | *slope* | $L_{50\%}$ |
| Females | -3.2572 | 86.93 |
| Males | -0.978 | 68.00 |

*Figure 4.9-1. Fraction mature at total length (cm) for female and male white seabass based on data from Clark (1930)*

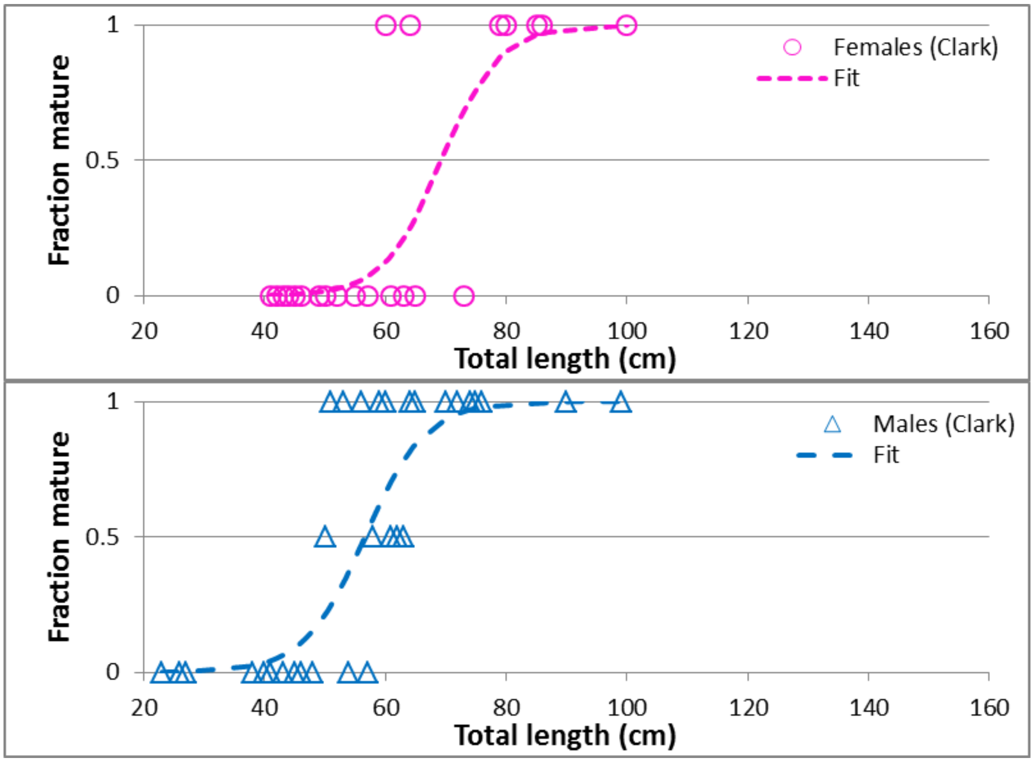
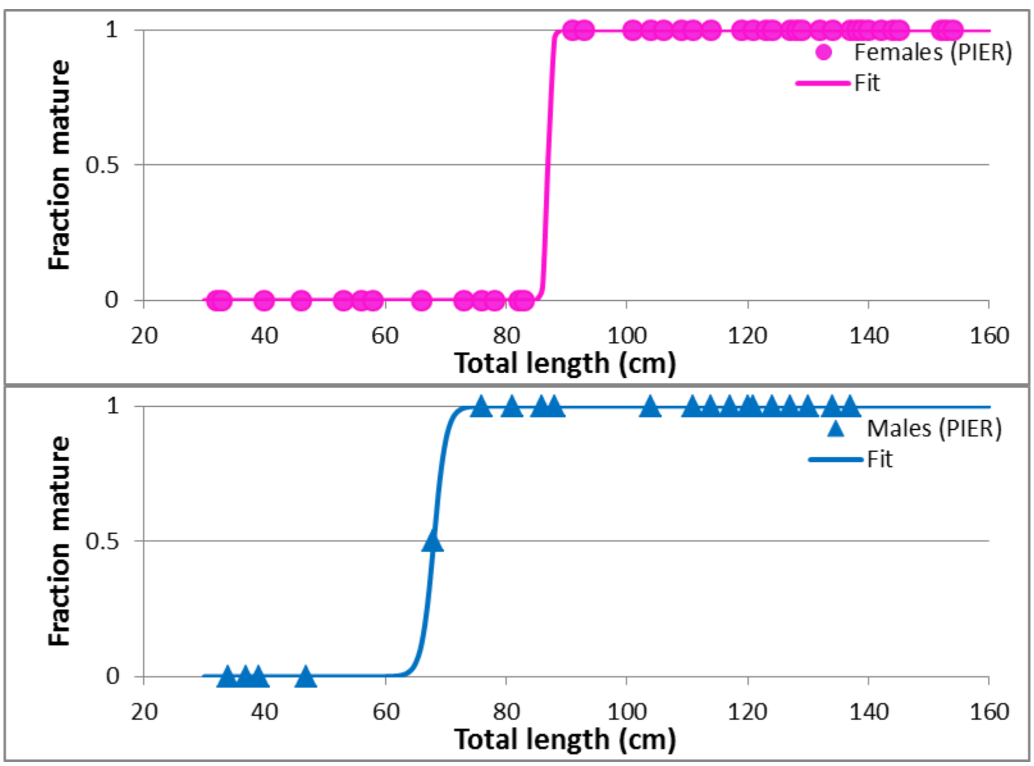



*Figure 4.9-2. Fraction mature at total length (cm) for female and male white seabass based on data from PIER*



## 4.10. Natural Mortality

Natural mortality is one of the most difficult population dynamics parameters to estimate given how confounded it typically is with other processes and parameters and the lack of sufficient or appropriate data. These issues often preclude estimating natural mortality internally in stock assessments, and the analyst often has to rely on external estimates.

There are several estimates of natural mortality for wild white seabass ranging from 0.08 to 0.303, based on age compositions and fishing effort between years (Thomas, 1968; MacCall et al. 1976) or model fits to record weights and assuming underlying population dynamics model (Dayton and MacCall 1992). There are other estimates of natural mortality from hatchery white seabass (Hervas et al. 2010) that were not considered in the stock assessment. Methods described by Hamel (2015) and Then (2015), that rely on maximum age to estimate natural mortality ($M$) were also evaluated. Hamel (2015), essentially $M = 5.4/Age_{Max}$, was applied to age datasets from HSWRI (sex specific) and Romo-Curiel (2015) (unsexed). Previous estimates and those resulted from this work are listed in Table 4.10-1.

Natural mortality rate estimates for the red drum (*Sciaenops ocellatus*), another sciaenid from the Gulf of Mexico and the Atlantic Ocean, ranged between 0.20 to 0.23 for juveniles (ages 1 to 5) and 0.12 to 0.13 for adults (ages 6 and older) (Vaughan and Carmichael, 2000).

*Table 4.10-1. Parameters of logistic models for proportion mature at length for male and female white seabass fitted to data from Clark (1930) and PIER. L50% is the length at 50% maturity.*

| **Natural Mortality estimates ($M$)** | | | **Method** | **Reference** |
|---|---|---|---|---|
| **Both Sexes** | **Females** | **Males** | | |
| 0.303 | | | Silliman (1943), Robson and Chapman (1961) | Thomas, 1968 |
| 0.130 | | | Silliman (1943), Robson and Chapman (1961) | MacCall et al. 1976 |
| 0.258 | | | 1-2 yr, OREHP data | Kent and Ford 1990 |
| 0.117 | | | 3-4 yr, OREHP data | Kent and Ford 1990 |
| 0.080 | | | Model fit to annual record weights | Dayton and MacCall 1992 |
| | 0.225 | 0.360 | Maximum age, Hamel (2015) and Then (2015) | This work, HSWRI otolith data |
| 0.200 | | | Maximum age, Hamel (2015) and Then (2015) | This work, CDFG (2002) otolith data |
| 0.193 | | | Maximum age, Hamel (2015) and Then (2015) | This work, Romo-Curiel (2015) otolith data |

## 4.11. Selectivity

There is not much quantitative information on selectivity for the different gears that catch white seabass. However, in general commercial gillnet gear catch larger fish (Thomas, 1968) than common recreational gear (CDFW, 2002) such as hook and line. However, other recreational gear also catches larger white seabass (i.e. spearfishing). Other gears that targets juveniles (e.g. research gillnets from HSWRI) or that catches primarily juveniles (e.g. power plants) are expected to have dome shape selectivity (e.g. Hervas et al. 2010).

## 4.12. Recruitment

White seabass spawning occurs from April to August with a peak in May/June, with northward movements to spawn in specific areas nearshore (Young, 1973; Aalbers and Sepulveda, 2012). Fecundity has been determined in the laboratory (CDFG 1994). White seabass are batch spawners, with the number of eggs released by single females at a spawning event ranging from 0.76 million to 1.5 million eggs as a function of mean female body weight (CDFC, 2002). White seabass have the largest eggs of the West Coast sciaenids. Eggs are buoyant and drift with the ocean currents (Moser et al. 1983). Larvae have been found along the coast mostly between May and August, peaking in July (Moser et al. 1983). Larvae appear to settle between Santa Rosa Island (California) to Bahia Santa Maria (Baja California, Mexico) (Moser et al. 1983).

Myers et al. (1999) estimated the steepness of the stock recruitment relationship from several species including one stock from the family Scianidae, white croaker (*Argyrosomus argentatus*). The estimate of steepness for *A. argentatus* was 0.87. It should be noted the methods used by Myers et al. (1999) produce negatively biased estimates of steepness (Maunder et al. 2011).

## 4.13. Catch-at-age data

There is no catch-at-age data available for white seabass in a way that is suitable for use in this stock assessment. There is limited catch-at-age data from scales available from 1958 to 1960 (Thomas, 1968). There are several issues with ageing from scales, such as problems reading fish older than 13. Moreover, they come from a range of gears and are therefore not suitable for using as age composition data since they cannot be completely associated with a fishery.

## 4.14. Catch-at-length data

### 4.14.1. CPFV observer data 1970s

The CPFV observer data for the 1970s with lengths of white seabass covers blocks in the 200s, 300s, 400s, 500s, and 600s. The data are from the years 1976, 1977, and 1978 (Figure 4.14.1-1). There are a total of 218 records of white seabass lengths and 40 of these records are from blocks in the 600s (Figure 4.14.1-2). The lengths are assumed to represent total length in mm (per discussion in Ally et al., 1991). There is no information to indicate whether these lengths come from fish that were retained or discarded. For the purposes of this assessment, these lengths are assumed to represent retained fish.

*Figure 4.14.1-1. Histogram of lengths (cm) by year from CPFV observer data from the 1970s.*

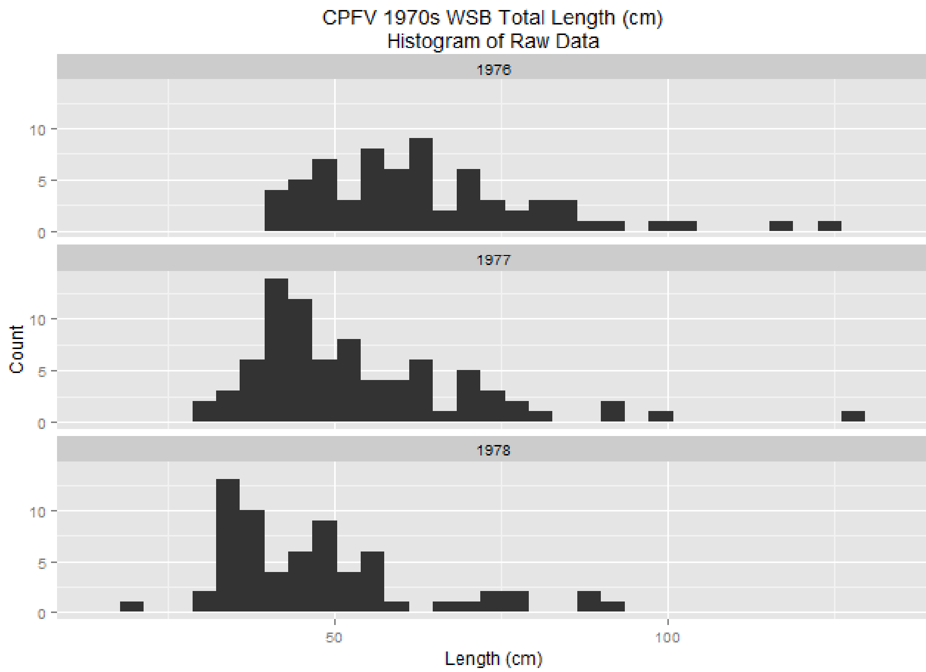
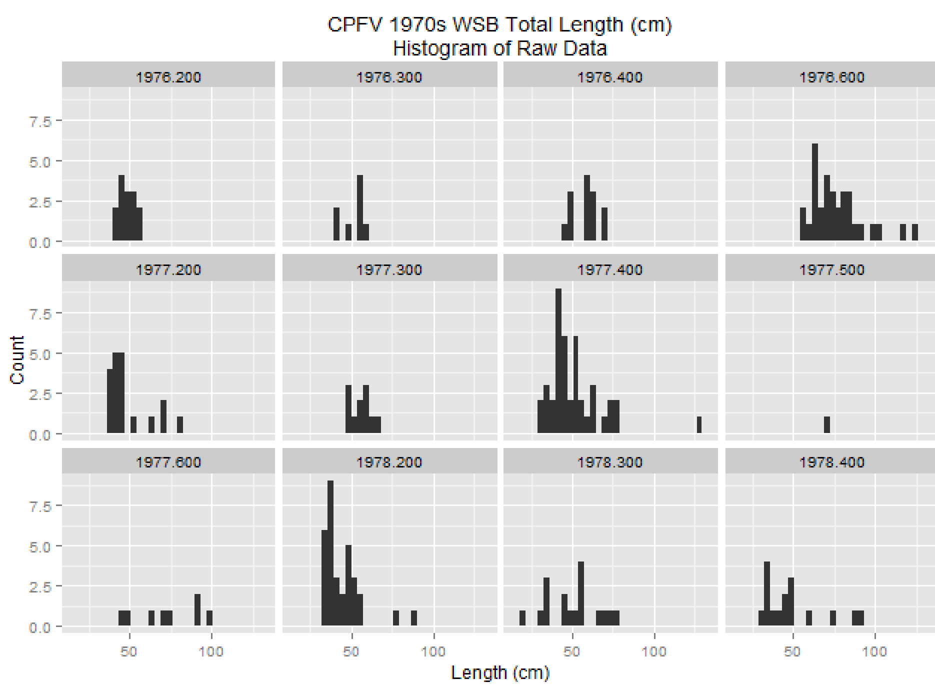



*Figure 4.14.1-2. Histogram of lengths (cm) from the CPFV observer dataset from the 1970s broken down by year and 100-level fishing block.*



### 4.14.2. CPFV observer data 1980s

The CPFV observer data from the 1980s with lengths of white seabass covers blocks in the 100s, 200s, 300s, 400s, 500s, and 600s and is for the years 1986, 1987, 1988, and 1989. There are 328 records of white seabass lengths (Figure 4.14.2-1). The lengths are given as total lengths in mm. For more details on how these samples were collected see Ally et al. 1991. It is unclear if these lengths are from retained or discarded fish. For the purposes of this assessment, these lengths are assumed to represent retained fish.

*Figure 4.14.2-1. Histogram of lengths (cm) from the CPFV observer dataset from the 1980s.*

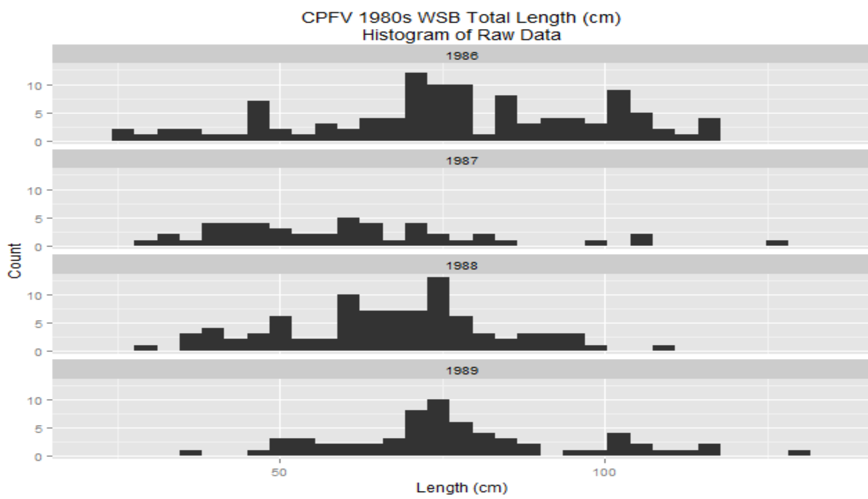
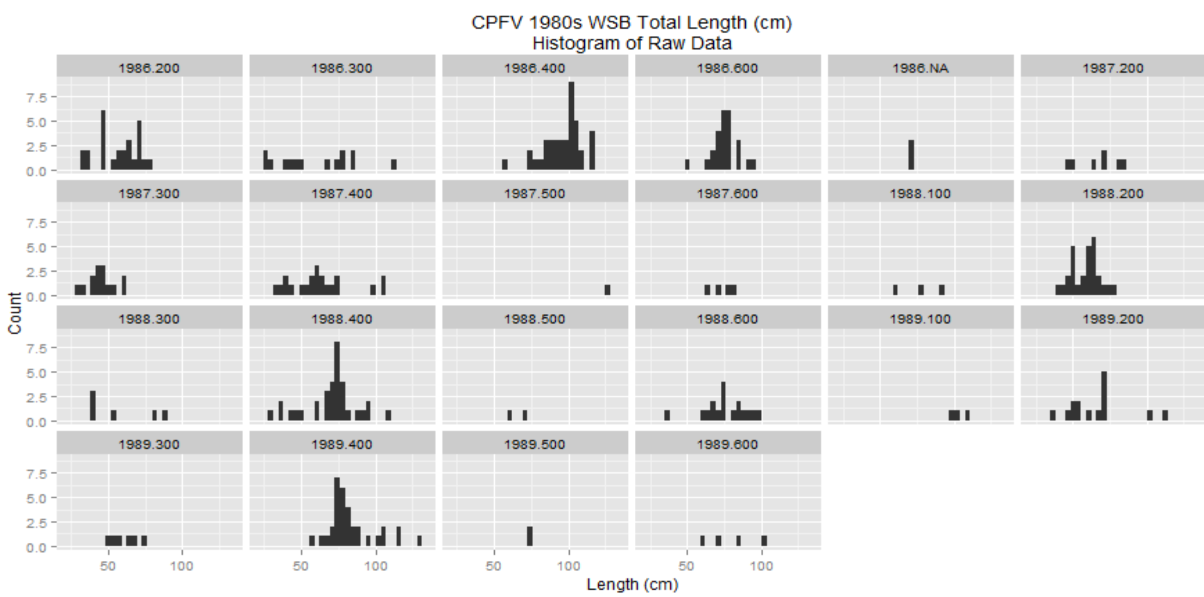


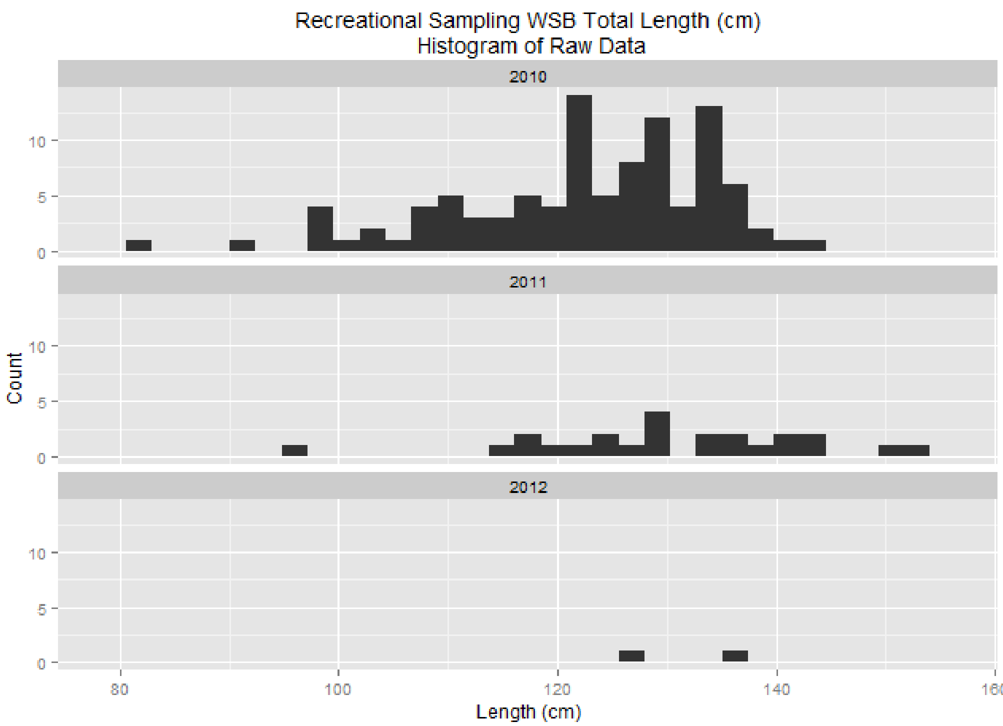

*Figure 4.14.2-2. Histogram of lengths (cm) from the CPFV observer dataset from the 1980s broken down by year and 100-level fishing block.*



### 4.14.3. Recreational observer data

The recreational observer data for white seabass lengths covers the years 2010 to 2012. The data comes from fishing blocks 472, 516, 526, 720, 807, and not specified. The data contain 255 records of white seabass lengths during this time. Only three data points are from 2012, the rest are from 2010 and 2011. For some data points no date is given (n=3). An additional six records have no length data. The lengths are given as total lengths in mm. The data represents three gear types: hook and line (gear type 1, n=167), harpoon/spear (gear type 12, n=1), and hand take (gear type 90, n=11). Based on the sparse data, no length composition expansion was done. Rather the lengths were just binned into 2cm bins and the proportion of the data in each bin was calculated. Binning, using 1, 2, 3, 5, and 10cm bins was also conducted. Due to the small sample size for each gear type and limited number of years, no expansion was done and just the raw length data was used. Histograms of the raw data are shown below (Figure 4.14.3-1).

*Figure 4.14.3-1. Histogram of fish lengths (cm) from recreational sampling data.*

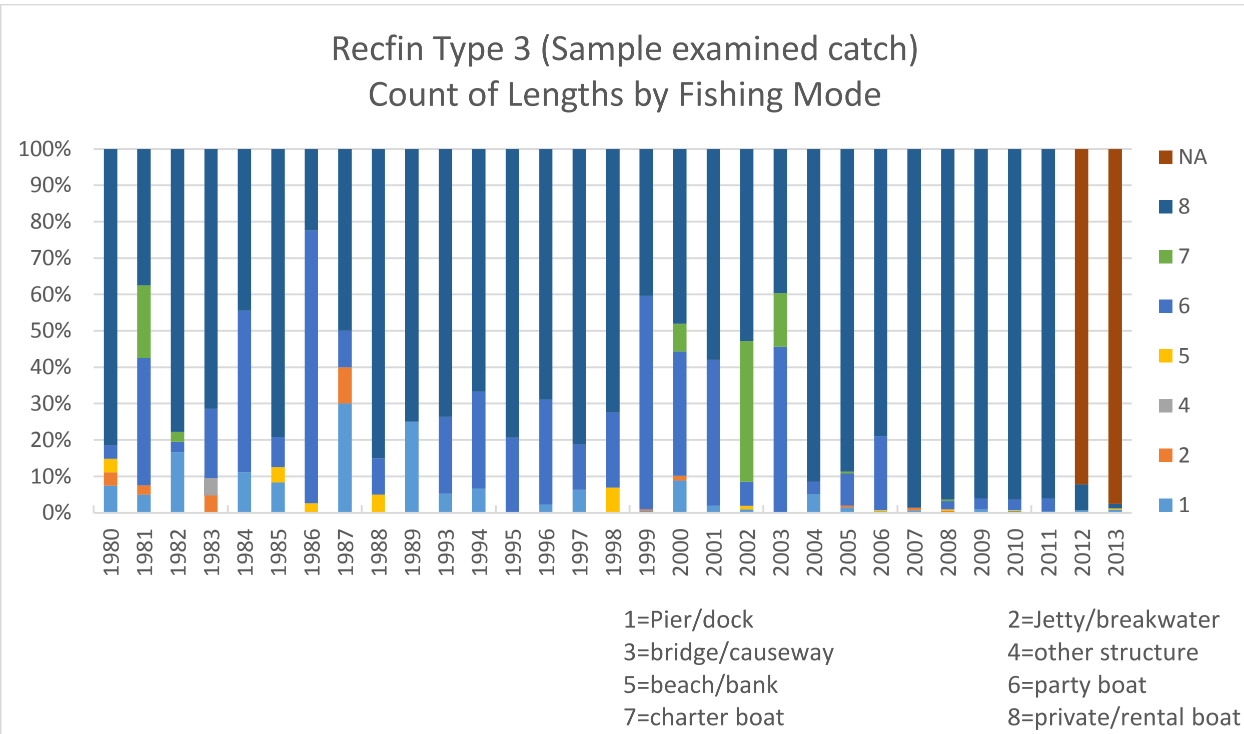



### 4.14.4. MRFSS/CRFS data (RecFIN)

The RecFIN type 3 data (sampler examined catch) for white seabass lengths covers the years 1980 to 1989 and 1993 to 2013. All of these data were from sampler examined retained catch. The source of the data is given by area. There were 6 records from San Francisco Bay. Other areas include 2,911records from the Ocean and 88 records from a river. There are 380 data points with no area given. The data contains 3,394 records of white seabass lengths during this time, and nine of them are from Mexico. Data from 1980-1989 and 1993 to 2003 are from MRFSS surveys and data from 2004 onwards are from CRFS. The gap in data for 1990 to 1992 is due to a lack of funding for the federal MRFSS program to continue during this period.

In the CRFS dataset (all data 2004 and later) the lengths are all measured as fork length in millimeters. MRFSS protocol states that lengths should be collected as total lengths in millimeters. However, it appears that they were not always collected this way, and often fork lengths were measured. For the purpose of this assessment, the most complete dataset available was used, which was lengths given in fork length (mm). It appears that some of these fork lengths are actually conversions from another measurement (based on the number of decimal places given for some data points). According to CDFW, the lengths in the RecFIN database are fork lengths and should be converted to total length by adding 15mm, a conversion provided by Tim Hovey, a former hatchery manager at HSWRI (CDFW, 2002).

*Figure 4.14.4-1. Percentage of lengths from each mode type by year for the RecFIN type 3 (sample examined catch) data for white seabass.*




The majority of the lengths from RecFIN are from the private/charter boat fleet (Figure 4.14.41) and were caught using hook and line. Upon examination of the lengths that come from the party boat fleet and from private/ rental boats, it appears that, in general, spears/spear-guns off private/rental boats catch larger fish than those caught by hook and line on either private/ rental or party boats (Figure 4.14.42 and Figure 4.14.4-3). The private/rental boats catch smaller fish than party boats when both use hook and line. It is worth noting all lengths from party boats in RecFIN type 3 data come from hook and line as the gear type.

*Figure 4.14.4-2. Average length (cm) over time from RecFIN type 3 (sample examined catch) for white seabass. Only fishing modes 6, party boat, and 8, charter/private boat, are shown.  Gear types include hook and line, denoted 1, and spear/spear-gun, denoted by 8.*

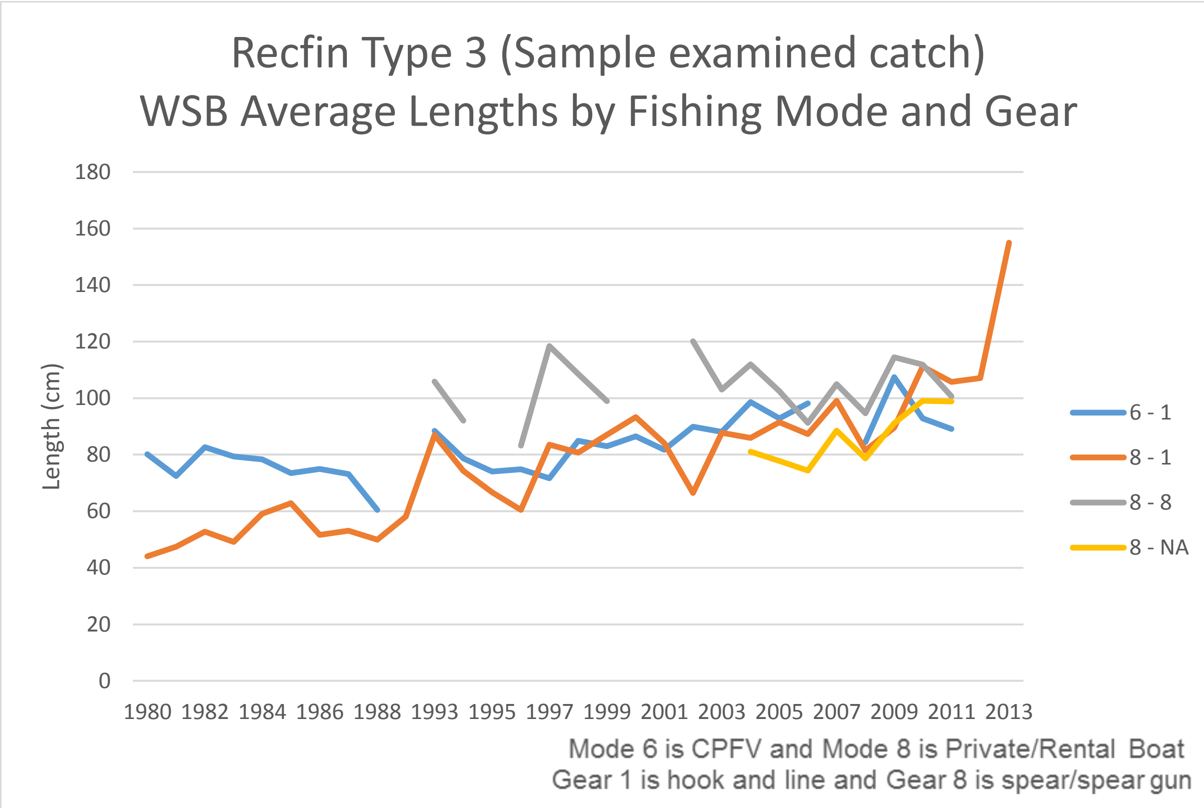
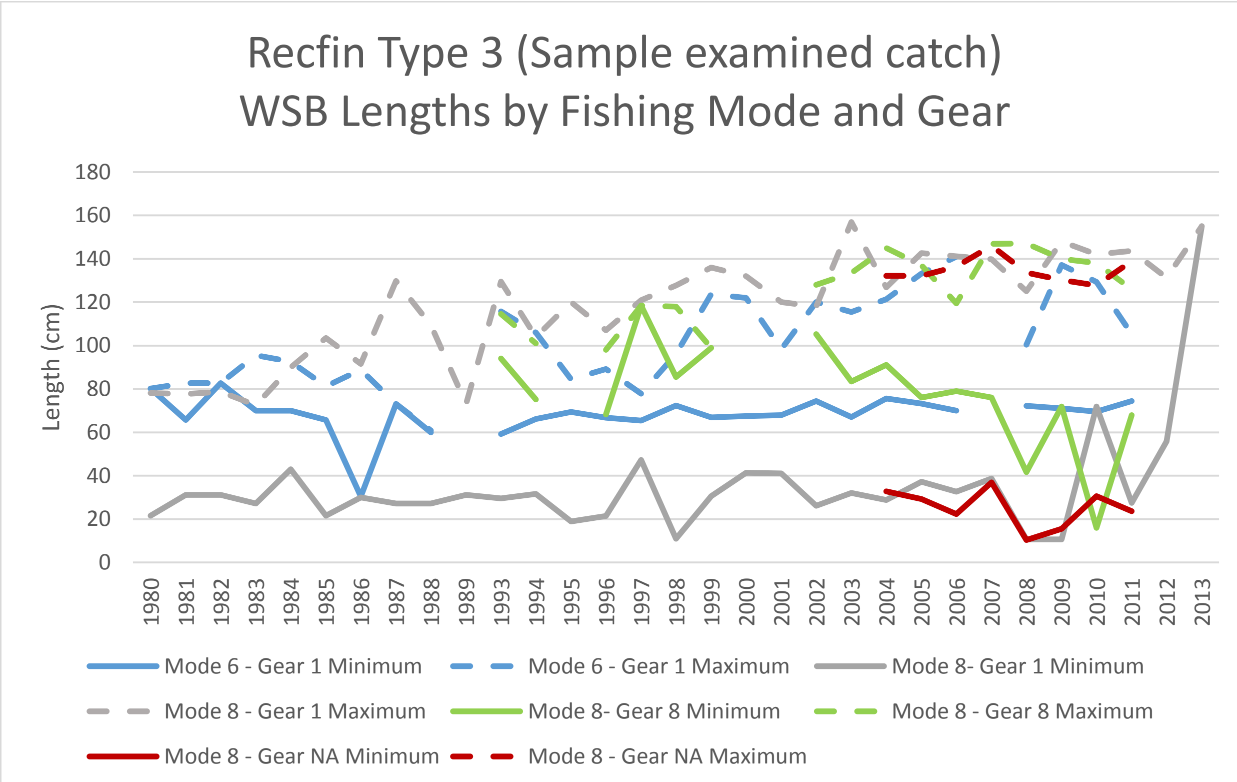
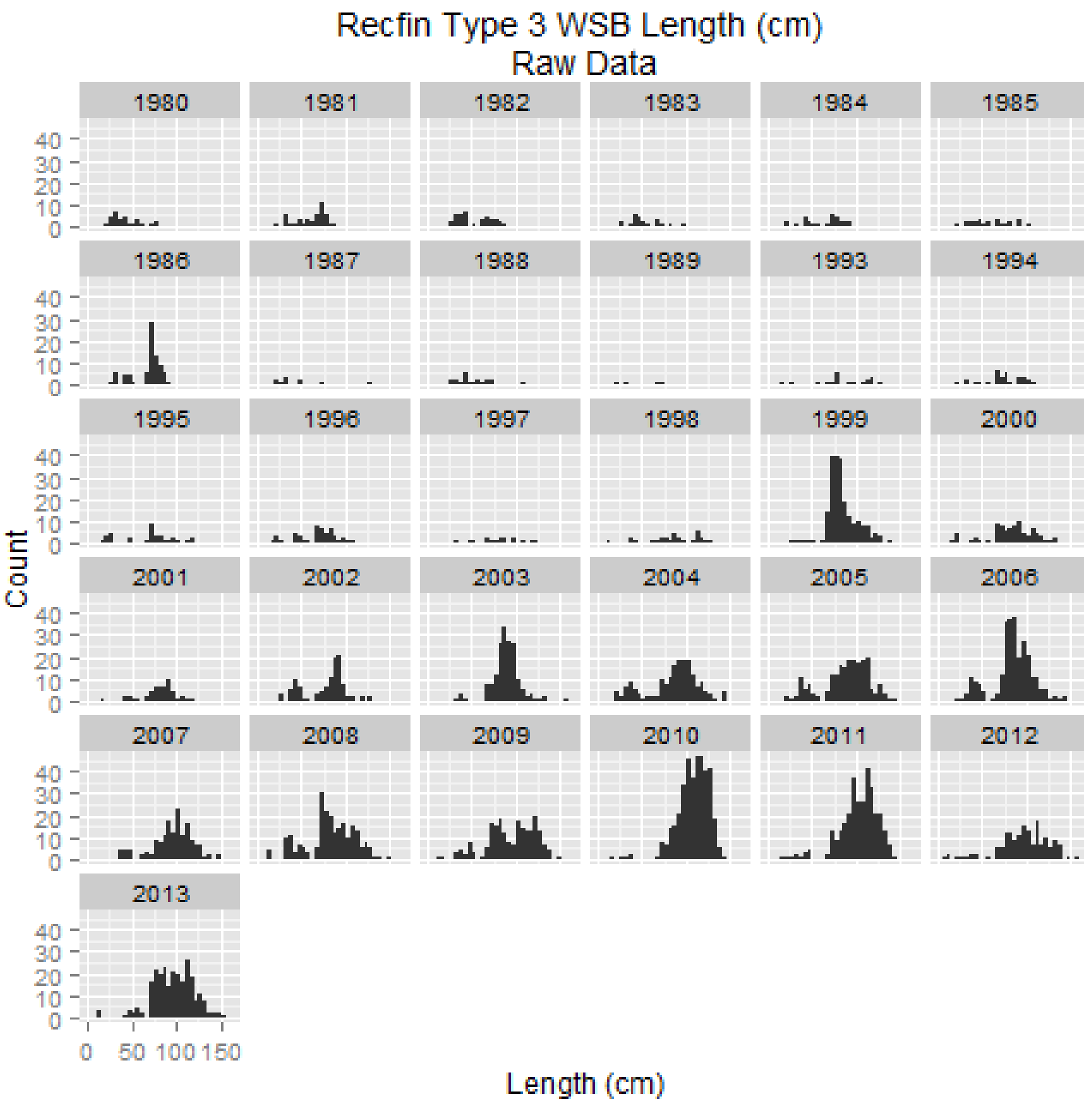


*Figure 4.14.4-3. Maximum and minimum lengths (cm) over time from RecFIN type 3 (sample examined catch) for white seabass. Only fishing modes 6, party boat, and 8, charter/private boat, are shown. Gear types include hook and line, denoted 1, and spear/spear-gun, denoted by 8.*




The catch data associated with RecFIN type 3 (sampler examined catch) was RecFIN type 2 (reported catch) and for many years the reported catch was less than the number of fish inspected for length, when filtered by fishing mode and/or gear type. For this reason, it is not possible to do a length composition expansion. Instead, the raw length data was binned by 2cm bins and used without an expansion. The sample size by year has varied throughout time, with a steady increase since the early 2000s (Figure 4.14.4-4).

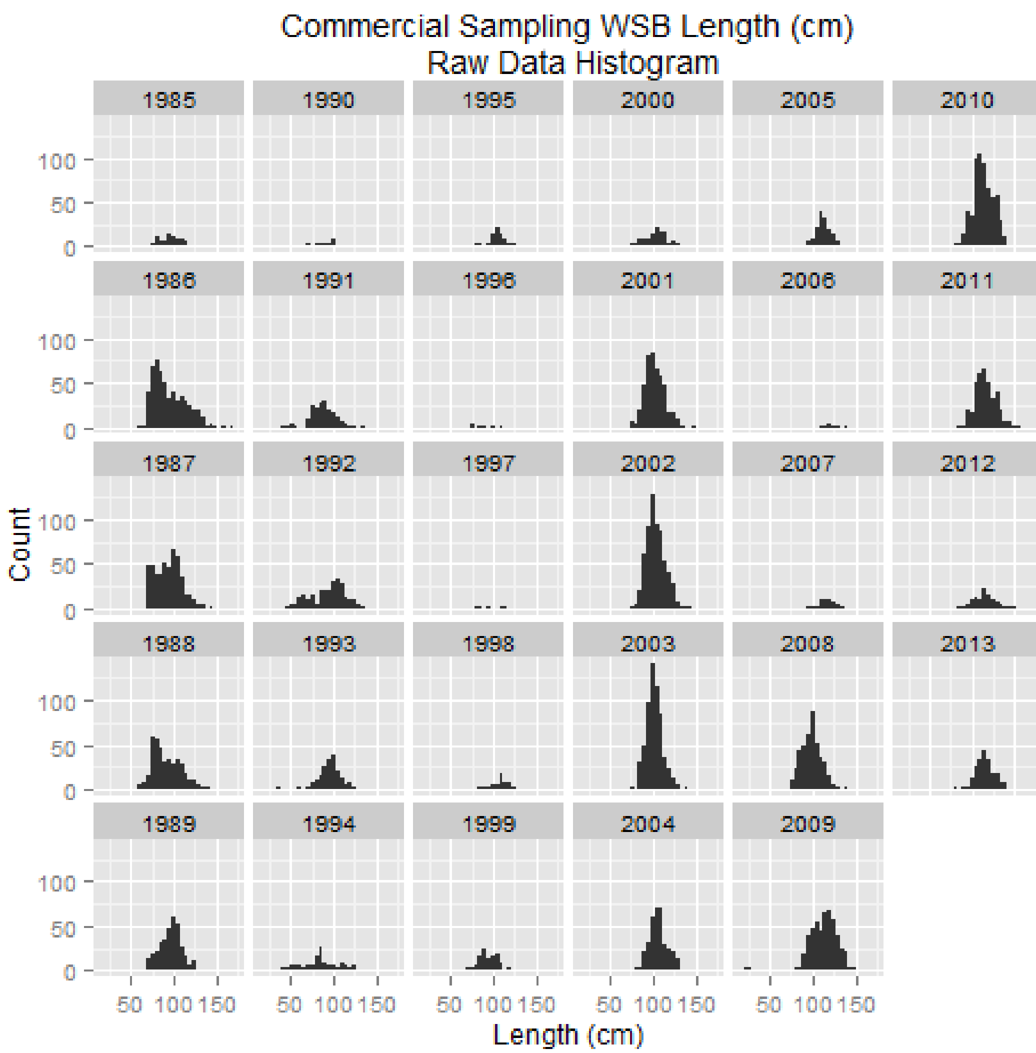
*Figure 4.14.4-4. Length composition (cm) data by year for RecFIN type 3 (sampler examined catch) for white seabass. Includes all fishing modes and all gear types. No expansion has been applied.*




## 4.14.5. Commercial observer data

The commercial observer data for white seabass lengths covers the years 1985 to 2013. The data comes from fishing blocks numbered 500s, 600s, 700s, and 800s. The data contains 7,716 records of white seabass lengths during this time, of which, 7,531 records are usable for length compositions. Records were removed for the following reasons: 5 data points had no length measurements associated with them and 180 records had no associated total landings or total weight, so expansion from these data were not possible. The lengths in the raw data are recorded as total lengths in mm. The data was also binned by 1cm, 2cm, 3cm, 5cm, and 10cm. For all analyses, expansions, and model input 2cm bins were used (Figure 4.14.5-1). Lengths in the raw data range from 207mm to 1671mm with a median of 1030mm. The majority of the data came from measurements taken in the 600, 700, and 800 blocks (CDFW fishing blocks), however, 58 records came from blocks 516 and 526 (20 and 38 records, respectively). Four types of gear are represented in this data, hook and line (gear type 1 in the data, n=124), bottom trawl (gear type 56 in the data, n=1), drift gillnet (gear type 65 in the data, n=1471), and set gillnet (gear type 66 in the data, n=5899).

*Figure 4.14.5-1. Histograms of recorded lengths (cm) from the commercial sampling program.*




A table of the number of fish measured each year and catch represented by those fish measured is shown below (Table 4.14.5-1). The table also shows the number of fish measures and the representative catch broken down by the four gear types (hook and line, bottom trawl, drift gillnet, and set gillnet along with records that had no recorded gear type).

*Table 4.14.5-1. Data from commercial sampling, including: number measured for lengths and catch that sample represents. Data is also given separated by recorded gear type.*

| | | | Hook and Line | | Bottom Trawl | | Drift Gillnet | | Set Gillnet | | Unknown Gear | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Number Measured | Total Catch (#) Represented | Number Measured | Catch(#) Represented | Number Measured | Catch(#) Represented | Number Measured | Catch(#) Represented | Number Measured | Catch(#) Represented | Number Measured | Catch(#) Represented |
| 1985 | 86 | 2044 | 4 | 32 | | | | | 82 | 2012 | | |
| 1986 | 557 | 14320 | 27 | 462 | | | | | 530 | 13858 | | |
| 1987 | 481 | 18159 | 7 | 20 | | | 154 | 8632 | 320 | 9507 | | |
| 1988 | 398 | 12648 | | | | | | | 398 | 12648 | | |
| 1989 | 341 | 19659 | | | | | 96 | 7481 | 244 | 12177 | 1 | 1 |
| 1990 | 28 | 202 | 1 | 1 | | | 22 | 186 | 5 | 15 | | |
| 1991 | 189 | 6762 | 10 | 150 | 1 | 1 | 17 | 918 | 161 | 5693 | | |
| 1992 | 256 | 6651 | 3 | 5 | | | 8 | 385 | 239 | 6249 | 6 | 12 |
| 1993 | 191 | 15224 | | | | | 32 | 8030 | 146 | 7117 | 13 | 77 |
| 1994 | 130 | 15039 | | | | | 109 | 15018 | 21 | 21 | | |
| 1995 | 82 | 4856 | | | | | 44 | 2573 | 26 | 2021 | 12 | 262 |
| 1996 | 11 | 103 | | | | | 7 | 98 | 4 | 5 | | |
| 1997 | 5 | 110 | | | | | | | 5 | 110 | | |
| 1998 | 60 | 831 | | | | | 24 | 343 | 36 | 488 | | |
| 1999 | 113 | 3428 | 2 | 12 | | | 67 | 1797 | 43 | 1617 | 1 | 2 |
| 2000 | 119 | 4183 | | | | | 4 | 24 | 115 | 4159 | | |
| 2001 | 463 | 54347 | | | | | 36 | 1239 | 427 | 53108 | | |
| 2002 | 626 | 62241 | | | | | 78 | 9151 | 548 | 53090 | | |
| 2003 | 607 | 121015 | | | | | 46 | 10262 | 561 | 110753 | | |
| 2004 | 342 | 66065 | | | | | | | 342 | 66065 | | |
| 2005 | 152 | 9766 | | | | | | | 152 | 9766 | | |
| 2006 | 14 | 184 | | | | | | | 14 | 184 | | |
| 2007 | 51 | 2173 | | | | | | | 51 | 2173 | | |
| 2008 | 426 | 60644 | | | | | 335 | 53326 | 91 | 7318 | | |
| 2009 | 500 | 36458 | | | | | 298 | 25032 | 202 | 11426 | | |
| 2010 | 613 | 51021 | 39 | 922 | | | 78 | 3795 | 496 | 46304 | | |
| 2011 | 377 | 28580 | 30 | 95 | | | 15 | 990 | 329 | 27480 | 3 | 15 |
| 2012 | 104 | 1356 | | | | | | | 104 | 1356 | | |
| 2013 | 209 | 9516 | 1 | 13 | | | 1 | 21 | 207 | 9482 | | |

Expanding by proportion measured within each 100-level block for a given gear, year combination results in the following plots (Figure 4.14.5-2, Figure 4.14.5-3, and Figure 4.14.5-4). This is the same as the proportion of lengths in each 2cm from the data filtered only by gear and year after being combined across 100-blocks, weighted according to number in each 100-block. Note, that when using this expansion, there is no longer bottom trawl (gear=1) as a gear type nor NA as a gear type. There are only 8 years of data (1985-1987, 1990, 1999, 2010-2011, and 2013) for the hook and line fishery (gear=1) and many of the years appear to be based on very few individuals for the total measured and for total catch. Furthermore, the hook and line data in a given year comes mainly from one 100-level block, or 2 at most. For the drift gillnet data there are more years (1987, 1989-1990, 1993-1996, 1998-2003, 2008-2011, and 2013) but some years have very little data and are poorly represented across all 100-blocks. The set gillnet data represents 27 years (1985-1988 and 1991-2013) and many of those years represent three of the 100-level blocks (600, 700, and 800). Only two of the 27 years have less than ten length measurements.

