

**REPORT OF THE 2008 ICCAT
YELLOWFIN AND SKIPJACK STOCK ASSESSMENTS MEETING**
(Florianópolis, Brazil – July 21 to 29, 2008)

1. Opening, adoption of Agenda and meeting arrangements

The meeting was opened by Mr. Papa Kebe on behalf of Mr. Driss Meski, ICCAT Executive Secretary. Mr. Kebe thanked the Brazilian government for hosting the meeting and providing all the logistical arrangements. Dr. Joao G. Pereira, General Rapporteur of the Tropical Species Group chaired the meeting.

The Agenda (**Appendix 1**) was adopted with minor modifications. The List of Participants is included in **Appendix 2**. The List of Documents presented at the meeting is attached as **Appendix 3**. The following served as rapporteurs:

P. Pallarés	Items 1, 9 and 10
H. Murua, L.V. González-Ania,	
P. Kebe, G. Scott	Item 2
A. Delgado de Molina, J. Ariz,	
P. Bannerman, E. Chassot	Item 3
H. A. Andrade, K. Ramírez	Item 4
S. Cass-Calay, K. Satoh	Items 5.1, 6.1 and 7.1
V. Restrepo, P. De Bruyn,	
J. Walters, E. Chassot	Items 5.2, 6.2 and 7.2
G. Scott and G. Díaz	Item 8

2. Review of biological information

2.1 Yellowfin

Yellowfin tuna is a tropical and subtropical species distributed mainly in the epipelagic oceanic waters of the three oceans. The sizes exploited range from 30 cm to over 170 cm; maturity occurs at about 100 cm. Smaller fish (juveniles) form mixed schools with skipjack and juvenile bigeye, and are mainly limited to surface waters, while larger fish form schools in surface and sub-surface waters. Reproductive output among females has been shown to be highly variable. The main spawning ground is the equatorial zone of the Gulf of Guinea, with spawning primarily occurring from January to April. Juveniles are generally found in coastal waters off Africa. In addition, spawning occurs in the Gulf of Mexico, in the southeastern Caribbean Sea, and off Cape Verde, although the relative importance of these spawning grounds is unknown. Although such separate spawning areas might imply separate stocks or substantial heterogeneity in the distribution of yellowfin tuna, a single stock for the entire Atlantic is assumed as a working hypothesis, taking into account data that indicates yellowfin are distributed continuously throughout the entire tropical Atlantic Ocean and west to east recovery of tags on a regular base. Males are predominant in the catches of larger sized fish.

Natural mortality is assumed to be higher for juveniles than for adults as showed from tagging studies in other oceans. The natural mortality rates have been showed to be size-dependant in bigeye, skipjack and yellowfin tuna in the western tropical Pacific Ocean using tagging data (Hampton, 2000). In summary, this work demonstrated that M was an order of magnitude higher in the smallest size-class in comparison to fish of midsized. Moreover, it showed that mortality changed from high to low around 40 cm FL, approximately the size at which the three species recruit to the PS fishery in the western Pacific. The results of this work underline the importance of accounting for size- or age-specific natural mortality rates. In that sense, variable mortality for yellowfin was discussed by the group and it was agreed to continue using variable M in the assessment.

Growth rates have been described as relatively slow initially, increasing at the time the fish leave the nursery grounds. Nevertheless, questions remain concerning the most appropriate growth model for Atlantic yellowfin tuna. A recent study (Shuford *et al.*, 2007) developed a new growth curve using daily growth increment counts from otoliths. The results of this study, along with other recent hard part analyses, did not support the concept of the two-stanza growth model (initial slow growth) which is currently used for ICCAT yellowfin tuna stock assessments. This discrepancy can be addressed in future analyses. However, various background documents

pertaining to biological information for tropical tunas were distributed with very valuable information about the growth, ecology and behavior of skipjack. These documents were basically peer-reviewed articles and working documents presented to the IOTC Working Party on Tagging Data Analysis and they contained new data in relation to tagging and growth studies of yellowfin. Papers made available from the IOTC Working Party on Tagging Data Analysis were mainly focused on skipjack and yellowfin growth curves in the Indian Ocean. Although the papers were not presented during the meeting, they provided a valuable source of information to compare growth rates between areas and other methods in use. For example, most of the papers considered that yellowfin has a two- or multiple- stanza growth whereas skipjack growth does not present such a pattern.

A document was presented to the Group (SCRS/2008/111) with new information for the western South Atlantic on sizes, sex ratio, and catch rates of yellowfin, collected by the Uruguayan Longline Tuna Fleet Observer Program during 1998-2007. Geographic and seasonal patterns in the proportion of subadults and adults were analyzed, as well as the relationship with sea surface temperature (SST). The highest catches were recorded in Uruguayan territorial waters, associated with the continental slope, especially sub-adult class fish (<100 cm). Higher CPUE occurred in southern latitudes between 35°S and 37°S for both adults and sub-adults, with a maximum at 36°S (1.6 and 4.7 fish/1000 hooks for sub-adults and adults, respectively). The higher CPUE values were also associated to SST between 19° and 21°C, with the maximum at 21°C (2.0 and 7.1 fishes/1000 hooks for subadults and adults, respectively) and the minimum for both classes at SST higher than 25°C. Sex composition was 1.3 males per female. Mean fork length for the whole period was 111.2 ± 16.7 cm (range: 52-180 cm), with minor differences between males (116.9 ± 15.4 cm; range: 65-180 cm) and females (117.1 ± 14.0 cm; range: 65-162 cm). Lower sizes were recorded between May and August, with a minimum in August (99.0 ± 14.7 cm) and a maximum in December (144.5 ± 12.9 cm). Changes in mean weight or length of fish landed in the fishery can be useful indicators of patterns of exploitation. However, much in the same way that nominal CPUE can be a misleading indicator of stock abundance due to changes in catchability, changes in nominal mean weight may not necessarily be an indicator of population-level changes in the mean weight. Standardization methods similar to those used for CPUE datasets should be considered to separate population-level changes in mean weight from changes in fishing location, timing or selectivity.

2.2 Skipjack

Skipjack tuna is a gregarious species that is found in schools in the tropical and subtropical waters of the three oceans. Skipjack is a species showing an early maturity (around the first or second year of life), high fecundity and spawns opportunistically throughout the year in warm waters above 25°C (Cayré and Farrugio, 1986). Skipjack is also thought to be a faster-maturing and shorter lived species than yellowfin tuna (Maunder, 2001). Moreover, some works have shown that its growth varies according to latitude (Gaertner *et al.*, 2008 in press).

Skipjack is the predominant species aggregated to FADs where it is caught in association with juvenile yellowfin tuna, bigeye tuna and with other species of epipelagic fauna. The increasing use of fish aggregation devices (FADs) since the early 1990s may have changed the behavior of the tuna schools. In this sense, Fonteneau (2000) noted that the free schools of mixed species were considerably more common prior to the introduction of FADs. Furthermore, the association with FADs may also have acted as an “ecological trap” which, in turn, affected negatively the growth, plumpness of skipjack tuna and may change the movement patterns of this species (Hallier and Gaertner, 2008).

No documents containing new biological information for skipjack were presented at the meeting.

Gaertner *et al.* 2008 (in press) investigated latitudinal variability in growth rates of eastern Atlantic skipjack tuna. They reanalyzed conventional tagging data collected by ICCAT since the 1960s. The results of this study suggest that the growth parameters of skipjack tuna vary with latitude. The estimated L_{∞} for skipjack tagged and recovered north of 10°N was lower than the L_{∞} estimated for skipjack tagged and recovered south of 10°N (89.4 cm vs. 112.3 cm, respectively), whereas the estimated growth rate coefficient was greater in the northern region of the eastern Atlantic Ocean than in the equatorial areas ($K = 0.376$ and 0.135 , respectively). The growth parameters estimated during this study are consistent with the range of growth estimates obtained in the Atlantic Ocean and in other oceans. However, the estimates of L_{∞} and K in the Senegalese region in the 1980s within the framework of the Skipjack Year Program, and traditionally applied in ICCAT assessments, are not supported by this study.

The latitudinal variability in the growth rates would complicate age-structured assessment techniques because the size-at-age would be dependant on geographic location and movement patterns. These authors suggested possible alternatives to standard age-structured models including the use of catch-at-size models and growth-

transition matrices by large geographic areas. The Group considered the implications of these results into the assessment. Taking into account the uncertainties associated to the growth curves, the variability in growth between areas and fish movements, no age slicing was performed during this meeting using the available growth curves. It was concluded that a better understanding of skipjack growth patterns is a high priority.

The Group was concerned about the low number of working papers presented during the meeting pertaining to biological information both for yellowfin and skipjack. Moreover, the Group underlined the importance of conducting biological (growth, maturation, reproduction, etc.) and ecological studies for the tropical tuna species for which this information is considered to be poor. This, apart from allowing a more comprehensive knowledge of the processes occurring in the population, will allow using more updated information in the assessment of the tropical tuna species.

The table below summarizes the biological parameters adopted by the SCRS and used in the 2008 Atlantic yellowfin and skipjack (East & West) assessments.

<i>Parameter</i>	<i>Yellowfin</i>
Natural mortality	Assumed to be 0.8 for ages 0 and 1, and 0.6 for ages 2+
Assumed “birth date” of age 0 fish	February 14 (approximate mid-point of the peak spawning season).
Plus group	Age 5+
Growth rates	Length at age was calculated from the Gascuel <i>et al.</i> (1992) equation:
Weights -at-age	$FL(\text{cm}) = 37.8 + 8.93 * t + (137.0 - 8.93 * t) * [1 - \exp(-0.808 * t)]^{7.49}$ Average weights-at-age were based on the Gascuel <i>et al.</i> (1992) growth equation and the Caveriviere (1975) length-weight relationship: $W(\text{kg}) = 2.1527 \times 10^{-5} * L(\text{cm})^{2.976}$
Maturity schedule	Assumed to be knife-edge at the beginning of age 3.
Partial recruitment	Based on output from age-structured VPA (see section addressing yield-per-recruit).
<i>Skipjack (East & West)</i>	
Natural mortality	Assumed to be 0.8 for all ages
Assumed “birth date” of age 0 fish	February 14 (approximate mid-point of the peak spawning season)
Plus group	Age 5+
Growth rates	$L(\text{cm}) = 94.9 * [1 - \exp(-0.340 * t)]$ (West) - Pagavino and Gaertner (1995) $L(\text{cm}) = 97.258 * [1 - \exp(-0.251 * t)]$ (East) - Hallier and Gaertner (2006)
Weights -at-age	$W(\text{kg}) = 7.480 \times 10^{-6} * FL(\text{cm})^{3.253}$ (Entire Atlantic)
Maturity schedule	Assumed to be knife-edge at the beginning of age 2.

3. Review of fishery statistics: Effort, and catch data, including size frequencies and fisheries trends

3.1 Description of fisheries

Yellowfin tuna are caught in the entire tropical Atlantic between 45°N and 40°S by surface gears (purse seine, baitboat and handline) and by longline (**Figure 1**). **Table 1** presents the yellowfin landings by flag and gear.

Skipjack are caught almost exclusively by surface gears throughout the Atlantic, although some minor catches are made by longline as by-catch (**Figure 2**). **Table 2** presents the skipjack landings by flag and gear.

3.1.1 Baitboat

In the East Atlantic, the baitboat fisheries exploit concentrations of juvenile yellowfin in schools mixed with bigeye and skipjack. There are several baitboat fisheries that operate along the African coast.

The most important, in terms of catch, is the Ghanaian baitboat fishery based at Tema. This fleet began to use Fads (fish aggregating device/floating object, which can be natural or artificial) in the early 1990's to enhance the capture of the species together with other tunas. Over 70-80% of these catches in the past five years are off FADs; the mean weight of the captured fishes has remained relatively stable at around 2 kg (mode around 48 cm).

There is another baitboat fishery based in Dakar that began operation in 1956 in the coastal areas off Senegal and Mauritania. Other baitboat fisheries operate in the various archipelagos in the Atlantic (Azores, Madeira, Canary Islands and Cape Verde), which target different species of tuna, including yellowfin and skipjack, according to the season. The average weight of yellowfin tuna taken by these fleets is highly variable (between 7 and 30 kg); lengths range from 38 cm to 80 cm with the mode around 48 cm. The average weight of skipjack taken by Dakar and Canary Island baitboat is 2.5 kg and 3 kg, respectively, with lengths ranging from 35 to 70 cm (mode near 45cm) for Dakar baitboat and from 38 cm to 72 cm (mode at 57 cm) for the Canary Island baitboat fleet. Since the early 1990s, the fleets in Dakar and the Canary Islands have operated using a different method, using the boat itself as a FAD, under which various species of tuna accumulate, including yellowfin tuna. These changes have resulted in an increase in the exploitable biomass of the skipjack stock (due to the expansion of the fishing area) and of its catchability.

In the West Atlantic, Venezuelan and Brazilian baitboats target yellowfin together with skipjack and other small tuna. The sizes for Venezuelan yellowfin are between 45cm and 175 cm and for Brazil between 45 to 115, with the mode at 65 cm.

3.1.2 Purse seine

The East Atlantic purse seine fisheries began in 1963 and developed rapidly in the mid-1970s. They initially operated in coastal areas and gradually extended to the high seas. Purse seiners catch large yellowfin in the equatorial region in the first quarter of the year, coinciding with the spawning season and area. They also catch small yellowfin in association with skipjack and bigeye. Since the early 1990s, several purse seine fleets (France, Spain and NEI) have operated fisheries using objects, with between 45 and 55% of the total catch being taken by this method, whilst before this the proportion of the catch taken by this fishing method was 15% of the total. The Ghanaian purse seine fleet predominantly fishes off floating objects (80%-85%). Frequently, FADs with accumulations of fish are first located by baitboats, who call in a purse seiner to make the set if the accumulation is large. In this situation, the catch is shared between the purse seiner and the baitboat.

Fishing with floating objects takes place mainly in the first and fourth quarters of the year, with skipjack as the dominant species together with lesser quantities of yellowfin and bigeye. The species composition of the schools associated with floating objects is very different from that of free schools. Yellowfin catches from floating objects comprised between 15% and 26% of the total catch in the years between 1991 and 2006 (22% in 2006 for the French, Spanish and NEI fleets) and between 52% and 86% for skipjack for the same period (86% in 2006 for the French, Spanish and NEI fleets).

