STOCK ASSESSMENT SUMMARY FOR CALIFORNIA HALIBUT

MODELING APPROACH

A sex-structured model with different growth, natural mortality, and selectivity for males and females developed using Stock Synthesis is used to assess California halibut (halibut) in two stocks within California separated at Point Conception. The models are fit to a Commercial Passenger Fishing Vessel (CPFV) index of relative abundance and length composition data from recreational and commercial fisheries. The central stock is also fit to indices of relative abundance from trawl logbook catch-per-unit effort (CPUE) and the San Francisco Bay young-of-the-year survey, a swept area trawl survey estimate of absolute abundance with associated age composition data, and age-conditioned-on-length data. Due to limited size composition and discard data for the central stock, all selectivity parameters, except for a few parameters for the selectivity curve of the recreational fishery and the bottom trawl fishery, for the central stock are fixed based on the southern stock assessment.

Historic catch data for central and southern California

The commercial catch has shown three large peaks in the 1910s, 1940s, and the 1960s (Figure S1). The second of these two peaks can be seen in both the recreational (CPFV) and the commercial catch. The earliest peak is during a period lacking recreational catch data so it is not clear if the recreational catch was also high. In general, the commercial catch has been higher than the recreational catch (based on reconstructing the recreational catch in weight from earlier years using the Commercial Passenger Fishing Vessel [CPFV] data). However, the recreational catch could have been higher than the commercial catch in the peak catch years. Since the model is initiated in 1971, only data starting in 1971 was used in the stock assessment and this data is available by port and fishing method.

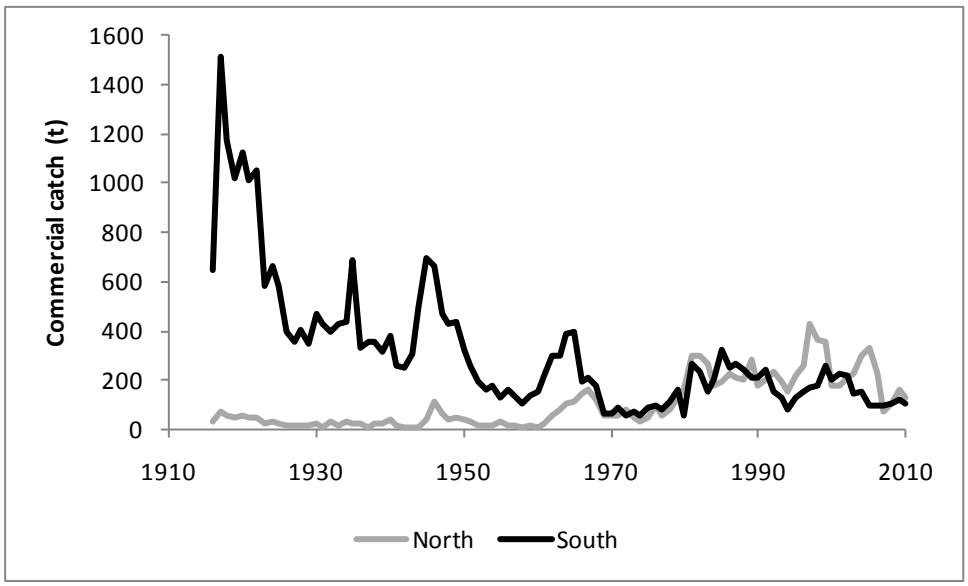

Figure S1. Commercial catch (metric tons) north and south of Point Conception

Recreational catch is available by fishing mode from the Marine Recreational Fisheries Statistics Survey (MRFSS) from 1980 to 2003 and the California Recreational Fisheries Survey (CRFS) since 2004 except for the period 1990-1992. Catch by the CPFV fleet is available from logbooks from 1947, but it does not cover all the vessels and is an underestimate of the total CPFV catch. Recreational data prior to 1947 is not available and data for the non-CPFV fisheries are not available prior to 1980. Therefore, the data for these years has to be reconstructed (Figure S2).