*Figure 4.14.5-2. Length composition expansions for the commercial sampling length data for hook and line. Expansion is based on 2cm length bins and expanded by number of measured fish in the 100 block.*

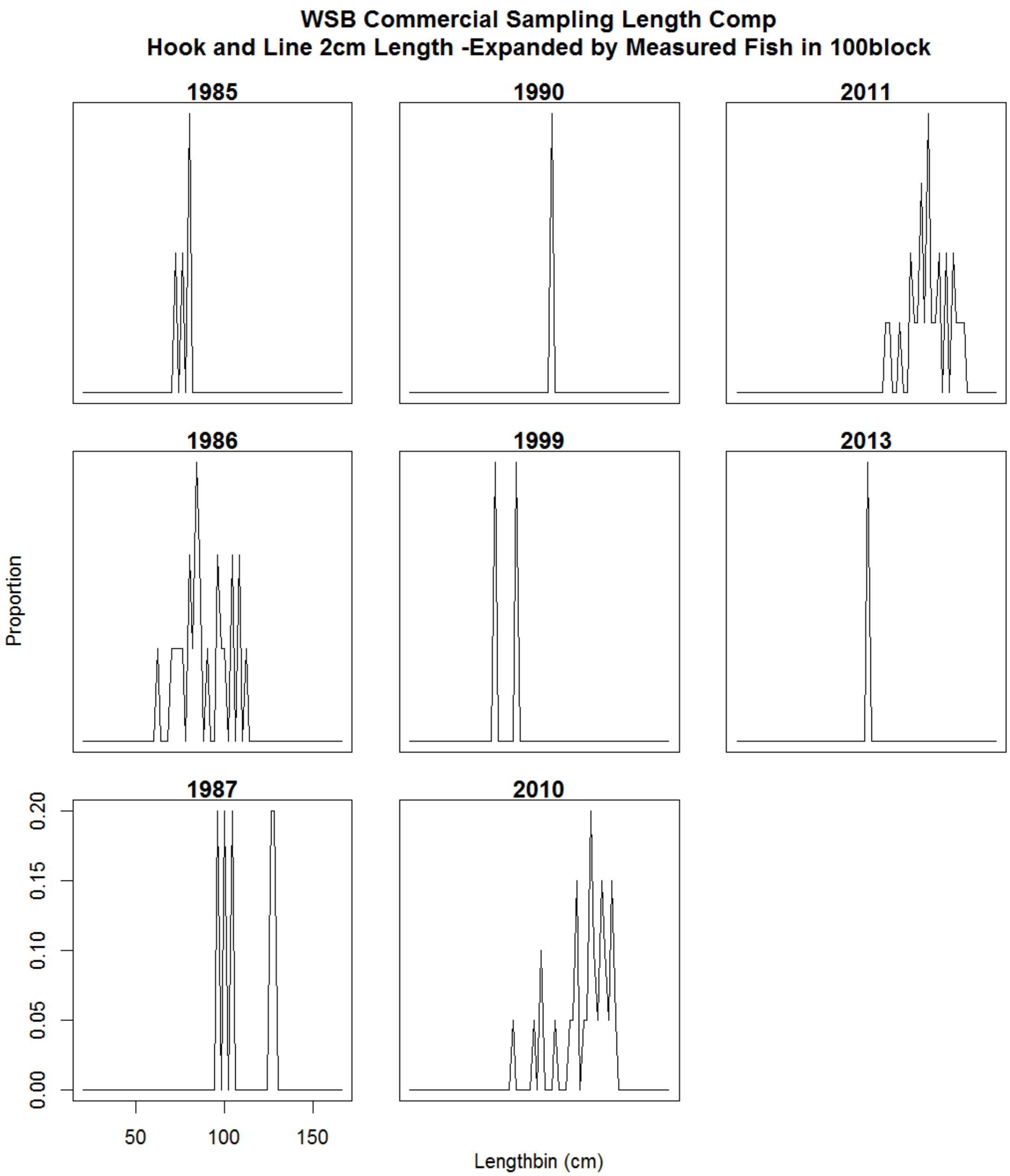


*Figure 4.14.5-3. Length composition expansions for the commercial sampling length data for drift gillnet. Expansion is based on 2cm length bins and expanded by number of measured fish in the 100 block.*

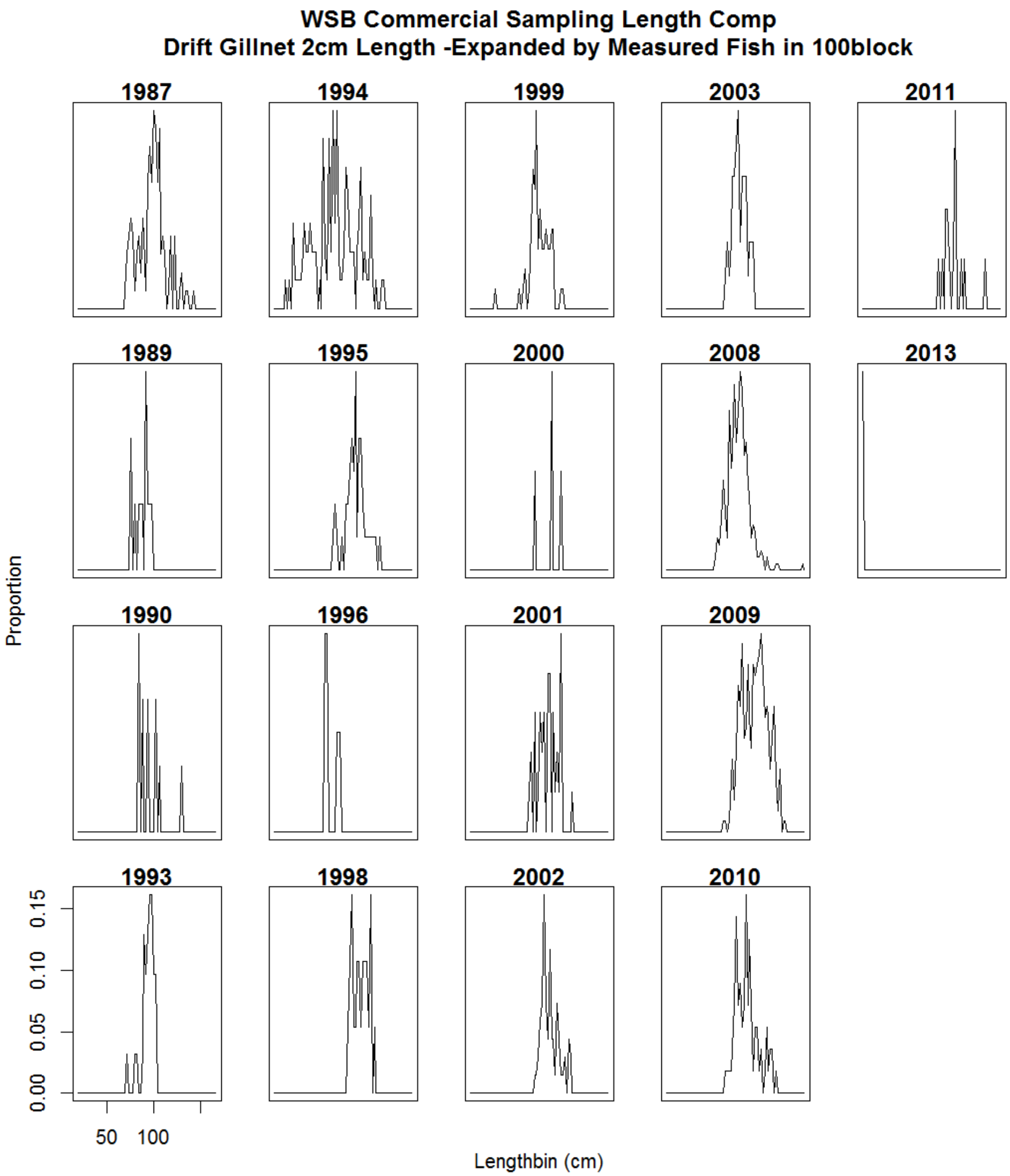
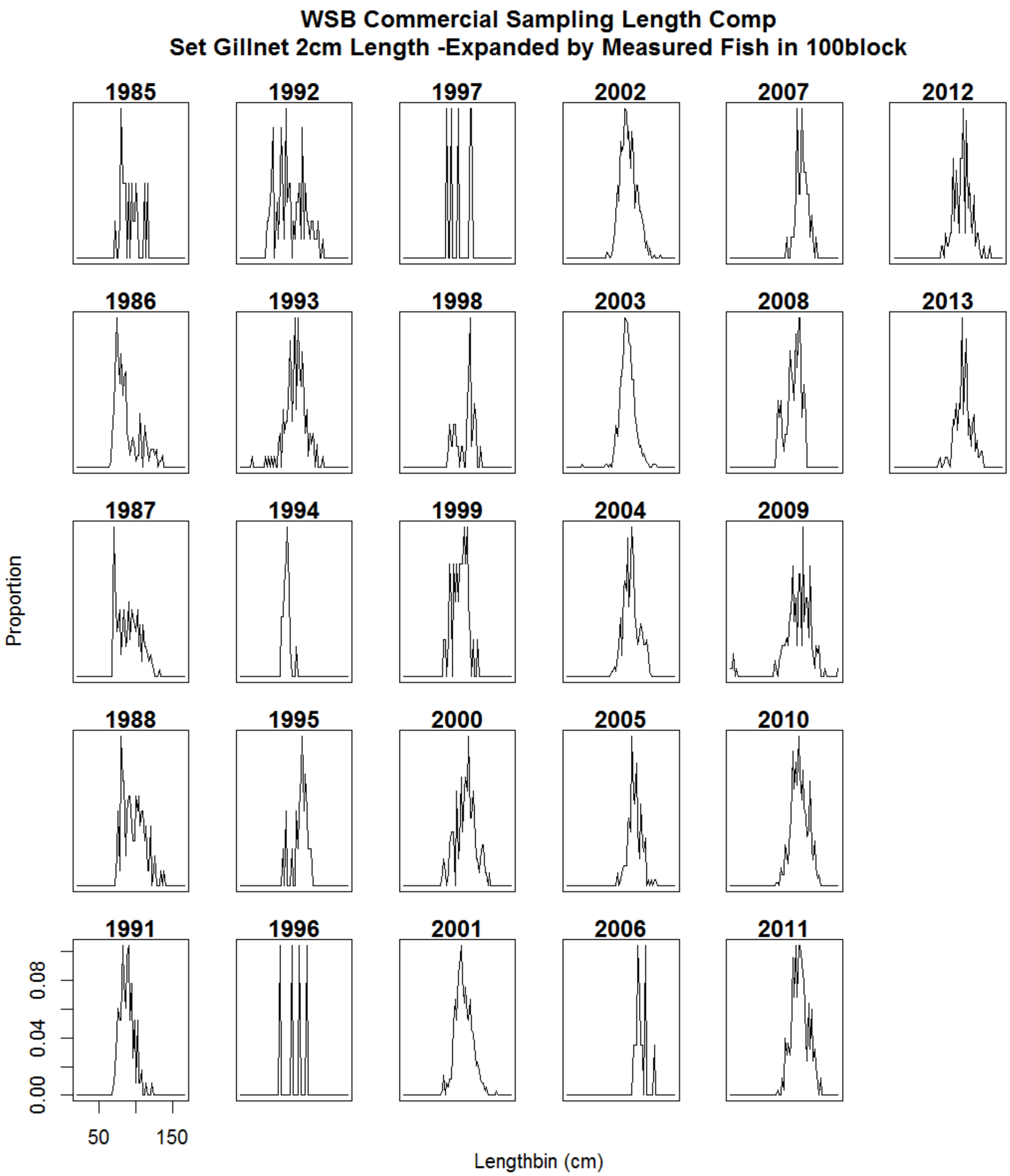


*Figure 4.14.5-4. Length composition expansions for the commercial sampling length data for set gillnet. Expansion is based on 2cm length bins and expanded by number of measured fish in the 100 block.*




The proportion of fish measured that fall in each 2cm length bin can then be expanded in terms of total associated catch within each 100-level block for a given gear, year combination results in the following plots (Figure 4.14.5-5, Figure 4.14.5-6, and Figure 4.14.5-7). Note that using this expansion based on 100-level block there is no longer bottom trawl (gear=1) as a gear type nor do NA as a gear type.

*Figure 4.14.5-5. Length composition expansions for the commercial sampling length data for hook and line. Expansion is based on 2cm length bins and expanded by total catch that was subsampled for lengths in the 100 block.*

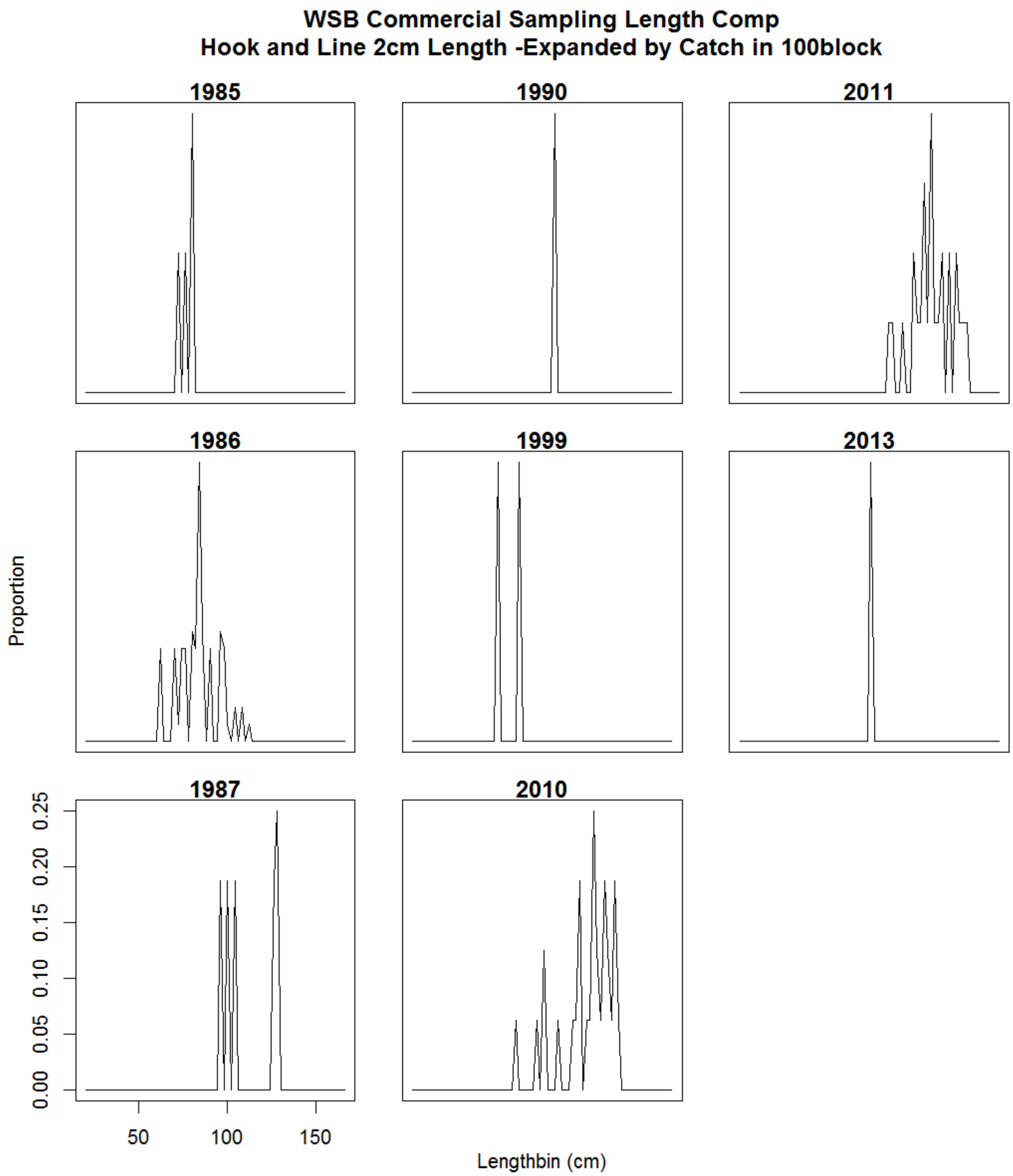


*Figure 4.14.5-6. Length composition expansions for the commercial sampling length data for drift gillnet. Expansion is based on 2cm length bins and expanded by total catch that was subsampled for lengths in the 100 block.*

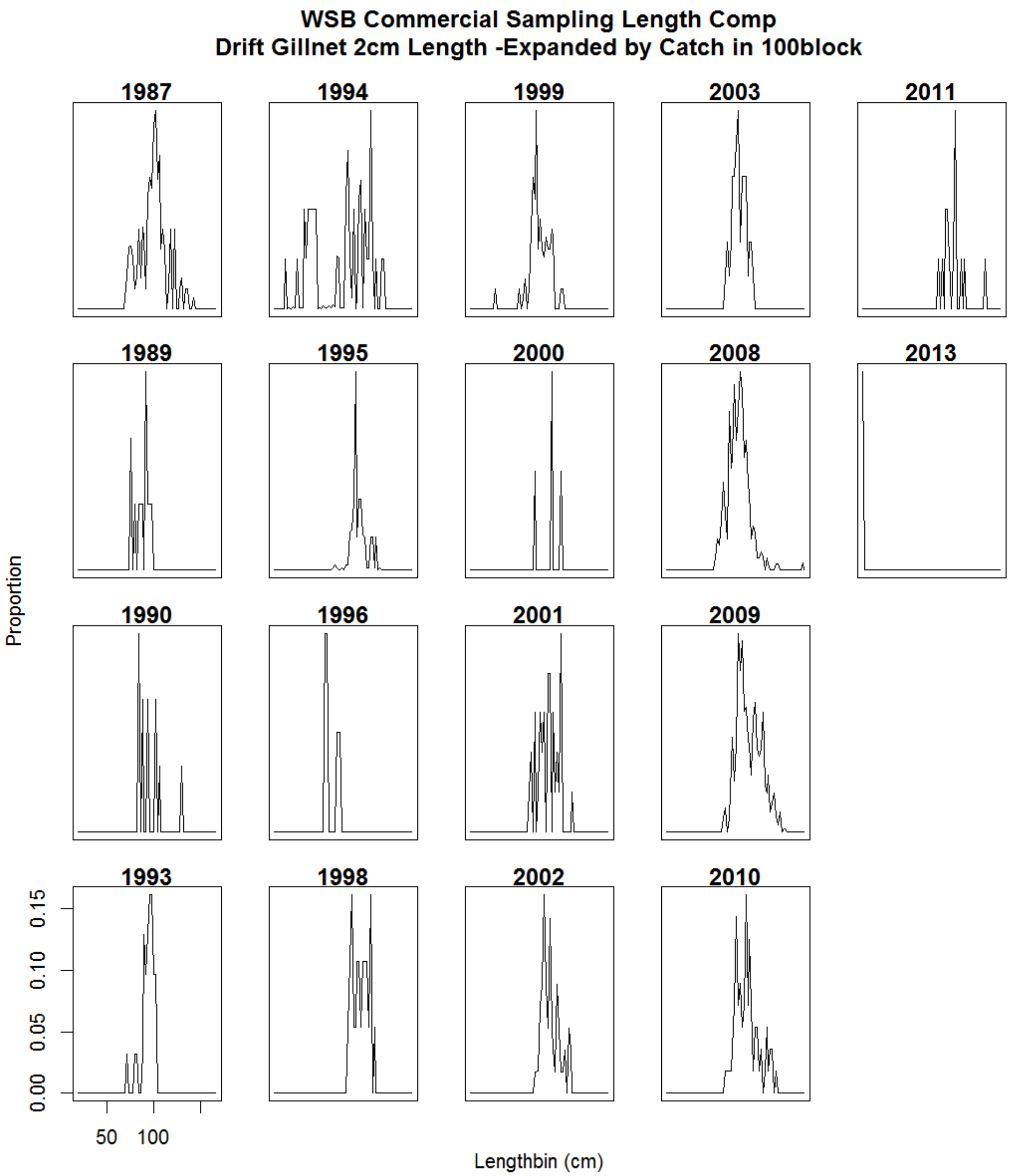
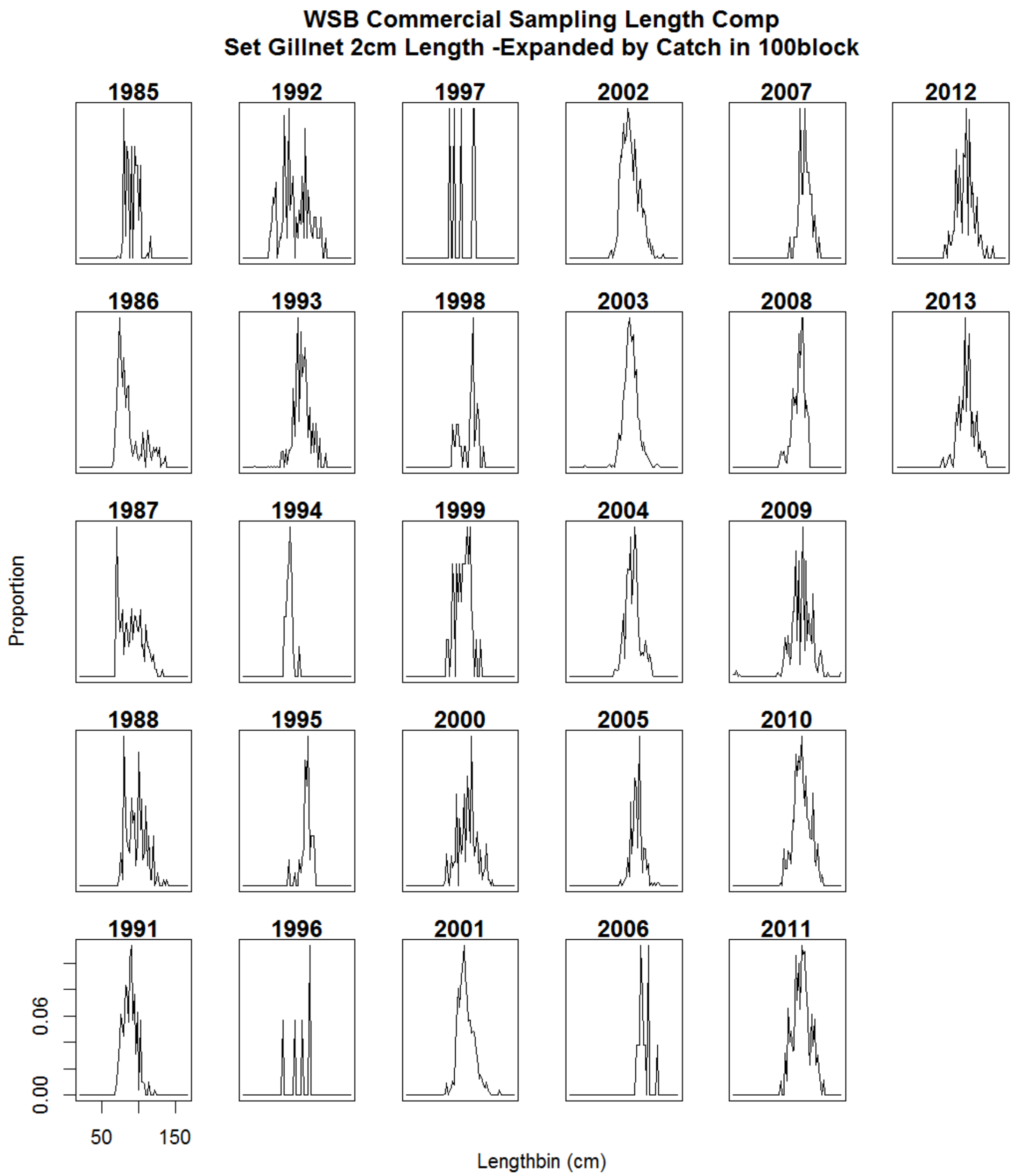


*Figure 4.14.5-7. Length composition expansions for the commercial sampling length data for set gillnet. Expansion is based on 2cm length bins and expanded by total catch that was subsampled for lengths in the 100 block.*




The expansion by proportion measured or proportion based on total associated catch produced similar results. The below table shows number and percentage of times that the two produce equal proportions, when the expansion based on proportion measured is greater than proportion based on total associated catch, and when it is less than (Table 4.14.5-2).

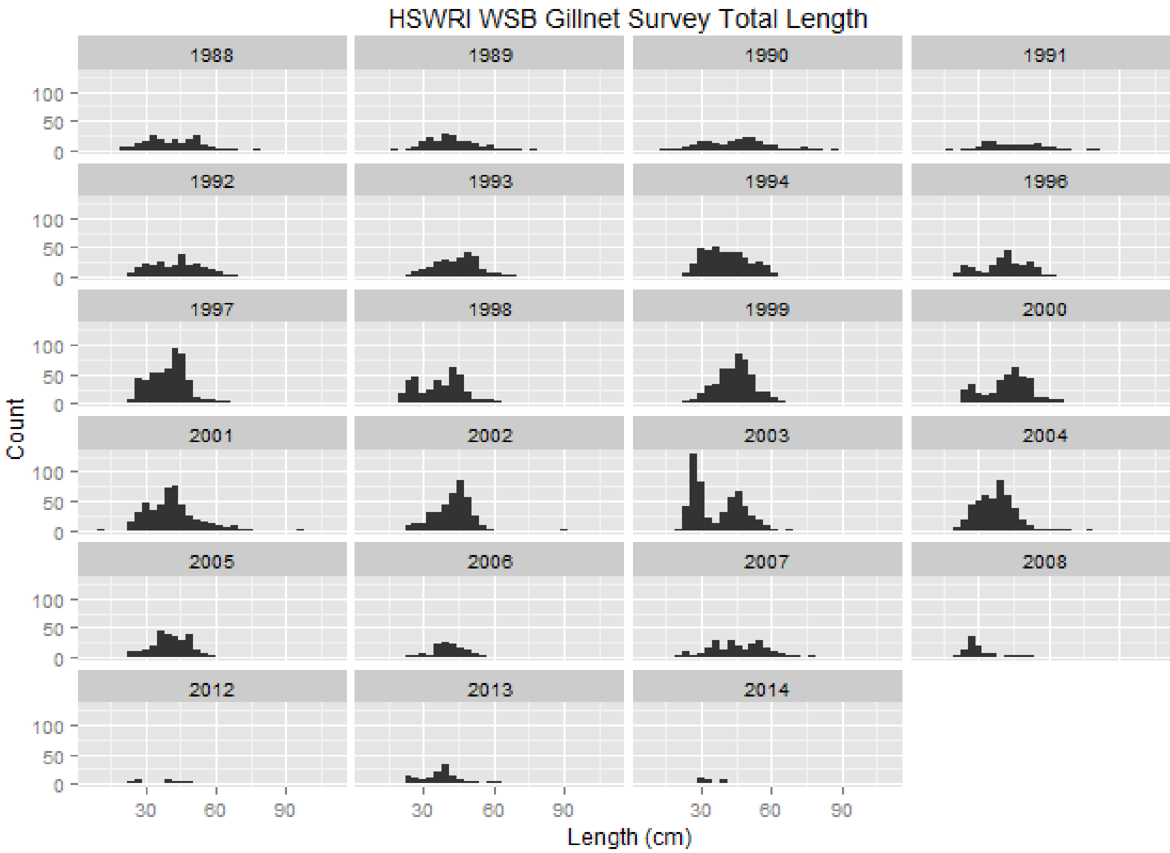
*Table 4.14.5-2. Comparison of length composition expansion based on number of measured fish per 100-level fishing block and number of fish caught per 100-level fishing block.*

| Gear Type | # Cases Equal | % Cases Equal | # Cases Measure>Tot. Catch | % Cases Measure > Tot. Catch | # Cases Measure < Tot. Catch | % Cases Measure < Tot. Catch | Total # |
|---|---|---|---|---|---|---|---|
| Hook and Line (1) | 571 | 96.6% | 12 | 2.0% | 9 | 1.5% | 591 |
| Drift Gillnet (65) | 1117 | 83.9% | 98 | 7.4% | 117 | 8.8% | 1332 |
| Set Gillnet (66) | 1426 | 71.4% | 300 | 15.0% | 272 | 13.6% | 1998 |

### 4.14.6. Survey (Hubbs Sea World Research Institute) Gillnet Data

Lengths are measured as standard lengths to the nearest mm (for details see Allen et al., 2007; Allen et al., 2001; and Allen and Franklin 1992). Lengths were provided by Mike Shane as total length (mm). After removing records where length was listed as either 0 or 9999, there are 6,305 records with length in the dataset. The lengths range from 103mm to 1051mm. The data was binned by 1cm, 2cm, 3cm, 5cm, and 10cm. For all analyses, expansions, and model input, 2cm bins were used (Figure 4.14.6-1).

*Figure 4.14.6-1. Histogram of lengths (shown in the plot in cm, but originally measured in mm) from HSWRI gillnet survey for white seabass separated by year.*




## 4.14.7. Survey (California State University) Gillnet Data

Similar to the HSWRI gillnet length data, all lengths are measured as standard lengths to the nearest mm. The lengths were converted to total lengths by Larry Allen, and the data was analyzed using total lengths. There are 11,814 records of length from this dataset. The data were binned by 1cm, 2cm, 3cm, 5cm, and 10cm. For all analyses, expansions, and model input, 2cm bins were used (Figure 4.14.7-1). The minimum total length was 7mm and the maximum total length was 1264mm. This data was not used in the assessment as an index was not created from this data (see Section 4.15.2 for further discussion).

*Figure 4.14.7-1. Histogram of total lengths (shown in cm, measured in mm) from CSUN gillnet survey sampling.*

### 4.14.8. Impingement and associated trawl survey data

Details about the sampling methodology for this data can be found in Miller et al. (2009 and 2011).

There were 27 recorded lengths for white seabass in the trawl survey data from the power plants (out of 2,838 trawls). The lengths were recorded as standard lengths (SL) in mm. All 27 data points were from the SONGS power plant and came from the time span 2010 to 2014. Due to the small sample size, no length expansion was done on the fish trawl data length measurements.

In the heat treatment (HT) dataset there are 3,634 recorded lengths (Table 4.14.8-1). Lengths are recorded as standard lengths (SL) and given in mm. They are distributed among various power plants and units within those power plants. Summary tables are given below (Table 4.14.8-2).

*Table 4.14.8-1. Number of fish measured for lengths from the heat treatment power plant data.*

| Year | Number of Fish Lengths | Year | Number of Fish Lengths | Year | Number of Fish Lengths |
|---|---|---|---|---|---|
| 1975 | 6 | 1989 | 52 | 2001 | 234 |
| 1976 | 2 | 1990 | 69 | 2002 | 105 |
| 1977 | 2 | 1991 | 21 | 2003 | 36 |
| 1978 | 21 | 1992 | 17 | 2004 | 277 |
| 1981 | 133 | 1993 | 134 | 2005 | 54 |
| 1982 | 88 | 1994 | 154 | 2006 | 47 |
| 1983 | 30 | 1995 | 90 | 2007 | 207 |
| 1984 | 260 | 1996 | 121 | 2008 | 66 |
| 1985 | 282 | 1997 | 411 | 2009 | 30 |
| 1986 | 348 | 1998 | 63 | 2010 | 14 |
| 1987 | 99 | 1999 | 8 | 2011 | 34 |
| 1988 | 53 | 2000 | 58 | 2012 | 8 |

*Table 4.14.8-2. Number of fish measured in heat treatment power plant data separated by power station and unit within station.*

| | **ESGS** | | | **HBGS** | **OBGS** | | | **RBGS** | | | | **SGS** | **SONGS** | | | | **Grand Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **UNIT** | **12** | **34** | **Total** | **Total** | **12** | **NA** | **Total** | **14** | **56** | **78** | **Total** | **Total** | **1** | **2** | **3** | **Total** | |
| **YEAR** | | | | | | | | | | | | | | | | | |
| 1975 | | | | | | | | | | 6 | 6 | | | | | | 6 |
| 1976 | | | | | | | | | | 2 | 2 | | | | | | 2 |
| 1977 | | | | | | | | | | 2 | 2 | | | | | | 2 |
| 1978 | | | | | | | | | | 21 | 21 | | | | | | 21 |
| 1981 | 4 | 3 | 7 | 115 | | | | | | | | | 11 | | | 11 | 133 |
| 1982 | 1 | 5 | 6 | 22 | | | | 58 | | | 58 | | 2 | | | 2 | 88 |
| 1983 | 18 | 10 | 28 | | | | | | 1 | | 1 | | | 1 | | 1 | 30 |
| 1984 | 1 | 73 | 74 | 156 | | | | 10 | | 8 | 18 | | | 10 | 2 | 12 | 260 |
| 1985 | | 9 | 9 | 190 | | | | | 2 | 16 | 18 | | 65 | | | 65 | 282 |
| 1986 | 1 | 7 | 8 | 294 | | 1 | 1 | | | 8 | 8 | | 26 | 11 | | 37 | 348 |
| 1987 | 2 | 3 | 5 | 58 | | 1 | 1 | | | | | | 27 | 5 | 3 | 35 | 99 |
| 1988 | | 1 | 1 | 20 | | | | | | 2 | 2 | | 19 | 11 | | 30 | 53 |
| 1989 | 3 | | 3 | 8 | | | | | 1 | | 1 | | 20 | 20 | | 40 | 52 |
| 1990 | | | | 7 | | | | | | | | | 9 | 53 | | 62 | 69 |
| 1991 | 1 | | 1 | | | 6 | 6 | | | 1 | 1 | | 6 | 7 | | 13 | 21 |
| 1992 | | | | 9 | | | | | | 2 | 2 | | 1 | | 5 | 6 | 17 |
| 1993 | 8 | 7 | 15 | 30 | 7 | | 7 | | | 18 | 18 | | | | 64 | 64 | 134 |
| 1994 | | 50 | 50 | 4 | 3 | | 3 | | | 2 | 2 | | | 22 | 73 | 95 | 154 |
| 1995 | | 2 | 2 | 34 | 4 | | 4 | | | 2 | 2 | | | 6 | 42 | 48 | 90 |
| 1996 | | | | | 2 | | 2 | | | 2 | 2 | | | 54 | 63 | 117 | 121 |
| 1997 | | 35 | 35 | 281 | 1 | | 1 | | | 2 | 2 | | | | 92 | 92 | 411 |
| 1998 | | 1 | 1 | 9 | 7 | | 7 | | | | | | | 10 | 36 | 46 | 63 |
| 1999 | | | | | | | | | | | | | | 3 | 5 | 8 | 8 |
| 2000 | 1 | 1 | 2 | | 1 | | 1 | | | 6 | 6 | 29 | | 1 | 19 | 20 | 58 |
| 2001 | | | | 190 | | | | | | 16 | 16 | 4 | | | 24 | 24 | 234 |
| 2002 | | | | 64 | | | | | | 3 | 3 | 34 | | | 4 | 4 | 105 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2003 | | | | 15 | | | | | | | | 2 | | 1 | 18 | 19 | 36 |
| 2004 | | | | 226 | | | | | | | | 38 | | | 13 | 13 | 277 |
| 2005 | | | | 41 | | | | | | | | 6 | | | 7 | 7 | 54 |
| 2006 | | | | 10 | | | | | | | | 17 | | 11 | 9 | 20 | 47 |
| 2007 | | | | 200 | | | | | | | | 5 | | | 2 | 2 | 207 |
| 2008 | | | | 51 | | | | | | | | 4 | | 7 | 4 | 11 | 66 |
| 2009 | | 1 | 1 | 12 | | | | | | | | | | 3 | 14 | 17 | 30 |
| 2010 | | | | 4 | | | | | | | | | | 5 | 5 | 10 | 14 |
| 2011 | | | | 5 | | | | | | | | | | 3 | 26 | 29 | 34 |
| 2012 | | | | 8 | | | | | | | | | | | | | 8 |
| **Grand Total** | **40** | **208** | **248** | **2063** | **25** | **8** | **33** | **68** | **4** | **119** | **191** | **139** | **186** | **244** | **530** | **960** | **3634** |

Overall, HBGS had the most length records, but HBGS was not broken down further into units within the station. HBGS also had the most consistent records through time with data from 1981-1982, 1984-1990, 1992-1995, 1997-1998, and 2001-2012. The longest continuous time series of length comes from SONGS (1981-2012).  Length expansions were investigated using the 2cm length bins (1, 3, 5, and 10 cm bins were also explored). Expansions were tried for within and across power plants. Tables showing the catch these length records represented are given below (Tables 4.14.8-3 and Tables 4.14.8-4).

*Table 4.14.8-3. Number of fish caught, sampling events, and total flow for subset of samples with length measurements from power plant heat treatment data.*

| Year | Total Caught | Sampling Events (#) | Total Flow $10^9 m^3$ | Year | Total Caught | Sampling Events (#) | Total Flow $10^9 m^3$ | Year | Total Caught | Sampling Events (#) | Total Flow $10^9 m^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 91 | 53 | 2.89 | 1986 | 391 | 58 | 6.2 | 2000 | 53 | 45 | 8.81 |
| 1973 | 154 | 42 | 2.89 | 1987 | 132 | 47 | 5.1 | 2001 | 320 | 55 | 5.67 |
| 1974 | 46 | 55 | 3.46 | 1988 | 109 | 45 | 5.36 | 2002 | 118 | 45 | 5.25 |
| 1975 | 29 | 49 | 2.98 | 1989 | 92 | 42 | 5.43 | 2003 | 47 | 37 | 5.14 |
| 1976 | 14 | 68 | 4.4 | 1990 | 112 | 47 | 5.39 | 2004 | 297 | 34 | 4.98 |
| 1977 | 53 | 65 | 4.3 | 1991 | 40 | 44 | 5.36 | 2005 | 64 | 35 | 11.9 |
| 1978 | 225 | 39 | 3.4 | 1992 | 41 | 59 | 6.4 | 2006 | 57 | 27 | 50.3 |
| 1979 | 218 | 63 | 3.95 | 1993 | 279 | 49 | 5.15 | 2007 | 276 | 35 | 6.08 |
| 1980 | 156 | 51 | 4.12 | 1994 | 157 | 52 | 6.05 | 2008 | 66 | 33 | 6.11 |
| 1981 | 285 | 54 | 4.13 | 1995 | 90 | 42 | 5.13 | 2009 | 21 | 25 | 3.4 |
| 1982 | 224 | 50 | 3.82 | 1996 | 168 | 54 | 8.82 | 2010 | 14 | 27 | 3.71 |
| 1983 | 332 | 48 | 4.85 | 1997 | 543 | 46 | 4.49 | 2011 | 34 | 30 | 4.62 |
| 1984 | 388 | 43 | 5.51 | 1998 | 96 | 45 | 8.83 | 2012 | 8 | 10 | 8.02 |
| 1985 | 307 | 56 | 6.75 | 1999 | 17 | 29 | 3.91 | | | | |

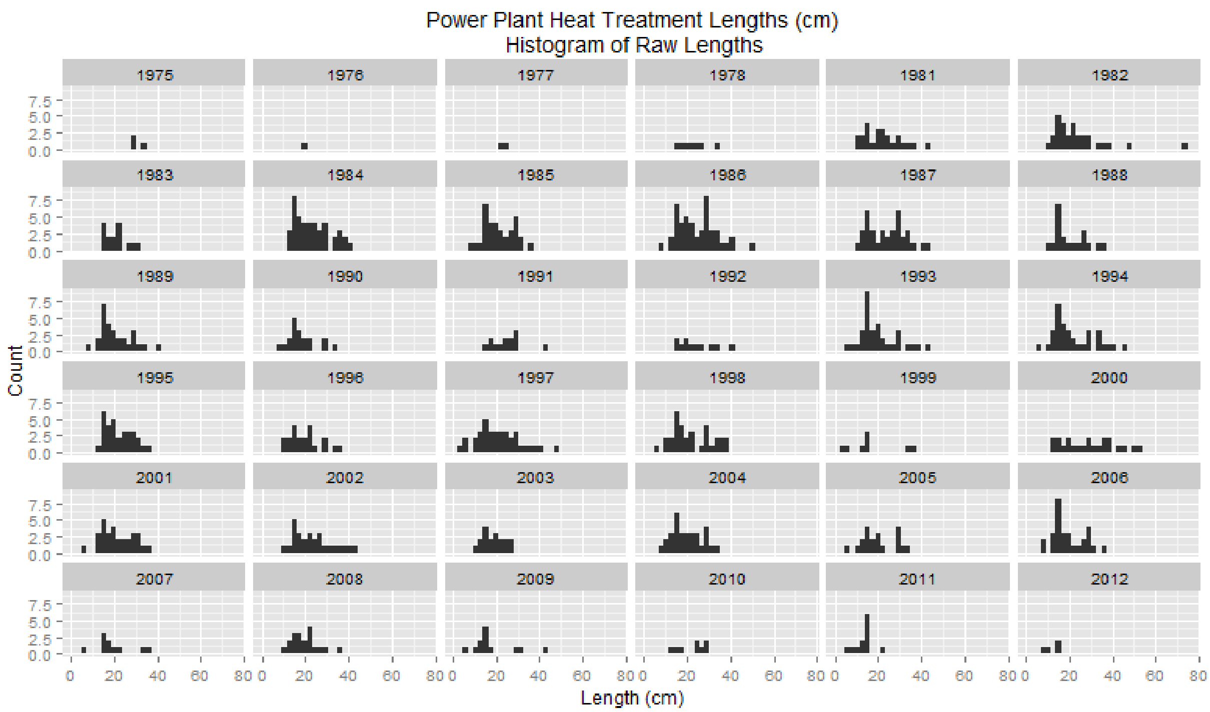
*Table 4.14.8-4. Number of fish caught each year for a given power station and unit at that station for the power plant heat treatment data.*

| | **ESGS** | | | **HBGS** | **OBGS** | | | **RBGS** | | | | | **SGS** | **SONGS** | | | | **Grand Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **12** | **34** | **Total** | **Total** | **12** | **NA** | **Total** | **14** | **16** | **56** | **78** | **Total** | **Total** | **1** | **2** | **3** | **Total** | |
| 1972 | 8 | 9 | 17 | 14 | | | | | 8 | | 7 | 15 | | 7 | | | 7 | 53 |
| 1973 | 7 | 7 | 14 | 13 | | | | | 3 | | 4 | 7 | | 8 | | | 8 | 42 |
| 1974 | 10 | 10 | 20 | 13 | | | | | 8 | | 6 | 14 | | 8 | | | 8 | 55 |
| 1975 | 10 | 11 | 21 | 12 | | 4 | 4 | | 6 | | 6 | 12 | | | | | | 49 |
| 1976 | 9 | 11 | 20 | 9 | | 8 | 8 | 8 | | 8 | 9 | 25 | | 6 | | | 6 | 68 |
| 1977 | 10 | 11 | 21 | 10 | | 9 | 9 | 6 | | 6 | 6 | 18 | | 7 | | | 7 | 65 |
| 1978 | 11 | 1 | 12 | 11 | | 1 | 1 | | | | 8 | 8 | | 7 | | | 7 | 39 |
| 1979 | 9 | 8 | 17 | 11 | | 11 | 11 | 5 | | 4 | 9 | 18 | | 6 | | | 6 | 63 |
| 1980 | 6 | 7 | 13 | 10 | | 10 | 10 | 5 | | 4 | 7 | 16 | | 2 | | | 2 | 51 |
| 1981 | 8 | 8 | 16 | 11 | | 9 | 9 | 4 | | 4 | 6 | 14 | | 4 | | | 4 | 54 |
| 1982 | 6 | 9 | 15 | 7 | | 6 | 6 | 5 | | 6 | 9 | 20 | | 1 | 1 | | 2 | 50 |
| 1983 | 7 | 3 | 10 | 7 | | 6 | 6 | 5 | | 4 | 7 | 16 | | | 7 | 2 | 9 | 48 |
| 1984 | 3 | 3 | 6 | 7 | | 5 | 5 | 3 | | 4 | 7 | 14 | | | 6 | 5 | 11 | 43 |
| 1985 | 5 | 7 | 12 | 7 | | 6 | 6 | 3 | | 4 | 9 | 16 | | 7 | 5 | 3 | 15 | 56 |
| 1986 | 3 | 6 | 9 | 8 | | 6 | 6 | 4 | | 9 | 8 | 21 | | 3 | 5 | 6 | 14 | 58 |
| 1987 | 4 | 5 | 9 | 4 | | 7 | 7 | | | 4 | 5 | 9 | | 8 | 4 | 6 | 18 | 47 |
| 1988 | 3 | 3 | 6 | 7 | | 6 | 6 | | | 3 | 5 | 8 | | 5 | 7 | 6 | 18 | 45 |
| 1989 | 2 | 1 | 3 | 6 | | 7 | 7 | | | 2 | 5 | 7 | | 6 | 6 | 7 | 19 | 42 |
| 1990 | 3 | 5 | 8 | 6 | | 8 | 8 | | | 5 | 4 | 9 | | 4 | 7 | 5 | 16 | 47 |
| 1991 | 4 | 1 | 5 | 3 | | 6 | 6 | | | 2 | 6 | 8 | 5 | 6 | 4 | 7 | 17 | 44 |
| 1992 | 4 | 5 | 9 | 5 | 12 | | 12 | | | 4 | 5 | 9 | 1 | 8 | 8 | 7 | 23 | 59 |
| 1993 | 3 | 4 | 7 | 8 | 6 | | 6 | | | 4 | 6 | 10 | 6 | | 6 | 6 | 12 | 49 |
| 1994 | 4 | 4 | 8 | 8 | 8 | | 8 | | | 3 | 8 | 11 | 1 | | 8 | 8 | 16 | 52 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 1 | 4 | 5 | 6 | 5 | | 5 | | | 5 | 5 | 10 | 3 | | 6 | 7 | 13 | 42 |
| 1996 | 1 | 4 | 5 | 8 | 8 | | 8 | | | 2 | 10 | 12 | 6 | | 7 | 8 | 15 | 54 |
| 1997 | 3 | 6 | 9 | 7 | 5 | | 5 | | | 3 | 9 | 12 | 1 | | 6 | 6 | 12 | 46 |
| 1998 | 1 | 2 | 3 | 4 | 5 | | 5 | | | 1 | 7 | 8 | 8 | | 9 | 8 | 17 | 45 |
| 1999 | 2 | 1 | 3 | | 7 | | 7 | | | 1 | 1 | 2 | 5 | | 7 | 5 | 12 | 29 |
| 2000 | 5 | 7 | 12 | | 6 | | 6 | | | 1 | 4 | 5 | 6 | | 7 | 9 | 16 | 45 |
| 2001 | 3 | 4 | 7 | 3 | | 7 | 7 | | | 8 | 12 | 20 | 5 | | 8 | 5 | 13 | 55 |
| 2002 | | 5 | 5 | 7 | | 5 | 5 | | | 1 | 5 | 6 | 6 | | 6 | 10 | 16 | 45 |
| 2003 | | 4 | 4 | 7 | | 4 | 4 | | | | 2 | 2 | 4 | | 9 | 7 | 16 | 37 |
| 2004 | | 3 | 3 | 7 | | 2 | 2 | | | 1 | 3 | 4 | 6 | | 6 | 6 | 12 | 34 |
| 2005 | | 2 | 2 | 4 | | 1 | 1 | | | 1 | 3 | 4 | 5 | | 9 | 10 | 19 | 35 |
| 2006 | | 4 | 4 | 5 | | | | | | | 2 | 2 | 5 | | 6 | 5 | 11 | 27 |
| 2007 | | 3 | 3 | 5 | | | | | | | 1 | 1 | 5 | | 8 | 13 | 21 | 35 |
| 2008 | | 3 | 3 | 7 | | | | | | | 1 | 1 | 6 | | 9 | 7 | 16 | 33 |
| 2009 | | 2 | 2 | 3 | | | | | | | | | 6 | | 7 | 7 | 14 | 25 |
| 2010 | | 2 | 2 | 8 | | | | | | | | | 5 | | 6 | 6 | 12 | 27 |
| 2011 | | | | 5 | | | | | | | | | 6 | | 12 | 7 | 19 | 30 |
| 2012 | | | | 5 | | | | | | | | | 4 | | | 1 | 1 | 10 |
| **Grand Total** | **155** | **195** | **350** | **288** | **62** | **134** | **196** | **48** | **25** | **104** | **217** | **394** | **105** | **103** | **202** | **195** | **500** | **1833** |

Instead of attempting a length expansion, the raw data was used. This is because for many years the number of length records was greater than the reported catch it was meant to represent, which made those years problematic for expansion. Further issues arose in that the expansion could not be consistently done across years, since not all the same power plants and units were sampled each year nor had length records. Plots of the raw length records are shown below (Figure 4.14.8-1).

*Figure 4.14.8-1. Histograms of raw length data from the power plant heat treatment surveys.*




## 4.15. Indices of abundance

All data processing was done using the statistical environment R (R Core Team 2013). The packages 'plyr' (Wickham 2011) 'data.table' (Dowle et al. 2011), 'date' (Therneau et al. 2014), 'lubridate' (Grolemund and Wickham 2011), and 'ggplot2' (Wickham 2009) were used in formatting and exploring the data.

A modified delta-glmm (delta-generalized linear mixed model) was used to generate a relative index of abundance. R code was based off the 'nwfscDeltaGLM' package (Thorson and Ward, 2013). The model used JAGS (Su and Yajima, 2009) for fitting the delta-glmm in a Bayesian framework, and the package 'R2jags' was used in R. Delta-glmm models allow for the probability of catch being non-zero (catch probability) and expected values of non-zero catches (catch rate) to be modeled.

The probability of catch (in either weight or numbers) being non-zero is approximated with a logistic regression model and the probability density of catch given it is non-zero is approximated by a gamma distribution. The expected catch is approximated by an exponential-transformed linear model.

A variety of models were fit, that varied by which parameters were included and if the parameters were included as random or fixed effects. Examples of model specifications can be found in Thorson and Ward (2013). In order to minimize uncertainty, strata were collapsed so that blocks (used as the strata) were tabulated in terms of the 100-level block they corresponded to for data from the recreational and commercial fleets. This means models including the interaction of strata and year, were fit using three strata, corresponding to block 600, 700, and 800. For survey data, the definition of strata is dependent on the data particular to the survey. Further details can be found in the sections detailing survey data.

For all models, the effects of both year and strata were modeled as fixed effects. The effects of the interaction between strata and year (denoted strata*year in tables) were modeled as random effects, with each interaction effect being normally distributed around a mean of zero (representing no effect of the interaction between strata and year) with a shared standard deviation. The effects of the interaction between strata and year were assumed to be uncorrelated. Details can be found in Thorson and Ward (2013). Finally, for models which included month effects, each year had a random month effect centered around an overall month effect across years. For example, in year 1982 the effect of the month of January was modeled as being normally distributed around a mean January effect across years and a standard deviation shared by all Januarys.

Model comparison was done using a variety of methods. Convergence statistics and plots were evaluated within the R framework. The information criterion metric DIC (Deviance Information Criterion) was considered under the standard assumption that models with lower DIC are more parsimonious. Delta-DIC is presented, instead of DIC. Delta-DIC is the measure of how much larger a model is compared to the best fitting (lowest DIC) model, from a given set of comparisons. To evaluate convergence, the Gelman-Rubin statistic for every parameter was evaluated, and the number of parameters with Gelman-Rubin statistics greater than 1.01, 1.05, and 1.10 were calculated. Using parameter estimates, predicted catch was compared to observed catch as an additional metric of model performance. The model that had all parameters passing with a Gelman-Rubin statistic of 1.05 and had the lowest DIC of the models meeting the first criteria, was the model selected for use in stock synthesis. This wound up being the model including effects of year and strata, but no interaction effect.

For each stock synthesis model run included in this analysis, the data used as input for that model is described. Mean estimates of the relative index of abundance along with 95% Bayesian Credible Intervals (95% Bayes CI) are provided for the model used in stock synthesis.

The delta-glmm model assumes that positive catch follows a gamma distribution. This assumption was evaluated by looking at Q-Q plots of the positive catch residuals. The Q-Q plots show that in the future other models may want to be considered. The modern CPFV logbook data, historic CPFV logbook data, set net logbook, HSWRI gillnet survey, and power plant data (although to a much lesser extent) all show a positive trend (the empirical values are less than estimated values) in the residuals at mid-values of catch. The drift net logbook data shows negative residuals (empirical values are greater than estimated values) at mid-values of catch. However, the Q-Q plot for the power plant data may indicate the gamma is a good fit to the data as the data plots close to the 1-1 line.

### 4.15.1 CPFV logbook

#### *4.15.1.1 Historical CPFV Logbook Data*

The CPFV logbook data from 1936 to 1979 was split into one table for effort and one table for catch. All data from the CPFV historical logbook data is provided as totals from a given block-month combination. Data does not exist for the CPFV historical logbook data at the trip level, it has been aggregated by month-block combination. A temporary variable, unique to each month-block combination, was created in order to combine the effort and catch data. For month-block combinations that recorded the catch of no white seabass, the catch was set to zero. Many of the month-block combinations had no records of white seabass for all of 1936 to 1979. Any month-block combinations with no information on effort were removed. Prior to fitting the delta-glmm model, for all data that was retained (see next paragraph for further details), the blocks were assigned to a 100-block level (following procedures previously described). After some initial runs it was decided that the delta-glmm would only be run using data in the 600, 700, and 800 block level (i.e., Southern California. The lower level blocks (200s-500s) were removed as the data was extremely sparse and this led to large levels of uncertainty. Mexico (900 blocks) was also removed from the data as the catch history used in this assessment is for the United States catch only.

The delta-glmm model was fit using (1) retaining blocks which only caught at least 1 white seabass during the entire timespan; (2) retaining blocks which only caught at least 5 white seabass during the entire timespan; and (3) retaining blocks which only caught at least 10 white seabass during the entire timespan. Three separate delta-glmm models were fit to the historical CPFV logbook data, including (1) model with effect of year only; (2) model with effects of year and strata; and (3) a model with effects of year, strata, and the interaction between strata and year. No models using month were considered as the finest resolution for the data is at the month-block combination.

Looking at results from fitting the three delta-glmm models to data that had been filtered to retain blocks that caught at least 1 white seabass during the entire time span, once again only model 1 and model 2 have all parameters pass at the 1.05 level for the Gelman-Rubin statistic (Table 4.15.1.1-1). Using DIC to choose between these two models, the model with effects of year and strata was selected as the best fitting model (Table 4.15.1.1.-1).