The East Atlantic purse seine fishery shows a bimodal distribution in the size classes for yellowfin, with modes near 50 cm and 150 cm but with very few intermediate sizes and a high proportion of large fish (more than 160 cm). The average weight of yellowfin tuna caught by the European and NEI purse seine fleets was 13.4 kg in 2006 (4.2 kg with FADs and 30.5 kg unassociated fish). The sizes of yellowfin caught by the Ghanaian purse seiners have ranged around 48-52 cm for the past decade. The average weight of skipjack caught by the European and NEI purse seine fleets was 2.5 kg in 2006 (2.0 kg on FADs and 2.5 kg on free schools), with sizes between 30 cm and 65 cm, with the mode around 45 cm.

The Task I catch series available for these stock assessments includes, for the first time, catches of "faux poisson" (fish sold in the local markets of the landing ports, which are not reported in the logbooks). The "faux poisson" catches made by the European purse seine fleets have been calculated since 1981.

Between 1997 and 2004, new developments in the purse seine fishery which affect yellowfin catches arose from the establishment of a closed season/area for fishing with artificial FADs, for a period of three months in a wide area of the equatorial Atlantic. Starting in 2005, those restrictions were discontinued, and instead a new closed season/area was established with a smaller area (Piccolo) and only for one month (November).

In the West Atlantic, the purse seine fisheries, which were sporadic between 1970 and 1980, have operated in coastal areas since 1980 to the North of the Venezuelan coast and in the south of Brazil. Sizes are in a smaller range than that of fish taken in the east (from 40 to 140 cm), with the majority being of intermediate size. Yellowfin is not the target species of these fleets.

Purse seine skipjack fisheries, with much lower catches than the baitboat fleets, one only operated by Venezuela and Brazil. The sizes of fish from those fisheries are between 35 cm and 65 cm with the mode around 55 cm for Venezuela and for Brazil between 35cm and 75 cm, with a mode around 40 cm.

3.1.3 Longline

The longline fishery began in the late 1950s and soon became important, with significant catches being taken by the early 1960s. Since then, the catches have gradually decreased. Longline fisheries capturing yellowfin tuna are found throughout the Atlantic (**Figure 1**). The degree of targeting yellowfin varies across the longline fleets. In the Gulf of Mexico, both U.S. and Mexican longline vessels target yellowfin (the average weight of yellowfin has remained between 32 and 39 kg during the period from 1994 to 2006). Venezuelan vessels also target yellowfin, at least seasonally. In contrast, Japanese and Chinese Taipei vessels began in the early 1980s to shift targeting away from albacore and yellowfin toward bigeye tuna through the use of deep longline. Uruguayan longliners also catch yellowfin in the Southwest Atlantic, together with other target species. Yellowfin FL sizes ranged from 52 to 180 cm with a mode of 110 cm. (SCRS/2008/111).

3.2 Catch

3.2.1 Yellowfin

Table 1 and **Figure 3** show the development of yellowfin catches in the East Atlantic, West Atlantic and total Atlantic. Total yellowfin catches in 2006 amounted to 108,623 t. Task I catches for 2007 shown are informative only, since they are preliminary and incomplete (important fleets are missing) figures.

In overall, the total Atlantic Task I yellowfin catches have imperceptibly changed since the 2007 SCRS. Although, minor updates have been made to the historical Task I nominal catch series that will slightly change the catch composition of both, Atlantic East and West Atlantic management units. The revisions made were:

- “Unclassified” Atlantic (not split by eastern and western management units) longline catch series of Chinese Taipei (1962-65), NEI (Flags related) (1983-03), Panama (1986-99) and EC. Spain (2005-2006), was split into eastern and western geographic units using the corresponding geographical information of Task II catch and effort (except the NEI fleets and Panama for which Chinese Taipei was used). Details are shown in **Table 3**.
- The historical Task I catch series of Sao Tomé & Principe (1988-1903), disaggregated by species (those catches existed in Task I as tuna unclassified since 1970), were presented and discussed at the end of the 2007 SCRS meeting and incorporated into the Task I catches.
- Cape Verde carryovers from 2004 onwards were replaced by official catch statistics reported before the current meeting.
- An estimate of the “*faux poisson*” caught by the European purse seine fleets (1981-1907) was presented during the meeting by French scientists and consequently incorporated into Task I as “Mix.FR+ES” fleet.

Yellowfin catches increased from the 1950s to reach an average of 150,000 t in the 1980s, and in 1990 reached their highest value (193,448 t). Since then, the catches had shown a gradual decline, and in recent years are at a similar level to those in the early 1970s.

Baitboat: Total catch by this gear for the whole Atlantic was 13,129 t in 2006 although in 1993 the catch was nearly 25,000 t (**Figure 4**). The development is different for the various fisheries.

In the East Atlantic, boats from Angola, Cape Verde and Japan, which took significant catches in the early period of the fishery, have decreased their catches, while other fisheries have increased theirs. In 2006 the catch was 10,434 t (**Figure 5**), with a record catch in 1968 of 22,135 t. Documents SCRS/2008/105, SCRS/2008/106 and SCRS/2008/124 show the various statistical data for the Spanish tropical, Canary Islands and total European and NEI fisheries, respectively.

In the West Atlantic (**Figure 6**) baitboat catches started in 1974, increasing regularly from 1,300 t. in 1974 to 7,000 t in 1994, and later decreasing to about 2,695 t in 2006.

Purse seine: Yellowfin catches by this fleet reached 62,761 t for the entire Atlantic in 2006. In the East Atlantic, catches increased spectacularly in the early years of the fishery (**Figure 4**), from 10,000 t in the 1960s to 100,000 t in 1980, stabilizing at this level until 1983 before decreasing by half in 1984. This occurred as a result of the drastic decrease in effort which took place following the drop in yield of large sized yellowfin, mainly due to the French, Spanish and NEI purse seine fleets abandoning the fishery. Catches later increased again, with a record catch in 1990 of over 129,000 t, followed by a decreasing trend in subsequent years, reaching, 58,319 t in 2006. Documents SCRS/2008/105 and SCRS/2008/124 present statistical data for the Spanish and European and NEI purse seine fisheries. For the “*faux poisson*”, the estimates corresponding to yellowfin show that the highest figure was 2,750 t in 1993, with 1,063 t in 2006.

Estimates of discards and by-catch in the French purse seine fishery of the eastern Atlantic Ocean were derived from observer trips conducted during 2005-2008 (SCRS/2008/117). Results showed that there were almost no discards observed on free schools during this period and that skipjack and little tunny (*Euthynnus alletteratus*) composed the bulk of the discards that were essentially made under fishing aggregating devices (FADs). In 2007, the average discard rates of skipjack and yellowfin tunas under FADs were estimated at 42.9 kg and 1.3 kg per ton landed, respectively. Data samples on size of “*faux poisson*” collected at the fishing port of Abidjan showed that there was no significant difference between discard and “*faux poisson*” size distributions for skipjack, yellowfin, and bigeye tunas. Small skipjack have dominated the “*faux poisson*” tuna landings in Abidjan since the early 1980s and the annual average landings on the local market during 2004-2007 were higher than 9,500 kg while the total landings in Abidjan for the canneries were about 40,000 t each year during the same period. Hence, the average rate of “*faux poisson*” in recent years was about 235 kg per ton of skipjack landed. For yellowfin, the annual average biomass of “*faux poisson*” landed was about 1,900 t during 2004-2007 compared to 37,000 t of commercial landings in Abidjan. The average rate of “*faux poisson*” was then of about 50 kg per ton of yellowfin landed for the canneries. Quantities of juvenile tunas sold as “*faux poisson*” could then largely exceed discards for skipjack, emphasizing the need to improve sampling of “*faux poisson*” that are currently missing from official statistics and not included in stock assessment models.

In the West Atlantic (**Figure 6**) catches increased since the beginning of the fishery in the early 1960s to 1983, when they reached 25,000 t. Catches in the following years showed considerable variation as a part of this fleet shifted its fishery to the Pacific Ocean. Caches in 2006 were 4,442 t. The most important catches in the West Atlantic are taken by the Venezuelan purse seine fishery (in some years being 100% of the total catch).

Longline: After a maximum of over 50,000 t reached in the 1959-1961 period, longline catches decreased to a level of around 30,000 t in the early 1970s, and to about 25,000 t in the 1990s. Longline catches in 2006 reached 22,238 t. The main fisheries are those of Brazil, Chinese Taipei, Japan, Mexico and the United States. The appearance of important catches, beginning in 1985, by NEI fleets in unknown areas is of concern as it is uncertain to what extent these catches actually occurred in the Atlantic. Document SCRS/2008/125 presents statistical data for the longline Mexican fishery in the Gulf of Mexico.

3.2.2. Skipjack

Table 2 and **Figure 7** (catch by area) show the development of skipjack catches in the East Atlantic, West Atlantic and total Atlantic. Total skipjack catches in 2006 amounted about 142,200 t (about 115,700 t in the East and about 26,500 in the West). This catch level has remained relatively stable in the last 11 years, although it is notably lower than that of 1991 and 1993 when the highest level in catches of this species was reached (approximately 200,000 t). Task I catches shown for 2007 shown are informative only as they are preliminary and incomplete (important fleets are missing).

As for yellowfin, minor revisions have been made to the skipjack Task I historical catches since the 2007 SCRS. Nevertheless, this only affects the eastern stock. The revisions made were:

- The historical Task I catch series of S. Tomé e Príncipe (1988-2003) disaggregated by species (those catches existed in Task I as “Tuna Unclassified” since 1970) presented and discussed at the 2007 SCRS meeting incorporated into the Task I catches.
- Cape Verde carryovers from 2004 onwards were replaced by official catch statistics reported before the current meeting.

- An estimate of the “faux poisson” caught by the European purse seine fleets (1981-1907) was presented during the meeting by French scientists and consequently incorporated into Task I as “Mix.FR+ES” fleet.

The breakdown of “unclassified” Atlantic catches into East and West stocks was already made during the 2007 Inter-sessional Meeting of Tropical Tunas (Recife, Brazil, April 11 to 16, 2007) (Anon. 2008).

In the East Atlantic (**Figure 8**), currently the most important fisheries are those of the purse seine fleets, mainly those of France, Ghana, the NEI fleet (Belize, Guinea, Netherlands Antilles, Panama, Malta, Morocco, St. Vincent and Vanuatu), and Spain followed by the baitboat fleets of France, Ghana, Portugal and Spain.

In the West Atlantic (**Figure 9**), the most important fisheries are the Brazilian and Venezuelan baitboat fisheries.

Baitboat: Total catch by this gear for the whole Atlantic was 64,924 t in 2006.

In the East Atlantic, the most important baitboat fleets are the Ghanaian, Senegal and North Islands (Canarias, Madeira and Azores). In 2006 the catches reached 41,175 t, the same level from the end of 1980s. Documents SCRS/2008/105, SCRS/2008/106 and SCRS/2008/124 show the various statistical data for the Spanish tropical, Canary Island and total European and NEI fisheries, respectively.

In the West Atlantic, baitboat catches reached 20,000 t in 1982 and from then remain at the same level, between 18,000 t and 28,000 t (**Figure 9**). In 2006 the catches in these fisheries reached 23,749 t. The most important fishery is the Brazilian baitboat fishery, the target species of which is only skipjack. Cuban and Venezuelan baitboats have also participated in the fishery.

Purse seine: Total catch by this gear for the whole Atlantic was 71,215 t in 2006.

In the East Atlantic, the purse seine fishery was developed in the 1960s, originally as a coastal fishery, but eventually, became more high seas orientated. In the early 1970s the catches of skipjack reached 50,000 t (**Figure 8**). At the beginning of the 1980s, the catches reached 70,000 t. In 1985, there was a considerable decline in the catches of purse seiners, due to the displacement of a large part of the French and Spanish fleets to the Indian Ocean. This situation changed in the years immediately following, skipjack catches then reaching 142,000 t in 1991. From this time there was a marked decline in catches, which dropped to 66,819 t in 2002 and in 2006 reached 69,170 t.

Documents SCRS/2008/105 and SCRS/2008/124 present statistical data for the Spanish and European and NEI purse seine fisheries.

For the “faux poisson”, the estimates corresponding to skipjack (the main species of tunas inside this group) show that the highest figure was 13,750 t in 1993, reaching 5,313 t in 2006.

In the West Atlantic, the purse seine fisheries that developed in the 1960s (USA fleet) had much lower catches than the baitboat fleets; currently, the only purse seine operations are conducted by Venezuela and Brazil. By the end of the 1970s, annual catches reached 3,000 t, and in the 1980s they soon reached 18,000 t (1984), with catches fluctuating in the 1990s between 12,800 t (1993) and 2,100 t (1995). Catches in 2006 were 2,045 t. The most important catches in the West Atlantic are taken by the Venezuelan purse seine fishery (in some years being 100% of the total catch).

3.3 Fishing effort

In general, the fisheries that target tropical tunas are fisheries where it is extremely difficult to discriminate the effective fishing effort by species. However, exceptions do exist among those are several longline fisheries that target yellowfin and the Brazilian baitboat fishery that has skipjack as a target species.

Beginning in the 1990s, important changes have taken place in the East Atlantic main surface fisheries that further complicate the estimation of effective effort, including the greatly increased use of floating objects by purse seiners and baitboats, as well as the use of baitboats as FADs in Dakar and other baitboat fisheries.

As indicators of the nominal effort in the East Atlantic, the carrying capacity of the purse seiner and baitboat fleets has traditionally been used. **Figure 10** shows the development of the carrying capacity of the surface fleets in the East Atlantic for the 1972-2006 period. The baitboat carrying capacity has remained stable since the late

1970s at around 10,000 t. The carrying capacity of the purse seine fleet, on the other hand, has undergone significant changes during the whole period being reviewed, with a constant increase from the start of the fishery until 1983, when carrying capacity exceeded 70,000 t. After that, until 1990, the carrying capacity decreased considerably to 37,000 t, due to part of the fleet abandoning this fishery. There was a slight recuperation in the following two years (1991 and 1992) followed since then by a progressive decline, with capacity at around 29,700 t in the last year (2006).

Document SCRS/2008/124 shows the development of both nominal fishing effort measures for EC and NEI purse seiners: the number of 1-degree rectangles explored and the number with effort greater than 1 fishing day, and total purse seiners fishing days (1991-2007). It can be observed that, while the searching area remains at the same level during these periods, the number of fishing days has diminished considerably.

For the West Atlantic, there have been substantial recent changes in the amount and distribution of fishing effort in the Brazilian longline fishery. Until 1995, sharks were the primary target species (58% of the total catches). However, since 1993, the proportion of sharks has declined, being replaced by swordfish as the dominant species in this fishery (swordfish now represent 48% of the total catches). Effort in the Venezuelan surface fisheries has been high since 1992 (more than 8,000 t vessel carrying capacity). Effort in the U.S. longline fishery, which is active in the northwestern Atlantic and in the Gulf of Mexico, has declined somewhat in the last few years. Japanese longline effort for yellowfin tuna has also declined in recent years. This fleet mainly targets other species (bigeye and bluefin).

