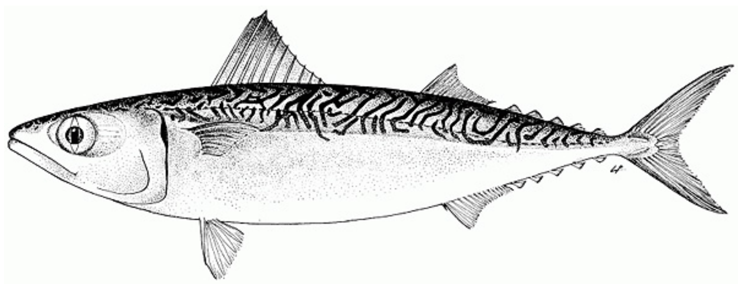
Appendix B: Pacific Mackerel Stock Assessment

PACIFIC MACKEREL (*Scomber japonicus*) STOCK ASSESSMENT FOR USA MANAGEMENT IN THE 2011-12 FISHING YEAR



by

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TABLE OF CONTENTS

PREFACE

Pacific mackerel stock assessment is conducted annually in support of the Pacific Fishery Management Council (PFMC) process, which ultimately establishes a harvest guideline ('HG' or quota) for the Pacific mackerel fishery that operates off the USA Pacific coast. The HG for mackerel applies to a fishing/management season that spans from July 1st and ends on June 30th of the subsequent year (henceforth, presented as a 'fishing year'). In this context, in this document, both a two-year (2010-11) and single-year (2010) reference refer to the same fishing year that spanned from July 1, 2010 to June 30, 2011. The primary purpose of the assessment is to provide an estimate of current abundance (in biomass), which is used in a harvest control rule for calculation of annual-based HGs. For details regarding this species' harvest control rule, see Amendment 8 of the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP), section 4.0 (PFMC 1998). It is important to note that in 2010, federal mandates required regional fishery Councils to begin transitioning to a revised process for quota determination, which relies on additional statistics not previously included in stock assessment documents and thus, such information is presented here along with the typical HG-related parameters of interest, see Amendment 13 of the CPS FMP (PFMC 2010a) and Ralston et al. (2011) for details regarding these changes.

The last stock assessment and related reviews for this species were completed in 2009 (Crone et al. 2009), with a HG serving for two years (PFMC 2010b). That is, in the past, this species was assessed annually, but given both the population's biology and limited fishing pressure the two-year span was deemed reasonable and adopted by the PFMC in 2009. The stock assessment presented here reflects a 'full' assessment that has undergone formal review as outlined by the PFMC and Science and Statistical Committee (SSC), see PFMC (2010c). Specifically, a stock assessment review (STAR) panel was convened from May 2-5, 2011 (NOAA Fisheries, Southwest Fisheries Science Center in La Jolla, CA) to evaluate the ongoing Pacific mackerel stock assessment. Important areas of general consensus reached by the STAR panel regarding the Pacific mackerel stock assessment conducted in 2011 follow [for further details of the week-long review see STAR (2011a)]:

- first and foremost, the stock assessment documentation/presentation followed stipulations set forth in the CPS stock assessment 'Terms of Reference' (PFMC 2010c) and produced a 'base case' model on which to provide formal management advice regarding exploitation of the Pacific mackerel population harvested off the Pacific coast of the United States (USA);
- a base case model (henceforth, Model *XA*) was identified as the final model configuration (hypothesized 'state of nature' or model 'scenario'), included fishery-dependent sources of data (landings, biological distributions, and catch-per-unit-effort indices of abundance), and represented a robust model that was developed via statistical (model fits and diagnostics supported 'inside the model') and pragmatic bases (sound assumptions/parameterizations supported 'outside the model');
- Model *XA* represented the culmination of substantial work over an extended timeframe, including evaluations at the data source (time series) and modeling (sensitivity analysis) levels, however, the current 'final' model is an ongoing effort that is improved upon as more pertinent time series become available and as such, still includes areas of uncertainty regarding the species' biology and influential model parameterizations, which necessarily

precludes precise estimation of absolute abundance and ultimately, may warrant consideration when setting harvest levels for this species [see Assessment uncertainty and Research and Data Needs sections, and STAR (2011a)].

Given the inherent difficulties presenting the voluminous amount of results from stock assessment modeling efforts extended over a broad time period, discussion and related displays are largely presented only for the final Model *XA*, with summaries/comparisons/etc. to other models of interest where appropriate (e.g., estimated time series from previous assessments and/or the sensitivity analysis conducted in 2011).

EXECUTIVE SUMMARY

Stock

Pacific mackerel (*Scomber japonicus*) in the northeastern Pacific Ocean range from southeastern Alaska to Banderas Bay (Puerto Vallarta), Mexico, including the Gulf of California. The fish are common from Monterey Bay, California, to Cabo San Lucas, Baja California, but are most abundant south of Point Conception, California. There are possibly three spawning 'stocks' along the Pacific coasts of the USA and Mexico: one in the Gulf of California; one in the vicinity of Cabo San Lucas; and one along the Pacific coast north of Punta Abreojos, Baja California and extending north to waters off southern California and further, off the Pacific Northwest depending on oceanographic conditions (say regimes). This latter sub-stock, the 'northeastern Pacific Ocean' population, is harvested by fishers in the USA and Baja California, Mexico, and is the population considered in this assessment.

Catches

Pacific mackerel landings from both commercial and recreational fisheries in California and commercial landings in Baja California represent the catch time series used in the assessment, with landings pooled into the two broadly-defined fisheries for all modeling purposes, i.e., commercial and recreational fishing sectors, respectively. Historically, total catch time series over the last 100 years can be broadly defined by two or more 'modes,' e.g., late 1920s to mid 1960s and late 1970s to the present (Figure ES-1). Recent catches are presented in Table ES-1. Note that a historically complete catch time series is presented for illustrative purposes only, given the final Model *XA* began in 1983.

Currently, catch (including biological) data are largely collected through a California Department of Fish and Game (CDFG) port (commercial) sampling program, as well as via the Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW). That is, the CDFG has collected biological data on Pacific mackerel landed in the San Pedro (southern California) fishery since the late 1920s. Further, to some degree, port sampling data have been collected by researchers from Ensenada, Mexico (Instituto Nacional de la Pesca, INP) since 1989; however, this information is only now being distributed at a broader scale through government/academic supported programs. Recreational catches are primarily associated with southern California's marine recreational angler community, including commercial passenger fishing vessel (CPFV), as well as other modes of fishing, such as pier and private vessel. Recreational fishery-based landings are much lower than those related to commercial fisheries (i.e., sport fisheries generate less than 5% of the total catch in any given year).

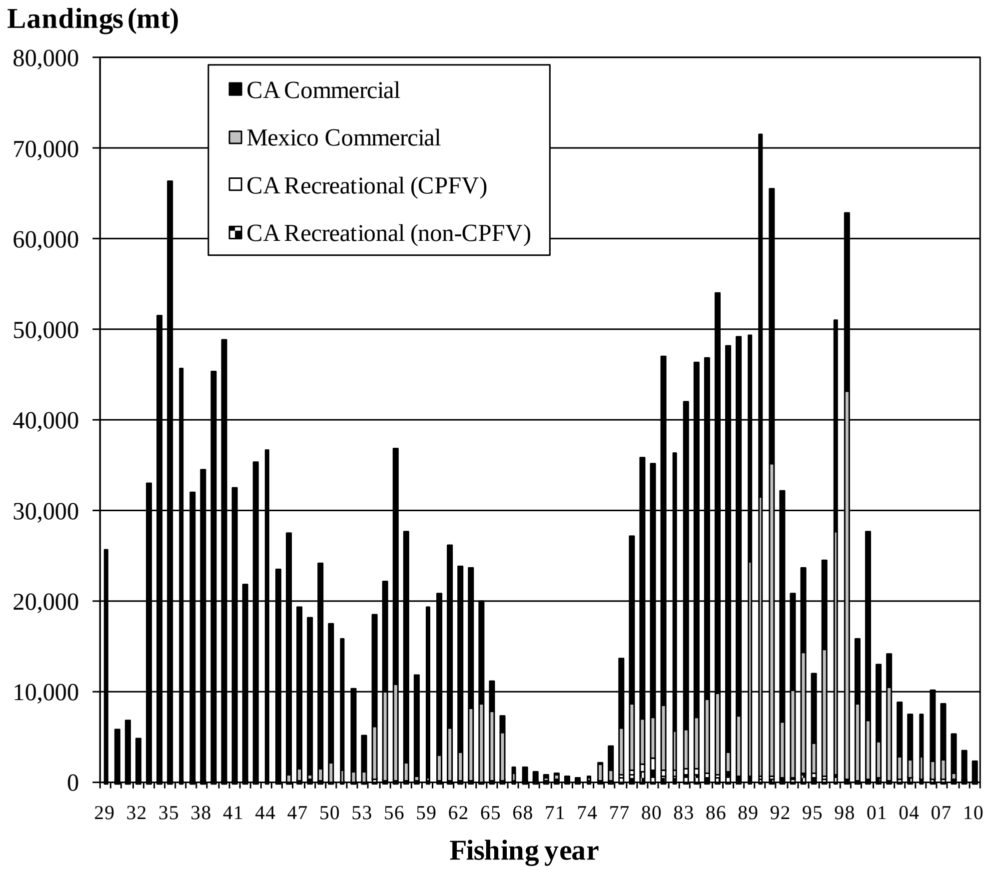

Figure ES-1. Commercial and recreational landings (mt) of Pacific mackerel in the USA (CA commercial, recreational-CPFV, and recreational-non-CPFV) and Mexico (commercial), (1929-10).

Table ES-1. Commercial and recreational landings (mt) of Pacific mackerel in the USA (CA commercial, recreational-CPFV, and recreational-non-CPFV) and Mexico (commercial), (2000-10).

Fishing year	USA Commercial (mt)	Mexico Commercial (mt)	Recreational CPFV (mt)	Recreational non-CPFV (mt)	Total (mt)
00	20,936	6,530	78	248	27,792
01	8,436	4,003	51	520	13,010
02	3,541	10,328	22	232	14,123
03	5,972	2,618	28	295	8,913
04	5,012	2,017	23	510	7,562
05	4,572	2,507	21	375	7,475
06	7,870	1,986	16	356	10,228
07	6,208	2,218	19	291	8,737
08	4,281	803	13	267	5,364
09	3,011	171	13	254	3,450
10	2,086	171	5	95	2,357

Data and assessment

Historically, various age-structured assessment models have been used to assess the status of Pacific mackerel off the west coast of North America, which were generally based on fishery landings and length/age distributions, as well as relative indices of abundance from fisheries and/or research surveys. The last assessment of Pacific mackerel was completed in 2009 for USA management in the 2009-10 fishing year. The current assessment includes the following primary sources of data: catch time series (USA/Mexico commercial and USA recreational fisheries); length (USA recreational fishery) and age (USA commercial fishery) distribution time series; and index of abundance time series from recreational fishery surveys.

Unresolved problems and uncertainties

First and foremost, given Pacific mackerel is a 'transboundary' stock, the assessment would benefit greatly from additional biological and/or 'survey' data (e.g., index of abundance time series) from Mexico. In particular, there is currently no synoptic survey (fishery-independent) index of abundance that pertains to the entire (hypothesized) range of the modeled stock. However, it is important to note that progress continues in terms of addressing these two research efforts, which are expected to gain further support in the coming years. That is, the need for formal data exchange workshops with Mexico (as well as Canada) researchers, and commitment to synoptic surveys that provide representative sample data, particularly, programs related to the CalCOFI and acoustic-trawl survey operations based at the SWFSC. Also, see Research and data needs below.

Total stock biomass

Total biomass (age-1+ biomass, *B*) has steadily declined from the mid 1980s to the early 2000s, at which time the population began to increase moderately in size, with some signs of 'rebuilding' observed over the last several years (Figure ES-2 and Table ES-2). However, in historical terms, the population remains at a relatively low abundance level, due primarily to oceanographic conditions, given limited fishing pressure over the last decade has not likely compromised this species' biology (i.e., role in the larger CPS assemblage off the Pacific coast of North America). Finally, as noted previously, recent estimates of stock size are necessarily related to assumptions regarding the dynamics of the fish (biology) and fishery (operations) over the last several years, which generally confounds long-term (abundance) forecasts for this species (also see Assessment uncertainty section).

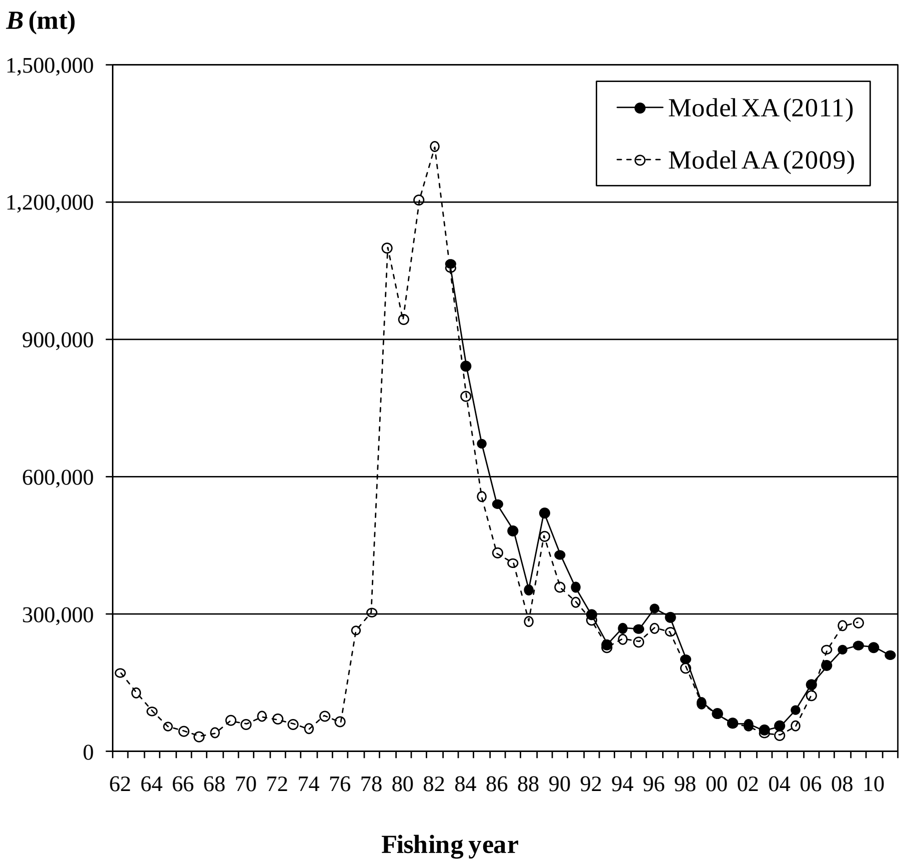

Figure ES-2. Estimated total stock biomass (age 1+ fish in mt, *B*) of Pacific mackerel based on the final Model *XA* (1983-11). Also presented is estimated *B* time series from the previous assessment conducted in 2009 (Model *AA*, 1962-09). Note Model *XA* starts in 1983 (vs. 1962).

Table ES-2. Estimated recruitment (*R*), total biomass (*B*), and spawning stock biomass (*SSB*) of Pacific mackerel based on the final Model *XA* (1983-11).

Fishing year	*R* (age-0, in 1,000s)	*B* (age-1+, mt)	*SSB* (mt)
98	91,301	202,367	116,867
99	158,241	108,333	73,713
00	206,257	83,644	56,033
01	197,479	62,130	32,964
02	90,622	60,757	25,380
03	225,580	47,902	21,127
04	435,040	56,302	20,756
05	625,105	91,182	25,241
06	585,916	146,630	37,196
07	589,941	188,743	55,562
08	427,113	222,844	77,881
09	371,214	231,853	99,082
10	280,972	228,015	112,880
11		211,126	

Spawning stock biomass

Spawning stock biomass (*SSB*) followed the general trajectory as observed in the estimated *B* time series, with magnitudes that are roughly one-half the size of total stock biomass (Figure ES-3 and Table ES-2).

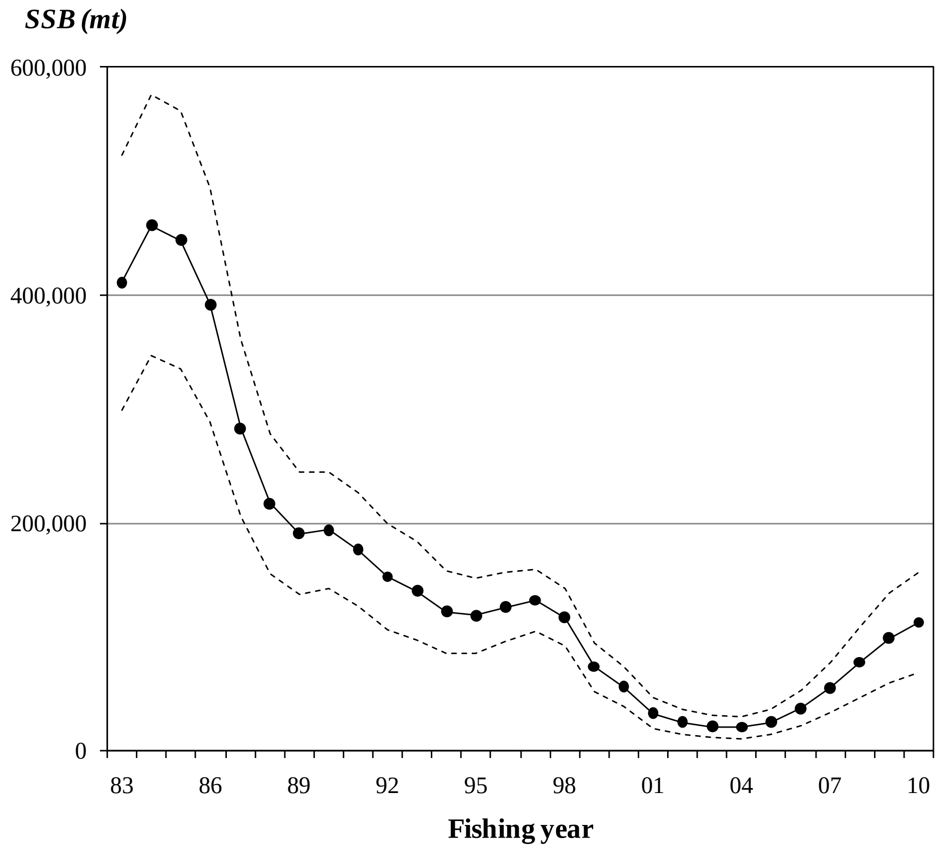

Figure ES-3. Estimated spawning stock biomass (*SSB*) of Pacific mackerel based on the final Model *XA* (1983-10). A confidence interval (95% CI) is also presented as dashed lines.

Recruitment

As expected, historically, estimated recruitment (*R*) has been highly variable, remaining relatively low since the population's last period of (high) recruitment success in the mid 1980s and moderate recruitment levels in the mid 1990s (Figure ES-4 and Table ES-2).

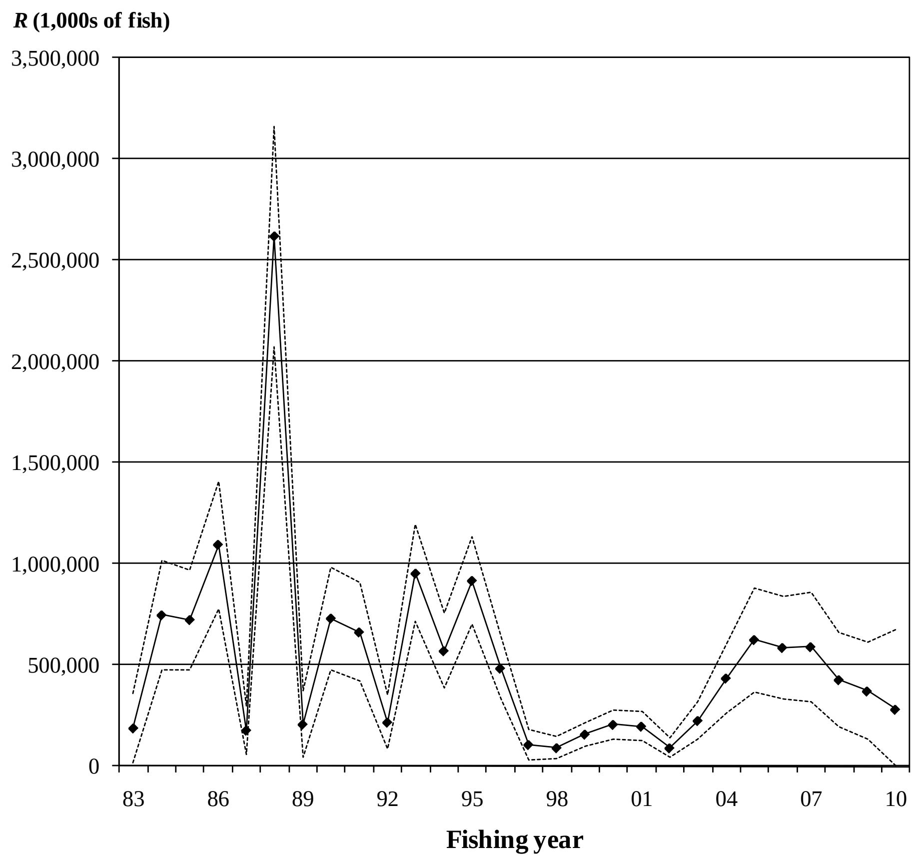

Figure ES-4. Estimated recruitment (age-0 fish in 1,000s, *R*) of Pacific mackerel based on the final Model *XA* (1983-10). A confidence interval (95% CI) is also presented as dashed lines.

Management performance

Since 2000, Pacific mackerel has been managed under a Federal Management Plan (FMP) harvest policy, stipulating that a maximum sustainable yield (MSY) for this species should be set according to the following harvest control rule:

Harvest = (Biomass-Cutoff) • Fraction • Distribution,

where Harvest is the harvest guideline (HG), Biomass is age 1+ stock biomass (mt) in the current assessment year (211,126 mt on July 1, 2011), Cutoff (18,200 mt) is the lowest level of estimated biomass at which harvest is allowed, Fraction (30%) is the proportion of biomass above the Cutoff that can be harvested by fisheries, and Distribution (70%) is the average fraction of total Biomass (ages 1+) assumed in USA waters (PFMC 1998). The HGs under the federal FMP are applied to a July-June fishing 'year.' Landings and associated HGs since 1992 are presented in Figure ES-5. The HG for the 2011-12 fishing year based on Model *XA* is 40,514 mt (Table ES-3). Also see Harvest Control Rule for USA Management in 2011-12 section for alternative methods for quota determination that are used in concert with the current HG.

From 1985 to 1991, the biomass exceeded 136,000 mt and no state quota restrictions were in effect. State quotas for 1992-00 fishing years averaged roughly 24,000 mt. The HGs averaged roughly 15,000 mt from 2001-06. In 2007, the HG was increased substantially to over 70,000 mt based largely on assumptions regarding variability surrounding estimated recruitment and remained at an elevated level until 2009, when the calculated HG (55,408 mt) was reduced by management (PFMC) to 10,000 mt to address uncertainty related to two alternative models (see Preface and PFMC 2010b); the 10,000 mt HG was adopted in 2010 as well. Finally, note that the HG in 2011 (40,514 mt) is strictly preliminary, given formal adoption of the HG will be addressed at the next Council meeting in June 2011. It is important to note that over the last decade, from a management context, the fishery has not fully utilized HGs, with average yields since this time of roughly 5,000 mt (Figure ES-5).

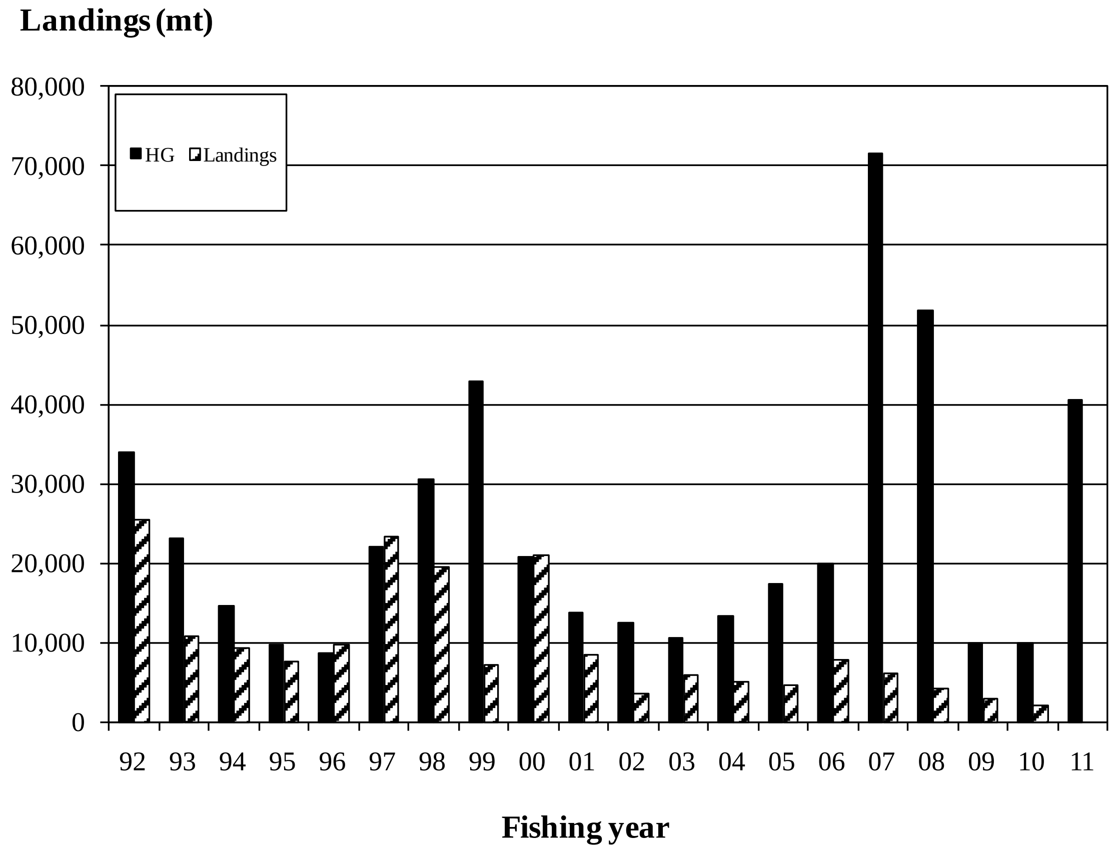

Figure ES-5. Commercial landings (USA directed fishery in mt) and quotas (HGs, mt) for Pacific mackerel (1992-11).

Table ES-3. Harvest control rule statistics for the Pacific mackerel fishery (2011-12). Also, see Harvest Control Rule for USA Management in 2011-12.

B **(Age 1+, mt)**	**Cutoff (mt)**	**Fraction**	**Distribution**	**HG (mt)**
211,126	18,200	30%	70%	**40,514**

Research and data needs

First and foremost, given the transboundary status of this fish population, it is imperative that efforts continue in terms of encouraging collaborative research and data exchange between NOAA Fisheries (Southwest Fisheries Science Center) and researchers from both Canada’s and in particular, Mexico’s academic and federal fishery bodies, i.e., such cooperation is critical to providing a synoptic assessment that considers available sample data across the entire range of this species in any given year.

Second, fishery-independent survey data for measuring (relative) changes in mackerel spawning (or total) biomass are currently lacking. Further, at this time, two indices of relative abundance are used in the assessment, which are developed from a marine recreational fishery (CPFV fleet and related fishing modes) that typically do not (directly) target the species. That is, the recently implemented CRFS provides useful information regarding this species' dynamics and further, represents a valuable survey for obtaining abundance trends for finfish generally targeted by marine recreational fishers in coastal waters off California. In this context, it is imperative that future research funds be focused on improvement (e.g., broadening the scope and increasing the frequency) of the current fishery-independent surveys operating out of the NOAA's SWFSC (e.g., CalCOFI and acoustic-trawl surveys), with emphasis on a long-term horizon, which will necessarily rely on cooperative efforts between the industry, research, and management, as well as cooperation from international fishery agencies.

Third, given the importance of age (and length) distribution time series to developing a sound understanding of this species’ population dynamics, it is critical that data collection programs at the federal and particularly, the state level continue to be supported adequately. In particular, CDFG/NOAA funding should be bolstered to ensure ongoing ageing-related laboratory work is not interrupted, as well as providing necessary funds for related biological research that is long overdue. For example, maturity-related time series currently relied upon in the assessment model are based on data collected over twenty years ago during a period of high spawning biomass that does not reflect current levels, i.e., the SWFSC and CDFG have begun field/laboratory efforts collecting, processing, and analyzing reproductive samples from Pacific mackerel harvested in both the recreational and commercial fisheries. Also, further work is needed to obtain more timely error estimates from production ageing efforts in the laboratory, i.e., accurate interpretation of age-distribution data used in the ongoing assessment necessarily requires a reliable ageing error time series.

Finally, the MSY control rule (HG) utilized in the Pacific mackerel federal CPS-FMP was developed in the mid-1980s based on estimated abundance and stock-recruitment data at that time and thus, the control rule should be re-examined using new data and simulation methods. Given substantial amounts of additional sample data have accumulated since the initial research that was undertaken to formally establish this harvest strategy, it would be prudent to conduct further simulation modeling work to address particular parameters included in the overall control rule (including ‘cutoff,’ ‘fraction,’ and ‘distribution’ values). This particular research need should be considered in context with the new federal mandates regarding quota determination, i.e., in concert with reliance on current HG vs. new stipulations (PFMC 2010a).

INTRODUCTION

Distribution

Pacific mackerel (*Scomber japonicus*; a.k.a. 'chub mackerel' or 'blue mackerel') in the northeastern Pacific range from southeastern Alaska to Banderas Bay (Puerto Vallarta), Mexico, including the Gulf of California (Hart 1973). They are common from Monterey Bay, California, to Cabo San Lucas, Baja California, but are most abundant south of Point Conception, California. Pacific mackerel usually occur within 30 km of shore, but have been captured as far as 400 km offshore (Fitch 1969; Frey 1971; Allen et al. 1990; MBC 1987).

Migration

Pacific mackerel adults are found in water ranging from 10 to 22.2°C (MBC 1987) and larvae may be found in water around 14°C (Allen et al. 1990). As adults, Pacific mackerel move north in summer and south in winter between Washington and Baja California (Fry and Roedel 1949; Roedel 1949), with northerly movement in the summer accentuated during El Niño events (MBC 1987). There is an 'inshore-offshore' migration off California, with increased inshore abundance from July to November and increased offshore abundance from March to May (Cannon 1967; MBC 1987). Adult Pacific mackerel are commonly found near shallow banks. Juveniles are found off sandy beaches, around kelp beds, and in open bays. Adults are found from the surface to 300 m depth (Allen et al. 1990). Pacific mackerel often school with other coastal pelagic species (CPS), particularly jack mackerel and Pacific sardine, and likely based on age-dependent attributes as well (Parrish and MacCall 1978).

Over the last two decades, the stock has likely more fully occupied the northernmost portions of its range in response to a warm oceanographic regime in the northeastern Pacific Ocean, with further evidence, given Pacific mackerel have been found as far north as British Columbia, Canada (Ware and Hargreaves 1993; Hargreaves and Hungar 1995). During the summer months, Pacific mackerel are commonly caught incidentally in commercial whiting and salmon fisheries off the Pacific Northwest, but historically, these catches have been limited. Pacific mackerel sampled from Pacific Northwest incidental fisheries are generally older and larger than those captured in the southern California fishery (Hill 1999). In addition, this species is harvested by recreational anglers on CPFVs and private vessels, but is typically not highly prized in the fishery, with catches relatively low when compared with commercial landings.

Life history

Pacific mackerel found off the Pacific coast of North America are the same species found elsewhere in the Pacific, Atlantic, and Indian Oceans (Collette and Nauen 1983). Synopses regarding the biology of Pacific mackerel are presented in Kramer (1969) and Schaefer (1980).

Currently, the general consensus within the coastal pelagic species research forum is that there are likely three spawning stocks in the northeastern Pacific Ocean: one in the Gulf of California, one near Cabo San Lucas, and one along the Pacific coast north of Punta Abreojos, Baja California to British Columbia, Canada. Spawning occurs from Point Conception, California to Cabo San Lucas from 3 to 320 km offshore (Moser et al. 1993). Off California, spawning occurs from late April to September at depths to 100 meters. Off central Baja California, spawning occurs year round, peaking from June through October. Around Cabo San Lucas, spawning occurs primarily from late fall to early spring. Pacific mackerel seldom spawn north of Point Conception (Fritzsche 1978; MBC 1987), although young-of-year (age-0) fish have been recently reported as far north as Oregon and Washington.

Like many coastal pelagic species with similar life history strategies, Pacific mackerel have indeterminate fecundity and appear to spawn whenever sufficient food is available and appropriate oceanographic conditions prevail. Individual fish may spawn eight times or more per year and release batches of 68,000 eggs per spawning. Actively spawning fish appear capable of spawning daily or every other day (Dickerson et al. 1992).

Pacific mackerel larvae eat copepods and other zooplankton, including fish larvae (Collette and Nauen 1983; MBC 1987). Juvenile and adult mackerel feed on small fish, fish larvae, squid, and pelagic crustaceans, such as euphausids (Clemmens and Wilby 1961; Turner and Sexsmith 1967; Fitch 1969; Fitch and Lavenberg 1971; Frey 1971; Hart 1973; Collette and Nauen 1983). Pacific mackerel larvae are subject to predation from a number of invertebrate and vertebrate planktivores. Juvenile and adults are eaten by larger fishes, marine mammals, and seabirds. Principal predators include porpoises, California sea lions, pelicans, and large piscivorous fishes, such as sharks and tunas. Pacific mackerel school as a defense against predation, often with other pelagic species, including jack mackerel and Pacific sardine.

Population dynamics of the Pacific mackerel stock off southern California have been extensively studied in the past and of particular importance was pioneering research conducted during the 1970s and 1980s, e.g., Parrish (1974), Parrish and MacCall (1978), Mallicoate and Parrish 1981, and Macall et al. (1985). More recently, USA-based research efforts associated with pelagic species that inhabit coastal areas of the Pacific coast of North America have focused on the Pacific sardine population. Pacific mackerel experience cyclical periods of abundance ('boom-bust'), which is typical of other small pelagic species that are characterized by relatively short life spans and high intrinsic rates of increase. Analysis of mackerel scale-deposition data (Soutar and Issacs 1974) indicated that periods of high biomass levels, such as during the 1930s and 1980s, are relatively rare events that might be expected to occur, on average, about once every 60 years (MacCall et al. 1985). It is important to note that assessment model structure and results generally support MacCall's research, with periods of strong recruitment estimates occurring no more frequently than at least 30 years or so. Recruitment is highly variable over space and time and not likely related to spawning biomass stock size (Parrish 1974), or at least not tightly linked to parent abundance levels within the historical range of estimated spawning stock biomass levels (Parrish and MacCall 1978).