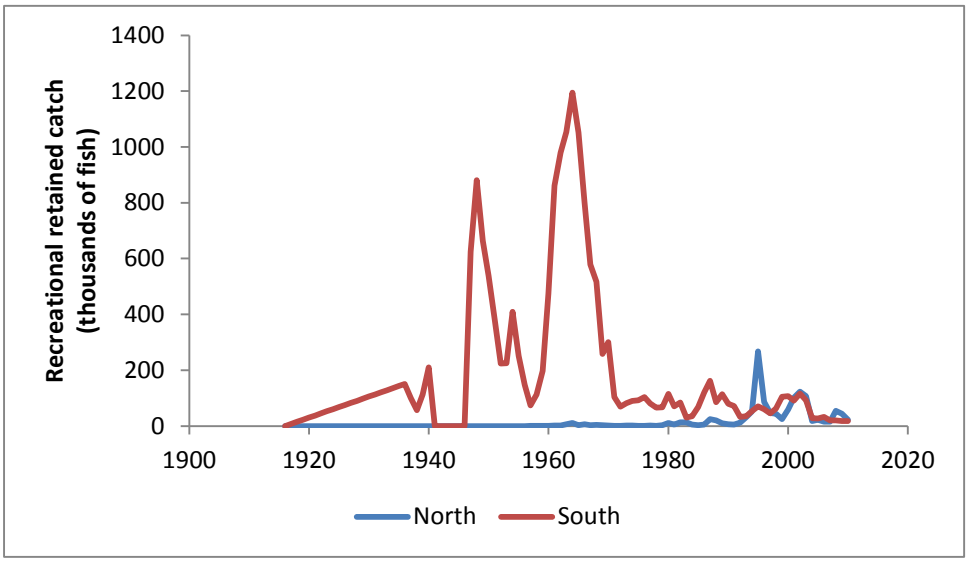

Figure S2. Recreational retained catch north and south of Point Conception

SOUTHERN CALIFORNIA

Maximum sustainable yield (MSY) is estimated to occur at a very low fraction of the unexploited spawning biomass. Therefore, even though the population is estimated to be depleted, it is still estimated to be above the spawning biomass level that would produce MSY and the fishing mortality is lower than the level that would produce MSY. This is partly due to the assumption recruitment is independent of stock size, at least at the abundance levels observed, which is not contradicted by the data. In other words, halibut as a species, like many other flatfishes, are prolific enough, and have a high reproductive potential, such that when environmental conditions are favorable, biomass can increase relatively quickly in a short time frame. MSY and related quantities are also dependent on the size of fish caught, natural mortality, and growth. There is substantial uncertainty about many of the biological and fishing processes including the stock-recruitment relationship, natural mortality, growth, and the survival of discarded fish. Despite the resilience of flatfish and the fact that California halibut have sustained high exploitation rates for several decades, the uncertainty in the biological and fishing processes and the recent series of low recruitments indicate that management action may be needed to reduce the risk of fishery collapse.

Southern California Catch Data

Data used in the southern California assessment are only from south of Point Conception. Catch by fishery is shown in Figures S3 and S4.