Venezuelan and Mexican longline effort for yellowfin tuna has increased in recent years.

3.4 Task II size frequencies

The updated catalogues of Task II size frequencies available in the ICCAT database (observed samples and extrapolated size frequencies reported), for both yellowfin and skipjack, are shown in **Tables 4** and **5**, respectively. They contain a set of metadata information (time and space stratification, number of fish in the dataset, type of size frequencies, etc.) which allows having a clear picture of the level of heterogeneity in the size data.

When comparing the current catalogues with the ones published for revision on the ICCAT web (May 2008) one can verify that:

- Revisions before 2006, were only reported by Japan (2003-05, size and catch-at-size data) for yellowfin only, and Chinese Taipei (2005 size samples) for both species.
- New size information (2006 onwards) has been reported by various countries: Canada (2007); Chinese Taipei (2006-07); Japan (2006); USA (2006-07); EC-Spain (2007, tropical and Canary based fleets); EC-France (2007, tropical fleet); EC-Portugal (2007); Cape Verde (2007); and Ghana (2007);

Details about the species covered and type of size frequencies can be obtained on the corresponding tables.

3.5 Catch-at-size and catch-at-age

At the beginning of the meeting the Secretariat presented, the updated catch-at-size (CAS) data sets for yellowfin (1970-1907) and skipjack (1969-07), together with their corresponding substitution tables. The substitution rules, as also the size datasets used in the estimations were revised by the Group, and updated accordingly. Year 2007 was discarded for both species due to the lack of size information (and Task I catches) of important fisheries.

3.5.1 Yellowfin

The yellowfin CAS includes the complete rebuild of 2005 (considerably incomplete in previous estimations) and 2006. The historical CAS series (1970-2004) was left exactly the same as in previous assessment. After revising the substitution tables, the Group decided to include in the revised CAS:

- the new “faux poissons” series (1981-06) estimated by the European purse seine fleet (a reference file with samples from April 2007 to February 2008, stored in the ICCAT-DB as being from EC-France and EC-Spain)

- the carry over (from 2005) figures for Task I to 2006 for Colombia, Cuba, Dominican Republic, EC-Latvia, Gabon, and Libya.

No changes have been made to the substitution criteria.

A problem identified later by Japan had to do with discrepancies between reported Japanese CAS revision (2003-2004) which has not been included in the historical CAS, and also, a discrepancy in the number of fish found in 2005 (only 65% of the size information has been incorporated in ICCAT database, due to a problem of incompleteness in the ICCAT Form-5 reported, and a corresponding weakness on the code that automatically reads the forms and omits these possibilities). At the same time, Japan also presented a complete (all quarters) CAS revision for 2006. The Group considered that, it was too late to change the revised CAS again and decided to keep the incomplete CAS series of 2006 (first quarter only). The Group determined that these updates should be made before the next SCRS meeting.

The Secretariat also informed about the inconsistencies (small for the overall Atlantic CAS) existent between Task I and CAS at the fleet/gear discrimination level in the period 1975-1983, which could have implications when selecting various fleet related indexes for VPA analyses. During that period CAS has various fleet catches aggregated (longline, baitboat and purse seine fisheries) without a strait correspondence with Task I figures. The Group considered that this revision of historical CAS should be made for the next assessment.

After the creation of a revised CAS version, the corresponding CAA matrices have been obtained by the Secretariat (overall and also fishery based matrices).

A comparison between Task I and CAS is shown in **Figure 11**. Catch-at-age distribution is shown in **Figure 12**. **Tables 6** and **9** show the overall CAS and CAA matrices.

The details of the final yellowfin CAS estimations shall be recollected in a SCRS document (SCRS/2008/128) and presented at the SCRS by the Secretariat.

3.5.2 Skipjack

The skipjack CAS includes the complete rebuilt of 2005 (incomplete in previous estimations) and 2006. The historical CAS series (1969-2004) has been slightly adjusted with the inclusion of São Tomé and Cape Verde. After revising the substitution tables, the Group decided to include in the revised CAS:

- the new “*faux poissons*” series (1981-1906) estimated by the European purse seine fleet (a reference file with samples from April 2007 to February 2008, stored in the ICCAT-DB as being from EC-France and Spain)
- the carryover (from 2005) figures for Task I to 2006 for Cape Verde and EC-Ireland.

No changes to the criteria of substitution have been made.

A comparison between Task I and CAS is shown in **Figure 13**. **Tables 7** and **8** show the CAS matrix for eastern and western stocks.

The details of the final skipjack CAS estimations shall be recollected in a SCRS document (SCRS/2008/126) and presented at the SCRS by the Secretariat.

3.5.2 Catch at age

The yellowfin catch at size data in ICCAT variable format was used to create catch at age following the cohort slicing parameters (**Table 10**) by length class used in a previous assessment. The catch at age in number of fish for selected fisheries and the total amount was presented by the Secretariat and used further in the assessment (**Figure 13** and **Table 9**). The catch at age in weight for the same fisheries was also created using the same cohort slicing and the following length weight relationship:

- 1) Kevin Davis (1991) ($RWT = 0.000000089 * FL^{2.88}$) where RWT is in pounds and fork length in mm.
- 2) Gaertner *et al.* (1992) $RWT = 0.00006611 * FL^{2.7148}$ and;
- 3) Caveriviere (1975) $RWT = 0.00002153 * FL^{2.976}$

A new cohort slicing from Shuford *et al.* (2007) was also raised and the group felt that further investigation should be carried out to test possible discrepancies with earlier calculations.

3.6 Multifan data preparations

Prior to the assessment session, it was agreed to attempt to conduct Multifan-CL (MFCL) analyses of skipjack and yellowfin at the 2008 assessment meeting, in order to improve the account for spatial and fishery dynamics related to these species throughout the Atlantic.

For skipjack, the preliminary fishery definitions are given in **Table 11** and those for yellowfin in **Table 12**. Intersessionally, the Secretariat prepared catch data through 2006 by area (5x5) and quarter as well as the available Task II size and catch/effort information. National scientists prepared CPUE indices for specific fisheries by quarter (see Section 4), and the ICCAT Task II data were examined to produce catch rate indicators for the remaining fisheries.

The temporal time-step agreed for the MFCL applications was quarterly. As such, catch and effort and size frequency information by fishery and quarter were compiled from the ICCAT CATDIS, and Task II size and catch effort information. Quarterly effort data by fishery were estimated from the Task II data applying Generalized Linear Models controlling for Fleet, Gear Type, and Effort Type within each Fishery Definition recorded in the Task II database. **Appendix 4** documents the procedures used to generate the time-series CPUE, which was then divided into the fishery specific catch information to estimate effort patterns for MFCL. In all cases, where detailed, standardized CPUE was available from National Scientists or based on work conducted by the Group at the assessment meeting, those CPUE patterns were used to compute quarterly effort patterns for use in MFCL. The resulting catch and effort time-series by fishery are shown in **Figures 14** and **15** and in **Appendix 4**.

Size frequency data held in the ICCAT Task II data set were also organized by MFCL fishery definition and quarter for skipjack and yellowfin tunas. A criterion of at least 50 size observations per fishery/quarter was used to filter the data for use (**Figures 16** and **17**). The SAS code used for summarizing the data are given in **Appendix 4**.

In support of the MFCL data preparations, for the European and associated purse seine fleet annual skipjack standardized CPUEs, for both FAD and free school fishing modes, were obtained using GLM (see Section 4 for more details). In order to incorporate these indices to the MFCL runs, some adjustments were needed to obtain quarterly standardized CPUEs. During the meeting, it was not possible to obtain new standardized indices by quarter. Therefore, a procedure was established to split the annual standardized CPUE by quarter. In the case of the skipjack free school CPUE the partial residuals corresponding to the factor quarter were used as criteria to split CPUEs. From the graphic of partial residuals, a multiplier was obtained relative to the average value and then quarterly CPUE were obtained multiplying the annual value by these multipliers. In the case of the skipjack, FAD standardized CPUE, partial residuals were not available; hence, the same annual value was considered for each of the four quarters.

Yellowfin

For the European and associated purse seine fleet annual yellowfin tuna <10 kg. standardized CPUEs, for FADs fishing mode and first quarter standardized catch rate for spawner yellowfin (>30 kg) were obtained using GLM (see Section 4 for more details). The information available on the index of small yellowfin, and skipjack, did not allow establishing any criteria to split the index by quarter. Therefore, the same annual value was considered for all quarters.

Appendix 4 contains the preliminary FRQ files prepared for skipjack and yellowfin and are available at the Secretariat on request.

4. Relative abundance indices and other fishery indicators

4.1 Skipjack

4.1.1 Fishery indicators

Eastern Atlantic

The Group examined several general indicators of the purse seine and baitboat fisheries. The carrying capacity of EU purseseines and the number of baitboats has decreased (**Figure 10**). However, in the Dakar-based fisheries the carrying capacity increased, while the number of baitboats decreased in the Dakar-based fisheries (**Figure 18**). The total number of sets and the percentage of successful sets by fishing mode (**Figure 19**) and total areas visited and fished (**Figures 20** and **21**) were also used as indicators of effort.

Catch-at-size data of eastern Atlantic skipjack were used in document SCRS/2008/114 to estimate changes in total mortality and in selectivity patterns for two surface fisheries (the pole and line fishery operating from Dakar, Senegal and the purse seine fleets, omitting Ghanaian vessels) from 1971 to 2005. The general pattern depicted by Z (**Figure 22**) is in agreement with previous knowledge on this fishery: a state at, or close to, full exploitation during the 1990s, followed by a decrease since the mid-1990s, likely due to a combined result of the decrease in purse seine nominal fishing effort, and the adoption of the seasonal moratorium for fishing under FADs. Even if the total selectivity pattern remains relatively stable over the years, the decreasing trend in selectivity observed for purse seiners since the early 1990s suggests that these fleets have shifted from targeting small fish. This is in agreement with the development of the FADs fishing operations since the same period.

Regarding the European baitboats based in Dakar (Senegal), the nominal catch rates of skipjack have increased regularly over the entire time series. When analyzing these data it must be kept in mind that since the beginning of the 1990s these baitboats have developed a fishing technique (mainly for targeting bigeye) in which the baitboat is used as the floating object, fixing the school (comprised of bigeye, yellowfin and skipjack) during the entire fishing season in waters off Senegal and Mauritania. As a consequence, it makes sense to assume that the adoption of this fishing technique has increased the overall catchability of tunas. Note, however, that the pattern described for skipjack contrasts with the decreasing trends in CPUEs observed for the other two tropical tuna species.

4.1.2 Catch rates

During the Group's Meeting held in Sète (France) in 2006 (Anon. 2007), it was recommended that analyses of the CPUE trends for fisheries along the fringes of species distribution be conducted by scientists from various Contracting Parties. The results of the standardization of the CPUEs for the Azorean baitboats were presented and discussed during the Species Group. As expected, due to the location of this fishing area with respect to the distribution range of skipjack, the standardized index showed high variability, but without significant trend (**Figure 23**).

The Group stressed the importance of updating the catch rates of the main fisheries reporting catches of skipjack. It must be stressed that skipjack tuna are often a secondary species, depending on the price differential and on the catchability of other target species. Consequently, estimation of the effective effort exerted on skipjack (e.g. effort proportional to fishing mortality) remains problematic and catch rates may sometimes depict a different trend than abundance.

For purse seiners, fishing alternatively on free schools and on FADs, it was considered that search time may be the best measure of basic effort on free schools. It was also suggested that the analysis data set might be further restricted to effort associated with free school sets by assuming that vessels that travel longer distances overnight are moving between FADs, as they can not be searching for free schools at night. However, this approach would likely require further study, including the incorporation of VMS data, to determine if it is both feasible and appropriate. A new EU-funded CEDER Project (Catch, Effort and Discards Estimates in Real Time), which started in 2006, will deal in part with this question. The basic objective developed within the framework of this project is to analyze the individual trajectory of purse seiners in order to characterize fishing behavior reflecting searching time for un-associated schools or moving towards FADs previously detected by radio range beacon (bearing in mind, however, that whatever the fishing mode researched, every tuna school detected by chance can be set on). Other factors which might be considered include the changes over time, which have resulted in a reduction of the time necessary to make sets and to offload catches (increasing efficiency of fishing effort over time).

For continuity with the previous assessment the catch rates of the European purse seine fleet (France and Spain), obtained after standardizing nominal fishing effort to category 5 (450-750 TRB) FIS purse seiners and assuming a 3% annual increase in fishing efficiency of the fleet from 1981, were updated. The objective of incorporating an increase in efficiency was to take account of the changes that have occurred in the purse seine fleet during these years. The estimate of a 3% annual increase in efficiency is derived from a study by Gascuel *et al.* (1993). The Group discussed the convenience of maintaining this assumption when the vessels fishing in the Atlantic are old (on average more than 20 years old) and their skippers and crews have a low profile compared with those fishing in other oceans (e.g. Indian Ocean). Considering that the estimate of the 3% increase was made 15 years ago, the Group decided to conduct a new estimate of changes in catchability of purse seiners. These new estimates showed a higher increase in efficiency of the fleet, an average annual increase of about a 5% (all three species combined). Nevertheless, the Group decided to use the index estimated with a 3% increase for continuity with the last two assessments.

Standardized indices for juvenile yellowfin and skipjack for the European and associated purse seine fleets fishing on FADs were presented to the Group (SCRS/2008/116). Logbook set by set on FADs data as well as fleet characteristics were used. Indices were developed using a delta-lognormal model. In this case, the model was formulated different to the general use to take into account the problem related with the species composition of the purse seine catch of small fish (>10 kg). These catches are estimated from sampling to correct the bias detected in the logbook data. Therefore, the model included two distinct generalized linear models: a lognormal model which describes the variability in the non-zero catch of species less than 10 kg, and a data and binomial model which describes the proportion of each of the three species in the catch. The results of this approach are different, depending on the species, and the skipjack catch rates showed a U shape with a minimum in 1998 during the whole period.