*Table 4.15.1.1-1. Results from fitting delta-glmm models to CPFV logbook data from 1939 to 1979 when only records from blocks which caught at least 1 white seabass during the entire timespan were retained. Results include Δ DIC, number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | 1,931.53 | 78 | 0 | 0 | 0 |
| x | x | | 698.25 | 84 | 0 | 0 | 0 |
| x | x | x | 0.00 | 314 | 52 | 2 | 0 |

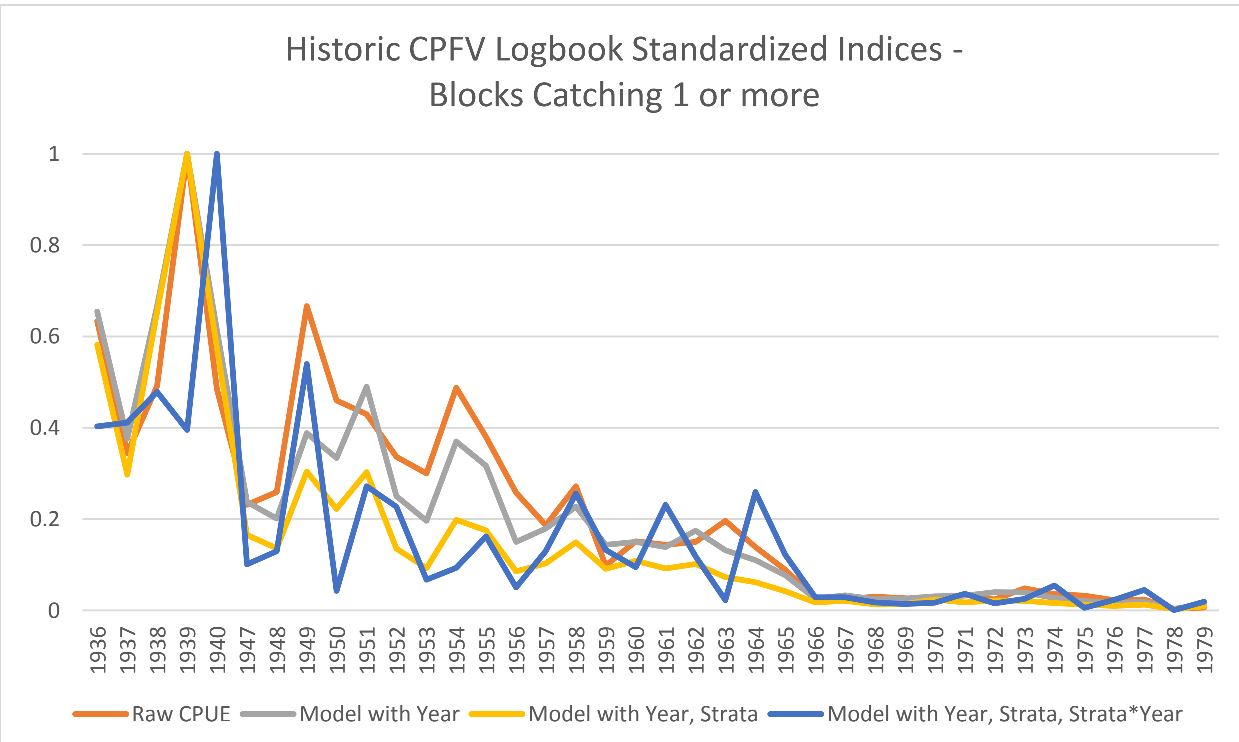
All three models do very well at predicting the observed catches overall (Table 4.15.1.1-2). All three models do better at predicting zero-catches than positive-catches.

*Table 4.15.1.1-2. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the CPFV logbook data from 1939 to 1979 when only records from blocks which caught at least 1 white seabass during the entire timespan were retained.*

| Year | Strata | Strata*Year | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|
| x | | | 0.9787347 | 1 | 0.9453925 |
| x | x | | 0.9805954 | 1 | 0.9500342 |
| x | x | x | 0.9782031 | 1 | 0.9441036 |

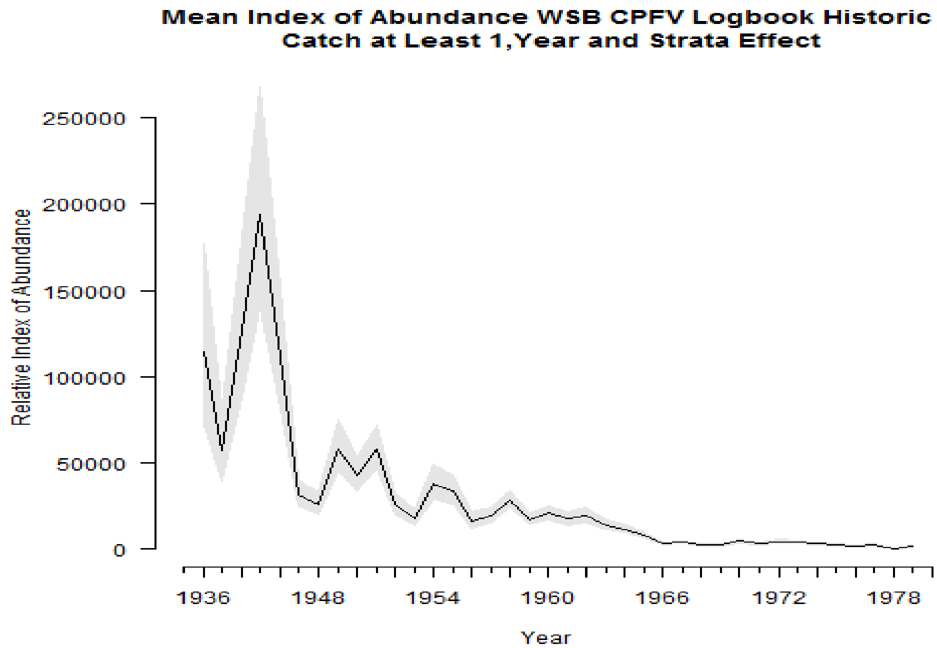
Looking at the standardized relative indices of abundance and the standardized raw catch-per-unit effort, it is clear that all of them show a decline from the 1930's till the mid 1960's, at which point the standardized indices all stabilize at a relatively low level compared to the start of the time series (Figure 4.15.1.1-1).

*Figure 4.15.1.1-1. Standardized relative indices of abundance from the historic CPFV logbook data, filtered to retain blocks that catch at least 1 white seabass during the entire timespan. Also shown is the standardized raw catch-per-unit-effort index.*



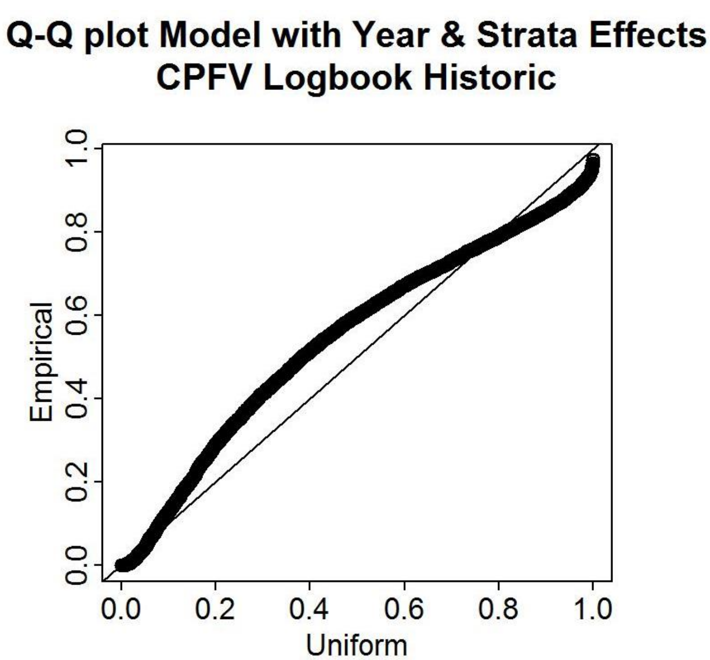

When the CPFV historic logbook data filtered by blocks catching at least 1 white seabass was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show a decline from the start of the time series till the mid-1960s (Figure 4.15.1.1-2).

*Figure 4.15.1.1-2. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the historic CPFV logbook data for white seabass, filtered by trips catching at least 1 white seabass, using only records from Southern California, the 600-800 blocks.*




The Q-Q plot for historic CPFV logbook data shows a positive trend (the empirical values are less than estimated values) in the residuals at mid-values of catch (Figure 4.15.1.1-3).

*Figure 4.15.1.1-3. Q-Q plot for historical CPFV logbook data for white seabass for the model including effects of year and strata.*



Looking at results from fitting the three delta-glmm models to data that have been filtered to retain blocks that caught at least 5 white seabass during the entire time span, once again only model 1 and model 2 have all parameters pass at the 1.05 level for the Gelman-Rubin statistic (Table 4.15.1.1-3). Using DIC to choose between these two models, the model with effects of year and strata is selected as the best fitting model (Table 4.15.1.1.-3).

*Table 4.15.1.1-3. Results from fitting delta-glmm models to CPFV logbook data from 1939 to 1979 when only records from blocks which caught at least 5 white seabass during the entire timespan were retained. Results include Δ DIC, number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | 1,912.87 | 78 | 0 | 0 | 0 |
| x | x | | 698.84 | 84 | 0 | 0 | 0 |
| x | x | x | 0.00 | 314 | 85 | 6 | 1 |

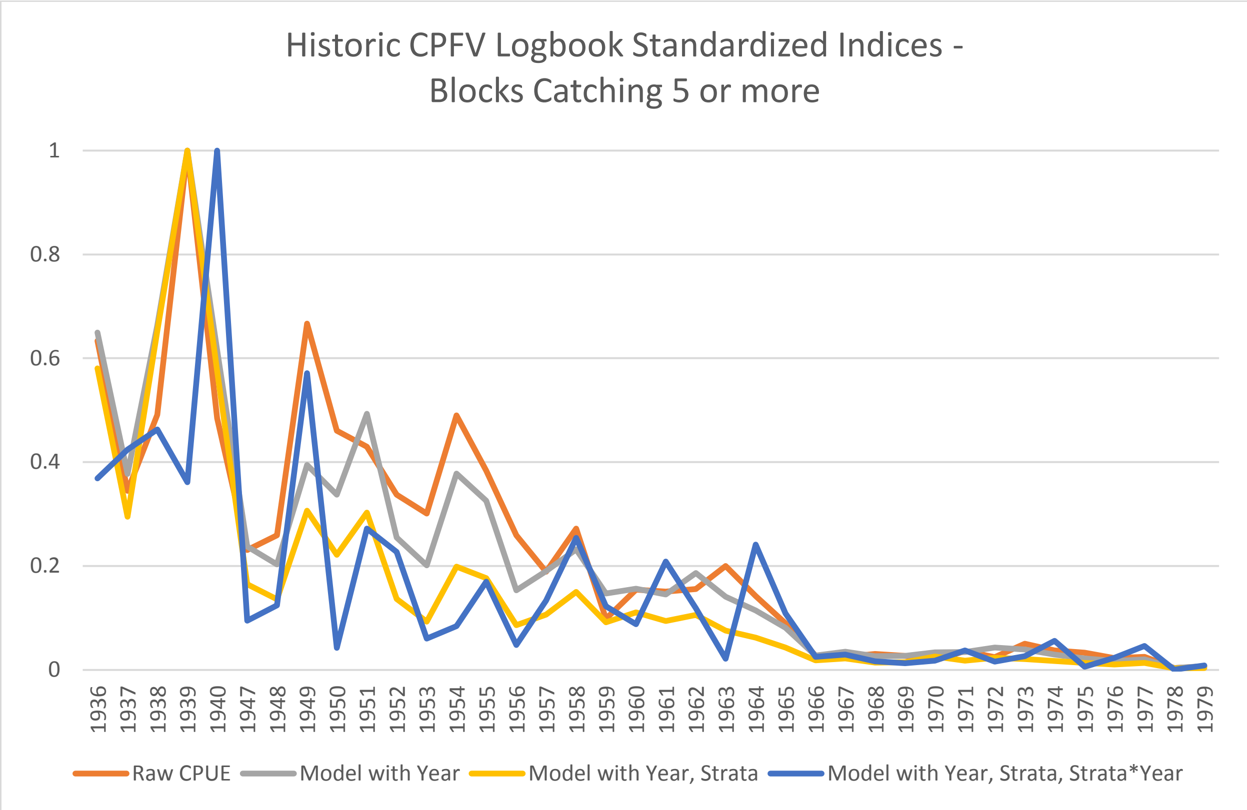
All three models do very well at predicting the observed catches (Table 4.15.1.1-4). All three models do better at predicting zero-catches than positive-catches.

*Table 4.15.1.1-4. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the CPFV logbook data from 1939 to 1979 when only records from blocks which caught at least 5 white seabass during the entire timespan were retained.*

| Year | Strata | Strata*Year | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|
| x | | | 0.9745813 | 1 | 0.9373156 |
| x | x | | 0.9787679 | 1 | 0.9468563 |
| x | x | x | 0.9763756 | 1 | 0.9414381 |

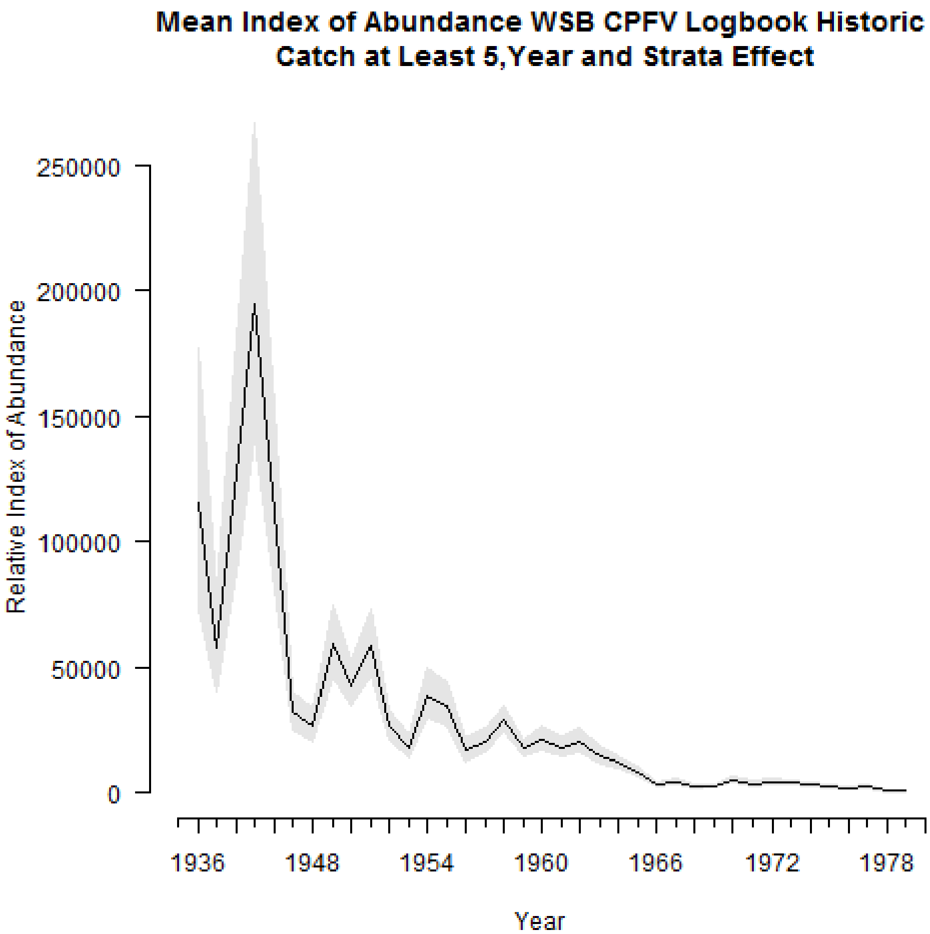
Looking at the standardized relative indices of abundance and the standardized raw catch-per-unit effort, it is clear that all of them show a decline from the 1930’s till the mid 1960’s, at which point the standardized indices all stabilize at a relatively low level compared to the start of the time series (Figure 4.15.1.1-4). The trends from the data filtered by blocks that caught at least 5 white seabass and those that caught at least 1 white seabass (Figure 4.15.1.1-1) are very similar.

*Figure 4.15.1.1-4. Standardized relative indices of abundance from the historic CPFV logbook data, filtered to retain blocks that catch at least 5 white seabass during the entire timespan. Also shown is the standardized raw catch-per-unit-effort index.*




When the CPFV historic logbook data filtered by blocks catching at least 5 white seabass was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show a decline from the start of the time series till the mid-1960s (Figure 4.15.1.1-5).

*Figure 4.15.1.1-5. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the historic CPFV logbook data for white seabass, filtered by trips catching at least 5 white seabass, using only records from Southern California, the 600-800 blocks.*




Next, are the results from fitting the three delta-glmm models to data that have been filtered to retain blocks that caught at least 10 white seabass during the entire time span, once again only model 1 and model 2 have all parameters pass at the 1.05 level for the Gelman-Rubin statistic (Table 4.15.1.1-5). Using DIC to choose between these two models, the model with effects of year and strata is selected as the best fitting model (Table 4.15.1.1.-5).

*Table 4.15.1.1-5. Results from fitting delta-glmm models to CPFV logbook data from 1939 to 1979 when only records from blocks which caught at least 10 white seabass during the entire timespan were retained. Results include Δ DIC, number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | 1954.24 | 78 | 0 | 0 | 0 |
| x | x | | 696.13 | 84 | 0 | 0 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| x | x | x | 0.00 | 314 | 96 | 9 | 0 |

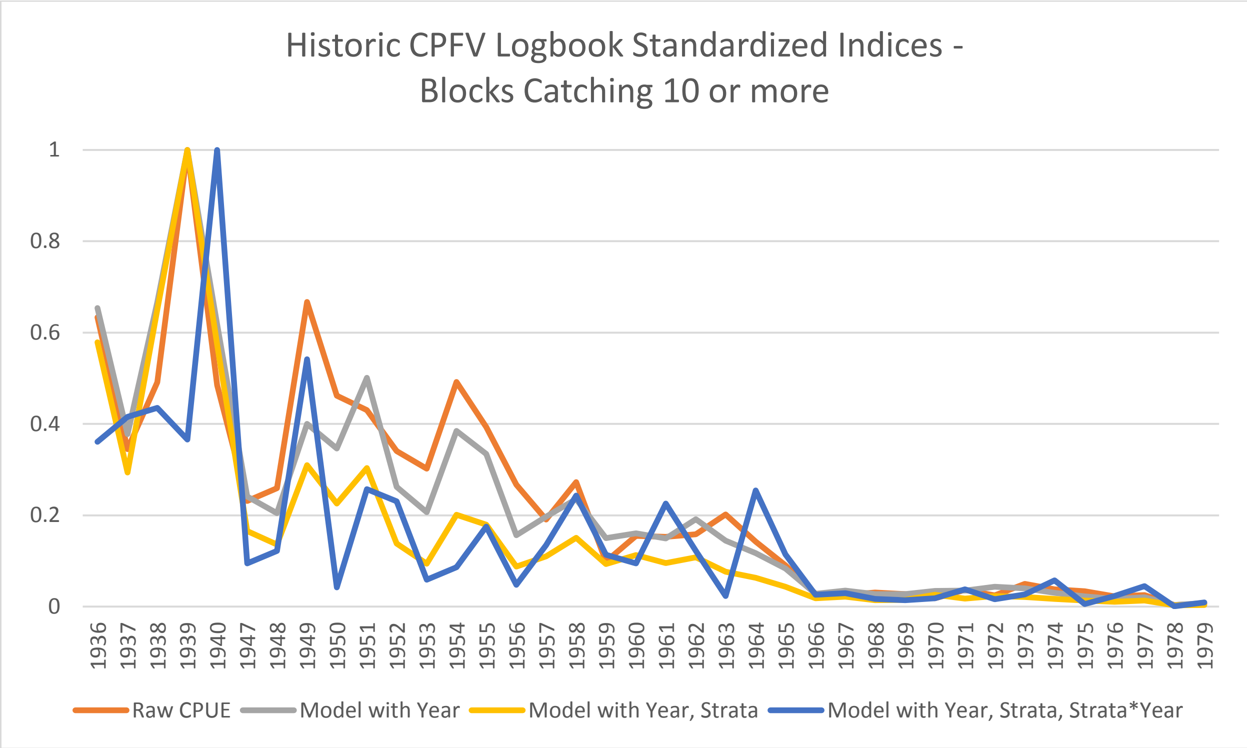
All three models do very well at predicting the observed catches (Table 4.15.1.1-6). All three models do better at predicting zero-catches than positive-catches.

*Table 4.15.1.1-6. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the CPFV logbook data from 1939 to 1979 when only records from blocks which caught at least 10 white seabass during the entire timespan were retained.*

| Year | Strata | Strata*Year | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|
| x | | | 0.9749679 | 1 | 0.94 |
| x | x | | 0.9778562 | 1 | 0.9471264 |
| x | x | x | 0.9778562 | 1 | 0.9440389 |

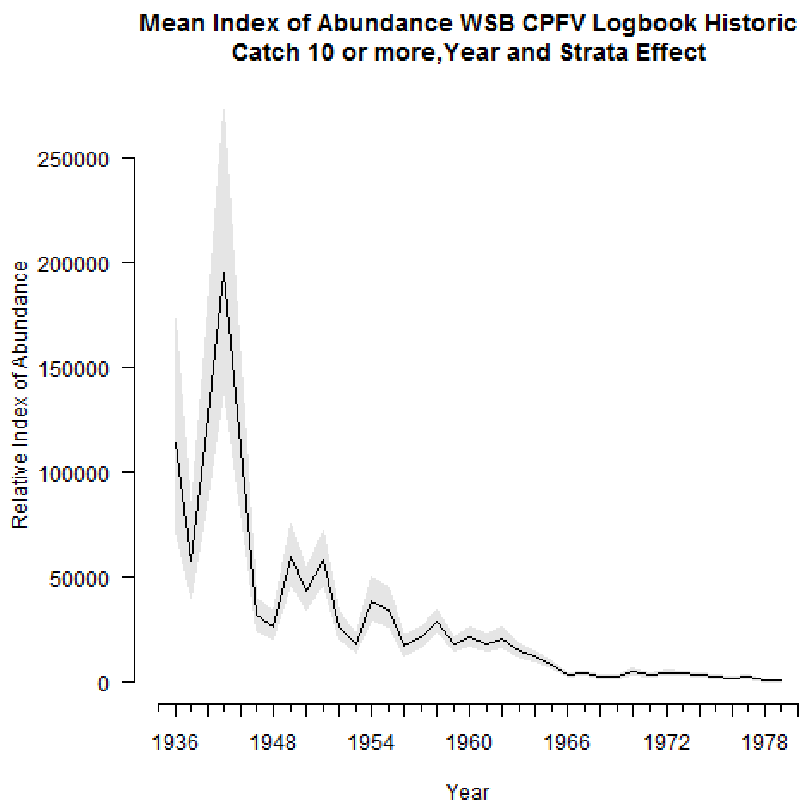
Looking at the standardized relative indices of abundance and the standardized raw catch-per-unit effort, it is clear that all of them show a decline from the 1930's till the mid 1960's, at which point the standardized indices all stabilize at a relatively low level compared to the start of the time series (Figure 4.15.1.1-6). The trends from the data filtered by blocks that caught at least 10 white seabass and those that caught at least 1 white seabass (Figure 4.15.1.1-1) and those that caught at least 5 white seabass (Figure 4.15.1.1-4) are very similar.

*Figure 4.15.1.1-6. Standardized relative indices of abundance from the historic CPFV logbook data, filtered to retain blocks that catch at least 10 white seabass during the entire timespan. Also shown is the standardized raw catch-per-unit-effort index.*



When the CPFV historic logbook data filtered by blocks catching at least 10 white seabass was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show a decline from the start of the time series till the mid-1960s (Figure 4.15.1.1-7).

*Figure 4.15.1.1-7. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the historic CPFV logbook data for white seabass, filtered by trips catching at least 10 white seabass, using only records from Southern California, the 600-800 blocks.*




### 4.15.1.2 Modern CPFV Logbook Data

The CPFV logbook data from 1980-2013 was processed to remove all rows: missing dates; missing effort (given as minutes fished); with flagged effort; with flagged species; missing fishing location (given as California fishing block); and with 0 minutes of fishing. The data was filtered to remove all rows which had the number kept in each fishing trip flagged but this resulted in all data from 1998-2009 being removed, and so this filter was not used in the final assessment. Trip information corresponding to trips in Northern California (blocks denoted in the 200s-500s) and Mexico (900 blocks) were removed as well. Only fishing blocks in which at least 11 or more white seabass were caught were kept for the analysis.

Six separate delta-glmm models were fit to the modern CPFV logbook data. Three of them did not include a month effect and three did. The models that did not include a month effect were similar to the models fit to the historical CPFV logbook data including (1) model with year-effect only; (2) model with year-effect and strata-effect; and (3) a model with year-effect, strata-effect, and strata-year effect. The three models that included a month effect included (1) a model with a year-effect and month-effect; (2) a model with year-effect, month-effect, and strata-effect; and (3) a model with a year-effect, month-effect, strata-effect, and year-strata effect. For models including a month effect, the month effect was modeled such that month was hierarchical in that all January's had some mean effect, as did all February's, and so on. For a given year, say 1993, the effect of January 1993 was normally distributed with some mean effect of January and a standard deviation specific to January.

To select the best model, DIC values and the number of parameters from that model that have Gelman-Rubin statistics greater than 1.01, 1.05, and 1.10 were evaluated (Table 4.15.1.1-1). A Gelman-Rubin statistic cutoff of 1.05 was used to evaluate convergence of each parameter. Only two models have all parameters pass the Gelman-Rubin statistic, the model with only the effect of year and the model with the effects of year and strata. Between those two models, the model with effects of year and strata has a much smaller DIC value, and was thus identified as the best fitting model.

*Table 4.15.1.2-1. Table of results from fitting delta-glmm models to CPFV modern logbook data from 1980 to 2013 analyzed. Results include ∆ DIC, number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Month | ∆ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | | 13,370.60 | 70 | 0 | 0 | 0 |
| x | x | | | 11,029.30 | 76 | 0 | 0 | 0 |
| x | x | x | | 9,054.80 | 282 | 138 | 9 | 0 |
| x | | | x | 4,185.00 | 934 | 917 | 908 | 908 |
| x | x | | x | 1,841.40 | 940 | 915 | 908 | 908 |
| x | x | x | x | 0.00 | 1146 | 1062 | 988 | 939 |

Looking at the fraction of times that the 95% Bayesian Credible Interval from the posterior predictions includes the observed value (Table 4.15.1.2-2), it is clear that all models do very well at predicting zero-catches. All models do poorly at predicting positive-catches (fractions around 0.28 without a month effect and fractions around 0.40 with a month effect). For the best fitting model, the model with effects of year and strata the overall fraction of observed catches falling within the 95% Bayesian Credible Interval is high at 0.97, however, for the positive catches the fraction is relatively low at 0.29.

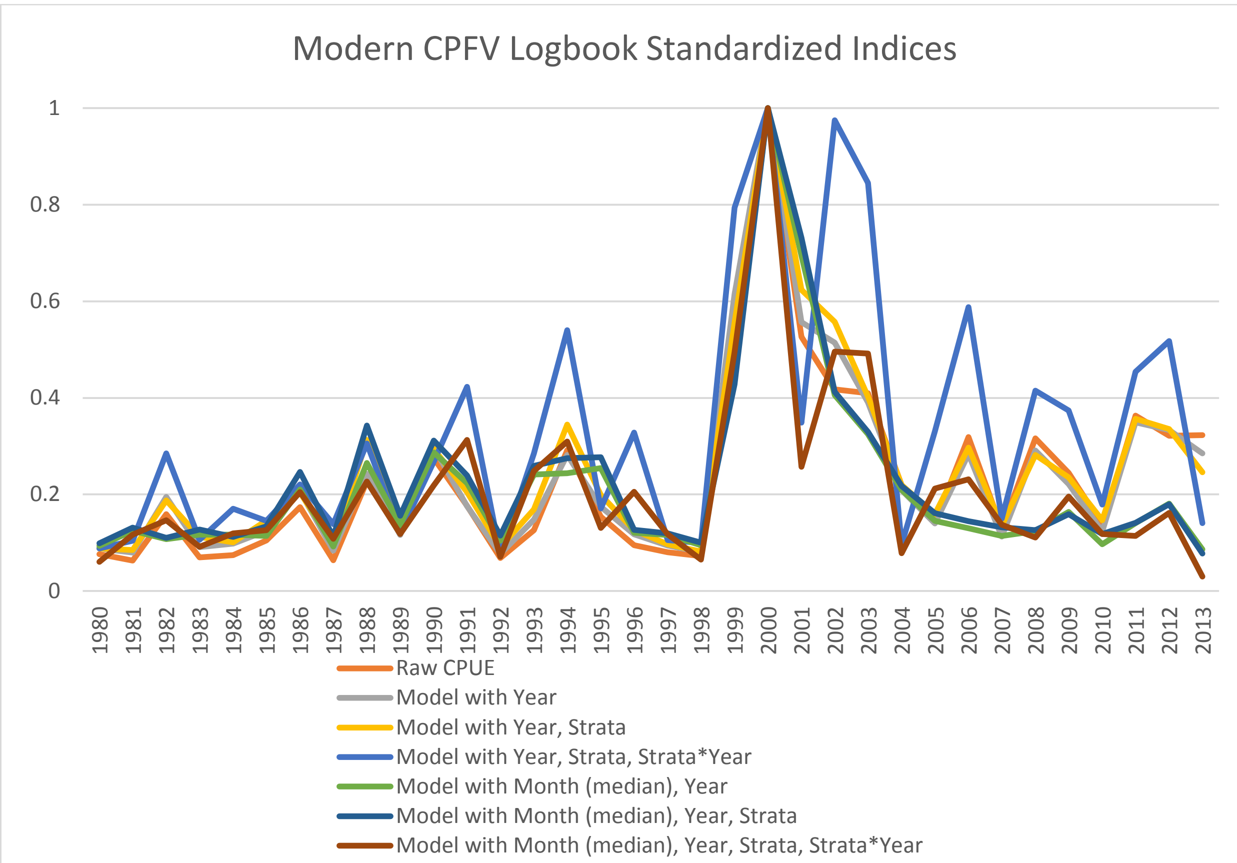
*Table 4.15.1.2-2. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the CPFV modern logbook data from 1980 to 2013 analyzed.*

| Year | Strata | Strata*Year | Month | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|---|
| x | | | | 0.9774 | 1.0000 | 0.2928 |
| x | x | | | 0.9773 | 1.0000 | 0.2878 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| x | x | x | | | 0.9778 | 1.0000 | 0.2987 |
| x | | | | x | 0.982 | 1.0000 | 0.4023438 |
| x | x | | | x | 0.9825294 | 1.0000 | 0.4187867 |
| x | x | x | | x | 0.9834706 | 1.0000 | 0.444664 |

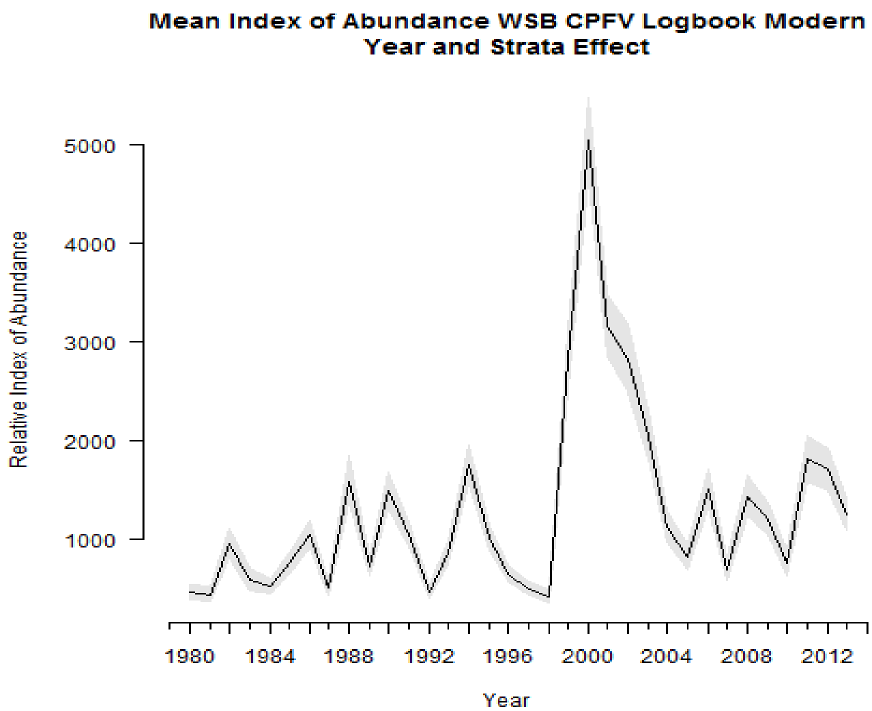
A plot of the standardized relative indices from all six models and standardized raw catch-per-unit-effort (CPUE) show that the model with year and strata is similar to the raw index (Figure 4.15.1.2-1).

*Figure 4.15.1.2-1. Standardized relative indices of abundance for the CPFV modern (1980 to 2013) logbook data.*



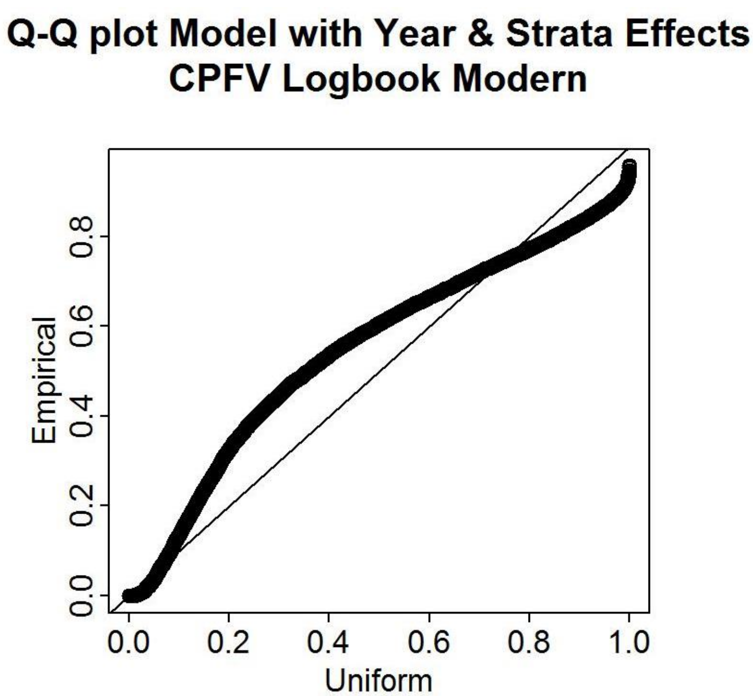

When the CPFV modern logbook data was included in the stock synthesis runs, results from the model with effects of strata and year was used.  The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show a decline from the start of the time series till the mid-1960s (Figure 4.15.1.2-2).

*Figure 4.15.1.2-2. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the modern CPFV logbook data for white seabass, using only records from Southern California, the 600-800 blocks.*




The Q-Q plot for modern CPFV logbook data shows a positive trend (the empirical values are less than estimated values) in the residuals at mid-values of catch (Figure 4.15.1.2-3).

*Figure 4.14.1.2-3. Q-Q plot for modern CPFV logbook data for white seabass for the model including effects of year and strata.*



### *4.15.1.3 Combined CPFV Logbook Data*

In order to combine the historical and modern CPFV logbook data into compatible standardized dataset, the modern data was collapsed to be on the month, block resolution. First, the effort was collapsed to get total effort for each month, block combination. Next, the catch of white seabass was collapsed to get total white seabass catch for each month, block combination. The two datasets were combined using a unique variable representing each month, block combination. Similar to the analysis on the historical dataset, the delta-glmm models were fit using (1) all of the data; (2) retaining blocks which only caught at least 1 white seabass during the entire timespan; and (3) retaining blocks which only caught at least 5 white seabass during the entire timespan. Only data from Southern California was retained.

Similar to the historical CPFV logbook data, three separate delta-glmm models were fit to the combined CPFV logbook data, including (1) model with year-effect only; (2) model with year-effect and strata-effect; and (3) a model with year-effect, strata-effect, and strata-year effect.

First, looking at the combined CPFV logbook data in which all of the data is retained, DIC values and the number of parameters from that model that have Gelman-Rubin statistics greater than 1.01, 1.05, and 1.10 (Table 4.15.1.3-1) can be used to select the best model. A value of 1.05 was used as the Gelman-Rubin statistic cutoff. Only two models have all parameters pass the Gelman-Rubin statistic, the model with only the effect of year and the model with the effects of year and strata. Between those two models, the model with effects of year and strata has a much smaller DIC value, by over 500 DIC units, and was thus selected as the best fitting model.

*Table 4.15.1.3-1. Table of results from fitting delta-glmm models to CPFV logbook data from 1939 to 2013 analyzed at the month level, with all data retained. Results include Δ DIC, number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | 1611.30 | 146 | 0 | 0 | 0 |
| x | x | | 1110.70 | 152 | 0 | 0 | 0 |
| x | x | x | 0.00 | 586 | 161 | 11 | 3 |

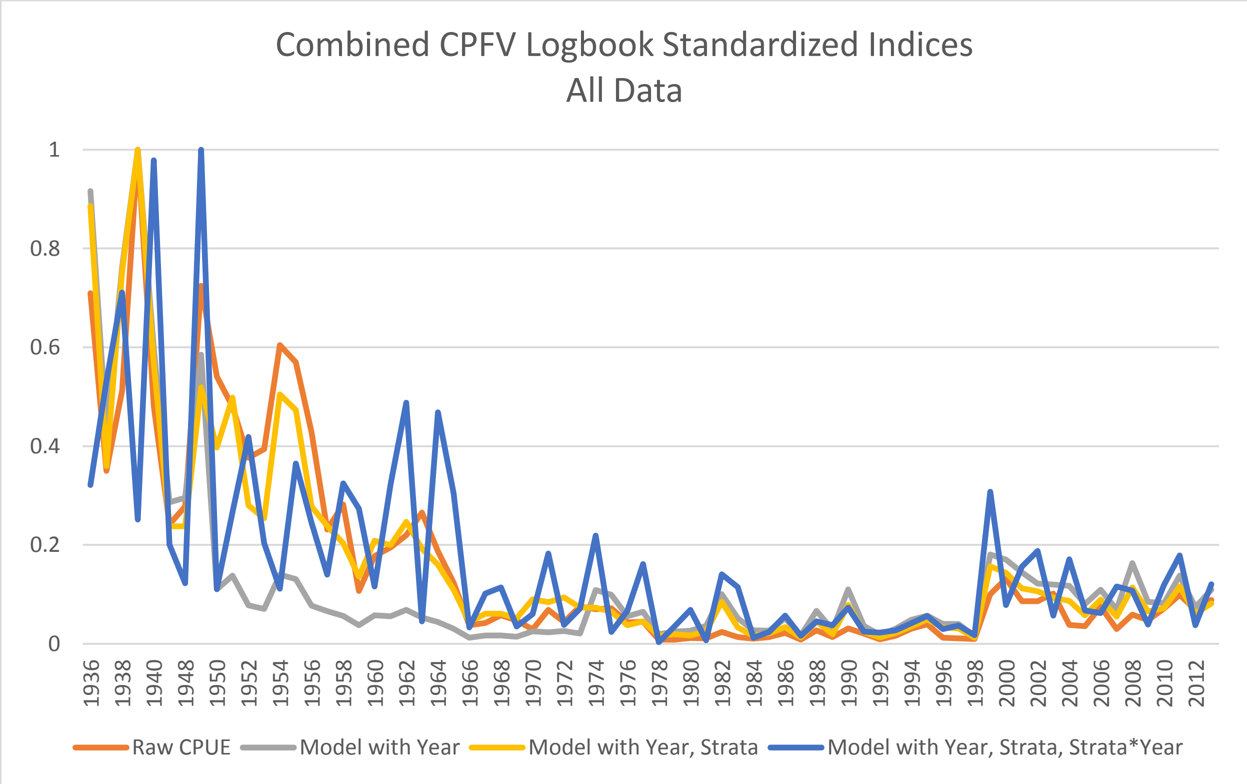
Looking at the fraction of times the 95% Bayesian Credible Interval from the posterior predictions includes the observed value (Table 4.15.13-2), all models do very well at predicting zero-catches (fraction >.99). For the best fitting model, the model with effects of year and strata the overall fraction of observed catches falling within the 95% Bayesian Credible Interval is high at 0.96.

*Table 4.15.1.3-2. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the CPFV logbook data from 1939 to 2013 analyzed at the month level, with all data retained.*

| Year | Strata | Strata*Year | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|
| x | | | 0.9684028 | 0.9878049 | 0.9672312 |
| x | x | | 0.9649306 | 0.9929577 | 0.963477 |
| x | x | x | 0.9604167 | 1 | 0.9579025 |

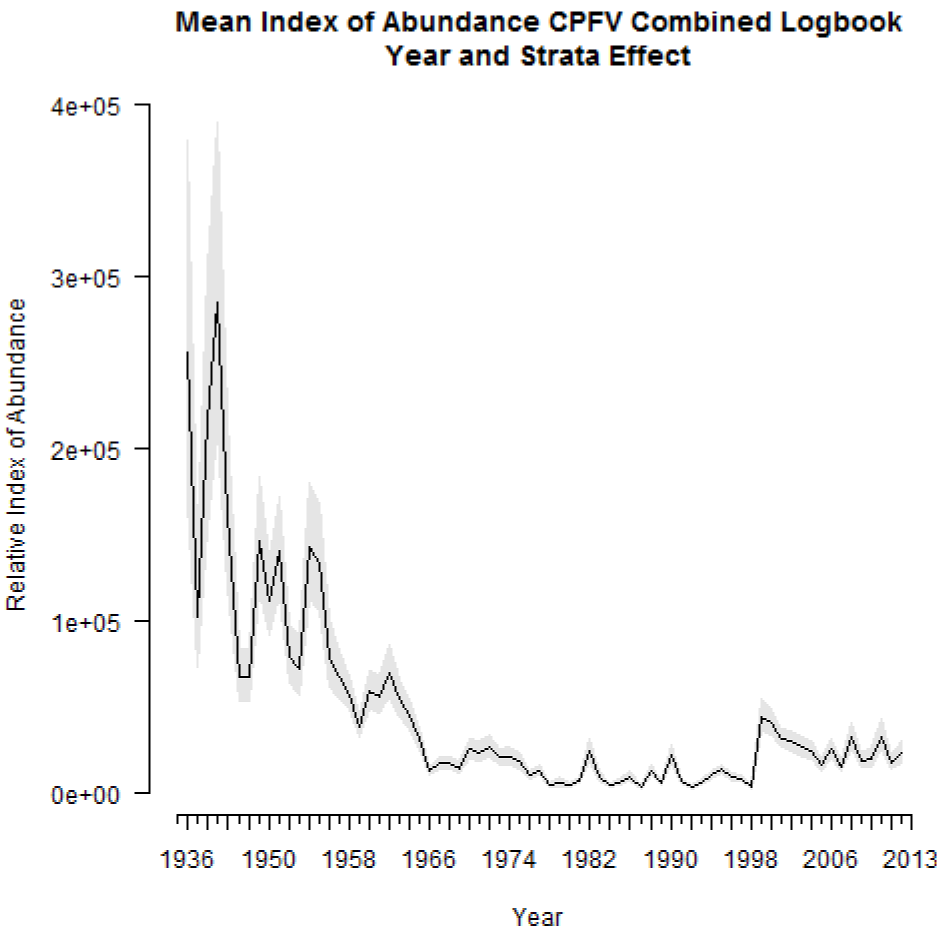
A plot of the standardized relative indices from all six models and standardized raw catch-per-unit-effort (CPUE) show that the model with year and strata is similar to the raw index (Figure 4.15.1.3-1). Starting around 2000, there is a slight increase in the standardized indices relative to levels in the 1980s and 19990s. However, the standardized indices in 2000s and 2010s are still much lower than the values in the 1930s to 1950s.

*Figure 4.15.1.3-1. Standardized relative indices of abundance for the combined CPFV logbook data from 1936 to 2013, using all data. Also shown is the standardized raw catch per unit effort.*




When the CPFV combined logbook data was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show a decline from the start of the time series till the mid-1960s (Figure 4.15.1.3-2).

*Figure 4.15.1.3-2. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the combined CPFV logbook data for white seabass, when all data was retained, using only records from Southern California, the 600-800 blocks.*




Next, is the combined CPFV logbook data in which only data coming from blocks in which at least one white seabass was caught (when data is tabulated by month and block combination). To select the best model, DIC values and the number of parameters from that model that have Gelman-Rubin statistics greater than 1.01, 1.05, and 1.10 (Table 4.15.1.3-3) were used. A value of 1.05 was used as the Gelman-Rubin statistic cutoff. Only two models have all parameters pass the Gelman-Rubin statistic, the model with only the effect of year and the model with the effects of year and strata. Between those two models, the model with effects of year and strata has a much smaller DIC value, by over 500 DIC units, and thus was selected as the best fitting model.

*Table 4.15.1.3-3. Table of results from fitting delta-glmm models to CPFV logbook data from 1939 to 2013 analyzed at the month level, with data retained from blocks where at least one white seabass was caught. Results include Δ DIC, number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | 1616.40 | 146 | 0 | 0 | 0 |
| x | x | | 1115.40 | 152 | 0 | 0 | 0 |
| x | x | x | 0.00 | 586 | 142 | 8 | 1 |

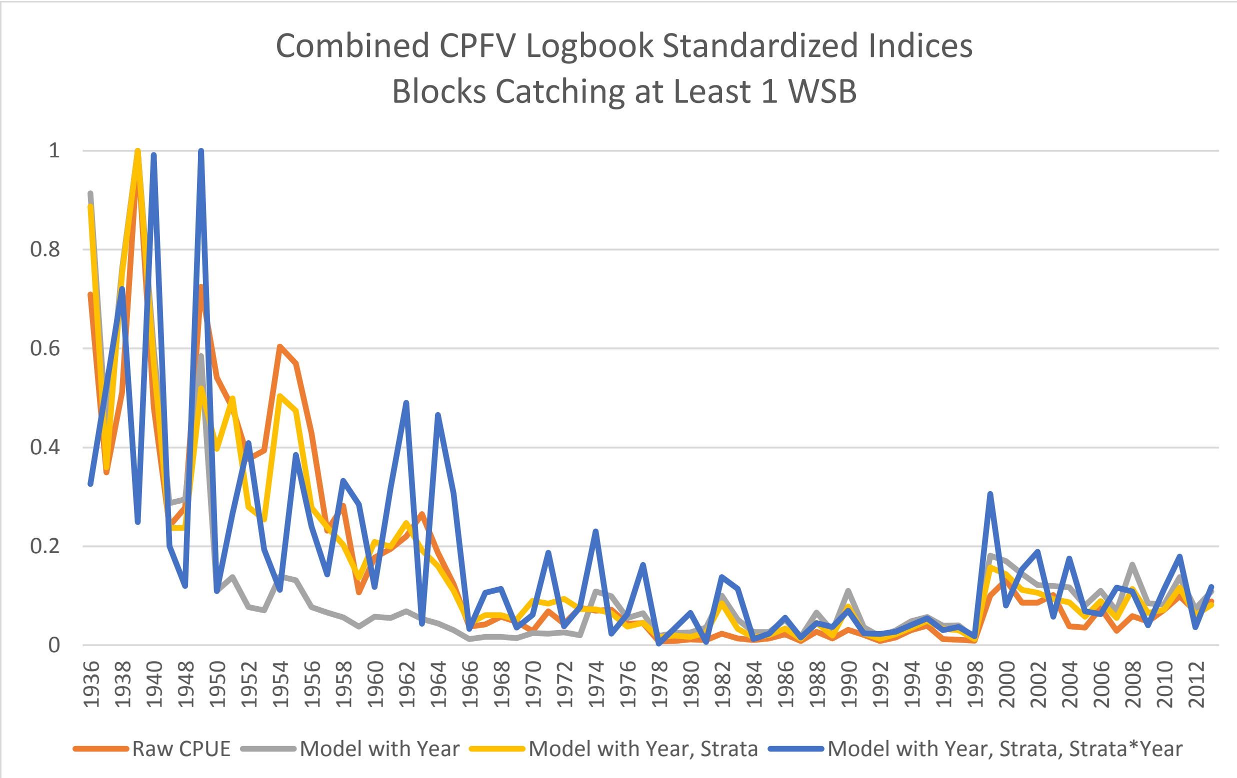
Looking at the fraction of times the 95% Bayesian Credible Interval from the posterior predictions includes the observed value (Table 4.15.13-4), all models do very well at predicting zero-catches (fraction >.99). For the best fitting model, the model with effects of year and strata the overall fraction of observed catches falling within the 95% Bayesian Credible Interval is high at 0.959.

*Table 4.15.1.3-4. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the CPFV logbook data from 1939 to 2013 analyzed at the month level, with data retained from blocks where at least one white seabass was caught.*

| Year | Strata | Strata*Year | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|
| x | | | 0.9607639 | 1 | 0.9584406 |
| x | x | | 0.9590278 | 0.9939024 | 0.9569219 |
| x | x | x | 0.9649306 | 1 | 0.9626203 |

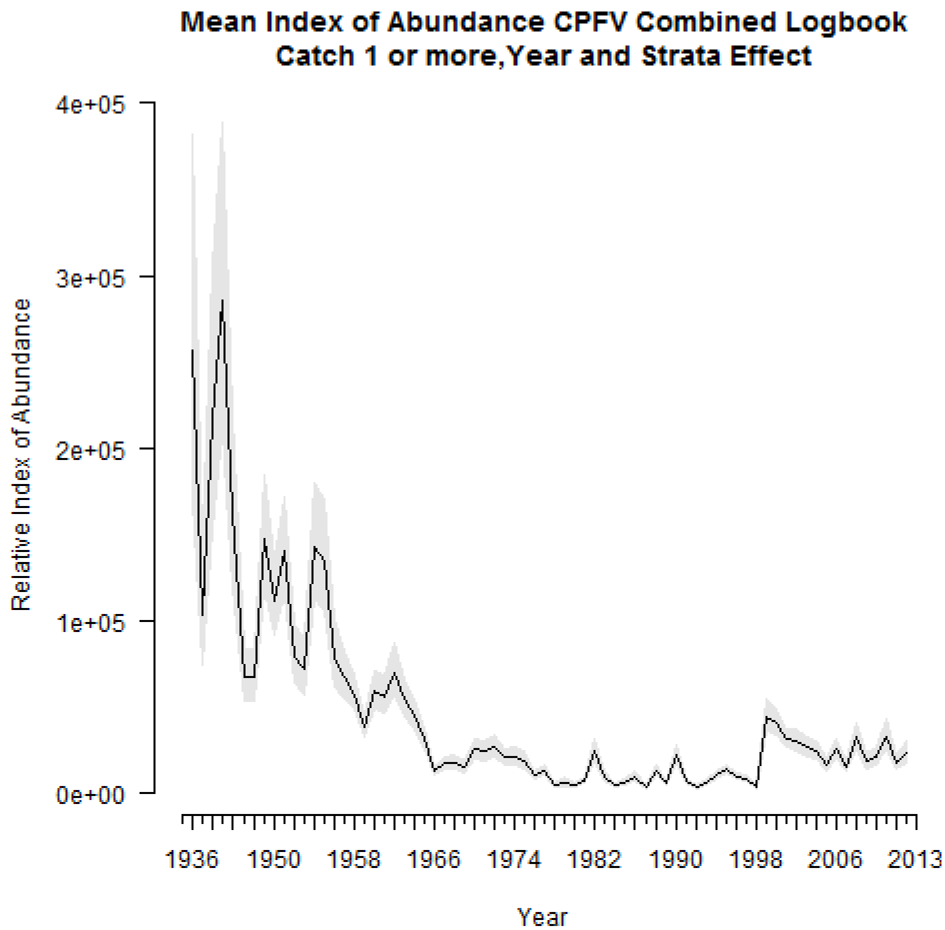
A plot of the standardized relative indices from all six models and standardized raw catch-per-unit-effort (CPUE) show that the model with year and strata is similar to the raw index (Figure 4.15.1.3-3). As with the combined CPFV logbook data when all data is used, starting around 2000, there is a slight increase in the standardized indices relative to levels in the 1980s and 19990s. However, the standardized indices in 2000s and 2010s are still much lower than the values in the 1930s to 1950s.