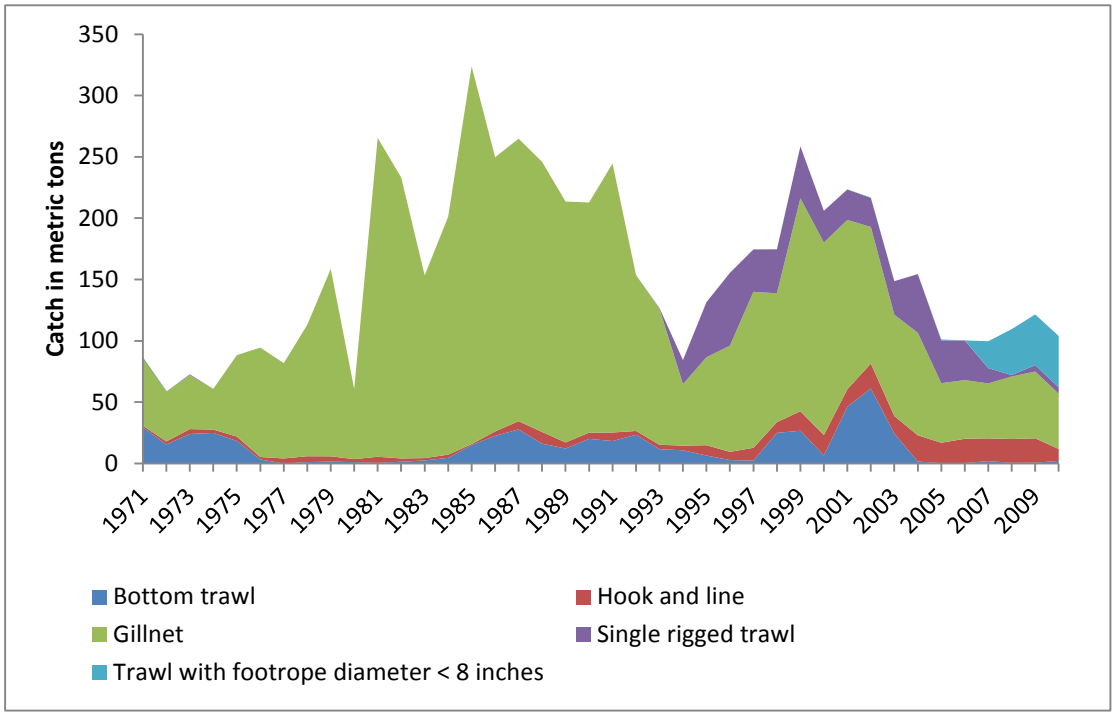

Figure S3. Commercial catch south of Point Conception in metric tons by gear type.

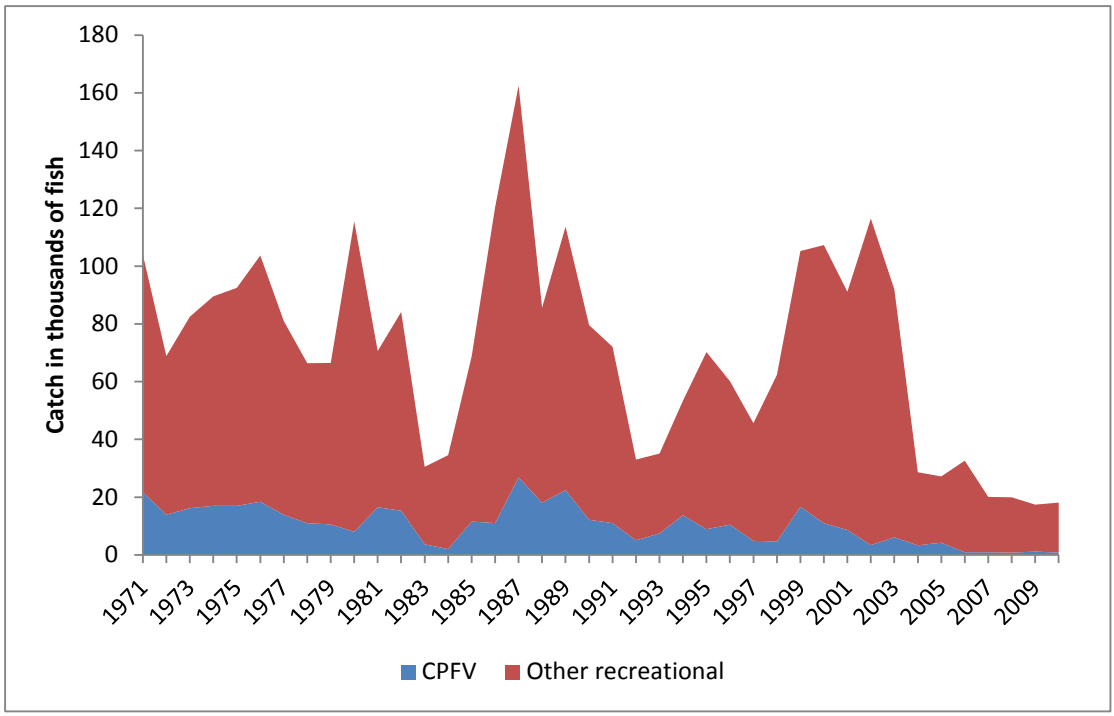

Figure S4. Recreational catch couth of Point Conception by fishing mode in thousands of fish.

Primary Data Sets Used in Southern California Model

The model is fit to an index of relative abundance (index) based on standardized catch-per-unit effort from CPFV logbooks (Figure S5). Only data from CPFV trips that were considered to target California halibut based on expert judgment about associated species are used to create the index, which extends from 1980 to 2010. The data was split into two inshore areas separated at Palos Verdes and an island area. The combined year effect from the binomial and lognormal components of the regression was used as the index of relative abundance. A combined index was created as the average weighted by the number of blocks in each sub-area. The index is assumed proportional to the number of fish selected by the CPFV fishery. The index was used in the assessment model.