In addition, a standardized index for skipjack for the Spanish fleet, fishing on free schools, was presented (SCRS/2008/118). This index corresponds to the seasonal fishery on free schools developed by the Spanish fleet offshore Senegal mainly during the second and third quarters of the year. This fishery mainly targets skipjack. Logbook set by set data as well as fleet characteristics were used. In this model, only the free school sets were included for the period (1991-2006) during which the extension of the FADs fishery started and information on fishing mode exists. For the historical period it was assumed that free school was the fishing mode. Data were also limited to the off Senegal area. An index was developed using a delta-lognormal model. The variables considered were *year*, *quarter* and *vessel category* (volume of wells). The series covered the period 1980 to 2006. Also a threshold of 120 fishing days by vessel and year was established. The standardized catch rates showed an increasing trend in the 1980s, followed by a decrease in the early 1990s and high variability since then. The Group considered that the availability of skipjack in this area could be related to environmental factors and that this index would be more representative of changes in catchability than in abundance.

All the standardized catch rates estimated by the Group for the east stock are shown in **Figure 24**. Some of the data series are not complete. For example, there are no estimations for Ghana baitboat after 1992. Estimations that were not used in assessment analyses (purse seine on free schools-EC) are not included in the figure. Estimations as calculated for the Portugal and Canada database showed large variations with several peaks and plunges. Estimations of standardized catch rates of Dakar purse seines increased until the early-1990s but there is no clear time trend since 1992.

Western Atlantic

In contrast with the large fishing areas observed in the eastern part of the Atlantic Ocean, the fishing grounds in the western Atlantic are generally more coastal. Most of skipjack landed in the west have been caught by Brazilian baitboats. Actually skipjack is the main target species in this case. Note that the catch rates reported for this fishery are higher than the CPUEs observed in all the eastern baitboat fisheries. For the Venezuelan purse seiners fishing mainly in the Caribbean Sea, no new information has been provided since the 2007 SCRS meeting.

Standardized catch rates were calculated for west stock. In most of the papers, Generalized Linear Model and Delta-lognormal distribution were used to calculate the relative abundance indices. Generalized Linear Mixed models were used to analyze catch and effort data from the U.S. Marine Recreational Fisheries Statistical Survey (MFRSS) of the Atlantic coast and Gulf of Mexico (SCRS/2008/122). Positive data were modeled using a lognormal model, while the proportion of positive catches was modeled with a binomial distribution. Geographic area, season and fishing mode (charter or private fishing boat) were the factors considered in the model.

Standardized catch rates calculated using the delta-lognormal model varied annually showing no clear trend.

Standardized catch rates of skipjack caught by U.S. pelagic longline fleets in the Gulf of Mexico calculated using GLM were presented in SCRS/2008/121. Response variables considered for skipjack were the CPUEs for the period 1992-2007. In the analysis, the delta-lognormal models with the following explanatory variables were used: year, area, season, gear characteristics and fishing characteristics. Overall, there appears to be an increasing trend in skipjack catch rates in 2006 and 2007 though this may be explained by increasing rates of observer coverage. Currently, skipjack tuna is not a target species for the U.S. longline fleet and there are few reports of positive sets in logbooks.

Most of skipjack landed in the West Atlantic are caught by the Brazilian baitboat fleet. In order to obtain standardized catch rates per year and quarter two approaches were used (SCRS/2008/113). In the first, catches equal to zero were discarded and a model (lognormal) was selected to analyze the positive dataset. In the second approach, the zero catches (< 2% of the total database) were also considered and a delta-lognormal model was used to estimate standardized catch rates. Indices showed large variations across the years but there was no trend.

All the standardized catch rates used in the assessment analyses are in **Figure 25**. Estimations gathered in the analysis of Brazilian and U.S. datasets showed no trend. Estimations calculated for the Venezuelan database showed dropped abruptly in the early-1980s but showed a slight decreasing trend since 1983.

4.1.3 Fishery-specific patterns for skipjack

The fishery definitions used are shown in the following table and generally follow the definitions used for MULTIFAN CL assessment modeling of bigeye tuna.

Fishery definitions proposed for use in further analysis for skipjack.

<i>Stock</i>	<i>Fishery</i>	<i>Flags</i>	<i>Gear</i>	<i>Period</i>
Atlantic East	1E	EC-France, EC-Spain and Others	PS	1969-1979
Atlantic East	2E	EC-France, EC-Spain and Others	PS	1980-1990
Atlantic East	3E	EC-France, EC-Spain and Others-Free School	PS	1991-2005
Atlantic East	4E	EC-France, EC-Spain and Others-FADs	PS	1991-2005
Atlantic East	5E	Ghana	PS & BB	1973-2005
Atlantic East	6E	EC-France, EC-Spain (Dakar Based), Senegal	BB	1965-1983
Atlantic East	7E	EC-France, EC-Spain (Dakar Based), Senegal	BB	1984-2005
Atlantic East	8E	Azores, Madeira, Canaries	BB	1965-2005
Atlantic East	9E	Others	BB	1965-2005
Atlantic East	10E	Others	Others	1965-2005
Atlantic West	1W	Brazil	BB	1965-2005
Atlantic West	2W	Venezuela	PS+BB	1965-2005
Atlantic West	3W	All	Others	1965-2005

Selection of the abundance indices for skipjack

To select among the candidate fisheries the most appropriate series of CPUEs in terms of representativeness of changes in the abundance of skipjack in both parts of the Atlantic Ocean, attention has been paid to criteria such as the average total catch, the surface of the fishing grounds and the size of the time series.

In the eastern Atlantic, the baitboat fisheries depicting changes over time of the abundance of different size classes of skipjack were selected as follows:

- Portuguese-Azorean fleet (standardized index after omitting the smallest boats fishing in coastal Azorean waters): 1970-2006;
- Spanish Canary Islands vessels (a non-standardized series, divided for periods of time, prior to and following the adoption of the associated school fishing technique in 1992): 1980-1991; 1992-2006;
- Baitboat fleets (EC-France, EC-Spain, FIS, Senegal) operating from Dakar (Senegal), (standardized for the whole time series, then broken down prior to and following the adoption of the associated school fishing technique in 1984): 1969-1983; 1984-2006; and

- Ghanaian vessels (non-standardized CPUE); from 1969 to 1982 (Wise 1986).

Two purse seine series were used:

- The Spanish and associated purse seiners, targeting free schools of skipjack off Senegal during the second quarter of the year from 1980 to 2006. The advantage of using purse seine CPUE in this region is the possibility to calculate an index of apparent abundance for school fishing operations only, which is not the case in other areas.
- The EC-purse seiners fishing on FADs mainly in equatorial areas: 1991-2006.

For the western stock, three indices of catch rates were used:

- The Brazilian baitboat fishery, known to target specifically skipjack (standardized index): 1981-2006;
- The Venezuelan purse seiners, operating in general with the assistance of the bait boats (non standardized index, corrected by accounting for a moderate annual 1% increase in efficiency): 1982-2005; and
- The U.S. recreational fishery (standardized series): 1986-2006.

4.1.4 Average weight

Figure 26 shows average weight of skipjack for the eastern and western Atlantic. The average weight of fish landed showed no trend in the most recent period. Since the early 1980s the average weight of fish landed in the western part doubled the weight of fish landed in the East Atlantic.

4.2 Yellowfin

4.2.1 Average weight

The average weight of yellowfin showed some variability but a decreasing trend is evident since the early 1970s (**Figure 27**). When analyzing the information separated by gear it is apparent that the decreasing trend is mainly due to longline and purse seine.

4.2.2 Catch rates

Purse seine

Standardized catch rates for adult yellowfin caught by purse seiners fishing during the period 1980-2006 in the tropical Atlantic Ocean were presented in SCRS/2008/115. Two approaches were used to obtain the indices from the results of the generalized linear model: (a) least-square means; and (b) average of the fitted values. Estimations of variance made with the second approach were lower. Nevertheless, standardized catch rates did not show a trend.

In document SCRS/2008/116 information on logbook set by set on FADs was also analyzed in order to obtain standardized catch rates for juvenile yellowfin. A delta-lognormal model and GLM were used to estimate the indices. Explanatory variables included in the model were *year*, *region*, *quarter* and *vessel category*. Standardized catch rates for yellowfin showed a flat trend during the period 1991-2006.

Catch rates available in this meeting were contradictory (**Figure 29**). Estimates calculated for Venezuelan indices showed three peaks but a decreasing trend. Nevertheless, tropical purse seine indices peaked in 1989 but did not show many changes after 1992. Standardized catch rates as calculated for the EC database appear flat in the period 1991-2005.

Baitboat

Nominal catch rates for the Canary Islands fleet show several peaks and plunges (**Figure 30**). Estimated values gathered with the Brazilian database dropped abruptly from 1981 to 1982 and then showed a slightly decreasing trend. The nominal catch rates of Dakar peaked in 1993 and then showed a decreasing trend.

Recreational fisheries

Generalized Linear Mixed and delta-lognormal distribution were used to analyze the catch rates of yellowfin caught in the Atlantic and Gulf of Mexico as reported in the U.S. Marine Recreational Fisheries Statistical Survey (MFRSS) database (SCRS/2008/122). Geographic area, season and fishing mode (charter or private fishing boat) were the factors considered in the model. Standardized catch rates vary annually but without trend (**Figure 31**). There were some peaks in 1984, 1994 and 1999, as well as plunges at the end of the 1980s and in the mid-1990s. A decreasing trend is apparent after 1999.

Longline

Several CPUE indices were presented at the meeting from fisheries other than purse seine. All the indices were standardized using GLM, differing in the assumption of the error distribution (log-normal or Poisson). They had the same basic factors in common, such as year, season and area, along with other factors particular to each case.

Standardized catch rates for yellowfin tuna caught by Japanese longline fleet from 1965 to 2006 were estimated using a generalized linear model (GLM) (SCRS/2008/108). Factors considered in the model were year, quarter, SST (sea surface temperature), number of hooks between floats and kind of main and branch lines. Main effects and interactions were included in the analysis. Catch rates were modeled using a lognormal density distribution and a positive constant were added to catch rate in order to deal with catches equal to zero. Standardized catch rates as estimated in year and quarter base decreased through mid 1970s. Estimations were close to 1.7 (fish/1000 hooks) until early 1990s when it dropped to 0.6 (fish/1000 hooks). After that plunge standardized catch rates variation showed not trends. Variations of standardized indices as calculated in weight were similar to those gathered in calculations based in number of fish. Nominal catch rates for the 1960s and the early 1970s as reported for Japanese as well as for all other longline fleets were considered doubtful in an earlier meeting. Therefore, the Group decided not to use the estimations for the very early years.

In the southwest Atlantic, yellowfin tuna are caught mainly by the fleets operating drifting pelagic longline. SCRS/2008/109 presented the CPUE of yellowfin tuna caught by the longline fleets of Brazil and Uruguay in the Atlantic Ocean for the period 1980-2006 standardized using General Linear Models with a Delta Lognormal approximation. There number of analyzed hauls was 76,521, with a total effort of 136,947,483 hooks between 7°N-45°S and 57°-20°W. The response variables considered in the model were CPUE and a nominal CPUE weighted by total catch (CPUEp). There were considered as explanatory variables for the models the year, quarter, area, water surface temperature and type of fishing gear. Both CPUE and standardized CPUEp show oscillations along all the period with a downward trend in the last seven years and a moderate peak in 2005. Standardized catch rates showed large variations all across the years with a decrease from 2000 to 2006. In a companion paper, only the Uruguayan database was considered (SCRS/2008/110). The results were similar to those mentioned above.

A GLM was also used to analyze the CPUE of yellowfin caught by the Brazilian longline fleet but the catch rate (number of fish/100 hooks) was assumed to follow Poisson and Tweedie densities distributions (SCRS/2008/112). The four factors considered when analyzing data from 1986 to 2007 were year, area, quarter and target. Cluster analysis of species compositions caught in the fishing sets was used to define the levels of the “target” factor. Estimations gathered with Poisson and Tweedie models were similar. Standardized catch rates were large between 1988 and 1990, decreased through 1993 and did not show any trends at the end of the time series.

For the Mexican and U.S. longline fishery in the Gulf of Mexico (1992-2006) a combined index was presented (SCRS/2008/119), based on available observer data. The variables included by year and quarter, fleet, quarter, sets, temperature and bait type.

In document SCRS/2008/120 yellowfin CPUE were in weight and number for the period 1987-2007. Standardized catch rates for yellowfin have declined since 1987 but appear to be increasing since 2003. Overall the standardized indices show a decrease since 1986 but a rather flat trend since 1992. The proportion of positive catches and the catch rate of positive datasets for yellowfin showed contradictory trends in some of the fishing grounds. That issue was discussed but there were no agreement on the explanation for those contradictory patterns.

For this assessment, datasets from Japan, Brazil, Uruguay, United States and a combined index between Mexico and United States were used. Most of the standardized catch rate time series showed a continuous decreasing trend (**Figure 32**). The exceptions were the indices calculated for Chinese Taipei and for the Uruguayan

databases. Estimations for Chinese Taipei data dropped in the early 1970s and appeared flat after 1974, while estimations for Uruguayan data showed large variability but no trend.

Indices used in the analysis

After evaluating all catch rate indices available during the meeting the Group decided to use some of them for virtual population analysis but not for production models. Some of the indices showed unreliable time trends. Catch rate indices selected for the assessment analysis are included in **Appendix 7**.

Combined indexes

Combined indexes were estimated for both species using a GLM approach (see **Appendix 5**). For yellowfin, the model included the Japanese longline, the combined Mexico and U.S. longline in the Gulf of Mexico, U.S. rod and reel, Brazilian longline, Chinese Taipei longline, Canadian baitboat, Venezuelan purse seine, Brazilian baitboat, EC Dakar-based baitboat, Venezuelan longline, and EC purse seine assuming a constant annual increase in catchability of 3%. The estimated unweighted and weighted combined indices are presented in **Table 13** and **Figure 33**. Both the unweighted and weighted index showed similar trends with a sharp decrease in the late 1960s followed by a relatively stable period until about 1990. From 1990 onward both indexes showed a continuous declining trend.

For skipjack, the fisheries used to estimate the combined index for the ATE stock were the EU-Dakar and EU-FAD purse seine fisheries and the Ghana, Canary Islands, Portugal and EC Dakar-based baitboat fisheries. In the case of the western Atlantic skipjack stock they were the Venezuelan purse seine, the U.S. rod and reel and the Brazilian baitboat. The combined index for the eastern Atlantic skipjack stock showed a variable but constant increasing trend from the beginning of the time series in 1965 to the end in 2006. The western Atlantic stock series started in 1981 and also showed a series with highly variable values but with a relatively constant trend. Values of the estimated combined indexes for each stocks and matrices of weighting factors are shown in **Table 13** and **Figure 33**.