*Figure 4.15.1.3-3. Standardized relative indices of abundance for the combined CPFV logbook data from 1936 to 2013, using only records from blocks in which at least 1 white seabass was captured during the entire time series. Also shown is the standardized raw catch per unit effort.*




When the CPFV combined logbook data, filtered to include only records from blocks where 1 or more white seabass was caught, was included in the stock synthesis runs, results from the model with effects of strata and year was used.  The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show a decline from the start of the time series till the mid-1960s (Figure 4.15.1.3-4).

*Figure 4.15.1.3-4. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata from the combined CPFV logbook data for white seabass, filtered to keep blocks where 1 or more white seabass was caught, using only records from Southern California, the 600-800 blocks.*




Next, is the combined CPFV logbook data in which only data coming from blocks in which at least five white seabass was caught (when data is tabulated by month and block combination). To select the best model, DIC values and the number of parameters from that model that have Gelman-Rubin statistics greater than 1.01, 1.05, and 1.10 (Table 4.15.1.3-5) are used. Using 1.05 as the Gelman-Rubin statistic cutoff, only two models have all parameters pass the Gelman-Rubin statistic, the model with only the effect of year and the model with the effects of year and strata. Between those two models, the model with effects of year and strata has a much smaller DIC value, by nearly 900 DIC units, and thus was selected as the best fitting model.

*Table 4.15.1.3-5. Table of results from fitting delta-glmm models to CPFV logbook data from 1939 to 2013 analyzed at the month level, with data retained from blocks where at least five white seabass were caught. Results include Δ DIC, number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | 2346.00 | 146 | 0 | 0 | 0 |
| x | x | | 1440.60 | 152 | 1 | 0 | 0 |
| x | x | x | 0.00 | 586 | 141 | 14 | 0 |

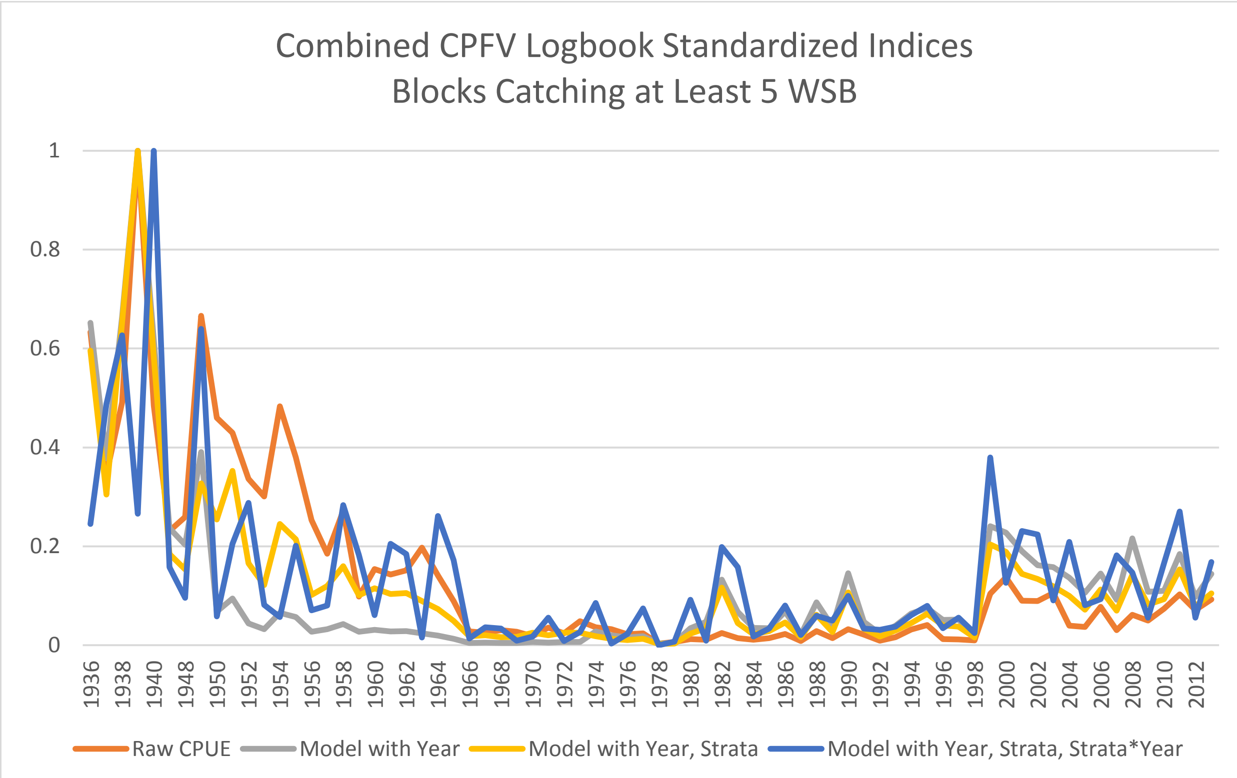
Looking at the fraction of times the 95% Bayesian Credible Interval from the posterior predictions includes the observed value (Table 4.15.1.3-6), all models do very well at predicting zero-catches (fraction >.99). For the best fitting model, the model with effects of year and strata the overall fraction of observed catches falling within the 95% Bayesian Credible Interval is high at 0.97.

*Table 4.15.1.3-6. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the CPFV logbook data from 1939 to 2013 analyzed at the month level, with data retained from blocks where at least five white seabass were caught.*

| Year | Strata | Strata*Year | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|
| x | | | 0.9720775 | 0.9996164 | 0.9554007 |
| x | x | | 0.9738137 | 1 | 0.9582661 |
| x | x | x | 0.9704861 | 0.999617 | 0.9528017 |

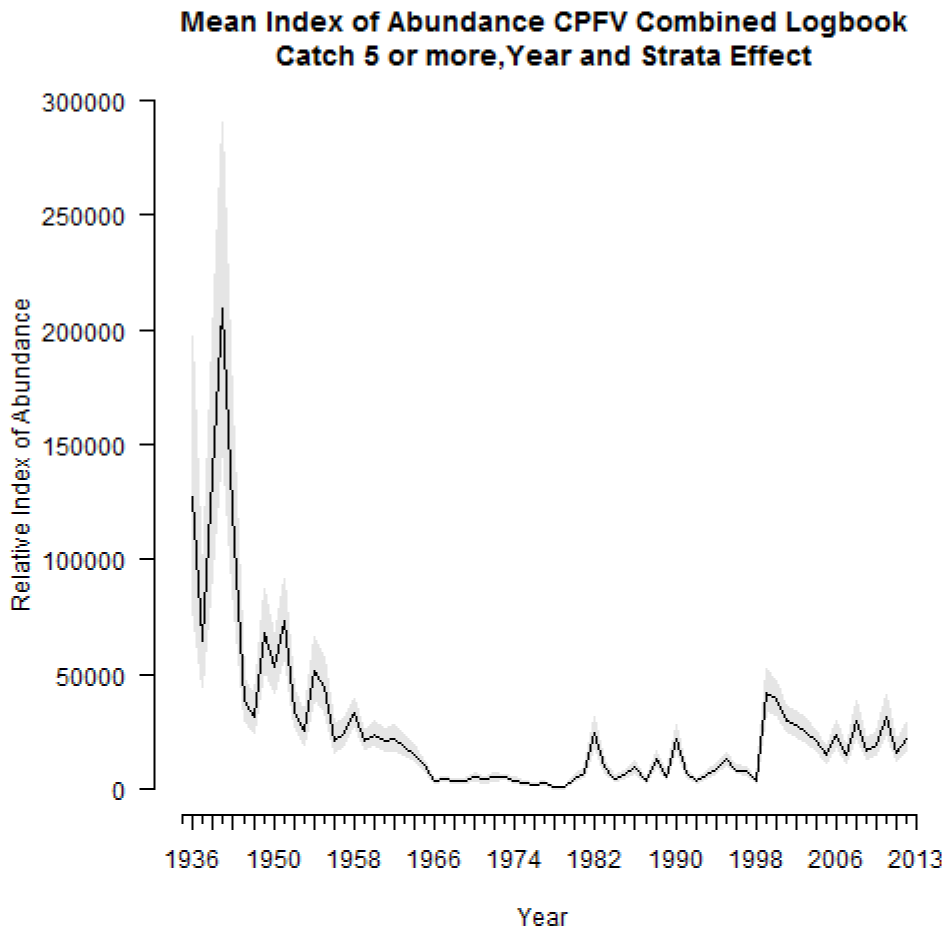
A plot of the standardized relative indices from all six models and standardized raw catch-per-unit-effort (CPUE) show that the model with year and strata is similar to the raw index (Figure 4.15.1.3-5). As with the combined CPFV logbook data when all data is used and data from blocks catching at least one white seabass, starting around 2000, there is a slight increase in the standardized indices relative to levels in the 1980s and 1990s. However, the standardized indices in 2000s and 2010s are still much lower than the values in the 1930s to 1950s.

*Figure 4.15.1.3-5. Standardized relative indices of abundance for the combined CPFV logbook data from 1936 to 2013, using only records from blocks in which at least 5 white seabass was captured during the entire time series. Also shown is the standardized raw*




When the CPFV combined logbook data, filtered to include only records from blocks where 5 or more white seabass was caught, was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show a decline from the start of the time series till the mid-1960s (Figure 4.15.1.3-6).

*Figure 4.15.1.3-6. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the combined CPFV logbook data for white seabass, filtered to keep blocks where 5 or more white seabass was caught, using only records from Southern California, the 600-800 blocks.*

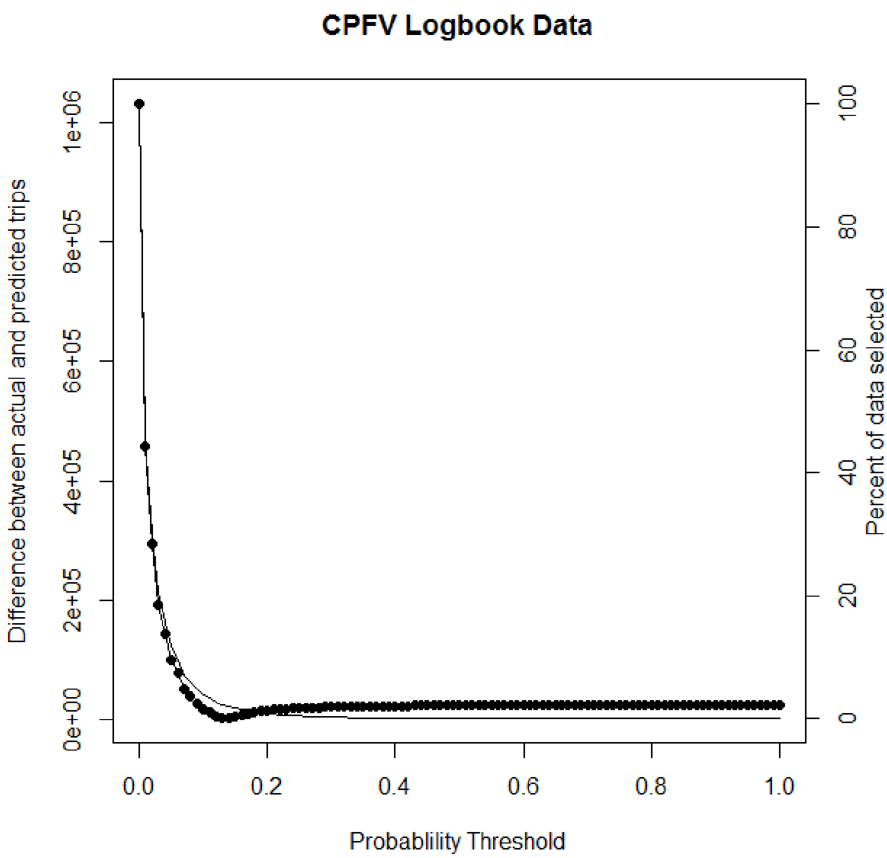



### 4.15.1.4 CPFV Modern Logbook Data fit using Stephens-MacCall Method for Effort Allocation

Following the methods of Stephens and MacCall (2004) logistic regression on presence-absence data is used to subset the CPFV logbook data to determine what fraction of effort was most likely to produce positive white seabass catch. The trips that were selected based on the Stephens and MacCall method were used to fit a delta glmm to the data to create a CPUE index of abundance. It was used to make a table that had one row per trip and then one column for each species, for which a zero was assigned if absent and 1 if present. Then a logistic regression was fit to the data using R and the function 'glm' with the binomial family. All data was retained at this step. A logistic regression was done using only species that occurred more than 50 times during the entire data set. The results for both were similar. Code provided by Melissa Haltuch (NMFS/NOAA) was used to implement the logistic regression and create matrices of the selected trips.

First, results from the logistic regression applied to all of the data are shown (Figure 4.15.1.4-1 and Figure 4.15.1.4-2).

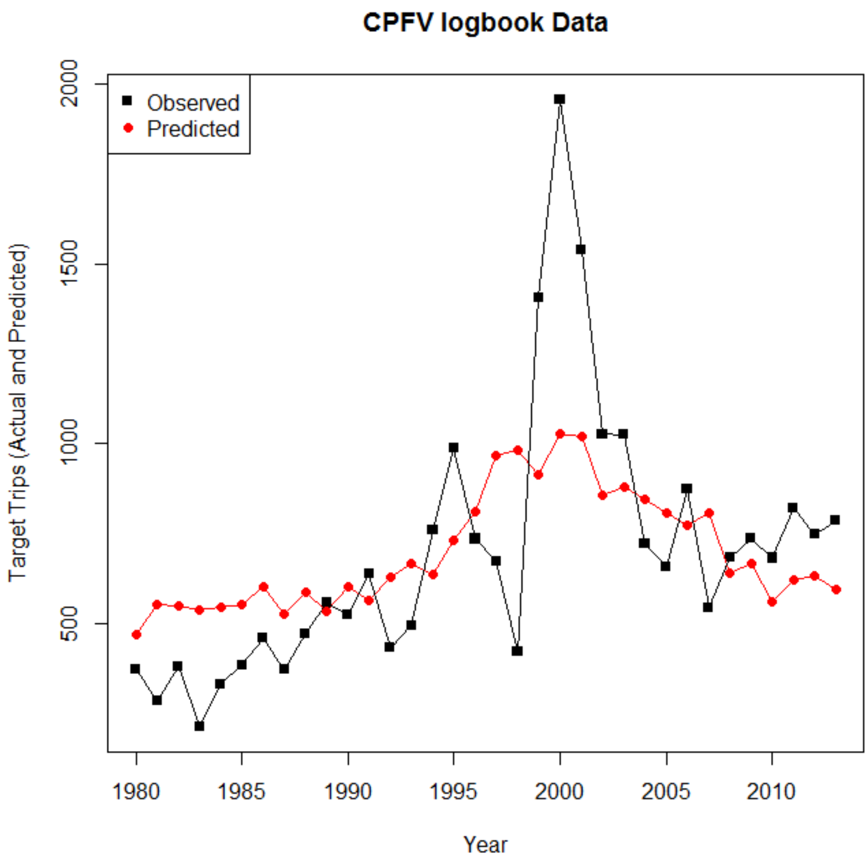
*Figure 4.15.1.4-1. Results of the application of the method of Stephens and MacCall (2004) to the CPFV logbook data from 1980 to 2013, showing the difference between the number of records in which white seabass are observed (smooth line) and the number in which they are predicted to occur (dots).*




It is worth noting that nearly three times as many species have negative relationships with the occurrence of white seabass. That is, for most species, when they are caught white seabass tend not to be caught.

Looking at the predicted versus actual number of trips that catch white seabass (Figure 4.15.1.4-2), it is clear the predicted values miss the larger swings in the number of trips catching white seabass, for example around the year 2000, but the overall trend through time is captured.

*Figure 4.15.1.4-2. Actual and predicted number of trips catching white seabass for the modern (1980-2013) CPFV logbook data. Actual trips are shown in black with squares and predicted trips are in red with diamonds.*



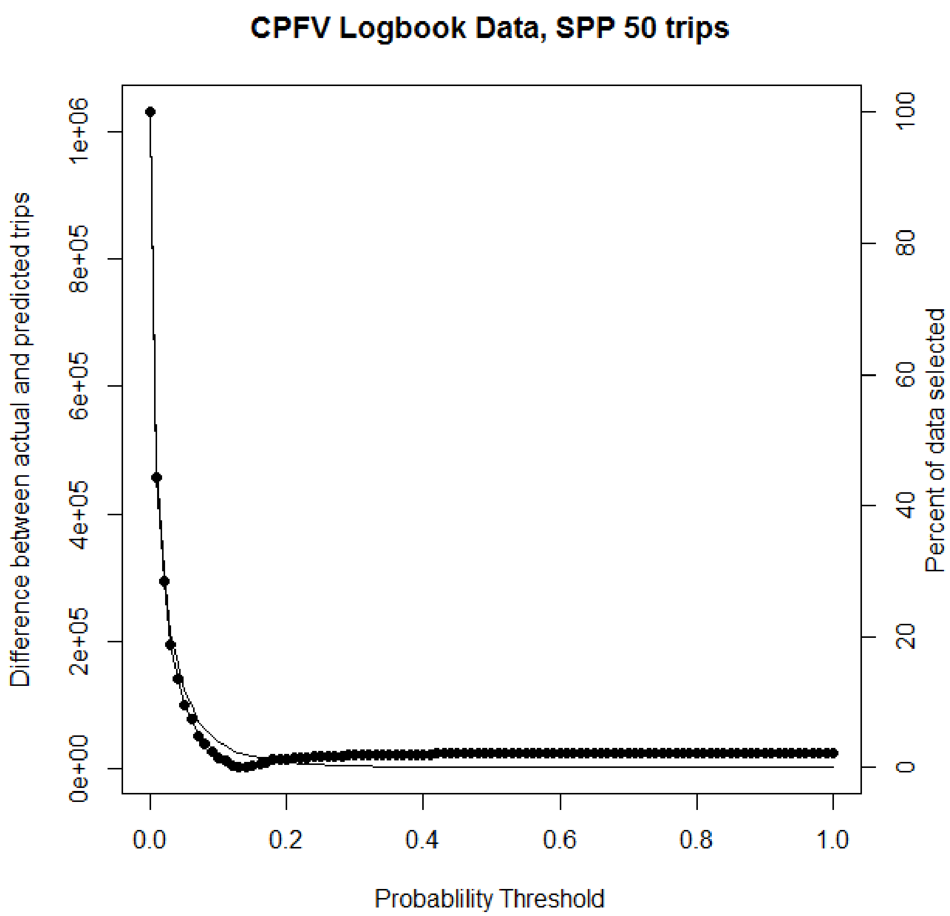

The species with the highest positive and negative coefficients from fitting the Stephens-MacCall method are shown in Table 4.15.1.4-1.

*Table 4.15.1.4-1. Table of coefficients for species with most positive and most negative associations with White seabass from applying method of Stephens-MacCall to CPFV modern logbook data.*

| **Coefficient** | **Species** | **Coefficient** | **Species** |
|---:|---:|---:|---:|
| -15.0069 | Tanner Crab | 20.23476 | Agar |
| -14.5706 | Kellet's Whelk | 4.042248 | Greenstriped Rockfish |
| -14.4276 | Common Washington Clam | 3.592488 | Darksplotched Rockfish |
| -14.4272 | Zebra Goby | 2.717428 | Rosethorn Rockfish |
| -14.2864 | Common Littleneck Clam | 2.661827 | Yellowfin Goby |
| -13.9303 | Shortfin Corvina | 2.387592 | Sailfish |
| -13.9278 | Group Slope Rockfish | 2.226259 | Blacktip Shark |
| -13.8546 | Turtle | 2.104356 | Squarespot Rockfish |
| -13.8488 | True Smelts | 2.006967 | Shark Bigeye Thresher |
| -13.8322 | Mantis Shrimp | 1.461455 | Garibaldi |
| -13.7537 | Curlfin Turbot | 1.326137 | Senorita |
| | | 1.322518 | Halibut |

Next are the results from the logistic regression fit to data filtered to only retain species that were caught on at least 50 trips (Figure 4.15.1.4-3).

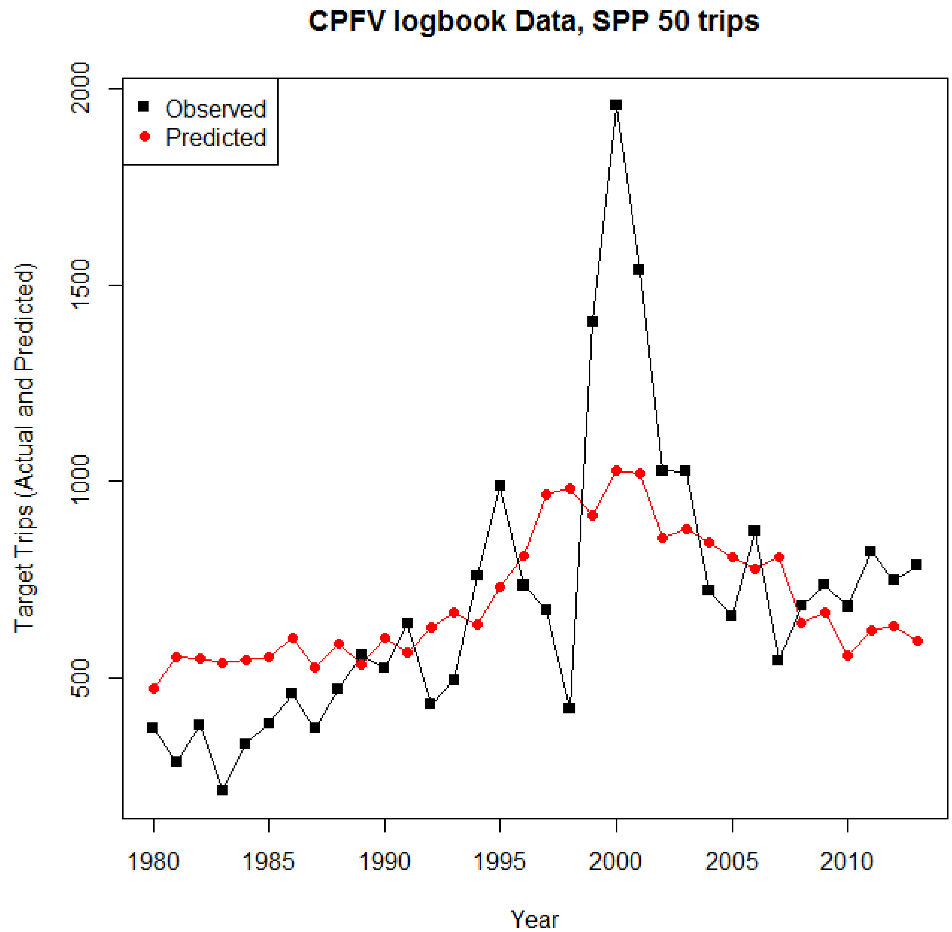
*Figure 4.15.1.4-3. Results of the application of the method of Stephens and MacCall (2004) to the CPFV logbook data from 1980 to 2013, that was filtered to only retain species caught on at least 50 unique trips before applying the method of Stephens and MacCall (2004), showing the difference between the number of records in which white seabass are observed (smooth line) and the number in which they are predicted to occur (dots).*




Similar to using all of the data, more species have a negative coefficient in their relationship to the occurrence of white seabass. Also, the negative coefficients are much larger than the positive coefficients (when compared through absolute values).

Looking at the predicted versus actual number of trips that catch white seabass (Figure 4.15.1.4-4), it is clear the predicted values miss the larger swings in the number of trips catching white seabass, for example around the year 2000, but the overall trend through time is captured.

*Figure 4.15.1.4-4. Actual and predicted number of trips catching white seabass for the modern (1980-2013) CPFV logbook data that was filtered to only retain species caught on at least 50 unique trips before applying the method of Stephens and MacCall (2004). Actual trips are shown in black with squares and predicted trips are in red with diamonds.*




Trips selected from the Stephens and MacCall (2004) method applied to all of the data were further filtered by retaining only trips that had effort data and trips taking place in either the 600, 700, or 800 level blocks (Southern California). The same 6 delta-glmm models described previously were then fit using the data. Three models do not have month effects and include: (1) effect of year only; (2) effects of year and strata; and (3) effects of year, strata, and the interaction between strata and year. The final three models all include a month effect. They are models with: (4) effect of month and year; (5) effect of month, year, and strata; and (6) effect of month, year, strata, and the interaction between strata and year.

To select the best model, DIC values and the number of parameters from that model that have Gelman-Rubin statistics greater than 1.01, 1.05, and 1.10 (Table 4.15.1.4-2) were used. Using 1.05 as the Gelman-Rubin statistic cutoff, only two models have all parameters pass the Gelman-Rubin statistic, the model with only the effect of year and the model with the effects of year and strata. Between those two models, the model with effects of year and strata has a much smaller DIC value, by nearly 700 DIC units, and is thus selected as the best fitting model.

*Table 4.15.1.4-2. Table of results from fitting delta-glmm models to the modern (1980-2013) CPFV logbook data using the method of Stephens and MacCall (2004). Results include Δ DIC , number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Month | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | | 1,555.19 | 70 | 0 | 0 | 0 |
| x | x | | | 855.82 | 76 | 0 | 0 | 0 |
| x | x | x | | 129.14 | 282 | 135 | 103 | 12 |
| x | | | x | 367.00 | 934 | 921 | 913 | 908 |
| x | x | | x | 80.40 | 940 | 921 | 829 | 658 |
| x | x | x | x | 0.00 | 1146 | 974 | 908 | 853 |

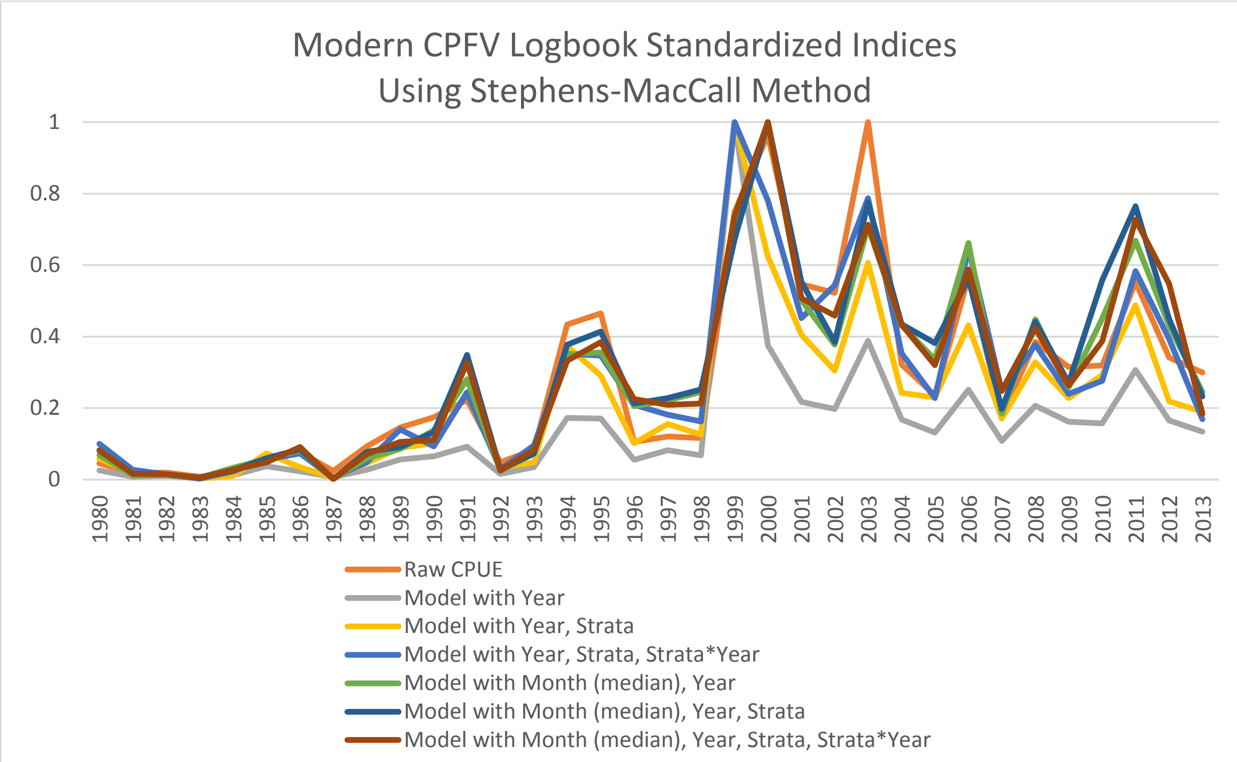
Looking at the fraction of times the 95% Bayesian Credible Interval from the posterior predictions includes the observed value (Table 4.15.1.4-3), all models do very well at predicting zero-catches (fraction =1). For the best fitting model, the model with effects of year and strata the overall fraction of observed catches falling within the 95% Bayesian Credible Interval is high at 0.98. Similar to the results from the modern CPFV logbook data, the fraction of 95% Bayesian Credible Intervals that contain the positive-catches are very low.

*Table 4.15.1.4-3. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the modern (1980-2013) CPFV logbook data using the method of Stephens and MacCall (2004).*

| Year | Strata | Strata*Year | Month | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|---|
| x | | | | 0.9802353 | 1 | 0.3823529 |
| x | x | | | 0.9801176 | 1 | 0.3372549 |
| x | x | x | | 0.9775294 | 1 | 0.3321678 |
| x | | | x | 0.9816471 | 1 | 0.3929961 |
| x | x | | x | 0.9781176 | 1 | 0.3564014 |
| x | x | x | x | 0.9747059 | 1 | 0.295082 |

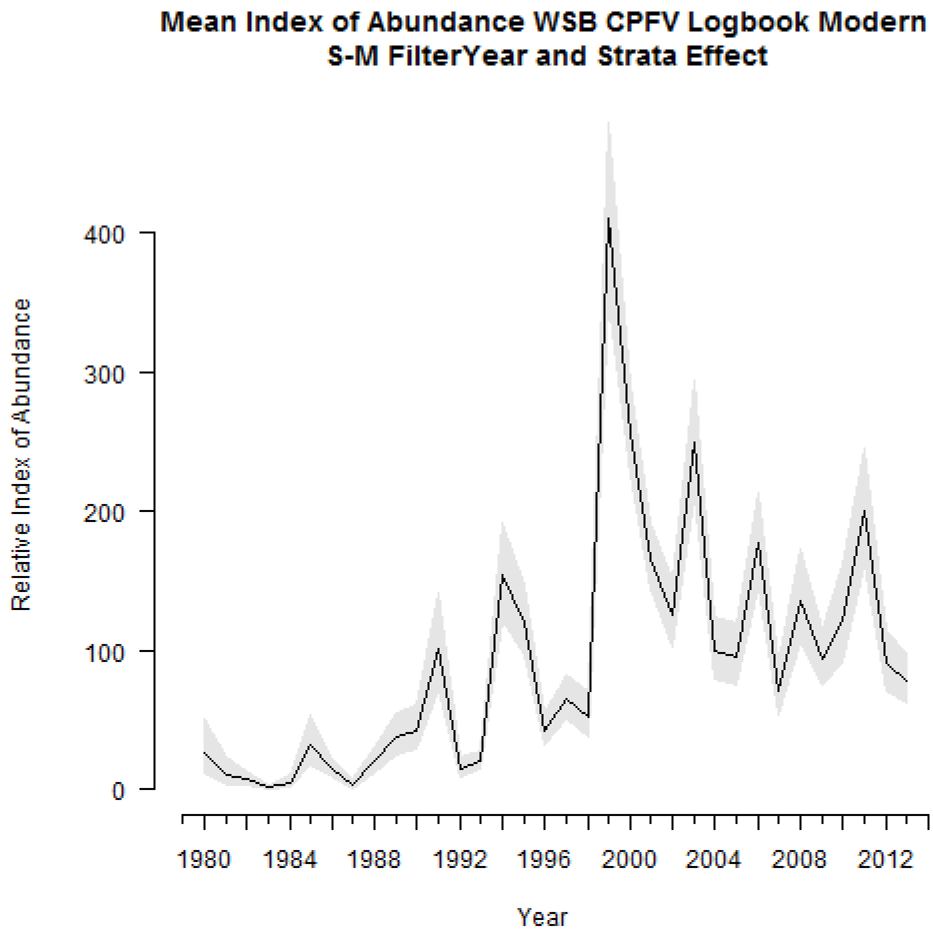
A plot of the standardized relative indices from all six models and standardized raw catch-per-unit-effort (CPUE) show that the model with year and strata is similar to the raw index (Figure 4.15.1.4-5).

*Figure 4.15.1.4-5. Standardized relative indices of abundance for the CPFV logbook data from 1980 to 2013, using the method of Stephens and MacCall to filter the data first. Also shown is the standardized raw catch-per-unit-effort.*




When the CPFV modern logbook data, filtered using the method of Stephens-MacCall, was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show a decline from the start of the time series till the mid-1960s (Figure 4.15.1.4-6).

*Figure 4.15.1.4-6. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the modern CPFV logbook data for white seabass, when the Stephens-MacCall filter was used, using only records from Southern California, the 600-800 blocks.*




### 4.15.2. Ocean Resources Enhancement Hatchery Program Gillnet Survey (CSUN/HSWRI)

The OREHP gillnet survey data from CSUN was used only as raw data to make a CPUE. This is because catch data could not be linked back to effort data. No unique ID key was provided with the data and a unique one could not be created using date and location information. To further complicate things, the study design for the CSUN data has changed through time.

The OREHP gillnet survey data from HSWRI was used to make a CPUE index using the delta-glmm method previously described. Some sites had a large number of sets with zero white seabass. In, so order to increase the model fit all data from site MBCH (Mission Bay channel) and site TP (Torrey Pines) were removed before fitting the delta-glmm. It is worth noting that both sites, MBCH and TP, only had data for the years 1988 and 1989 which is when many of the other sites were not sampled. Six model parameterizations were evaluated: (1) year effect only; (2) year and strata effects; (3) including effects of strata, year, and the interactive effect of strata and year; (4) month and year effect; (5) month, year, and strata effect; and (6) month, year, strata and the interactive effect of strata and year. The same six models were also fit to the HSWRI data using only data from the year 1996 and on. The year 1996 was used as a cutoff as this is when the methods used by HSWRI were standardized and repeated every year.

Using the Gelman-Rubin statistics, only the model with year effect (model 1, as described above) has all parameters pass at the 1.01 level. Using 1.05 as the cutoff instead, then the models with (1) year; (2) year and strata; and (3) year, strata, and the interactive effect of year and strata pass (Table 4.15.2-1). Then using DIC to select between these three models, the model with year, strata, and the interactive effect of year and strata has the lowest DIC by over 300 DIC units.

*Table 4.15.2-1. Table of results from fitting delta-glmm models to the OREHP HSWRI data. Results include Δ DIC , number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Month | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | | 783.56 | 48 | 0 | 0 | 0 |
| x | x | | | 429.67 | 82 | 15 | 0 | 0 |
| x | x | x | | 112.79 | 866 | 44 | 0 | 0 |
| x | | | x | 511.24 | 648 | 631 | 602 | 564 |
| x | x | | x | 198.68 | 682 | 650 | 623 | 607 |
| x | x | x | x | 0.00 | 1466 | 643 | 622 | 605 |

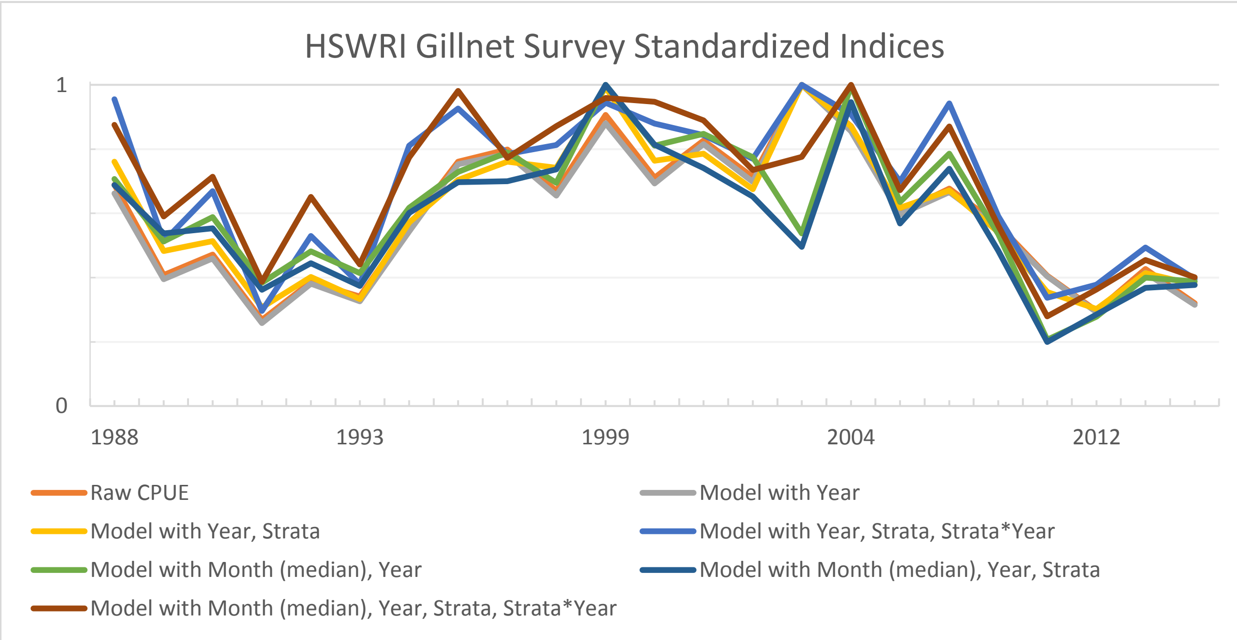
Looking at the fraction of observed catches that fall within the 95% Bayesian Credible Interval from the posterior prediction for all catches, zero-catches, and positive-catches, models 1, 2, and 3 perform relatively similarly (Table 4.15.2-2). All three models predict zero-catches perfectly. The models all predict the positive-catches at a similar level, approximately 92-93% of the 95% Bayesian Credible Intervals capture the observed positive-catches.

*Table 4.15.2-2. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the OREHP HSWRI data.*

| Year | Strata | Strata*Year | Month | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|---|
| x | | | | 0.97343 | 1 | 0.9385475 |
| x | x | | | 0.9677939 | 1 | 0.9226306 |
| x | x | x | | 0.97343 | 1 | 0.9375 |
| x | | | x | 0.9766506 | 1 | 0.9424603 |
| x | x | | x | 0.9871176 | 1 | 0.9700375 |
| x | x | x | x | 0.9822866 | 1 | 0.9582543 |

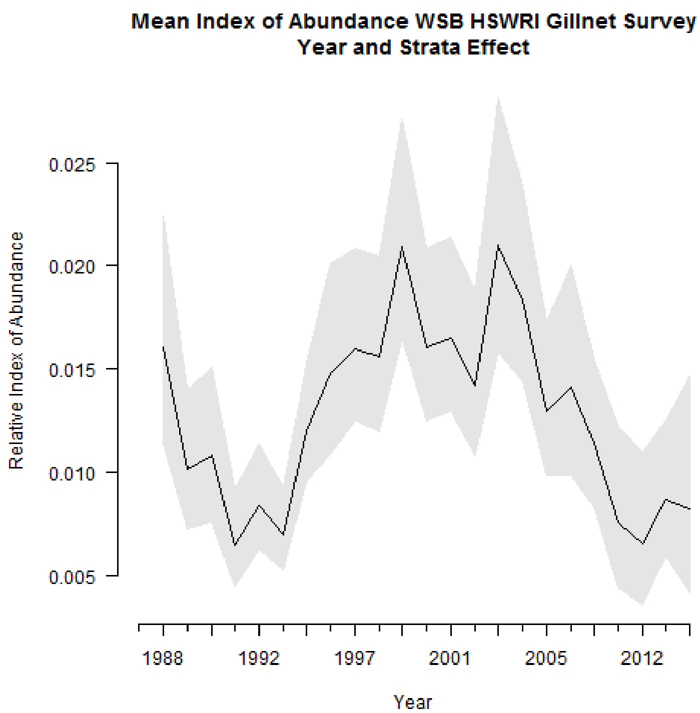
A plot of the standardized relative indices from all models standardized raw catch-per-unit-effort (CPUE) show that the model with year and strata is similar to the raw index (Figure 4.15.2-1).

*Figure 4.15.2-1. Standardized relative indices of abundance from the OREHP HSWRI data along with raw catch per unit effort.*



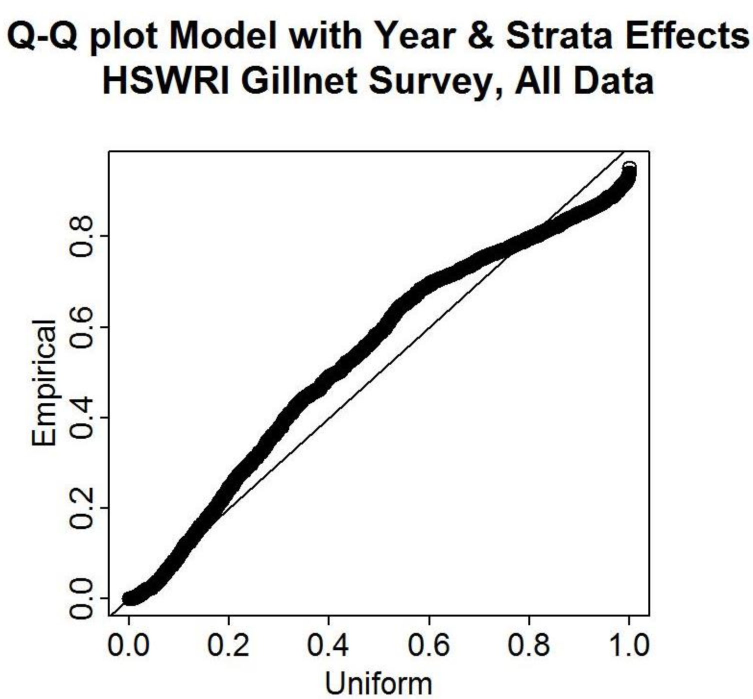

When the HSWRI gillnet survey data was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show an increase starting in the early 1990s and then a decline starting in the early 2000s(Figure 4.15.2-2).

*Figure 4.15.2-2. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the HSWRI gillnet data.*




The Q-Q plot for the HSWRI gillnet survey shows a positive trend (the empirical values are less than estimated values) in the residuals at mid-values of catch (Figure 4.15.2-3).

*Figure 4.15.2-3. Q-Q plot for HSWRI gillnet survey data for white seabass for the model including effects of year and strata.*



Looking at only the OREHP HSWRI data from 1996 and on, using the Gelman-Rubin statistics only the model with year effect only (model 1, as described above) has all parameters pass at the 1.01 level. If 1.05 is used as the cutoff instead, then the models with (1) year and (2) year and strata pass for all parameters (Table 4.15.2-3). Using DIC to select between these three models, the model with year and strata has the lowest DIC by over 300 DIC units.

*Table 4.15.2-3. Table of results from fitting delta-glmm models to the OREHP HSWRI data from 1996 and on. Results include Δ DIC , number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Month | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | | 702.16 | 34 | 0 | 0 | 0 |
| x | x | | | 382.64 | 54 | 2 | 0 | 0 |
| x | x | x | | 63.58 | 376 | 37 | 30 | 19 |
| x | | | x | 492.05 | 370 | 318 | 304 | 296 |
| x | x | | x | 219.69 | 390 | 321 | 283 | 283 |
| x | x | x | x | 0.00 | 700 | 332 | 273 | 270 |

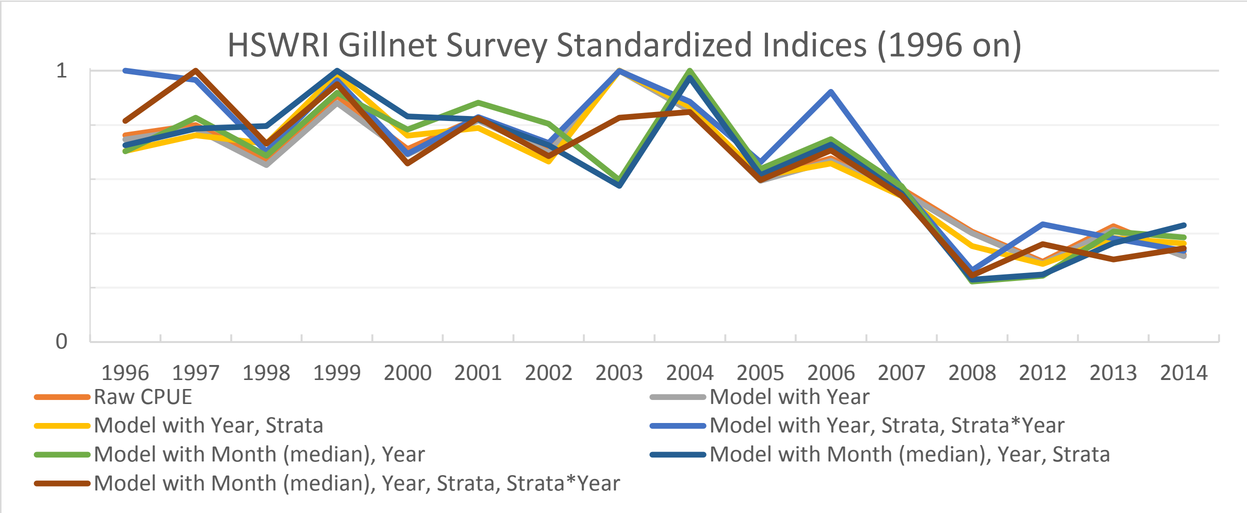
Looking at the fraction of observed catches that fall within the 95% Bayesian Credible Interval from the posterior prediction for all catches, zero-catches, and positive-catches, models 1 and 2 perform relatively similarly (Table 4.15.2-4). Both models predict zero-catches perfectly. The models both predict the positive-catches at a similar level, approximately 92-94% of the 95% Bayesian Credible Intervals of the posterior predictions capture the observed positive-catches.

*Table 4.15.2-4. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches from the OREHP HSWRI data from 1996 and on.*

| Year | Strata | Strata*Year | Month | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|---|
| x | | | | 0.974537 | 1 | 0.9402174 |
| x | x | | | 0.9664352 | 1 | 0.9262087 |
| x | x | x | | 0.9826389 | 1 | 0.9630542 |
| x | | | x | 0.9780093 | 1 | 0.9447674 |
| x | x | | x | 0.9722222 | 1 | 0.933518 |
| x | x | x | x | 0.9791667 | 1 | 0.952381 |

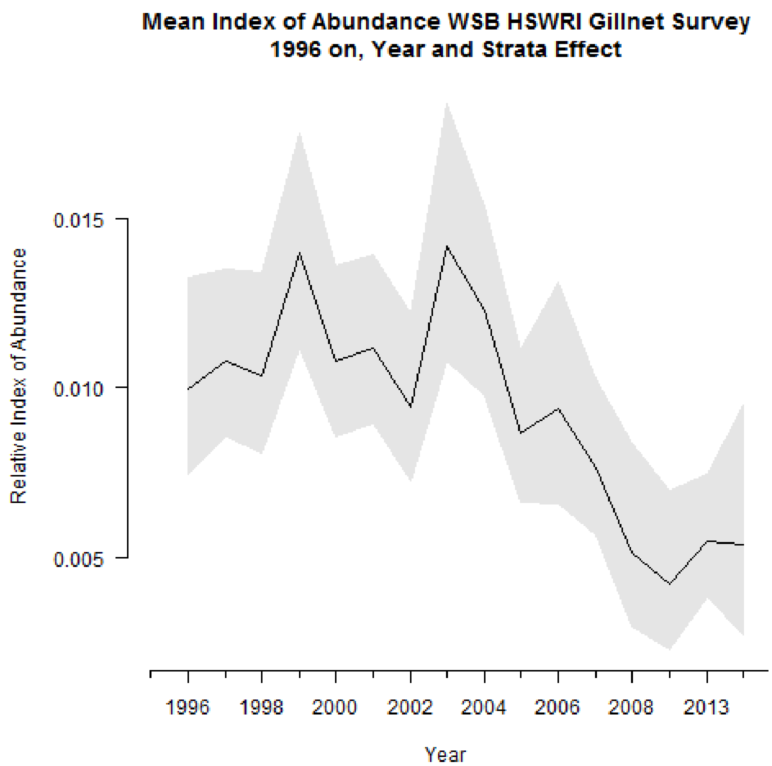
A plot of the standardized relative indices from all models and standardized raw catch-per-unit-effort (CPUE) show that the model with year and strata is similar to the raw index (Figure 4.15.2-4).

*Figure 4.15.2-4. Standardized relative indices of abundance from the OREHP HSWRI data from 1996 on along with raw catch per unit effort.*




When the HSWRI gillnet survey data from 1996 on was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI show a slow decline from the start of the time series till the early 2000s (Figure 4.15.2-5).

*Figure 4.15.2-5. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the HSWRI gillnet data from 1996 on.*



### 4.15.3 Impingement and associated trawl survey

Data from the impingement and associated trawl survey have 3 total types. Two are impingement type data, fish chase and heat treatment data, and the other is a trawl survey. Details about the sampling methodology for this data can be found in Miller et al. (2009 and 2011). The fish chase (FC) data comes from the San Onofre Nuclear generating station (SONGS) units 2 and 3 and covers the years 1989 to 2012, there are 330 data records (Table 4.15.3-1 and Table 4.15.3-2). There was only one record for 2012 in the SONG FC, so it was removed from further analyses.