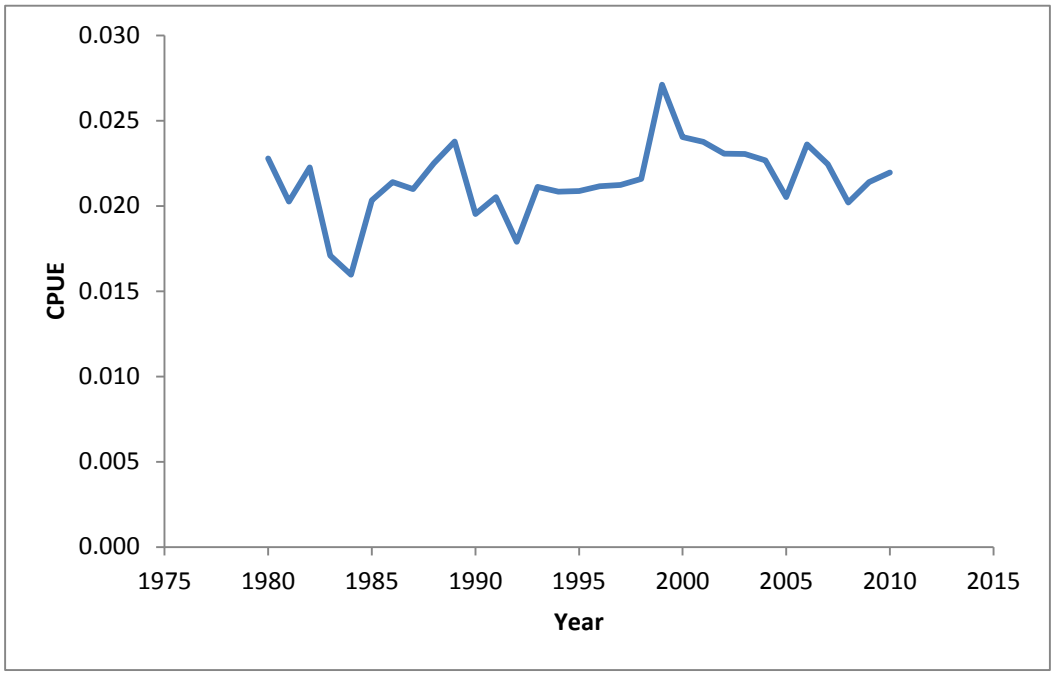

Figure S5. Index of relative abundance for the CPFV logbook data.

The model is fit to CPFV discard catch estimates from observer data (1986-1989) and logbooks (1995-2007). The model is fit to bottom trawl and gill net length composition data for both combined sexes and for proportions of males and females that sum to one. Years with sample sizes less than 20 fish were excluded from the analysis. Data from hook-and-line, and the two other trawl methods were excluded because the samples sizes are small and it is considered better to remove fish at somewhat wrong sizes than to mix length composition samples from gears that may have different selectivities. Length composition data of retained and discarded halibut from a gill net observer program were included in the model to estimate the gill net retention curve. The model is fit to both whole catch and to retained catch length (or weight) composition data for the CPFV fishery and to retained catch length (or weight) composition for the private/rental boat fishery. Length composition data for the other recreational fisheries (shore based fisheries) is not used because the sample sizes are small and the catch by those fisheries is small.

Southern California Results

The southern population is estimated to be depleted to about 14% of its unexploited spawning biomass level. The population level is estimated to have been at a low level since the start of the modeling time period (1971)(Figure S6). There was substantial catch prior to 1971, but changes in the management (e.g., minimum legal size) and lack of data prior to 1971 prevent adequate assessment of the abundance prior to 1971. The assessment is able to estimate the depletion level in 1971 by calculating the abundance at age that is consistent with the length composition data seen in the fisheries compared to what would be expected in the absence of fishing. Recent recruitments since 1999 are estimated to be low and are supported by data not included in the assessment. Recruitment does not appear to be related to spawning stock size. The estimated depletion level is sensitive to the value of natural mortality, the average length assumed for the oldest fish, and the method used to derive an index of relative abundance from the CPFV CPUE data.