Stock structure and management units

The full range of Pacific mackerel in the northeastern Pacific Ocean is from southeastern Alaska to Banderas Bay (Puerto Vallarta), Mexico, including the Gulf of California. The majority of the fish are typically distributed from Monterey Bay, California, to Cabo San Lucas, Baja California, being most abundant south of Point Conception, California. It is likely that multiple 'spawning' stocks exist along the Pacific coasts of the USA and Mexico, although at this time, stock structure exhibited by this species is not known definitively: one in the Gulf of California; one in the vicinity of Cabo San Lucas; and one along the Pacific coast north of Punta Abreojos, Baja California and extending north to waters off southern California and further, off the Pacific

Northwest depending on oceanographic conditions (say regimes). This latter sub-stock, the 'northeastern Pacific Ocean' population, is harvested by fishers in the USA and Baja California, Mexico, and is the population considered in this assessment.

The Pacific Fishery Management Council (PFMC) manages the northeastern Pacific stock as a single unit, with no area- or sector-specific allocations. However, the formal Fishery Management Plan (FMP) harvest control rule does include a stock distribution adjustment, based on a long-term assumption that roughly 70% of this transboundary population resides in USA waters in any given year (PFMC 1998).

Fishery descriptions

Pacific mackerel are currently harvested by three 'fisheries': the USA commercial fishery that primarily operates out of southern California; a sport fishery based largely in southern California; and the Mexico commercial fishery that is based in Ensenada and Magdalena Bay, Baja California. In the commercial fisheries, Pacific mackerel are landed by the same boats that catch Pacific sardine, anchovy, jack mackerel, and market squid (generally, referred to as the west coast 'wetfish' fleet). There is no directed fishery for mackerel in Oregon or Washington; however, small amounts (100-300 mt annually) are taken (incidentally) by whiting trawlers and salmon trollers. Catches in the Pacific Northwest peaked at 1,800 mt following the major El Niño event of 1997-98.

The history of California's Pacific mackerel fishery has been reviewed by Croker (1933; 1938), Roedel (1952), and Klingbeil (1983). Pacific mackerel supported one of California's major fisheries during the 1930s and 1940s and more recently, particular years in the 1980s and 1990s. During the early years of the fishery, Pacific mackerel were taken by lampara and pole-and-line boats, which were replaced in the 1930s by the same purse seine fleet that fished for sardine. Before 1929, Pacific mackerel were taken incidentally, in relatively small volumes, with sardine and sold as fresh fish (Frey 1971). Canning of Pacific mackerel began in the late 1920s and increased as greater processing capacities and more marketable 'packs' were developed. Landings decreased in the early 1930s due to the economic depression and subsequent decline in demand, but increased significantly by the mid-1930s (66,400 mt in 1935-36). During this period, Pacific mackerel were second only to Pacific sardine in total (annual) landings. Harvests subsequently underwent a long-term decline and for many years, demand for canned mackerel remained steady and exceeded supply. Supply reached record low levels in the early 1970s, at which time the State of California implemented a 'moratorium' on the directed fishery.

Following a period of 'recovery' that spanned from the mid to late 1970s, the moratorium was lifted and subsequently, through the 1990s, the fishery ranked third in volume for finfish landed in California. During this time, the market for canned mackerel fluctuated due to availability and economic conditions. Domestic demand for canned Pacific mackerel eventually waned and the last mackerel cannery in California closed in 1992. At present, most Pacific mackerel is used for human consumption or pet food, with a small, but increasing amount sold as fresh fish.

Pacific mackerel are caught by recreational anglers in southern California, but seldom as a target species (Young 1969). During the 1980s, California's recreational catch averaged 1,500 mt per year, with Pacific mackerel being one of the most important species harvested by the California-based CPFV fleet. Pacific mackerel are also harvested in California's recreational fishery as bait for directed fishing on larger pelagic species. Additionally, Pacific mackerel are caught by anglers in central California, but typically, only in small amounts. The state-wide sport harvest constitutes a small fraction (less than 5% in weight) of the total landings.

The Mexico fishery for Pacific mackerel is primarily based in Ensenada and Magdalena Bay, Baja California. The Mexico purse seine fleet has slightly larger vessels, but is similar to southern California's fleet with respect to gear (mesh size) and fishing practices. The fleet operates in the vicinity of ports and also targets other small pelagic species. Demand for Pacific mackerel in Baja California increased after World War II. Mexico landings remained stable for several years, rose to 10,725 mt in 1956-57, then declined to a low of 100 tons in 1973-74. Catches in Mexico remained relatively low through the late 1980s. Landings of Pacific mackerel in Ensenada peaked twice, first in 1991-92 at 34,557 mt, and again in 1998-99, at 42,815 mt. The Ensenada fishery has been comparable in volume to the southern California fishery since 1990. In Baja California, Pacific mackerel are either canned for human consumption or reduced to fish meal.

Management history

The state of California first applied management measures to Pacific mackerel in 1970, after the stock had collapsed in the mid 1960s. A moratorium was placed on the fishery at this time, with a small allowance for incidental catch in mixed-fish landings. In 1972, legislation was enacted that imposed a landing quota based on the estimate of age-1+ ($\geq$1-yr old fish) biomass generated from formal assessments. A couple of very strong year classes in the late 1970s triggered a stock recovery (increase in total abundance), which was followed by the fishery being reopened under a quota system in 1977. During the span of the recovery period from 1977 to 1985, various adjustments were made to quotas for directed take of Pacific mackerel and to incidental catch limits, i.e., even during the 'moratorium' substantial allowances were made for incidental catches associated with this species (Parrish and MacCall 1978).

State regulations enacted in 1985 imposed a moratorium on directed fishing when the total biomass was less than 18,200 mt, and limited the incidental catch of Pacific mackerel to 18% during such moratoriums. The fishing year was set to extend from July 1st to June 30th of the following year. Seasonal quotas, equal to 30% of the total biomass in excess of 18,200 mt, had been allowed when the biomass was between 18,200 and 136,000 mt, and there was no quota limitation when the total biomass was 136,000 mt or greater.

A federal fishery management plan (FMP) for coastal pelagic species, including Pacific mackerel, was implemented by the PFMC in January 2000 (PFMC 1998). The FMP's harvest policy for Pacific mackerel, originally implemented by the State of California, is based on simulation analysis conducted during the mid 1980s, with the addition of a proration to account nominally for the portion of the 'stock' assumed to inhabit USA waters, see MacCall et al. (1985) and PFMC (1998). The current maximum sustainable yield (MSY) control rule for Pacific mackerel is:

$$\text{Harvest} = (\text{Biomass-Cutoff}) \bullet \text{Fraction} \bullet \text{Distribution},$$

where Harvest is the harvest guideline (HG), Cutoff (18,200 mt) is the lowest level of estimated biomass at which harvest is allowed, Fraction (30%) is the proportion of biomass above the Cutoff that can be harvested by fisheries, and Distribution (70%) is the average fraction of total Biomass (ages 1+) assumed in USA waters. The HGs under the federal FMP are applied to a July-June 'fishing year.'

California's recreational catch of Pacific mackerel is included within the USA HG, but there are no other restrictions (e.g., size or bag limits) on this fishery. Total annual harvest of Pacific mackerel by the Mexico fishery is not regulated by quotas, but there is a minimum legal size limit of 255 mm. International management agreements between the USA and Mexico regarding transboundary stocks, such as Pacific mackerel, have not been developed to date (see Preface and Research and data needs).

Management performance

From 1985 to 1991, the biomass exceeded 136,000 mt and no state quota restrictions were in effect. State quotas for 1992-00 fishing years averaged roughly 24,000 mt. The HGs averaged roughly 15,000 mt from 2001-06. In 2007, the HG was increased substantially to over 70,000 mt based largely on assumptions regarding variability surrounding estimated recruitment and remained at an elevated level until 2009, when the calculated HG (55,408 mt) was reduced by management (PFMC) to 10,000 mt to address uncertainty related to two alternative models (see Preface and PFMC 2010b); the 10,000 mt HG was adopted in 2010 as well. It is important to note that over the last decade, from a management context, the fishery has not fully utilized HGs, with average yields since this time of roughly 5,000 mt. Finally, recent legislation concerning management of exploited fisheries in the USA now require alternative methods for quota determination that are used in concert with the HG method above [see PFMC (2010a), SSC (2010), and Ralston et al. (2011) for methods used to derive OFL, ABC, ACL, and associated buffer values]. Also, see Harvest Control Rule for USA Management in 2011-12 section below.

ASSESSMENT

Ultimately, the Pacific mackerel stock assessment final Model *XA* presented here reflects two primary changes from recently conducted assessments, including: (1) an additional index of abundance derived from recreational fishery data collected through the newly implemented California Recreational Fishery Survey (CRFS, 2004-10); and (2) additional (historical) length distribution data collected from an observer (CPFV) sampling program conducted by CDFG from 1985-89. Other changes associated with estimation methods for influential areas of parameterization were also necessary, particularly, those related to selectivity/catchability associated with biological distributions and indices of abundance. Parameterization details associated with Model *XA* are presented below (see Model description sections) and in Table 5.

A full suite of assessment-related displays for the final Model *XA* are presented in the body of this document. Additionally, SS program files associated with Model *XA* are presented in Appendix 1. Finally, Table 5 presents a broad range of important parameter-related statistics associated with Model *XA*, as well as for the final model adopted in the previous formal assessment conducted in 2009 (aka Model *AA*).

History of modeling approaches

Parrish and MacCall (1978) were the first to provide stock status determinations for Pacific mackerel using an age-structured population model (i.e., traditional virtual population analysis, VPA). The ADEPT model (the 'ADAPT' VPA modified for Pacific mackerel; Jacobson 1993 and Jacobson et al. 1994b) was used to evaluate stock status and establish management quotas for approximately 10 years. The assessment conducted in 2004 (for 2004-05 management) represented the final ADEPT-based analysis for this stock (see Hill and Crone 2004a). That is, the forward-simulation model ASAP (Legault and Restrepo 1998) was reviewed and adopted for Pacific mackerel at the 2004 STAR Panel (Hill and Crone 2004b). The ASAP model was used for assessments and management advice from 2005 through 2008. The STAR conducted in 2009 determined that the SS model provided the best (most flexible) platform for assessing the status of Pacific mackerel currently (i.e., the 2009-10 fishing year) and in the future, see STAR (2009).

Sources of data

Fishery-dependent data

<u>Overview</u>

Fishery-related data for assessing Pacific mackerel included: landings (California commercial, California recreational, and Mexico commercial); port sample (biological) data from California's commercial (purse seine) and recreational (CPFV) fisheries; biological (length) data from an observer (CPFV) sampling program coordinated through the CDFG; and logbook (CPFV) and survey (CRFS) data from marine recreational fisheries for purposes of developing catch-per-unit-effort (CPUE) indices. Since 1992, the CDFG has collected biological data on Pacific mackerel landed in the southern California fishery (primarily, San Pedro). Samples have also been collected from the Monterey fishery when available. For this assessment, raw sample data were available from 1962 through 2010. Biological samples include whole body weight, fork length, sex, maturity, and otoliths for age determination. Currently, CDFG collects 12 'random' (port) samples per month (25 fish per sample) to determine length/age distributions, catch-at-age, weight-at-age, etc. for the directed fishery. Mexico port sampling data have been collected by INP-Ensenada since 1989, but have not been available for purposes of inclusion in this ongoing assessment effort and thus, California commercial data were assumed to be representative of the combined commercial fisheries. Lack of Baja California port sampling data is not a serious problem for some years when Mexico catches were low. However, in recent years, Baja California and California catches have been roughly equal in volume, which necessarily increases the likelihood that potential biases associated with the omission of (and subsequent assumptions concerning) sample data from the Mexico fishery. Sample sizes associated with this data collection program are presented in Table 1.

Pacific mackerel were aged by CDFG biologists, based on identification of annuli in whole sagittae. Historically, a birth date of May 1st was used to assign year class (Fitch 1951). In 1976, ageing protocols changed to a July 1st birth date, which coincided with a rebounding resource, resumed fishery sampling, and a change in the management season from a May 1st opening to a July 1st start date.

Fishery inputs were compiled by 'biological year,' based on the birth dates used to assign age. Therefore, data prior to 1976-77 were aggregated in the biological year of May 1st (year$_x$) through April 30th (year$_{x+1}$), and data from 1976-77 forward were aggregated July 1st (year$_x$)

through June 30th ($year_{x+1}$). The biological year used in this assessment is synonymous with the 'fishing year' defined previously, as well as with 'fishing season' as reported in the historical literature. That is, the change in birth date assignment from May 1st to July 1st coincided with a change in the management season in the mid-1970s, with historical sources of landings and biological data reflecting this change.

Catches

The assessment includes commercial and recreational landings in California and commercial landings in Baja California (Mexico) from 1983 to 2010. Annual (fishing year) landing estimates of Pacific mackerel are presented in Table 2 and Figure 1.

The following discussion regarding harvest prior to 1983 is provided for general information only, given the current assessment model (Model *XA*) begins in 1983. California commercial landings of Pacific mackerel were obtained from a variety of sources based on dealer landing receipts (CDFG) and in some cases, augmented with port sampling for mixed load portions. Data from 1929-61 were obtained from Parrish and MacCall (1978). Monthly landings for the period May 1962 to September 1976 were obtained from CDFG fish bulletins recovered to an electronic data base format (PFEL 2005). Raw landing receipt data for Pacific mackerel from 1976 to 1991 were of marginal quality, owing to the large quantities of Pacific mackerel landed as mixed loads with jack mackerel. During this period, many processors reported either species as 'unspecified' mackerel on landing receipts. For these years, mackerel landings receipts were augmented with shoreside 'bucket' sampling of mixed loads to estimate species compositions. The CDFG reported these data in two forms: (1) annual stock status reports to the California legislature; and (2) single page 'CDFG Wetfish Tables.' Both sources are considered more accurate than PacFIN or other landing receipt-based statistics for this period. Data sources from late 1976 to the present are as follows: October-December 1976 are from Klingbeil and Wolf (1986); January-December 1977 are from Wolf and Worcester (1988); January 1978-December 1981 are from Jacobson et al. (1994a); January 1982-December 2010 are from CDFG Wetfish Tables, as well as PacFIN (for the limited landings from Oregon and Washington); and finally, landing estimates for January-June 2011 and July 2011-June 2012 were assumed to be similar to the analogous time blocks of the previous year, namely, January-June 2010 and July 2010-June 2011, respectively.

California recreational landings (mt) from 1980 to the present (2-month 'wave' resolution) were obtained directly from Pacific RecFIN data base estimates. Historical estimates (pre-1980) of total recreational catch were derived from CPFV logbook data collected since 1936 (Hill and Schneider 1999). The CPFV catch (number) was converted to metric tons using an assumed average weight of 0.453 kg (1 lb) per individual, based on RecFIN samples and consistent with Parrish and MacCall (1978). The CPFV harvest was expanded to total recreational tonnage using wave-specific ratios from RecFIN.

Baja California data include landings from commercial purse seine fisheries in Ensenada, Cedros Island, and Magdalena Bay. Ensenada landings were compiled as follows: 1946-47 through 1969-70 (May-April) data are from Parrish and MacCall (1978); 1970-71 through 1975-76 (May-April) data are from Schaefer (1980); quarterly data from July 1976 through December 1986 are from Jacobson et al. (1994b); monthly data from January 1987 through November 2003 were provided by INP-Ensenada (García and Sánchez, 2003; Celia Eva-Cotero, INP-Ensenada, personal communication, INP-Ensenada staff); monthly landings from December 2003 through December 2004 were not available and thus, were substituted with corresponding months from the previous year. Ensenada landings in 2005, available from Cota et al. (2006), were apportioned into monthly catch using ratios from the previous few years. Ensenada landings for January to June 2006 were taken from Cota et al. (2006). Monthly landing data for the Cedros Island (January 1981-December 1994) and Magdalena Bay (January 1981 – May 2003) fisheries were provided by R. Felix-Uraga (CICIMAR-IPN, La Paz, personal communication). The fishery off Cedros Island ceased in 1994. For 2003 to 2009, commercial landings for the Ensenada and Magdalena Bay fisheries were taken from CONAPESCA's web archive of Mexican fishery yearbook statistics (CONAPESCA 2010).

Finally, small volumes (100 to 300 mt per year) of Pacific mackerel are taken incidentally in other fisheries (e.g., whiting, salmon troll, and Pacific sardine) off Oregon and Washington. Biological samples collected from these fisheries (Hill 1999) indicated fish from these waters are typically larger and older than the directed fishery off California and thus, these limited samples have not been included in the current assessment model presented here.

Length distributions

All model scenarios included length distributions for the USA recreational fisheries, including CPFV (1985-89, 1992-10) and non-CPFV (2004-10) time series, i.e., utilizing age-based selectivity. Age-based selectivity was used in all model scenarios, including: age distribution time series from the fishery, as well as mean length-at-age time series (see Age distributions and Mean length-at-age distributions below); and length distribution time series (no age data available) from the recreational fisheries. Length distributions for the recreational fisheries were partitioned into CPFV (Figure 2A) and non-CPFV time series (Figure 2B): CPFV time series is developed from both a CDFG observer sampling program (1985-89) and the Marine Recreational Fishing Statistical Survey (MRFSS and related Pacific RecFIN data base) using sample examined catch data (1992-10); and non-CPFV time series developed from the California Recreational Fishery Survey (2004-10).

The CDFG conducted a CPFV onboard observer sampling program in southern California from 1975-78 and from 1985-89, and in central and northern California from 1987-98. That is, the earlier time series (1975-78) was omitted, given the model started in 1983, and the latter time series (1987-98) was omitted, given limited sample data over this time period, as well as having a representative time series for these data already in the model (i.e., 1992-10). Ultimately, selectivity parameterization for both the recreational fishery and CPFV index of abundance (i.e., mirrored the recreational fishery) was based on the length distribution developed from only the CPFV fishery. Finally, see Reilly et al. (1998) for further details of this sampling program and overall data collected.

The length distribution from CRFS represented fish caught via all recreational fishing modes, but the CPFV fleet, which allowed for the most reasonable selectivity parameterization for the CRFS index of abundance, see CRFS abundance index section below.

Length distributions were developed using 1-cm length (fork) bins, with the smallest bin equal to 1 cm and the largest equal to 60 cm. The 60-cm bin includes fish that were greater than or equal to 60 cm. The total number of lengths (say specimens measured for length) observed in each distribution (of each time step) was divided by 25 (the average number of fish collected per sample) and subsequently, used as the effective sample size in baseline model configurations. Ultimately, length distributions (in numbers of fish) were converted to proportion estimates for all modeling efforts.

Age distributions

Age distribution time series were developed from the same (CDFG) port sample data base described previously, i.e., the sampling program entails recording length, sex, age (via otolith collections), etc. from each fish in the 25-fish sample taken from a completed fishing trip. It is important to note that age (and length) distributions developed from this sampling program are considered to be representative of the landings associated with the (commercial) fishery and thus, serve as the foundation for evaluating cohort dynamics in the fully-integrated models. Ultimately, age distributions (in proportion-at-age) were based on 9 age bins that represented age-0 to age-8+, i.e., a 'plus group' that includes $\geq$8-yr old fish. The total number of ages (say specimens measured for age) observed in each distribution was divided by 25 (the average number of fish collected per sample) and subsequently, used as the effective sample size in baseline model configurations. Ultimately, age distributions (in numbers of fish) were converted to proportion estimates for all modeling efforts. Annual age distributions (1983-10) associated with all models are presented in Figure 3.

Mean length-at-age distributions

For the primary purpose of evaluating growth dynamics associated with this species, mean length-at-age time series (1983-10) were developed from the same (CDFG) port sample data base described above and used in conjunction with age distributions in SS model scenarios (Figure 4). Effective sample size estimates were obtained using the same 25-fish adjustment employed for the other biological distributions, based on typically sample sizes from a completed fishing trip.

Ageing error distribution

In efforts to provide the most realistic measure of uncertainty associated with estimated age distribution time series, an ageing error vector, based on standard 'double-read' methods, was also included in all model scenarios, i.e., a SD vector by age was used in all SS model scenarios (Figure 5). It is important to note that further ageing error analysis pertaining to this species is warranted, given the current vector is considered preliminary at this time.

Commercial passenger fishing vessel (CPFV) index of abundance

California Fish and Game legislation has required CPFV captains to provide records of catch and effort data to CDFG since 1936. In the past, Pacific mackerel have been among the top five species reported on CPFV logs, both in southern California and state-wide; however, the species is not typically targeted per say by the fishery. This information resides in a logbook data base (Hill and Barnes 1998; Hill and Schneider 1999) that summarizes CPFV catch and effort by month and Fish and Game statistical blocks (10 nm^2). A single state-wide index of relative abundance was developed, based on a delta-Generalized Linear Model (delta-GLM) approach for estimating year effects (Dick 2010), i.e., a CPUE time series of relative abundance (Figure 6A). The index is based on a fishing year basis, as is the case with other time series used in the models. Selectivity parameterization associated with this index mirrored the recreational fishery (i.e., age-based selectivity based on length distribution time series).

To account for potential changes in catchability associated with the CPFV fleet over time, a delta-GLM model was used to 'standardize' the data and separate effects from critical factors (e.g., spatial-temporal). That is, by incorporating year as a factor, the delta-GLM generates estimates of annual standardized catch rate and its variance that can be generally interpreted as a relative index of abundance of the population. Ultimately, the index of abundance is based on two GLMs: the first GLM estimates the probability of a positive observation, based on a binomial likelihood and logit link function; and the second GLM estimates the mean response for the positive observations, assuming a gamma error distribution. The final index is the product of the back-transformed year effects from the two GLMs. Technical details concerning the delta-GLM analysis follow:

(1) data were combined within year/quarter/fleet strata (i.e., the overall, statewide fishery was partitioned into a northern and southern 'fleet' based on latitude/longitude spatial fishing 'blocks');
(2) CPUE was calculated (number of fish/1,000 angler-hours fishing) for each spatial/temporal stratum;
(3) fishing years 1983 to 2010 were used in the analysis;
(4) latitude/longitude blocks were combined into broader spatial areas based on the fishing practices of the northern and southern CPFV fleets, i.e., historically, the southern fleet has exerted the vast amount of fishing pressure associated with this overall fishery (Pt. Conception was used as the 'north/south' delimiter to partition the two regional fleets);
(5) the delta-GLM method models the probability of obtaining a zero catch and the catch rate separately, given the catch rate is non-zero (Stefansson 1996; Maunder and Punt 2004). In this assessment, we estimate the probability of a positive observation using a binomial distribution and a logit link function. Then, the mean response for positive observations was estimated assuming a gamma distribution for the error term. The basic model for positive observations included the log of mean catch rate (μ) as a function of three main effects (fishing year *i*, quarter *j*, and fleet *k*),

$$\log_e(\mu_{ijk}) = U_R + Y_i + Q_j + F_k + \varepsilon_{ijk},$$

where μ_{ijk} is the mean catch rate (number of fish/1,000 angler-hours) in year *i*, quarter *j*, and fleet *k*. The fishing year effect is denoted by Y_i (i=1, 2, ..., I; I=49 fishing years). The quarter of the year effect is denoted by Q_j (j=1, 2, ..., J; J=4 quarters). The fleet effect is denoted as F_k (k=1, ..., K; K=3 fleets). The error term is denoted ε_{ijk}, where for each combination of indices, ε_{ijk} is *iid* and gamma distributed. Finally, the reference cell is denoted as *UR* (R=1 reference cell, i.e., year=2004, quarter=4, and fleet=south);
(6) no temporal/spatial interactions (e.g., year and fleet or quarter and fleet) were included in the final delta-GLM model, given such interactions had little effect on increasing the amount of variability in mean catch rate as a function of the suite of explanatory variables (i.e., minor improvement of R^2 statistic, see Hill and Crone 2005, Crone et al. 2006); and

(7) a delta-GLM function written in the statistical programming language R (Dick 2010) was used to estimate a mean catch rate from the CPFV data set. A major feature of this function is that it estimates coefficients of variation (CV) for the relative index of abundance using a jackknife (leave-one-out) method. However, because the CPFV data were very extensive (nearly 90,000 observations), estimation of both year effects for the survey simultaneously with measures of dispersion (i.e., CVs) was problematic and ultimately, unsuccessful, i.e., an average CV (0.30) was used for each annual estimate of the time series.

Finally, note that all other estimation techniques used to evaluate these data, including GLMs, GAMs, and even nominal mean time series resulted in very similar results, i.e., ultimately, trajectories used in the model to model relative population size over time.

<u>California Recreational Fisheries Survey (CRFS) index of abundance</u>
The California Recreational Fisheries Survey (CRFS) began in 2004 to provide catch and effort estimates for California marine recreational finfish fisheries in six coastal districts and four fishing modes. It represents a collaborative effort between the CDFG and the Pacific States Marine Fisheries Commission (PSMFC) and provides higher spatial and temporal resolution than the previous federal-based survey (MRFSS, 1980-03). See PSMFC (2010) for details regarding survey goals, methods, data availability/accessibility, etc.

The CRFS index of abundance was evaluated at the fishing mode level (Figure 6B), and developed in a similar manner as that above for the CPFV logbook-related index, with the final time series used in modeling efforts having the following differences:

(1) all fishing modes, with the exception of the CPFV fleet (Figure 6A-B);
(2) CPUE was calculated as the number of fish per fishing party/day, i.e., data base structure and limited (examined) sample information precluded calculations at a finer scale (e.g., angler/hour), however, the units of CPUE are likely inconsequential to the overall analysis, given 'positive catch' records composed roughly 1-4% (depending on fishing mode) of the total records (see Table 3 for summary CRFS statistics and Figure 6A-B applicable to Pacific mackerel and the overall survey); and
(3) fishing years 2004 to 2010 were used in the analysis.

Finally, this time series represents an additional index of abundance that has not been included in past assessments and was considered an alternative index in sensitivity analysis conducted in 2011, which in effect, complements the CPFV index above, given it includes data from leisure fishing modes not included in the CPFV analysis.

Biological data

<u>Weight-length</u>

A weight-length (W-L) relationship for Pacific mackerel was modeled using port sample data collected by CDFG from 1962 to 2010 (see Fishery-dependent data above). A straightforward power function was used to determine the relationship between weight (kg) and fork length (cm) for both sexes combined:

$$W_L = a\ (L^b),$$

where W_L is weight-at-length L, and a and b are the estimated regression coefficients. Weight-length parameters based on data from 1962-10 (a = 3.1E-06 and b = 3.4) were used (fixed) in all model scenarios (Figure 7).

<u>Length-at-age</u>

The von Bertalanffy growth equation was used to model the relationship between fork length (cm) and age for Pacific mackerel (1962-10):

$$L_A = L_\infty\ (1 - e^{-k(A-to)}),$$

where L_A is the length-at-age A, L_∞ ('L-infinity') is the theoretical maximum length of the fish, k is the growth coefficient, and t_o ('t-zero') is the theoretical age at which a fish would have been zero length. Length-at-age was estimated internally in all SS model scenarios, generally based on the following baseline growth equation for this population calculated from the CDFG data base (1962-10): L_∞ = 39.3 mm, k = 0.342, and t_o = -1.752 (Figure 7). Of particular note is the rapid growth exhibited by this species, i.e., past research (Parrish and MacCall 1978; Mallicoate and Parrish 1981), as well as analysis conducted here on recent biological sample data, indicates fish, on average, realize over 50% of their total growth (in length) in the first year of life and subsequently, grow a few cm per year until death at roughly 40 cm (approximately, age 7-8). Sensitivity analysis resulted in relatively robust estimates of $k \approx 0.30$.

<u>Maximum size and age</u>

The largest recorded Pacific mackerel was 63.0 cm in length (FL) and weighed 2.9 kg (Roedel 1938; Hart 1973), but the largest Pacific mackerel taken by commercial fishing (CA) was 47.8 cm FL and 1.72 kg. The oldest recorded age for a Pacific mackerel was 14 years, but most commercially caught Pacific mackerel are less than 4 years old, with few living beyond age 8 and larger than 45 cm.

<u>Maturity-at-age</u>

The estimated maturity schedule (ogive) used in the past for this stock was assumed in all model scenarios here (Table 4 and Figure 7). That is, normalized net fecundity-at-age (the product of fraction mature, spawning frequency, and batch fecundity) was used to interpret CalCOFI ichthyoplankton data and ultimately, generate estimates of *SSB*. Fraction mature was estimated by fitting a logistic regression model to age and fraction mature data from Dickerson et al. (1992). Spawning frequency was estimated by fitting a straight line to age and spawning frequency data from the same study. Following Dickerson et al. (1992), batch fecundity per gram of female body weight was assumed constant.

Natural mortality

Natural mortality rate (*M*) was assumed to be 0.5 yr^{-1} for all ages and both sexes, and used in all modeling efforts presented here (Figure 7). Parrish and MacCall (1978) estimated natural mortality for Pacific mackerel using early catch curves (*M* = 0.3-0.5), regression of *Z* on *f* (*M* = 0.5), and comparative studies of maximum age (*M* = 0.3-0.7; Beverton 1963) and growth rate (*M* = 0.4-0.6; Beverton and Holt 1959). The above authors considered the regression of *Z* on *f* to be the most reliable method, with the estimate *M* = 0.5 falling within the range of the plausible estimates, i.e., an instantaneous *M* = 0.5 can be practically interpreted as an annual rate of roughly 40% of the stock dying each year due to 'natural causes.'

Stock-recruitment

A Beverton-Holt (B-H) stock-recruitment (*S/R*) relationship was assumed for this population for all models scenarios, i.e., as observed in the historical literature, as well as from modeling efforts here, recruitment is highly variable and not likely related closely to absolute levels of *SSB* biomass (*SSB*). However, it is important to note that steepness (*h*) ranged from roughly 0.35 to 0.75, depending on the model scenario, indicating that at low *SSB* levels, recruitment is estimated to decrease slightly to moderately (Figure 8). Parrish (1974) and Parrish and MacCall (1978) discussed general life history strategies for this population that are tightly linked to oceanographic conditions and further, that periods of strong year classes (cohorts) are likely produced only when *SSB* is high (or moderately so) and more importantly, not likely to occur more than once or twice every 60 years.

Responses to past STAR/SSC recommendations

The three overriding recommendations from past reviews focused on data availability from Mexico, omission/inclusion/parameterization of available indices of relative abundance used in the ongoing assessment, and updating biological parameters considered influential in the overall modeling effort. See STAR (2009) for further discussion regarding these issues.

Regarding relations with Mexico and issues surrounding future data exchange and professional collaboration on research projects … *SWFSC staff continue to engage in such discussions, meetings, conferences, etc. with academic colleagues and federal researchers from Mexico, e.g., updated landing information and additional, albeit preliminary, larval survey data have been made available recently*.

Regarding indices of relative abundance used in the current assessment … *substantial progress was made with developing an alternative index of abundance (see CRFS index of abundance above), sensitivity analysis that addressed inclusion/omission of the suite of alternative indices, and further examinations of time-varying catchability/selectivity within an index (see Model description sections, Assessment model results, and Assessment uncertainty below).*

Regarding updating biological parameters used in the ongoing assessment ... *SWFSC and CDFG have jointly begun field/laboratory efforts collecting, processing, and analyzing reproductive samples from Pacific mackerel harvested in both the recreational and commercial fisheries. It is important to note that an 'aggressive' sampling plan over a 2 to 4 year time horizon will be required to accumulate enough samples to develop an updated maturity schedule for use in stock assessments due to limited landings of this species, coupled with few field-based surveys*.

Model description

Overview

The Stock Synthesis (SS, Methot 2005, 2011) model is founded on the AD Model Builder software environment, which essentially is a C++ library of automatic differentiation code for nonlinear statistical optimization (Otter Research 2001). The model framework allows full integration of both population size and age structure, with explicit parameterization both spatially and temporally. The model incorporates all relevant sources of variability and estimates goodness of fit in terms of the original data, allowing for final estimates of precision that accurately reflect uncertainty associated with the sources of data used as input in the overall modeling effort.

The SS model comprises three sub-models: (1) a population dynamics sub-model, where abundance, mortality, and growth patterns are incorporated to create a synthetic representation of the true population; (2) an observation sub-model that defines various processes and filters to derive expected values for different types of data; and (3) a statistical sub-model that quantifies the difference between observed data and their expected values and implements algorithms to search for the set of parameters that maximizes goodness of fit. This modeling platform is also very flexible in terms of estimation of management quantities typically involved in forecast analysis. Finally, from an international context, the SS model is rapidly gaining popularity, with SS-based stock assessments being conducted on numerous marine species throughout the world. The SS model used in this assessment was the most recently distributed version, namely, version 3.20b (January 2011).

Likelihood components and model parameters

Likelihood components and estimates for important SS model scenarios are presented in Table 5, including, fits to catch, age/length distributions, and indices, as well as parameter estimates for initial conditions (age distribution, recruitment, and fishing mortality), growth, recruitment, stock-recruitment relationship, etc.

Convergence criteria

The convergence criterion for maximum gradient determination was set to 0.0001 in the SS model. Fidelity of model convergence was explored by changing particular 'starting' values for multiple parameters and evaluating the converged 'minimum' values, i.e., evaluating 'global' vs. 'local' convergence properties of the overall, multi-dimensional numerical estimation.

Model selection and evaluation

We strongly adhered to model development (say parameterization involved in the various scenarios constructed in sensitivity analysis) that was based on the following: supports general consensus regarding this species' life history; results in no noticeable inconsistencies (across likelihood components) within the fully-integrated model scenario; addresses uncertainty in a sound, robust, and parsimonious manner; and finally, produces realistic (meaningful) results that can be directly assimilated into ongoing management efforts.

Sensitivity analysis

Sensitivity analysis resulted in a suite of models for review at the onset of the STAR meeting in May 2011, as well as numerous model scenarios developed during the interactive meeting itself.