5. Methods and other data relevant to the assessment

5.1 Methods – Yellowfin

5.1.1 ADAPT-VPA

The parameter specifications used in the 2008 VPA base model were generally the same as those used in the 2003 base-case VPA model (Mérida, Mexico, July 2003) (Anon. 2004). A summary of the model control settings and parameters appears below and in **Tables 14** (Control Settings) and **15** (Parameters).

VPA models require the estimation or assumption of terminal year fishing mortality rates (F). Like the previous assessment, the 2008 base cases (Runs 5 and 8) allowed terminal F values to be estimated for Ages 0-4. The oldest age class represents a plus group (ages 5 and older) and the corresponding terminal fishing mortality rate is specified as the product of $F_{age\ 4}$ and an estimated ‘F-ratio’ parameter that represents the ratio of $F_{age\ 5}$ to $F_{age\ 4}$. For Runs 5 and 10 the initial F-Ratio (1970) was estimated as a frequentist parameter, and then allowed to vary annually using a random walk with a standard deviation equal to 0.2 and a prior expectation equal to the previous annual estimate.

The indices of abundance were fitted assuming a lognormal error structure and equal weighting (i.e., the coefficient of variation was represented by a single estimated parameter for all years and indices). The catchability (scaling) coefficients for each index were assumed constant over the duration of that index and estimated by the corresponding concentrated likelihood formula.

The natural mortality rate was assumed to be age-dependent (Ages 0 and 1 = 0.8 yr⁻¹; Ages 2+ = 0.6 yr⁻¹) as in previous assessments.

Description of model runs

The indices used during the various model runs are summarized in **Table 16**. Methods used to estimate index selectivities are described in **Table 17**. A general description of the model runs follows.

- **Continuity Run:** The “continuity run” was performed to determine the 2008 stock status using model settings and structure identical to the 2003 base assessment (i.e. identical parameter settings, constraints and indices of abundance). It is intended to facilitate comparison of the 2008 and 2003 assessment results. Indices of abundance and catch data were updated and extended through 2008.
- **Runs 5 and 10** were chosen as “base runs” and were combined to develop management advice.
- **Run 5:** Run 5 differs from the “continuity” and 2003 model runs in that:
 - 1) All indices recommend by the 2008 assessment working group were used.
 - 2) A penalty was applied to restrict deviations in vulnerability-at-age (Penalty applied to 2004-2006, Ages 0-5+, Standard Deviation = 0.4)
 - 3) The peak of the spawning season was set at February 14. Weight-at-age of spawners was also calculated from the growth curve using that date.
- **Run 10:** This run is identical to Run 5 except that the LONGLINE and TROP_PS indices were assumed to have fixed “flat-topped” selectivity patterns rather than the steeply “dome-shaped” patterns estimated by Run 5. To accommodate this assumption, the selectivity patterns estimated during RUN 5 were used until full selectivity was reached. Then, full selection (1.0) was retained for older ages.

5.1.2 ASPIC

The yellowfin stock was also assessed with a Surplus Production Model (ASPIC v. 5.16) using landings for the period 1950-2006. Three different sets of fisheries were considered in the runs:

- 1) A combined fleet with a combined index for the period 1965-2007. This case used a weighted combined index (see Section 4) for the Japanese longline, the combined Mexico and U.S. longline in the Gulf of Mexico, the US rod and reel, the Brazilian longline, the Chinese Taipei longline, the Canary Islands baitboat, the Venezuelan purse seine, the Brazilian baitboat, the EC Dakar-based baitboat, the Venezuelan longline, and the EC-purse seine assuming a constant annual increase of 3% in catchability.
- 2) Ten separate fleets with indexes that cover some portions of the period 1965-2007. This case used separate landings and indexes of abundance for the Japanese longline, the U.S. rod and reel, the Brazilian longline, the U.S. longline, the Uruguayan longline, the Venezuelan purse seine, the Brazilian baitboat, and the EU-Dakar baitboat fleets. A tenth fleet included all other landings and it did not have a corresponding index of abundance.
- 3) A combined fleet with a combined index for the period 1956-2006. This case used 1965 to 2006 combined index extended back to 1956 using Task II data.

Table 18 shows the indexes of abundance used in each case while **Table 19** provides de catches. These three scenarios tested different combinations of different model forms (logistic vs. Generalized), weighted or unweighted indexes, and fix or estimated value of B_1/K . A total of ten initial cases were considered which are summarized in **Table 20**.

5.2 Methods - Skipjack

5.2.1 Catch-only model

The catch-only model combines a Schaefer biomass dynamics model with a logistic exploitation dynamics model (Vasconcellos and Cochrane, 2005). The model assumes that the fisheries harvest follows a logistic curve that depends on two parameters. The model predicts the total catches, which are fitted to the observed catches using Bayesian methods (Gelman *et al.*, 2004). The fits are done using a Bayesian framework in order to allow the use of prior information, which could boost the information extraction from catches. Preliminary simulation testing (Minte-Vera *et al.* in prep) showed that, for artificial data sets, catch data combined with informative priors on some parameters could produce acceptable management quantities.

Catch only model is given by

$$C_{t+1} = P_t \left[1 + x \left(\frac{B_t}{aK} - 1 \right) \right] \left[B_t + rB_t \left(1 - \frac{B_t}{K} \right) - C_t \right]$$

where:

C_{t+1} is catch in at time t ;

P_t is the proportion of biomass caught at time t ;

B_t is the population biomass at time t ;

K is the carrying capacity, or biomass at which the growth of the population is zero;

r is the intrinsic rate of population biomass change;

x is a multiplier that defines the increase in fishing mortality over time;

a ($0 < a < 1$) is the bio-economic equilibrium as a proportion of K .

In this model, four parameters are estimated: r , K , a and x . The population was assumed to be lightly fished at the beginning of the time-series (so $B_0 = K$), and that the first catch (C_0) was measured without error (so $P_0 = C_0/B_0$).

The parameters were estimated using Bayesian techniques. Several combinations of priors were used. For the Western stock, priors for K were set as $K \sim U(100\,000, 1\,000\,000)$, $\ln(K) \sim U(\ln(100\,000), \ln(1\,000\,000))$ or a lognormal distribution with mean 350 000 t and CV=0.5. For the eastern stock, priors for K were set as $K \sim U(200\,000, 2\,000\,000)$, $\ln(K) \sim U(\ln(200\,000), \ln(2\,000\,000))$ or a lognormal distribution with mean 700 000 t and CV=0.5. Priors for r were set as $r \sim U(0.4, 2.0)$ or a prior based on demographic methods (see **Appendix 6**, McAllister *et al* 2001). The priors for a were set as uniform on the possible range of the parameter $a \sim U(0, 1)$. Sensitivity for the priors for x were done, because some combinations of a and x values may generate unrealistic oscillations on the harvest rate and consequently on the biomass. Initially, priors on x were set as $x \sim U(0, 10)$, then the range was restricted to $x \sim U(0, 1)$ or $x \sim U(0, 1.1)$ for the eastern and western stocks, respectively.

The observed catches were assumed to follow a log-normal likelihood function (Casella and Berger 2002) with expected value equal to the catches predicted by the models:

$$L(\phi | w) = \prod_{t=1}^n \frac{1}{\sigma C_t \sqrt{2\pi}} \exp \left[-\frac{1}{2\sigma^2} (\ln C_t - \mu)^2 \right]$$

Where:

$$\mu = \ln E(C_t) - \frac{\sigma^2}{2}$$

n is the length of the catch time-series

C_t is the observed catch in year t

\hat{C}_t is the expected catch for year t predicted by the model

σ is the variability parameter assumed known and equal to 0.4.

The parameters were estimated using SIR-Sampling Importance Resampling (McAllister *et al.* 1994; Gelman *et al.* 2004). The importance function was equal to the joint prior function, and thus the importance ratio is equal to the likelihood. One million parameter vectors were randomly sampled from the joint prior distribution; of those 20 000 samples were taken with replacement with probability proportional to the importance ratio. Punt and Hilborn (1997) found that the resampling need to be done until no vector is assigned more than 1% of the posterior probability (MSD-maximum single density). In our case, the MSD was monitored and no vector occurred in more than 1% of the resamples. Other diagnostics for convergence were also used such as the coefficient of variation in the average importance weight (McAllister and Kirchner, 2002) and the maximum importance ratio (McAllister and Pikitch, 1997).

The data used in the first set of runs were the time series of total catches from 1950 to 2006 for the eastern stock and 1976 to 2006 for the western stock. Although, the catches for the western skipjack stock start at 1953, they stay very low until mid-1970s. Preliminary runs using the whole catch series would not run because the model was unable to find a combination of parameters that would produce a trajectory with a small harvest rate for almost 30 years. For the second set of runs, the model was fit to a restricted catch series for the eastern stock in

order to have only catches coming from a more homogeneous fishery (see section 3.2). The series was divided in two periods, from 1965 to 1984 and from 1985 to 2006.

5.2.2 PROCEAN

The PROCEAN (Production Catch/Effort ANalysis) model is a multi-fleet surplus production model developed in a Bayesian framework to conduct stock assessments based on catch and effort time series data (Maury, 2001; Maury and Chassot, 2001). PROCEAN is a biomass dynamics model based on the generalized surplus production model (Pella and Tomlinson, 1969) that includes process error for fishing fleet catchability, stock carrying capacity, and a robust process error on fishing mortality.

The eight independent time series of abundance indices defined during the Working Group were used as well as the combined abundance index weighted by fishing area (see Section 4).

Preliminary runs showed that there was not enough information in the data to estimate the shape parameter (m) regarding the typical one-way trip of the eastern Atlantic skipjack fishery so it was fixed when running the model. The initial biomass of the stock in 1969 (B_0) was also difficult to estimate and assumed equal to a fixed proportion of the carrying capacity (K). Informative prior distributions were considered for the growth rate parameter (r) and the maximum sustainable yield (MSY). Normal distributions with mean 1.17 (S.D. = 0.26) and 150,000 (S.D. = 20,000) were assumed for the intrinsic growth rate (Section 5.3.2) and MSY, respectively. A sensitivity analysis was conducted to account for uncertainty in some input parameters and to assess the impact of the prior distributions on posterior estimates (see Section 6.2.4).

5.2.3 Bayesian Surplus Production Model methods

The Bayesian Surplus Production model (McAllister *et al.* 2001) is a non-equilibrium surplus production model that allows prior distributions on intrinsic rate of population increase (r), carrying capacity (K), biomass in the first modeled year defined as a ratio ($\alpha.b0$) of K , average annual catch before data were recorded as well as variance, the shape parameter (n) for a Fletcher/Scheaffer model and catchability parameters for each time series. The model uses a sampling importance resampling algorithm (SIR, McAllister and Kirkwood 1998) and can fit either a Scheaffer or a Fletcher/Scheaffer type production model. The BSP model has been accepted into the ICCAT catalog and has been applied to several previous ICCAT species (white marlin, bluefin tuna, billfishes, bigeye tuna) however this is the first time that the model has been applied to skipjack tuna.

In this application we use the logistic Schaefer formulation of the model and estimate r and k and $\alpha.b0$ using prior distributions. A lognormal($\text{mean} = 1$, $\text{sd} = 0.01$) prior distribution for $\alpha.b0$ was assumed on the basis that biomass in the first year of the model year (1950 for eastern skipjack and 1952 for western skipjack) was at or close to carrying capacity. Prior distributions for r were determined on the basis of demographic modeling described in Section 5.3.2. Priors for K were initially estimated to be uniform on either K or $\log K$ with maximum bounds equal to 10 times the maximum observed catch and minimum bounds equal to the maximum observed catch but were subsequently decreased to ~ 5 times the maximum catch. In this formulation of the BSP model we input prior distributions for the parameters r and K and assumed that K was equal to the biomass at the starting point for each of recorded catch for each model.

Initial model fitting and parameterization was necessarily to find suitable starting values for the input parameters r and K to get the model to estimate modal values which are either the maximum likelihood estimates for the non-Bayesian parameters or the mode of the posterior for the Bayesian parameters. This is performed during the ‘estimate mode’ component of the model fit procedure and often different starting values where necessary for different runs. Starting values for the various parameters are given in **Tables 21** and **22** for western and eastern skipjack, respectively. Indices used for western skipjack are given in **Table 23** and for eastern skipjack in **Tables 24** and **25**.

For each model run, the convergence diagnostics were examined during the ‘importance sample’ stage of modeling according to the methodology described in McAllister and Kirkwood (1998). Further, given the non-informative or contradictory nature of many of the input indices, examination of the diagnostics was particularly critical because of the potential bias that the importance function can impart on the posterior modes. It is recommended that the CV of the weights $\text{CV}(\text{wts})$ of the importance draws should be less than the CV of the likelihood times the priors $\text{CV}(L^*P)$ for the same draws. As a diagnostic of convergence for the SIR algorithm, the we used the ratio of the $\text{CV}(\text{wts})/\text{CV}(L^*P)$ assumed that ratios greater than 2 were unacceptable, ratios between 1 and 2 were marginal and ratios less than 1, acceptable.

5.3 Other methods

5.3.1 Estimation of potential trends in catchability in the European purse seine fleet

The Group noted than in various past analyses it has been assumed that the catchability associated with the EC tropical purse seine fleet has increased about 3% per year since 1980. The Group conducted additional analyses to determine if perhaps changes in catchability have not occurred at a constant rate since 1980.

The data used, see **Figures 34** and **35** (for the three tropical species separately and combined) were: 1950-2006 total catch; 1969-2006 catch and nominal effort (fishing days) of the EC and associated purse seine fleets. No attempt was made to separate FAD and free school sets. The 1983 and 1984 effort values seemed anomalously high and were excluded from the analyses.

The approach used can be summarized as follows: Conditional on the total catches, biomass trajectories were computed based on a deterministic Fox production model with assumed parameter values (these are explained below). From these biomass values and the total and purse seine catches and fishing effort, it is possible to derive values of fishing mortality and catchability by purse seine fleet. The trends in the resulting catchability values were then examined. The following equations explain the method used:

- 1) Assume values for MSY and K .
- 2) Assume that $B_{1980} = K$
- 3) Project the population forward using Fletcher's parameterization of the Fox model given the above values and the time series of known total catches:

$$B_{t+1} = B_t - e^4 MSY \frac{B_t}{K} \ln\left(\frac{B_t}{K}\right) - r C_t$$

- 4) Estimate total fishing mortality:

$$F_t = \frac{r C_t}{(B_t + B_{t+1})/2}$$

- 5) Estimate purse seine fishing mortality based on the ratio of purse seine catch (P) to total catch:

$$r_F = \frac{P_{C_t}}{T_{C_t} F_t}$$

- 6) Estimate purse seine catchability using the nominal effort:

$$q_t = \frac{r_F}{F_t}$$

The values assumed for MSY for bigeye and yellowfin were 90,000 t and 150,000 t, as estimated from the previous assessments. An MSY of 150,000 t was assumed for skipjack in the eastern Atlantic. When the three stocks were analyzed together, the overall MSY used was 390,000 t.