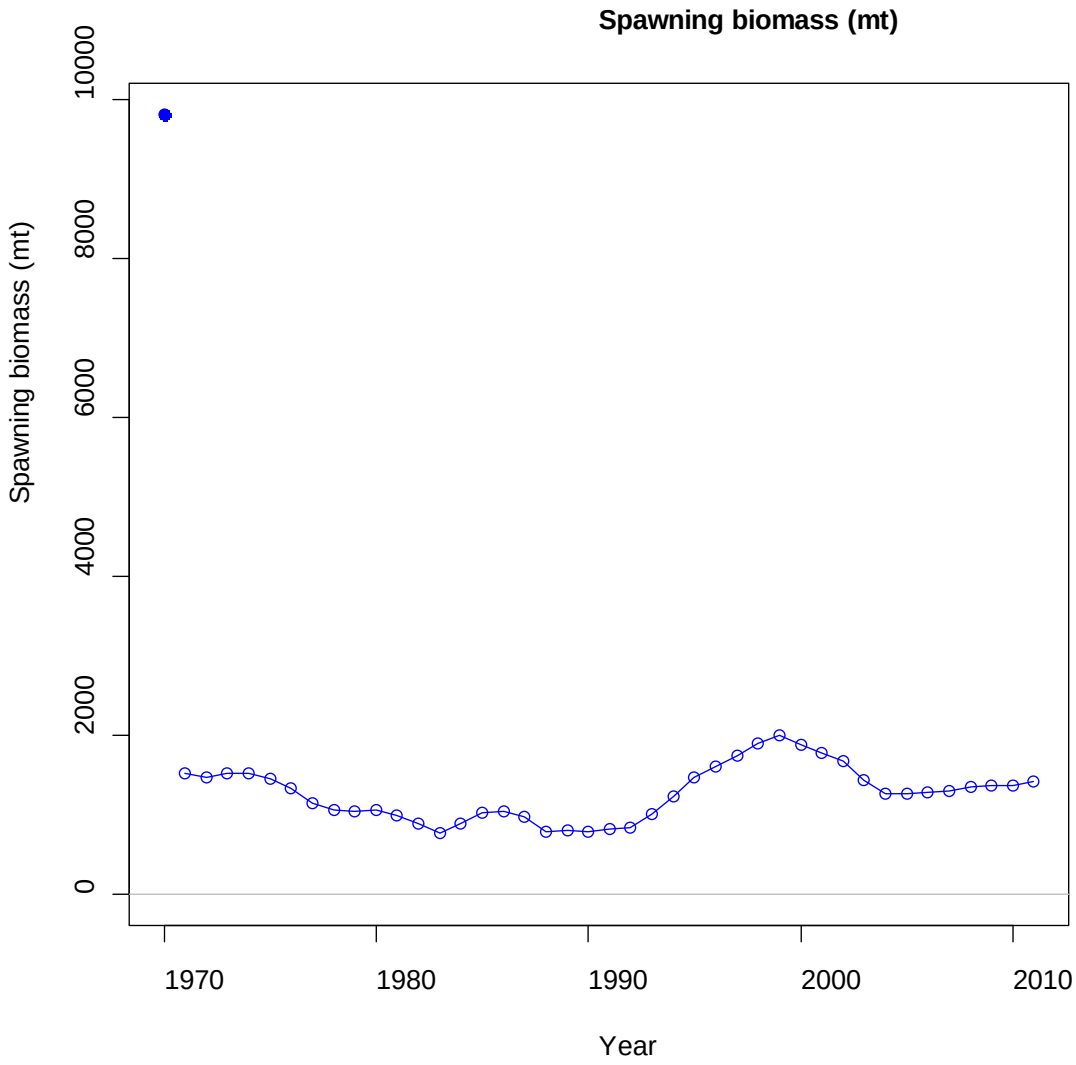

Figure S6. Estimated spawning biomass for southern California.

CENTRAL CALIFORNIA

The central population is estimated to have increased substantially since 1980 due to high recruitment. The model is very sensitive to initial parameter values and phases of estimation and has convergence issues. These are technical issues related to estimating parameters of the model that represent the biological and fishing processes and indicate that the values for these parameters determined by the model fitting procedure may not be reliable. However, the general conclusions remain consistent for different sets of parameters that are estimated.

Central California Catch Data

Data used in the assessment are only from north of Point Conception. Catch by fishery is shown in Figures S7 and S8.