In keeping with final assessment documentation protocols, model presentation is largely devoted to the final base case model selected by the STAR panel and STAT (i.e., Model *XA*). Pertinent summary statistics for both Model *XA* and for comparative purposes, the previous assessment final model (Model *AA*) adopted in 2009 are presented in Table 5A-D. Additionally, final sensitivity analysis for Model *XA* is presented in Table 5D, i.e., influential parameterizations were evaluated via 16 model scenarios to ensure the final model was both robust and generally consistent across data sources. Readers interested in details regarding the plethora of model scenarios evaluated in the review meeting via sensitivity analysis should consult STAR (2011). Finally, note that other model scenarios involved in the overall sensitivity analysis were generally similar to Model *XA*, i.e., parameterization differences largely reflected a step-wise approach, whereby a single change in a parameter of interest (e.g., selectivity for a fishery, omission/addition of time series, etc.). A complete suite of displays is presented for Model *XA* within the body of the document. Key features of the final Model *XA* follow:

Model *XA*:

- *Time period*: 1983-10 (new parameterization, i.e., previously, 1962);
- *Fishery structure*: two (USA/Mexico commercial and USA recreational);
- *Surveys*: two indices of relative abundance (CPFV index and the new CRFS index);
- *Time-step*: annual;
- *Gender structure*: combined sexes;
- *Longevity*: 12 years (new parameterization, i.e., previously, 15 years);
- *Natural mortality*: 0.5 for all ages. Also, see Natural mortality above.
- *Growth*: estimated and constant over time;
  As presented in previous literature that addressed growth dynamics associated with this stock (Parrish and MacCall 1978), there is little evidence in support of noticeable growth changes over time (i.e., in terms of length-at-age). However, growth during the species last period of high recruitment success (late 1970s to late 1980s) was potentially different (say faster and realizing larger sizes) than observed over the last two decades or so, but given a start year of 1983, growth was observed to be much more consistent over the last two decades. Finally, overall sensitivity analysis resulted in robust estimates of K (Ks ≈ 0.30). Additionally, sensitivity analysis that considered time-varying changes for growth in weight (i.e., in terms of weight-length/age), which in the vast majority of animal populations is the more 'plastic' growth attribute, revealed no indication that this growth parameter has changed markedly over the last 20 years;
- *Selectivity (biological distributions)*: age-based, a single time block, and asymptotic for the commercial fishery and dome-shaped for the recreational fishery. Selectivity issues regarding age- or size-based approaches were given much attention, based on relations to the actual operation of the fisheries and dynamics of the stock. That is, we feel that the distribution exhibited by this species on any given year and subsequently, its probability of capture (selectivity) is more influenced by 'time' (say age) than by size (say length), i.e., this is true for all age groups, from the high variability observed in the presence/absence of 0-1 yr-old fish to the adults in the estimated age distributions modeled here. Recognizing that in reality, both attributes are likely influential to some degree, it is more likely that movement (and capture) are driven by age, i.e., versus gear (mesh) constraints that also generally influence vulnerability. Given the biological sampling design in place provides 'random' samples of fish (for purposes of length, age, etc.) from completed boat trips,

selectivity parameterization based on representative age distributions of the catch becomes the logical approach. Although the biological distributions from the recreational fishery were in terms of size (length, given no age data available), age-based selectivity was estimated from CPFV length distribution for this fishery as well. Finally, preliminary modeling efforts indicated age- or size-based selectivity resulted in similar conclusions of stock status;

- *Selectivity (indices)*: age-based, a single time block, and dome-shaped (i.e., mirrors recreational fishery) for the CPFV index of abundance and age-based, a single time block, and dome-shaped (estimated from non-CPFV length distribution);
- *Catchability*: constant over time, with CVs = 0.30 for year effects;
- *Stock-recruitment*: Beverton-Holt stock-recruitment model. An asymptotic relationship between parents and offspring was assumed in all model scenarios. Also, see Stock-recruitment above. Variance associated with log recruitment estimation was fixed, i.e., σ_R = 1.0 (in most model scenarios, generated root MSEs were roughly = 1.0 (0.8-1.25); and
- *Variance adjustments to time series*: None. Note that in the final model in 2009, a variance adjustment was implemented for the recreational fishery length distribution parameterization, i.e., this re-weighting was not deemed necessary for the final model in 2011.

Assessment model results (Model *XA*)
Results are summarized below, with discussion regarding important topics related to the overall population analysis presented in the Assessment uncertainty section below. Trends of estimated trajectories of management-related time series (e.g., biomass, spawning stock biomass, and recruitment) from updated model scenarios in 2011 were very similar to those generated from the previous assessment in 2009, with strictly magnitude differences observed for the most dynamic period of the historical time series, i.e., higher estimates of stock size and recruitment in the late 1970s to late 1980s in the updated 2011 models, which were expected, given: (1) the additional length time series included in the updated models, i.e., 1975-78 and 1985-89 distributions, which were composed of large and old fish (also, see Length distributions section above); (2) related changes to estimated selectivity and time blocks associated with this roughly 10-yr period; (3) the inclusion of the mean length-at-age time series, coupled with a maturity schedule that is based on larger/older individuals being more fecund than smaller/younger fish; (4) catches and catch rates increasing markedly; which ultimately, (5) represented the high recruitment success for that narrow timeframe. It is important to note that the points above are essentially moot, given the final Model *XA* has a start year of 1983, which essentially resulted in a period of consistent growth over the modeled timeframe (1983-10).

Model fits to biological distributions are presented in the following displays: Figure 9A is observed vs. predicted estimates for the age distribution time series for the commercial fishery; Figure 9B is the associated Pearson residual plot for the age distribution fits; Figure 9C is the associated input vs. effective sample size plot for the age distribution fits; Figures 10A and 10D are observed vs. predicted estimates for the length distribution time series from the recreational fishery, CPFV and CRFS (non-CPFV fishing modes), respectively; Figures 10B and 10E are the associated Pearson residual plot for the length distribution fits, CPFV and CRFS (non-CPFV fishing modes), respectively; Figures 10C and 10F are the associated input vs. effective sample size plots for the length distribution fits, CPFV and CRFS (non-CPFV fishing modes), respectively; Figure 4 is the observed vs. predicted estimates for the mean length-at-age distribution time series for the commercial fishery; and Figure 11 is the associated Pearson residual plot for the mean length-at-age distribution fits. Estimated selectivity for the fishery catches is presented in Figure 12A (commercial fishery) and Figure 12B [recreational fishery, CPFV and CRFS (non-CPFV fishing modes)]. In general, fits to biological distributions were relatively good; however, in some years, large 'pulses' of younger fish were not fit with high precision, e.g., 0-1 yr-old fish in the commercial fishery age distributions.

Fits (normal and log space) to the indices of abundance are presented in Figures 13 and 14, for CPFV and CRFS, respectively. In general, model fits to the indices were relatively good; however, as previously noted above, no iterative reweighting of variance was conducted and thus, fits could be improved for the indices, noting that fits to the biological distributions would be compromised to some degree.

Estimated Beverton-Holt stock-recruitment relationship is presented in Figure 8 (see Stock-recruitment section above). Estimates of recruitment deviations and associated asymptotic standard errors are presented in Figure 15.

The estimated *F*-based spawning potential ratio (SPR) time series is presented in Figure 16. As expected, SPR estimates have varied over time, with exploitation declining markedly since roughly 2000 to historically low levels (see Assessment uncertainty below).

Estimated time series for management-related derived quantities of interest for Model *XA* are presented in the following displays: Figure 17 is total stock biomass (age 1+ fish in mt, *B*); Figure 18 is spawning stock biomass (*SSB* in mt); and Figure 19 is recruitment (age-0 fish in numbers). Both *B* and *SSB* as steadily declined from the mid 1980s to the early 2000s, at which time the population began to increase moderately in size, with some signs of 'rebuilding' observed over the last several years. However, as noted previously, recent estimates of stock size are necessarily related to assumptions regarding the dynamics of the fish (biology) and fishery (operations) over the last few, which generally confounds long-term (abundance) forecasts for this species. Again, estimated *B* time series from the overall sensitivity analysis were very similar in trend and as noted above, differed in magnitude only for a short period of time historically, when additional length data/selectivity from particularly the 1970s are included in the model scenario. Results from retrospective and prospective analyses for Model *XA* are presented in Figure 20A-B, i.e., for the retrospective analysis, data associated with terminal years 2010 to 2005 were omitted (sequentially) from the model and for the prospective analysis, the model was begun one year later than 1983 in a sequential manner. As observed in all past assessments, a retrospective pattern was evident in the current assessment as well, i.e., a tendency to overestimate stock abundance (*B*) in any current year, with future assessments based on additional data producing estimates lower in magnitude. The prospective analysis indicated moderate variability in model results based on later start years, but the pattern was not consistent from a chronological context as was the case with the retrospective. For comparative purposes, final estimated *B* time series for the historical assessment period (2004-11) are presented in Figure 21. It is important to note that in 2007, estimated *B* scaled upwards substantially, based largely on assumptions regarding variability surrounding estimated recruitment, i.e., since 2005, σ_R has increased from 0.25 to 0.7 to the current level of assumed variability of 1.0, which is more in line with internal estimation of recruitment uncertainty associated with assessment models developed recently for this (and other) species.

Assessment uncertainty

Assessment uncertainty can be partitioned into essentially two inter-related areas.

First and foremost, the collective information, i.e., all sample data (time series used in the stock assessment presented here) and modeling results (via sensitivity analysis), as well as time series from available survey data, laboratory research, and related stock status studies conducted in the past, indicate the following:

- in terms of life history strategy, the Pacific mackerel population off the Pacific coast of North America is in many (most really …) ways a typical coastal pelagic species, but in a (key) few, unique as well, including;
  - exhibiting high recruitment success not on a decadal basis, say like many small, large-schooling pelagic species, but rather, on a multi-decadal cycle spanning 30 to 50 or more years;
  - growing rapidly from a prey existence to a predator role, with nearly 70% of growth in size (length) realized by age 1;
  - upon reaching adult status, it maintains a relatively low profile at the CPS assemblage level for extended periods of time, until oceanographic conditions are favorable and SSB is at least average in size, which produces a brief period of population expansion;
- it is important to note that although the stock is currently at a low level (i.e., not experiencing the 50-yr or so boom in recruitment), it is not very likely due to fishing pressure, but rather a less than ideal oceanographic regime (say for this species);
  - harvest rates have been very low over the last decade (see Harvest Control Rule for USA Management in 2011-12 below), e.g., recent F_{SPR} estimates are 90%-95%, which is a very small removal of reproductive potential for such a species with a moderately high intrinsic rate of increase (*r*);
  - further, the species' has a relatively short life span, with longevity of roughly 8-10 years likely, which provides additional resiliency to ongoing artificial perturbations, such as fishing operations managed under conservative exploitation schemes; and
  - the bottom-line is this is a classical recruitment fishery situation, whereby the stock provides relatively little benefit to fishing interests (commercial or leisure) for protracted periods, with narrow windows of opportunity (very high abundance) every 30-60 years.

In terms of this stock assessment modeling effort, the following areas contribute the most variation in the overall model and in this context, would benefit from further evaluation, i.e., model robustness could be improved by further addressing the following:

- which data source(s) are emphasized in the model scenario, e.g., decisions regarding 'weighting' biological distributions vs. indices of abundance, the inclusion/omission of length and/or mean length-at-age distributions, etc.;
- selectivity and catchability parameterization;

   - selectivity estimation associated with age (commercial fishery) and length (recreational fisheries) distributions were sensitive in particular model scenarios of interest and related to other influential parameterizations, such as growth;
   - catchability estimation associated with the CPFV and CRFS indices of abundance is necessarily an ongoing parameterization effort, given re-weighting and model emphasis considerations regarding the sources of data included in the model scenario of interest;
- the need for two fisheries, given both the commercial and recreational fisheries harvest very similar fish and at low levels, particularly, the leisure fishery;
   - a model with fisheries combined was evaluated, but differences in some years concerning the size (and age) of fish harvested in each of the fisheries precluded further development of this model scenario at this time, i.e., further examinations of differences/similarities between the two fisheries is warranted, given such a parameterization would substantially simplify the current assessment; and finally,
- stock-recruitment parameterization related to sensitivity analysis should include evaluating the influence of steepness (h) set at different (hypothetical) values, particularly, h = 1.0, given suppositions regarding this species' reproductive compensation at low SSB levels.

Generally speaking, uncertainty in the overall assessment was evaluated using some combination of the following: the confidence intervals associated with estimated parameters of interest (e.g., time series of *SSB* and recruitment); sensitivity analysis (i.e., developing alternative model scenarios); and examinations (qualitative and quantitative) of important residual plots from critical model fits (e.g., fits to biological distributions and indices of abundance). All of the above were addressed in the assessment conducted here. Finally, it is important to note that model estimates of absolute stock size are likely more uncertain than presented here, given the final estimates are necessarily based on the following: strict probability samples in the field cannot be obtained; subjective assumptions used to develop model scenarios; potential weighting issues with particular data sources; and unaccounted for variability associated with related sources of data and parameters within the fully-integrated, multiple likelihood modeling platform.

HARVEST CONTROL RULE FOR USA MANAGEMENT IN 2011-12

As stipulated in Amendment 8 to the CPS FMP (PFMC 1998), the recommended maximum sustainable yield (MSY) control rule for Pacific mackerel is (Table 6A):

Harvest = (Biomass-Cutoff) • Fraction • Distribution,

Since 2000, Pacific mackerel has been managed under a Federal Management Plan (FMP) harvest policy, stipulating that a maximum sustainable yield (MSY) for this species should be set according to the following harvest control rule:

Harvest = (Biomass-Cutoff) • Fraction • Distribution,

where Harvest is the harvest guideline (HG), Biomass is age 1+ stock biomass (mt) in the current assessment year (211,126 mt on July 1, 2011), Cutoff (18,200 mt) is the lowest level of estimated biomass at which harvest is allowed, Fraction (30%) is the proportion of biomass above the Cutoff that can be harvested by fisheries, and Distribution (70%) is the average fraction of total Biomass (ages 1+) assumed in USA waters (PFMC 1998). The HGs under the federal FMP are applied to a July-June fishing year. Landings and associated HGs since 1992 are presented in Figure 22A.

From 1985 to 1991, the biomass exceeded 136,000 mt and no state quota restrictions were in effect. State quotas for 1992-00 fishing years averaged roughly 24,000 mt. The HGs averaged roughly 15,000 mt from 2001-06. In 2007, the HG was increased substantially to over 70,000 mt based largely on assumptions regarding variability surrounding estimated recruitment and remained at an elevated level until 2009, when the calculated HG (55,408 mt) was reduced by management (PFMC) to 10,000 mt to address uncertainty related to two alternative models (see Preface and PFMC 2010b); the 10,000 mt HG was adopted in 2010 as well. Note that the HG in 2011 (40,514 mt) is strictly preliminary, given formal adoption of the HG will be addressed at the next Council meeting in June 2011. It is important to note that over the last decade, from a management context, the fishery has not fully utilized HGs, with average yields since this time of roughly 5,000 mt (Figure 22A). 'Hypothetical' quotas and total landings, based on omission of the USA 'Distribution' parameter in the harvest control rule are presented in Figure 22B. Finally, recent legislation concerning management of exploited fisheries in the USA now require alternative methods for quota determination that are used in concert with the HG method above, see PFMC (2010a) and SSC (2010), and Ralston et al. (2011) for methods used to derive OFL, ABC, ACL, and associated buffer values (Table 6B).

RESEARCH AND DATA NEEDS

First and foremost, given the transboundary status of this fish population, it is imperative that efforts continue in terms of encouraging collaborative research and data exchange between NOAA Fisheries (Southwest Fisheries Science Center) and researchers from both Canada's and in particular, Mexico's academic and federal fishery bodies, i.e., such cooperation is critical to providing a synoptic assessment that considers available sample data across the entire range of this species in any given year.

Second, fishery-independent survey data for measuring (relative) changes in mackerel spawning (or total) biomass are currently lacking. Further, at this time, two indices of relative abundance are used in the assessment, which are developed from a marine recreational fishery (CPFV fleet and related fishing modes) that typically do not (directly) target the species. That is, the recently implemented CRFS provides useful information regarding this species' dynamics and further, represents a valuable survey for obtaining abundance trends for finfish generally targeted by marine recreational fishers in coastal waters off California. In this context, it is imperative that future research funds be focused on improvement (e.g., broadening the scope and increasing the frequency) of the current fishery-independent surveys operating out of the NOAA's SWFSC (e.g., CalCOFI and acoustic-trawl surveys), with emphasis on a long-term horizon, which will necessarily rely on cooperative efforts between the industry, research, and management, as well as cooperation from international fishery agencies.

Third, given the importance of age (and length) distribution time series to developing a sound understanding of this species' population dynamics, it is critical that data collection programs at the federal and particularly, the state level continue to be supported adequately. In particular, CDFG/NOAA funding should be bolstered to ensure ongoing ageing-related laboratory work is not interrupted, as well as providing necessary funds for related biological research that is long overdue. For example, maturity-related time series currently relied upon in the assessment model are based on data collected over twenty years ago during a period of high spawning biomass that does not reflect current levels, i.e., the SWFSC and CDFG have begun field/laboratory efforts collecting, processing, and analyzing reproductive samples from Pacific mackerel harvested in both the recreational and commercial fisheries. Also, further work is needed to obtain more timely error estimates from production ageing efforts in the laboratory, i.e., accurate interpretation of age-distribution data used in the ongoing assessment necessarily requires a reliable ageing error time series.

Finally, the MSY control rule utilized in the Pacific mackerel federal CPS-FMP was developed in the mid-1980s based on estimated abundance and stock-recruitment data at that time and thus, the control rule should be re-examined using new data and simulation methods. Given substantial amounts of additional sample data have accumulated since the initial research that was undertaken to formally establish this harvest strategy, it would be prudent to conduct further simulation modeling work to address particular parameters included in the overall control rule (including 'cutoff,' 'fraction,' and 'distribution' values).

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Table 1. Sample sizes associated with CDFG data collection program for Pacific mackerel (1983-10).

	Commercial	Recreational
Fishing Year	Age	Length
83	2,668	
84	2,291	
85	2,606	2,038
86	3,000	5,953
87	4,129	4,354
88	4,477	3,904
89	3,583	3,678
90	2,114	
91	1,655	
92	1,994	710
93	2,688	1,736
94	3,114	885
95	2,706	739
96	2,189	1,899
97	2,714	2,278
98	2,255	1,524
99	1,666	1,253
00	1,910	1,084
01	2,111	1,051
02	2,145	1,145
03	1,570	1,037
04	2,529	1,693
05	2,299	2,109
06	2,393	2,363
07	1,609	2,439
08	723	1,998
09	422	1,783
10	298	350

Table 2. Landings (mt) of Pacific mackerel by fishery (1983-2010).

Fishing year	USA Commercial (mt)	Mexico Commercial (mt)	Recreational CPFV (mt)	Recreational non-CPFV (mt)	Total (mt)
83	36,309	4,264	700	844	42,118
84	39,240	5,761	612	855	46,468
85	37,615	8,197	524	492	46,828
86	44,298	8,965	386	474	54,123
87	44,838	2,120	245	1020	48,223
88	41,968	6,608	181	507	49,265
89	25,063	23,724	167	451	49,406
90	39,974	30,961	230	386	71,551
91	30,268	34,557	252	429	65,505
92	25,584	6,170	135	329	32,217
93	10,787	9,524	196	413	20,920
94	9,372	13,302	226	837	23,737
95	7,615	3,368	439	574	11,996
96	9,788	14,089	320	366	24,563
97	23,413	26,860	104	700	51,076
98	19,578	42,815	108	322	62,823
99	7,170	8,587	55	97	15,910
00	20,936	6,530	78	248	27,792
01	8,436	4,003	51	520	13,010
02	3,541	10,328	22	232	14,123
03	5,972	2,618	28	295	8,913
04	5,012	2,017	23	510	7,562
05	4,572	2,507	21	375	7,475
06	7,870	1,986	16	356	10,228
07	6,208	2,218	19	291	8,737
08	4,281	803	13	267	5,364
09	3,011	171	13	254	3,450
10	2,086	171	5	95	2,357

Table 3. California Recreational Fisheries Survey (CRFS) summary statistics relevant to the CRFS index of abundance derived for Pacific mackerel (2004-10): Region is number of samples (i.e., interviewed party=sample) and NC=northern CA and SC=southern CA; Modes are number of samples, with All=zero catch and positive catch samples and Positive Creel=positive catch samples; Party Size is number of samples; Catch Size is number of samples (by number of fish in creel); Avg. No. Anglers in Party is average number of anglers; and Avg. Trip Length is average trip length in hours.

REGION		
Fishing Year	**NC**	**SC**
04	33,491	36,069
05	31,882	35,330
06	32,632	36,407
07	27,052	36,124
08	26,579	40,329
09	27,453	35,974
10	12,384	13,519
Total	191,473	233,752
Grand total	**425,225**	

PARTY SIZE				
Fishing Year	**0**	**1**	**2-4**	**≥5**
04	12,585	40,359	28,113	1,088
05	3,283	38,988	27,168	1,056
06	7,741	41,908	26,046	1,085
07	15,845	40,633	21,563	980
08	16,269	44,720	21,115	1,073
09	14,500	42,706	19,740	981
10	6,257	17,014	8,514	375
Total	76,480	266,328	152,259	6,638
Grand total		**501,705**		

CATCH SIZE (ALL)				
Fishing Year	**0**	**1**	**2-4**	**≥5**
04	68,030	492	503	535
05	65,842	423	409	538
06	67,692	406	440	501
07	61,556	439	552	629
08	65,265	437	581	625
09	61,916	467	473	571
10	25,504	125	128	146
Total	415,805	2,789	3,086	3,545
Grand total		**425,225**		

MODE (ALL)				
Fishing Year	**Man-made**	**Beach-Bank**	**Party-Charter**	**Private-Rental**
04	17,231	2,144	12,287	37,898
05	15,657	1,947	12,712	36,896
06	18,585	2,371	12,326	35,757
07	18,311	2,092	13,674	29,099
08	20,587	2,567	14,669	29,085
09	20,045	2,079	13,751	27,552
10	7,342	30	6,433	12,098
Total	117,758	13,230	85,852	208,385
Grand total		**425,225**		

MODE (POSITIVE CREEL)				
Fishing Year	**Man-made**	**Beach-Bank**	**Party-Charter**	**Private-Rental**
04	523	9	389	609
05	558	2	309	501
06	443	3	318	583
07	457	0	486	677
08	556	0	553	534
09	531	1	507	472
10	138	0	158	103
Total	3,206	15	2,720	3,479
Grand total		**9,420**		

AVG. NO. ANGLERS IN PARTY (INTERVIEW)				
Fishing Year	**Man-made**	**Beach-Bank**	**Party-Charter**	**Private-Rental**
04	1.09	1.07	1.11	2.20
05	1.07	1.03	1.13	2.20
06	1.05	1.04	1.14	2.20
07	1.04	1.04	1.16	2.21
08	1.04	1.03	1.16	2.20
09	1.05	1.03	1.17	2.17
10	1.04	1.00	1.21	2.10
Total	1.06	1.04	1.15	2.18
Grand total		**1.36**		

AVG. TRIP LENGTH (INTERVIEW)				
Fishing Year	**Man-made**	**Beach-Bank**	**Party-Charter**	**Private-Rental**
04	3.02	2.63	3.48	4.52
05	2.97	2.64	3.34	4.37
06	3.00	2.77	3.13	4.51
07	2.92	2.85	3.20	4.55
08	2.95	2.84	3.12	4.63
09	3.05	2.91	3.30	4.84
10	3.09	2.94	3.26	4.69
Total	3.00	2.80	3.26	4.59
Grand total		**3.41**		

Table 4. Normalized net fecundity calculations for Pacific mackerel, which in effect, represented the maturity schedule (ogive) used in all model scenarios[a].

Age (yrs)	Observed Fraction Mature	Predicted Fraction Mature	Observed Spawning Frequency (% spawning day^{-1})	Predicted Spawning Frequency (% spawning day^{-1})	Net Fecundity (eggs g^{-1})	Normalized Net Fecundity (eggs g^{-1})
0	0.000	0.000	0.000	0.000	0.000	**0.000**
1	0.214	0.487	0.000	1.380	0.672	**0.074**
2	0.867	0.636	3.900	3.520	2.240	**0.246**
3	0.815	0.763	6.800	5.660	4.320	**0.474**
4	0.851	0.855	9.900	7.800	6.670	**0.733**
5	0.882	0.916	7.700	9.940	9.110	**1.000**
6+	0.882	0.916	7.700	9.940	9.110	**1.000**

[a] Observed fraction mature and observed spawning frequency from Dickerson et al. (1992). Predicted fraction mature from logistic regression. Predicted spawning frequency from linear regression. Net fecundity is adjusted (normalized) to a maximum value of 1.0. Batch fecundity is assumed constant.

Table 5. Model scenario summaries for the final model (Model *XA*) selected for management purposes of the Pacific mackerel stock in the current year 2011 and for the previous assessment conducted in 2009 (Model *AA*), including: (A) new data sources and critical parameterizations; (B) likelihood component estimates and derived quantities of importance; (C) model parameters included in Model *XA*; and D) final sensitivity analysis for Model *XA*.

(A)

Time series	***Model scenario***	
	***AA* (2009)**	***XA* (2011)**
Landings - Commercial (USA/Mexico fisheries)	■	■
Landings - Recreational (USA fishery)	■	■
Age distributions - Commercial fishery	■	■
Length distributions - Recreational fishery (1992-10) - All fishing modes	■	
*Length distributions - Recreational fishery (1985-89) - CPFV (**new time series (2011)**)*		■
Length distributions - Recreational fishery (1992-10) - CPFV		■
Length distributions - Recreational fishery (2004-10)- non-CPFV		■
Mean length-at-age distributions - Commercial fishery	■	■
CPFV index	■	■
*CRFS index (2004-10) - **new time series (2011)***		■

Parameterization	***AA (2009)***	***XA (2011)***
Model structure		
Time period	1962-10	1983-10
Number of fisheries	2	2
Number of surveys	1	2
Genders	Combined	Combined
Time-step	Annual	Annual
Biology		
Maturity-at-age	Fixed	Fixed
Length-at-age (k)	Estimated	Estimated
Weight-length	Fixed	Fixed
Weight-at-age	Estimated	Estimated
Natural mortality (M)	Fixed - all ages (M=0.5)	Fixed - all ages (M=0.5)
Stock-recruitment		
$\ln(R_0)$	Estimated	Estimated
Offset for initial equilibrium R_1	Estimated	Estimated
Steepness (h)	Estimated	Estimated
σ-R	Fixed (σ-R=1.0)	Fixed (σ-R=1.0)
Initial conditions for population dynamics		
Age distribution	Non-equilibrium	Non-equilibrium
Fishing mortality (F) - Commercial fishery	Estimated	Estimated
Fishing mortality (F) - Recreational fishery	Fixed	Fixed
Selectivity		
Fisheries		
Parameterization	Estimated	Estimated
Time block	Commercial fishery=3 blocks / Recreational fishery=single	Single
Shape	Dome-shaped	Commercial fishery=asymptotic / Recreational fishery=dome-shaped
Surveys		
Parameterization	CPFV=mirrors recreational fishery	CPFV=mirrors recreational fishery / CRFS=dome-shaped
Time block	Single	Single
Shape	Dome-shaped	Dome-shaped
Catchability		
q - Surveys	Estimated (median unbiased)	Estimated (median unbiased)
Variance adjustment factors		
Biological distributions and indices	No additional weighting	No additional weighting

Table 5. Continued.

(B)

Likelihood component	***AA (2009)***	***XA (2011)***
Biological distributions		
Age distributions		
Commercial fishery	700.4	368.0
Length distributions		
Recreational fishery (All fishing mode: 1992-10)	201.4	Na
Recreational fishery (CPFV: 1985-10)	Na	184.9
Recreational fishery (non-CPFV: 2004-10))	Na	57.3
Sub-total		242.2
Length-at-age distributions		
Commercial fishery	540.4	232.4
Surveys		
CPFV	-18.3	-6.4
CRFS	Na	-5.3
Sub-total	-18.3	-11.7
Recruitment		
Model time period	34.7 (1958-08)	11.34 (1978-10)
Forecast	0.016 (2009)	0.245 (2011)
Global		
Likelihood (L)	1,458.6	842.5
Number of estimated parameters	84	57
Softbounds	0.0036	0.0028
Key estimated parameters and derived quantities		
Biology		
Length-at-age (k)	0.22	0.33
$\ln(R_0)$	13.5	13.6
Offset for initial equilibrium R_1	0.2473	0.4731
Steepness (h)	0.47	0.70
Initial conditions for population dynamics		
Fishing mortality (F) - Commercial fishery[a]	0.654	0.014
Fishing mortality (F) - Recreational fishery	0.001	0.001
Population time series		
SSB (peak year)	598,046 (1983)	461,354 (1984)
SSB (end year)	76,441 (2008)	112,880 (2010)
B (peak year)	1,321,550 (1982)	1,065,990 (1983)
B (end year)	282,849 (2009)	211,126 (2011)
HG (current year)	55,408	40,514

[a]Estimated initial fishing mortality was not fit to 'equilibrium' catch, but rather, implemented for purposes of providing a more robust initial non-equilibrium age composition.

Table 5. Continued.
(C)

Parameter	Min_Value	Max_Value	Init_Value	Fin_Value	SD
NatM_p_1_Fem_GP_1	0.3	0.7	0.5	0.5	_
L_at_Amin_Fem_GP_1	4	35	15	21.116	0.205664
L_at_Amax_Fem_GP_1	30	70	45	40.0231	0.197782
VonBert_K_Fem_GP_1	0.1	0.7	0.35	0.325098	0.0128458
CV_young_Fem_GP_1	0.01	0.5	0.1	0.279009	0.010219
CV_old_Fem_GP_1	0.0001	0.5	0.01	0.01	_
Wtlen_1_Fem	-1	5	0.00000312	3.12E-06	_
Wtlen_2_Fem	1	5	3.40352	3.40352	_
Mat50%_Fem	-3	3	3	3	_
Mat_slope_Fem	-3	3	3	3	_
Eggs/kg_inter_Fem	-3	3	1	1	_
Eggs/kg_slope_wt_Fem	-3	3	0	0	_
RecrDist_GP_1	-4	4	0	0	_
RecrDist_Area_1	-4	4	1	1	_
RecrDist_Seas_1	-4	4	0	0	_
CohortGrowDev	1	5	1	1	_
SR_R0	1	30	10	13.6014	0.217755
SR_steep	0.1	1	0.9	0.699827	0.211953
SR_sigmaR	0	2	1	1	_
SR_envlink	-5	5	0	0	_
SR_R1_offset	-15	15	0	0.47311	0.527798
SR_autocorr	0	2	0	0	_
Main_InitAge_5	_	_	_	-0.472933	0.843491
Main_InitAge_4	_	_	_	0.268622	0.759753
Main_InitAge_3	_	_	_	0.150757	0.772089
Main_InitAge_2	_	_	_	2.08434	0.398218
Main_InitAge_1	_	_	_	-0.506919	0.596872
Main_RecrDev_1983	_	_	_	-1.00104	0.489547
Main_RecrDev_1984	_	_	_	0.366911	0.296722
Main_RecrDev_1985	_	_	_	0.337156	0.279371
Main_RecrDev_1986	_	_	_	0.759464	0.264261
Main_RecrDev_1987	_	_	_	-1.03251	0.37629
Main_RecrDev_1988	_	_	_	1.68254	0.195281
Main_RecrDev_1989	_	_	_	-0.836794	0.413652
Main_RecrDev_1990	_	_	_	0.420333	0.233331
Main_RecrDev_1991	_	_	_	0.334561	0.228476
Main_RecrDev_1992	_	_	_	-0.759672	0.321362
Main_RecrDev_1993	_	_	_	0.731879	0.164942
Main_RecrDev_1994	_	_	_	0.242322	0.186322

Table 5. Continued.
(C)

Parameter	Min_Value	Max_Value	Init_Value	Fin_Value	SD
Main_RecrDev_1995	_	_	_	0.723032	0.151321
Main_RecrDev_1996	_	_	_	0.0728743	0.19468
Main_RecrDev_1997	_	_	_	-1.44384	0.362163
Main_RecrDev_1998	_	_	_	-1.5808	0.306414
Main_RecrDev_1999	_	_	_	-0.924772	0.200919
Main_RecrDev_2000	_	_	_	-0.577272	0.211409
Main_RecrDev_2001	_	_	_	-0.412906	0.338449
Main_RecrDev_2002	_	_	_	-1.06413	0.443654
Main_RecrDev_2003	_	_	_	-0.0524016	0.458841
Main_RecrDev_2004	_	_	_	0.614432	0.457423
Main_RecrDev_2005	_	_	_	0.869945	0.397333
Main_RecrDev_2006	_	_	_	0.621383	0.293877
Main_RecrDev_2007	_	_	_	0.476419	0.219778
Main_RecrDev_2008	_	_	_	0.0534656	0.236146
Main_RecrDev_2009	_	_	_	-0.144445	0.289408
Late_RecrDev_2010	_	_	_	-0.699974	0.699216
ForeRecr_2011	_	_	_	0	1
Impl_err_2011	_	_	_	0	_
InitF_1COM	0.0001	5	0.1	0.0144242	0.0897996
InitF_2REC	0.00001	5	0.001	0.001	_
AgeSel_1P_1_COM	-20	15	1	0.0576732	2.81372
AgeSel_1P_2_COM	-20	15	-5	-5	_
AgeSel_1P_3_COM	-20	15	4	-7.37128	121.562
AgeSel_1P_4_COM	-20	15	1.5	1.5	_
AgeSel_1P_5_COM	-20	20	-1	0.104554	24.0497
AgeSel_1P_6_COM	-20	20	15	15	_
AgeSel_2P_1_REC	-10	15	2	2.00031	0.320612
AgeSel_2P_2_REC	-10	15	-4	-2.3412	3.39767
AgeSel_2P_3_REC	-15	15	-1	-0.940619	0.654569
AgeSel_2P_4_REC	-20	15	-4	-2.09116	22.7202
AgeSel_2P_5_REC	-25	15	-5	-15.9471	104.601
AgeSel_2P_6_REC	-20	15	-2	-0.426842	0.341071
AgeSel_4P_1_CRFS	-10	15	2	0.505643	0.404807
AgeSel_4P_2_CRFS	-10	15	-4	-8.49388	30.5612
AgeSel_4P_3_CRFS	-15	15	-1	3.69201	128.658
AgeSel_4P_4_CRFS	-20	15	-4	-4.27335	70.9969
AgeSel_4P_5_CRFS	-25	15	-5	-13.2365	131.22
AgeSel_4P_6_CRFS	-20	15	-2	-12.6752	91.1591

Table 5. Continued.

(D)

Sensitivity run	**Model**	***B* (2011)**	***B* (2011) - Peak**	***-ln L* (Total)**	***-ln L* (CPFV)**	***-ln L* (CRFS)**
Base case	XA	211,126	1,065,990	842.5	-6.4	-5.3
2x λ (CPFV index)	XA1	219,896	1,123,910	830.4	-16.3	-6.2
2x λ (CRFS index)	XA2	200,383	1,073,720	836.4	-7.6	-6.6
2x λ (Recreational length distribution)	XA3	287,442	1,025,710	1,029.7	-5.8	-3.9
2x λ (Commercial age distribution)	XA4	178,682	981,870	1,188.6	10.8	-1.5
2x λ (Length-at-age distribution)	XA5	210,748	1,103,060	864.1	-5.9	-5.6
Omit CRFS data (inclusive)	XA6	251,550	1,047,730	785.2	-0.5	na
M = 0.3 yr^{-1}	XA7	95,667	323,656	853.9	4.4	-4.8
M = 0.4 yr^{-1}	XA8	130,857	444,452	860.2	-1.8	-3.4
M = 0.6 yr^{-1}	XA9	606,752	3,676,670	840.3	-8.6	-5.9
M = 0.7 yr^{-1} [a]	XA10	**	**	839.3	-6.7	-5.9
Start in 1978	XA11	171,415	1,080,300	1,231.6	-1.1	-5.2
Start in 1981	XA12	190,897	1,096,960	1,007.1	-4.3	-5.0
Start in 1990	XA13	217,789	556,043	455.0	-9.9	-4.9
Length-at-age max - estimate CV	XA14	226,929	1,082,290	851.5	-8.4	-4.3
Sigma r = 0.8	XA15	210,172	1,053,200	841.4	-6.9	-5.4
Sigma r = 1.2	XA16	211,258	1,071,720	845.0	-6.2	-5.3

**Biomass estimate from sensitivity run was essentially infinite and hessian may not be positive definite.

Table 6. Harvest control rule information for the Pacific mackerel fishery (2011-12) based on Model *XA*, including: (A) 'harvest guideline' statistics (see Harvest Control Rule and USA Management in 2011-12) ; and (B) harvest formulas associated with recent regulations associated with reauthorization of National Standards 1 of the MSFCMA, see PFMC (2010a) for parameter definitions (σ=0.36).