The values of K for bigeye and yellowfin were calculated such that the projected B_{1980}/B_{MSY} ratios were 0.9 and 1.0, respectively. The value of K for skipjack was fixed arbitrarily to 700,000 t, which is similar in magnitude to the values calculated for yellowfin and bigeye. The value of K for the analyses of the three species combined was the sum of the three individual K values.

The group calculated average percent changes in catchability by regressing $\ln(q_t)$ against time for different time periods. These were 1969-1979, 1980-1990 and 1991-2006, i.e. the same periods being considered to split the series for the Multifan analyses. In addition, the time period 2002-2006 was examined to investigate more recent trends.

Results

The projected biomass trends are shown in **Figure 36**. The models show steeper declines for bigeye and yellowfin than they do for skipjack or for the three species combined.

Table 26 provides the assumed population dynamics parameters and the resulting slopes of the regression of $\ln(q)$ against time for different time periods. The values of $\ln(q)$ for the entire time period are shown in **Figure 37**. These results suggest that during some time periods, catchability may have changed by more than 10% per year. This is evident primarily in the 1970s and 1980s. For the more recent five years, these analyses suggest that catchability continues to increase rapidly for skipjack, is decreasing for yellowfin, and is increasing slowly for bigeye.

Figure 38 and **39** show the input (nominal) fishing effort as well as the effort adjusted by the catchability estimates by species. Note that the largest impact of adjusting effort by catchability is for bigeye tuna, followed by skipjack and then yellowfin.

Figure 39 compares the nominal effort series with two adjusted series for yellowfin tuna. The blue line is adjusted using the catchability changes estimated in the present analyses. The red line was obtained following the same approach that was applied during the yellowfin session held in Cumana, Venezuela in 2000 (Anon. 2001), which assumes a 3% annual increase in q after 1980. (Note that the input effort series used for both analyses are different). The two adjusted series are similar in magnitude, although in some years the adjusted effort from the current analysis can be up to 60% higher than the effort adjusted by the 3% annual change in q .

In discussing the results obtained, the Group agreed that the approach used to calculate changes in q has strengths and weaknesses. One strength is that the rate at which q changes over time is not fixed. Another strength is that it is linked to a population dynamics model. In terms of weaknesses, the deterministic nature of the Fox model used is rather inflexible. A more flexible approach would be, for instance, to estimate catchability changes as random walks within a stock assessment framework such as Multifan-CL. Finally, the group did not examine in detail the effect that changes in assumed values of MSY and K would have on the results, although limited runs suggested that the trends in q were relatively insensitive to these.

For the stock assessment analyses, the Group concluded that both the effort series adjusted for a 3% increase in q per year, as well as adjusted by the catchability changes estimated in these analyses, should be used (see **Table 27**).

6. Stock status results

6.1 Stock status – Yellowfin

6.1.1 VPA Results

This section summarizes the results from VPA analyses explained in Section 5.1. The report file output by the VPA-2BOX software for the base VPA models (Runs 5 and 10) is included as **Appendix 7**. This appendix contains a complete description of the VPA results, including the matrix of estimated fishing mortality rates, abundance at age, stock biomass, recruitment, fits to indices, estimated index selectivities, F-ratios and Terminal Fs-at-age.

Diagnostics

Fits to the CPUE series for the VPA continuity and base models are summarized in **Figures 40** and **41**. The fits to the base models (Runs 5 and 10) are very similar, and show a substantial lack of fit to many indices (**Figure 41**).

Retrospectives

A retrospective analysis was completed by sequentially removing inputs of catch and abundance indices from the 2008 base case model, back to 2003. **Figure 42** shows the trends of spawning biomass and recruits for the base cases. SSB trends were scaled to the maximum value of the series to facilitate comparison. The SSB trends are sensitive to the sequential removal of data and show no convergence back in time. Instead, some series indicate a steeper decline in biomass. The estimated recruitment is fairly insensitive to the retrospective removal of data. In recent years, the recruitment estimates fluctuate with no obvious pattern.

Retrospective patterns in fishing mortality-at-age (FAA) and numbers-at-age (NAA) are summarized in **Figure 43** and **44**, respectively. Some substantial retrospective pattern in FAA is noted, particularly for Ages 4 and 5+ between 1990 and 2006. Retrospective pattern in NAA are less apparent. The model results are generally convergent until the most recent years, and then vary without obvious pattern.

Comparison of 2003 and 2008 VPA base models

The 2008 continuity run was constructed to examine the implications of adding recent years (2002-2006) to the VPA model without changing the indices used or the model settings. Trends in apical fishing mortality, spawning stock biomass (SSB), abundance (Ages 0-5+), recruitment (Age 0) and the annual F-Ratio (F5+/F4)

for the 2003 base and 2008 continuity models are shown in **Figure 45**. The 2003 base and 2008 continuity stock assessment results are similar, but some differences are evident in the recruitment, abundance and fishing mortality estimates, particularly between 1999 and 2001. These inconsistencies are likely to be caused by differences in the estimated F-Ratios during those years. The SSB estimates are quite similar throughout the time series.

VPA Base Models

Two models (Runs 5 and 10) were chosen by the working group to provide management advice. Annual trends in yield, total biomass, apical fishing mortality, recruits (Age 0), spawning stock biomass (SSB) and SSB relative to SSB at Fmax are shown in **Figure 46** (Run 5) and **Figure 47** (Run 10). Uncertainty in the annual values was estimated using 500 bootstraps runs of the index residuals.

The two runs are very similar, although run 10 estimates a slightly more optimistic stock status in 2006.

Sensitivity Runs

Several sensitivity runs were conducted to examine model sensitivity to:

- 1) The application/removal of penalties on deviations in recent recruitment.
- 2) The application/removal of penalties on deviations in recent estimates of vulnerability at age.
- 3) Changes in the timing applied to indices of abundance.
- 4) Various assumptions about the catch-at-age of the Japanese longline in 2006.
- 5) Estimating a single F-Ratio for all years (1970-2006).
- 6) Fixing the F-Ratio for all years at various values.

The Group considered these models during the development of the base run, but ultimately decided that these runs would not be used to develop management advice.

Stock status

The Working Group could not choose between the two VPA base cases, and since the model results were so similar (**Figures 46** and **47**), the Group recommended combining the model results into a single joint distribution. This joint distribution was used to determine stock status and develop management advice. Management references were calculated using the medians of the joint distribution, and assuming constant recruitment equal to the mean of the observed recruitments during 1970-2006. All management benchmarks and reference points are summarized in **Table 28**.

The trajectory of stock status during the time series is summarized in **Figure 48**. According to the joint distribution of the 2008 base models, yellowfin tuna have never been overfished, although overfishing has occurred (**Figure 48**; yellow symbols). Current stock status was estimated using SSB_{2006}/SSB_{MAX} and $F_{Current}/F_{MAX}$. According to the results of the joint distribution, the stock is not currently overfished ($SSB_{2006}/SSB_{MAX} = 1.09$) or undergoing overfishing ($F_{Current}/F_{MAX} = 0.84$) (**Figure 49**). Uncertainty in the stock status was estimated by bootstrapping the index residuals. 500 bootstraps were run from each VPA base model (**Figure 49**) Histograms of the bootstrap estimates of 2006 stock status from the joint distribution were constructed to examine the normality of the distribution. There is no evidence of a strong bias in the results (**Figure 50**).

The conclusions of this assessment do not capture the full degree of uncertainty in the assessments and projections. An important factor contributing to uncertainty is the accuracy of the growth curve and the age-slicing procedure. Age-slicing procedures are sensitive to small changes in slicing limits. Improved methods to estimate catch-at-age (e.g. stochastic approaches and/or directly observed age composition) have the potential to improve the reliability of age-structured models. Another important source of uncertainty is recruitment, both in terms of recent levels (which estimated with low precision in the assessment), and potential future levels. These models assumed recruitment would continue at the level observed during 1970-2006. It is possible that changes in fishing pressure or environment could invalidate this assumption.

6.1.2 ASPIC

Table 29 shows the initial results of the 10 runs. Estimated trajectories of relative biomass and relative fishing mortality for each of the 10 cases are presented in **Figure 51**. In the case of relative biomass, cases 1, 3, 7, and 9 showed very different trends compared to the other cases. For relative fishing mortality, cases 1, 3, 9, and 10 clearly showed trajectories with different trends. After initial examination of the results, the Group decided to run bootstraps for cases 2, 4, 6, and 8. The estimated deterministic trajectories for the 4 bootstrap cases are shown in **Figure 52**. The four cases showed the same trends with an increase in fishing mortality and a reduction of biomass that resulted in a period where the stock was overfished and undergoing overfishing, followed for a period of recovery. The present condition of the stock is overfished but not experiencing overfishing any longer. **Figure 53** shows the phase plots of each of the 4 bootstrap runs (500 bootstraps) for year 2006 (i.e., current condition). **Figures 54** and **55** show the relative biomass and relative F trajectories and the 80% CI estimated from 500 bootstraps. Results of bootstraps runs for cases 2, 4, 6, and 8 are summarized in **Table 30**.

6.2 Stock status – Skipjack

6.2.1 Multifan-CL model

The Group attempted several analyses of the eastern and western stocks combined. All of these showed very poor convergence, as expected because the tagging data were not judged to be very informative on ocean wide spatial scale. Subsequently, the Group made separate analyses for the eastern and western stocks. These are described below.

6.2.1.1 Eastern Atlantic

The eastern model included 10 separate fisheries (see Section 4.1.3), was divided into yearly and quarterly time frames and assumed four recruitment events, each occurring at the beginning of each quarter. Natural mortality was fixed at 0.2.quarter⁻¹. The options for the base case eastern model which included all catch data from 1950 to 2006, were similar to those for the base case model simulated for the western region. The major differences however, were that the model for the eastern region included a cubic spline selectivity function with three nodes (later increased to 5) and the penalties for the effort deviations were set to be the same for all the fisheries.

The model had great difficulty estimating the biomass at the beginning of the fishing period (**Figure 56**). The model estimate of biomass fluctuated greatly for the initial model years, repeatedly reducing to zero. The estimates of MSY and F_{MSY} were consequently nonsensical (**Figures 57** and **58**). As a result of the poor model estimation, another model run was carried out including data only from 1970-2006. The model was set to estimate the initial population age structure based on Z averaged over the last 20 time periods (quarters in this case). Also, the cubic spline selectivity option was removed and instead selectivity was set to be length dependant for all fisheries. Although these changes removed the occurrence of biomass reducing to zero in the initial years of the model run, it still resulted in an increase in biomass over time (**Figure 59**). MSY and F_{MSY} estimates (**Figures 60 and 61**) were superficially more plausible than the previous model run, but clearly unrealistic due to the strange biomass estimates.

Although several ad hoc variations and model options were simulated for this stock in order to improve the model outputs, they all resulted in similar unrealistic patterns for biomass. As a result, further analysis was discontinued. It is clear that at this stage, the data for the eastern region were unsuitable for Multifan-CL simulation within the time limitations of the working group meeting. Further modeling should be carried out inter-sessionally and possibly include tagging data once fully verified.

6.2.1.2 Western Atlantic

The basic run for the western stock used data from 1952 to 2006 for three fisheries (1=Brazil BB, 2= Venezuela BB+PS, and 3=Others) and the following assumptions/constraints:

- Assume starting population at equilibrium based on M
- Assume M=0.2 per quarter
- Estimate 4 annual recruitment events
- Allow higher variability in effort deviations for fisheries 2 and 3 (weights = 10, 3 and 3)
- Divide length frequencies by 10 (fishery 1) or 20 (fisheries 2 and 3)
- Estimate separate selectivities by fishery; assume constant selectivity after age 14 (quarters)
- Estimate the growth curve, starting from the one assumed by ICCAT (see Manual)

- Allow for random walks in the catchabilities of the 3 fisheries
- Fit a stock-recruitment relationship to estimate MSY-related statistics (steepness prior = 0.9)

An additional sensitivity run was made estimating natural mortality.

Summary fit diagnostics are plotted in **Figure 62**. The estimated selectivity patterns are shown in **Figure 63** and the recruitment and SSB trajectories are shown in **Figure 64**. Overall the model estimates dome-shaped selectivity patterns and substantial fluctuations in recruitment and spawning biomass. The model fit was imprecise. It was not possible to obtain variance estimates of all quantities of interest. Approximate 90% confidence intervals for recruitment and SSB are given in **Figure 65**.

In terms of benchmarks, the model estimated an MSY of 30,660 t per year, and current (2006) ratios of $B/B_{MSY}=2.04$ and $F/F_{MSY}=0.51$. A plot of relative B and relative F is given in **Figure 66**. When the sensitivity run estimating M was made (M was estimated at 0.32 per quarter), the benchmarks were estimated as follows: $MSY=35,960$ t, $B/B_{MSY}=2.31$, $F/F_{MSY}=0.47$.

The group was encouraged by these preliminary results and recommended that more work be undertaken in the future to refine the Multifan-CL model analyses for the stock.

6.2.2 Bayesian Surplus Production model results

6.2.2.1 Western skipjack

The indices used for the western Atlantic skipjack production model assessment gave quite contradictory information, particularly the sharp decline of the Venezuelan purse seine index (**Figure 67**) and the high fluctuations in the Brazilian baitboat and U.S. rod and reel index. There is little spatial overlap in the coverage of these indices and given the high viscosity of skipjack, these indices may reflect more local conditions rather than the overall western stock. It is, therefore, not unlikely that these indices could show contradictory trends.

Likely due to these contradictory trends, the BSP model runs for the western Atlantic stock of skipjack had initial problems with convergence indicated by very high CV of the weights of the importance draws relative to the CV of the likelihood times the priors $cv(wts)/cv(lp)$. Such a situation can occur when the input indices either are contradictory or uninformative as occurred in several shark stock assessments (McAllister and Kirkwood 1998), resulting in a very narrow importance function. As a remedy, McAllister recommended increasing the width importance function to allow for greater sampling variability with the parameter setting *expand.imp* or by decreasing the degrees of freedom for the multivariate t importance function (the importance function used for these models). The Group explored a series of runs (5-9) either expanding the importance function or increasing the degrees of freedom where each successive expansion improved the convergence criteria $cv(wts)/cv(lp)$ and widened the posterior for r (**Figure 68**). It is highly likely that runs 1-6 are unreasonable given the lack of achieving the convergence criteria. Runs 1-8 also were run with a very wide prior for r ($sd=.5$) rather than the originally desired 0.25. To correct this an additional run 9 with the correctly specified prior $N(1.17, 0.25)$ was conducted.