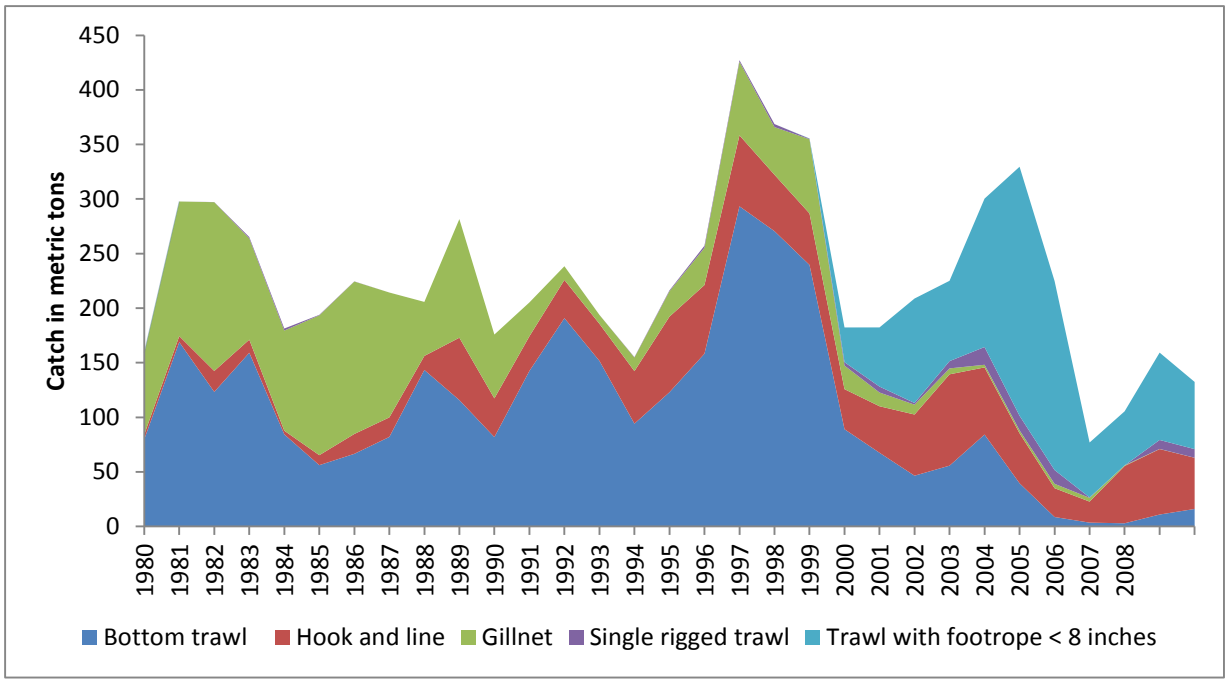

Figure S7. Commercial catch north of Point Conception in metric tons by gear type.

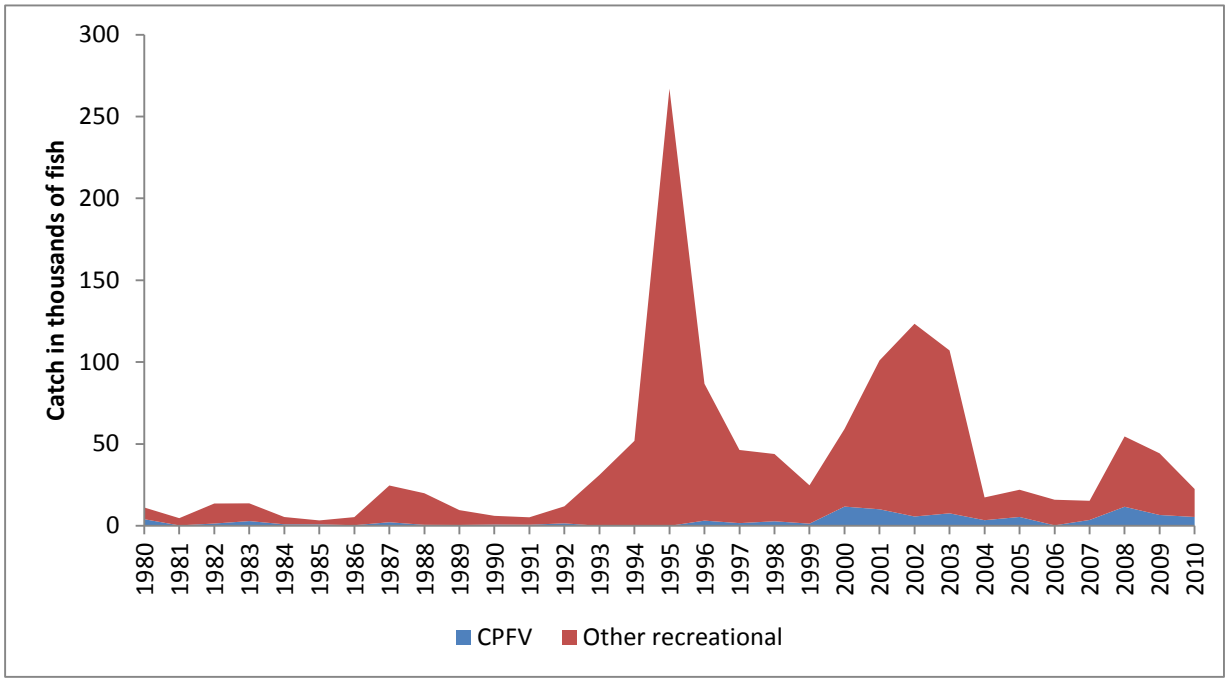

Figure S8. Recreational catch north of Point Conception by fishing mode in thousands of fish.