*Table 4.15.3-1. Power plant fish chase records of catch (number of fish) and effort (flow rate), summarized yearly.*

| Year | Total WSB (#) | Total Effort (Flow Rate $10^9$ $m^3$) | Raw CPUE (per Flow Rate $10^8$ $m^3$) |
|---|---|---|---|
| 1989 | 190 | 3.19 | 5.96 |
| 1990 | 302 | 2.85 | 10.6 |
| 1991 | 4 | 2.17 | 0.18 |
| 1992 | 43 | 3.71 | 1.16 |
| 1993 | 39 | 2.77 | 1.41 |
| 1994 | 16 | 3.52 | 0.46 |
| 1995 | 99 | 2.87 | 3.45 |
| 1996 | 26 | 3.33 | 0.78 |
| 1997 | 86 | 2.7 | 3.18 |
| 1998 | 44 | 3.53 | 1.25 |
| 1999 | 76 | 2 | 3.80 |
| 2000 | 35 | 3.3 | 1.06 |
| 2001 | 77 | 2.8 | 2.75 |
| 2002 | 13 | 3.14 | 0.41 |
| 2003 | 11 | 3.32 | 0.33 |
| 2004 | 5 | 2.58 | 0.19 |
| 2005 | 4 | 3.8 | 0.11 |
| 2006 | 28 | 49.3 | 0.06 |
| 2007 | 9 | 4.95 | 0.18 |
| 2008 | 33 | 4.9 | 0.67 |
| 2009 | 9 | 3.07 | 0.29 |
| 2010 | 26 | 2.91 | 0.89 |
| 2011 | 4 | 3.87 | 0.10 |

*Table 4.15.3-2. Power plant fish chase data summarized by year and unit within the San Onofre Nuclear generating station.*

| Year | Unit | Count Nonzero Samples | Total WSB (#) | Total Samples | % Nonzero Samples | % Zero Samples | Total Effort (Flow Rate in $10^9$ $m^3$) |
|---|---|---|---|---|---|---|---|
| 1989 | 1 | 3 | 186 | 6 | 0.50 | 0.50 | 1.53 |
| 1989 | 2 | 2 | 4 | 7 | 0.29 | 0.71 | 1.66 |
| 1990 | 1 | 6 | 294 | 7 | 0.86 | 0.14 | 1.49 |
| 1990 | 2 | 1 | 8 | 5 | 0.20 | 0.80 | 1.35 |
| 1991 | 1 | 1 | 3 | 3 | 0.33 | 0.67 | 1.10 |
| 1991 | 2 | 1 | 1 | 5 | 0.20 | 0.80 | 1.07 |
| 1992 | 1 | 4 | 40 | 7 | 0.57 | 0.43 | 1.83 |
| 1992 | 2 | 2 | 3 | 7 | 0.29 | 0.71 | 1.87 |
| 1993 | 1 | 2 | 7 | 6 | 0.33 | 0.67 | 1.43 |
| 1993 | 2 | 3 | 32 | 5 | 0.60 | 0.40 | 1.34 |
| 1994 | 1 | 3 | 8 | 8 | 0.38 | 0.63 | 1.76 |
| 1994 | 2 | 5 | 8 | 7 | 0.71 | 0.29 | 1.75 |
| 1995 | 1 | 4 | 11 | 6 | 0.67 | 0.33 | 1.33 |
| 1995 | 2 | 7 | 88 | 7 | 1.00 | 0.00 | 1.54 |
| 1996 | 1 | 2 | 5 | 7 | 0.29 | 0.71 | 1.67 |
| 1996 | 2 | 6 | 21 | 8 | 0.75 | 0.25 | 1.66 |
| 1997 | 1 | 4 | 20 | 6 | 0.67 | 0.33 | 1.36 |
| 1997 | 2 | 4 | 66 | 6 | 0.67 | 0.33 | 1.35 |
| 1998 | 1 | 3 | 7 | 9 | 0.33 | 0.67 | 1.69 |
| 1998 | 2 | 4 | 37 | 8 | 0.50 | 0.50 | 1.84 |
| 1999 | 1 | 3 | 16 | 8 | 0.38 | 0.63 | 1.21 |
| 1999 | 2 | 3 | 60 | 3 | 1.00 | 0.00 | 7.93 |
| 2000 | 1 | 1 | 5 | 7 | 0.14 | 0.86 | 1.49 |
| 2000 | 2 | 5 | 30 | 9 | 0.56 | 0.44 | 1.81 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2001 | 1 | 2 | 8 | 8 | 0.25 | 0.75 | 1.69 |
| 2001 | 2 | 3 | 69 | 5 | 0.60 | 0.40 | 1.11 |
| 2002 | 1 | 4 | 6 | 6 | 0.67 | 0.33 | 1.40 |
| 2002 | 2 | 5 | 7 | 10 | 0.50 | 0.50 | 1.74 |
| 2003 | 1 | 2 | 3 | 9 | 0.22 | 0.78 | 1.73 |
| 2003 | 2 | 2 | 8 | 7 | 0.29 | 0.71 | 1.59 |
| 2004 | 1 | 2 | 2 | 6 | 0.33 | 0.67 | 1.42 |
| 2004 | 2 | 1 | 3 | 6 | 0.17 | 0.83 | 1.17 |
| 2005 | 1 | 2 | 2 | 9 | 0.22 | 0.78 | 1.89 |
| 2005 | 2 | 2 | 2 | 10 | 0.20 | 0.80 | 1.92 |
| 2006 | 1 | 5 | 19 | 7 | 0.71 | 0.29 | 4.02 |
| 2006 | 2 | 3 | 9 | 5 | 0.60 | 0.40 | 9.06 |
| 2007 | 1 | 1 | 1 | 8 | 0.13 | 0.88 | 1.57 |
| 2007 | 2 | 3 | 8 | 12 | 0.25 | 0.75 | 3.38 |
| 2008 | 1 | 3 | 6 | 9 | 0.33 | 0.67 | 3.22 |
| 2008 | 2 | 1 | 27 | 7 | 0.14 | 0.86 | 1.69 |
| 2009 | 1 | 2 | 4 | 8 | 0.25 | 0.75 | 1.33 |
| 2009 | 2 | 2 | 5 | 8 | 0.25 | 0.75 | 1.74 |
| 2010 | 1 | 2 | 4 | 6 | 0.33 | 0.67 | 1.56 |
| 2010 | 2 | 4 | 22 | 7 | 0.57 | 0.43 | 1.35 |
| 2011 | 1 | 2 | 2 | 12 | 0.17 | 0.83 | 2.18 |
| 2011 | 2 | 2 | 2 | 7 | 0.29 | 0.71 | 1.69 |

Similar to the CPFV modern data, six separate delta-glmm models were fit to the SONGS FC data, three of them did not include a month effect and three did. The models that did not include a month effect were similar to the models fit to the historical CPFV logbook data including (1) model with year-effect only; (2) model with year-effect and strata-effect (here, strata refers to the power plant unit); and (3) a model with year-effect, strata-effect, and strata-year effect. The three models that included a month effect included: (1) a model with a year-effect and month-effect; (2) a model with year-effect, month-effect, and strata-effect; and (3) a model with a year-effect, month-effect, strata-effect, and year-strata effect. For each model DIC values were calculated and the number of parameters with Gelman-Rubin statistics greater than 1.01, 1.05, and 1.10 (Table 4.15.3-3). The only models that have all parameters with Gelman-Rubin statistics less than 1.05 are the model with (1) year effect and (2) year and strata effect. These two models have very similar DIC values. For the purpose of this assessment the model with year and strata is used in the stock synthesis runs.

*Table 4.15.3-3. Table of results from fitting delta-glmm models to power plant fish chase data. Results include Δ DIC , number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Month | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | | 140.81 | 50 | 0 | 0 | 0 |
| x | x | | | 140.12 | 54 | 0 | 0 | 0 |
| x | x | x | | 140.21 | 152 | 72 | 35 | 16 |
| x | | | x | 52.53 | 674 | 588 | 361 | 299 |
| x | x | | x | 0.00 | 678 | 556 | 374 | 319 |
| x | x | x | x | 30.79 | 776 | 427 | 286 | 268 |

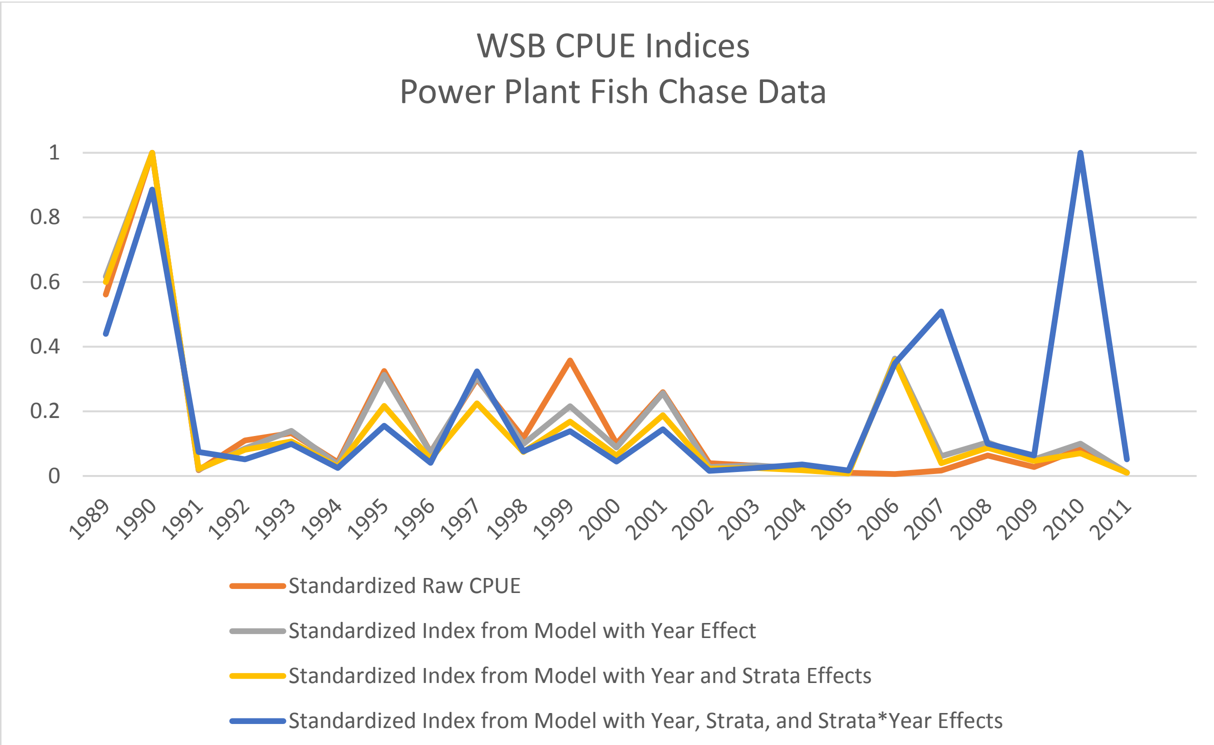
Using the fraction of observed catch values that fall within the 95% Bayesian Credible interval (Table 4.15.3-4), it is clear that all delta-glmm models are better at predicting zero-catches than positive catches. Also it is worth noting that all models perform very well (fraction >0.98) at predicting all catch and models without month effect perform very well (fraction >0.95) at predicting positive-catches. Taking a closer look at the model with the lowest DIC, the model including year, strata (unit), and the interaction between strata and year 98.48024% of the observed values fall within the 95% Bayesian credible interval (Bayes CI) of the predicted values. Using DIC alone for model selection would select the model with year, strata, and the interaction of strata and year.

*Table 4.15.3-4. Fraction of observed white seabass catches from the power plant fish chase data that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches.*

| Year | Strata | Strata*Year | Month | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|---|
| x | | | | 0.984849 | 1 | 0.962687 |
| x | x | | | 0.984849 | 1 | 0.962687 |
| x | x | x | | 0.981818 | 1 | 0.955224 |
| x | | | x | 1 | 1 | 1 |
| x | x | | x | 0.99697 | 1 | 0.992537 |
| x | x | x | x | 0.99697 | 1 | 0.992537 |

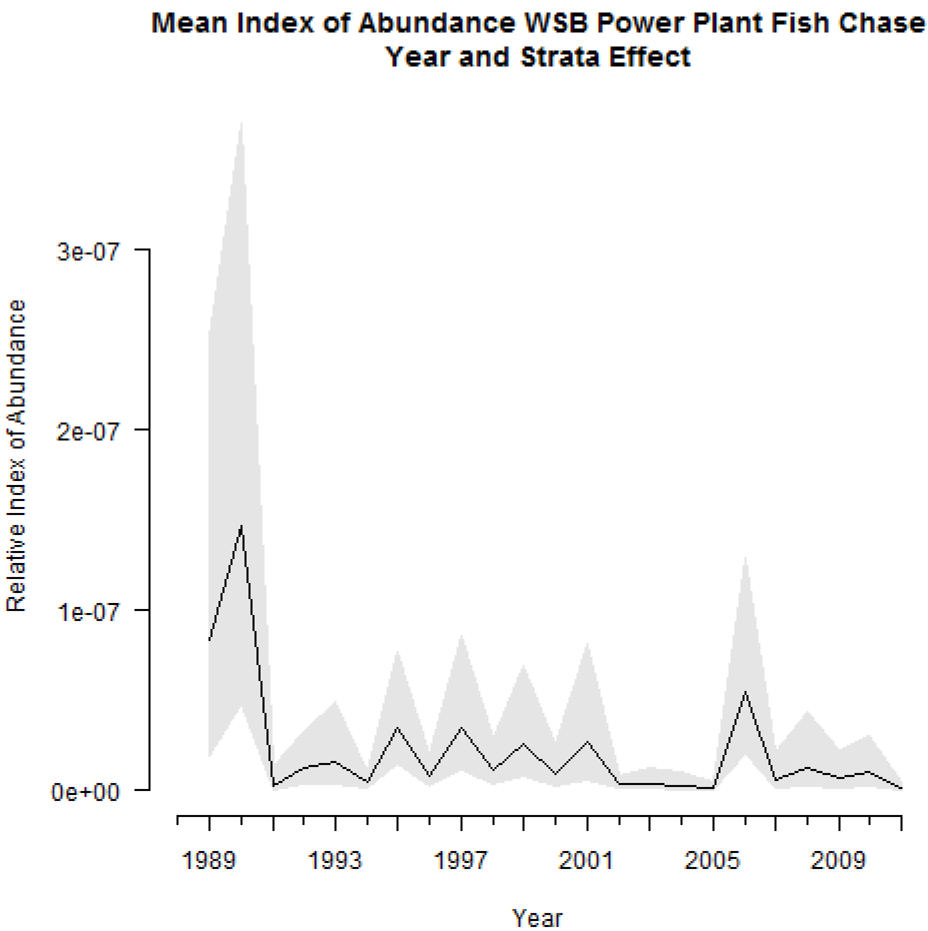
Until 2005 the standardized relative indices all track very similar to the raw standardized index (Figure 4.15.3-1)

*Figure 4.15.3-1. Standardized relative CPUE index values for the power plant fish chase data on white seabass. All relative indices have been standardized by being scaled against their maximum value. Strata and unit refer to the same thing for the power plant fish chase data.*




When the power plant fish chase data was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI are shown in Figure 4.15.3-2.

*Figure 4.15.3-2. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata from the power plant fish chase data.*




The heat treatment (HT) data comes from a total of 5 power plants: Ormond Beach generating station (OBGS); El Segundo generating station (ESGS); Redondo Beach generating station (RBGS); Huntington Beach generating station (HBGS); San Onofre Nuclear generating station (SONGS); and Scattergood Generating Station in El Segundo (SGS). The HT data runs from 1972 to 2012, but only 1972 to 2011 were analyzed for these analysis. Data from the year 2012 was not included in the analysis as the data did not represent a full year of sampling.

Similar to the SONGS FC, six separate delta-glmm models were fit to the SONGS HT data, three of them did not include a month effect and three did. The models that did not include a month effect included: (1) a model with year-effect only; (2) a model with year-effect and strata-effect (where strata is the unit); and (3) a model with year-effect, strata-effect, and strata-year effect. The three models that included a month effect included (1) a model with a year-effect and month-effect; (2) a model with year-effect, month-effect, and strata-effect; and (3) a model with a year-effect, month-effect, strata-effect, and year-strata effect. For all models DIC values were calculated (Table 4.15.3-5).

*Table 4.15.3-5. Table of results from fitting delta-glmm models to power plant heat treatment data. Results include Δ DIC , number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Month | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | | 384.65 | 82 | 0 | 0 | 0 |
| x | x | | | 0.00 | 102 | 0 | 0 | 0 |
| x | x | x | | 56.13 | 904 | 37 | 0 | 0 |
| x | | | x | 549.01 | 1090 | 1079 | 1069 | 1067 |
| x | x | | x | 266.94 | 1110 | 1089 | 10972 | 1065 |
| x | x | x | x | 441.09 | 1912 | 1070 | 1064 | 1064 |

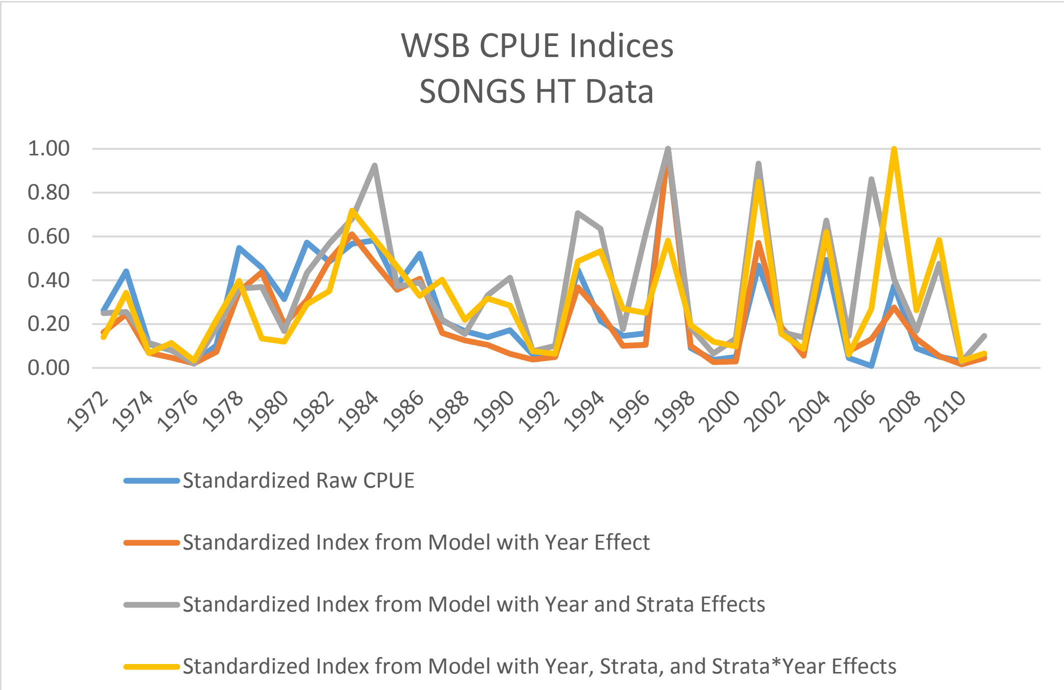
Using the fraction of observed catch values that fall within the 95% Bayesian Credible interval (Table 4.15.3-6), it is clear that all delta-glmm models are better at predicting zero-catches than positive catches. Also it is worth noting that all models perform very well (fraction >0.95) at predicting all catch and models without month effect perform very well (fraction >0.95) at predicting positive-catches.   Using DIC alone for model selection would select the model with year, strata, and the interaction of strata and year.  However, using the Gelman-Rubin statistic, three models pass for all parameters at the 1.05 level: (1) the model with year; (2) the model with year and strata; and (3) the model with year, strata, and the interaction of strata and year. For the input to stock synthesis the model with year and strata was used to match with other indices.

*Table 4.15.3-6. Fraction of observed white seabass catches from the power plant heat treatment data that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches.*

| Year | Strata | Strata*Year | Month | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|---|
| x | | | | 0.975 | 1 | 0.926686 |
| x | x | | | 0.975 | 1 | 0.930556 |
| x | x | x | | 0.981 | 1 | 0.945402 |
| x | | | x | 0.98 | 1 | 0.943182 |
| x | x | | x | 0.986 | 1 | 0.95977 |
| x | x | x | x | 0.985 | 1 | 0.958678 |

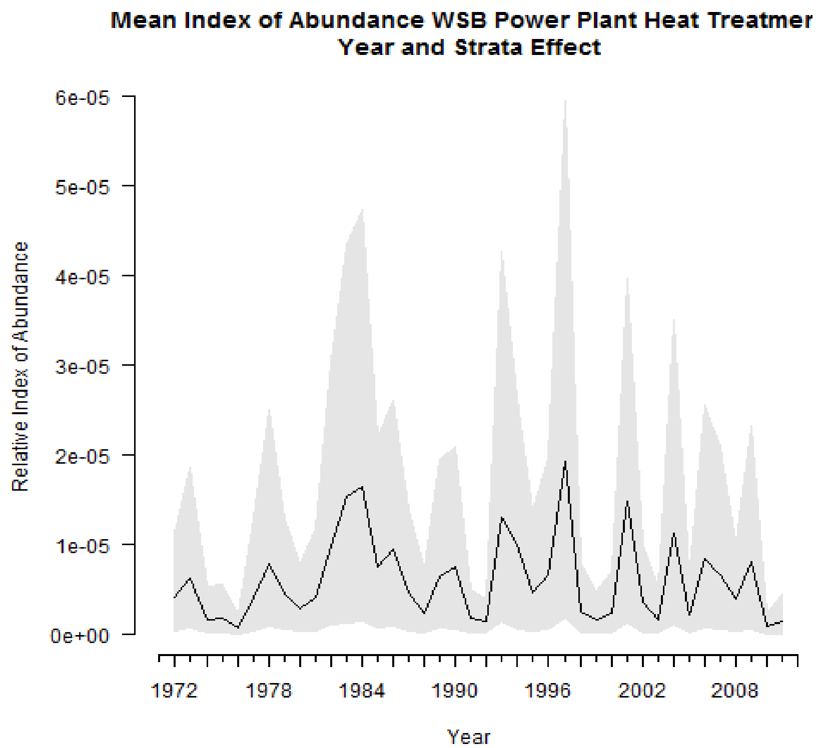
The standardized relative indices all track very similar to the raw standardized index from the heat treatment data (Figure 4.14.3-3).

*Figure 4.15.3-3. Standardized relative CPUE index values for the power plant heat treatment (HT) data on white seabass. All relative indices have been standardized by being scaled against their maximum value. Strata and unit refer to the same thing for the power plant heat treatment data.*



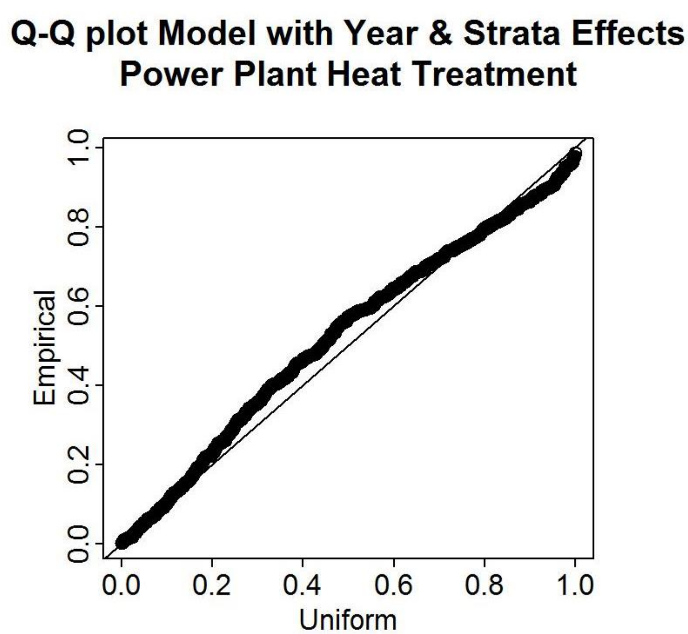

When the power plant heat treatment data was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI are shown in Figure 4.15.3-4.

*Figure 4.15.3-4. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, rom the power plant heat treatment data.*




The Q-Q plot for the power plant heat treatment data shows a slight positive trend (the empirical values are less than estimated values) in the residuals at mid-values of catch (Figure 4.15.3-5).

*Figure 4.15.3-5. Q-Q plot for power plant heat treatment data for white seabass for the model including effects of year and strata.*



### 4.15.4 Commercial gillnet logbooks set net

The gillnet logbook data required filtering prior to analysis. First, the data were filtered to retain records that indicated they were targeting white seabass. Next, the data were filtered to retain records from the US (excluding catch from Mexico). Then the data were filtered to retain data only from blocks that caught 11 or more white seabass using any method of fishing (drift net, set net, or other). Next, the data were filtered to only retain catch from the 100-level blocks 600, 700, and 800, and to retain records that had effort information (effort>0 hours). Finally, the data was split into drift net or set net.

Six separate delta-glmm models were fit to the set net gillnet logbook data Three of them did not include a month effect and three did. The three models that included a month effect included (1) a model with a year-effect and month-effect; (2) a model with year-effect, month-effect, and strata-effect; and (3) a model with a year-effect, month-effect, strata-effect, and an effect for the interaction between year and strata. The models that did not include a month effect were: (1) model with year-effect only; (2) model with year-effect and strata-effect; and (3) a model with year-effect, strata-effect, and an effect for the interaction between year and strata. For models including a month effect, the month effect was modeled as it was for the CPFV modern logbook data, such that month was hierarchical in that all January's had some mean effect, as did all February's, and so on

To choose the best fitting model, DIC value and the number of parameters that have a Gelman-Rubin statistic above a certain threshold, 1.01, 1.05 or 1.10, are used (Table 4.15.4-1). Using these three criteria, the models that pass the Gelman-Rubin test are the model with the effect of year and the model with the effects of year and strata. Using DIC to choose between these two models, the model with year and strata is the best fitting model.

*Table 4.15.4-1. Table of results from fitting delta-glmm models to set net gillnet logbook data. Results include Δ DIC , number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

| Effects Included in Model | | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Month | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | | 4,984.10 | 64 | 0 | 0 | 0 |
| x | x | | | 4,661.12 | 70 | 0 | 0 | 0 |
| x | x | x | | 2,680.98 | 258 | 146 | 40 | 16 |
| x | | | x | 1,993.05 | 856 | 839 | 792 | 754 |
| x | x | | x | 1,543.04 | 862 | 835 | 831 | 827 |
| x | x | x | x | 0.00 | 1050 | 955 | 862 | 839 |

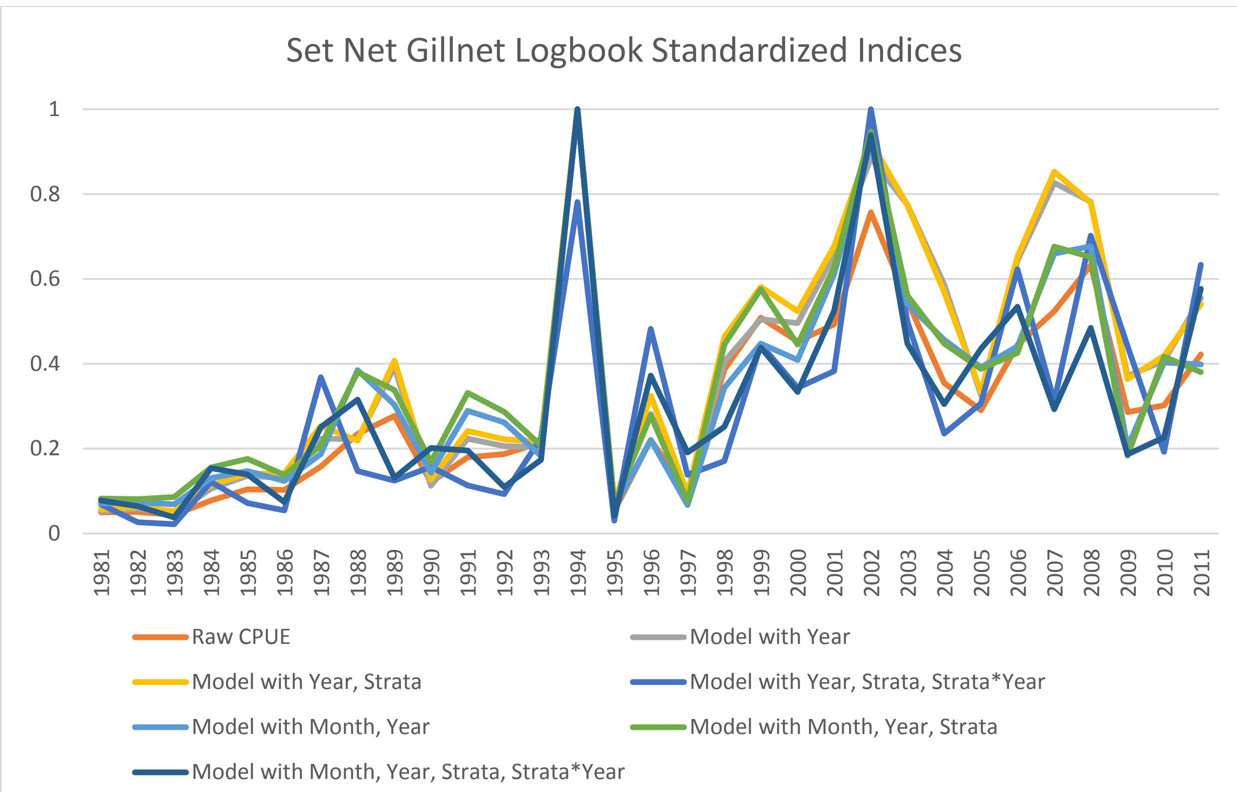
Using the fraction of observed catch values that fall within the 95% Bayesian Credible interval (Table 4.15.4-2), it is clear that all delta-glmm models are better at predicting zero-catches than positive catches. Also it is worth noting that all models perform very well (fraction >0.95) at predicting all catch and models without month effect perform very well (fraction >0.95) at predicting positive-catches.

*Table 4.15.4-2. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches.*

| Year | Strata | Strata*Year | Month | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|---|
| x | | | | 0.9727047 | 1 | 0.9633943 |
| x | x | | | 0.9727047 | 1 | 0.9611307 |
| x | x | x | | 0.9751861 | 1 | 0.9672131 |
| x | | | x | 0.9615385 | 1 | 0.8495114 |
| x | x | | x | 0.971464 | 1 | 0.9606164 |
| x | x | x | x | 0.971464 | 0.9950249 | 0.9636364 |

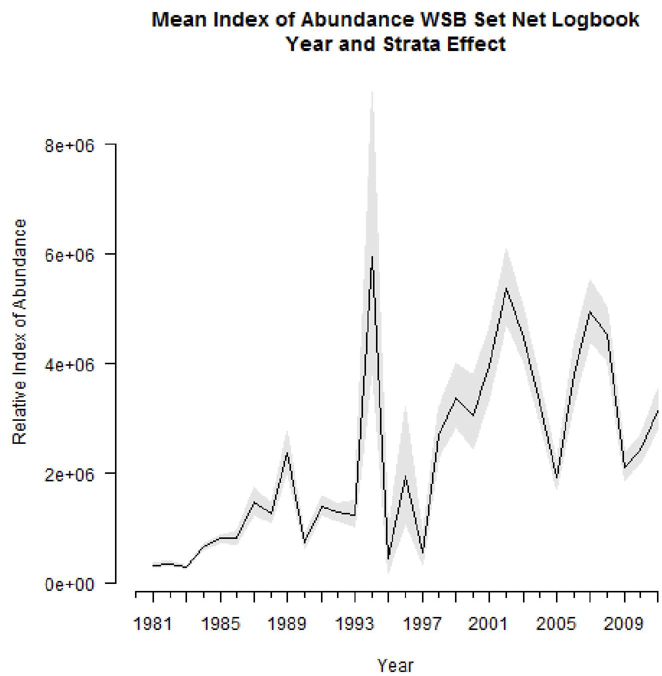
The standardized relative indices all track very similar to the raw standardized index from the heat treatment data (Figure 4.14.4-1).

*Figure 4.15.4-1. Standardized relative CPUE index values for the set net gillnet logbook data for white seabass. All relative indices have been standardized by being scaled against their maximum value.*



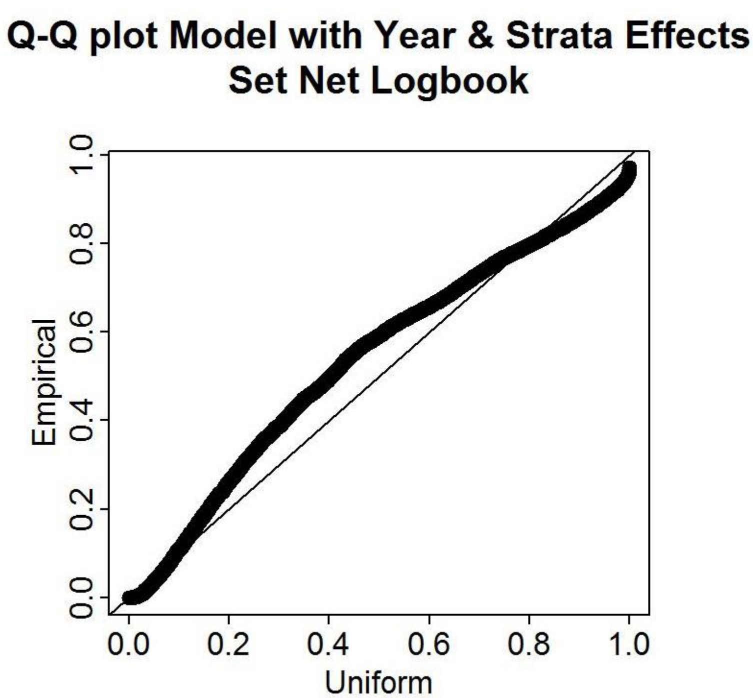

When the set net gillnet logbook data was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI shows a relative overall increase since the 1980s (Figure 4.15.4-2).

*Figure 4.15.4-2. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the set net gillnet logbook data.*




The Q-Q plot for set net gillnet logbook data shows a positive trend (the empirical values are less than estimated values) in the residuals at mid-values of catch (Figure 4.15.4-3).

*Figure 4.15.4-3. . Q-Q plot for set net gillnet logbook data for white seabass for the model including effects of year and strata.*



### 4.15.5 Commercial gillnet logbooks drift net

An index of relative abundance was made using drift net logbook entries from the years 1985 to 2011. The years 1981-1984 were not included because once the data were filtered, the years 1983 and 1984 had no data records and 1981 and 1982 has 6 and 2 records, respectively. The data filtering process is as described for the set net gillnet logbook data records. Six separate delta-glmm models were fit to the set net gillnet logbook data, three of them did not include a month effect and three did. The three models that included a month effect included (1) a model with a year-effect and month-effect; (2) a model with year-effect, month-effect, and strata-effect; and (3) a model with a year-effect, month-effect, strata-effect, and an effect for the interaction between year and strata. The models that did not include a month effect were: (1) model with year-effect only; (2) model with year-effect and strata-effect; and (3) a model with year-effect, strata-effect, and an effect for the interaction between year and strata.

To choose the best fitting model, DIC value and the number of parameters that have a Gelman-Rubin statistic above a certain threshold, 1.01, 1.05 or 1.10 are used (Table 4.15.5-1). Using these a cutoff of 1.05, the models that pass the Gelman-Rubin test are the model with the effect of year (model 1); the model with the effects of year and strata (model 2); and the model with the effects of year, strata, and the interaction between year and strata (model 3). Using DIC to choose between these three models, the model with year, strata, and the interaction between strata and year is the best fitting model.

*Table 4.15.5-1. Table of results from fitting delta-glmm models to drift net gillnet logbook data. Results include Δ DIC , number of parameters in model, and results of the how many parameters have a Gelman-Rubin statistic greater than 1.01, 1.05, or 1.10.*

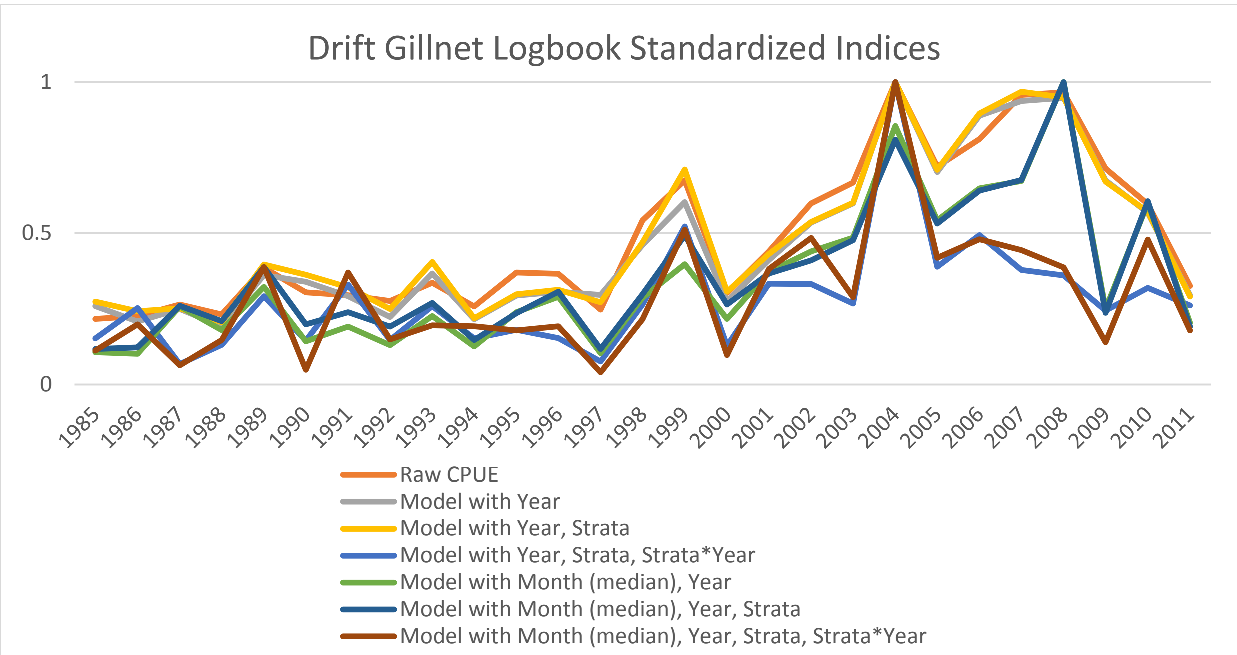
| Effects Included in Model | | | | | | Number of Parameters with Gelman-Rubin Statistics > | | |
|---|---|---|---|---|---|---|---|---|
| Year | Strata | Strata*Year | Month | Δ DIC | Number Parameters | 1.01 | 1.05 | 1.1 |
| x | | | | 957.61 | 56 | 0 | 0 | 0 |
| x | x | | | 879.56 | 62 | 0 | 0 | 0 |
| x | x | x | | 614.28 | 226 | 36 | 0 | 0 |
| x | | | x | 378.61 | 644 | 331 | 306 | 294 |
| x | x | | x | 250.04 | 650 | 336 | 307 | 306 |
| x | x | x | x | 0.00 | 806 | 397 | 323 | 268 |

Using the fraction of observed catch values that fall within the 95% Bayesian Credible interval (Table 4.15.5-2), the delta-glmm model does slightly better at predicting zero catches than non-zero catches. Also it is worth noting that all models perform very well (fraction >0.96) at predicting all catch and models without month effect perform very well (fraction >0.96) at predicting positive-catches. For the best fitting model, model 3 (with effects of year, strata, and the interaction between strata and year), the model does very well (fraction >0.97) at predicting all levels of catch.

*Table 4.15.5-2. Fraction of observed white seabass catches that fall within the 95% Bayesian Credible Interval from the posterior predictions for all catch data, zero-catches, and positive-catches for the drift gillnet logbook dataset.*

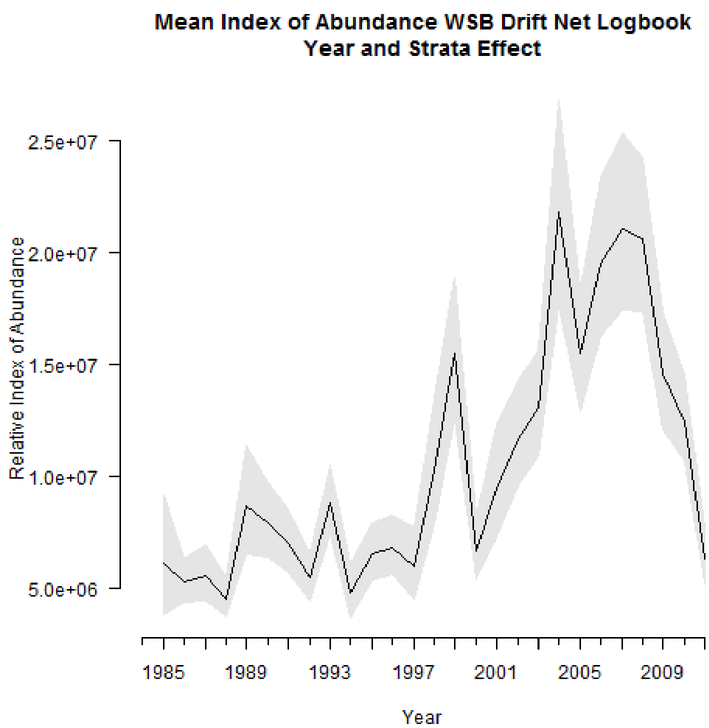
| Year | Strata | Strata*Year | Month | Fraction Observed Within Predicted 95% Bayes CI | Fraction Zero-catches Observed Within Predicted 95% Bayes CI | Fraction Positive-catches Observed Within Predicted 95% Bayes CI |
|---|---|---|---|---|---|---|
| x | | | | 0.9667944 | 0.9862385 | 0.9636499 |
| x | x | | | 0.9712644 | 0.9863636 | 0.9687964 |
| x | x | x | | 0.9706258 | 0.9853659 | 0.9684056 |
| x | | | x | 0.9687101 | 0.9861111 | 0.9659259 |
| x | x | | x | 0.9667944 | 0.9770642 | 0.9651335 |
| x | x | x | x | 0.9750958 | 0.9850746 | 0.9736264 |

*Figure 4.15.5-1. Standardized relative indices of abundance from the drift net gillnet logbook dataset.*



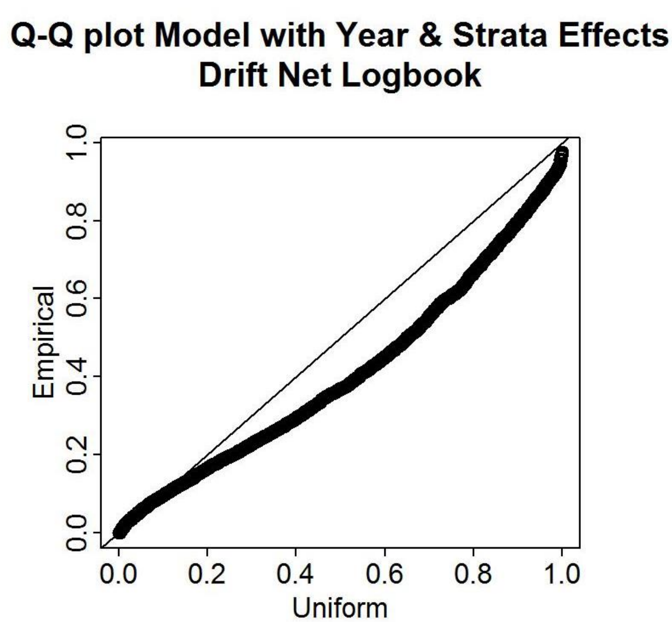

When the drift net gillnet logbook data was included in the stock synthesis runs, results from the model with effects of strata and year was used. The mean of the relative index of abundance from the model fit along with the 95% Bayes CI shows a slight increase from the start in 1985 to the mid 2000s(Figure 4.15.5-2).

*Figure 4.15.5-2. Mean of relative index of abundance and 95% Bayes CI for the model including effects of year and strata, from the drift net gillnet logbook data.*




The Q-Q plot for drift net gillnet logbook data shows a negative trend (the empirical values are less than estimated values) in the residuals at mid-values of catch (Figure 4.15.5-3).

*Figure 4.15.5-3. Q-Q plot for drift net gillnet logbook data for white seabass for the model including effects of year and strata.*



## 4.16. Discards

### 4.16.1. Discards from CPFV logbook data

Discard data is available from the CPFV logbook data for the period 1995 to 2013 (Table 4.16.1-1). It was not recorded prior to this time. In this time period there are 6,643 records of discarded fish, recorded as 'NumberReleased' in the dataset. These records represent 32,228 fish. There is no length or weight information linked to these records. There is also information on the number of white seabass lost to sea lions, although there is no information on the mortality associated with these numbers or clarification on certainty of the species of fish. The majority of the discards ('NumberReleased') in the CPFV logbook data, from 1995 to 2013, come from the 600,700, and 800 level blocks, i.e., Southern California (Table 4.16.1-2).

### 4.16.2. Discards from CPFV observer data

Discard data is available from the CPFV observer data for the period 1986 to 1989. There are no lengths available for the discarded fish from this data.  There are 217 records of discards from this time period. However, only 16 of these records come from Southern California (the 600-800 level blocks), and all 16 are from the 600 level blocks.  There is length information available for this data; however it is not possible to determine if the lengths are from fish retained during a trip or from the discarded fish. This data was not used in the analysis.

### 4.16.3. Discards from MRFSS/CRFS data

Discard data is available from the MRFSS/CRFS (RecFIN) data for the period 2003 to 2013. The discard data comes from sampler examined discards. There are 86 records for this time period. All but one of these records comes from party boats. Of the 85 records from party boats all but 7 of the records are of fish that are sublegal size.  There are length records for all 85 records of discards from this dataset.  This length data was used to help specify the length composition of the discards from the CPFV logbook data for 1995 to 2013.

### 4.16.4. Discards from Gillnet Logbook data

There are no data on discards in the gillnet logbook dataset.

*Table 4.16.1-1. Discard data from the CPFV logbook dataset. Discards, or number of fish released, were recorded starting in 1995 by the CPFV logbook records.  An additional category is number lost to sea lions and this dataset begins in 1994.*

| Year | Total Number Kept (number) | Total Number Released | Total Effort | Total Number Lost to Sea Lions |
|---|---|---|---|---|
| 1980 | 1003 | 0 | 5679979 | 0 |
| 1981 | 887 | 0 | 3790216 | 0 |
| 1982 | 1868 | 0 | 5364892 | 0 |
| 1983 | 1003 | 0 | 2871430 | 0 |
| 1984 | 973 | 0 | 4642558 | 0 |
| 1985 | 1046 | 0 | 6156558 | 0 |
| 1986 | 1634 | 0 | 6844685 | 0 |
| 1987 | 626 | 0 | 5099290 | 0 |
| 1988 | 2386 | 0 | 8035206 | 0 |
| 1989 | 1365 | 0 | 9446776 | 0 |
| 1990 | 2565 | 0 | 8191002 | 0 |
| 1991 | 1743 | 0 | 10288506 | 0 |
| 1992 | 701 | 0 | 6334622 | 0 |
| 1993 | 1403 | 0 | 7081892 | 0 |
| 1994 | 2485 | 0 | 15431655 | 143 |
| 1995 | 4383 | 2839 | 18988131 | 189 |
| 1996 | 1556 | 2484 | 14706551 | 103 |
| 1997 | 1644 | 2106 | 12625158 | 201 |
| 1998 | 1287 | 1538 | 7326697 | 103 |
| 1999 | 11861 | 2350 | 22238027 | 514 |
| 2000 | 17497 | 3090 | 31996533 | 29 |
| 2001 | 10335 | 3318 | 24608262 | 329 |
| 2002 | 8600 | 1623 | 16865995 | 490 |
| 2003 | 8543 | 2302 | 16879237 | 418 |
| 2004 | 3281 | 1311 | 10331176 | 104 |
| 2005 | 2933 | 1728 | 9315904 | 120 |
| 2006 | 6724 | 1651 | 13220395 | 127 |
| 2007 | 2323 | 964 | 7389539 | 81 |
| 2008 | 4132 | 1407 | 10762294 | 281 |
| 2009 | 3084 | 748 | 10119150 | 330 |
| 2010 | 3694 | 548 | 8990044 | 202 |
| 2011 | 5700 | 864 | 11899057 | 140 |
| 2012 | 4324 | 844 | 11211203 | 277 |
| 2013 | 4914 | 513 | 12723947 | 308 |

*Table 4.16.1-2. Breakdown of total number of discards (total number released), total retained, and total number lost to sea lions starting in 1995 from the CPFV logbooks. The data is broken down by records with blocks in the 600s, 700s, and 800s and other (including 200-599 blocks and blocks 900 and above, representing Northern California and Mexico, respectively).*

| Year | Block Level | Total Catch (Number) | Total Number Released | Total Number Lost to Sea Lions |
|---|---|---|---|---|
| 1995 | 600 | 103 | 1 | 0 |
| 1995 | 700 | 1927 | 1242 | 18 |
| 1995 | 800 | 2073 | 1362 | 163 |
| 1995 | Other | 282 | 234 | 8 |
| 1996 | 600 | 7 | 27 | 0 |
| 1996 | 700 | 739 | 1426 | 28 |
| 1996 | 800 | 555 | 968 | 52 |
| 1996 | Other | 255 | 63 | 23 |
| 1997 | 600 | 5 | 16 | 0 |
| 1997 | 700 | 752 | 1177 | 135 |
| 1997 | 800 | 700 | 704 | 40 |
| 1997 | Other | 187 | 209 | 26 |
| 1998 | 600 | 9 | 5 | 0 |
| 1998 | 700 | 619 | 743 | 65 |
| 1998 | 800 | 269 | 482 | 20 |
| 1998 | Other | 390 | 308 | 18 |
| 1999 | 600 | 108 | 21 | 0 |
| 1999 | 700 | 7052 | 1149 | 309 |
| 1999 | 800 | 4321 | 912 | 112 |
| 1999 | Other | 380 | 268 | 93 |
| 2000 | 700 | 11189 | 2032 | 22 |
| 2000 | 800 | 5032 | 755 | 1 |
| 2000 | Other | 1276 | 303 | 6 |
| 2001 | 600 | 45 | 1 | 0 |
| 2001 | 700 | 4727 | 1087 | 127 |
| 2001 | 800 | 3791 | 1787 | 127 |
| 2001 | Other | 1771 | 443 | 75 |
| 2002 | 600 | 16 | 3 | 5 |
| 2002 | 700 | 2806 | 493 | 235 |
| 2002 | 800 | 5199 | 952 | 221 |
| 2002 | Other | 579 | 175 | 29 |
| 2003 | 600 | 276 | 0 | 0 |
| 2003 | 700 | 2847 | 706 | 150 |
| 2003 | 800 | 5009 | 1242 | 231 |
| 2003 | Other | 411 | 354 | 37 |
| 2004 | 600 | 0 | 7 | 0 |
| 2004 | 700 | 2265 | 501 | 38 |
| 2004 | 800 | 760 | 646 | 57 |
| 2004 | Other | 256 | 157 | 9 |

| | | | | |
|---|---|---|---|---|
| 2005 | 600 | 42 | 0 | 0 |
| 2005 | 700 | 1693 | 599 | 34 |
| 2005 | 800 | 975 | 919 | 67 |
| 2005 | Other | 223 | 210 | 19 |
| 2006 | 600 | 26 | 0 | 0 |
| 2006 | 700 | 5143 | 794 | 49 |
| 2006 | 800 | 1117 | 763 | 76 |
| 2006 | Other | 438 | 94 | 2 |
| 2007 | 600 | 21 | 2 | 0 |
| 2007 | 700 | 877 | 342 | 10 |
| 2007 | 800 | 1166 | 536 | 63 |
| 2007 | Other | 259 | 84 | 8 |
| 2008 | 700 | 2663 | 591 | 16 |
| 2008 | 800 | 1204 | 763 | 229 |
| 2008 | Other | 265 | 53 | 36 |
| 2009 | 600 | 1 | 0 | 0 |
| 2009 | 700 | 1663 | 317 | 123 |
| 2009 | 800 | 969 | 331 | 150 |
| 2009 | Other | 451 | 100 | 57 |
| 2010 | 600 | 3 | 0 | 0 |
| 2010 | 700 | 889 | 116 | 1 |
| 2010 | 800 | 2038 | 199 | 109 |
| 2010 | Other | 764 | 233 | 92 |
| 2011 | 600 | 1 | 0 | 0 |
| 2011 | 700 | 3227 | 517 | 6 |
| 2011 | 800 | 2000 | 323 | 110 |
| 2011 | Other | 472 | 24 | 24 |
| 2012 | 600 | 1 | 1 | 0 |
| 2012 | 700 | 3270 | 217 | 10 |
| 2012 | 800 | 758 | 428 | 211 |
| 2012 | Other | 295 | 198 | 56 |
| 2013 | 600 | 14 | 0 | 0 |
| 2013 | 700 | 3740 | 93 | 84 |
| 2013 | 800 | 651 | 388 | 194 |
| 2013 | Other | 509 | 32 | 30 |

## 4.17. Tagging data

Capture-recapture data from a recent tagging program (Aalbers and Sepulveda, 2015) was provided by PIER. The data consists of 262 individual white seabass released between 2008 and 2013 resulting in 63 recaptures. The data was formatted to be used in SS and although used during model development it was not used in the base-case model.