(A)

B **(Age 1+, mt)**	**Cutoff (mt)**	**Fraction**	**Distribution**	**HG (mt)**
211,126	18,200	30%	70%	**40,514**

(B)

Harvest Formula Parameters	**Value**			
BIOMASS (ages 1+, mt)	211,126			
Pstar (probability of overfishing)	0.45	0.4	0.3	0.2
$BUFFER_{Pstar}$	0.95577	0.91283	0.82797	0.73861
F_{MSY}	0.3			
FRACTION	0.3			
CUTOFF (mt)	18,200			
DISTRIBUTION (U.S.)	0.7			

Amendment 13 Harvest Formulas	**MT**
OFL = BIOMASS * F_{MSY} * DISTRIBUTION	44,336
$ABC_{0.45}$ = BIOMASS * BUFFER0.45 * F_{MSY} * DISTRIBUTION	42,375
$ABC_{0.40}$ = BIOMASS * BUFFER0.40 * F_{MSY} * DISTRIBUTION	40,472
$ABC_{0.30}$ = BIOMASS * BUFFER0.30 * F_{MSY} * DISTRIBUTION	36,709
$ABC_{0.20}$ = BIOMASS * BUFFER0.20 * F_{MSY} * DISTRIBUTION	32,747
ACL=LESS THAN OR EQUAL TO ABC	TBD
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION	40,514
ACT=EQUAL TO HG OR ACL, WHICHEVER VALUE IS LESS	TBD

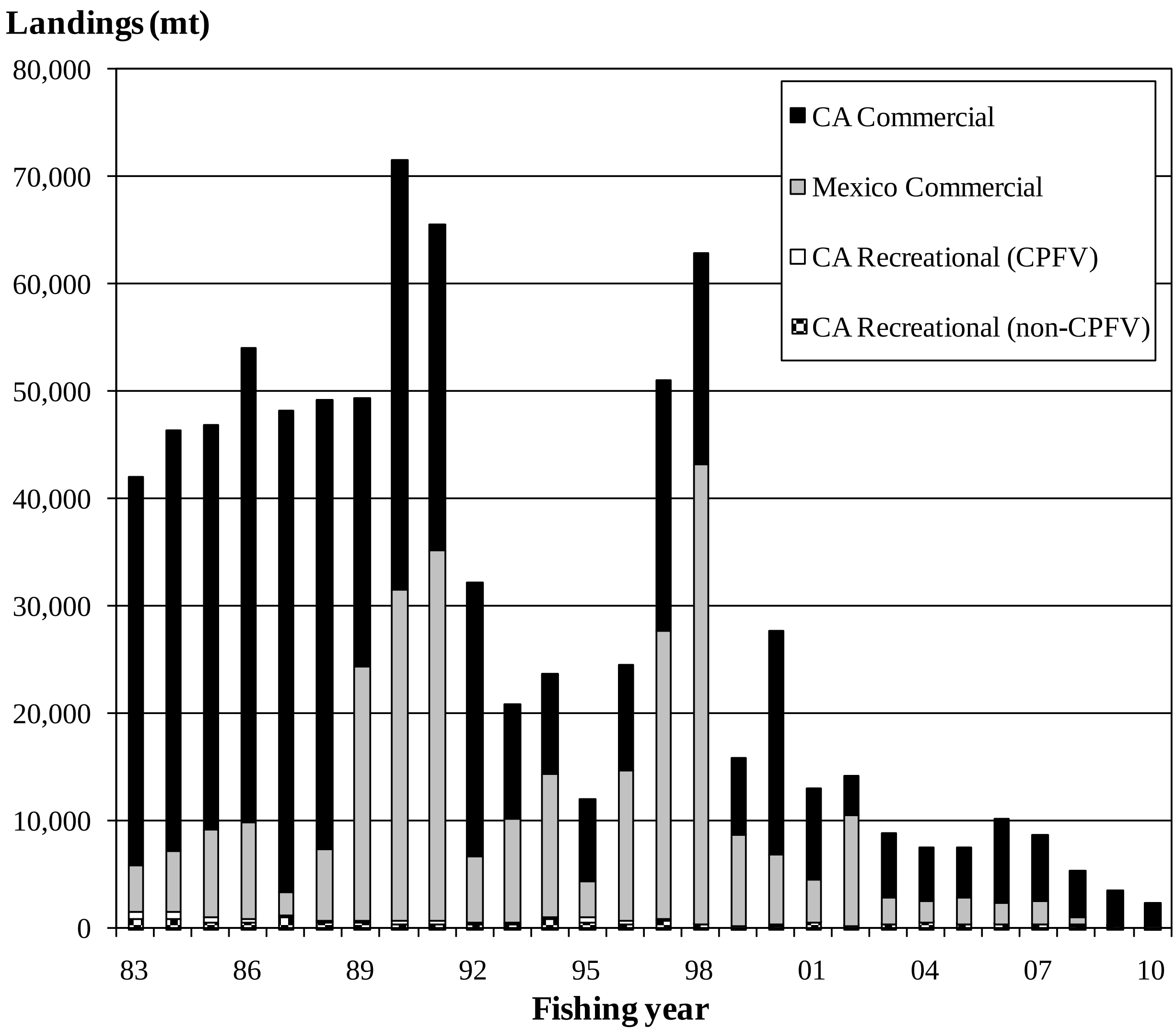
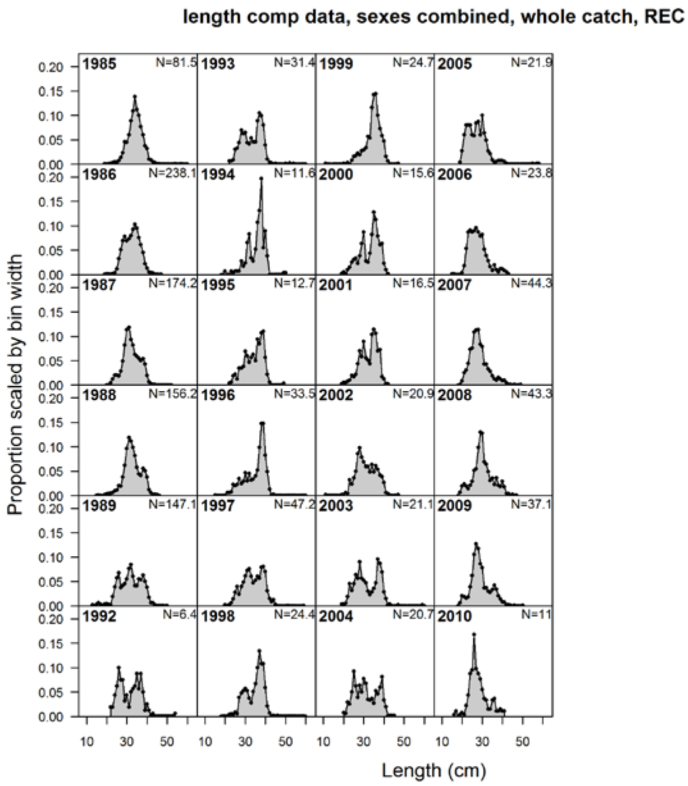


Figure 1. Commercial and recreational landings (mt) of Pacific mackerel in the USA (CA commercial, recreational-CPFV, and recreational-non-CPFV) and Mexico (commercial), (1983-10).

(**A**)



(B)

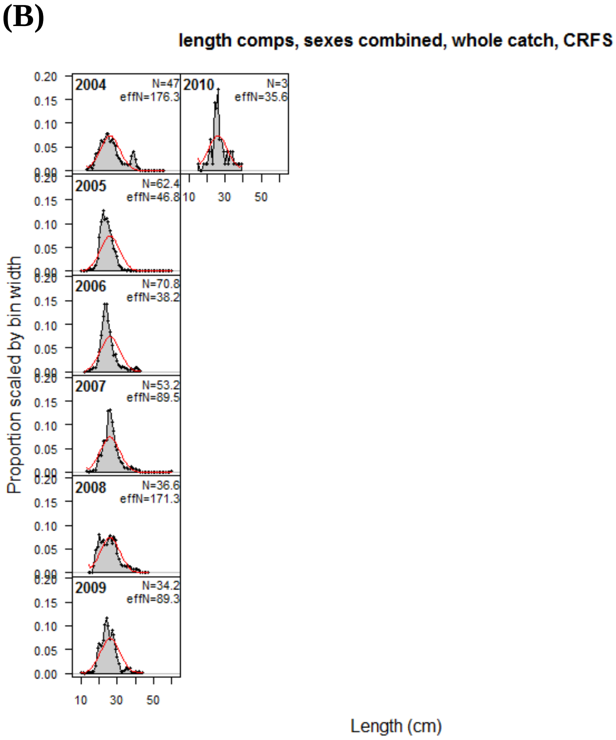


Figure 2. Length distributions of Pacific mackerel from: (A) the CDFG observer sampling program (1985-89) and RecFIN (CPFV) data base (1992-10) associated with the CPFV fishery; and (B) the CRFS sampling program (2004-10) associated with the non-CPFV fisheries.

age comp data, sexes combined, whole catch, COM

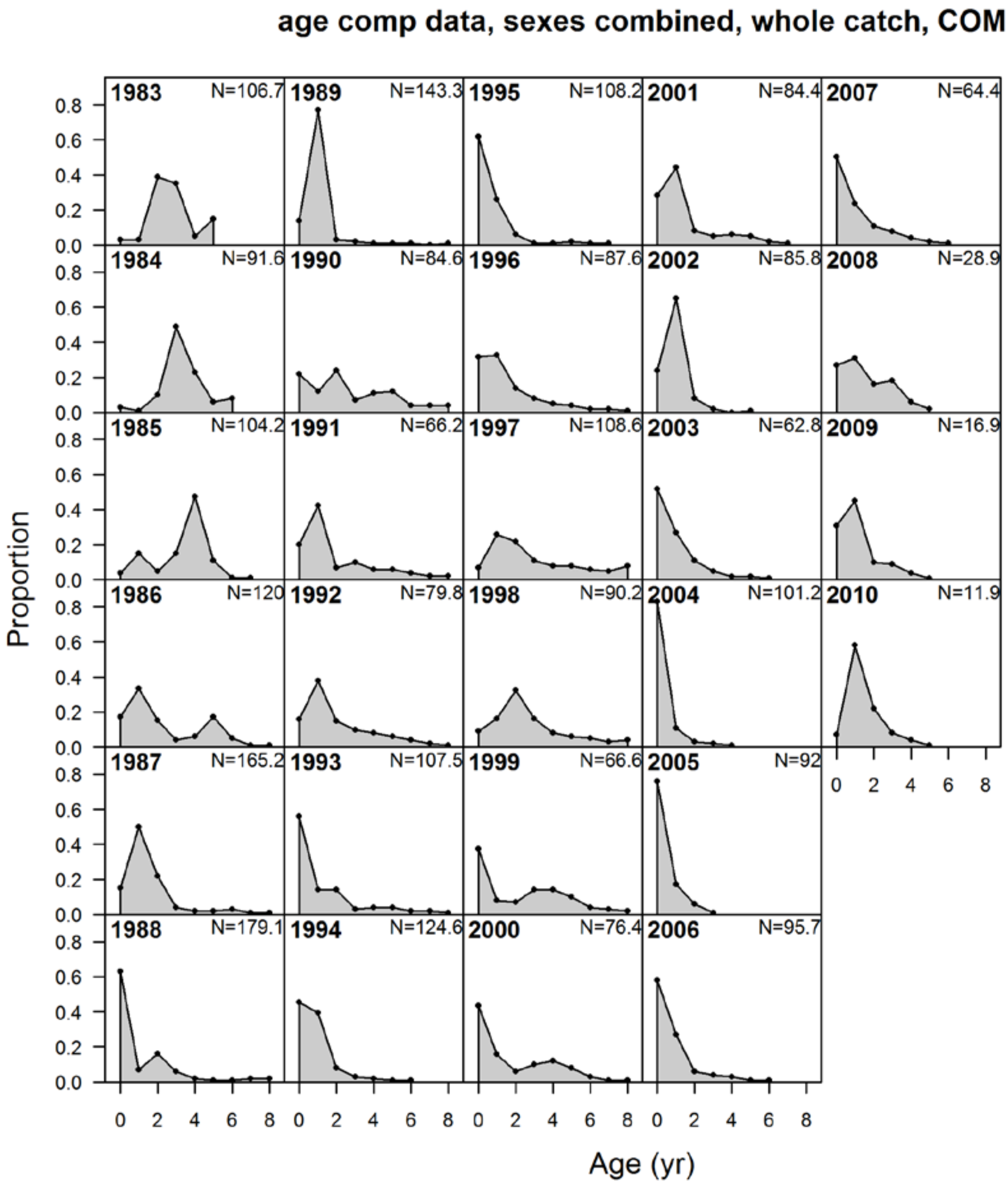


Figure 3. Age distributions of Pacific mackerel from the CDFG (commercial fishery) port sampling program (1983-10).

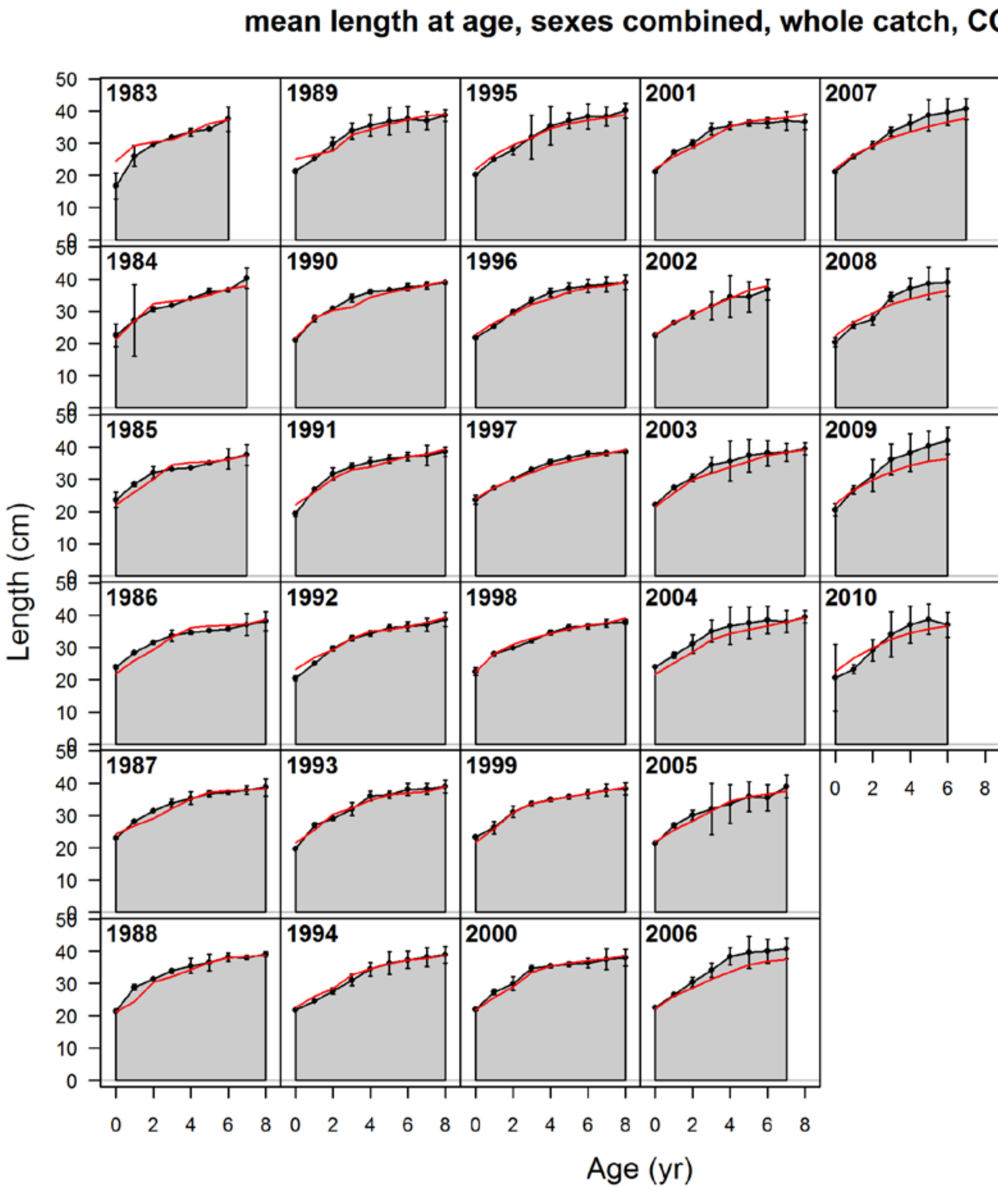


Figure 4. Estimated mean length-at-age (cm/yr, open circles) time series of Pacific mackerel from CDFG (commercial fishery) port sampling program (1983-10). Also, model fits to this time series are presented (curved line in each display).

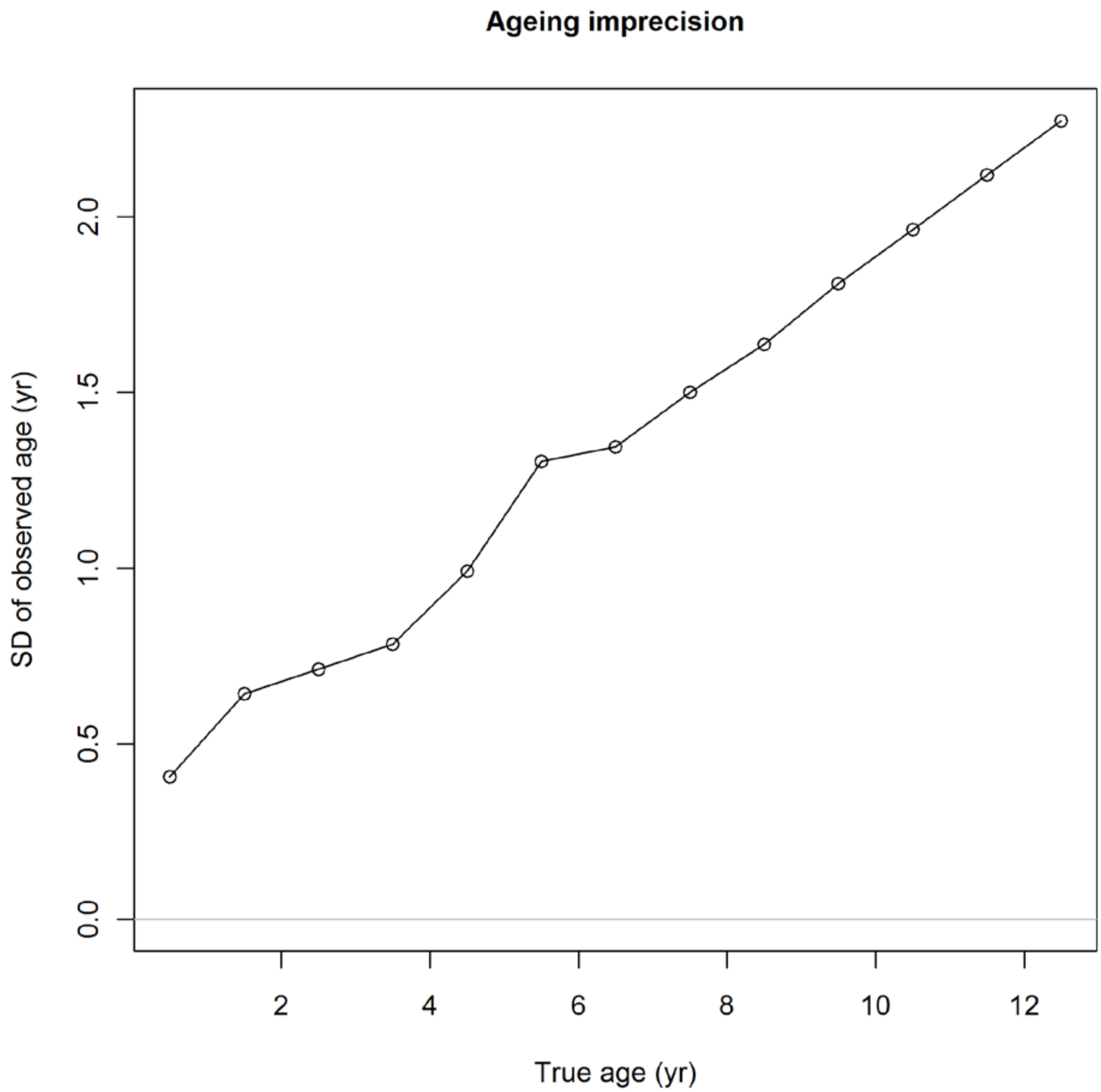


Figure 5. Pacific mackerel ageing error vector (SD by age) from CDFG age production laboratory based on double-read analysis.

(A)

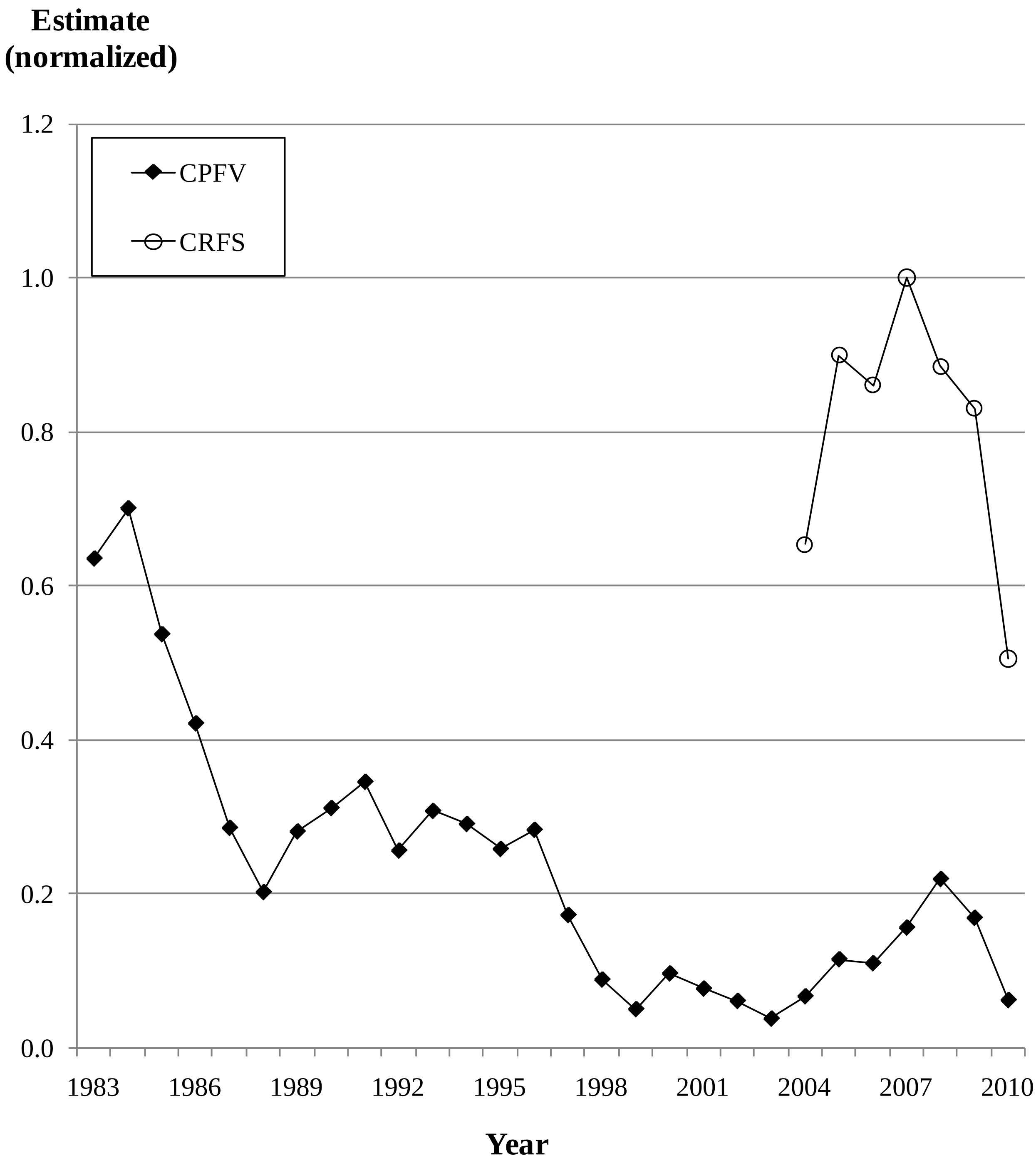
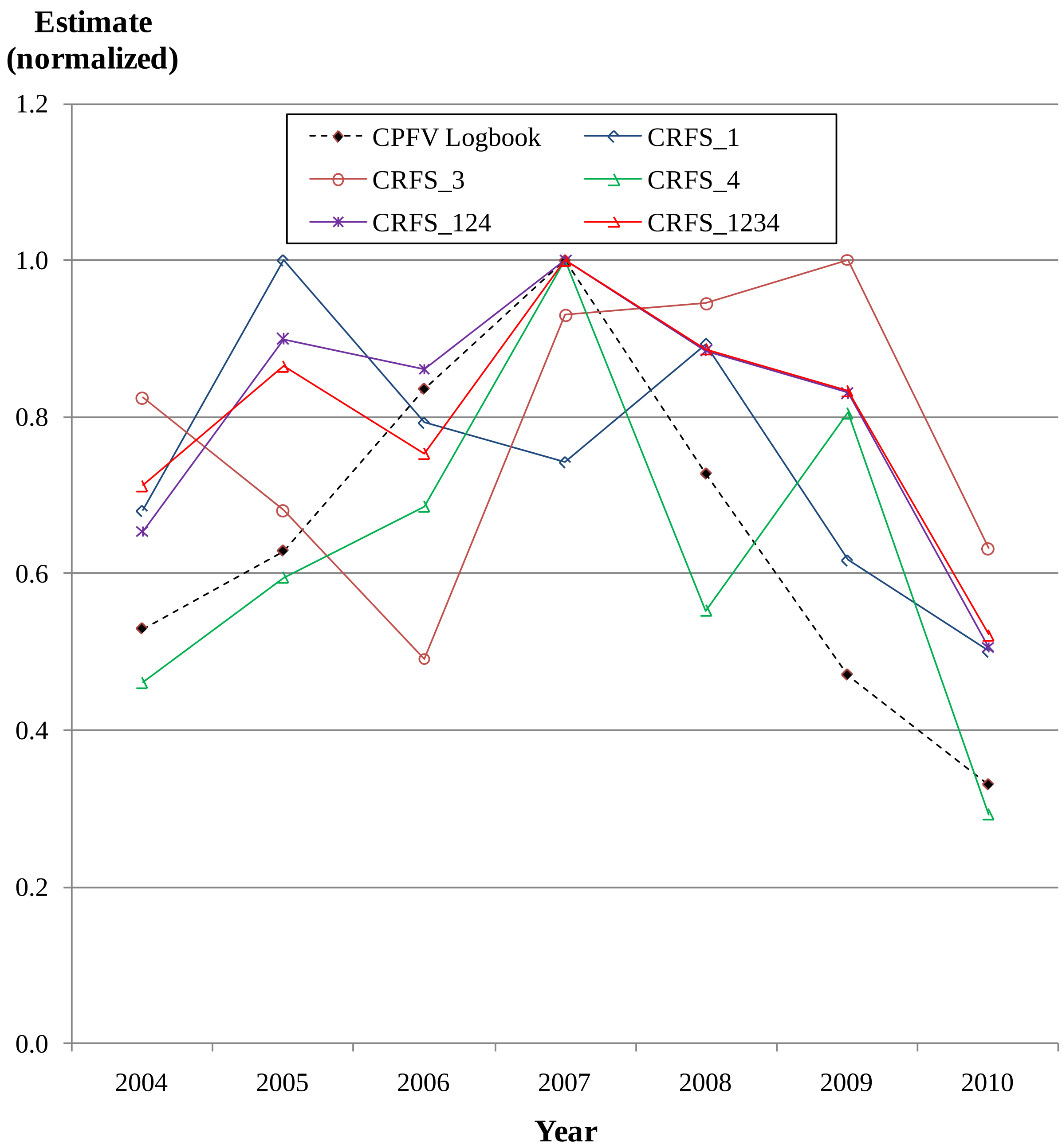


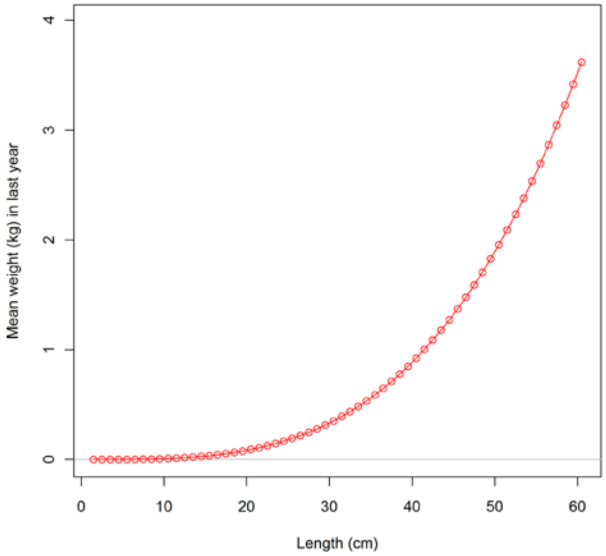
Figure 6. Indices of abundance: (A) CPFV (CPFV logbook sampling program) and CRFS (non-CPFV fisheries); and (B) the CRFS survey time series evaluated at the fishing mode level (CPFV Logbook=abbreviated CPFV in 6A, CRFS_1 = man-made, CRFS_2=beach/bank, CRFS_3=charter/party, CRFS_4=private/rental, CRFS_124=omits charter/party, and CRFS_1234=all modes). Note that only the CPFV and CRFS_124 indices were used in Model *XA*. Also, missing lines between data points reflects years with no sampling.

(B)

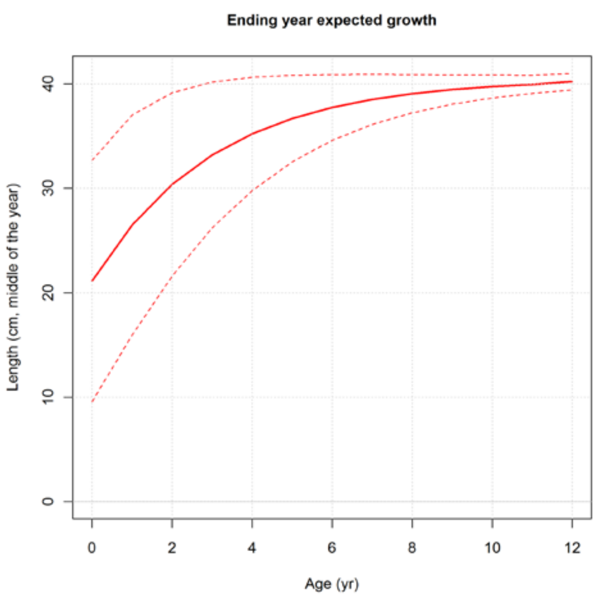


Estimate
(normalized)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
CPFV Logbook
CRFS_1
CRFS_3
CRFS_4
CRFS_124
CRFS_1234
2004
2005
2006
2007
2008
2009
2010
Year

(A) **(B)**



Mean weight (kg) in last year
Length (cm)
0
1
2
3
4
0
10
20
30
40
50
60



Ending year expected growth
Length (cm, middle of the year)
Age (yr)
0
10
20
30
40
0
2
4
6
8
10
12

(C)

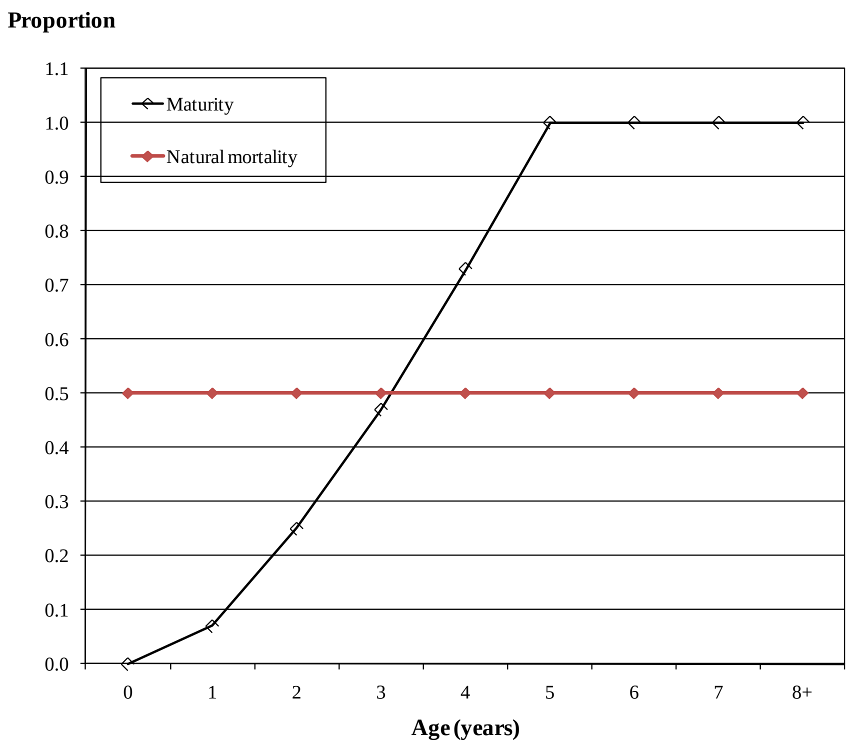


Figure 7. Biological parameters for Pacific mackerel either assumed or estimated in the assessment models: (A) weight-length relationship; (B) length (cm)-at-age (yr); and (C) maturity (also, see Table 4) and natural mortality (*M*).