Primary Data Sets Used in Central California Model

The model is fit to an index of relative abundance based on standardized catch-per-unit-effort (CPUE) from CPFV log books (Figure S9). Only data from CPFV trips that

were considered to target California halibut based on expert judgment about associated species are used to create the index, which extends from 1980 to 2010. Data is also available prior to 1980, but lack detail to identify the target species. The catch of California halibut per angler hour for inshore blocks separated into north (Pigeon Point to Point Arena), central (Lopez Point to Pigeon Point), and south (Point Conception to Lopez Point). Sub-areas were standardized separately for the categorical variables year, month, and block using a delta-lognormal regression. A combined index was created as the average weighted by the number of blocks in each sub-area. This index is assumed proportional to the number of fish selected by the CPFV fishery. The index was used in the assessment model.

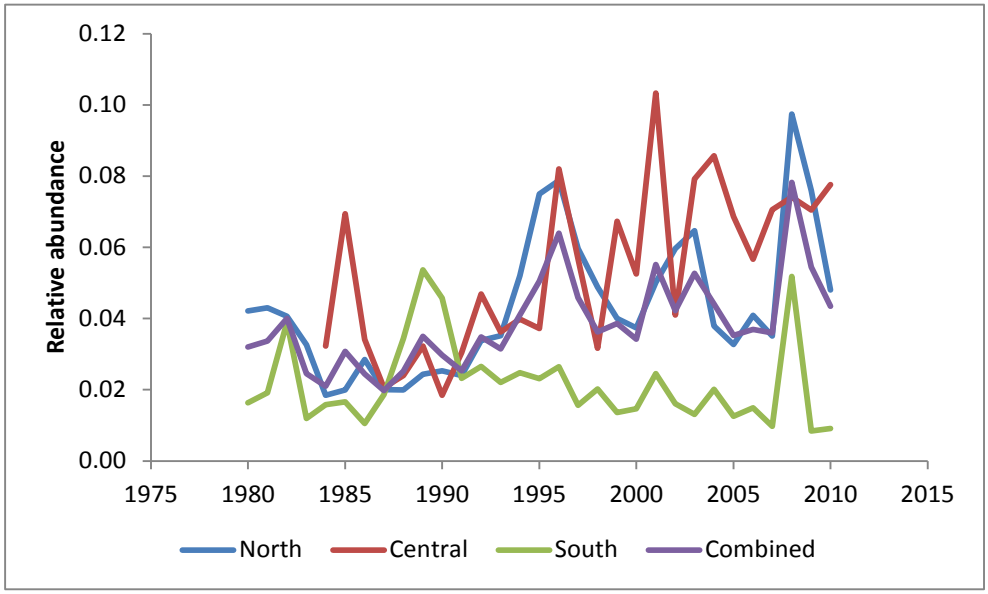

Figure S9. Index of relative abundance for the CPFV logbook data for three sub-areas north of Point Conception.

The model is also fit to indices of relative abundance based on trawl logbook CPUE, the Bay Delta trawl survey, and to an estimate of absolute abundance based on a swept area trawl survey. The model is fit to retained catch length and weight composition data for the CPFV/charter boat and private/rental boat fisheries. Length composition data for the other recreational fisheries (shore-based fisheries) are not used because the sample sizes are small and the catch by those fisheries is small. Length composition data for only the bottom trawl commercial fisheries are used because the sample sizes are small for the other fisheries and they are only available for a few years. Only one year of length composition data is used for the trawl fishery, but the selectivity is very different from the southern stock. The model is also fit to length composition data for the Bay Delta trawl survey and sex-specific age composition from the swept area trawl survey. A multinomial likelihood with the recorded sample sizes is used for the likelihood function. Years with sample sizes less than 20 fish were excluded from the analysis.

Central California Results

The population is estimated to be well above the biomass associated with maximum sustainable yield (Bmsy) and fishing mortality is well below the fishing mortality rate

associated with maximum sustainable yield (Fmsy) either using the estimated MSY quantities or the 25% proxy. The stock is estimated to have increased rapidly starting in 1995 (Figure S10). The increase in abundance is due to large recruitments, which appear to occur in a cyclic pattern, and the magnitude of the cycles increased after 1990.