The results of Runs 7 and 8 both achieve reasonable but not great convergence criteria ($cv(wts)/cv(lp) \sim 1.6$) (**Table 31**). Runs 1-8 also were run with a very wide prior for r ($sd=.5$) rather than the originally desired 0.25. To correct this an additional Run 9 with the correctly specified prior $N(1.17, 0.25)$ was conducted, however it should be noted that the posterior for r was very wide (**Figure 68**). The fit to the indices for Run 9 was rather poor and not unexpected given the different trajectories of the indices (**Figure 69**) and the equal weighting given to them. The intrinsic rate of population increase, r , for Run 9 was estimated to be slightly lower than the prior mean and at a value of 1.159 with a standard deviation of 0.278.

Figure 70 shows the Biomass, B/B_{MSY} , F , and F/F_{MSY} trajectory with projections of 25,000 t starting in 2007 for SKJW-RUN9 showing the initial steep increase in fishing mortality with the creation of the fisheries and a current status assessment of B above B_{MSY} and F below F_{MSY} . It is important to note that expanding the importance function tends to let the model estimate a lower K and higher fishing mortality rates so that if there is a bias introduced by the lack of convergence of the earlier runs, it tends to give more optimistic results for this particular model set up (**Table 31**).

6.2.2.2 Eastern skipjack

The BSP model for eastern Atlantic skipjack production model assessment used eight indices (**Figure 71**), two a weighted combined and an unweighted combined index by area and two additional indices obtained from an analysis of the time series of nominal EC purse seine fishing effort with catchability changes estimated by year (**Table 27**). Despite the rather contradictory nature of some of the indices the BSP model runs for the eastern Atlantic stock of skipjack showed more acceptable convergence criteria than for the SKJ-W.

Nineteen runs using various combinations of indices, bounds on K, and with standard deviations for the priors for r (**Tables 32 and 33**). Many of the runs used the same data and should actually be considered as ‘ranging’ runs to determine appropriate boundary conditions for the further models. There was a strong effect of the bounds on the uniform prior for K (**Figure 72**). Decreasing the upper bound from 2 million metric tons (t) to 1 million metric tons (a value similar to 5 times the maximum observed catch) reduced the K values from approximately 1.2-1.3 million metric tons to values around 720-790 thousand metric tons. Given the extremely high K values predicted by using the higher bound on K (1.3 million t) it is likely more plausible to use a bound close to commonly used bounds such as 5 times the maximum observed catch.

Note that the prior distributions for r were originally run with a variance of 0.09 where $N \sim (\text{mean}=1.17, \text{sd}=0.3)$. This was slightly different from the demographic analysis standard deviation which estimated a sd of 0.25, however the results are likely very comparable to using a $N \sim (1.17, \text{sd}=0.3)$ prior. An input of the standard deviation rather than the variance as the mean for the prior distribution facilitated an impromptu sensitivity analysis of the effects of using a narrow ($\text{sd}=0.25$) or wide ($\text{sd}=0.5$) prior for r . This set of runs indicated that there was little effect on the posterior modes (**Tables 32 and 33**) resulting in little actual affect on the status results for each run. The resulting posterior distributions were, however, much broader with the wide or uninformative prior, resulting in wider coefficients of variation around the mode of the posterior distributions for status results (**Tables 32 and 33**). In addition, the higher r values of the posterior suggest that freeing the prior on r allows the model to estimate a higher posterior value for r (~1.3-1.7) than for the informative priors. Based on earlier demographic modeling (section 5.3.2) these higher values seem unlikely for skipjack tuna.

As such, RUN5BZ with using a uniform (250000, 1000000) prior on $\ln K$, a $N \sim (1.17, 0.3)$ prior on r and all indices weighted equally may be considered the best model incorporating all of the data, though the fits to the indices were generally poor (**Figure 73**). Trajectories of Biomass, B/Bmsy, F, and F/Fmsy with projections of 100,000 t starting in 2007 for SKJE-RUN5BZ (**Figure 74**), indicate the relatively high B/Bmsy status and low F/Fmsy status predicted by the model.

6.2.3 Catch-only model

Western skipjack

Two sets of runs were conducted for the western stock (**Table 34**). For both sets, the catch series used ranged from the year 1976 to 2006, in order to include the years when the catches start to increase (see **Figure 7**). For the first set (A), the prior on x was set as wide values $x \sim U(0,10)$. Explorations of the behaviour of the model for combinations of a , x parameters showed that for high x and low a the model predictions for biomass and harvest had wide unrealistic oscillations. A second set (B) of runs with a narrow prior on x was also conducted. When narrower prior on x were assumed, the model was able to gain more information from the catches than for a wider prior on x . **Figure 75** has the results only for run 1 of the two sets, which were similar for the other runs within each set (see **Appendix 8** for full results).

The estimations were sensitive to the prior on x . The first set of runs (A) included less information from the catches as suggested by the wider posteriors when compared to the priors (**Figures 75 and 76**). For the first set of runs the median of the posterior for MSY ranged from 54,000 to 83,000 t. The second set of runs (B) were able to incorporate more information from the catches than the first set of runs, as suggested by narrower posteriors on the parameters and derived quantities, when compared to the priors (**Figure 75**), and were selected for inference. For the second set of runs, the median of the posteriors for MSY were around 30,000 t.

Eastern skipjack

For the eastern stock of skipjack, three sets of runs were performed (**Table 35**). For first set (A) the catch series of 1950 to 2006 was used as well as a wider prior on x . The catch series showed a decline in the mid 1980 when there was displacement of a large part of the French and Spanish purse seiners fleets to the Indian Ocean. The catch-only model assumes that the harvest rate increases and levels off following a logistic curve. It was

suggested by the Group to run the model only with the catches from 1985 to 2006, in order to fulfill the assumptions of the catch-only model. Two other sets of runs were conducted. Set B included runs fit to the catches from 1965 to 1984 and set C included runs fit to catches from 1985 to 2006. For those two sets the prior on x was narrower (**Table 35**).

Similarly to the SKJ-W, the results appear sensitive to priors on x , and the first set of runs (A) included less information from the catches than the set C as suggested by the wider posteriors (**Figure 77**). The set C of runs was considered the best fit because no posterior concentrated towards the bounds as for set A and B (**Figure 77** and see **Appendix 8**). For the set A of runs, the medians of the posterior distributions for MSY ranged from 200,000 t to 275,000 t. For the set C of runs, the medians of the posterior distributions for MSY ranged from 143,000 t to 156,000 t.

6.2.4 PROCEAN

6.2.4.1 Eastern skipjack

The model generally fitted well the data for the different runs although European and Senegalese baitboat fisheries and European purse seiners based in Dakar showed increasing trends in the residuals. In all runs, it was shown that informative priors were required for convergence of the model. Maximum posterior estimates of MSY were in the range 154,000-185,000 t and appeared quite sensitive to the mean of the MSY prior (**Table 36**). F_{MSY} appeared robust to the changes made in input parameters and prior distributions, the value of 0.48 for $m = 2$ being related to the shape of the production curve and leading to a value of F/F_{MSY} in 2006 close to the other runs.

For the standard run, catches observed and predicted were close to the equilibrium production curve (**Figure 78**). This might be due to the relatively short time span of the skipjack that are mainly caught before age 4 and to their high growth rate. The stock appeared underexploited in 2006 with the fishing mortality below the fishing mortality at MSY, i.e. $F/F_{MSY} = 0.32$ in 2006, and the biomass above the biomass at MSY, i.e. $B/B_{MSY} = 1.79$.

The model run conducted with the combined abundance index led to similar results in terms of diagnostic of the stock, although the MSY was estimated about 10,000 t lower than in the standard run (**Table 36**). The quality of the fit was however quite poor and results showed an increasing trend in the residuals, indicating that the data did not conform to the assumption of lognormal error. The inclusion of process error on catchability for the standard run parameter settings improved the fit of the model by removing trend in the residuals and allowed tracking the changes in catchability through time (**Figure 79**).

In particular, results suggested that the catchability of baitboat fishing fleets based in Dakar would have continuously increased by about 4% each year since the 1970s. This could be related in the 1980s to the introduction and development of associated-school fishing (Fonteneau and Diouf, 1994). Despite the 3% increase already accounted for in the abundance indices, the European purse seine fishing fleet based in Dakar fishing on free schools showed a step-increase in catchability around 1990 followed by a relative stability (**Figure 79**). This would suggest that technological improvements in the late 1980s and early 1990s would have led to a larger increase in catchability than generally assumed (see section 5.3.1).

7. Projections

7.1 Projections – Yellowfin

7.1.1 VPA model projections

Specifications

The projections for yellowfin tuna (Runs 5 and 10) were based on the bootstrap replicates of the fishing mortality-at-age and numbers-at-age matrices produced by the VPA-2BOX software. The Group agreed that projections and benchmarks should be computed using a resampling of observed recruitments during 1970-2006. This resulted in an essentially constant recruitment at the mean value of the time series. This is in contrast with the approach used during the 2003 assessment which used a fixed Beverton and Holt S-R relationship estimated externally to the model. The extent of recruitment variability, σ_R , for each bootstrap replicate was modeled using a standard deviation of 0.5 with no autocorrelation.

Because no management changes occurred during 2007 and 2008 (projected by the VPA model because data is not yet available), these years were projected at F Current¹. Projections were made at various levels of constant catch or constant F, including:

1) Catch = 50,000 t	2009-2016
2) Catch = 70,000 t	2009-2016
3) Catch = 90,000 t	2009-2016
4) Catch = 110,000 t	2009-2016
5) Catch = 130,000 t	2009-2016
6) Catch = 150,000 t	2009-2016
7) Fishing mortality = F0.1	2009-2016
8) Fishing mortality = F _{max}	2009-2016
9) Fishing mortality = F _{Current}	2009-2016
10) Fishing mortality = F1992	2009-2016

Projections that used various levels of constant catch employed a restriction that the fully-selected F was constrained not to exceed 3 yr⁻¹.

Results

The Working Group recommended that management advice be constructed using the joint distribution of VPA runs 5 and 10. Therefore, the projections reflect the median outcome of both base runs.

Projection of total biomass, yield, fishing mortality, SSB and recruitment are shown in **Figures 80** and **81** SSB and F are also plotted relative to the management benchmarks (SSB @ F_{max} and F_{max}). Projections of constant catch (**Figure 81**) indicate that catches of 130,000 t or less are sustainable during the projection interval. Catches in excess of 130,000 t cause an overfished and overfishing condition during the projection interval. Projections of constant fishing mortality (**Figure 81**) indicate that current (2003-2006) fishing mortality levels allow the spawning biomass to gradually increase during the projection interval. Increasing fishing pressure to 1992 levels causes the stock status to deteriorate to an overfished and overfishing condition during the projection interval.

7.1.2 ASPIC

ASPIC projections (**Figure 82**) for each of the 4 cases were run for the following catch scenarios: 108,263 t (2006 catch level), 80,000 t, 100,000 t, 120,000 t, 140,000 t, and 160,000 t. All runs indicated that catch levels of 120,000 t or less will recover the stock from the overfished condition. A catch level of 140,000 t will not recover the stock according to the results of the case 6, but it will recover it for the other three cases. All 4 cases showed that the stock will not recover if the catch levels are 160,000 t or more.

7.2 Projections – Skipjack

8. Recommendations

- The Group agreed that the level of landings of “faux poisons” in Abidjan (on the order of 10,000 t for skipjack) and the small size of the fish landed was important enough to potentially affect the results of stock assessments. Therefore, the Group recommends the development and implementation of sampling protocols to collect detailed information on the amounts of landings, the species composition and the size composition of false fish landings.
- As it has been already implemented by other RFMOs, carefully design extensive conventional tagging studies should be implemented by ICCAT to complement the use of fishery dependent data used to estimate indexes of abundance.
- Although there have been improvements, the Group agree there is a need to increase efforts towards biological studies of the three tropical tuna species: yellowfin, skipjack and bigeye.
- The Group was encouraged by the preliminary results obtained for the western skipjack stock and recommended that more work be undertaken in the future to refine the Multifan-CL model analyses for this

¹ F current was calculated as the maximum value (apical) of the geometric mean F-at-age. The geometric mean was calculated for the years 2003-2006.

stock. Regarding the eastern stock, the Group recommended to carry out further modeling inter-sessionally and possibly include tagging data once fully verified.

- The Secretariat needs sufficient resources to prepare available data files (table of substitutions, catch-at-size, catch-at-age, tagging) at least two weeks before the meeting and National Scientists need to devote sufficient resources to review those files before the start of the meeting and request any necessary modifications, if applicable. Note that this issue should be addressed to the Sub-Committee on Statistics and revised in the SCRS plenary and the use of modern web conferencing techniques should be considered.

9. Other matters

The Group reviewed the 2007 Report of Panel 1, which included as part of the discussions, the suggestion that *the SCRS analyze and present a range of options to the Commission in time for consideration at the 2008 Special Meeting to increase the yield per recruit and MSY of bigeye tuna by reducing mortality on small bigeye tuna through the use of closed areas (i.e. total closure of all surface fisheries) and moratoriums on the use of fish aggregating devices (FADs)*. In addition it was also suggested that the SCRS *analyze the impacts of such measures on the catches of yellowfin tuna and skipjack tuna as well* (ICCAT 2008). The Group considered that the Panel suggestion was addressed to the analyses conducted in 2005, which included a wide range of management scenarios as well as different approaches to assess the effect of the moratorium and other alternative measures. Nonetheless, the Group considered it useful to analyze the effect of the time-area closure established by [Rec. 04-01], because at the time of the 2005 meeting there were no observation data to conduct such analyses, since the Recommendation had only recently been agreed at that time. However, these analyses could not be conducted at the assessment meeting as the main thrust of the assessment meeting was to update the evaluations of the status of the skipjack and yellowfin stocks. Discussions were held to plan analyses to be conducted between the assessment meeting and the Species Group discussions in September, 2008.

As for previous analyses, the Group discussed which period of reference to consider in the analyses. Taking into account that the compliance during the first time-area closure was only partial, considering the period prior to 2004 as reference would likely lead to an overestimate of the effects of the current time-area closure. On the other hand, considering years prior (1993-1996) to the first moratorium would make it difficult to separate the effect of the continuous decrease of effort by the European and associated fleets since this period. As an alternative, the Group decided to limit the analyses to the European and associated fleets assuming that these fleets have fully implemented the different time-area closures.