# 5. History of modeling approaches

There are no prior modern stock assessments for white seabass. However, two works conducted in the mid-1970s and early-1990s estimated white seabass abundance. MacCall et al. (1976) estimated the abundance of white seabass in the mid-1970s, based on a simple model using fishery dependent data collected from 1947-1973 (MacCall et al. 1976). MacCall et al. (1976) used catch-per-unit-effort (CPUE) data from United States-based commercial and recreational catches and calculated an MSY for white seabass of 748 metric tons (1.65 million pounds).

Dayton and MacCall (1992) used annual record weight (reported heaviest fish caught) of white seabass taken by Avalon Tuna Club member fishing out of Santa Catalina to estimate white seabass pre-exploitation biomass. Dayton and MacCall (1992) estimated pre-exploitation biomass of 20,000 tons (CV between 0.25 to 0.4) corresponding to 2-2.5 million fish. They also reported a Gulland potential yield rule-of-thumb of 500-900 metric tons ($Y\_potential = M * B_0 / 2$).

# 6. Stock assessment

## Model

An integrated statistical age-structured model with different growth for females and males was implemented using Stock Synthesis (Methot and Wetzel 2013) version 3.24u (provided by Dr. Richard Methot at the NWFSC) to assess White Seabass from California, USA. The internal population dynamics model tracks ages 0-25, where age 25 is the 'plus-group'. Alternative model runs were conducted covering white seabass dynamics between 1889-2014 and 1969-2014.

Owing to the lack of sex specific information in size composition data and the lack of age data, except conditional age at length, the same natural mortality and selectivity was used for females and males. The model is fit to several relative indices of abundance: CPFV historic (pre-1980), CPFV modern (post-1980), drift gillnet logbook CPUE, set gillnet logbook CPUE, HSWRI gillnet CPUE and Power Plants Heat Treatment CPUE. The model is also fit to length composition data for hook and line, drift gillnet and set gillnet commercial fisheries. For the recreational data the model was fit to lengths from CPFV observers (modern and historic) and lengths from a combined "Other recreational" group. The model was also fitted to lengths from HSWRI gillnet surveys, Power Plants (Heat Treatment) and conditional age at length from HSWRI. No prior distributions were used in the model.

## Fisheries

White seabass are caught by multiple gears and fleets, some of which are of unknown gear or fleet and with varying degrees of other data available for gears and fleets (e.g. associated size compositions, CPUE, etc.). In order to have a parsimonious model that balances the complexity of the fishing gears and fleets catching white seabass, and given the data available, seven fisheries were modeled. These fisheries were defined based on the amount of white seabass catch they represented and in cases where catch was relatively small, or the origin unknown, by similar combining fleets/gears were combined. The modeled fisheries and the acronym used are:

1) Commercial historical (HistCom),
2) Commercial Hook and Line (HL),
3) Drift Gillnet (Drift),
4) Set Gillnet (Set),
5) Historic Commercial Passenger Fishing Vessel (CPFV_H),
6) Modern Commercial Passenger Fishing Vessel (CPFV_M),
7) Other Recreational (OtherRec)

A variety of commercial gears (some of which are not currently in use, may have changed names, or are otherwise ambiguous or unknown) were used to catch white seabass before 1969. Since there are no available commercial size or age compositions to estimate selectivity before 1969, catches were combined in the "HistCom" fishery and its selectivity was mirrored to the selectivity of the "Set" fishery. This was done given the fact that historically commercial fishermen have used a number of nets such as gillnets; trawl nets; and round haul gear such as lampara and purse seine nets to take white seabass (Whitehead 1930; CDFG, 2002). Although other gears have also been used historically (e.g. hook and line), there is no way to calculate a proportion between the gears and therefore it is assumed that selectivity for the primarily net based historical commercial fishery (Vojkovich and Reed, 1983) can be described with the current net fishery for which there is the most length frequency data to estimate selectivity ("Set"). Catches recorded as "'Entangling gear" were split between "Drift" and "Set" gillnet fisheries in proportion to their relative effort by year. During model development, modern period (after 1969) commercial catches of gears "Unknown", "Trawl" and "Purse seine" were attempted to be either further investigated or modeled separately but were eventually combined with "Set".

Recreational fisheries were split between CPFV fisheries and Other Recreational. The "OtherRec" fisheries were broken into further components but the resulting size compositions were too sparse to be of use in the model. CPFV were separated by a historic period (pre-1980) and a modern period (post-1980). There are no recorded other recreational fisheries pre-1980. That is not to say that there were no other recreational catches, there are no other records available for this assessment.

## Initial conditions

White seabass have been exploited for more than 125 years. The first quantitative records date back to 1889. Even if catches are combined at that time with Mexico, assuming that the California/Mexico share was similar to more reliable records post 1916, the total catches around the 1900s were in the same order as catches during the last decade. That is, even if the model were to start using the earliest type of data (catches), the stock was already exploited at that time. During model development, models starting in 1889, when catch records begin, were explored. However, the large number of management and regulation changes and the paucity of other data made usability of those models difficult. The only other data available prior to 1969 is historical

CPFV, whose usability is also problematic including the lack of targeting information, the time scale of the data (monthly rather than trips) and the many management and regulatory changes that occurred historically. Given these issues and convergence problems for models starting in 1889, the model started at 1969 when the commercial data can be separated in the fisheries described in the previous section. Length frequency data and various relative indices of abundance become available around that time. The equilibrium catch prior to 1969 for each commercial fleet was calculated by distributing the average 1889-1968 catches among the commercial fleets present in 1969, proportional to landings in 1969, and estimated initial equilibrium fishing mortalities. An initial equilibrium catch was calculated for the CPFV in a similar way to the commercial, and also estimated its initial equilibrium fishing mortality. This is not intended to represent a detailed population dynamic process. It is only a way to parsimoniously parameterize the initial conditions away from theoretical non-fishing equilibrium.

### Growth and fecundity

Growth was estimated internally in the model taking advantage of the availability of conditional age at length data from HSWRI. All five parameters of the growth model in SS3 (*Lmin, Lmax, K, CVyoung, CVold*) were estimated internally. Growth was estimated separately for both sexes, male growth was estimated as an offset from the females. Weight at length is fixed in the model and based on the relationship calculated from PIER data (see section 4.3 on Growth for more details). Female maturity at length is fixed in the model using the logistic relationship estimated from the PIER data set (see section 4.9 on Maturity for more details). Fecundity is assumed proportional to weight.

### Natural mortality

Natural mortality (*M*) was fixed in the model to 0.225 for both sexes based on maximum age estimated from HSWRI data (see section 4.10 on Natural mortality for more details).

### Recruitment

Recruitment is modelled as random deviates during 1969-2012 from a Beverton-Holt spawning stock – recruitment relationship with steepness (*h*) fixed at 0.87 based on results from Myers et al. (1999) for the white croaker (*Argyrosomus argentatus*). The sex ratio at birth is assumed to be 50:50. *SigmaR* is fixed in the model at 0.75. The model is expected to draw most of the information on recruitment from length compositions and indices that catch mainly juveniles (HSWRI, PP). A ramped up and down recruitment bias adjustment correction following Methot and Taylor (2001) was used.

### Catch

Commercial catch for each modelled fishery was included in metric tons and recreational catch was used in thousands of fish. The distribution of recorded catch from the recorded fleets/gears to the fisheries as defined in the stock assessment varied depending on the starting year of the model, see section above on “Fisheries”.

*Figure 6-1. Summary of data sources used in the SS models by fleet and year for Historical model runs.*

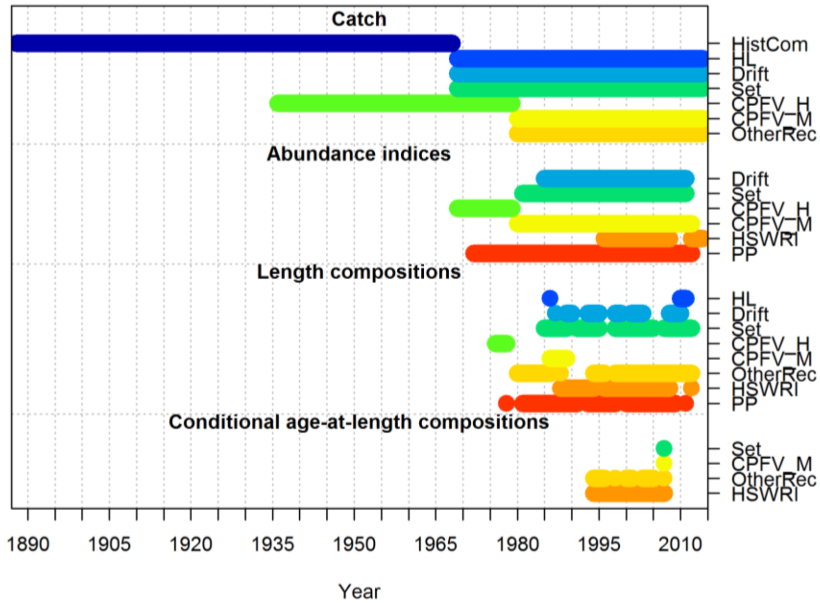



*Figure 6-2. Summary of data sources by fleet and year for the Base-case model.*

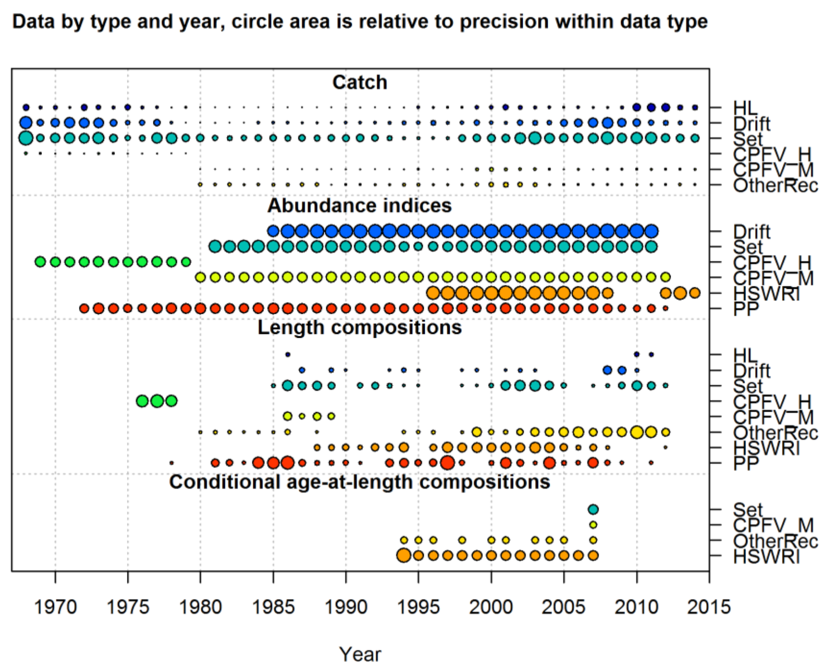


*Figure 6-3. Total landings in metric tons (mt) from 1889 to 2014 by fleets as defined in the stock assessment model.*

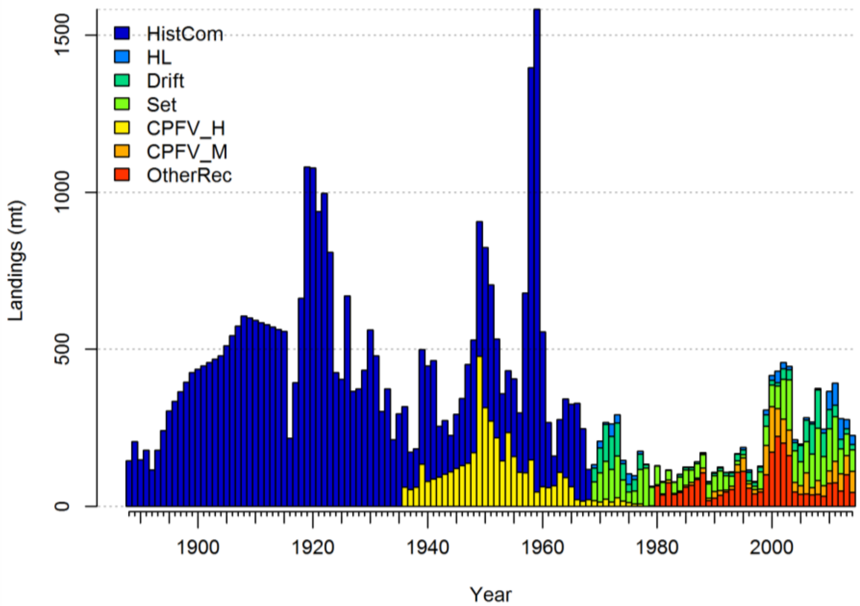
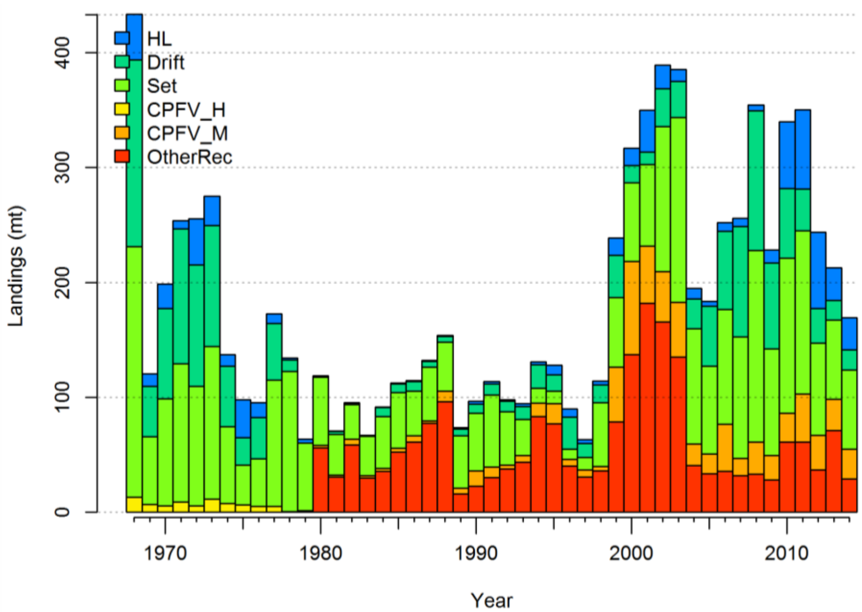



*Figure 6-4. Total landings in metric tons (mt) from 1969 to 2014 by fleets as defined in the stock assessment model.*



## Indices of abundance

Six standardized indices of abundance were used, from two commercial gillnet fisheries (Drift and Set), two recreational fisheries (CPFV_H and CPFV_M) and two surveys, or fishery-independent indices (HSWRI and PP). The year specific standard deviation of the logarithm of the index (approximately equivalent to the CV obtained during CPUE standardization) was used as the initial input in the base model. A parameter containing an additive constant to be added to the input CV for each index was used. In the base model all indices of abundance are assumed to be proportional to biomass (for commercial indices) or numbers (for recreational and survey indices), except for the CPFV_M where non-linearity in the relationship between the index and numbers was allowed. Alternative model runs were carried out allowing for non-linearity of other indices, although in some cases it lead to instability or convergence issues.

*Figure 6-5. Index of relative abundance for the drift gillnet commercial fishery (Drift) and 95% confidence intervals.*

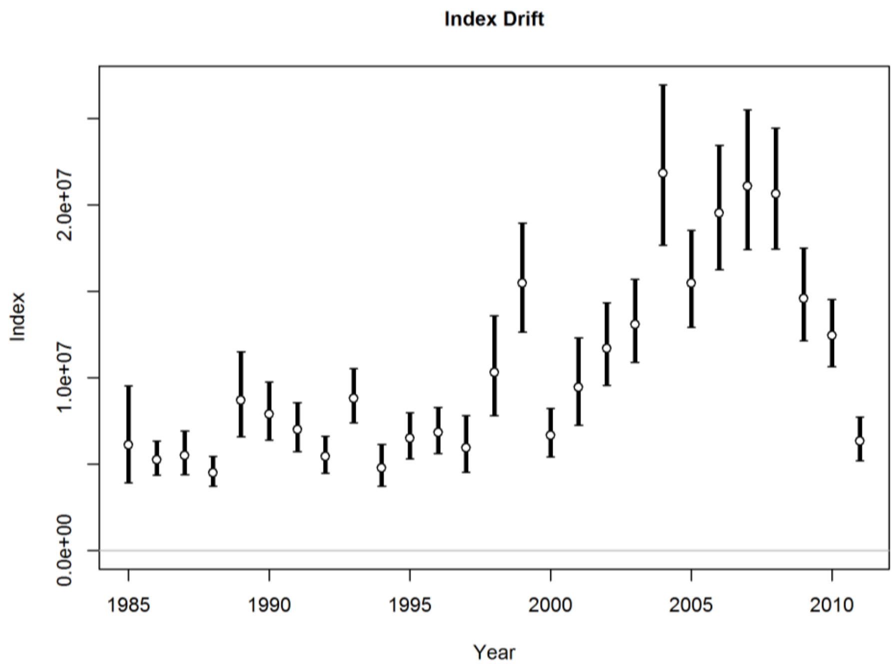



*Figure 6-6. Index of relative abundance for the set gillnet commercial fishery (Set) and 95% confidence intervals*

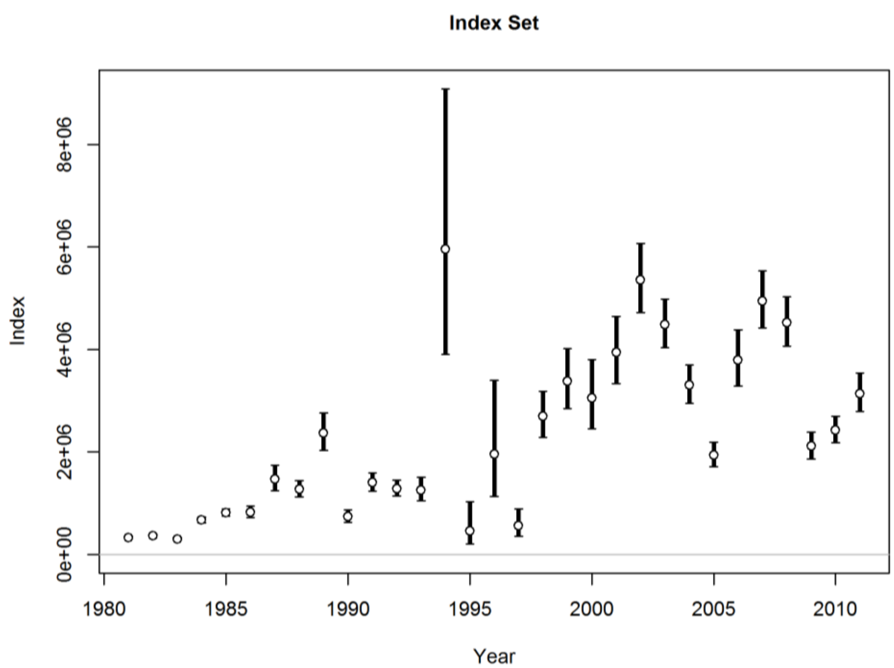
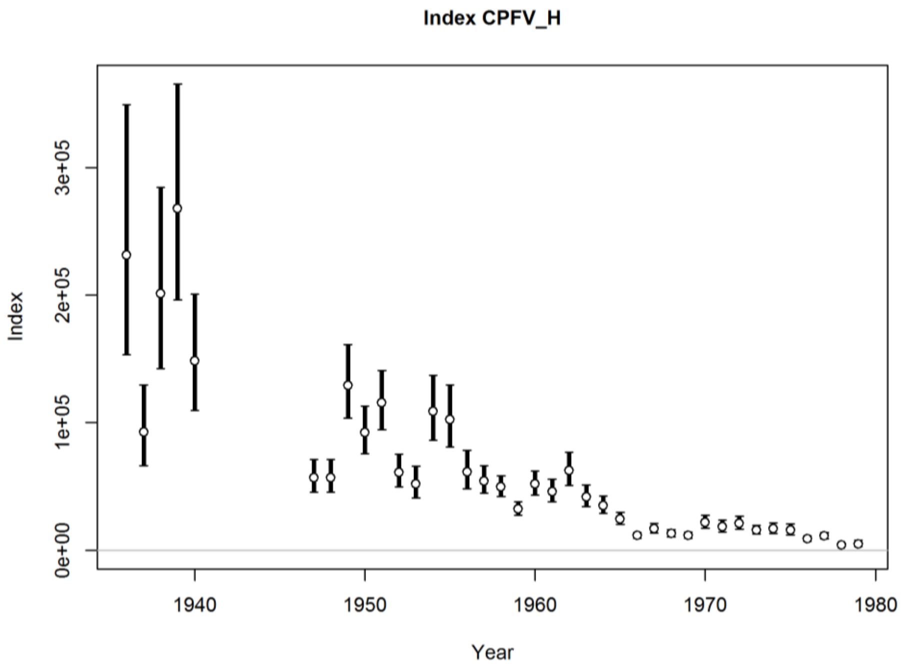


*Figure 6-7. Index of relative abundance for the Historical Commercial Passenger Fishing Vessel fishery (CPFV_H) and 95% confidence interval for two periods: 1936-1979 (Top panel) and 1969-1979 (Bottom panel).*



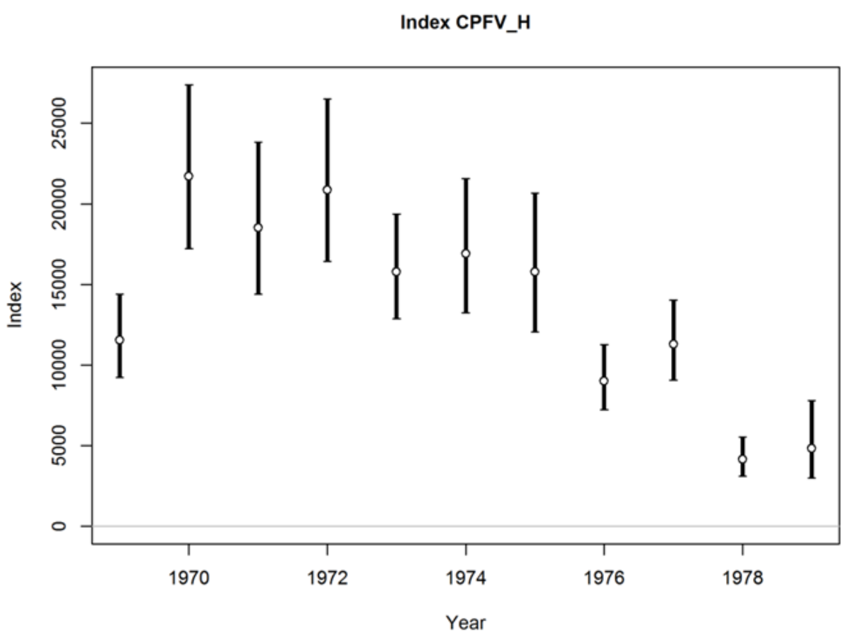



*Figure 6-8. Index of relative abundance for the Modern Commercial Passenger Fishing Vessel fishery (CPFV_M) and 95% confidence intervals*

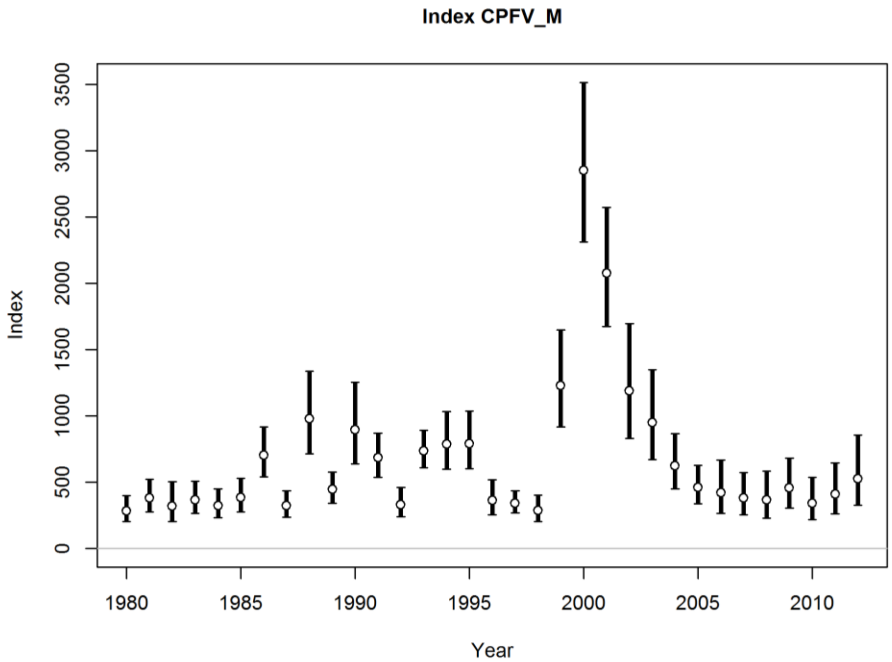


*Figure 6-9. Index of relative abundance for the Hubbs SeaWorld Research Institute gillnet survey (HSWRI) and 95% confidence intervals.*

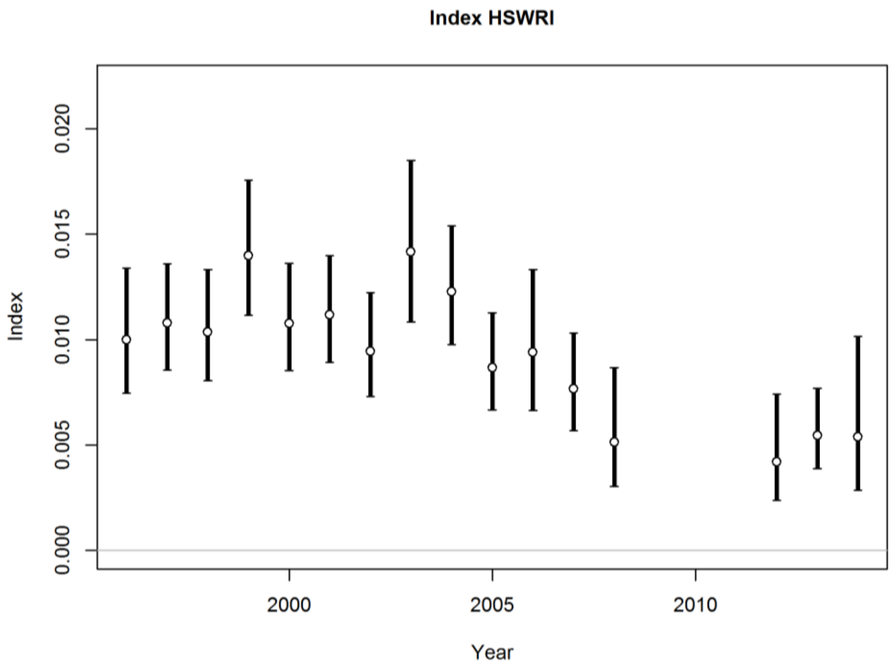
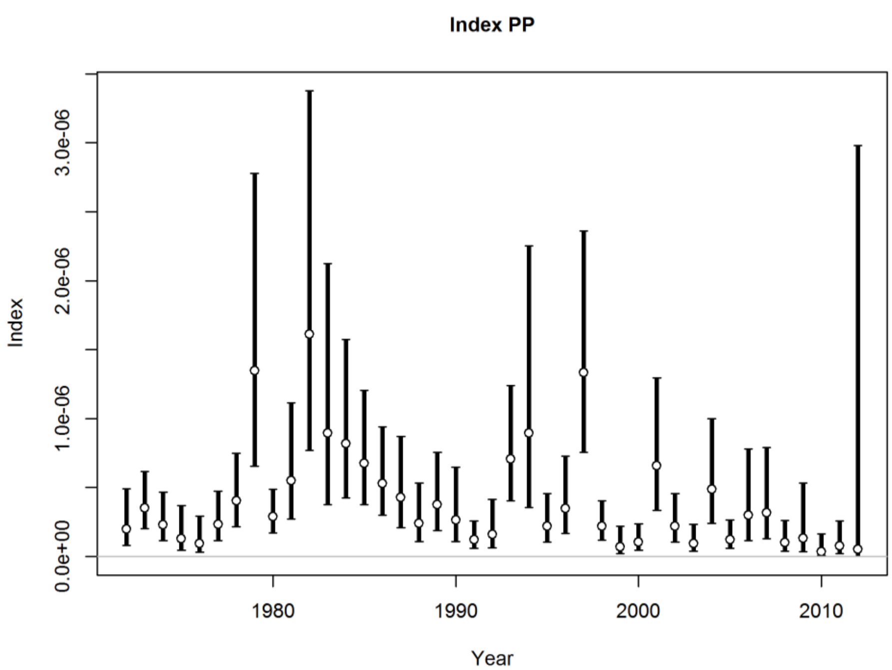



*Figure 6-10. Index of relative abundance for the Power Plants Heat Treatment (PP) and 95% confidence intervals.*



## Length composition data

Length composition data is available for several, but not all of the sources of data used in the assessment. Some of the years for some fleets had very low numbers of fish sampled so years with less than 20 fish in the sample were excluded.

*Figure 6-11. Length compositions by year for retained fish in the Hook and Line (HL) commercial fishery. Sample sizes (N) are the number of fish sampled.*

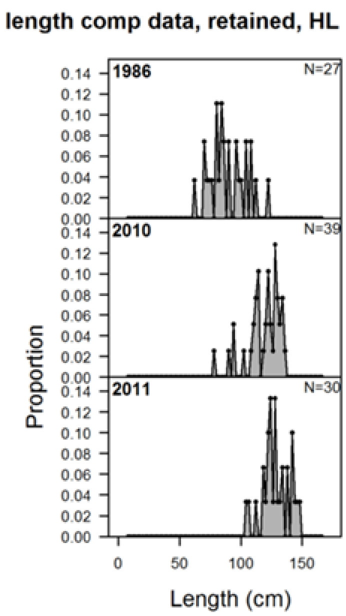


*Figure 6-12. Length compositions by year for retained fish in the Drift gillnet (Drift) commercial fishery. Sample sizes (N) are the number of fish sampled.*

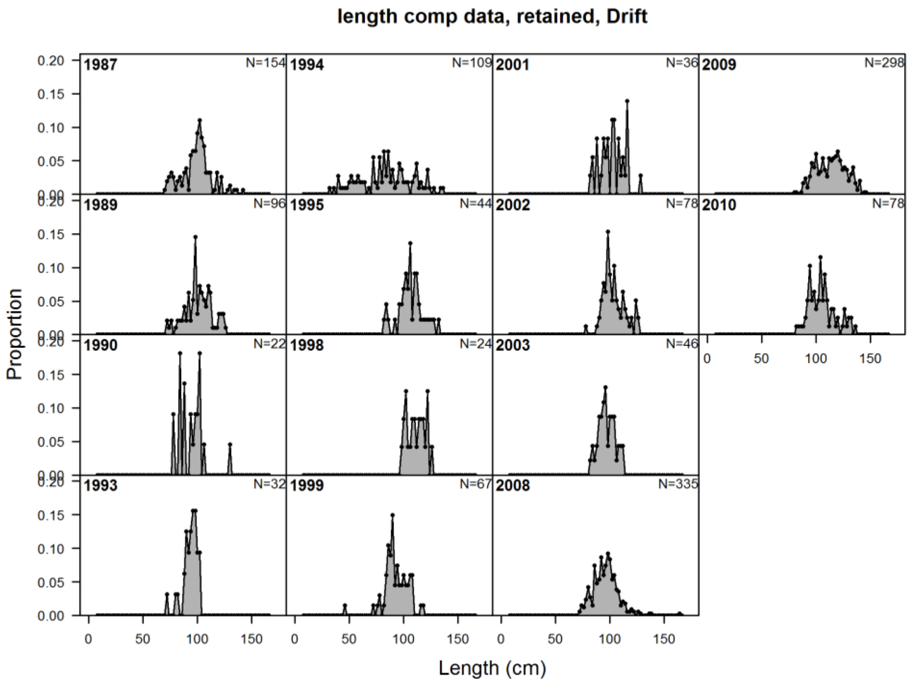



*Figure 6-13. Length compositions by year for retained fish in the Set gillnet (Set) commercial fishery. Sample sizes (N) are the number of fish sampled.*

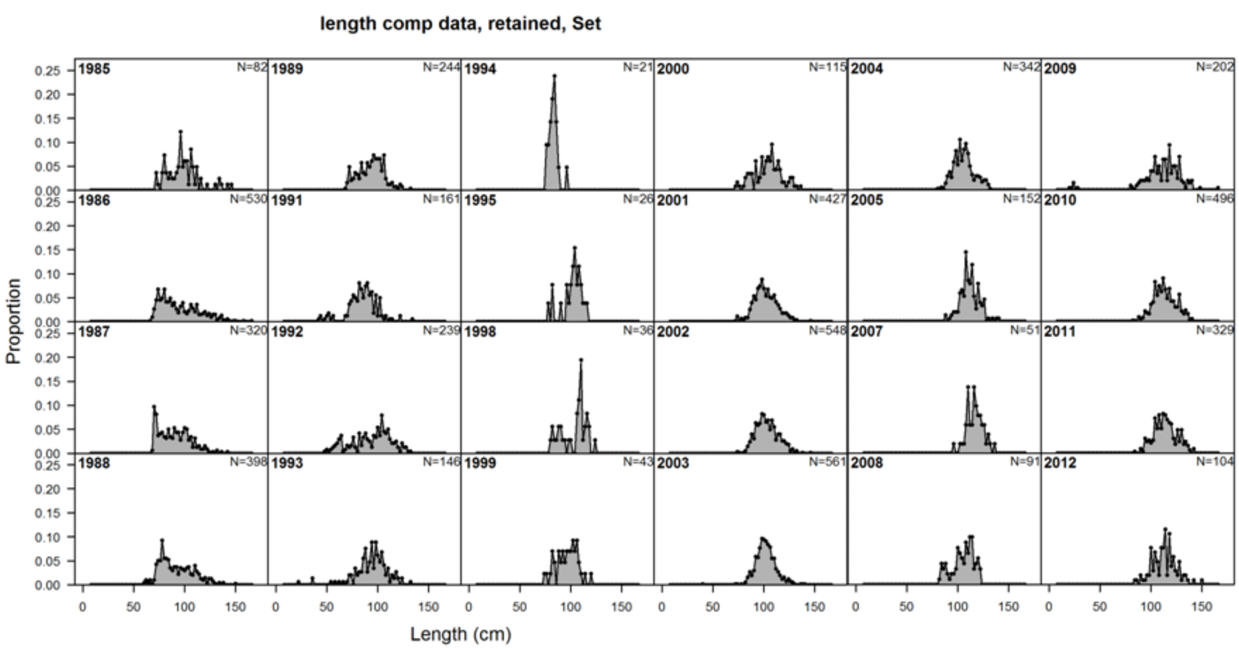


*Figure 6-14. Length compositions by year for retained fish in the Historical (CPFV_H) and Modern (CPFV_M) Commercial Passenger Fishing Vessel fisheries. Sample sizes (N) are the number of fish sampled.*

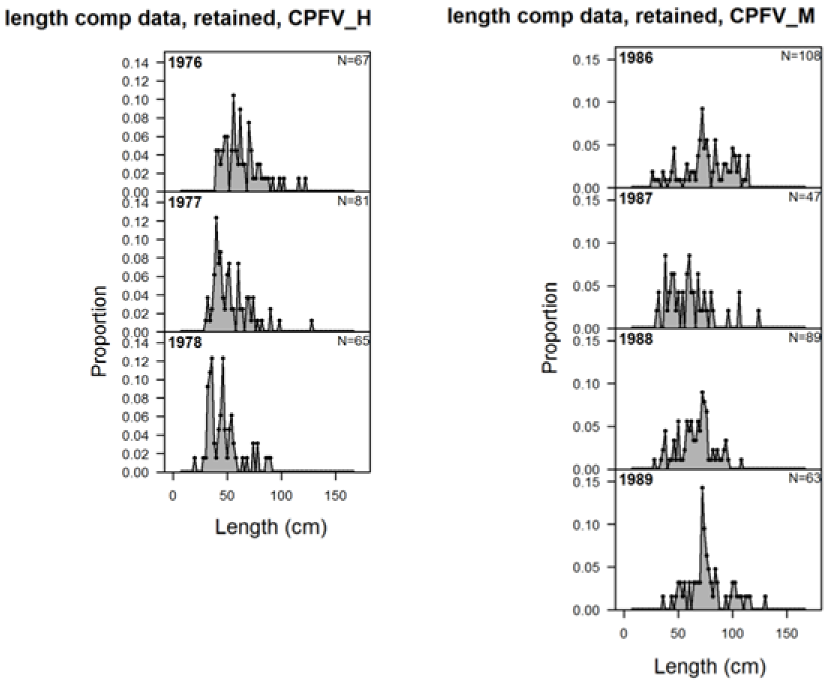



*Figure 6-15. Length compositions by year for retained fish in the combined non-CPFV recreational fishery (OtherRec). Sample sizes (N) are the number of fish sampled.*

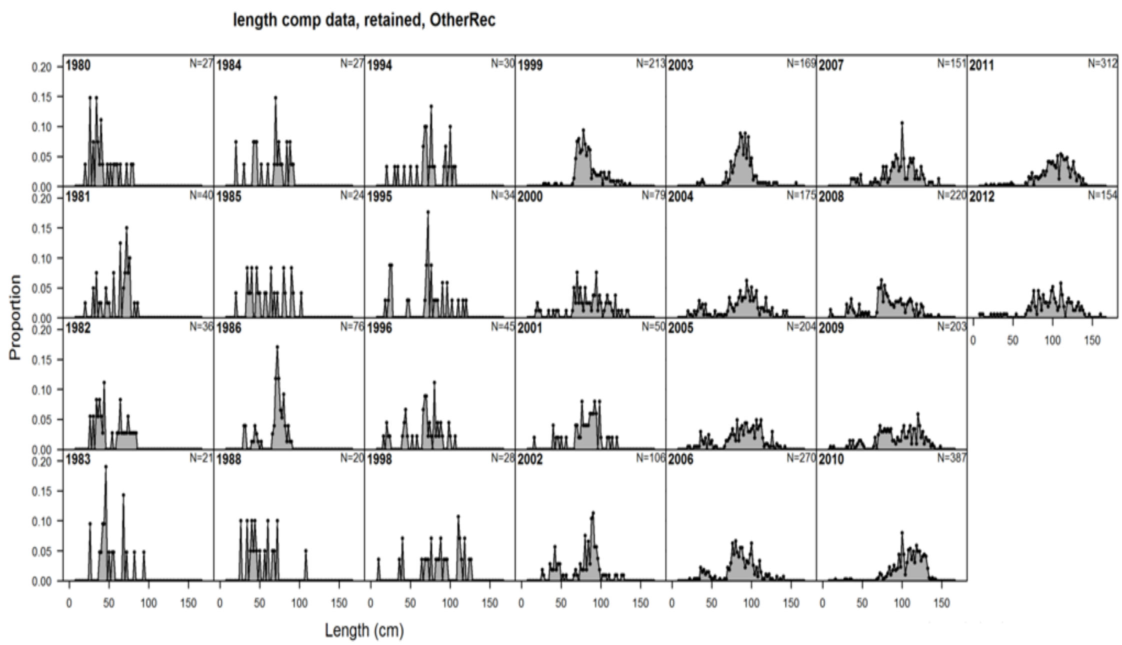


*Figure 6-16. Length compositions by year for sampled fish in the gillnet survey from Hubbs SeaWorld Research Institute (HSWRI). Sample sizes (N) are the number of fish sampled.*

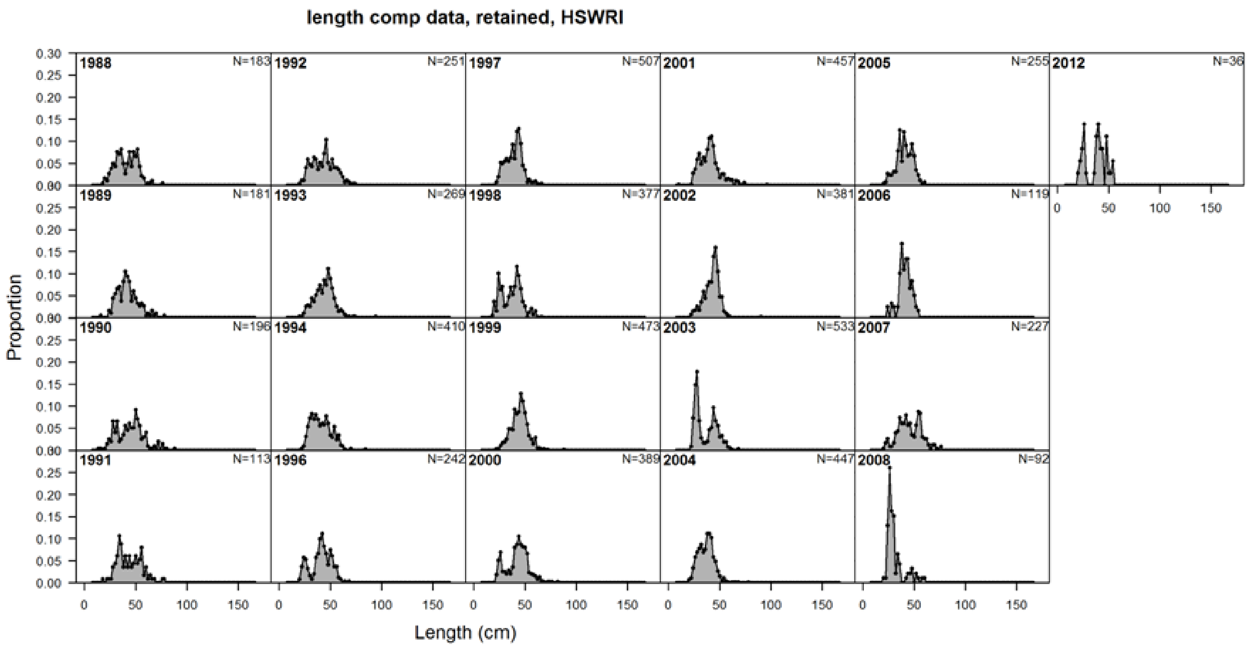


*Figure 6-17. Length compositions by year for sampled fish in the Power Plants Heat Treatment (PP) sampling program. Sample sizes (N) are the number of fish sampled.*

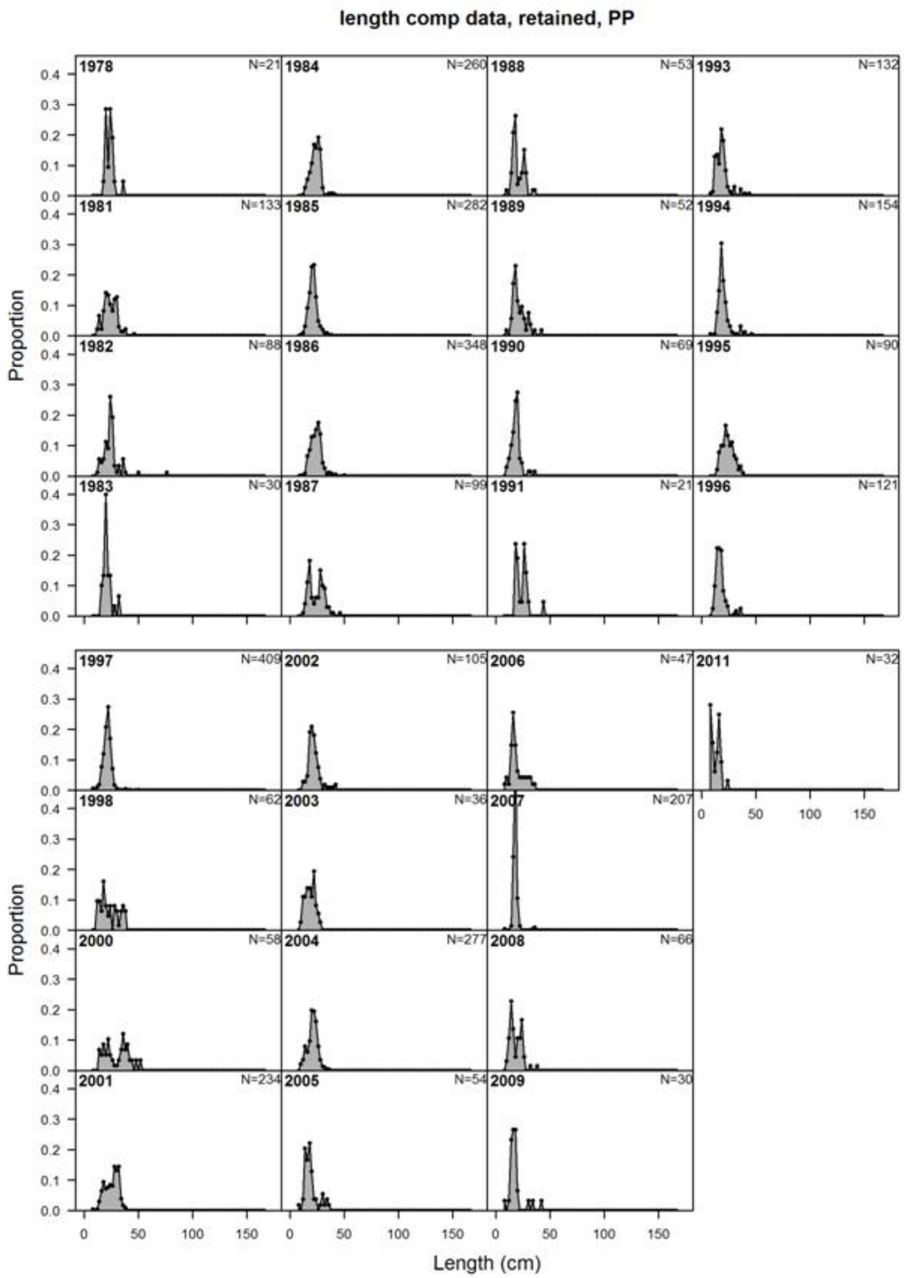


*Figure 6-18. Length compositions aggregated across time and fleet. Sample sizes (N) are the total number of fish sampled.*

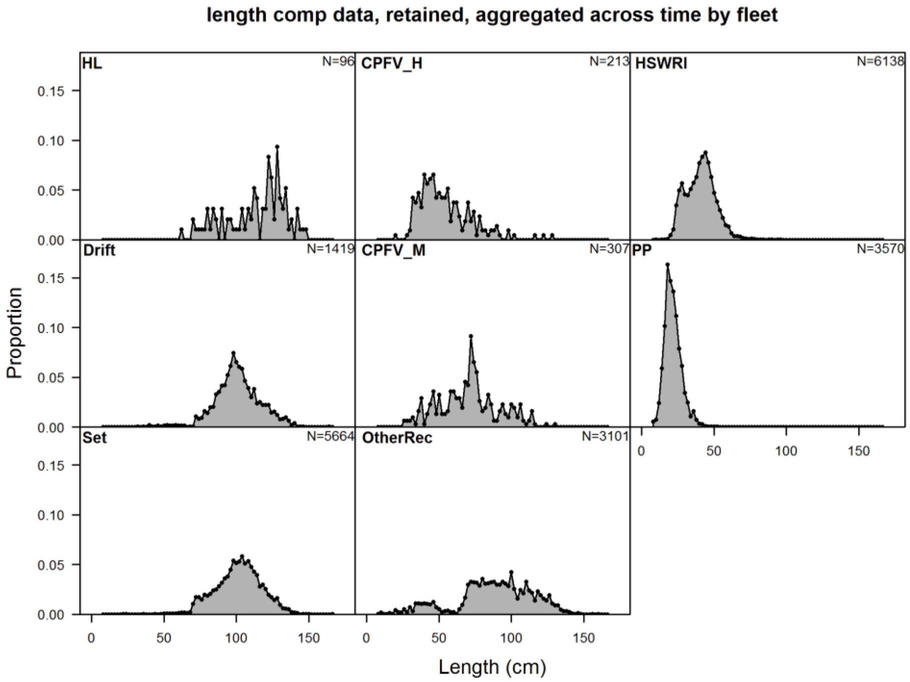
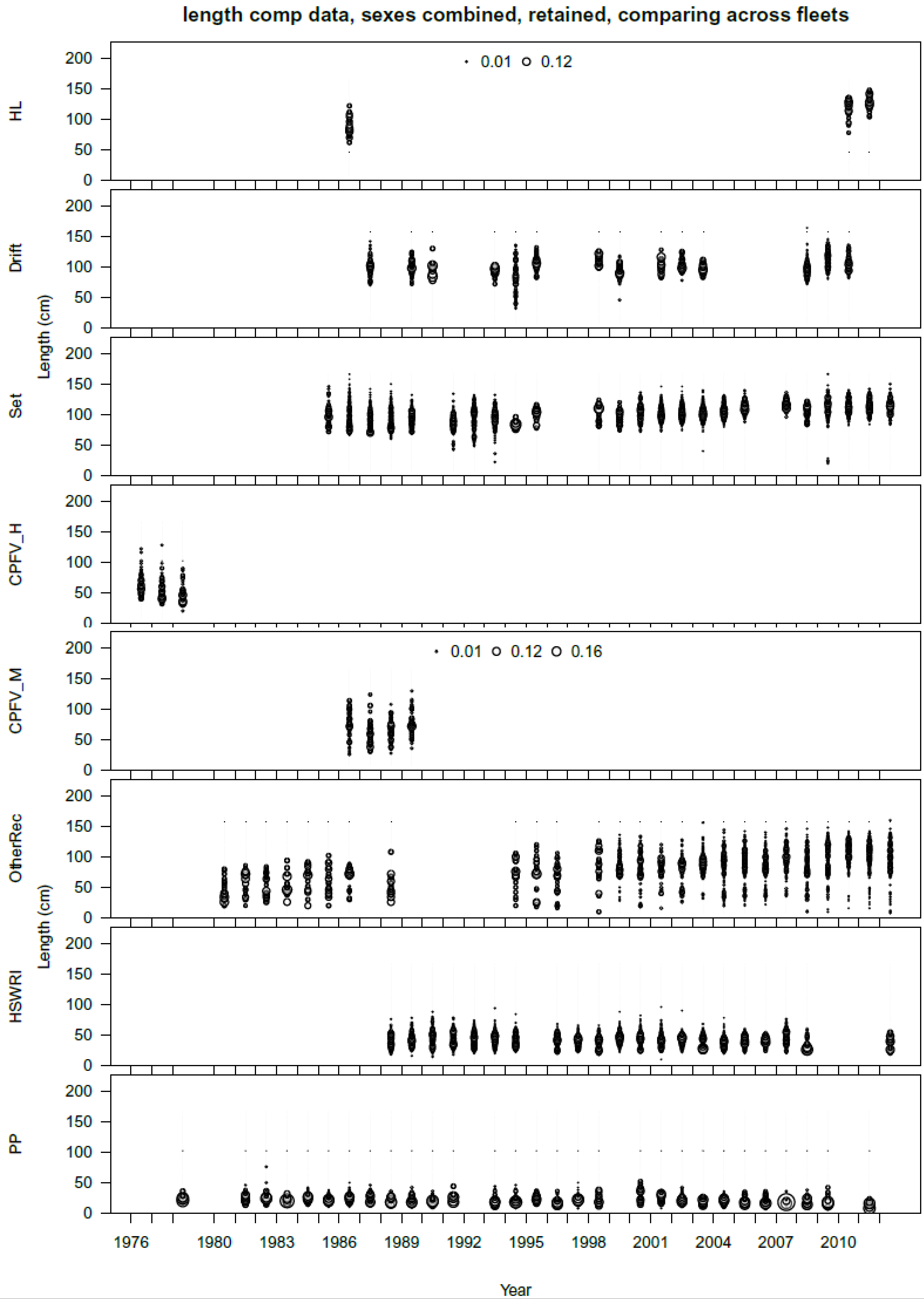


*Figure 6-19. Length compositions by year and fleet, size of bubbles is proportional to the fraction of fish by size.*



### Conditional age-at-length data

There is sex-specific (355 females and 389 males) conditional age-at-length data for wild white seabass from HSWRI. These fish were collected by a variety of gears including the following (in parentheses the fleet assigned in the model) HSWRI Gillnet sampling (HSWRI), Recreational Hook & Line Fishers (OtherRec), Recreational Spear Fishers (OtherRec), Power Plant Entrainment (PP), Commercial Market Landings (Set) and Commercial Passenger Fishing Vessels (CPFV_M). Although the fish were collected between 1994 and 2007, about 50% were collected in 2007 and at most 7% during any other year, from a multitude of fisheries. There is the possibility that this data were collected not at random, but with the intent of using them to estimate growth rather than to obtain a random sample of the age composition of the population. Given this reason, the marginal ages were not used and instead this data was used to estimate growth internally in the model.