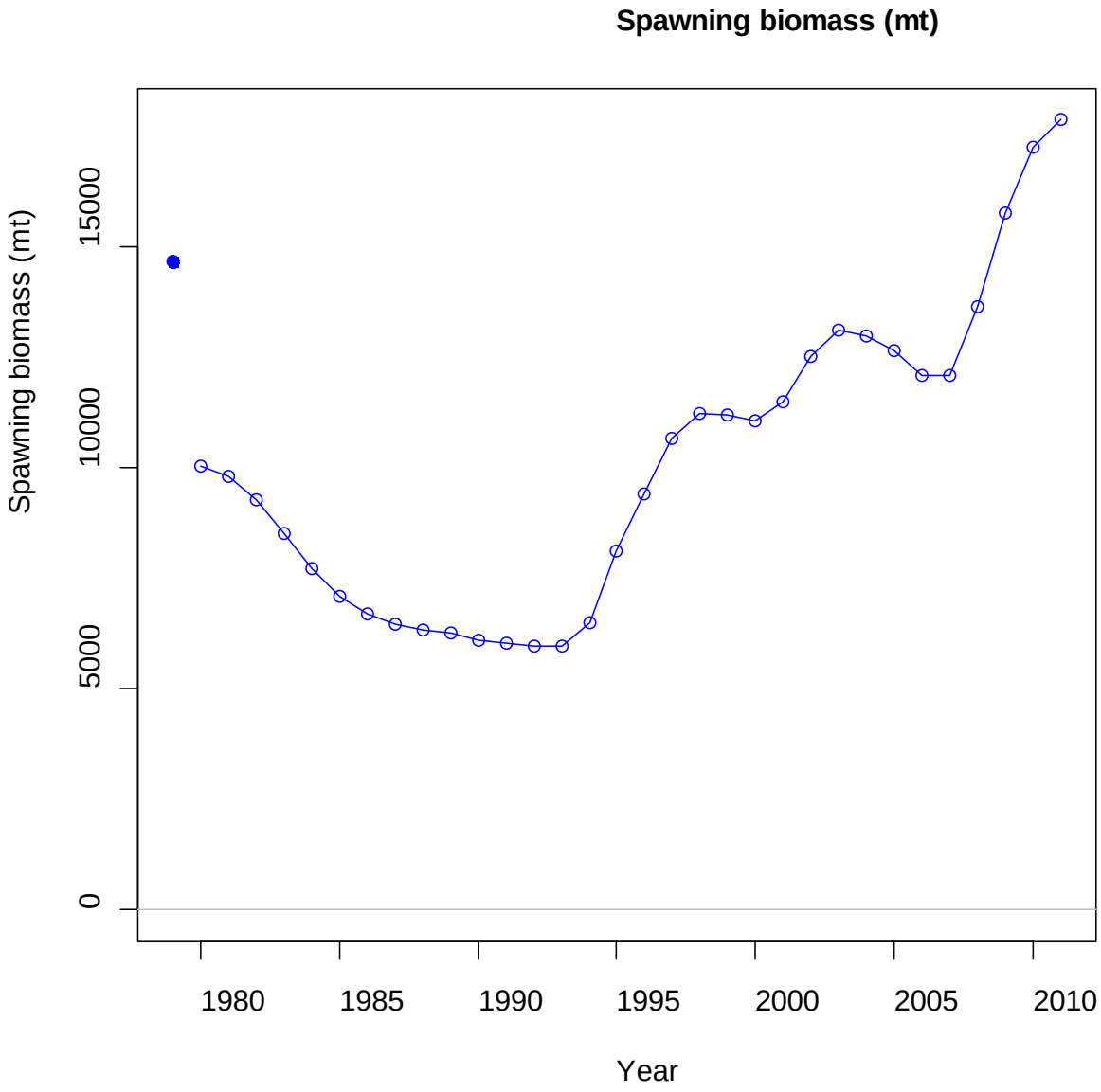

Figure S10. Estimated spawning biomass in Central Region..

The stock assessment results are consistent with the data. The estimated abundance trend is consistent with the trends in the indices of abundance. The model is only able to provide reasonable estimates of the absolute abundance if the swept area trawl survey estimate of absolute abundance is used in the model. However, the trends in abundance are robust and follow from the recruitment estimates. These results suggest the stock abundance is driven by recruitment, which is probably environmentally driven, and fishing is not currently a major factor in controlling the abundance level.