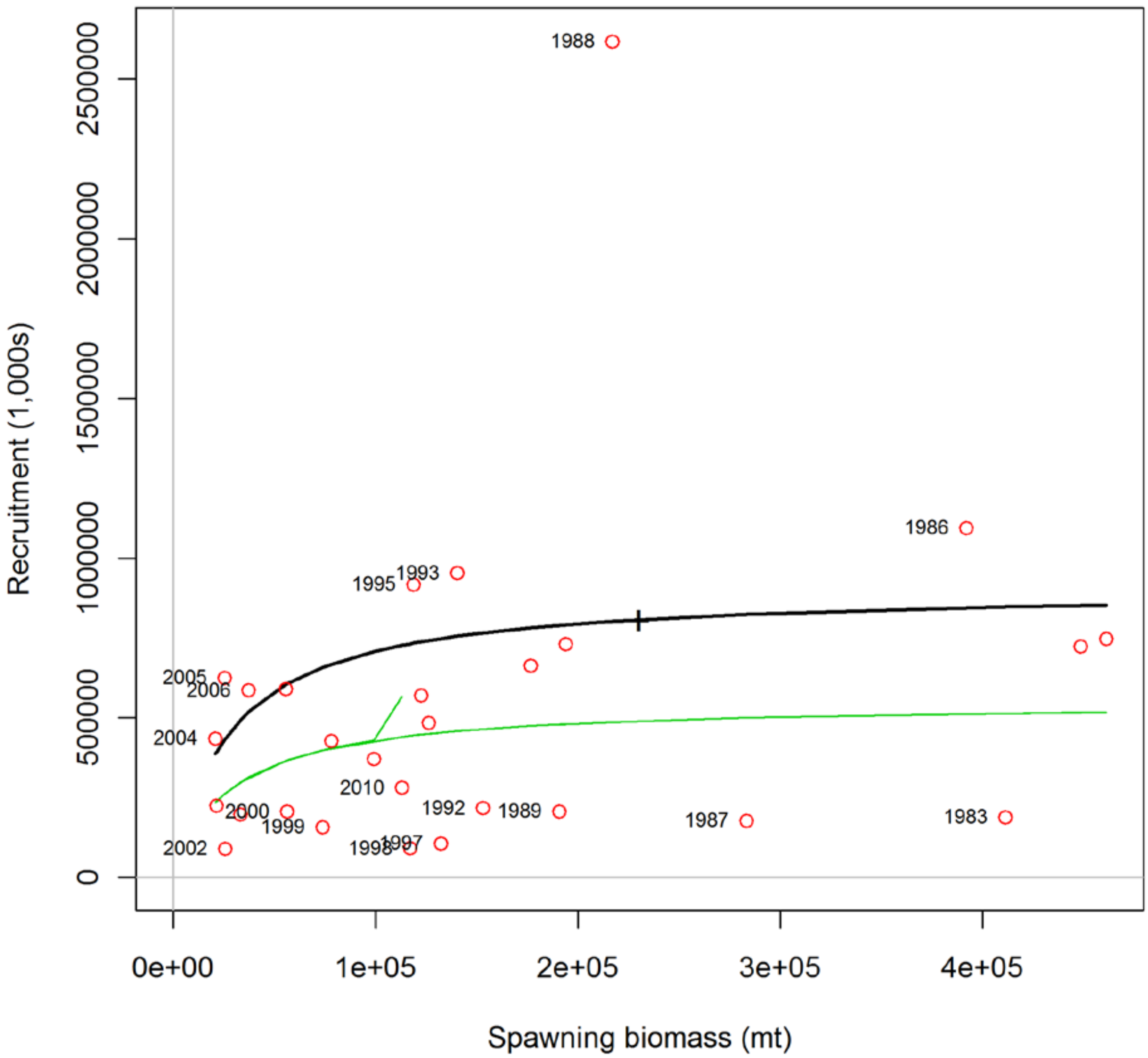


Figure 8. Beverton-Holt stock (*SSB* in 1000s mt)-recruitment (*R* in millions of fish) relationship for Pacific mackerel estimated in the final Model *XA*. Recruitment estimates are presented as (year+1) values. Strong year classes are highlighted and steepness (*h*) = 0.70.

(A)

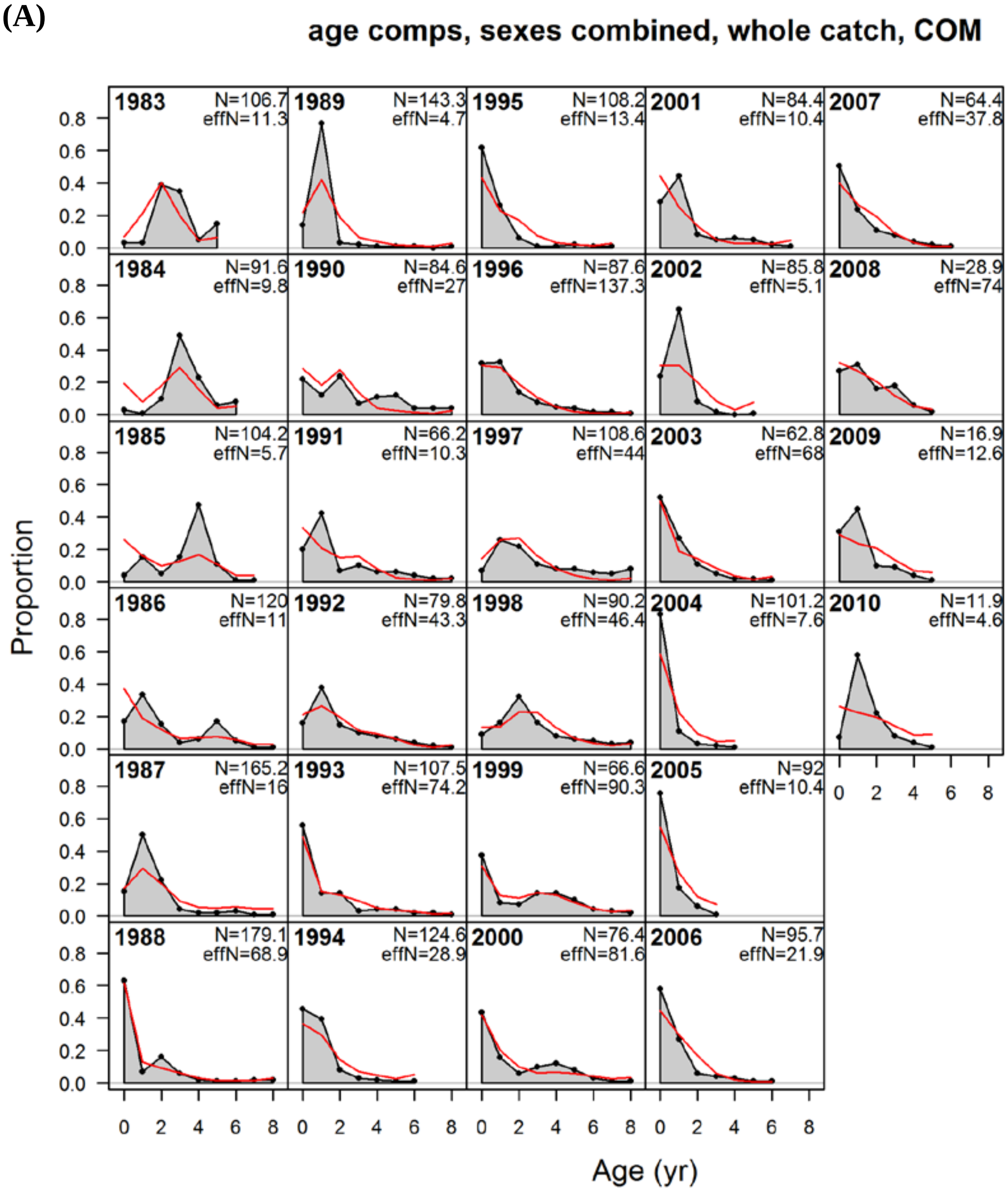
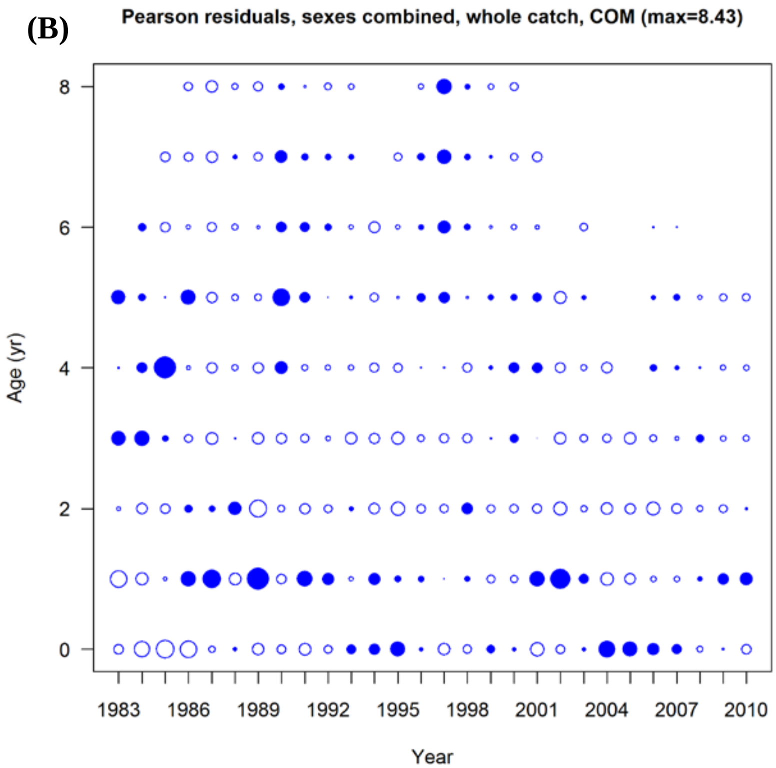


Figure 9. Model *XA* fit diagnostics associated with the commercial fishery age distribution time series (1983-10): (A) observed (open circles) vs. predicted (line) estimates; (B) Pearson standardized residuals (observed – predicted; maximum bubble size = 8.43; dark circles represent positive values); and (C) effective vs. observed (input) sample sizes for the commercial fishery age distribution time series (solid line represents a 1:1 relationship and the dashed line reflects a loess smoother).

(B)



(C)

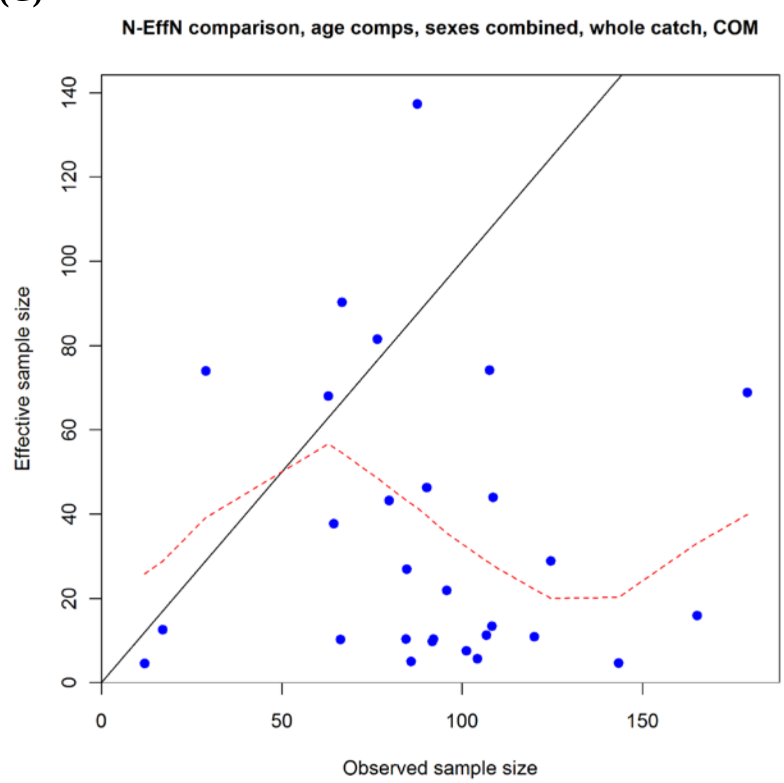


Figure 9. Continued.

(A)

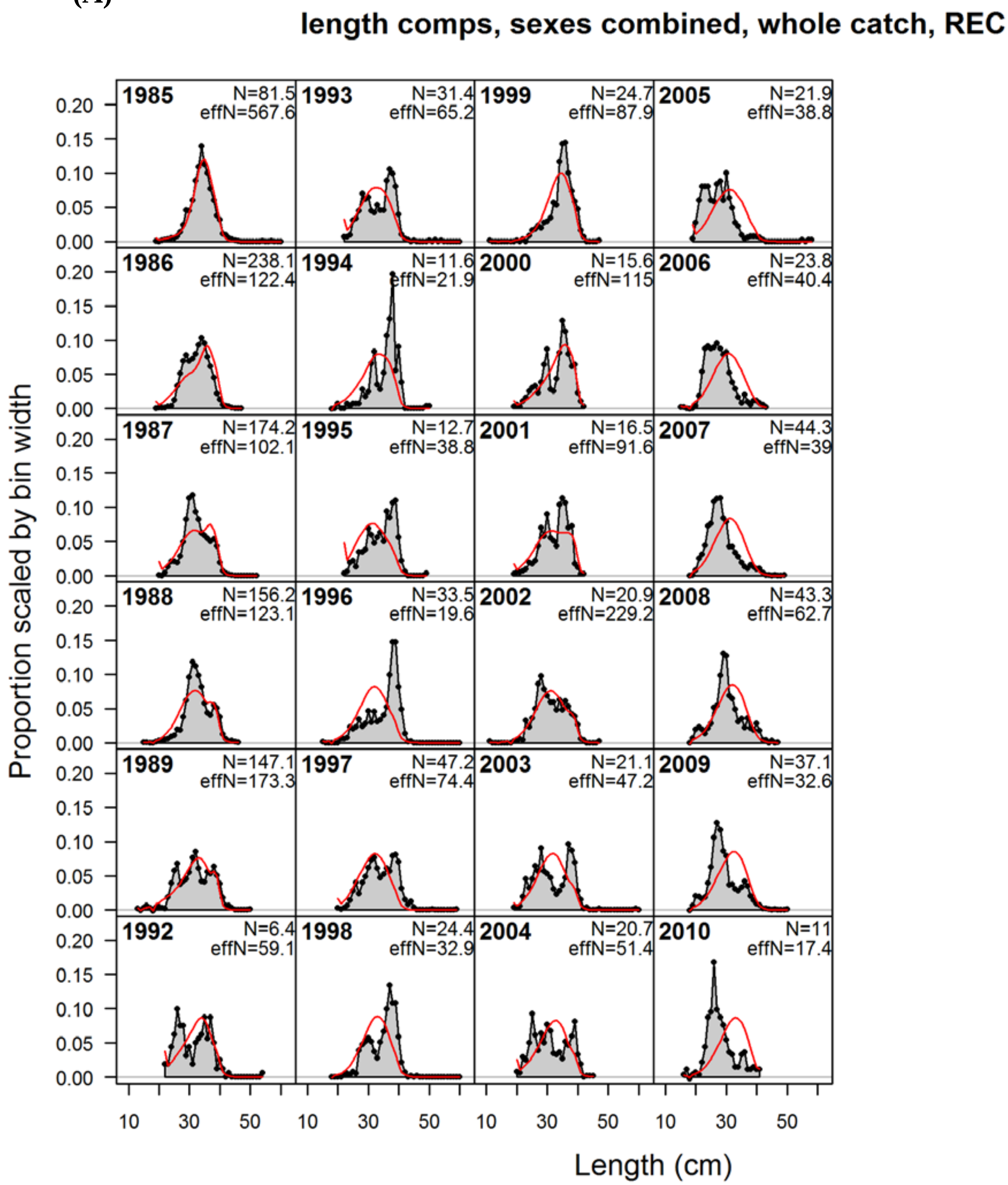
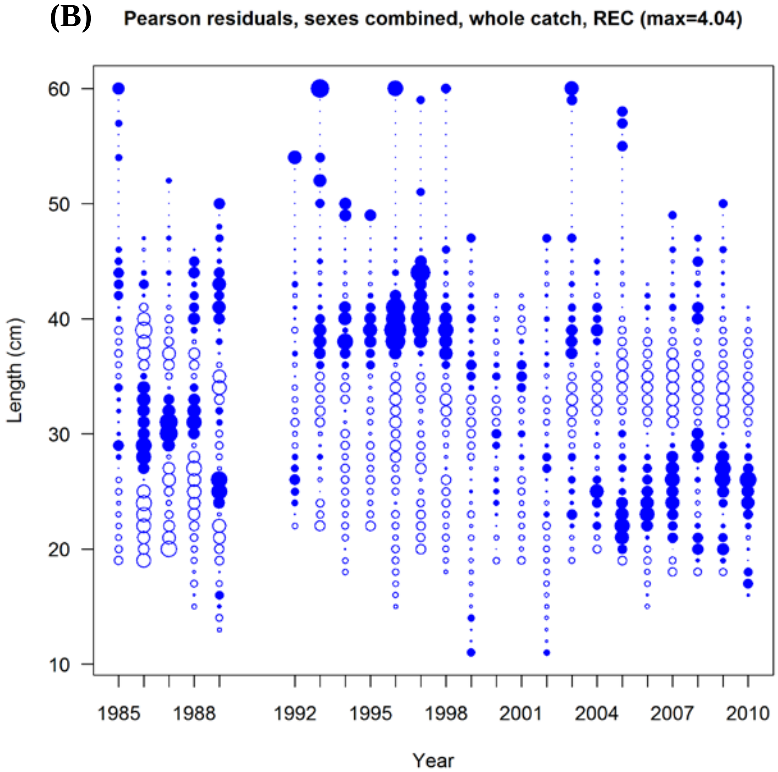


Figure 10. Model *XA* fit diagnostics associated with the recreational fisheries length distribution time series (displays A-C=CPFV fishery via CPFV logbook sampling program and displays D-F=non-CPFV fisheries via CRFS): (A and D) observed (open circles) vs. predicted (line) estimates; (B and E) Pearson standardized residuals (observed – predicted; maximum bubble size = 4.04 and 3.88, dark circles represent positive values); and (C and F) effective vs. observed (input) sample sizes for the commercial fishery age distribution time series (solid line represents a 1:1 relationship and the dashed line reflects a loess smoother).

(B)



(C)

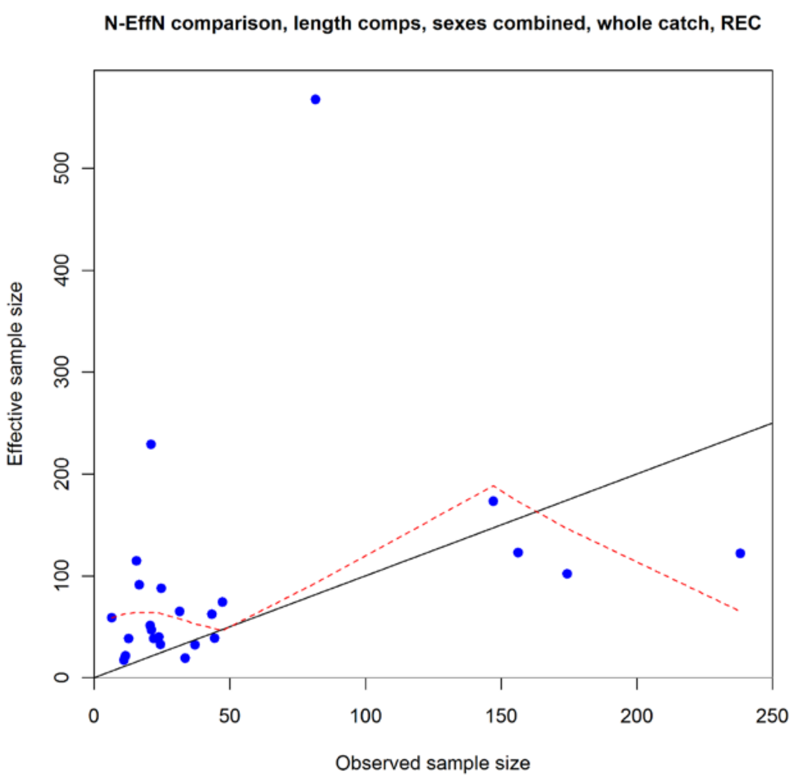


Figure 10. Continued.

(D)

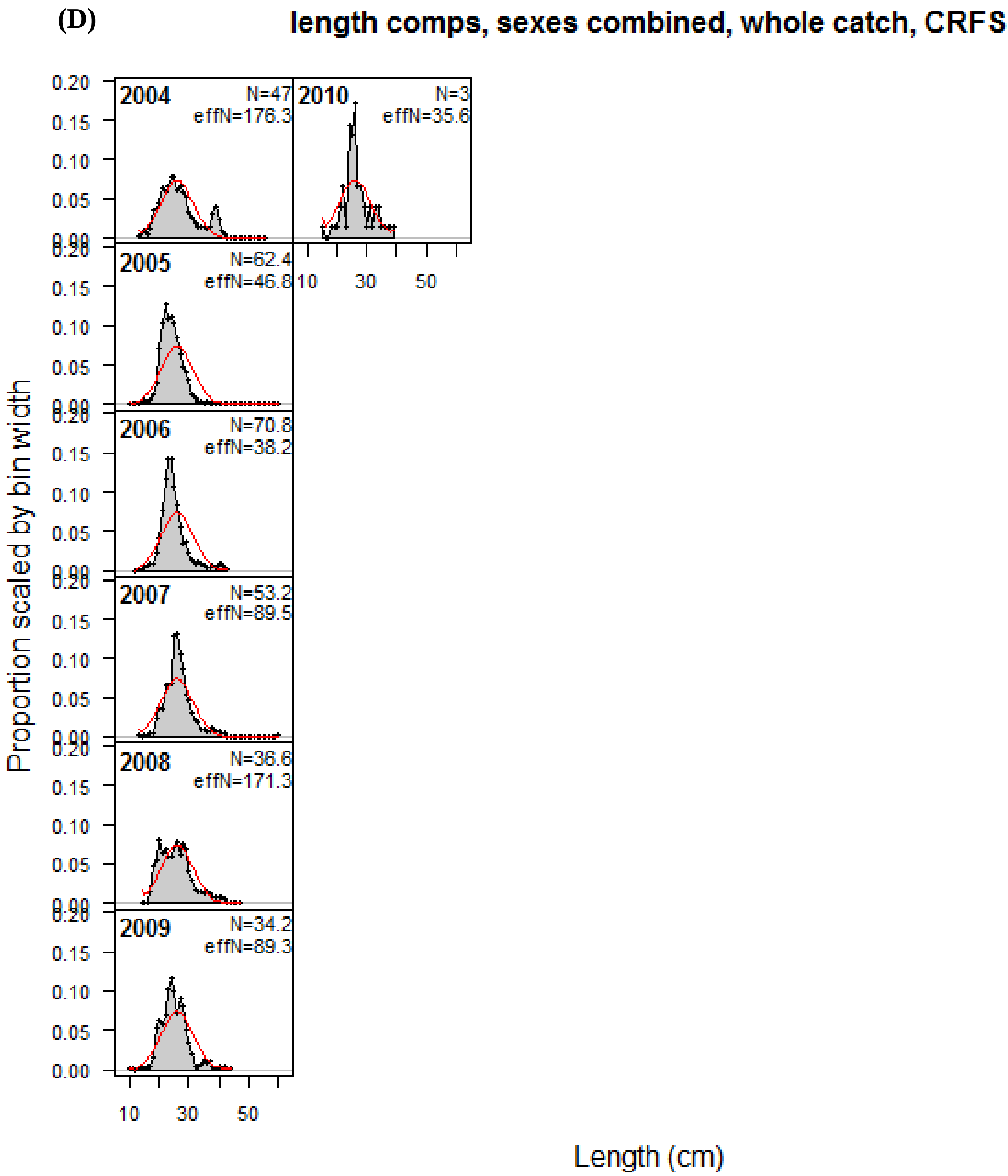
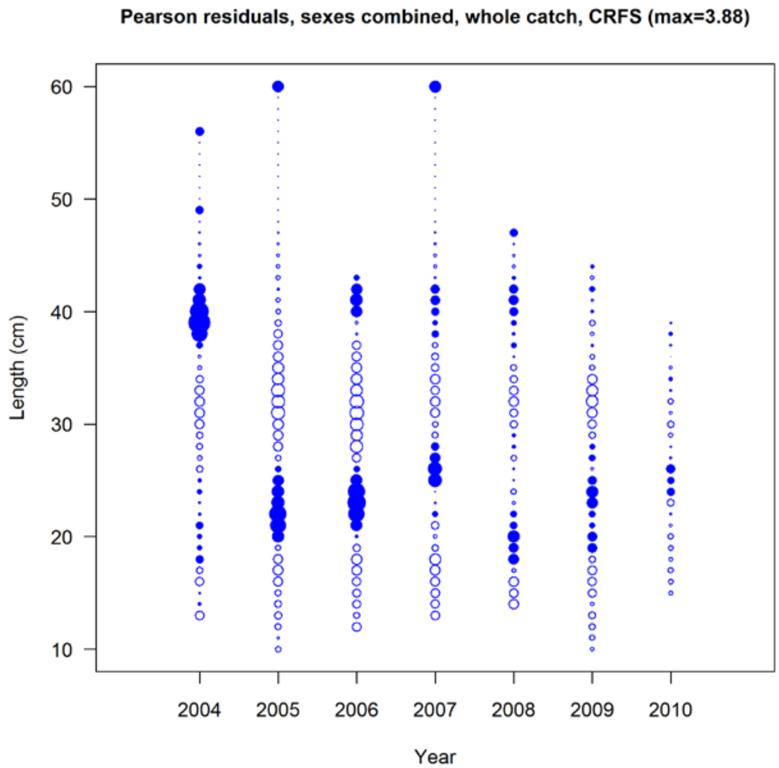


Figure 10. Continued.

(E)



(F)

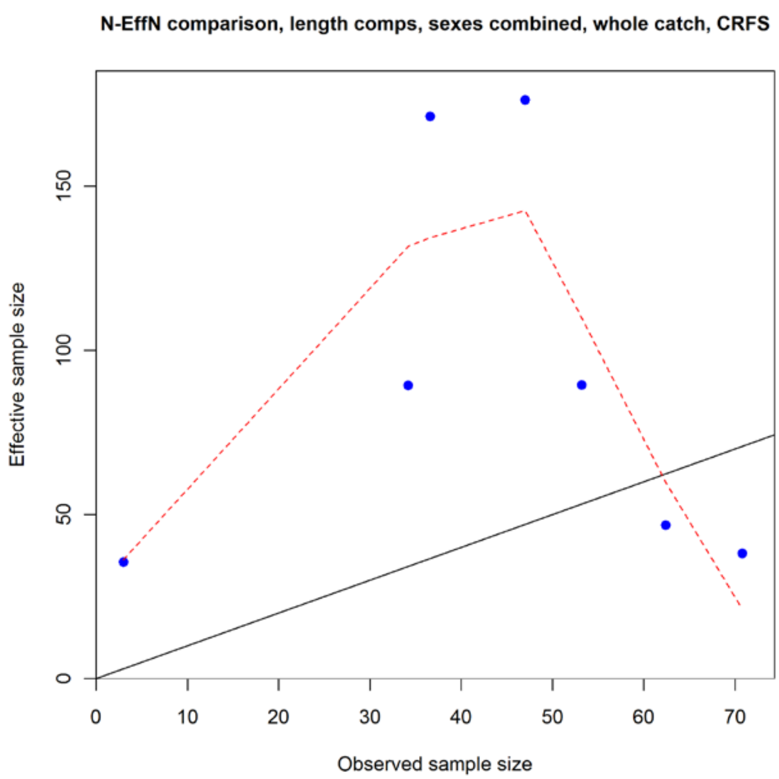


Figure 10. Continued.

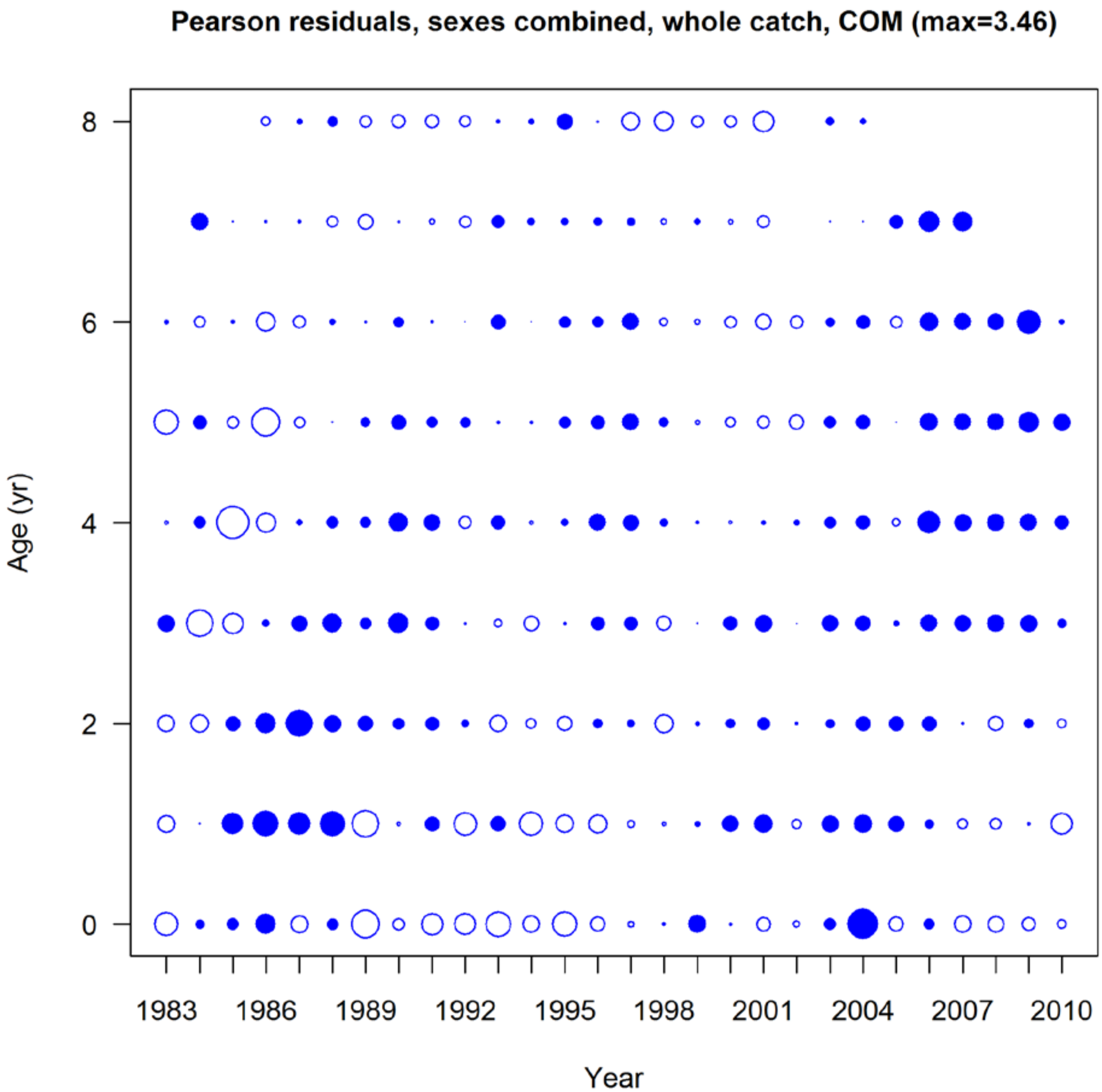
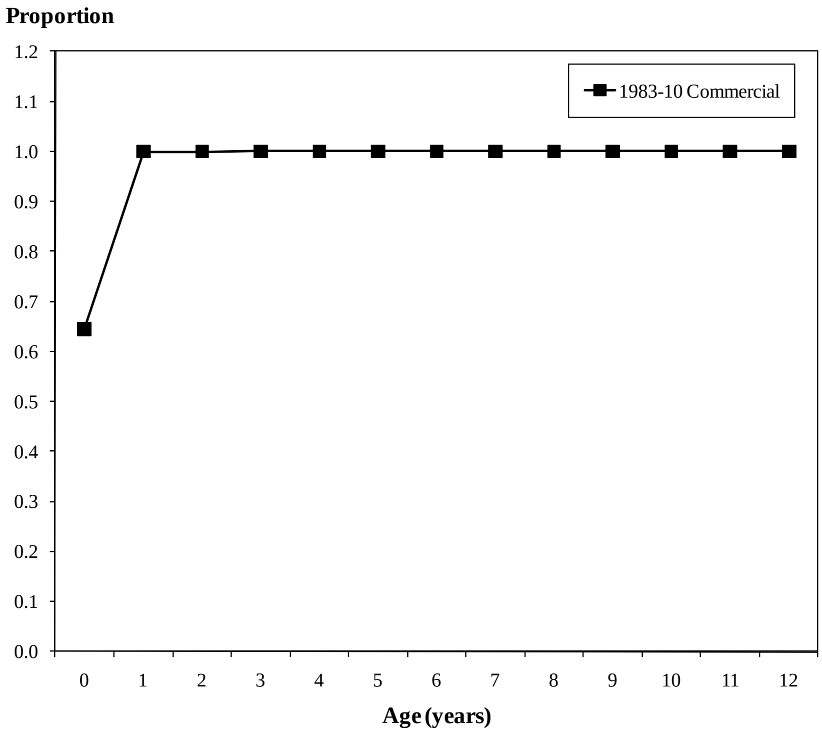


Figure 11. Model *XA* fit diagnostics associated with the commercial fishery mean length-at-age time series (1983-10), i.e., the associated Pearson standardized residuals plot (observed – predicted; maximum bubble size = 3.46; dark circles represent positive values). Also, see Figure 4 related diagnostics.

(A)



(B)

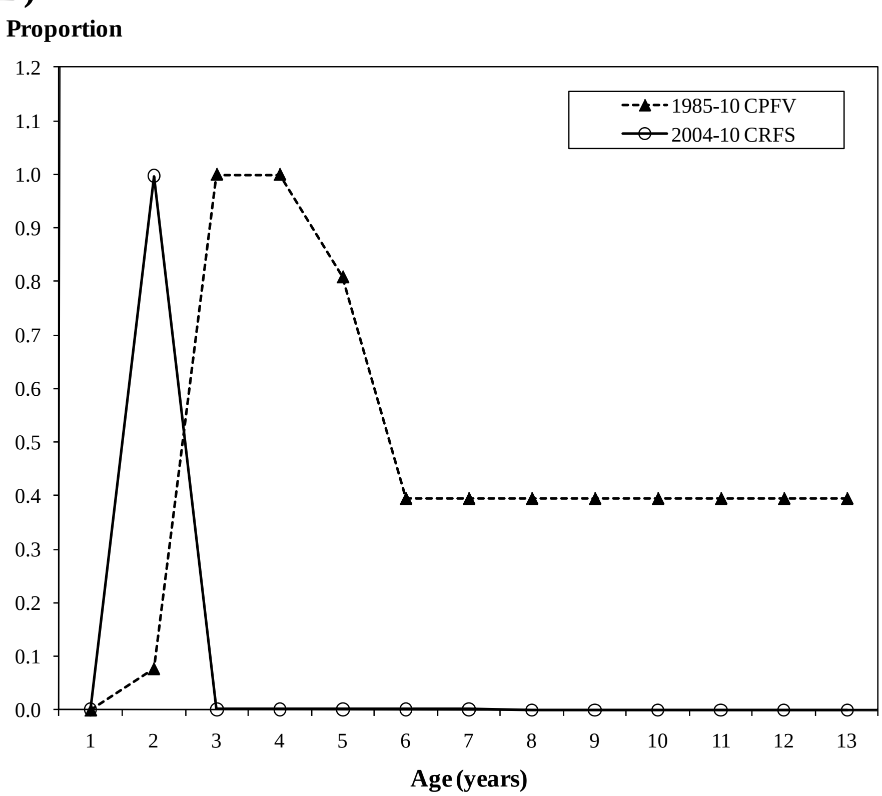


Figure 12. Estimated time-varying age-based selectivity distributions associated with model *XA*: (A) commercial fishery (1983-10); and (B) recreational fishery (1985-10 CPFV) and (2004-10 CRFS).