### Selectivity

Length composition data is only available for some of the fisheries and fishery independent indices. There is no sex-specific length composition data and only limited sex-specific conditional age at length data. Therefore, selectivity is shared among some fisheries and several assumptions are made when defining selectivity. Females and males are assumed to not differ in selectivity as there is no data to estimate separate sex selectivities.

Selectivity is assumed to be purely determined by fish length, setting selectivity at age at 1 for all ages. All selectivities at length are modelled as double normal, pattern 24 in SS3. All selectivities describe the retained fraction of the catch. Estimates of selectivity for the OtherRec were very unstable and led to convergence issues so the OtherRec selectivity was fixed. There is limited information on discards for CPFV fisheries, mainly numbers discarded but very limited information on sizes of discards and even less in survival of discards. All selectivities are estimated as asymptotic, except for HSWRI gillnet and PP (Heat Treatment) that are estimated as dome-shaped given that they catch almost exclusively juveniles.

### Model Results

The base model estimates of growth main parameters (*K*, *Linf*) are consistent with estimates of growth from other works, estimated *CV* of length at age are also consistent with external estimates (Table 6-1). The selectivity estimates appear reasonable based on a priori examination of the size compositions for the different fisheries and surveys and examination of the fit to the length compositions by fleet aggregated throughout time. Fit to the length composition data was reasonably good, both on the aggregated across time and less so on a year by year, were particular years had some very large residuals for the Set and OtherRec fleets.

*Table 6-2. Main parameters of the base-case model.*

| **Parameter** | **Value** | **Estimation** |
|---|---|---|
| Natural mortality (year$^{-1}$), females | 0.2250 | Fixed |
| Length at $a_0$ (cm), females | 33.3086 | Estimated |
| Length at $A_{max}$ (cm), females | 150.5090 | Estimated |
| Growth rate (year$^{-1}$), females | 0.1411 | Estimated |
| *CV* $L_1$ (-), females | 0.1374 | Estimated |
| *CV* $L_\infty$ (-), females | 0.0312 | Estimated |
| Natural mortality (year$^{-1}$), males | 0.2250 | Fixed |
| Length at $a_0$ (cm), males | 25.2928 | Estimated |
| Length at $A_{max}$ (cm), males | 118.0219 | Estimated |
| Growth rate (year$^{-1}$), males | 0.2399 | Estimated |
| *CV* $L_1$ (-), males | 0.2100 | Estimated |
| *CV* $L_\infty$ (-), males | 0.0313 | Estimated |
| Length-weight scaling (kg cm), females | 7.45E-06 | Fixed |
| Allometric factor (-), females | 3.0335 | Fixed |
| Length at 50% maturity (cm), females | 86.9300 | Fixed |
| Maturity slope (cm$^{-1}$), females | -3.2572 | Fixed |
| Length-weight scaling (kg cm), males | 7.45E-06 | Fixed |
| Allometric factor (-), males | 3.03350 | Fixed |
| Unfished recruitment (R0, thousands) | 189.03837 | Estimated |
| Steepness (-) | 0.87000 | Fixed |
| Recruitment variability ($\sigma_R$) | 0.75000 | Fixed |
| Initial recruitmen offset | 0.06553 | Estimated |
| Non linearity for catchability for *CPFV_M* | -0.26146 | Estimated |
| Extra SD for *HistCom* index | 1.00006 | Estimated |
| Extra SD for *Drift* index | 0.17129 | Estimated |
| Extra SD for *Set* index | 0.30094 | Estimated |
| Extra SD for *CPFV_H* index | 0.37960 | Estimated |
| Extra SD for *CPFV_M* index | 0.35212 | Estimated |
| Extra SD for *HSWRI* index | 0.15000 | Fixed |
| Extra SD for *PP* index | 0.15000 | Fixed |
| Catchability for *CPFV_M* | 1.84006 | Estimated |

*Figure 6-20. Sex specific growth curves with 95% confidence intervals from the internal estimation of growth.*

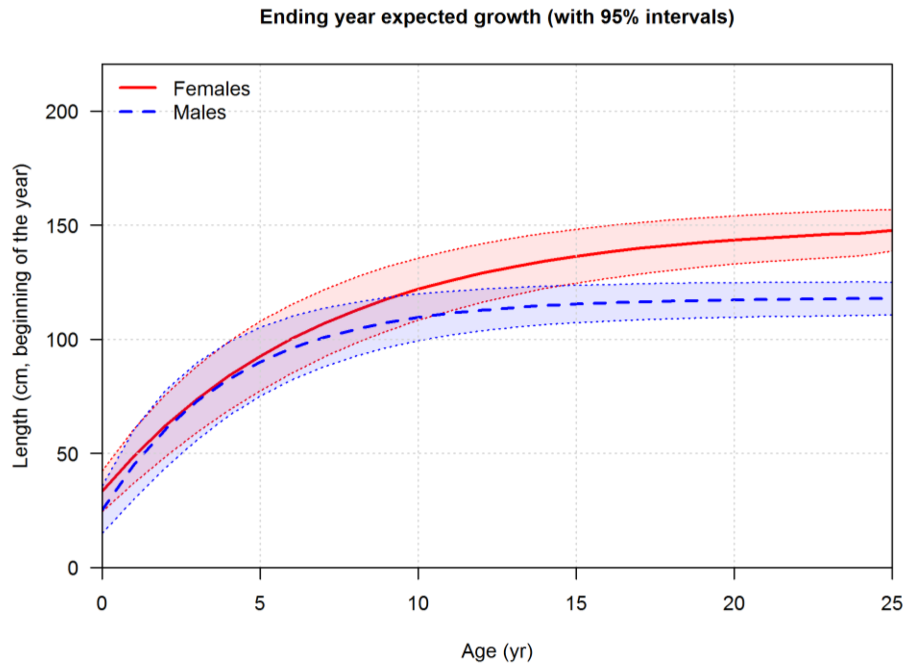
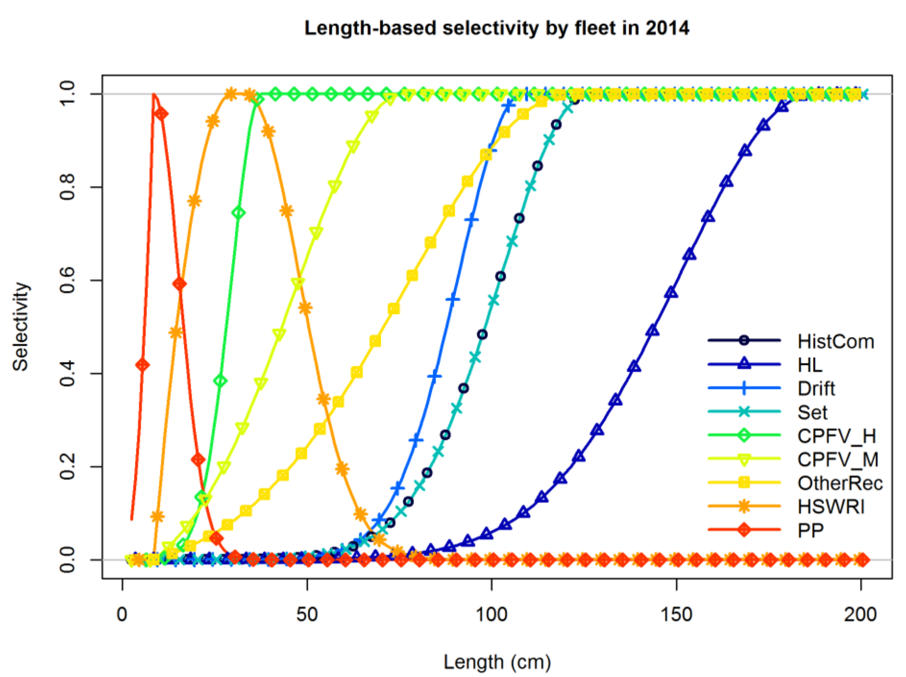



*Figure 6-21. Length-based selectivities for each fleet used in the model..*



Fit to the indices of abundance varies by fleet. Fit to the Drift index is reasonably good; however there is a pattern of residuals around and after 1999, such that the model cannot capture an apparent shift in the index data. There are no obvious changes in management or regulation supporting a potential change in catchability during those years. Fit to the Set index is also reasonably good, however there is a large outlier for 1994, coinciding with the implementation of the nearshore gillnet ban. Fit to the CPFV_H index is relatively poor, the index data is relatively flat and the model estimates an additional variance to the index. Fit to the CPFV_M is relatively poor, particularly around and after 1999, where the model does not capture a marked increase after 1999 and captures a decline after 2001 only partially. Fit to the HSWRI gillnet survey is reasonably good and to the PP index also, with some residual patterns.

The base-case model estimates extremely low spawning biomass during the 1970s (Figure 6-38). This does not necessarily imply that biomass was that low, but could instead be indicative of a violation of the closed population assumption of the assessment. There is evidence of transboundary movements between US-Mexico, so it could be also indicative of changes in availability of the stock, with portions leaving the assessment area. The base case model estimates white seabass female spawning biomass in 2015 at 569 mt (~95% asymptotic interval: 241- 896 mt) (Figure 6-38, Table 6-2). Virgin unfished female spawning biomass (*B0*) is estimated at *B0*: 2092 mt (~95% asymptotic interval: 1600 - 2584 mt). Recruitment of age-0 white seabass is estimated to have been at lower levels during the 1970s and early 1990s, followed by an increase to higher levels during 1997-1998 and then by a decline to low values during the late 2000s, years after 2010 are estimated less reliably or forecasted so do not imply a recovery in recruitment (Figure 6-39). The base case model estimates 2015 depletion at 0.27 (~95% asymptotic interval: 0.16- 0.39). White seabass biomass is estimated to be decreasing over the last 9 years (Figure 6-40).

*Table 6-2. Summary of reference points and management quantities for California white seabass base-case model.*

| **Quantity** | **Estimate** | **95% Confidence Interval** |
|---|---|---|
| Unfished spawning biomass (mt) | 2092 | (1600-2584) |
| Unfished recruitment (R0, thousands) | 189 | (145-233) |
| 2015 Spawning biomass (mt) | 569 | (241-896) |
| 2015 Depletion | 0.272 | (0.158-0.386) |
| **Reference points based on $SB_{40\%}$** | | |
| Proxy spawning biomass ($B_{40\%}$) | 837 | (640-1034) |
| SPR resulting in $B_{40\%}$ ($SPRB_{40\%}$) | 0.422 | (0.422-0.422) |
| Yield with $SPRB_{40\%}$ at $B_{40\%}$ (mt) | 271 | (209-333) |
| **Reference points based on $SPR_{50\%}$ proxy for MSY** | | |
| Spawning biomass | 1006 | (769-1242) |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 243 | (187-298) |
| **Reference points based on estimated MSY values** | | |
| Spawning biomass at MSY ($SB_{MSY}$ ) | 447 | (340-554) |
| $SPR_{MSY}$ | 0.243 | (0.237-0.249) |
| MSY (mt) | 307 | (238-376) |

*Figure 6-22. Length compositions aggregated across time and fleet (grey areas) and model fits (green line).*

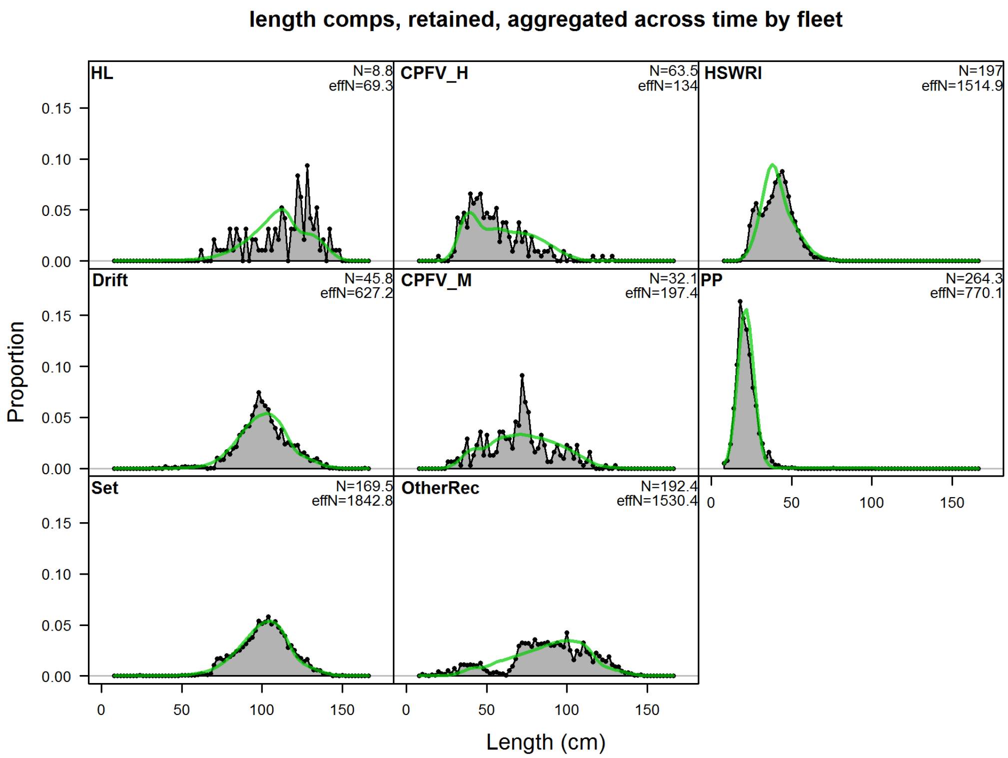


*Figure 6-23. Residuals in fit to length compositions by year and fleet. Filled circles indicate observed values greater than expected values.*

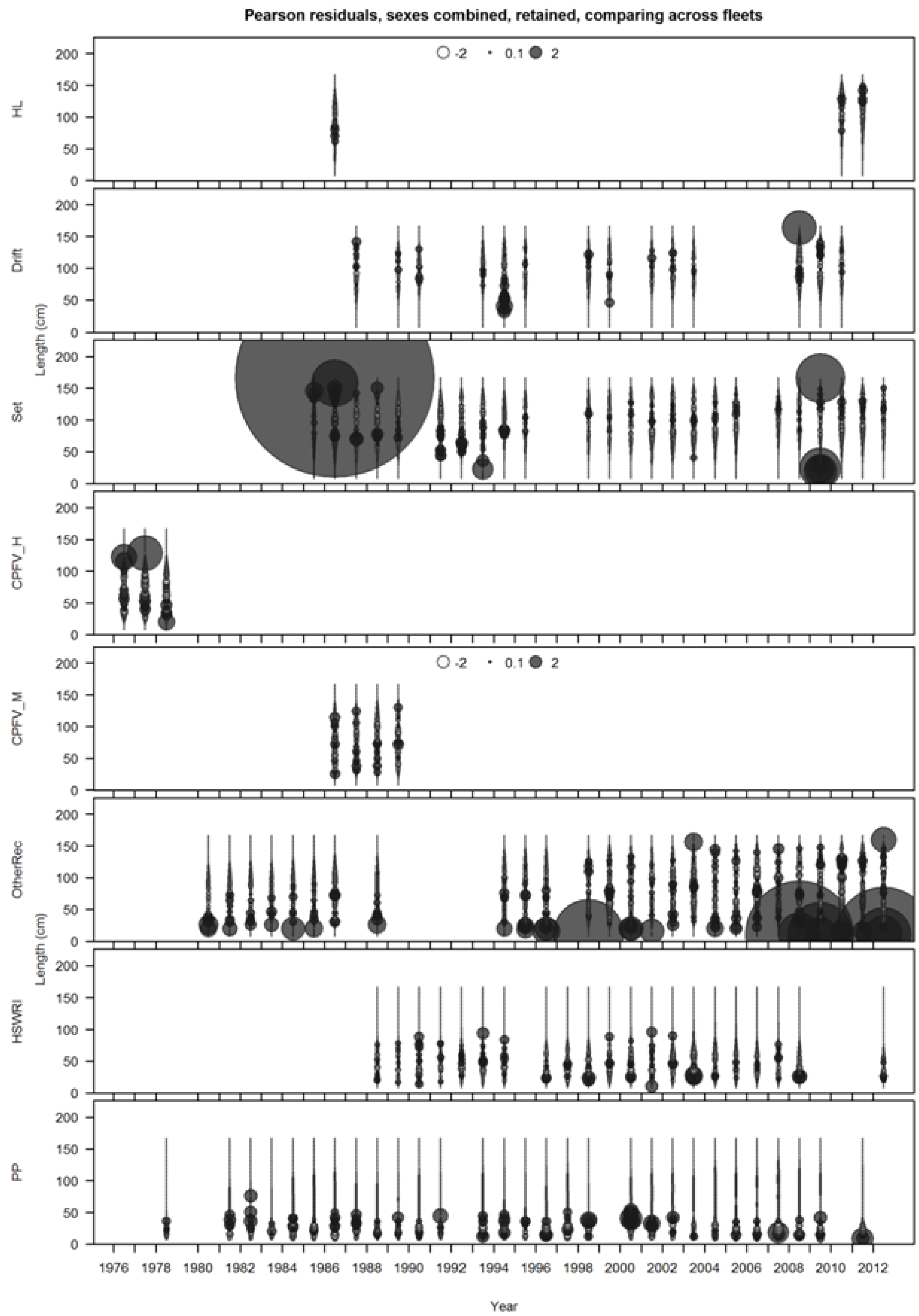


*Figure 6-24. Model fit (green line) to length compositions by year for retained fish in the Hook and Line (HL) commercial fishery.*

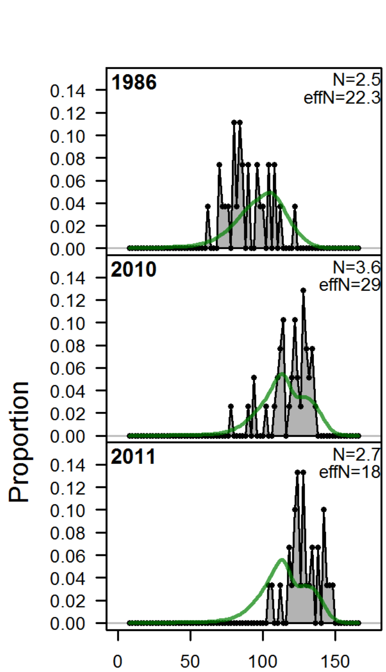



*Figure 6-25. Model fit (green line) to length compositions by year for retained fish in the Drift gillnet (Drift) commercial fishery.*

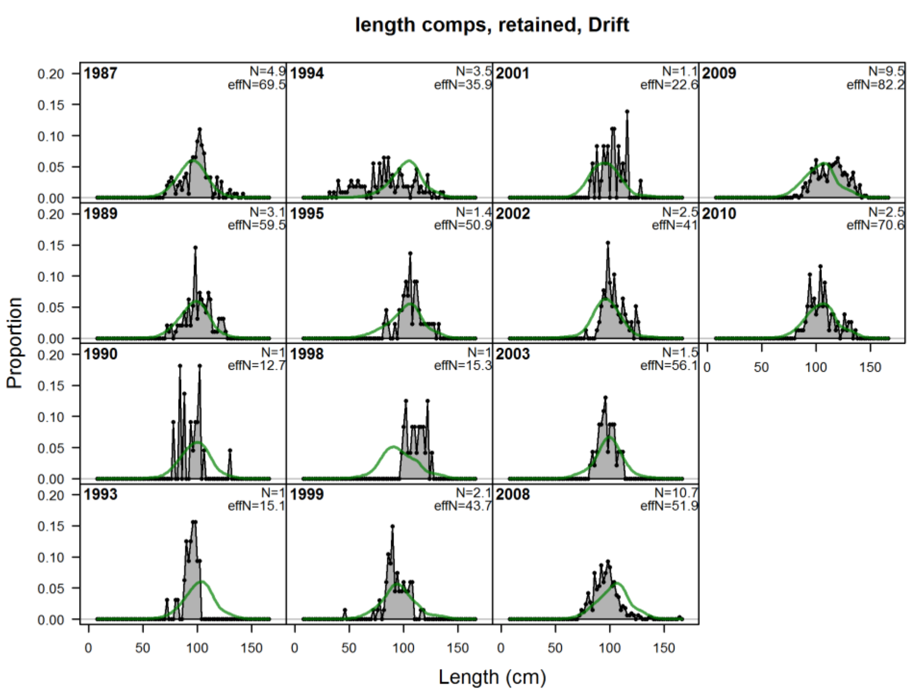
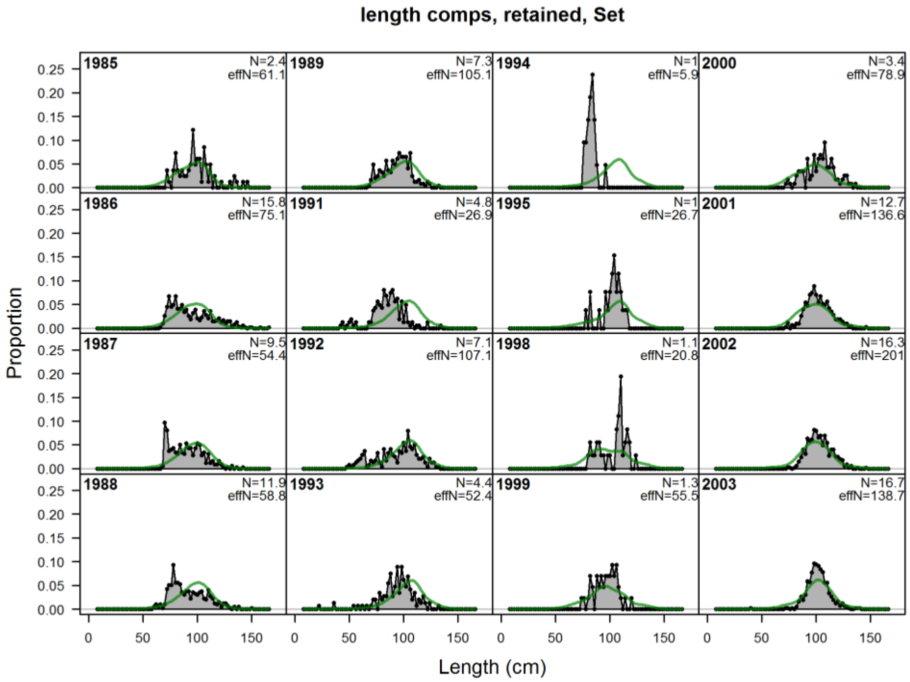


*Figure 6-26. Model fit (green line) to length compositions by year for retained fish in the Set gillnet (Set) commercial fishery.*



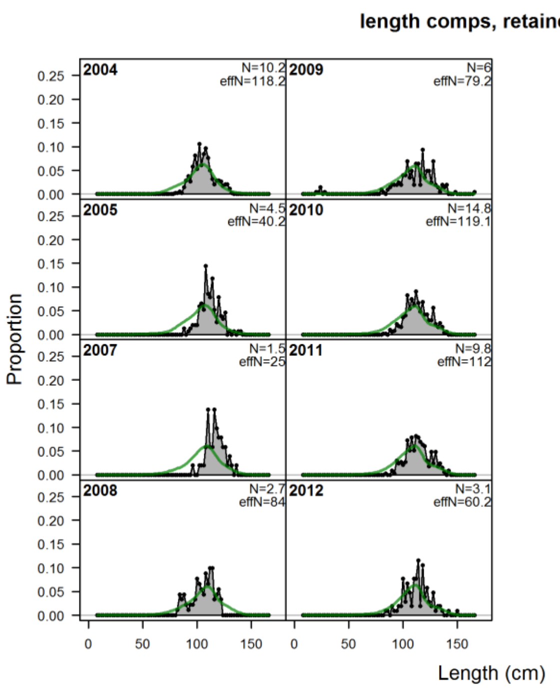



*Figure 6-27. Model fit (green line) to length compositions by year for retained fish in the Historical (CPFV_H) Commercial Passenger Fishing Vessel fishery.*

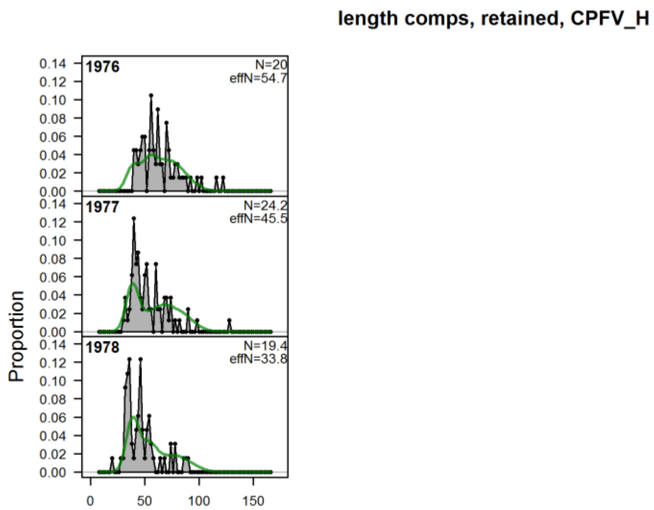



*Figure 6-28. Model fit to (green line) to length compositions by year for retained fish in the Modern (CPFV_M) Commercial Passenger Fishing Vessel fishery.*

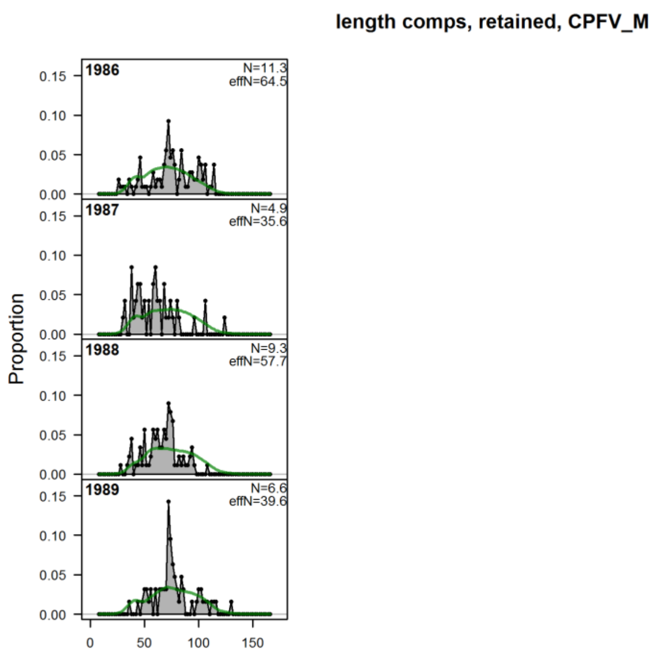
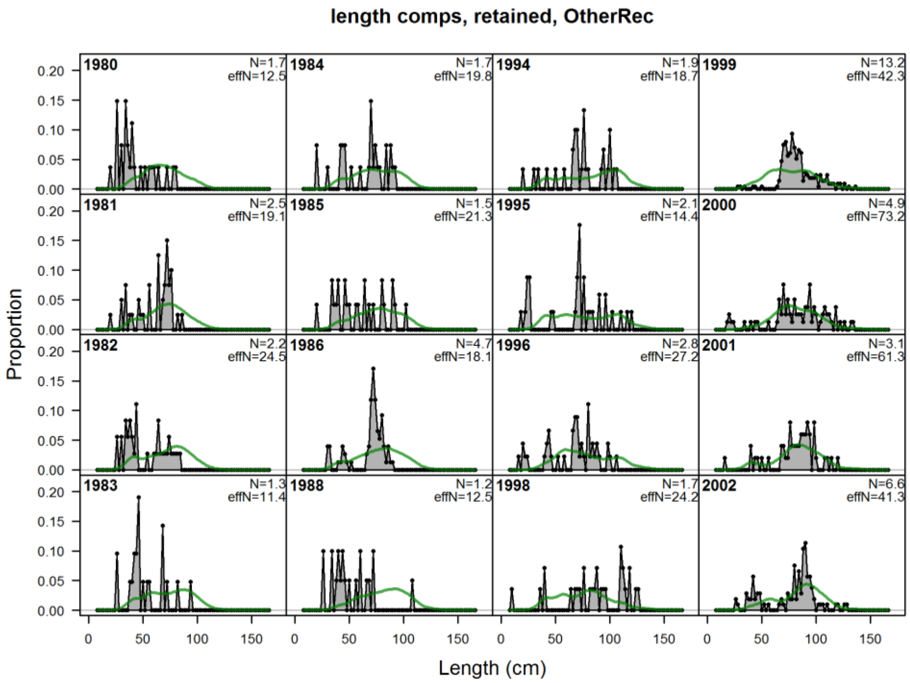


*Figure 6-29. Model fit (green line) to length compositions by year for retained fish in the combined non-CPFV recreational fishery (OtherRec).*



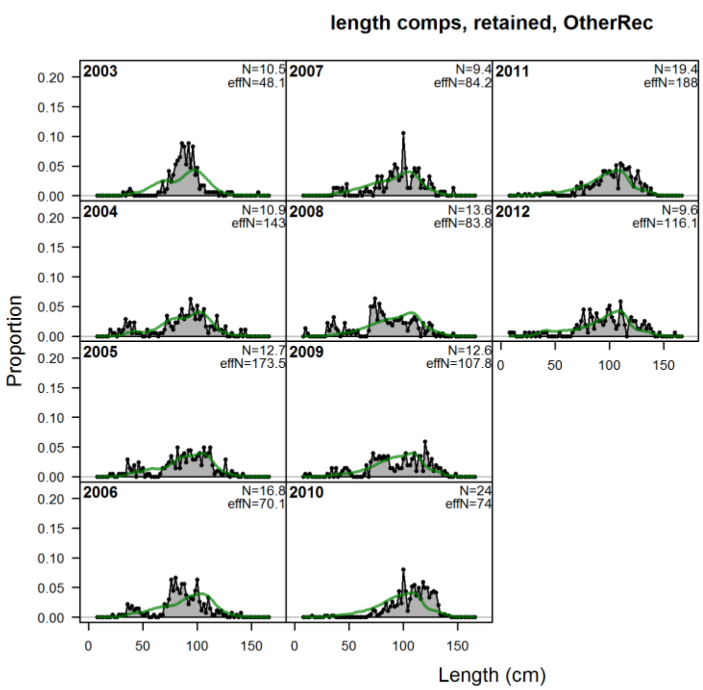
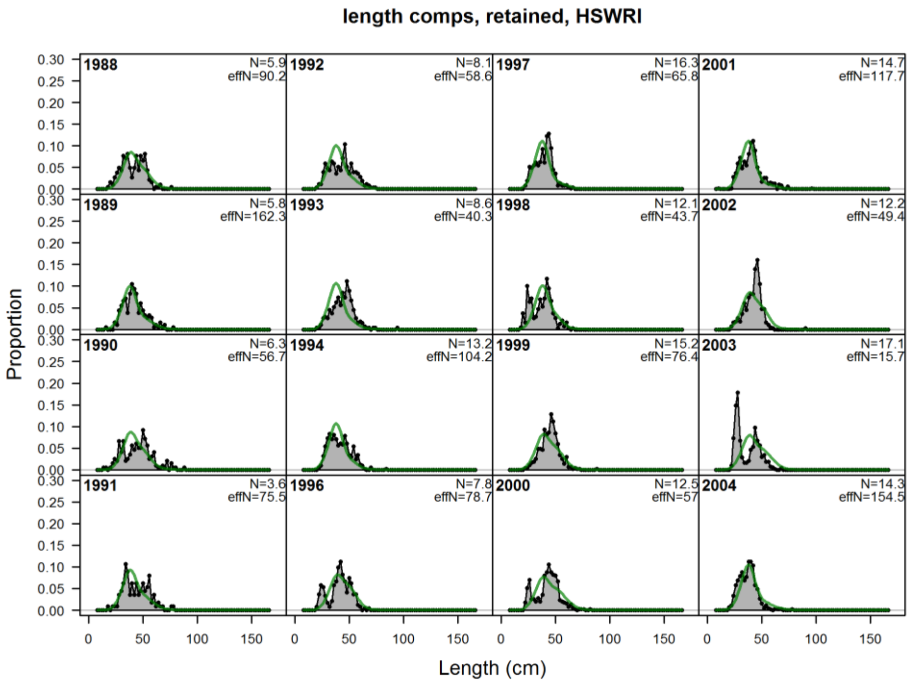



*Figure 6-30. Model fit (green line) to length compositions by year for sampled fish in the gillnet survey from Hubbs SeaWorld Research Institute (HSWRI).*



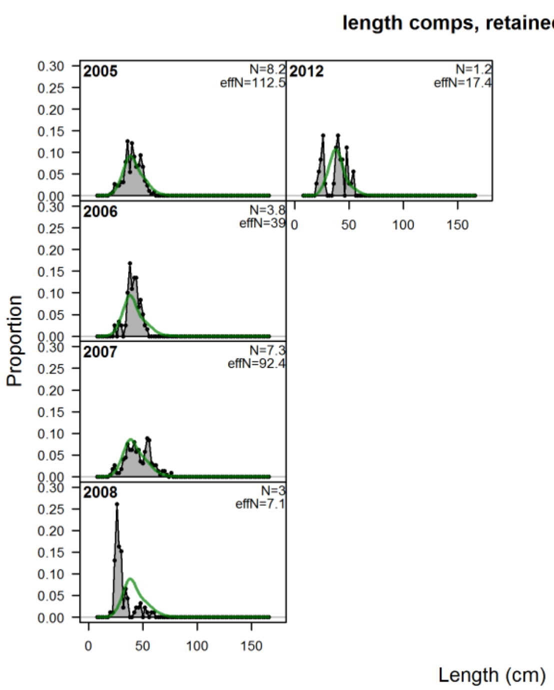
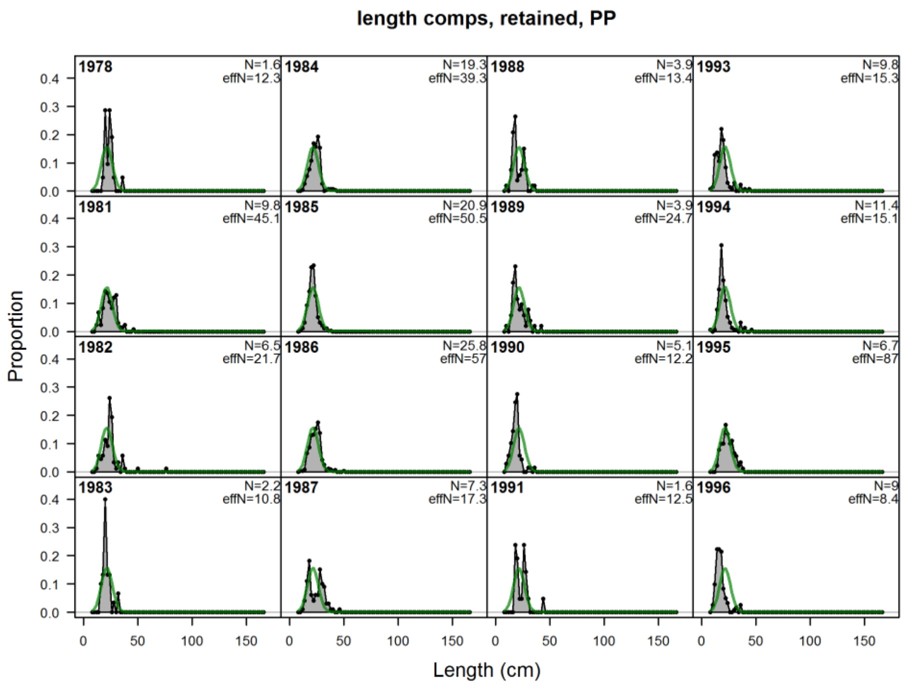



*Figure 6-31. Model fit (green line) to length compositions by year for sampled fish in the Power Plants Heat Treatment sampling program (PP).*



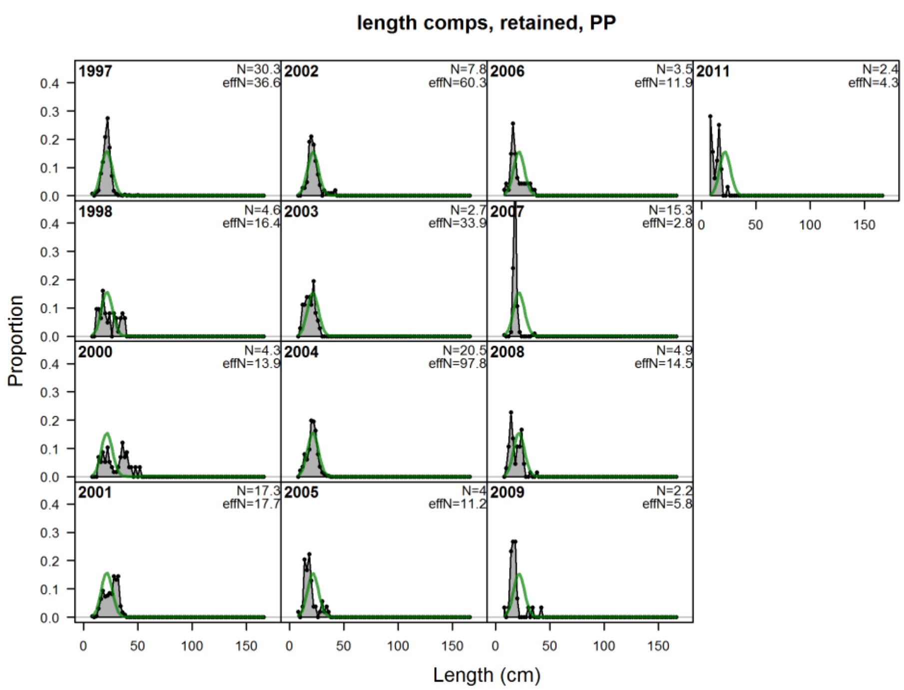



*Figure 6-32. Model fit (blue line) the drift gillnet commercial fishery (Drift). Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty.*

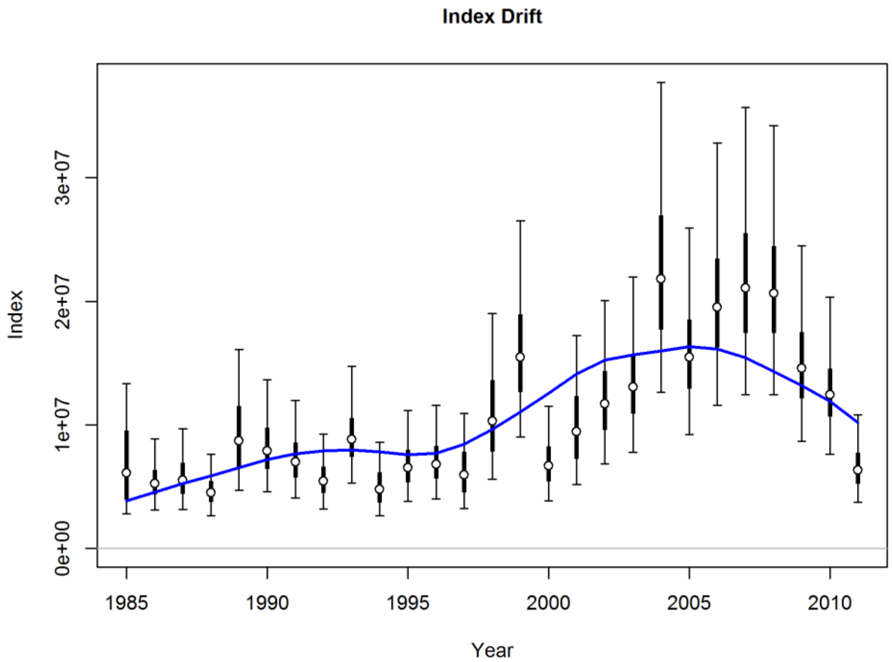



*Figure 6-33. Model fit (blue line) the set gillnet commercial fishery (Set). Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty.*

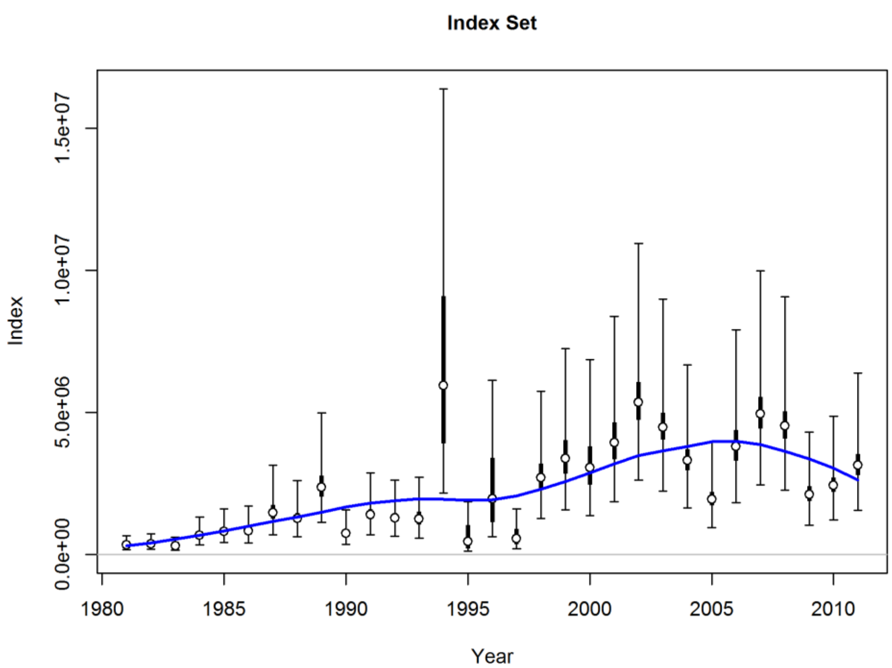


*Figure 6-34. Model fit (blue line) to the historical CPFV index (CPFV_H). Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty.*

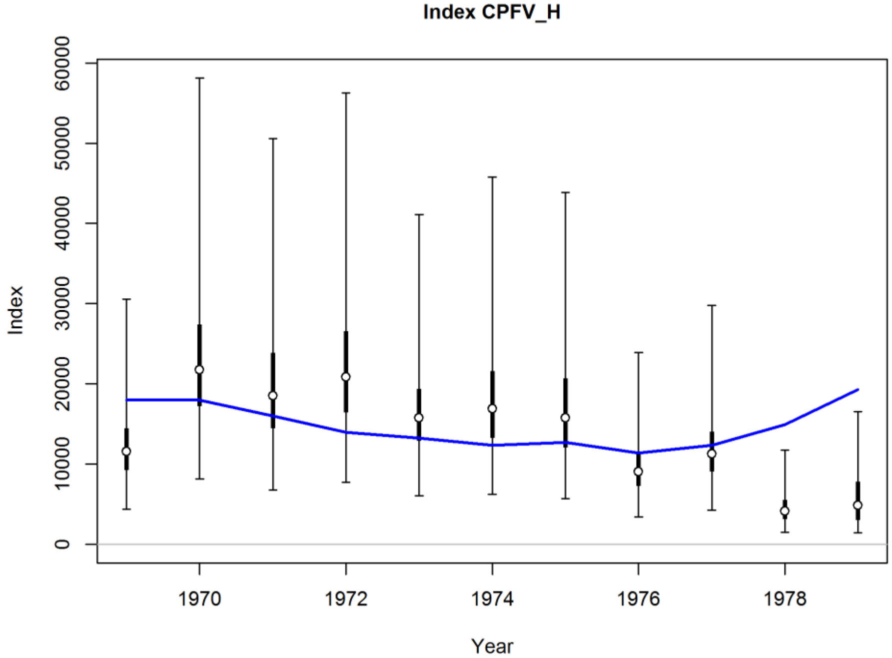



*Figure 6-35-1. Model fit (blue line) to the modern CPFV index (CPFV_M). Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty.*

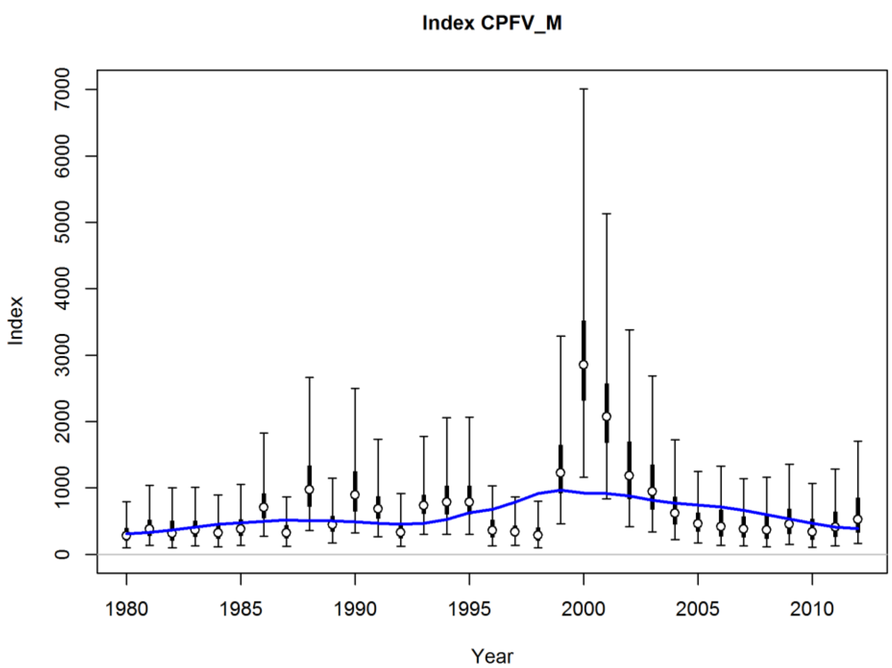


*Figure 6-35-2. Relationship between Catchability and vulnerable biomass for the CPFV modern (CPFV_M) as estimated by the base-case model.*