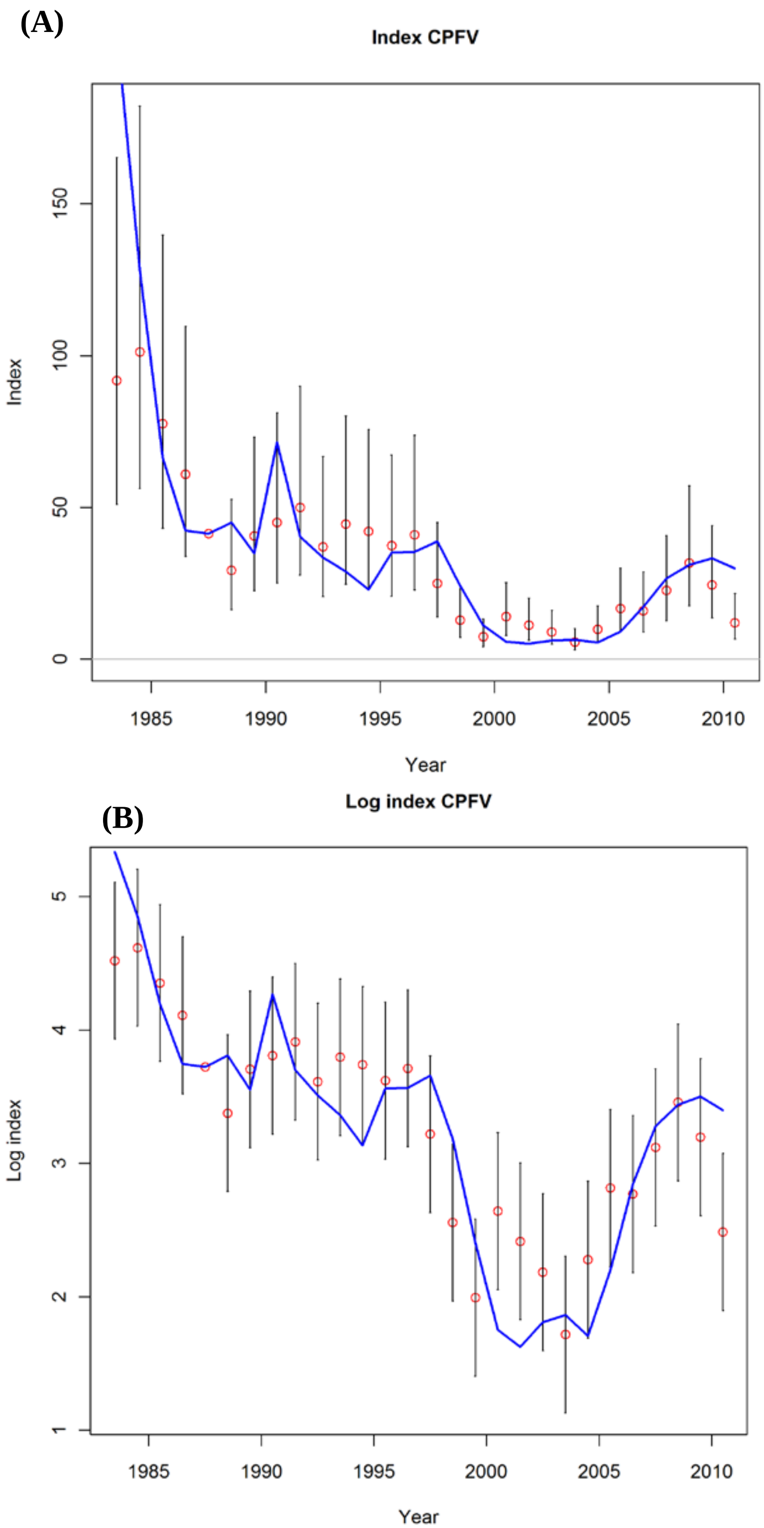


Figure 13. Model *XA* fits to the CPFV index of relative abundance (one time block, 1983-10): (A) normal space; and (B) log space.

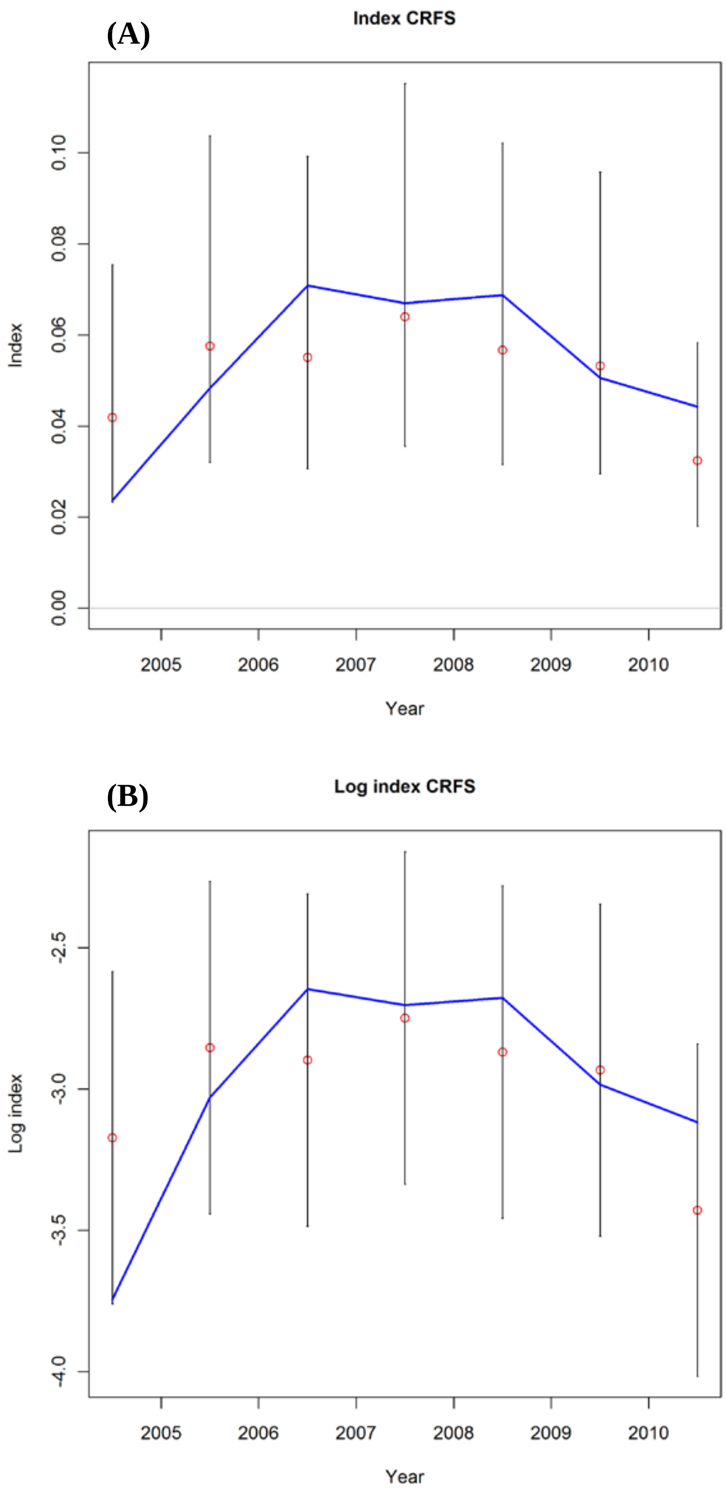
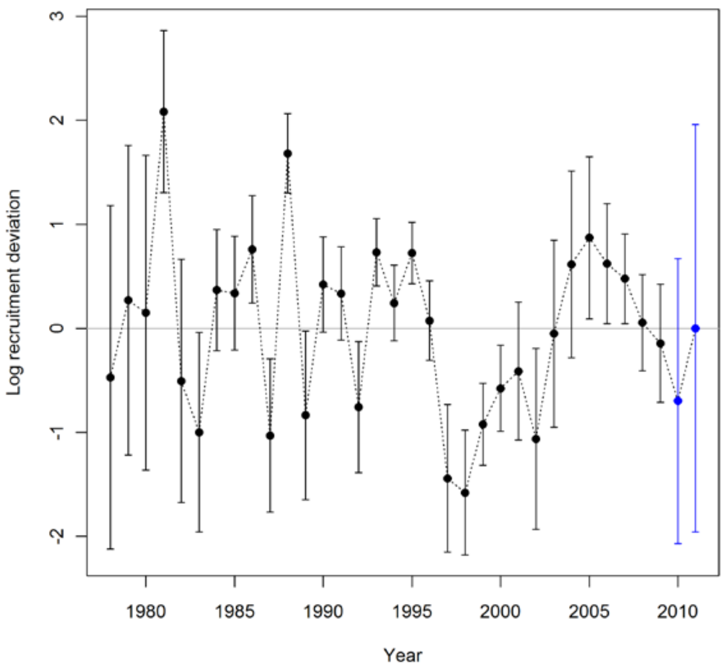


Figure 14. Model *XA* fits to the CRFS index of relative abundance (one time block, 2004-10): (A) normal space; and (B) log space.

(A)



(B)

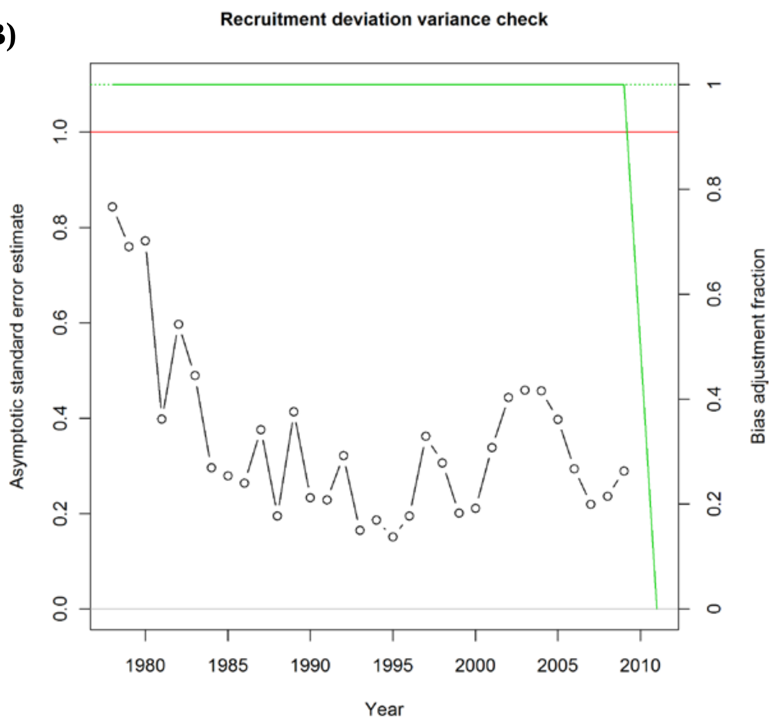


Figure 15. Recruitment-related estimates from model *XA*: (A) recruitment deviations; and (B) SEs associated with the deviations (horizontal line indicates the estimate of the standard deviation of log recruitment deviations, i.e., fixed σ_R =1.0).

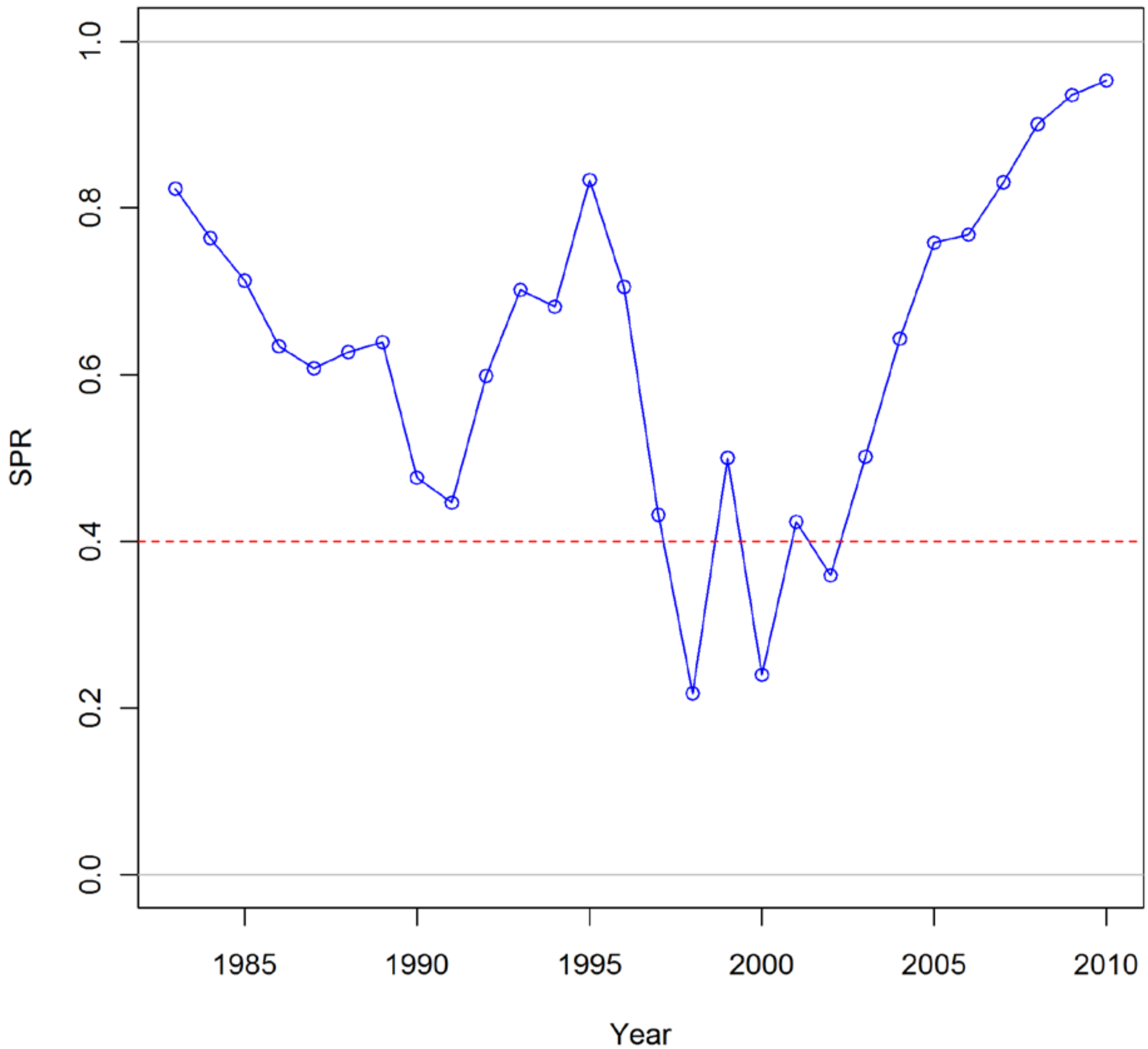


Figure 16. Estimated *F*-based spawning potential ratio time series for model *XA* (1983-10).

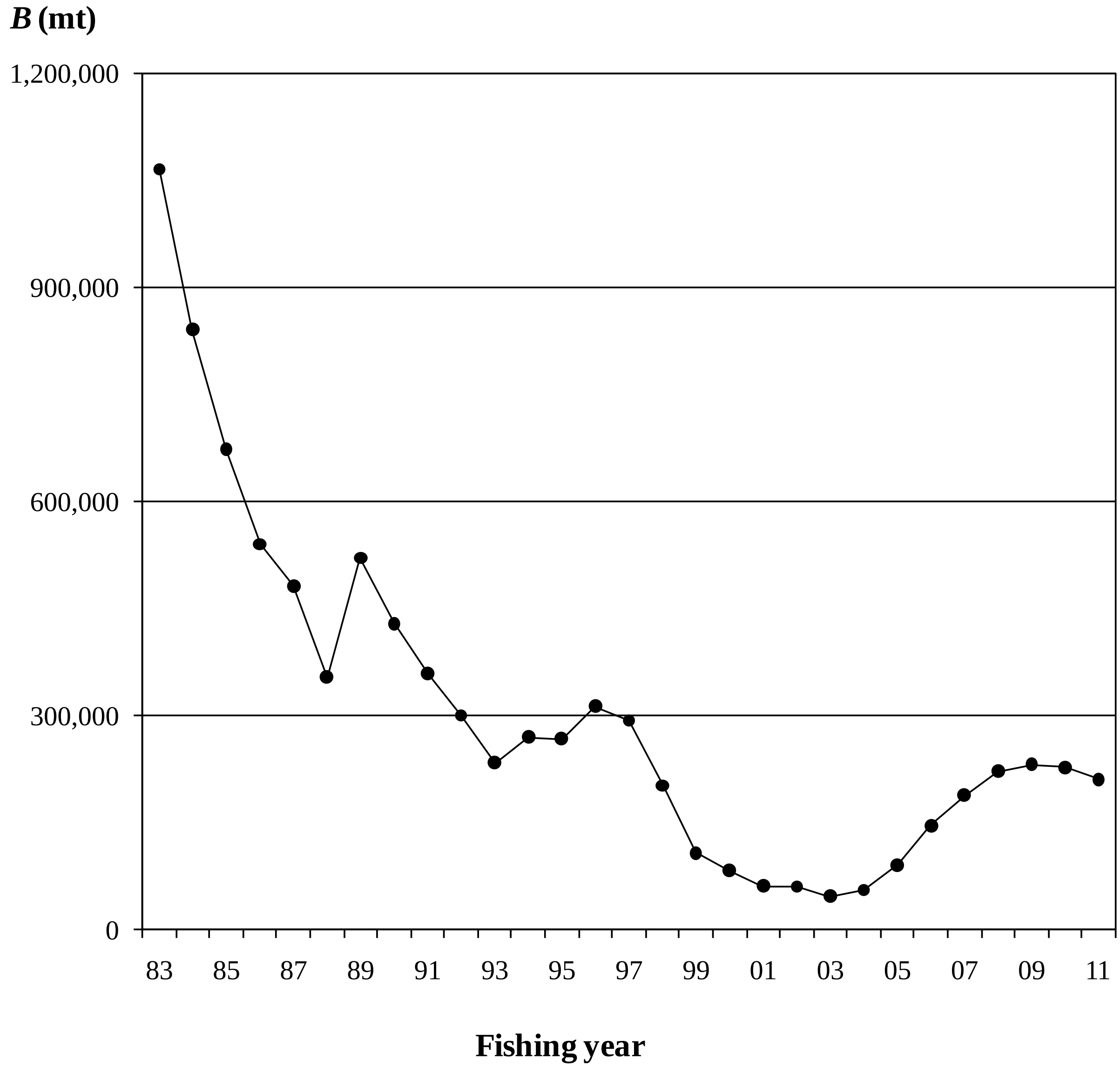


Figure 17. Estimated total stock biomass (age 1+ fish in mt, *B*) of Pacific mackerel based on Model *XA* (1983-11).

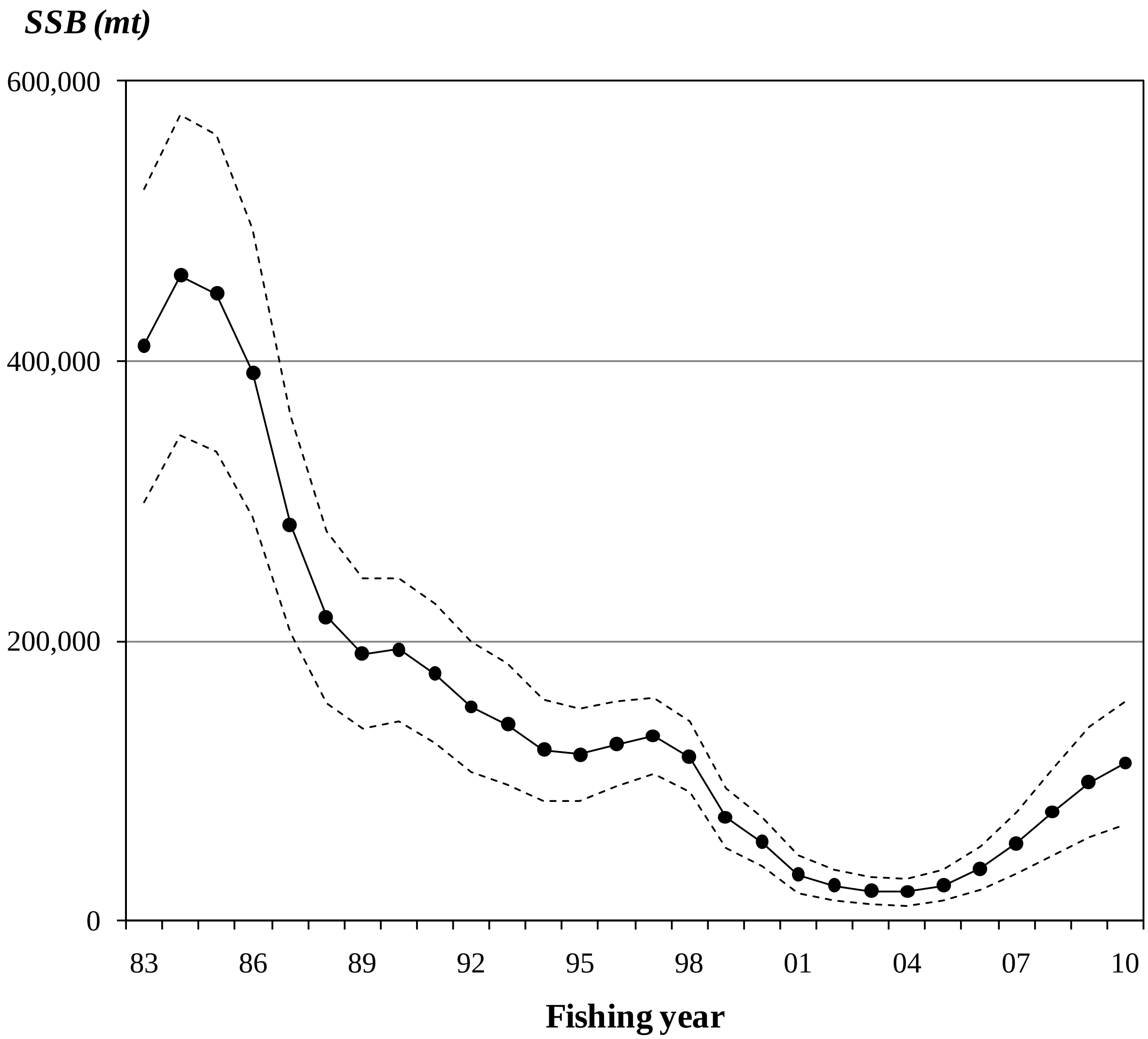


Figure 18. Estimated spawning stock biomass (*SSB*) of Pacific mackerel based on Model *XA* (1983-10). A confidence interval (95% CI) is also presented as dashed lines.

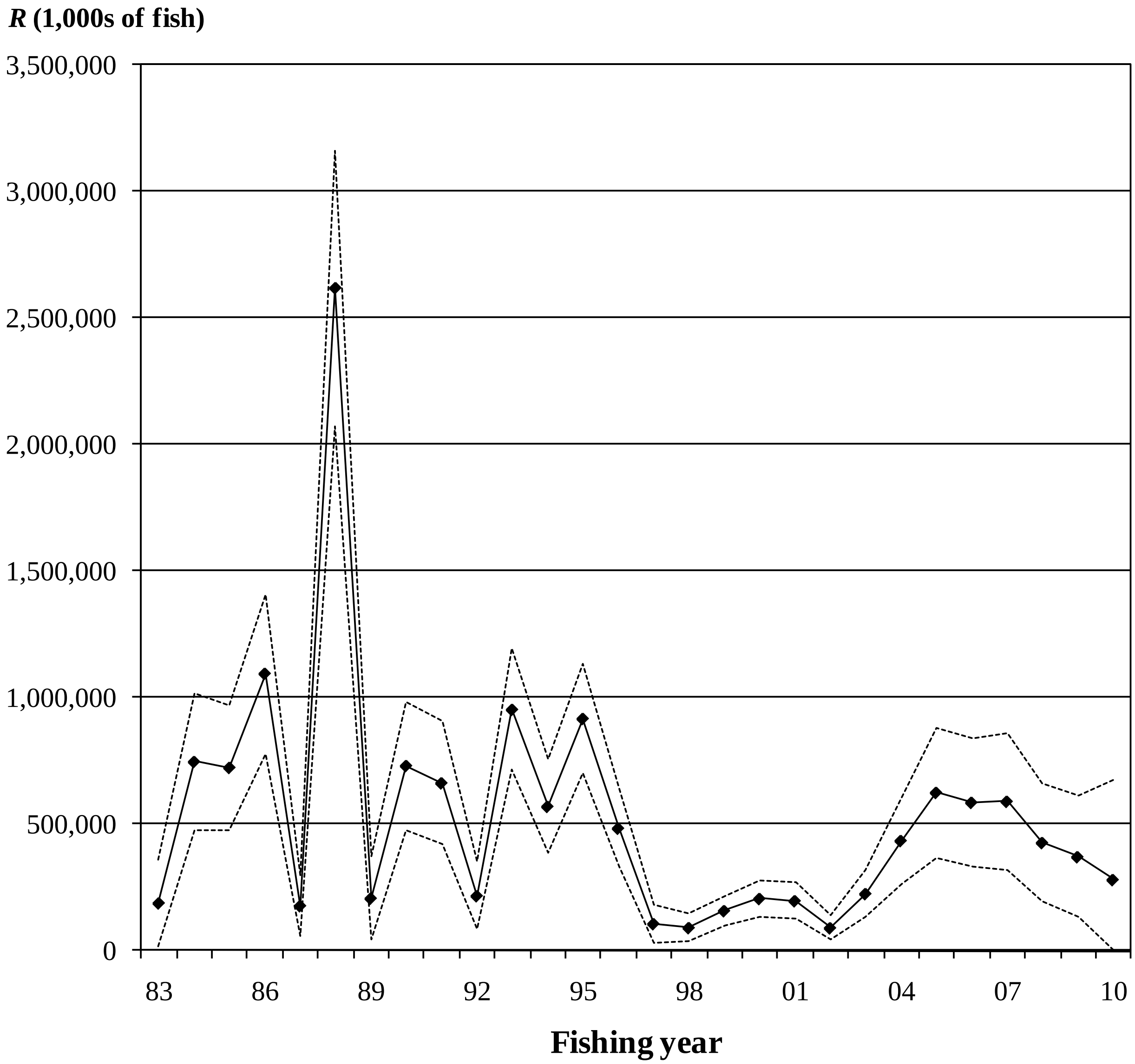
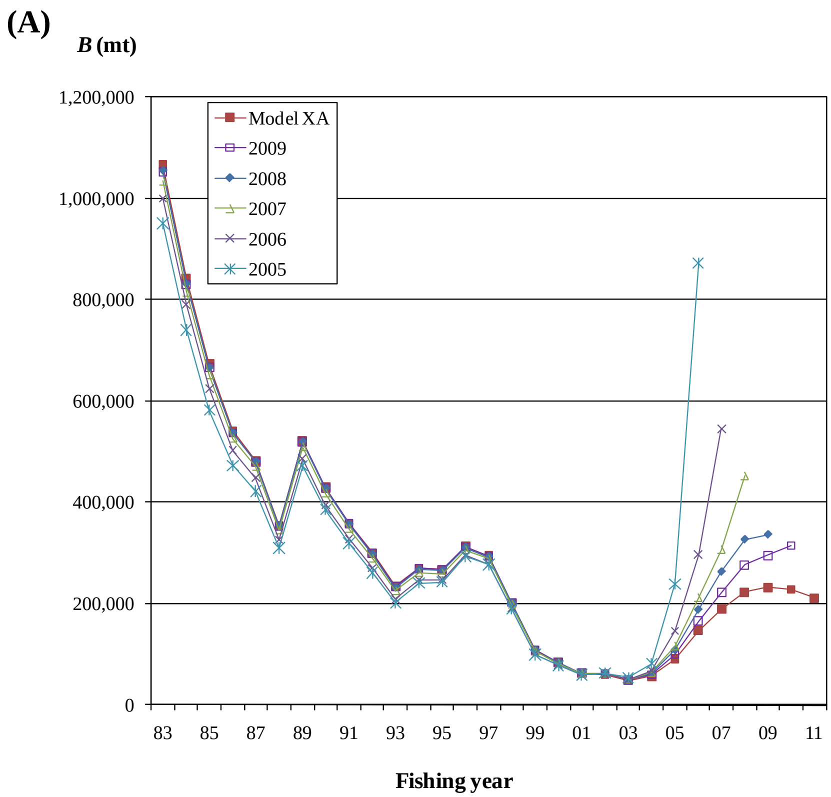


Figure 19. Estimated recruitment (age-0 fish in 1,000s, *R)* of Pacific mackerel based on Model *XA* (1983-10). A confidence interval (95% CI) is also presented as dashed lines.



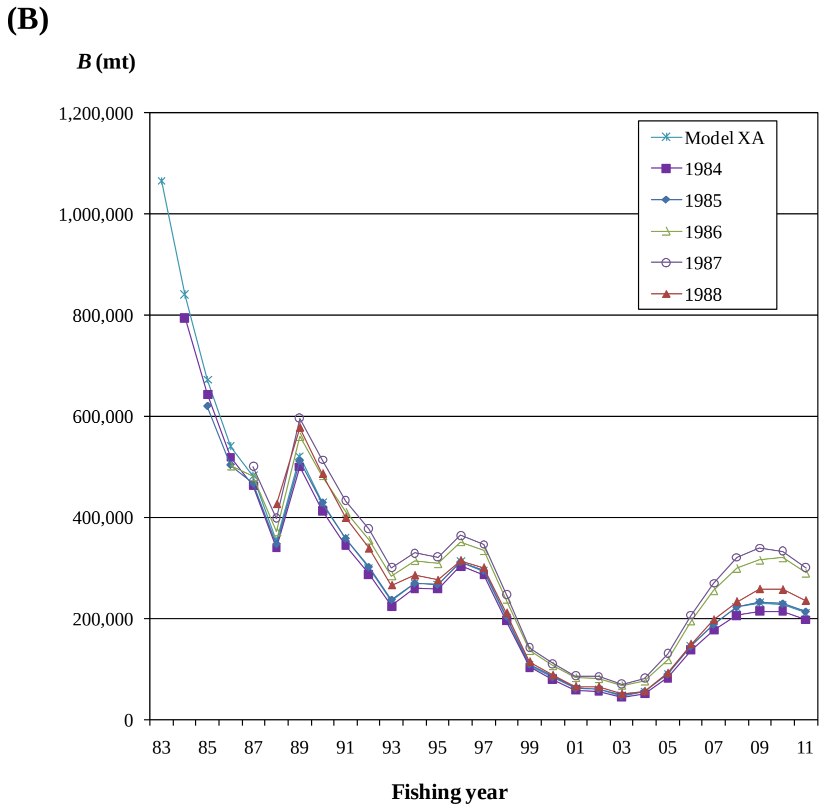


Figure 20. Estimated total stock biomass (age 1+ fish in mt, *B*) of Pacific mackerel based on a: (A) retrospective analysis that omitted one year of data in chronological order (2006-10), i.e., Model *XA*=2010; and (B) prospective analysis that started the model one year later in chronological order, i.e., Model *XA*=1983.

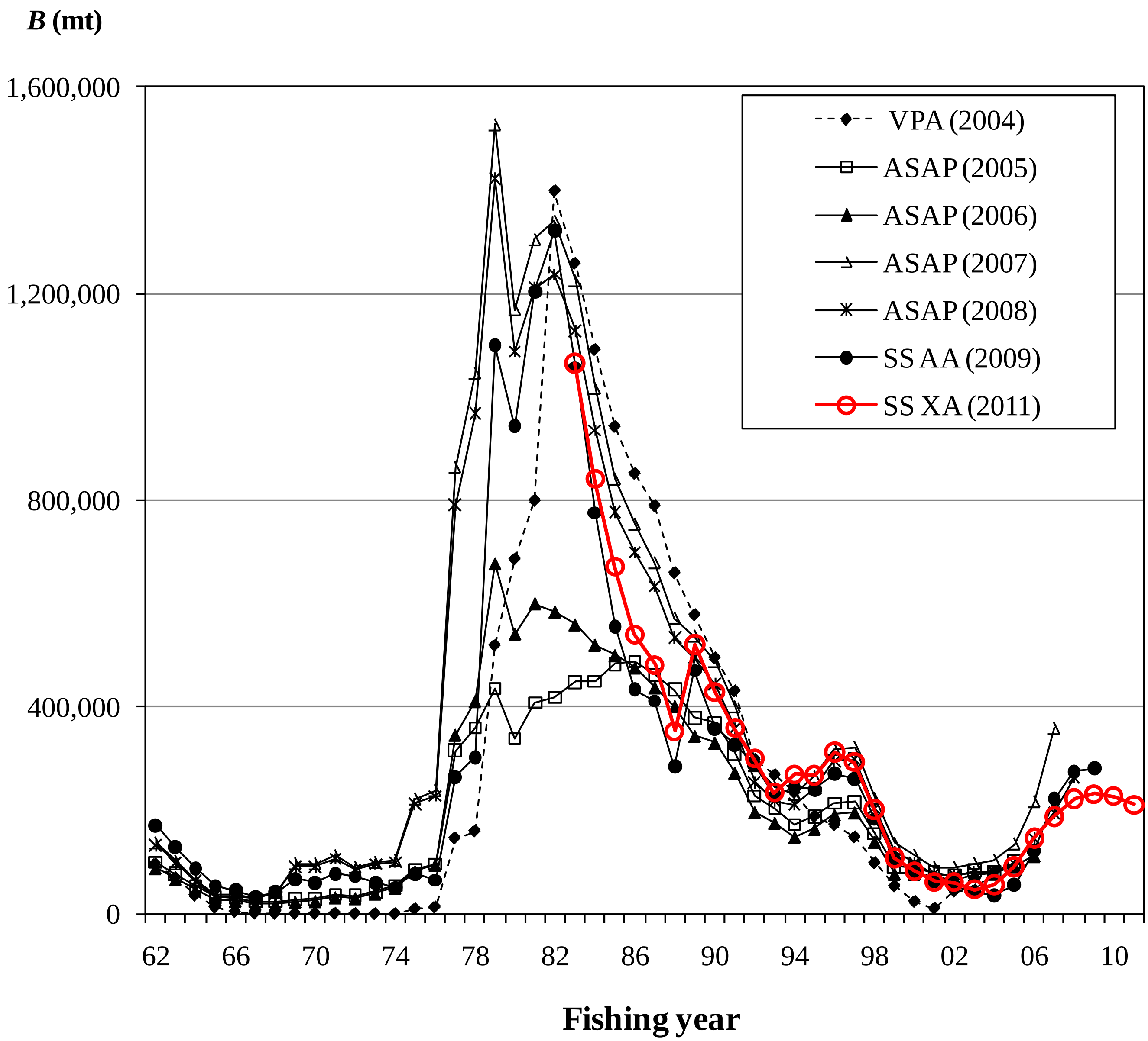


Figure 21. Estimated total stock biomass (*B* age 1+ fish in mt) of Pacific mackerel for the historical assessment period (2004-11): VPA model-based assessments from 1994-04; ASAP model-based (2005-08); and SS model-based (2009-11).

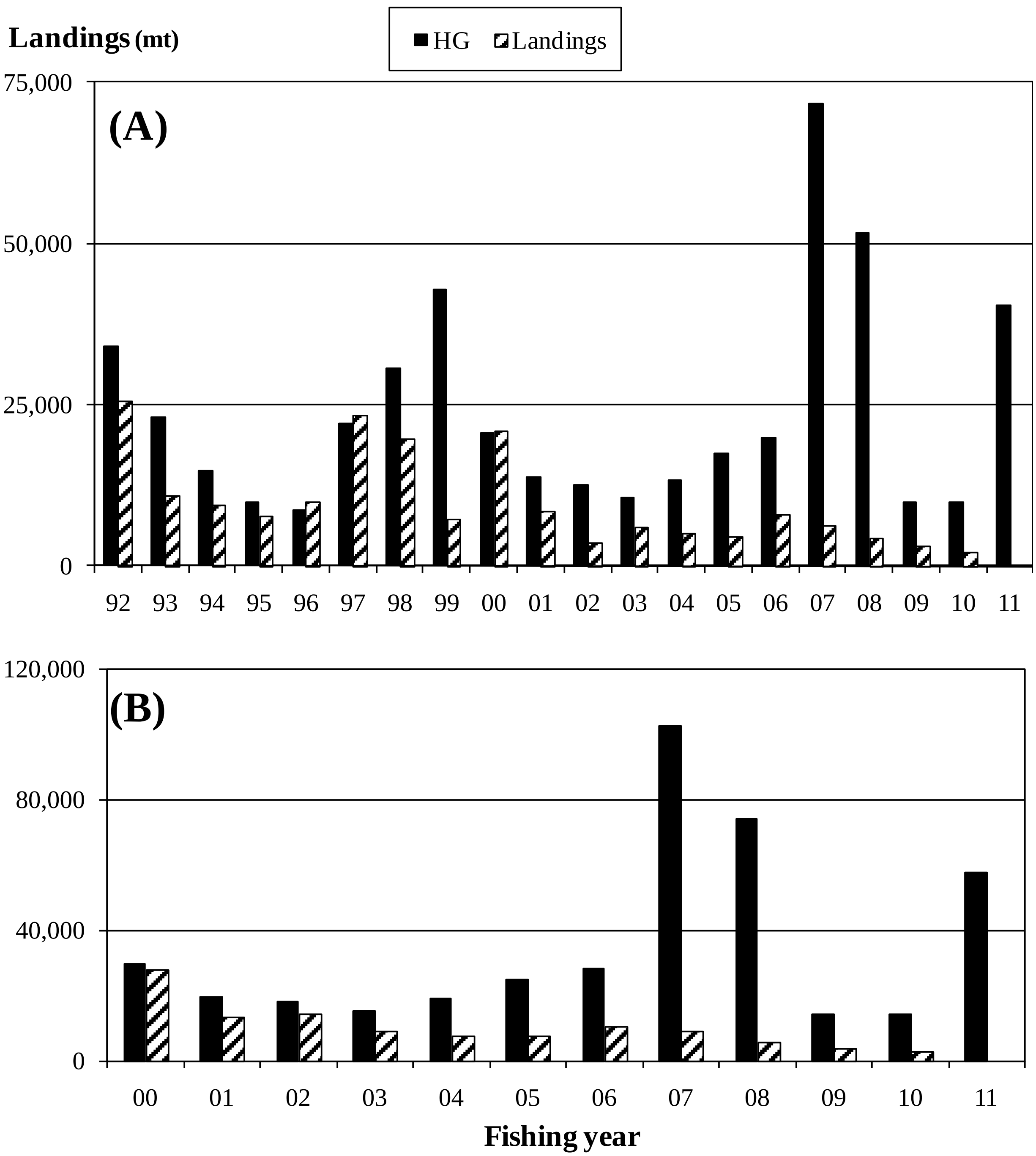


Figure 22. Harvest guideline statistics for Pacific mackerel: (A) commercial landings (USA directed fishery in mt) and quotas (HGs in mt), (1992-11); and (B) total landings (mt) and hypothetical quotas based on no USA 'Distribution' parameter in the harvest control rule. Incidental landings from Pacific Northwest fisheries are not included, but typically are limited, ranging 100 to 300 mt per year. Also, see Harvest Control Rule for USA Management in 2011-12 section.

Appendix 1

SS Model *XA (2011)* files

```
##############################################################################
# P. mackerel stock assessment (1983-10)
# P. R. Crone (June 2011)
# Stock Synthesis 3 (v. 3.20b) - R. Methot
# Model XA: number of fisheries = 2 / surveys = 2 / time-step = annual /
  biological distributions = age, length, and mean length-at-age /
  selectivity = age-based
#
# NOTES: ** ... ** = Pending questions and/or comments
#
```

 # STARTER FILE

```
#
XA.dat # Data file
XA.ctl # Control file
0 #   Read initial values from 'par' file: 0 = no, 1 = yes
1 #   DOS display detail: 0, 1, 2
1 #   Report file detail: 0, 1, 2
0 #   Detailed checkup.sso file: 0 = no, 1 = yes
0 #   Write parameter iteration trace file during minimization
1 #   Write cumulative report: 0 = skip, 1 = short, 2 = full
0 #   Include prior likelihood for non-estimated parameters
1 #   Use soft boundaries to aid convergence: 0 = no, 1 = yes (recommended)
1 #   Number of bootstrap data files to produce    ** New parameterization **
20 #  Last phase for estimation
10 #  MCMC burn-in interval
2 #   MCMC thinning interval
0 #   Jitter initial parameter values by this fraction
-1 #  Minimum year for SSB sd_report: (-1 = styr-2, i.e., virgin population)
-2 #  Maximum year for SSB sd_report: (-1 = endyr, -2 = endyr+N_forecastyrs
0 #   N individual SD years
0.0001 # final convergence criteria (e.g., 1.0e-04)
0 #   Retrospective year relative to end year (e.g., -4)
1 #   Minimum age for 'summary' biomass
1 #   Depletion basis (denominator is: 0 = skip, 1 = relative X*B0, 2 =
      relative X*Bmsy, 3 = relative X*B_styr
0.6 # Fraction for depletion denominator (e.g., 0.4)
1 #   (1-SPR) report basis: 0 = skip, 1 = (1-SPR)/(1-SPR_tgt), 2 = (1-
      SPR)/(1-SPR_MSY), 3 = (1-SPR)/(1-SPR_Btarget), 4 = raw_SPR ** If no
      Forecast, then option = 4 **
1 #   F SD report basis: 0 = skip, 1 = exploitation(Bio), 2 =
      exploitation(Num), 3 = sum(F_rates) ** If no Forecast, then option = 0
      **
1 #   F report basis: 0 = raw, 1 = F/Fspr, 2 = F/Fmsy, 3 = F/Fbtgt  ** New
      parameterization **
999 # End of file
```

```
################################################################################
# P. mackerel stock assessment (1983-10)
# P. R. Crone (June 2011)
# Stock Synthesis 3 (v. 3.20b) - R. Methot
# Model XA: number of fisheries = 2 / surveys = 2 / time-step = annual /
  biological distributions = age, length, and mean length-at-age / selectivity
  = age-based
#
# NOTES: ** ... ** = Pending questions and/or comments
#
```

FORECAST FILE

```
1 #   Benchmarks: 0 = skip, 1 = calculate (F_SPR, F_btgt, F_MSY) ** Related
      to Benchmark relative_F basis, Forecast, and F and SPR report basis (in
      ctl file) options **
2 #   MSY: 0 = none, 1 = set to F_SPR, 2 = calculate F_MSY, 3 = set to
      F_Btgt, 4 = set to F(endyr)
      0.3 # SPR target - relative to B0 (e.g., 0.3)
      0.5 # Biomass target - relative to B0 (e.g., 0.5)
#     Benchmark years: begin_bio, end_bio, begin_selex, end_selex,
      begin_relative F, end_relative F (enter actual year, -999 = start_yr, 0
      = end_yr, <0 = relative end_yr)
0 0 0 0 0 0
1 #   Benchmark relative_F basis: 1 = use year range, 2 = set relative_F same
      as Forecast below
#
1 #   Forecast: 0 = none, 1 = F_SPR, 2 = F_MSY, 3 = F_Btgt, 4 = Avg_F (uses
      first-last relative_F years), 5 = input annual F scalar
1 #   Number of forecast years
1.0 # F scalar (only used for Forecast = 5)
#     Forecast years: begin_selex, end_selex, begin_relative F, end_relative
      F (enter actual year, -999 = start_yr, 0 = end_yr, <0 = relative
      end_yr)
0 0 0 0
#
1 #   Control rule method: 1 = catch = f(SSB) West Coast, 2 = F = f(SSB)
      0.5 # Control rule Biomass level (as fraction of B0, e.g. 0.40) above
      which F is constant
0.1 # Control rule Biomass level (as fraction of B0, e.g. 0.10) below which F
     is set to 0
0.75# Control rule target as fraction of F_limit (e.g., 0.75)
3 #   Number of forecast loops (1-3: fixed at 3 for now)
3 #   First forecast loop with stochastic recruitment
0 #   Forecast loop control #3 (reserved for future bells&whistles)
0 #   Forecast loop control #4 (reserved for future bells&whistles)
0 #   Forecast loop control #5 (reserved for future bells&whistles)
2015 # First year for caps and allocations (should be after years with fixed
inputs)
0 #   SD of log(realized F/target F) in forecast (set value >0.0 to cause
      active implementation error)
0 #   Do West Coast groundfish rebuilder output (0 = no, 1 = 0)
2007 #Rebuilder: first year catch could have been set to zero (Ydecl)(-1 to
      set to 1999)
2010 #Rebuilder: year for current age structure (Yinit) (-1 to set to
     endyear+1)
```

```
1 #   fleet relative F: 1 = use first-last allocation year, 2 = read
      season(row) x fleet(column) below
#     Note: that fleet allocation is used directly as average F if Forecast =
      4
2 #   Basis for forecast catch tuning and for forecast catch caps and
      allocation: 2 = dead_bio, 3 = retain_bio, 5 = dead_num, 6 = retain_num
#      Conditional input if relative F = 2 (total of 4 lines)
#      Fishery relative F: rows = seasons and columns = Fishery
#      Fishery: F1 F2 F3
# 0.1 0.1
#      Maximum total catch by fishery (-1 to have no max)
-1 -1
#      Maximum total catch by area (-1 to have no max)
-1
#      Fleet assignment to allocation group (enter group ID# for each Fishery,
0      for not included in an allocation group)
0 0
#      Conditional on >1 allocation groups (total of 3 lines)
#      Allocation fraction for each of: 0 allocation groups
#      No allocation groups
2 #    Number of forecast catch levels to input (otherwise calculate catch
       from forecast F)
2 #    Basis for input forecast catch: 2 = dead catch, 3 = retained catch, 99
       = input Hrate(F) with units that are from fishery units (note new codes
       in SSv3.20b)
#      Input fixed catch values: year, season, Fishery, catch (or F)
2011 1 1 2257
2011 1 2 100
999 # End of file
```

```
################################################################################
# Pacific mackerel stock assessment (1983-10)
# P. R. Crone (June 2011)
# Stock Synthesis 3 (v. 3.20b) - R. Methot
# Model XA: number of fisheries = 2 / surveys = 2 / time-step = annual /
  biological distributions = age, length, and mean length-at-age / selectivity
  = age-based
#
```

 # CONTROL FILE

```
#
# MODEL DIMENSION PARAMETERS
================================================================================
#
#      Morph parameterization
#
1 #    Number of growth patterns (morphs)
1 #    Number of sub-morhps within morphs
#
#      Note: 'conditional' (8) lines follow, based on above morp/season/area
       parameterization
#
#      Time block parameterization (time-varying parameterization)
1 #    Number of block designs: Selectivity/Catchability
2 #    Blocks in design 1
#
1983 1989 1990 2011 # Blocks - design 1
#
# BIOLOGICAL PARAMETERS
================================================================================
#
0.5 # Fraction = female (at birth)
#      Natural mortality (M)
0 #    Natural mortality type: 0 = 1 parameter, 1 = N_breakpoints, 2 =
       Lorenzen, 3 = age-specific, 4 = age-specific with season interpolation
#      Placeholder for number of M breakpoints (if M type option >0)
#      Placeholder for Age (real) at M breakpoints
#      Growth
1 #    Growth model: 1 = VB with L1 and L2, 2 = VB with A0 and Linf, 3 =
       Richards, 4 = readvector
0.5 # Growth_age at L1 (L_min): Age_min for growth
12 #   Growth_age at L2 (L_max) - (to use L_inf = 999): Age_max for growth
0 #    SD constant added to length-at-age (LAA)
0 #    Variability of growth: 0 = CV_f(LAA), 1 = CV_f(A), 2 = SD_f(LAA), 3 =
       SD_f(A)
#      Maturity
3 #    Maturity option: 1 = logistic (length), 2 = logistic (age), 3 = fixed
       (vector of proportion-at-age), 4 = read age fecundity
#      Maturity-at-age (if maturity option = 3)
0 0.07 0.25 0.47 0.73 1 1 1 1 1 1 1 1 # Maturity-at-age (proportion) for
       option = 3, i.e., 'Accumulator age' + 1 **;
1 #    First mature age (no read if maturity option = 3)
1 #    Fecundity option: 1 is eggs=Wt*(a+b*Wt), 2 is eggs=(a*L^b), 3 is
       eggs=(a*Wt^b)
0 #    Hermaphroditism option: 0 = none, 1 = invoke female to male transition
1 #    MG parameter offset option: 1 = none, 2 = M,G,CV_G as offset from GP1,
       3 = like SS2
```

```
1 #   MG parameter adjust method: 1 = do SS2 approach, 2 = use logistic
      transformation to keep between bounds of base parameter approach
#
#     M, maturity, and growth parameterization
#     Low High Initial Prior_mean Prior_type SD Phase Env_var Use_dev
      Dev_minyr Dev_maxyr Dev_stddev Block_def Block_type
#     M parameterization
0.3 0.7 0.5 0 -1 0 -3 0 0 0 0 0 0 0 0 # M_p1 (M = 0.5, all ages)
#     Growth parameterization
#     Length-at-age
4 35 15 0 -1 0 3 0 0 0 0 0 0 0 0 # VB_L_Amin (Length-at-age = 0.5)
30 70 45 0 -1 0 3 0 0 0 0 0 0 0 0 # VB_L_Amax  (Length-at-age = 12)
0.1 0.7 0.35 0 -1 0 3 0 0 0 0 0 0 0 0 # VB_K
0.01 0.5 0.1 0 -1 0 3 0 0 0 0 0 0 0 0 # CV_young
0.0001 0.5 0.01 0 -1 0 -3 0 0 0 0 0 0 0 0 # CV_old
#     Weight-length
-1 5 3.12e-006 0 -1 0 -3 0 0 0 0 0 0 0 0 # W-L_a
1 5 3.40352 0 -1 0 -3 0 0 0 0 0 0 0 0 # W-L_b
#     Maturity parameterization ** fixed vector for maturity-at-age **
-3 3 3 0 -1 0 -3 0 0 0 0 0 0 0 0 # Maturity (inflection)
-3 3 3 0 -1 0 -3 0 0 0 0 0 0 0 0 # Maturity (slope)
-3 3 1 0 -1 0 -3 0 0 0 0 0 0 0 0 # Eggs/gm (intercept)
-3 3 0 0 -1 0 -3 0 0 0 0 0 0 0 0 # Eggs/gm (slope)
#     Population recruitment apportionment (distribution) ** Placeholders **
-4 4 0 0 -1 0 -4 0 0 0 0 0 0 0 0 # Recruitment distribution (growth pattern)
-4 4 1 0 -1 0 -4 0 0 0 0 0 0 0 0 # Recruitment distribution (area)
-4 4 0 0 -1 0 -4 0 0 0 0 0 0 0 0 # Recruitment distribution (season)
#     Cohort growth deviation
1 5 1 0 -1 0 -4 0 0 0 0 0 0 0 0 # Cohort growth deviation
#
# 1 # Custom environment (MG) parameterization
#
# 1 # Custom block (MG) parameterization ** No time block for growth
      parameterization **
#     Low High Initial Prior_mean Prior_type SD Phase
# -5 5 0 0 -1 0 3 # VB_L_Amin: (1962-89)
# -5 5 0 0 -1 0 3 # VB_L_Amin: (1990-10)
# -5 5 0 0 -1 0 3 # VB_L_Amax: (1962-89)
# -5 5 0 0 -1 0 3 # VB_L_Amax: (1990-10)
# -5 5 0 0 -1 0 3 # VB_K: (1962-89)
# -5 5 0 0 -1 0 3 # VB_K: (1990-10)
#
#     Seasonal effects on biology parameters
0 0 0 0 0 0 0 0 0 0 # ** Placeholder **
#
#     Stock-recruit (S-R)
3 #   S-R function: 1 = B-H w/flat top, 2 = Ricker, 3 = standard B-H, 4 = no
      steepness or bias adjustment
#     Low High Initial Prior_mean Prior_type SD Phase
1 30 10 0 -1 0 1 # ln(R0)
0.1 1 0.9 0 1 0 5 # Steepness
0 2 1.0 0 -1 0 -3 # Sigma_R
-5 5 0 0 -1 0 -3 # Env link coefficient
-15 15 0 0 -1 0 1 # Initial eqilibrium recruitment offset
0 2 0 0 -1 0 -3 # Autocorrelation in recruitment devs
0 #   Index for environment variable to be used
0 #   Environment target
```

```
#
#     Recruitment residual (recruitment devs) parameterization
1 #   Recruitment dev type: 0 = none, 1 = dev_vector, 2 = simple
1978 # Start year for recruitment devs
2009 # Last year for recruitment devs
1 #   Phase for recruitment devs
0 #   Read 11 advanced recruitment options: 0 = off, 1 = on - ** Placeholders
**
#     Start year for (early) recruitment devs
#     Phase for (early) recruitment devs
#     Phase for forecast recruitment devs
#     Lambda for forecast recruitment devs (before endyr+1)
#     Last recruitment dev with no bias adjustment
#     First year of full bias correction adjustment
#     Last year for full bias correction adjustment in MPD
#     First recent year no bias adjustment in MPD
#     Lower bound for recruitment devs
#     Upper bound for recruitment devs
#     Read initial values for recruitment devs
#
# FISHING MORTALITY PARAMETERS
=============================================================================
#
#     Fishing mortality (F) parameterization
0.1 # F ballpark for tuning early phases
-2000 # F ballpark year (negative value = off)
1 #   F method: 1 = Pope, 2 = instantaneous F, 3 = hybrid
0.9 # F or Harvest rate (depends on F method)
#     No additional F input needed for F method = 1 - ** Placeholders **
#     Read overall start F value, overall phase, N detailed inputs to read
      for F method = 2
#     Read N iterations for tuning for F method = 3 (recommend 3 to 7)
#
#     Initial F parameters ** non-equilibrium initial age distribution
      implemented **
#     Low High Initial Prior_mean Prior_type SD Phase
0.0001 5 0.1 0 -1 0 1 # Initial F (F1)
0.00001 5 0.001 0 -1 0 -1 # Initial F (F2)
#
# CATCHABILITY (q) PARAMETERS
=============================================================================
#
#     Catchability (q) parameterization
#     Columns: Do den_dep power (0 = off and survey is proportional to
      abundance, 1 = add parameter for non-linearity); Do env_link (0 = off,
      1 = add parameter for env effect on q);
#     Do extra SD (0 = off, 1 = add parameter for additive constant to input
      SE in ln space); q_type (<0 = mirror other fishery/survey, 0 = no
      parameter q - median unbiased,
#     1 = no parameter q - mean unbiased, 2 = estimate parameter for ln(q), 3
      = ln(q)+set of devs about ln(q) for all years - parm_rand_dev,
#     4 = ln(q)+set of devs about q for index_yr-1 - parm_rand_walk)
0 0 0 0 # F1 = COM (USA commercial and Mexico commercial)
0 0 0 0 # F2 = REC (USA recreational)
0 0 0 0 # S1 = CPFV
0 0 0 0 # S2 = CRFS
#     q parameters (if any)
```

```
#     Low High Initial Prior_mean Prior_type SD Phase
# -1 1 0.0001 0 -1 99 3 # ln(q) - S1
#
# SELECTIVITY (S) PARAMETERS
=============================================================================
#
#     Selectivity/retention parameterization
#     Size (length) parameterization
#     A = selectivity option: 1 - 24
#     B = do retention: 0 = no, 1 = yes
#     C = male offset to female: 0 = no, 1 = yes
#     D = mirror selectivity (fishery/survey)
#     A B C D
#     Size selectivity (S) - ** No size-based S **
0 0 0 0 # F1
0 0 0 0 # F2
0 0 0 0 # S1
0 0 0 0 # S2
#
#     Age selectivity (S) - ** Age-based S is implemented **
20 0 0 0 # F1 (double-normal distribution)
20 0 0 0 # F2 (double-normal distribution)
15 0 0 2 # S1 (mirror F2)
20 0 0 0 # S2 (double-normal distribution)
#
#     S (age) parameters
#     Low High Initial Prior_mean Prior_type SD Phase Env_var Use_dev
      Dev_minyr Dev_maxyr Dev_stddev Block_def Block_type
#     F1 (double-normal)
-20 15 1 0 -1 0 4 0 0 0 0 0 0 0 # P_1 (1983-10, peak size)
-20 15 -5 0 -1 0 -4 0 0 0 0 0 0 0 # P_2 (1983-10, top logistic)
-20 15 4 0 -1 0 4 0 0 0 0 0 0 0 # P_3 (1983-10, ascending limb width - exp)
-20 15 1.5 0 -1 0 -4 0 0 0 0 0 0 0 # P_4 (1983-10, descending limb width -
     exp)
-20 20 -1 0 -1 0 4 0 0 0 0 0 0 0 # P_5 (1983-10, initial S - at first age
     bin)
-20 20 15 0 -1 0 -4 0 0 0 0 0 0 0 # P_6 (1983-10, final S - at last age bin)
#
#     F2 (double-normal)
-10 15 2 0 -1 0 4 0 0 0 0 0 0 0 # P_1 (1983-10, peak size)
-10 15 -4 0 -1 0 4 0 0 0 0 0 0 0 # P_2 (1983-10, top logistic)
-15 15 -1 0 -1 0 4 0 0 0 0 0 0 0 # P_3 (1983-10, ascending limb width - exp)
-20 15 -4 0 -1 0 4 0 0 0 0 0 0 0 # P_4 (1983-10, descending limb width - exp)
-25 15 -5 0 -1 0 4 0 0 0 0 0 0 0 # P_5 (1983-10, initial S - at first age
    bin)
-20 15 -2 0 -1 0 4 0 0 0 0 0 0 0 # P_6 (1983-10, final S - at last age bin)
#
#     S1 (mirror F2) ** no additional parameter lines needed **
#
#     S2 (double-normal)
-10 15 2 0 -1 0 4 0 0 0 0 0 0 0 # P_1 (1983-10, peak size)
-10 15 -4 0 -1 0 4 0 0 0 0 0 0 0 # P_2 (1983-10, top logistic)
-15 15 -1 0 -1 0 4 0 0 0 0 0 0 0 # P_3 (1983-10, ascending limb width - exp)
-20 15 -4 0 -1 0 4 0 0 0 0 0 0 0 # P_4 (1983-10, descending limb width - exp)
-25 15 -5 0 -1 0 4 0 0 0 0 0 0 0 # P_5 (1983-10, initial S - at first age
      bin)
-20 15 -2 0 -1 0 4 0 0 0 0 0 0 0 # P_6 (1983-10, final S - at last age bin)
```

```
#
# 1 # Conditional: custom Sel_env parameterization ** No time block for
      selectivity parameterization **
#     Low High Initial Prior_mean Prior_type SD Phase
# -2 2 0 0 -1 99 -2
#
# 1 # Conditional: custom Sel-block parameterization
#     F1 S time blocks (block design 1) ** For age-based S **
#     Low High Initial Prior_mean Prior_type SD Phase
#
# 1 # Conditional: selparm trends
# 1 # Conditional: for selparm_dev_Phase
# 1 # Conditional: env/block/dev adjust method (1 = standard, 2 = logistic
      transition to keep in base parm bounds, 3 = standard with no bound
      check)
#
#     Tag loss and reporting parameterization
0 #   TG_custom: 0 = no read, 1 = read if tags exist
#     Conditional if no tag parameters
#     Low High Initial Prior_mean Prior_type SD Phase Env_var Use_dev
      Dev_minyr Dev_maxyr Dev_stddev Block_def Block_type
# -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0
#
# LIKELIHOOD COMPONENT PARAMETERS
=========================================================================
#
1 #   Variance and sample size/effective sample size adjustments (by
      fleet/survey): (0/1)
#     F1 F2 S1 S2
0 0 0 0 # constant (added) to survey CV
0 0 0 0 # constant (added) to discard CV
0 0 0 0 # constant (added) to body weight CV
1 1 1 1 # scalar (multiplied) to length distribution sample size (effective
     ss)
1 1 1 1 # scalar (multipled) to age distribution sample size (effective ss)
1 1 1 1 # scalar (multiplied) to size-at-age distribution sample size
     (effective ss)
#
1 #   Maximum lambda phase: 1 = none
1 #   SD offset: 1 = include
#
#     Likelihood component (lambda) parameterization
#     Likelihood component codes:
# 1 = survey, 2 = discard, 3 = mean body weight, 4 = length distribution, 5 =
      age distribution, 6 = weight distribution, 7 = size-at-age
      distribution,
# 8 = catch, 9 = initial equilibrium catch, 10 = recruitment devs, 11 =
      parameter priors, 12 = parameter devs, 13 = crash penalty, 14 = morph
      composition
# 15 = tag composition, 16 = tag neg_bin
#
4 #   Number of changes to likelihood components
#     Columns: Likelihood_comp Fishery/Survey Phase Lambda_value
      Size_distribtuion_method
#
#     Surveys
# 1 3 1 0 1 # Survey off = S1
```

```
# 1 4 1 0 1 # Survey off = S2
#
#     Length distributions
4 1 1 0 1 # Length distribution off = F1
#
#     Age distributions
# 5 1 1 0 1 # Length distribution off = F1
#
#     Mean size-at-age distributions
# 7 1 1 0 1 # Size-at-age distribution off = F1
#
#     Equilibrium catch
9 1 1 0 1 # Equilibrium catch off = F1
9 2 1 0 1 # Equilibrium catch off = F2
#
#     Priors
11 1 1 0 1 # Priors = off
#
0 #   SD reporting option: (0/1)
999 # End of file
```

```
#############################################################################
# Pacific mackerel stock assessment (1983-10)
# P. R. Crone (June 2011)
# Stock Synthesis 3 (v. 3.20b) - R. Methot
# Model XA: number of fisheries = 2 / surveys = 2 / time-step = annual /
  biological distributions = age, length, and mean length-at-age /
  selectivity = age-based
#
# INPUT DATA FILE
#
1983 # Start year
2010 # End year
1 #   Number of 'seasons' (quarters)
12 #  Number of months per season
1 #   Spawning season
2 #   Number of fishing 'fleets' (fisheries)
#     F1 = COM (USA commercial and Mexico commercial)
#     F2 = REC (USA recreational)
2 #   Number of 'surveys' (CPUE Indices: annual-based)
#     S1 = CPFV
#     S2 = CRFS
#
1 #   Number of areas (populations)
      COM%REC%CPFV%CRFS
0.5 0.5 0.5 0.5 # Fishery/survey timing within time block
1 1 1 1 # Area assignment for each fishery/survey
#
1 1 #       Catch units: 1=biomass, 2=numbers
0.01 0.01 # SE of ln(catch), i.e., equals CV in ln space
#
1 #   Number of genders
12 #  Number of ages (accumulator age)
#     Catch: initial (annual) 'equilibrium' catch (mt)
100 100
#     Number of catch records (lines)
28
#     Catch time series (biomass in mt): Columns=fisheries, year, season
40573.39    1544.12     1983  1
45001.01    1467.32     1984  1
45811.90    1015.90     1985  1
53263.39    859.20      1986  1
46958.31    1264.46     1987  1
48576.06    688.56      1988  1
48787.53    618.27      1989  1
70934.59    616.06      1990  1
64824.75    680.14      1991  1
31753.59    463.87      1992  1
20311.09    608.80      1993  1
22674.40    1062.65     1994  1
10982.43    1013.40     1995  1
23877.14    685.54      1996  1
50272.33    803.99      1997  1
62393.05    429.61      1998  1
15757.21    152.65      1999  1
27466.58    325.32      2000  1
12439.36    571.05      2001  1
```

```
13868.67    254.10      2002  1
8589.59     323.26      2003  1
7028.76     533.46      2004  1
7079.24     395.84      2005  1
9856.14     372.11      2006  1
8426.80     310.00      2007  1
5084.47     280.00      2008  1
3182.60     267.00      2009  1
2256.99     100.00      2010  1
#
#     Number of observations (lines) for all surveys (indices)
35
#     Columns: Fishery/Survey, Units (0=numbers, 1=biomass, 2=F), Error type
      (-1=normal, 0=lognormal), >0=t-dist. (df = input value)
1 1 0 # F1 = COM (USA commercial and Mexico commercial)
2 1 0 # F2 = REC (USA recreational)
3 0 0 # S1 = CPFV
4 0 0 # S2 = CRFS
#
#     Columns: Year, Season, Survey, Observation, Error
1983  1     3     91.82 0.30
1984  1     3     101.23      0.30
1985  1     3     77.63 0.30
1986  1     3     60.91 0.30
1987  1     3     41.32 0.00
1988  1     3     29.28 0.30
1989  1     3     40.64 0.30
1990  1     3     45.04 0.30
1991  1     3     49.95 0.30
1992  1     3     37.06 0.30
1993  1     3     44.49 0.30
1994  1     3     42.05 0.30
1995  1     3     37.36 0.30
1996  1     3     40.95 0.30
1997  1     3     24.98 0.30
1998  1     3     12.89 0.30
1999  1     3     7.34  0.30
2000  1     3     14.03 0.30
2001  1     3     11.19 0.30
2002  1     3     8.88  0.30
2003  1     3     5.56  0.30
2004  1     3     9.75  0.30
2005  1     3     16.70 0.30
2006  1     3     15.95 0.30
2007  1     3     22.64 0.30
2008  1     3     31.73 0.30
2009  1     3     24.45 0.30
2010  1     3     12.00 0.30
2004  1     4     0.0419      0.30
2005  1     4     0.0576      0.30
2006  1     4     0.0551      0.30
2007  1     4     0.0640      0.30
2008  1     4     0.0567      0.30
2009  1     4     0.0532      0.30
2010  1     4     0.0324      0.30
#
#     Discard parameterization
```

```
0 #   Number of Fisheries with discard
#     Placeholder for discard units (1 = same as catch units, 2 = fraction, 3
      = number)
#     Placeholder for Fishery discard error type (>0 = df of t-dist - read CV
      below, 0 = normal with CV, -1 = normal with se, -2 = lognormal)
#     Columns: Fishery, Units, Error type
0 #   Number of discard observations (lines)
#     Placeholder for discard lines
#     Columns: Year, Season, Fishery, Observation, Error
#
#     Mean body weight parameterization
0 #   Number of mean body weight observations (lines)
100 # df for t-dist - not conditional, i.e., needs number even if no mean
      body weight observations
#
#     Population size distributions
1 #   Length bin method: 1 = use fishery length bins below, 2 = generate from
      min/max/width below, 3 = read count and vector below
#     Placeholder for number of population length bins
#     Placeholder for vector of population length bins
#
0 #   Compression of length/age distribution 'tails'
0.0001 # Constant added to length/age data (constant added to expected
      frequencies)
#
0 #   Combine males and females at or below this bin number
#
#     Fishery/Survey size distributions
60 #  Number of length bins
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55
56 57 58 59 60
#
59 #  Number of fishery length distribution observations (lines) ** Length
      distributions for Fishery 1 are not used (included for
      provisional/comparative purposes only **
#     Length distributions (1983-10) - annual (percent)

#     Length distributions: Columns=year, season, fishery/survey, gender,
      partition, sample size, length bin observations (in numbers)
1983  1     1     0     0     106.7 0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00037     0.00225     0.00075     0.00300     0.00300
      0.00150     0.00450     0.00300     0.00150     0.00262     0.00300
      0.00000     0.00112     0.00525     0.00937     0.02211     0.03636
      0.06297     0.09370     0.12969     0.14355     0.14318     0.13718
      0.08883     0.05022     0.02849     0.01237     0.00600     0.00187
      0.00187     0.00037     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1984  1     1     0     0     91.6  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00044     0.00306     0.00480
      0.01135     0.00436     0.00567     0.00262     0.00262     0.00000
      0.01528     0.04845     0.10170     0.16194     0.16019     0.12353
```

```
      0.10214     0.08904     0.07071     0.04801     0.02750     0.01091
      0.00393     0.00175     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1985  1     1     0     0     104.2 0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00038     0.00230
      0.00652     0.01266     0.00959     0.00767     0.01880     0.02916
      0.02533     0.04490     0.04029     0.07252     0.13315     0.17920
      0.16500     0.10860     0.07905     0.04068     0.01765     0.00422
      0.00153     0.00077     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1986  1     1     0     0     120.0 0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00100     0.00967     0.01633     0.00400     0.00933
      0.00800     0.01133     0.01767     0.04000     0.06067     0.07867
      0.09633     0.09800     0.06600     0.05633     0.05700     0.06567
      0.09267     0.07833     0.06000     0.03867     0.01767     0.01000
      0.00433     0.00133     0.00067     0.00033     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1987  1     1     0     0     165.2 0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00194     0.00509     0.01332     0.01502
      0.02349     0.03391     0.04384     0.06491     0.08695     0.08937
      0.07798     0.07145     0.09106     0.11940     0.08646     0.04626
      0.03197     0.02228     0.02180     0.02083     0.01502     0.01380
      0.00315     0.00048     0.00024     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1988  1     1     0     0     179.1 0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00022     0.00156     0.01474     0.11660     0.20415
      0.16038     0.08979     0.02859     0.00960     0.00692     0.00893
      0.01631     0.02993     0.04333     0.04981     0.04646     0.03931
      0.03239     0.02792     0.01720     0.01273     0.01631     0.01407
      0.00871     0.00290     0.00089     0.00022     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1989  1     1     0     0     143.3 0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00056     0.00112     0.02428     0.05833
      0.04996     0.09433     0.21100     0.19620     0.13536     0.07089
      0.03684     0.02623     0.01423     0.01144     0.00726     0.00977
      0.00893     0.00893     0.01144     0.00921     0.00670     0.00558
      0.00084     0.00056     0.00000     0.00000     0.00000     0.00000
```

```
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1990  1     1     0     0     84.6  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00095     0.01183     0.02933     0.03926     0.04494
      0.05771     0.02365     0.00473     0.00757     0.01892     0.02838
      0.04588     0.04730     0.07569     0.06575     0.04730     0.03453
      0.03974     0.06433     0.09413     0.10218     0.06575     0.02980
      0.01372     0.00520     0.00142     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1991  1     1     0     0     66.2  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00121     0.02236     0.05619     0.04592     0.02961     0.02840
      0.01873     0.01390     0.01873     0.04773     0.08520     0.09184
      0.08761     0.06767     0.03625     0.01269     0.02477     0.04230
      0.05438     0.04955     0.05015     0.04773     0.03565     0.01873
      0.00846     0.00363     0.00060     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1992  1     1     0     0     79.8  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00100     0.00150     0.01153     0.02758     0.05065     0.03862
      0.02909     0.06620     0.09478     0.10782     0.08024     0.04965
      0.03009     0.02407     0.03410     0.03059     0.03661     0.03410
      0.05817     0.05918     0.05316     0.03912     0.02758     0.00903
      0.00401     0.00150     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1993  1     1     0     0     107.5 0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00446     0.04576     0.11942     0.12649     0.09710     0.08966
      0.04018     0.02493     0.01414     0.03460     0.03832     0.04167
      0.04799     0.05952     0.03720     0.02344     0.01079     0.00632
      0.00967     0.02121     0.02269     0.02902     0.02641     0.01860
      0.00670     0.00335     0.00000     0.00037     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
1994  1     1     0     0     124.6 0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00032     0.00000     0.00417     0.01638     0.05845     0.12139
      0.13712     0.15125     0.16506     0.11689     0.05652     0.03565
      0.02408     0.01574     0.01991     0.01413     0.01060     0.00578
      0.00385     0.00417     0.00803     0.01509     0.00867     0.00450
      0.00161     0.00064     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
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     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000
1995 1     1     0     0     108.2 0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00333     0.04361     0.14412     0.19586     0.13673
     0.09054     0.04435     0.05839     0.07095     0.06689     0.04028
     0.02772     0.00776     0.00665     0.00517     0.00665     0.00333
     0.00333     0.00296     0.00407     0.01109     0.01220     0.00739
     0.00333     0.00296     0.00037     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000
1996 1     1     0     0     87.6  0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00091     0.00183     0.00594     0.04523     0.09228
     0.10233     0.09274     0.09045     0.07766     0.06578     0.04888
     0.04797     0.03609     0.03518     0.02421     0.02101     0.02878
     0.02787     0.02969     0.02330     0.03563     0.02787     0.02604
     0.01005     0.00137     0.00046     0.00000     0.00046     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000
1997 1     1     0     0     108.6 0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00074     0.00074     0.00221     0.00626     0.00774
     0.00516     0.01363     0.02174     0.05232     0.06890     0.08364
     0.07148     0.06043     0.05453     0.05269     0.05748     0.03758
     0.04422     0.04937     0.05453     0.07443     0.08438     0.06190
     0.02763     0.00590     0.00037     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000
1998 1     1     0     0     90.2  0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00044     0.00089     0.00576     0.00710     0.01330
     0.02217     0.02483     0.01729     0.01729     0.02483     0.03991
     0.07894     0.12772     0.11264     0.09534     0.06962     0.05366
     0.03503     0.05144     0.07317     0.06208     0.03503     0.01951
     0.01020     0.00177     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000
1999 1     1     0     0     66.6  0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00060     0.00900     0.02821
     0.09364     0.09844     0.08884     0.06002     0.03241     0.02281
     0.01681     0.01801     0.02161     0.02641     0.03541     0.06002
     0.08643     0.08944     0.07263     0.06843     0.03902     0.01981
     0.00780     0.00180     0.00180     0.00060     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000
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2000  1     1     0     0     76.4  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00209     0.00524     0.00681     0.01728     0.05079     0.10419
      0.12094     0.09110     0.04764     0.02513     0.01675     0.01623
      0.03874     0.04607     0.03665     0.02094     0.01047     0.01990
      0.05445     0.09319     0.06702     0.05288     0.03665     0.00995
      0.00471     0.00366     0.00052     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2001  1     1     0     0     84.4  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00284     0.01137     0.04121     0.06821     0.05590
      0.03932     0.03648     0.04074     0.05921     0.08764     0.09664
      0.10137     0.06490     0.03932     0.02795     0.02226     0.01611
      0.03316     0.04074     0.04500     0.03221     0.02416     0.00758
      0.00521     0.00047     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2002  1     1     0     0     85.8  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00140     0.01119     0.02797     0.05035
      0.05221     0.06900     0.08159     0.11608     0.14592     0.15758
      0.14079     0.06247     0.03683     0.01772     0.00839     0.00420
      0.00373     0.00373     0.00186     0.00326     0.00233     0.00140
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2003  1     1     0     0     62.8  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00255     0.01338     0.04777     0.11911
      0.13567     0.13376     0.04841     0.03822     0.05796     0.06943
      0.08025     0.06369     0.04013     0.02229     0.02102     0.01656
      0.01911     0.01529     0.01847     0.01656     0.01083     0.00573
      0.00191     0.00127     0.00064     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2004  1     1     0     0     101.2 0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00119     0.00356     0.00514     0.01463     0.02847     0.05299
      0.11111     0.13642     0.14591     0.14037     0.11190     0.07078
      0.07038     0.03361     0.01423     0.01305     0.00989     0.00830
      0.00395     0.00751     0.00633     0.00237     0.00435     0.00237
      0.00079     0.00040     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2005  1     1     0     0     92.0  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
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      0.00000     0.00000     0.00000     0.00000     0.00000     0.00043
      0.00304     0.01914     0.02305     0.06916     0.15485     0.17529
      0.13658     0.08830     0.04959     0.04045     0.04393     0.03045
      0.03871     0.03958     0.04002     0.02044     0.01305     0.00783
      0.00261     0.00000     0.00043     0.00130     0.00087     0.00087
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2006  1     1     0     0     95.7  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00084     0.00084     0.00919     0.01713     0.03886     0.09193
      0.13623     0.12996     0.11032     0.10155     0.06979     0.06728
      0.04931     0.03636     0.02591     0.01546     0.01379     0.01212
      0.01588     0.00501     0.00125     0.00669     0.01087     0.01421
      0.01045     0.00627     0.00125     0.00042     0.00042     0.00042
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2007  1     1     0     0     64.4  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00062
      0.00808     0.03791     0.01740     0.02051     0.06464     0.13735
      0.11933     0.09136     0.07769     0.06588     0.05221     0.03294
      0.02548     0.03543     0.02735     0.02921     0.01927     0.02113
      0.01989     0.02610     0.02300     0.01429     0.01305     0.00622
      0.00808     0.00373     0.00186     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2008  1     1     0     0     28.9  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00138     0.00000     0.01107     0.04841     0.09544     0.09820
      0.05394     0.04149     0.03873     0.04149     0.07746     0.07884
      0.08990     0.03320     0.00830     0.00968     0.00968     0.03596
      0.04149     0.05256     0.04426     0.03596     0.02213     0.01660
      0.00553     0.00553     0.00138     0.00138     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2009  1     1     0     0     16.9  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00474     0.05924     0.12085     0.06872
      0.02370     0.01422     0.03318     0.07583     0.10664     0.11137
      0.10664     0.06635     0.01896     0.00237     0.02133     0.01185
      0.02133     0.01422     0.01659     0.04739     0.01185     0.01659
      0.00948     0.01185     0.00474     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
2010  1     1     0     0     11.9  0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.01342     0.08725     0.14094
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        0.10738     0.06040     0.05369     0.08389     0.06376     0.04698
        0.05034     0.03356     0.06711     0.02685     0.02013     0.03691
        0.03356     0.00671     0.01678     0.01342     0.02349     0.00671
        0.00671     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000
1985    1     2     0     0     81.5  0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00049     0.00000     0.00098
        0.00196     0.00294     0.00491     0.00442     0.00736     0.01374
        0.02355     0.04563     0.04514     0.06035     0.08881     0.10893
        0.13935     0.11237     0.10059     0.07704     0.06035     0.03778
        0.03189     0.01079     0.00883     0.00491     0.00294     0.00098
        0.00049     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00049     0.00000     0.00000     0.00049
        0.00000     0.00000     0.00147
1986    1     2     0     0     238.1 0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00034     0.00118     0.00101
        0.00084     0.00252     0.00403     0.01209     0.03292     0.05107
        0.06971     0.07845     0.06971     0.07324     0.07979     0.09306
        0.10297     0.09525     0.07593     0.06165     0.04569     0.02217
        0.01361     0.00521     0.00353     0.00286     0.00084     0.00017
        0.00000     0.00017     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000
1987    1     2     0     0     174.2 0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00046     0.00023
        0.00436     0.01263     0.02067     0.02067     0.01883     0.02825
        0.04892     0.08222     0.11346     0.11805     0.09348     0.08199
        0.06270     0.05926     0.05489     0.04984     0.05397     0.04318
        0.01929     0.00666     0.00299     0.00138     0.00092     0.00023
        0.00000     0.00023     0.00000     0.00000     0.00000     0.00000
        0.00023     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000
1988    1     2     0     0     156.2 0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00026
        0.00051     0.00000     0.00154     0.00179     0.00307     0.00435
        0.00512     0.00564     0.00948     0.01101     0.01998     0.01895
        0.03817     0.06199     0.09606     0.11885     0.11194     0.09887
        0.08171     0.05815     0.04406     0.04073     0.05507     0.05072
        0.03765     0.01230     0.00538     0.00205     0.00282     0.00154
        0.00026     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000
1989    1     2     0     0     147.1 0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000     0.00190     0.00027     0.00299
        0.00653     0.00299     0.00625     0.00381     0.00489     0.00299
        0.00218     0.01876     0.03915     0.05791     0.06770     0.03752
        0.04160     0.04568     0.05492     0.07667     0.08510     0.06090
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        0.04160     0.04133     0.05546     0.05356     0.06362     0.05057
        0.03834     0.01767     0.00625     0.00598     0.00245     0.00054
        0.00027     0.00054     0.00027     0.00000     0.00082     0.00000
        0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
        0.00000     0.00000     0.00000
1992    1     2     0     0     6.4   0     0     0     0     0     0     0
        0     0     0     0     0     0     0     0     0     0     0     0
        0     0     0.01875     0.01875     0.04375     0.0625      0.1   0.075
        0.075 0.03125     0.04375     0.01875     0.05  0.05625     0.0625
        0.0875      0.05625     0.0875      0.05  0.0125      0.025 0.0125
        0     0.00625     0     0     0     0     0     0     0     0     0
        0     0.00625     0     0     0     0     0     0
1993    1     2     0     0     31.44 0     0     0     0     0     0     0
        0     0     0     0     0     0     0     0     0     0     0     0
        0     0     0.00636     0.00636     0.00891     0.03053     0.03308
        0.04453     0.06997     0.06234     0.06489     0.04453     0.04198
        0.05344     0.0458      0.0458      0.08906     0.1056      0.09924
        0.08015     0.03944     0.01018     0.00382     0.00254     0
        0.00127     0     0     0     0     0.00127     0     0.00254     0
        0.00127     0     0     0     0     0     0.00509
1994    1     2     0     0     11.56 0     0     0     0     0     0     0
        0     0     0     0     0     0     0     0     0     0     0.00346
        0     0.00692     0     0     0.00692     0.00346     0.00692
        0.00692     0.00692     0.02768     0.0173      0.02422     0.06574
        0.08304     0.0346      0.02768     0.0519      0.10727     0.13149
        0.19723     0.05536     0.08997     0.03806     0     0     0     0
        0     0     0     0.00346     0.00346     0     0     0     0     0
        0     0     0     0     0
1995    1     2     0     0     12.72 0     0     0     0     0     0     0
        0     0     0     0     0     0     0     0     0     0     0     0
        0     0     0.00314     0.00629     0.01887     0.02201     0.01258
        0.03459     0.03459     0.03774     0.06918     0.05975     0.04717
        0.0566      0.06289     0.05031     0.09434     0.08491     0.10692
        0.11006     0.0566      0.02201     0.00629     0     0     0     0
        0     0     0.00314     0     0     0     0     0     0     0     0
        0     0     0
1996    1     2     0     0     33.48 0     0     0     0     0     0     0
        0     0     0     0     0     0     0     0.00119     0     0     0
        0     0     0.00597     0.00597     0.00717     0.0227      0.02031
        0.0227      0.03465     0.02389     0.02867     0.04659     0.02987
        0.0454      0.03106     0.03345     0.04062     0.05257     0.09916
        0.14815     0.14815     0.08244     0.04898     0.01314     0.00119
        0.00239     0     0     0     0     0     0     0     0     0     0
        0     0     0     0     0     0.00358
1997    1     2     0     0     47.24 0     0     0     0     0     0     0
        0     0     0     0     0     0     0     0     0     0     0     0
        0.00254     0.00085     0.00254     0.00593     0.01439     0.02794
        0.0398      0.02371     0.0398      0.04911     0.06181     0.07282
        0.07621     0.06097     0.04742     0.0525      0.06097     0.05673
        0.07959     0.08129     0.07028     0.03133     0.01524     0.00847
        0.0127      0.00339     0     0     0     0     0     0.00085     0
        0     0     0     0     0     0     0.00085     0
1998    1     2     0     0     24.44 0     0     0     0     0     0     0
        0     0     0     0     0     0     0     0     0     0     0.00164
        0     0     0     0.00327     0.00491     0.00327     0.00818
        0.00491     0.03928     0.04746     0.05237     0.05728     0.05237
        0.03764     0.02782     0.05074     0.0671      0.09984     0.13421
```

```
     0.10802     0.10802     0.05892     0.02128     0.00655     0
     0.00164     0     0.00164     0     0     0     0     0     0     0
     0     0     0     0     0     0     0.00164
1999 1     2     0     0     24.68 0     0     0     0     0     0     0
     0     0     0     0.00162     0     0     0.00162     0     0     0
     0     0     0.00162     0     0.00324     0     0.0081      0.01621
     0.01783     0.02269     0.01945     0.02755     0.02917     0.03404
     0.05673     0.05348     0.11669     0.14263     0.14425     0.10049
     0.07293     0.05835     0.047 0.01621     0.00648     0     0     0
     0     0.00162     0     0     0     0     0     0     0     0     0
     0     0     0     0
2000 1     2     0     0     15.6  0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0
     0.00256     0.00513     0.00256     0.01026     0.01538     0.02564
     0.03077     0.03333     0.02308     0.03846     0.0641      0.08718
     0.02821     0.02564     0.04359     0.08205     0.12821     0.11282
     0.07949     0.06154     0.0641      0.02308     0.01026     0.00256
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0
2001 1     2     0     0     16.52 0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0
     0.00242     0.00484     0.00484     0.00726     0.00969     0.01937
     0.01695     0.02179     0.04358     0.07022     0.05811     0.08959
     0.05569     0.05085     0.04358     0.10412     0.1138      0.10654
     0.07022     0.07264     0.01695     0.01211     0.00242     0.00242
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0
2002 1     2     0     0     20.88 0     0     0     0     0     0     0
     0     0     0     0.00192     0     0     0     0     0     0     0
     0.00192     0.00192     0.00575     0.00383     0.03257     0.02299
     0.0364      0.04981     0.08621     0.0977      0.07854     0.06897
     0.05939     0.05939     0.04789     0.06322     0.04789     0.0613
     0.05364     0.04215     0.03831     0.02682     0.00575     0.00383
     0     0     0     0     0.00192     0     0     0     0     0     0
     0     0     0     0     0     0     0
2003 1     2     0     0     21.12 0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0
     0.00379     0.00379     0.00568     0.01894     0.04545     0.0322
     0.04545     0.06439     0.05682     0.09091     0.05682     0.05303
     0.04735     0.0303      0.02273     0.02841     0.03598     0.04735
     0.09659     0.08712     0.07008     0.02841     0.01515     0.00189
     0.00379     0     0     0     0.00189     0     0     0     0     0
     0     0     0     0     0     0     0.00189     0.00379
2004 1     2     0     0     20.68 0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0.00774     0.0058      0.02901     0.02515     0.05029     0.09284
     0.0619      0.03868     0.06383     0.05029     0.07737     0.0677
     0.03482     0.03288     0.03675     0.02708     0.05222     0.04642
     0.05996     0.08124     0.03288     0.01934     0     0.00193
     0.00193     0.00193     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
2005 1     2     0     0     21.88 0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0
     0.00366     0.02742     0.06033     0.08044     0.08044     0.08044
     0.06033     0.0585      0.0841      0.08775     0.06033     0.10055
     0.06399     0.04936     0.02742     0.02194     0.00914     0.00366
     0.00548     0.00731     0.00731     0.00731     0.00548     0.00183
```