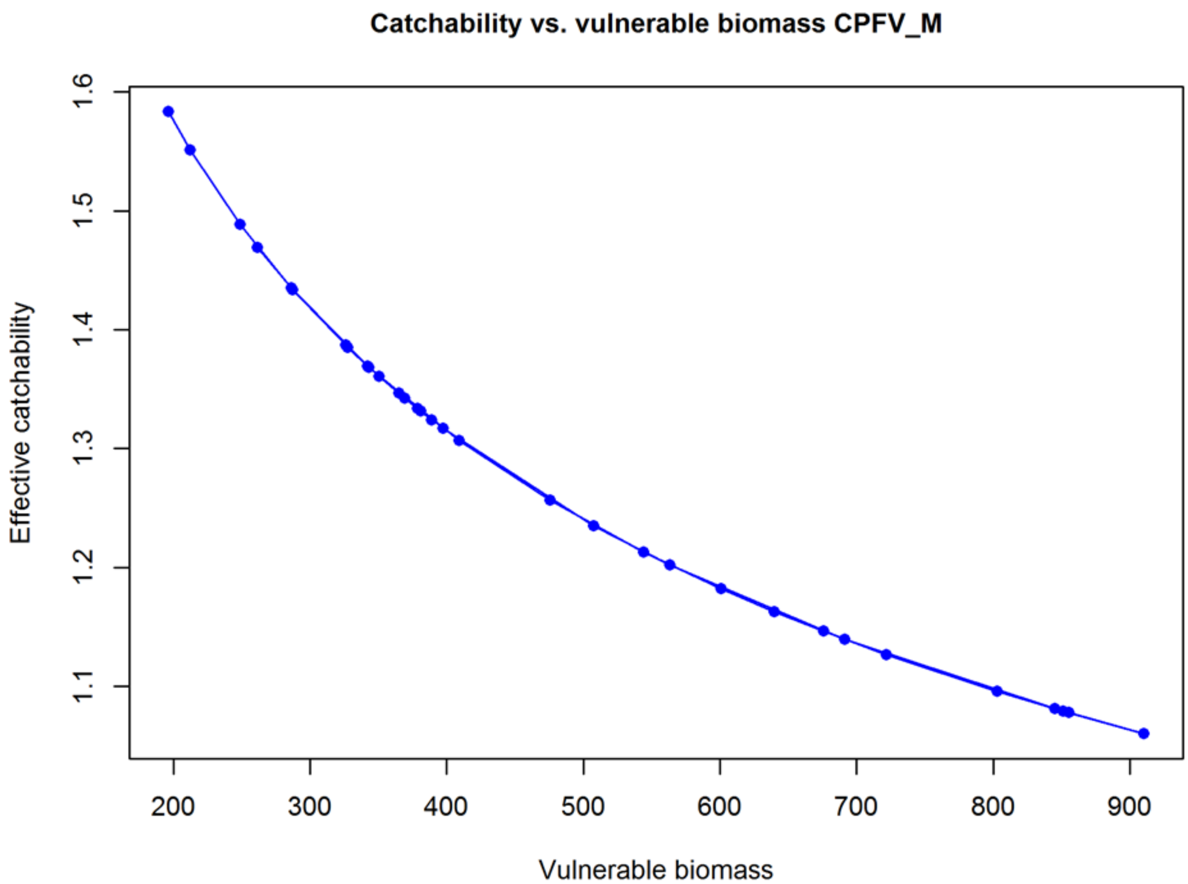


*Figure 6-36. Model fit (blue line) to the HSWRI gillnet survey index (HSWRI). Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty.*

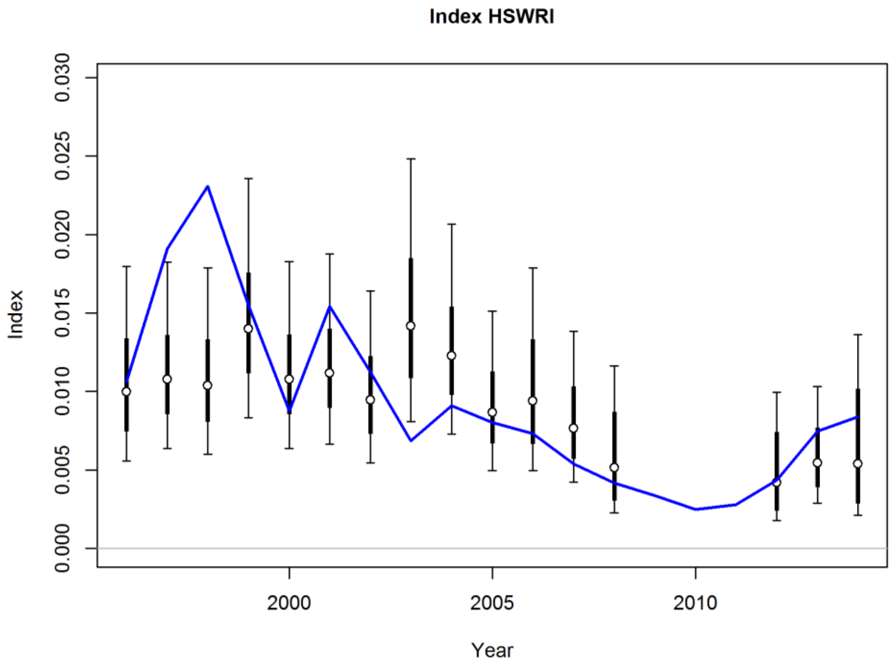



*Figure 6-37. Model fit (blue line) to the Power Plant Heat Treatment (PP) index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty.*

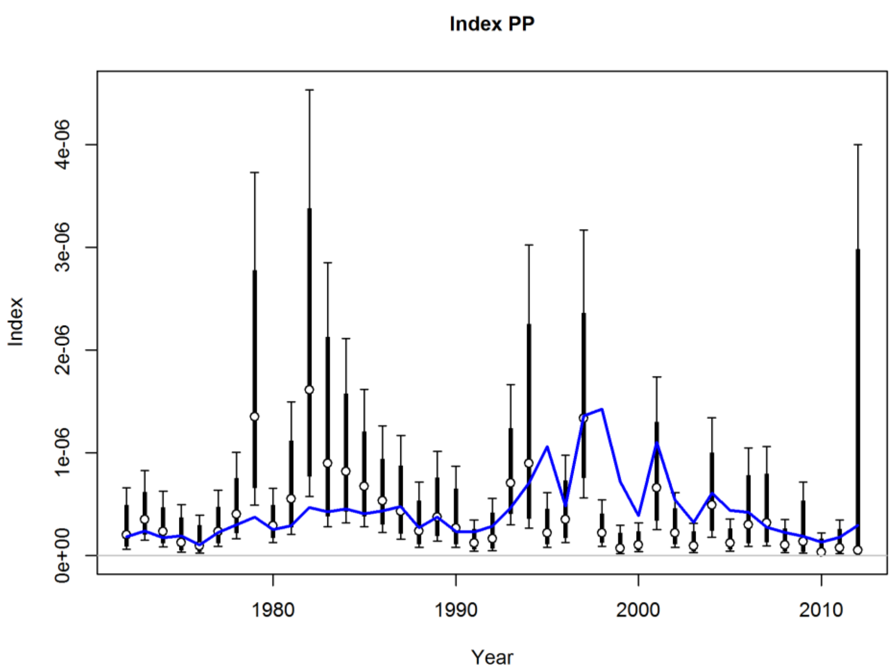


*Figure 6-38. Time series of estimated female spawning biomass with 95% asymptotic confidence intervals. The blue dot before the start of the time series is the estimated equilibrium virgin unfished female spawning biomass (B0) with 95% asymptotic confidence interval.*

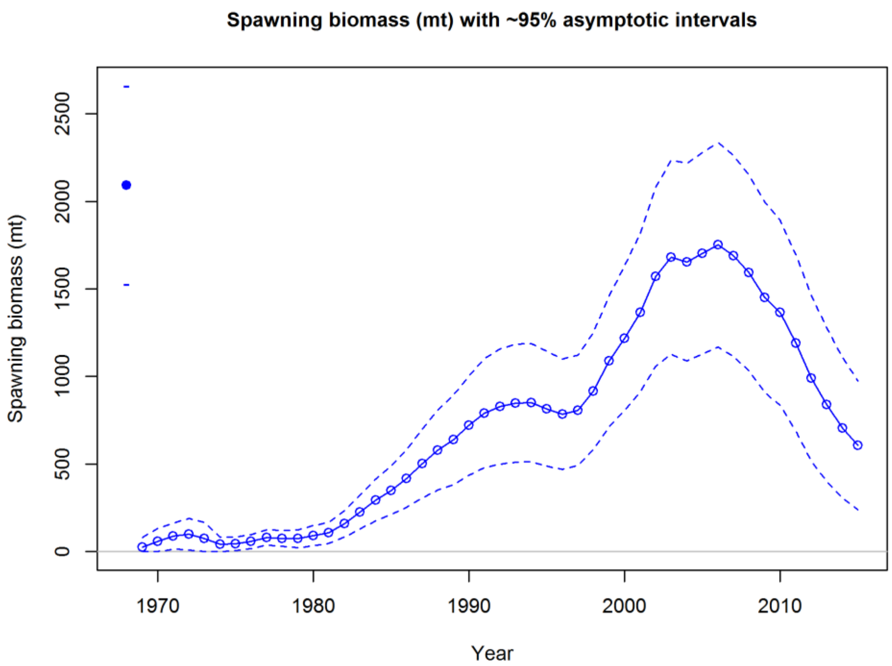



*Figure 6-39. Time series of estimated age-0 recruits with 95% asymptotic confidence intervals. The blue dot before the start of the time series is the estimated equilibrium unfished average recruitment (R0) with 95% asymptotic confidence interval.*

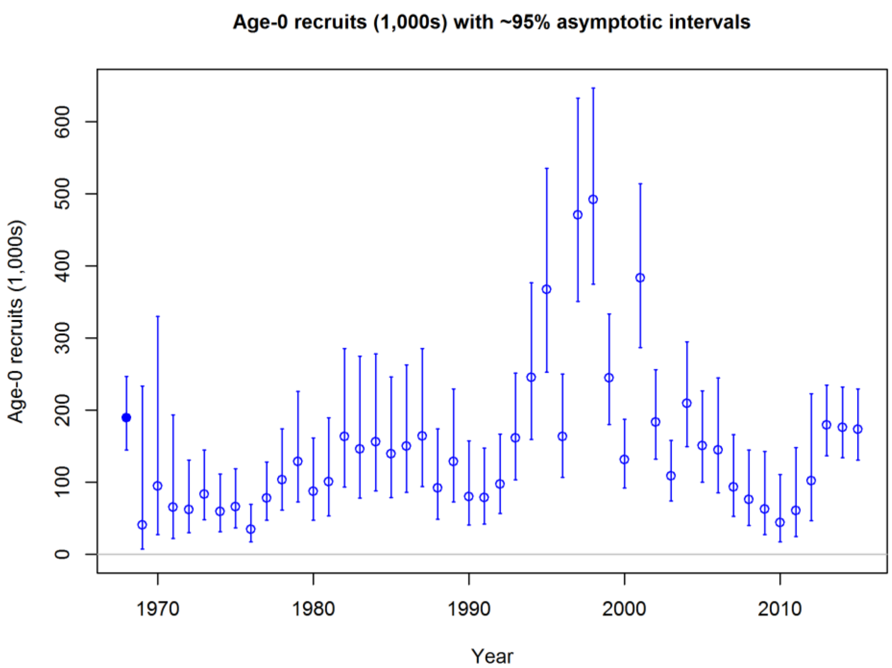
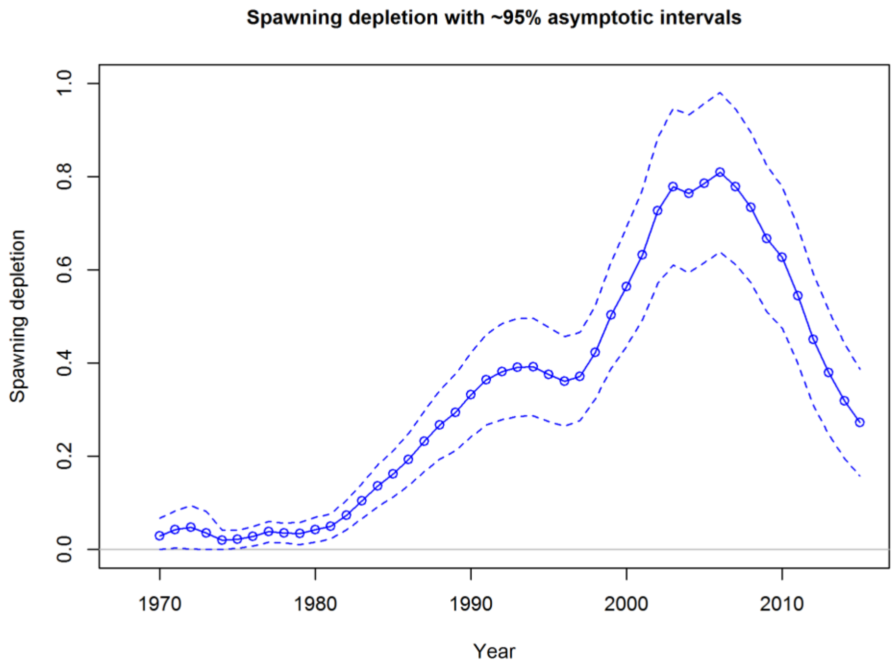


*Figure 6-40. Estimated female spawning biomass depletion with 95% asymptotic confidence intervals.*




## Data-weighting

The number sampled fish was used as the initial input sample sizes for length and conditional length-at-age compositions. Length composition sample sizes were tuned by the "Francis method" (also known as "TA1.8") (Francis 2011), as implemented in the r4ss package. This approach involves comparing the residuals in the model's expected mean length with respect to the observed mean length and associated uncertainty derived from the composition vectors and their associated input sample sizes. The sample sizes are then tuned so that the observed and expected variability are consistent. After adjustment to the sample sizes, models were not re-tuned as long as the bootstrap uncertainty value around the tuning factor overlapped 1. Conditional age-at-length data were also re-weighted using the Francis method.

Indices of relative abundance all had variance estimates generated as part of the analysis of CPUE standardization. These variances are converted to standard deviations in log space for use in the model; additional variances for the indices of abundance were estimated inside the model.

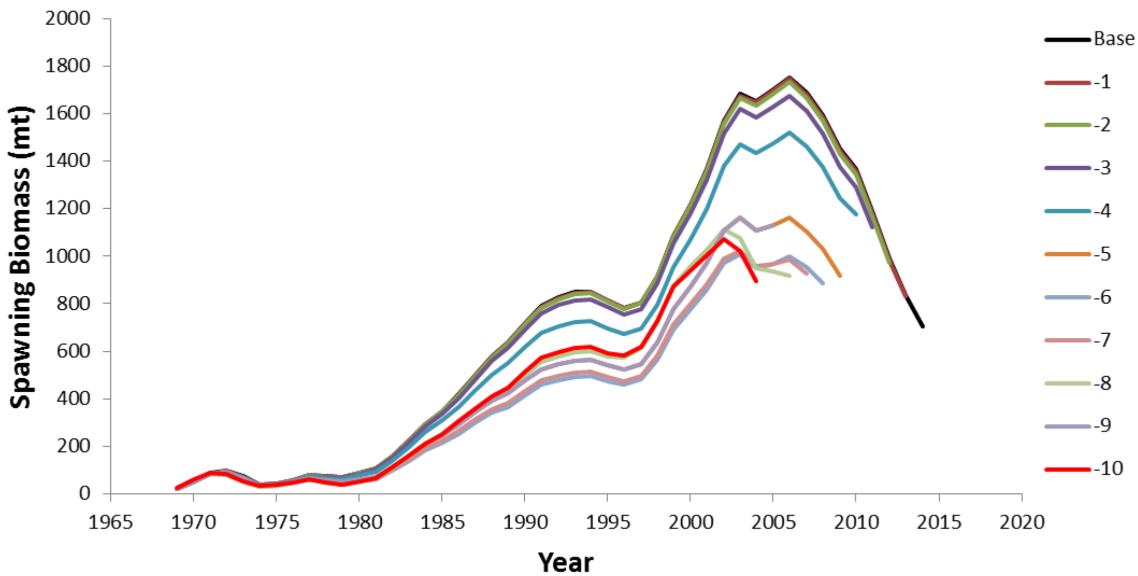
## Convergence

Convergence was evaluated via the ability of models to invert the Hessian matrix. Additional convergence testing was carried out by using dispersed starting parameter values to explore potential areas of the multivariate likelihood surface. Jitter is a SS option that generates random starting values from a normal distribution logistically transformed into each parameter's range (Methot 2015). Jitter levels of 0.01 and 0.05 were used in sets of 100 runs. For the base model, 100% of the jitter runs at 0.01 converged to the initial model. For jitter runs at 0.05, 80% of the model jitter runs converged to the same minimum as the base model. The remaining 20% created likelihood errors or converged or otherwise resulted in large gradients and did not converge.

## Retrospective analysis

Retrospective analyses were conducted for the base model by conducting model runs that sequentially remove the last year of data over the last 10 base model years. For the first 3 years of year removal there was little change in estimated spawning biomass trajectory as a result of this data removal. However, after year 3, the estimated trajectory was lower as each data year was removed. Inspection of the fit to indices suggest that this corresponds to the removal of the last years of the HSWRI gillnet survey, indicating the base model is sensitive to the addition of new data.

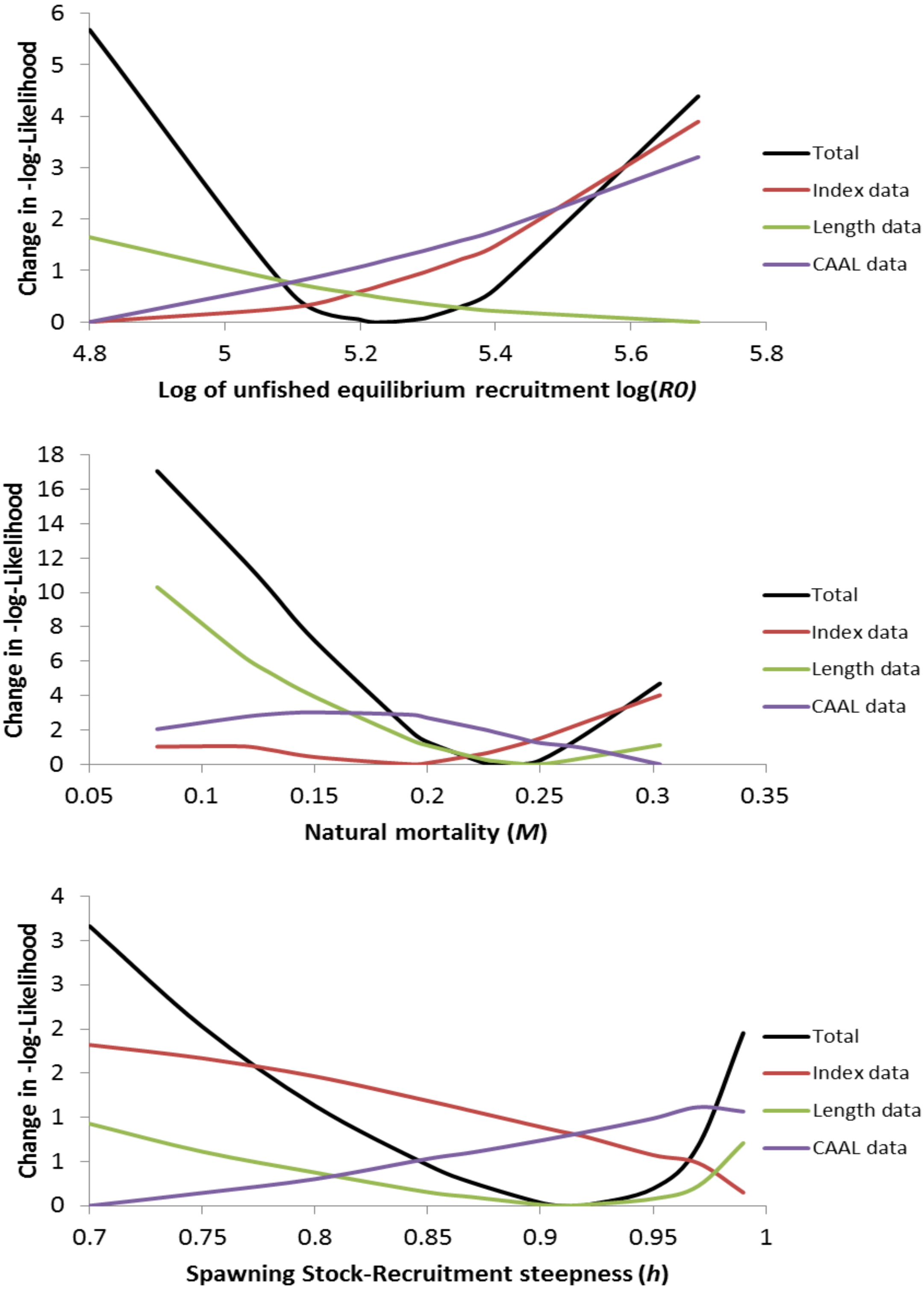
*Figure 6-41. Retrospective analysis for the base-case model. Each line represents the removal of as many years as indicated in the legend from 0 years of data removed (Base) to the most recent 10 years of data removed (-10).*




## Likelihood profiles

Likelihood profiles for unfished equilibrium recruitment (*R0*), natural mortality (*M*), and stock recruitment steepness (*h*), were conducted to investigate the uncertainty in these parameters and their influence on the fit to different data sources. The values fixed in the base case model for natural mortality (*M*=0.225) and steepness (*h*=0.87) are very close to the best total likelihood found when profiling over those parameters. The Index data supports lower values of *M* than the conditional age at length (CAAL) data. Conversely, the Index data supports higher values of *h* the CAAL data. Finally, both the Index and CAAL data support smaller *R0* than the length composition data.

*Figure 6-42. Likelihood profiles over unfished equilibrium recruitment (R0), natural mortality (M) and stock-recruitment steepness (h) showing changes in negative log-likelihoods by data type.*



## Alternative models explored

Sensitivity analyses included a comparison of key model assumptions and were based on nested models including asymptotic vs. domed selectivity, alternative values of *M*, *h*, proportional vs. non-proportional relationship between indices of abundance and biomass. Alternative models were run allowing for a change in catchability for the drift and set commercial gillnets in 1994, the year that the southern California nearshore gillnet ban went into effect (CDFG, 2002). Runs modelling dynamics between 1889 and 2014 (*Historical*), between 1870 and 2014 (*Historical2*) were conducted, contrasting with the base-case model 1969 to 2014 (*Modern*) time frame. Although *Modern* models explored during sensitivity analyses converged, *Historical* and *Historical2* models were unstable and had convergence issues. Additional sensitivities were conducted during the review and are also included in the Review Panel Report. Sensitivity analyses showed that the general results in terms of estimated population trajectories did not change markedly, although the estimated scale of the population showed some variability.

Figures 6-43 to 6.45 show estimated times series of female spawning biomass and female spawning biomass depletion for the following alternative models:

*Base*: base-case model

*Dome*: estimating dome-shape selectivities for all fleets

*M_0.303*: fixing natural mortality (*M*) for both sexes at *M*: 0.303 $yr^{-1}$

*M_0.15*: fixing natural mortality (*M*) for both sexes at *M*: 0.15 $yr^{-1}$

*Q_1994ban*: time-varying block drift and set gillnet catchability (*Q*) in 1994

*Historical*: modelling dynamics between 1889 and 2014

*Historical2*: modelling dynamics between 1870 and 2014

*sexM*: fixing *M*: 0.225 $yr^{-1}$ (females) and *M*: 0.360 $yr^{-1}$ (males)

*medEqC:* set initial equilibrium catch at the median historical catch instead of the average

*RecDev1950*: estimate recruitment deviates starting in 1950

*EarlyRec1950*: estimate early recruitment deviates starting in 1950

*RecDev2009*: set final year of recruitment deviate estimation as 2009

*FinitCV*: allow for a larger CV in the estimate of the initial fishing mortalities (*F*)

*CatchCap*: cap historical catch levels to a maximum of 800 mt

*PP_HSWRI_ExtraSD*: allow for the internal estimation of extra variability in the Power Plant (PP) and Hubbs Sea World Research Institute (HSWRI) indices of relative abundance.

*Figure 6-43. Estimated female spawning biomass (Top panel) (in thousands of metric tons) and female spawning biomass depletion (Bottom panel) for the base and alternative models. Modern models starting in 1969 show a vertical line that is not the estimated trajectory but the difference between the estimated virgin spawning biomass and the estimated biomass in the first year. See text for description of alternative models.*

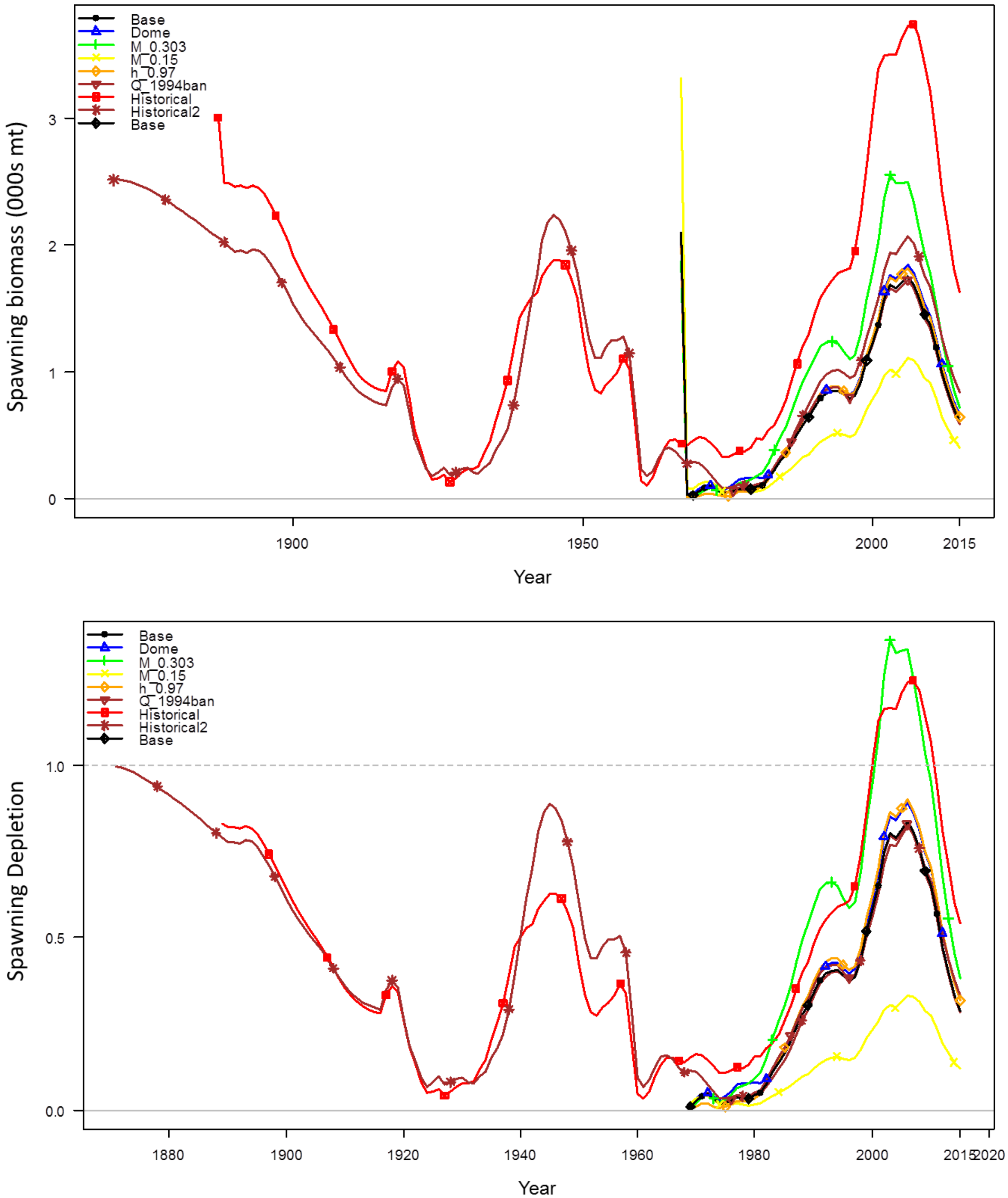
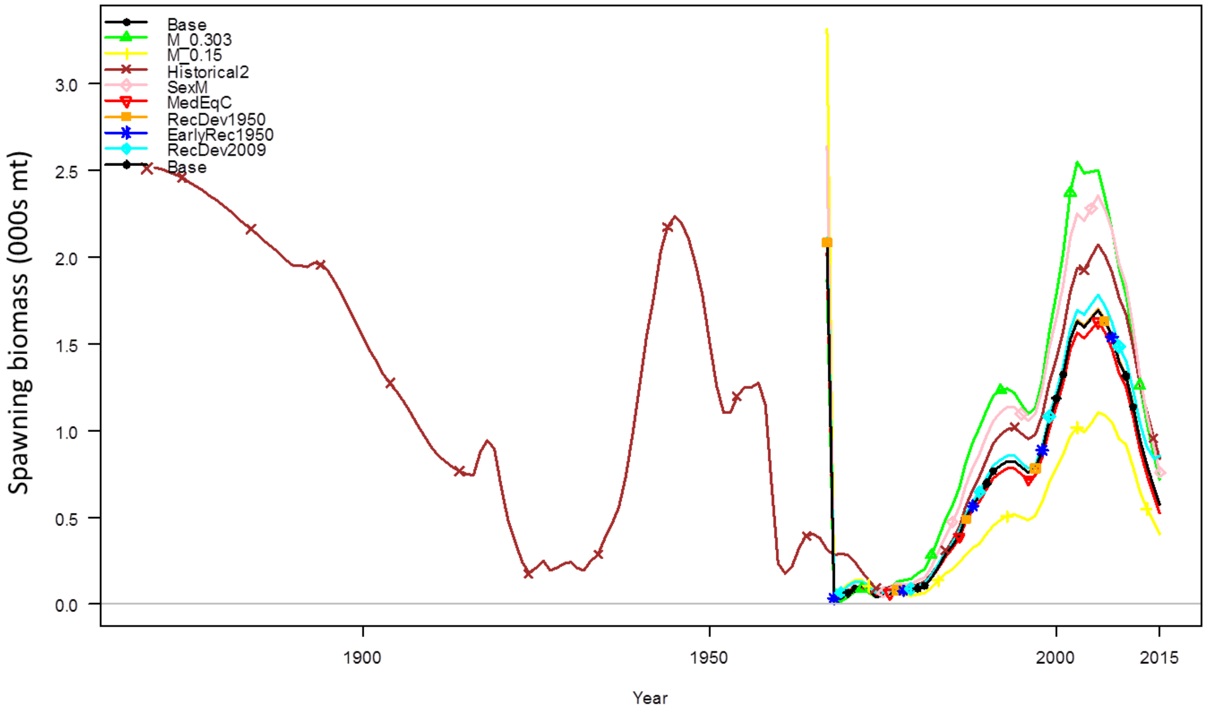


*Figure 6.44. Estimated female spawning biomass (Top panel) (in thousands of metric tons) and female spawning biomass depletion (Bottom panel) for the base and alternative models. Modern models starting in 1969 show a vertical line that is not the estimated trajectory but the difference between the estimated virgin spawning biomass and the estimated biomass in the first year. See text for description of alternative models.*



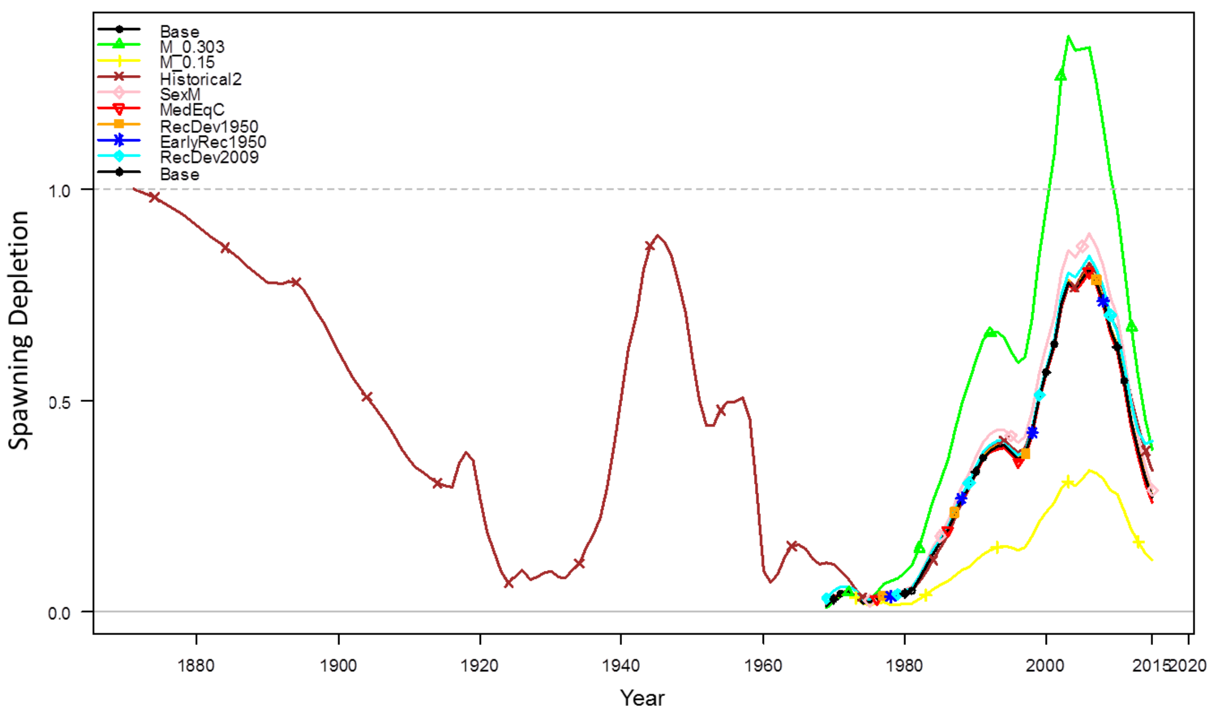
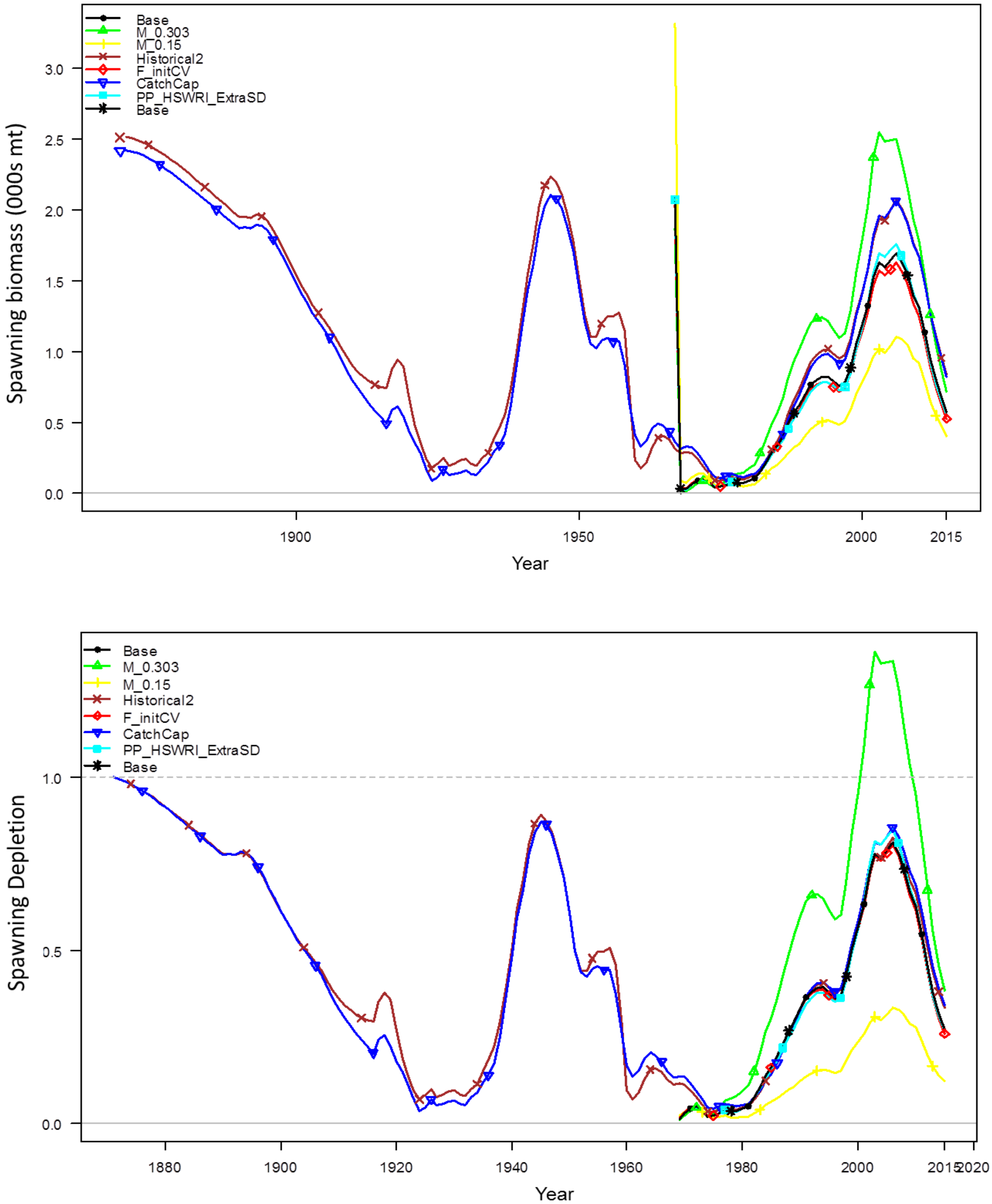



*Figure 6.45. Estimated female spawning biomass (Top panel) (in thousands of metric tons) and female spawning biomass depletion (Bottom panel) for the base and alternative models. Modern models starting in 1969 show a vertical line that is not the estimated trajectory but the difference between the estimated virgin spawning biomass and the estimated biomass in the first year. See text for description of alternative models.*



## 7. Reference points

The White Seabass Fishery Management Plan (WSFMP) (CDFW, 2002) determined that white seabass is a data-poor species. The WSFMP uses a framework plan approach for managing the white seabass fishery that relies on a series of trigger mechanisms and points of concern (CDFW, 2002). Management alternatives based on Maximum Sustainable Yield (MSY) are also considered in the WSFMP. The MSY calculations used in the WSFMP are based on early population modelling on white seabass (MacCall et al. 1976; Dayton and MacCall 1992) and resulted in a MSY proxy of 1.6 million pounds (CDFW, 2002), or 726 metric tons. The WSFMP also defines alternative Optimal Yields (OY) of 0.75 and 0.8125 of MSY, corresponding to 1.2 and 1.3 million pounds (544 mt and 590 mt) respectively.

A summary of reference points and management quantities estimated for California white seabass by this stock assessment's base-case model is available in Table 6-2. Maximum Sustainable Yield (MSY) is estimated by this stock assessment at less than half of that reported by previous works and to occur at a relatively low fraction of the unexploited female spawning biomass (Figure 7-1). The base case model estimates a MSY of 306 (95% asymptotic CI: 225 - 388) metric tons, corresponding to a female spawning biomass ($B_{MSY}$) of 447 mt (CV = 0.14) and to a depletion of 0.24 (Figure 7-1). Estimated MSY depends on the size of fish caught, natural mortality (*M*), growth and the productivity shape of the spawning stock curve determined by steepness (*h*). There is uncertainty about many of the biological and fishing processes including the stock-recruitment relationship, natural mortality, growth, maturity, survival of discarded fish. Some of the uncertainty in this process is incorporated in the assessment, for example when estimating growth and selectivities. However other important parameters had to be fixed in the assessment, including *M* and *h*. This is common in several other assessments where there is not enough information, or not the right type of information, to estimate these parameters, which are often confounded between themselves and other parameters of the model. MSY was estimated for a range of fixed values of *M* and *h*. Alternative values of MSY ranged between 294 and 475 mt for alternative vales of *M* (Figure 7-2, top) and between 260 and 336 mt for alternative values of *h* (Figure 7-2, bottom).

The base case model estimates white seabass female spawning biomass in 2015 at 569 mt (~95% asymptotic interval: 241- 896 mt) (Figure 6.38). Virgin unfished female spawning biomass (*B0*) is estimated at *B0*: 2092 mt (~95% asymptotic interval: 1600 - 2584 mt). The base case model estimates 2015 depletion at 0.27 (~95% asymptotic interval: 0.16- 0.39) (Figure 6.40). Under Pacific Fishery Management Council (PFMC) Groundfish management policy, if the current spawning biomass of a stock falls at or below 25% of the unexploited biomass, the stock is considered overfished. The estimated 2015 depletion of 0.27 (~95% asymptotic interval: 0.16-0.39) (Figure 6.40) is below what would be a PFMC biomass target of 40% depletion, but above what would be a PFMC minimum stock size threshold of 25% biomass depletion. White seabass biomass is estimated to be decreasing over the last 9 years (Figure 6.40). However, under California State guidelines (set in the white seabass fisheries management plan (CDFG, 2012)) white seabass would be considered overfished only if three conditions are met simultaneously: 1) total annual commercial catch of white seabass in pounds landed (from fish receipt data) for two consecutive years declines each year by 20% or greater from the prior five-year average of landings; 2) a 20% decline occurs in the number of fish and average size of fish (round weight) for the same two consecutive years for white seabass caught in the recreational fishery as determined from the best available data and 3) recruitment of juvenile white seabass declines each year by 30% or greater from the prior five-year average of recruitment as determined from the best available data.

*Figure 7-1. Estimated equilibrium yield (mt)) versus relative depletion.*

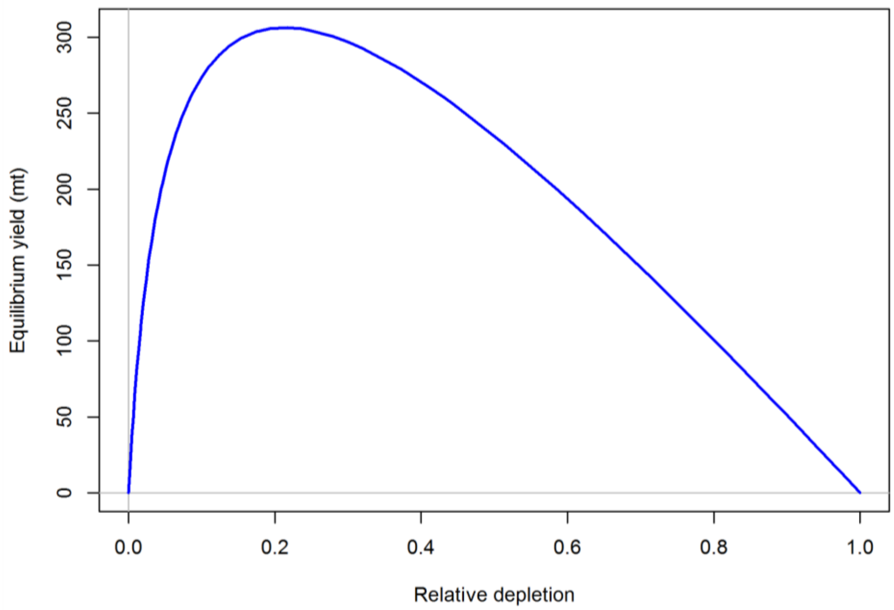
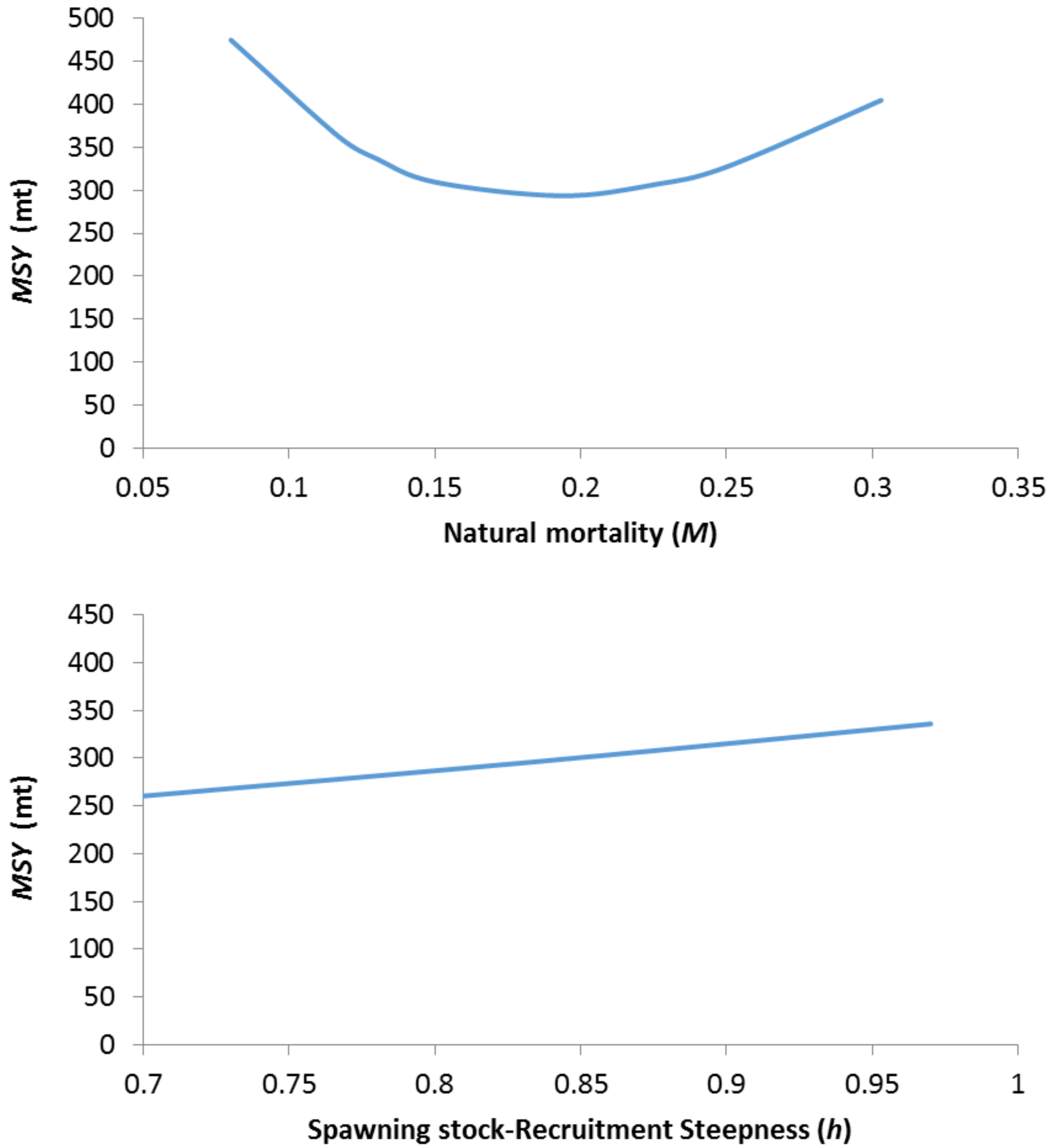


*Figure 7-2. Relationships between estimated maximum sustainable yield (MSY) in metric tons versus: (top panel) natural mortality (M) and (bottom panel) stock-recruitment steepness (h).*



## 8. Research needs

The following is a list of stock assessment and research recommendations, they are not prioritized. A complimentary list of research needs is available in the Stock Assessment Review Report.

Additional research on the CPFV datasets is needed, including information on CPFV trips that caught nothing, and the types of targeted species from CPFV trips. Better analysis of spatial information on fishing effort and catch is needed. There are many discrepancies in datasets by fishing block. For instance, in the 1980's CPFV observer data, at least some trip records are assigned to one fishing block while the associated length record is assigned a different fishing block. Furthermore, CPFV could possibly fish in more than one fishing block, while trips are assigned exclusively to a single block.

Additional work on parsing out the recreational component of the data is needed. In this assessment an "other" recreational fishery ("OtherRec") was defined to separate it from the CPFV fishery. However, the OtherRec fishery could not be separated into its major components given the lack of appropriate length composition data to be able to estimate separate selectivities, or develop indices of relative abundance.

There is indication that white seabass are caught as bycatch in other fisheries, for example purse seines for small pelagic fish and fisheries for market squid. However there is no information on the magnitude and composition of this bycatch or the survival of discarded fish. More information on mortality from other fisheries not targeting white seabass is needed.

Collection and processing of otoliths for estimating age compositions of the catch of different gears is needed. If there are any otolith samples from previous years that have not being analyzed for age determination they should be considered as well. The collection program should include gender-specific age sampling of commercial and recreational fishery catches and discards. Such a program would allow for alternative estimates of sex and age specific selectivity.

The rationale behind the use of a minimum size limit is allowing the fish to spawn before being killed. A fish can be killed either by being retained when caught or by being discarded or released post-capture but not surviving the capture event. Given the current use of a minimum size limit, undersized white seabass caught by recreational and commercial fisheries are released or discarded. There is limited information on the total amount discarded, and only for some fisheries. There is very little information on size/age/sex of discards or released fish. Collection of discard data, both regarding the amount, size/age/sex compositions and survival of discarded fish would allow the estimation of retention curves and better estimation of total mortality of the stock.

In addition to exploring the effect of alternative size limits, it is recommended to explore impacts of alternative potential harvest strategies (including selectivity, alternative size limits and/or seasonal closures, total catch, etc.), tradeoffs between different sectors.

The available maturity information for white seabass is very limited. Additional data should be collected on the relationship between fish size and maturity state. Age data should also be collected to determine maturity at size and/or age.

Sampling and estimation of the relationship between fork length and total length of white seabass is needed to convert between the two data types. Some of the historical recreational data is currently in fork length and there is no relationship available other than a length-invariant constant added. It would be expected that the amount to add to fork length will vary by total length.

Support, enhance and expand tagging programs for white seabass. Fishery independent programs seem logistically challenging for this species. Tagging projects can be a way to incorporate less-fishery dependent data in future analyses. Tagging data can inform about fish movement, abundance, survival and growth.

There is evidence of white seabass transboundary movements, both seasonal and inter annual, between Mexico and USA. Collaborative work between researchers of both countries is expected to increase understanding of white seabass dynamics under exploitation including: life history, history of catches, and interpretation of relative abundance indices in years where oceanographic conditions are suspected to affect distributional changes across the border.

Timely updates to this stock assessment (the first white seabass) are recommended given the large changes in estimated biomass, the ongoing 9-year decline in spawning biomass, current depletion levels and the lack of updated data up to the final year of the model.

# 9. Acknowledgements

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An Independent Review Panel reviewed this Stock Assessment during May 2-3, 2016 at the Scripps Campus in La Jolla. The review panel consisted of Ian G. Taylor and Jason Cope (FRAM stock assessment team members, NOAA Fisheries). The review was open to the public with participants from California Department of Fish and Wildlife, Pfleger Institute of Environmental Research, California Sea Grant, Hubbs SeaWorld Research Institute, Scripps Institution of Oceanography, University of California San Diego and from the fishing community. We want to thank both reviewers for their input; insightful comments and suggestions that helped improve the quality of this work.

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