0 0 0 0 0 0 0 0 0 0 0 0
0.00183 0 0.00183 0.00183 0 0
2006 1 2 0 0 23.76 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0.00168 0.00168 0
0.00168 0 0.00337 0.01852 0.05387 0.08754
0.09091 0.08754 0.08923 0.09596 0.08754 0.07912
0.08249 0.05219 0.03872 0.02862 0.01684 0.00842
0.0202 0.0101 0.00505 0.01178 0.01178 0.00842
0.00505 0.00168 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
2007 1 2 0 0 44.28 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0.0009
0.0009 0.00813 0.02529 0.03071 0.04426 0.07317
0.07588 0.1084 0.11292 0.11382 0.08401 0.07859
0.04246 0.04246 0.03342 0.028 0.01897 0.01265
0.00994 0.01536 0.01265 0.00903 0.00994 0.00452
0.0009 0.0009 0 0.0009 0 0 0.0009 0
0 0 0 0 0 0 0 0 0 0
2008 1 2 0 0 43.32 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0.00185
0.00646 0.01939 0.02308 0.01939 0.01385 0.02124
0.02862 0.05171 0.05448 0.0988 0.13019 0.12742
0.06925 0.06464 0.04894 0.03047 0.03509 0.02216
0.03601 0.02124 0.01847 0.02862 0.01754 0.00369
0.00369 0 0.00277 0 0.00092 0 0 0 0
0 0 0 0 0 0 0 0 0
2009 1 2 0 0 37.08 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0.00108
0.00647 0.0205 0.01942 0.01618 0.01834 0.03883
0.06257 0.10572 0.12729 0.11758 0.0863 0.07875
0.03668 0.03776 0.0302 0.02805 0.03344 0.04207
0.03452 0.0205 0.01402 0.00863 0.00755 0.00216
0.00216 0.00108 0 0.00108 0 0 0 0.00108
0 0 0 0 0 0 0 0 0 0
2010 1 2 0 0 10.96 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0.00365 0.01095
0.01095 0.00365 0.0073 0.00365 0.0219 0.0438
0.08759 0.09489 0.16788 0.09854 0.08759 0.07664
0.05474 0.0365 0.03285 0.0146 0.0146 0.03285
0.0365 0.01095 0.01095 0.0146 0.01095 0.01095
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0
2004 1 4 0 0 47.0 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00170 0.00765 0.01020
0.00425 0.01190 0.03571 0.03741 0.04592 0.06293
0.05952 0.06633 0.07738 0.07823 0.06207 0.06548
0.05867 0.05187 0.03316 0.02551 0.01871 0.01531
0.01531 0.01531 0.01190 0.01446 0.02976 0.03997
0.02381 0.01020 0.00595 0.00085 0.00085 0.00000
0.00000 0.00000 0.00000 0.00085 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00085 0.00000
0.00000 0.00000 0.00000
2005 1 4 0 0 62.4 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00064 0.00128 0.00064 0.00064 0.00256 0.00577
0.00384 0.00512 0.01217 0.02691 0.07047 0.10570

```
     0.12748     0.10955     0.11211     0.10506     0.08520     0.06470
     0.04741     0.04100     0.03139     0.01217     0.00897     0.00320
     0.00384     0.00192     0.00256     0.00128     0.00064     0.00128
     0.00128     0.00064     0.00128     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00128
2006 1     4     0     0     70.8  0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00057     0.00170     0.00170     0.00339
     0.00565     0.00735     0.00904     0.02374     0.04240     0.07801
     0.11702     0.14302     0.14245     0.10797     0.08423     0.05596
     0.03392     0.03561     0.02148     0.01357     0.00791     0.01018
     0.00848     0.00565     0.00396     0.00283     0.00565     0.00339
     0.00848     0.00791     0.00452     0.00226     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000
2007 1     4     0     0     53.2  0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00150     0.00000     0.00150
     0.00301     0.00451     0.00376     0.02404     0.03681     0.03456
     0.06612     0.06536     0.06912     0.12923     0.13223     0.10518
     0.08790     0.05334     0.04808     0.02930     0.02029     0.01803
     0.00902     0.00977     0.00751     0.00601     0.01052     0.00601
     0.00601     0.00526     0.00376     0.00075     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00150
2008 1     4     0     0     36.6  0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00109     0.00000
     0.00000     0.01530     0.04809     0.05355     0.08087     0.06448
     0.06995     0.06011     0.06011     0.07213     0.07760     0.06230
     0.07541     0.06885     0.04044     0.02951     0.01749     0.01421
     0.01421     0.01202     0.01421     0.01311     0.00765     0.00656
     0.00765     0.00656     0.00437     0.00109     0.00000     0.00000
     0.00000     0.00109     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000
2009 1     4     0     0     34.2  0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00117     0.00000     0.00000     0.00000     0.00467     0.00117
     0.00234     0.00467     0.01636     0.05257     0.06308     0.05841
     0.07009     0.10280     0.11682     0.10047     0.07126     0.08995
     0.08061     0.05023     0.03388     0.01986     0.00467     0.00234
     0.00584     0.01285     0.00935     0.01051     0.00467     0.00117
     0.00350     0.00117     0.00234     0.00000     0.00117     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000
2010 1     4     0     0     3.0   0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
     0.00000     0.00000     0.00000     0.00000     0.00000     0.01316
     0.00000     0.00000     0.01316     0.01316     0.01316     0.03947
     0.06579     0.01316     0.14474     0.13158     0.17105     0.06579
     0.06579     0.03947     0.01316     0.03947     0.01316     0.03947
```

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      0.03947     0.01316     0.01316     0.01316     0.01316     0.01316
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
      0.00000     0.00000     0.00000
#
#     Fishery age distributions
9 #   Number of age_bins
0 1 2 3 4 5 6 7 8
#
1 #   Number of ageing error matrices ('Accumulator age' (12) + 1 vectors)
0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10.5 11.5 12.5 # Age bin mid-points
      0.406 0.642 0.712 0.784 0.992 1.304 1.345 1.5 1.637 1.809 1.964 2.119
      2.273 # Age bin SD
#
28 #  Number of age distributions observations (lines)
2 #   Length bin method for Lbin_lo and Lbin_hi: 1 = use population length
      bin index, 2 = use length data bin index, 3 = actual lengths (must use
      population length index option)
-1 #  Combine males and females at or below this bin number
#
#     Fishery age distributions (1983-10) - annual (percent)

#     Age distributions: Columns=year, season, fishery/survey, gender,
      partition, ageing error (age bin SD), Lbin_lo, Lbin_hi, sample size,
      age bin observations (in percent)
1983  1     1     0     0     1     -1    -1    106.72      0.03  0.03  0.39
      0.35  0.05  0.15  0.00  0.00  0.00
1984  1     1     0     0     1     -1    -1    91.64 0.03  0.01  0.10  0.49
      0.23  0.06  0.08  0.00  0.00
1985  1     1     0     0     1     -1    -1    104.24      0.04  0.15  0.05
      0.15  0.47  0.11  0.01  0.01  0.00
1986  1     1     0     0     1     -1    -1    120         0.17  0.33  0.15
      0.04  0.06  0.17  0.05  0.01  0.01
1987  1     1     0     0     1     -1    -1    165.16      0.15  0.50  0.22
      0.04  0.02  0.02  0.03  0.01  0.01
1988  1     1     0     0     1     -1    -1    179.08      0.63  0.07  0.16
      0.06  0.02  0.01  0.01  0.02  0.02
1989  1     1     0     0     1     -1    -1    143.32      0.14  0.77  0.03
      0.02  0.01  0.01  0.01  0.00  0.01
1990  1     1     0     0     1     -1    -1    84.56 0.22  0.12  0.24  0.07
      0.11  0.12  0.04  0.04  0.04
1991  1     1     0     0     1     -1    -1    66.2  0.20  0.42  0.07  0.10
      0.06  0.06  0.04  0.02  0.02
1992  1     1     0     0     1     -1    -1    79.76 0.16  0.38  0.15  0.10
      0.08  0.06  0.04  0.02  0.01
1993  1     1     0     0     1     -1    -1    107.52      0.56  0.14  0.14
      0.03  0.04  0.04  0.02  0.02  0.01
1994  1     1     0     0     1     -1    -1    124.56      0.45  0.39  0.08
      0.03  0.02  0.01  0.01  0.00  0.00
1995  1     1     0     0     1     -1    -1    108.24      0.62  0.26  0.06
      0.01  0.01  0.02  0.01  0.01  0.00
1996  1     1     0     0     1     -1    -1    87.56 0.32  0.33  0.14  0.08
      0.05  0.04  0.02  0.02  0.01
1997  1     1     0     0     1     -1    -1    108.56      0.07  0.26  0.22
      0.11  0.08  0.08  0.06  0.05  0.08
```

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1998  1     1     0     0     1     -1    -1    90.2  0.09  0.16  0.32  0.16
      0.08  0.06  0.05  0.03  0.04
1999  1     1     0     0     1     -1    -1    66.64 0.37  0.08  0.07  0.14
      0.14  0.10  0.04  0.03  0.02
2000  1     1     0     0     1     -1    -1    76.4  0.44  0.16  0.06  0.10
      0.12  0.08  0.03  0.01  0.01
2001  1     1     0     0     1     -1    -1    84.44 0.28  0.44  0.08  0.05
      0.06  0.05  0.02  0.01  0.00
2002  1     1     0     0     1     -1    -1    85.8  0.24  0.65  0.08  0.02
      0.00  0.01  0.00  0.00  0.00
2003  1     1     0     0     1     -1    -1    62.8  0.52  0.27  0.11  0.05
      0.02  0.02  0.01  0.00  0.00
2004  1     1     0     0     1     -1    -1    101.16      0.83  0.11  0.03
      0.02  0.01  0.00  0.00  0.00  0.00
2005  1     1     0     0     1     -1    -1    91.96 0.75  0.17  0.06  0.01
      0.00  0.00  0.00  0.00  0.00
2006  1     1     0     0     1     -1    -1    95.72 0.58  0.27  0.06  0.04
      0.03  0.01  0.01  0.00  0.00
2007  1     1     0     0     1     -1    -1    64.36 0.51  0.24  0.11  0.08
      0.04  0.02  0.01  0.00  0.00
2008  1     1     0     0     1     -1    -1    28.92 0.27  0.31  0.16  0.18
      0.06  0.02  0.00  0.00  0.00
2009  1     1     0     0     1     -1    -1    16.88 0.31  0.45  0.10  0.09
      0.04  0.01  0.00  0.00  0.00
2010  1     1     0     0     1     -1    -1    11.92 0.07  0.58  0.22  0.08
      0.04  0.01  0.00  0.00  0.00
#
#     Fishery mean length-at-age distributions
28 #  Number of mean length-at-age observations (lines)
#      Mean length-at-age distributions (1983-10) - annual (cm)
#     Mean length-at-age distributions: Columns=year, season, fishery/survey,
      gender, partition, ageing error, sample size (nominal only), mean
      length-at-age observations (in cm), mean length-at-age sample sizes
1983  1     1     0     0     1     1     16.69 26.03 29.62 31.87 33.46 34.46
      37.50 -1.00 -1.00 2.68000     2.68000     41.96000    37.04000
      5.84000     16.28000    0.24000     0.00000     0.00000
1984  1     1     0     0     1     1     22.59 27.14 30.71 31.76 34.03 36.10
      36.64 40.25 -1.00 2.84000     0.56000     9.48000     45.04000
      21.20000    5.32000     7.04000     0.16000     0.00000
1985  1     1     0     0     1     1     23.66 28.55 32.11 33.15 33.61 35.06
      36.34 37.57 -1.00 4.24000     15.76000    5.28000     16.12000
      49.36000    10.96000    1.40000     1.12000     0.00000
1986  1     1     0     0     1     1     23.94 28.44 31.43 33.63 34.66 35.27
      35.76 37.13 38.17 20.96000    39.88000    17.88000    4.56000
      7.68000     20.96000    6.20000     0.96000     0.92000
1987  1     1     0     0     1     1     22.98 28.03 31.41 33.85 35.41 36.77
      37.24 37.92 38.77 25.04000    82.48000    36.76000    6.08000
      3.16000     3.88000     4.76000     2.12000     0.88000
1988  1     1     0     0     1     1     21.51 28.83 31.43 33.94 35.50 36.54
      38.16 38.08 39.10 112.00000   13.20000    28.44000    11.52000
      2.72000     1.84000     2.44000     3.80000     3.12000
1989  1     1     0     0     1     1     21.35 25.20 29.88 33.87 35.53 36.86
      37.50 37.08 38.61 19.36000    111.00000   4.76000     3.00000
      1.72000     1.16000     0.88000     0.52000     0.92000
1990  1     1     0     0     1     1     21.02 27.82 30.80 34.15 36.07 36.62
      37.47 38.08 38.93 18.20000    9.92000     20.48000    6.24000
      9.56000     9.84000     3.64000     3.20000     3.48000
```

```
1991  1     1     0     0     1     1     19.30 26.99 31.83 34.03 35.47 36.34
      37.12 37.54 38.61 13.56000    28.00000    4.88000     6.60000
      4.00000     4.00000     2.68000     1.04000     1.44000
1992  1     1     0     0     1     1     20.44 25.01 29.66 32.87 34.36 36.08
      36.49 37.00 38.63 12.80000    30.32000    11.68000    8.20000
      6.76000     4.80000     2.96000     1.60000     0.64000
1993  1     1     0     0     1     1     19.68 27.00 29.05 31.97 36.08 36.48
      38.08 38.24 39.06 60.44000    15.32000    14.84000    3.60000
      4.08000     3.80000     2.04000     2.04000     1.36000
1994  1     1     0     0     1     1     21.76 24.51 27.75 31.04 34.44 36.38
      37.36 38.21 39.00 55.60000    48.60000    10.08000    4.04000
      2.64000     1.36000     1.32000     0.56000     0.36000
1995  1     1     0     0     1     1     20.24 25.00 27.92 31.82 35.45 37.08
      38.32 38.38 40.10 67.16000    28.64000    6.36000     1.12000
      0.80000     1.92000     1.00000     0.84000     0.40000
1996  1     1     0     0     1     1     21.90 25.28 29.72 33.37 35.87 37.18
      37.96 38.41 38.96 27.64000    29.16000    11.88000    6.96000
      4.60000     3.16000     1.80000     1.36000     1.00000
1997  1     1     0     0     1     1     23.69 27.33 30.10 33.00 35.44 36.77
      38.01 38.16 38.56 7.28000     28.20000    23.92000    12.48000
      8.92000     8.52000     6.08000     5.00000     8.16000
1998  1     1     0     0     1     1     22.55 27.94 29.90 32.01 34.62 36.26
      36.59 37.45 37.98 8.52000     14.20000    28.84000    14.40000
      7.52000     5.76000     4.60000     2.92000     3.44000
1999  1     1     0     0     1     1     23.24 26.21 31.15 33.65 34.92 35.81
      36.71 37.87 38.24 24.80000    5.44000     4.68000     9.56000
      9.32000     6.88000     2.80000     1.80000     1.36000
2000  1     1     0     0     1     1     21.89 27.38 29.95 34.71 35.47 35.98
      36.37 37.50 38.00 33.28000    12.48000    4.32000     7.28000
      9.08000     5.80000     2.60000     0.96000     0.60000
2001  1     1     0     0     1     1     21.15 27.26 29.92 34.37 35.42 36.30
      36.31 36.95 36.60 23.68000    36.88000    6.88000     4.28000
      5.04000     4.32000     2.08000     0.88000     0.40000
2002  1     1     0     0     1     1     22.58 26.38 28.95 31.67 34.56 34.55
      36.71 -1.00 -1.00 20.52000    55.44000    7.04000     1.72000
      0.36000     0.44000     0.28000     0.00000     0.00000
2003  1     1     0     0     1     1     22.11 27.41 30.49 34.46 35.67 37.38
      38.13 38.40 39.50 32.60000    17.24000    7.12000     3.04000
      0.96000     0.96000     0.60000     0.20000     0.08000
2004  1     1     0     0     1     1     23.94 27.68 31.05 35.08 36.72 37.67
      38.50 38.00 39.50 84.00000    10.76000    3.28000     2.08000
      0.72000     0.12000     0.08000     0.04000     0.08000
2005  1     1     0     0     1     1     21.31 27.00 30.13 32.04 33.64 35.83
      35.50 39.00 -1.00 68.96000    15.36000    5.84000     1.00000
      0.44000     0.24000     0.08000     0.04000     0.00000
2006  1     1     0     0     1     1     22.55 26.51 30.47 34.16 38.46 39.68
      40.05 40.83 -1.00 55.60000    26.28000    5.88000     3.48000
      2.44000     1.00000     0.80000     0.24000     0.00000
2007  1     1     0     0     1     1     21.11 25.87 29.37 33.63 36.16 38.70
      39.64 40.67 -1.00 32.68000    15.52000    7.00000     5.20000
      2.32000     1.08000     0.44000     0.12000     0.00000
2008  1     1     0     0     1     1     20.44 25.77 27.59 34.54 37.11 38.64
      39.00 -1.00 -1.00 7.84000     9.04000     4.56000     5.12000
      1.84000     0.44000     0.08000     0.00000     0.00000
2009  1     1     0     0     1     1     20.57 26.73 31.19 36.14 38.29 40.33
      42.00 -1.00 -1.00 5.16000     7.68000     1.68000     1.48000
      0.68000     0.12000     0.08000     0.00000     0.00000
```

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2010  1     1     0     0     1     1     20.60 23.26 29.03 34.04 37.00 38.75
      37.00 -1.00 -1.00 0.80000     6.88000     2.60000     0.96000
      0.48000     0.16000     0.04000     0.00000     0.00000
#
0 #   Number of 'environmental' variables
0 #   Number of 'environmental' observations
0 #   Weight distributions
0 #   Tag data
0 #   Morph data
999 # End of file
```