In addition to these analyses, the Group considered that some general scenarios of reduction in effort for different fleet components, as suggested by Panel 1, and its effects on yield per recruit, could be carried out. These analyses could provide the range of options requested by Panel 1.

In order to facilitate the work of the Group in September, during the Species Group meeting, it was suggested that scientists conduct these analyses in advance to the Species Group meeting and present the results as SCRS documents.

The results of the analyses conducted prior and during the Species Group meeting are included as **Appendix 9**.

10. Report adoption and closure

The Chairman again thanked the local hosts for the organization of the meeting. The report was adopted and the meeting adjourned.

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Table.1 Task I - Estimated catches (t) of yellowfin tuna (*Thunnus albacares*) by major area, gear and flag.

		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	
	TOTAL	145361	136265	162247	193448	166901	163760	162753	172551	153246	153040	137211	148564	140366	136235	164650	140279	125515	119936	107322	108623	75156	
	ATE	113379	101671	125345	160717	130004	126048	124009	124336	117973	119984	104871	117644	109656	101725	124363	110619	100595	88794	81344	80225	62697	
	ATW	31982	34594	36902	32731	36897	37712	38745	48215	35274	33056	32341	30919	30710	34510	40287	29660	24920	31143	25979	28398	12459	
Landings	ATE	Bait boat	16750	16020	12168	19560	17772	15095	18471	15652	13496	13804	12907	17330	19256	13267	19071	13432	11513	15354	12012	10434	7498
		Longline	6624	8956	7566	10253	9082	6516	8537	14605	13718	14233	10488	13869	13561	11364	7570	5790	9075	11501	7494	7857	2851
		Other surf.	2932	2646	2586	2175	3748	2450	2122	2030	1989	2065	2136	1674	1580	2424	2074	1826	2540	2928	3062	3615	1456
		Purse seine	87074	74049	103025	128729	99402	101987	94880	92050	88770	89882	79339	84771	75260	74670	95648	89572	77468	59011	58776	58319	50892
	ATW	Bait boat	5468	5822	4834	4718	5359	6276	6383	7094	5297	4560	4275	5511	5349	5649	5315	6009	3764	4868	3867	2695	
		Longline	14291	19046	17128	18851	13667	16594	11439	11343	10059	11111	11554	11671	13326	15760	14872	11922	10136	15953	14409	14376	9108
		Other surf.	5557	3692	3293	2362	3457	3483	4842	10166	13580	6601	4801	4581	5345	5231	7027	3763	6413	7104	5069	6880	3345
		Purse seine	6665	6034	11647	6800	14414	11359	16081	19612	6338	10784	11710	9157	6523	7870	13072	7966	4607	3217	2634	4442	
Discards	ATW	Longline	0	0	0	0	0	0	0	0	0	0	0	0	167	0	0	0	0	0	0	5	6
Landings	ATE	Angola	51	246	67	292	510	441	211	137	216	78	70	115	170	35	34	34	34	111	0		
		Benin	3	2	7	1	1	1	1	1	1	1	3	1	1	1	0	0	0	0	0	0	
		Cambodia	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	
		Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Cape Verde	2675	2468	2870	2136	1932	1426	1536	1727	1781	1448	1721	1418	1663	1851	1684	1802	1855	3236	2127	2179	1355
		Cayman Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		China P.R.	0	0	0	0	0	0	139	156	200	124	84	71	1535	1652	586	262	1033	1030	1112	1017	
		Chinese Taipei	193	207	96	2244	2163	1554	1301	3851	2681	3985	2993	3643	3389	4014	2787	3363	4946	4145	2327	830	1791
		Congo	15	15	21	22	17	18	17	14	13	12	0	0	0	0	0	0	0	0	0	0	
		Côte D'Ivoire	0	0	0	0	0	0	0	0	0	0	2	0	0	673	213	99	302	565	175	482	216
		Cuba	1295	1694	703	798	658	653	541	238	212	257	269	0	0	0	0	0	0	0	0	0	
		EC.España	66093	50167	61649	68603	53464	49902	40403	40612	38278	34879	24550	31337	19947	24681	31105	31469	24884	21414	11795	11606	13417
		EC.Estonia	0	0	0	0	0	234	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		EC.France	17491	21323	30807	45684	34840	33964	36064	35468	29567	33819	29966	30739	31246	29789	32211	32753	32429	23949	22672	18940	13263
		EC.Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	
		EC.Latvia	0	0	0	0	255	54	16	0	55	151	223	97	25	36	72	334	334	334	334	334	
		EC.Lithuania	0	0	0	0	332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		EC.Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		EC.Portugal	278	188	182	179	328	195	128	126	231	288	176	267	177	194	4	6	4	5	16	274	854
		Faroe Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
		Gabon	0	0	0	0	0	0	12	88	218	225	225	295	225	162	270	245	44	44	44	44	
		Gambia	0	0	0	2	16	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Georgia	0	0	0	0	25	22	10	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Ghana	10830	8555	7035	11988	9254	9331	13283	9984	9268	11720	15437	17657	25268	17662	33546	23674	18457	15054	17493	11931	12954
		Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2906	6560	
		Guinea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Ecuatorial	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
		Japan	4521	5808	5882	5887	4467	2961	2627	4194	4770	4246	2733	4092	2101	2286	1550	1534	1999	5066	3137	4840	

Korea Rep.	1221	1248	1480	324	259	174	169	436	453	297	101	23	94	142	3	8	209	984	95	4	
Libya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	208	73	73	73	73	
Maroc	1529	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79	108	95	183	
Mixed flags (FR+ES)	933	932	825	1056	2220	2455	2750	1898	1172	1166	981	1124	1369	1892	1427	599	992	1052	933	1063	
Namibia	0	0	0	0	0	0	0	2	14	72	69	3	147	59	165	89	139	85	135	59	
NEI (ETRO)	2077	3140	5436	12513	4856	10921	9875	8544	8970	9567	6706	7225	5418	5448	10205	8209	5396	4294	6808	6151	6163
NEI (Flag related)	285	206	280	1115	2310	1315	1157	2524	2975	3588	3368	5464	5679	3072	2090	133	466	0	0	0	0
Netherlands																					
Antilles	0	0	0	0	0	0	0	0	0	3183	6082	6110	3962	5441	4793	4035	6185	4161	0	1939	1429
Norway	418	493	1787	1790	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Panama	1858	1239	901	1498	7976	8338	10973	12066	13442	7713	4293	2111	1315	1103	574	1022	0	1887	6170	8557	9363
Philippines	0	0	0	0	0	0	0	0	0	0	0	126	173	86	0	50	9	68	69	30	
Russian																					
Federation	0	0	0	0	3200	1862	2160	1503	2936	2696	4275	4931	4359	737	0	0	0	0	4	42	211
S. Tomé e																					
Príncipe	178	298	299	164	187	170	181	125	135	120	109	124	114	122	122	122	122	134	145	137	
Senegal	0	0	2	90	132	40	19	6	20	41	208	251	834	252	295	447	279	681	1301	1262	816
Seychelles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	
Seychelles (foreign obs.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	
South Africa	68	137	671	624	52	69	266	486	183	157	116	240	320	191	342	152	298	402	1156	1187	
St. Vincent and																					
Grenadines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	101	209
U.S.A.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
U.S.S.R.	1275	3207	4246	3615	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
UK.Sta Helena	93	98	100	92	100	166	171	150	181	151	109	181	116	136	72	9	0	0	0	0	344
Ukraine	0	0	0	0	215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Vanuatu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	145
Venezuela	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

ATW	Argentina	18	66	33	23	34	1	0	0	0	0	0	0	0	0	0	0	0	327	327	0
	Barbados	57	236	62	89	108	179	161	156	255	160	149	150	155	155	142	115	116	116	116	197
	Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	143
	Brasil	2266	2512	2533	1758	1838	4228	5131	4169	4021	2767	2705	2514	4127	6145	6239	6172	3503	6985	7223	3790
	Canada	40	30	7	7	29	25	71	52	174	155	100	57	22	105	125	70	73	304	240	293
	China P.R.	0	0	0	0	0	0	0	0	0	0	0	628	655	22	470	435	17	275	74	68
	Chinese Taipei	709	1641	762	5221	2009	2974	2895	2809	2017	2668	1473	1685	1022	1647	2018	1296	1540	1679	1269	430
	Colombia	258	206	136	237	92	95	2404	3418	7172	238	46	46	46	46	46	46	46	46	46	
	Cuba	1062	98	91	53	18	11	1	14	54	40	40	15	15	0	0	65	65	65	65	
	Dominica	0	0	0	18	12	23	30	31	9	0	0	0	80	78	120	169	119	81	119	
	Dominican Republic	0	0	0	0	0	0	0	0	0	0	0	0	89	220	226	226	226	226	226	
	EC.España	0	1	3	2	1462	1314	989	7	4	36	34	46	30	171	0	0	0	0	1	
	EC.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	EC.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151	60	
	Grenada	186	215	235	530	620	595	858	385	410	523	302	484	430	403	759	593	749	460	492	502

Jamaica	0	0	0	0	0	0	0	0	0	21	21	0	0	0	0	0	0	0
Japan	1647	2395	3178	1734	1698	1591	469	589	457	1004	806	1081	1304	1775	1141	571	755	1194
Korea Rep.	236	120	1055	484	1	45	11	0	0	84	156	0	0	0	0	0	0	580
Mexico	33	283	345	112	433	742	855	1093	1126	771	826	788	1283	1390	1084	1133	1313	1208
NEI (Flag related)	1012	2118	2500	2985	2008	2521	1514	1880	1227	2374	2732	2875	1730	2197	793	42	112	0
Netherlands Antilles	160	170	170	170	150	160	170	155	140	130	130	130	130	0	0	0	0	0
Panama	3289	2192	1595	2651	2249	2297	0	0	0	0	0	0	5	0	0	0	0	2804
Philippines	0	0	0	0	0	0	0	0	0	0	0	36	106	78	12	79	145	299
Seychelles	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0
St. Vincent and Grenadines	0	0	1	40	48	22	65	16	43	37	35	48	38	1989	1365	1160	568	4251
Sta. Lucia	76	97	70	58	49	58	92	130	144	110	110	276	123	134	145	94	139	147
Trinidad and Tobago	0	1	11	304	543	4	4	120	79	183	223	213	163	112	122	125	186	224
U.S.A.	9661	11064	8462	5666	6914	6938	6283	8298	8131	7745	7674	5621	7567	7051	6703	5710	7695	6516
UK.Bermuda	25	23	22	15	17	42	58	44	44	67	55	53	59	31	37	48	47	82
UK.British Virgin Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
UK.Turks and Caicos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Uruguay	109	177	64	18	62	74	20	59	53	171	53	88	45	45	90	91	95	204
Vanuatu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	681	689
Venezuela	11137	10949	15567	10556	16503	13773	16663	24789	9714	13772	14671	13995	11187	10549	18651	11421	7411	5774
Discards	ATW	Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
		U.S.A.	0	0	0	0	0	0	0	0	0	0	167	0	0	0	0	0

Table 2 Task I-Estimated catches (t) of skipjack tuna (*Katsuwonus pelamis*) by major area, gear and flag.

			1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
TOTAL			119229	144796	120419	144118	219733	170708	205685	185014	167381	154127	146082	151699	166488	148598	155767	116781	145293	158707	162241	142177	124546
ATE			95052	121060	94037	118008	186329	140554	172462	155065	145479	126557	114367	122436	139079	119202	124239	95144	120412	131085	133597	115704	124234
ATW			24164	23736	26382	26110	33404	30155	33221	29949	21859	27562	31712	29087	27356	29307	31451	21600	24749	27461	28517	26454	313
MED			13	0	0	0	0	0	2	0	43	9	4	176	53	90	77	37	132	161	127	20	
Landings	ATE	Bait boat	38803	48015	41000	36569	41611	35660	31656	37817	33691	32047	37293	42045	37696	29967	46281	27590	29847	39539	43603	41175	26321
		Longline	6	4	9	0	5	3	2	10	3	7	47	85	42	48	53	56	66	316	458	2957	8454
		Other surf.	1027	1506	1643	1357	2067	1602	1223	501	445	501	304	923	417	2423	764	681	551	816	1898	2402	1817
		Purse seine	55216	71535	51385	80082	142646	103288	139581	116737	111340	94002	76722	79383	100925	86763	77142	66817	89948	90414	87638	69170	87642
	ATW	Bait boat	18675	21057	23292	22246	23972	20852	19697	22645	17744	23741	26797	24724	23881	25754	25142	18737	21990	24082	26028	23749	
		Longline	6	9	25	23	33	29	20	16	33	19	12	21	58	23	60	349	95	206	207	287	38
		Other surf.	518	355	600	600	872	764	710	1577	2023	452	556	516	481	466	951	398	367	404	316	372	275
		Purse seine	4964	2315	2466	3241	8527	8509	12794	5712	2059	3349	4347	3826	2936	3063	5297	2116	2296	2769	1967	2045	
MED	Bait boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	17	21	13	8		
	Other surf.	13	0	0	0	0	0	0	2	0	43	9	4	176	53	90	77	32	12	40	16	12	

		Purse seine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	103	101	99	0				
Discards	ATW	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Landings	ATE	Angola	80	30	85	69	66	41	13	7	3	15	52	2	32	14	14	14	14	10	0	0			
		Benin	5	3	7	2	2	2	2	2	2	2	7	3	2	2	0	0	0	0	0	0			
		Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
		Cape Verde	2076	1456	971	806	1333	864	860	1007	1314	470	591	684	962	789	794	398	343	1097	637	929	325		
		Cayman Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		China P.R.	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0		
		Chinese Taipei	0	1	3	0	5	3	2	10	3	5	47	73	39	41	24	23	26	16	10	8	14		
		Congo Côte D'Ivoire	8	8	11	12	9	9	10	7	7	6	0	0	0	0	0	0	0	0	0	0	0		
		Cuba	81	206	331	86	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		EC.Bulgaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		EC.España	33076	47643	35300	47834	79908	53319	63660	50538	51594	38538	38513	36008	44520	37226	30954	25456	44837	38725	28139	22206	23621		
		EC.Estonia	0	0	0	0	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		EC.France	17114	16504	15211	17099	33271	21890	33735	32779	25188	23107	17023	18382	20344	18183	16593	16615	19899	21879	14850	7034	5782		
		EC.Germany	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0		
		EC.Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	14	14		
		EC.Latvia	0	0	0	0	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		EC.Lithuania	0	0	0	0	221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		EC.Portugal	8420	14257	7725	3987	8059	7477	5651	7528	4996	8297	4399	4544	1810	1302	2167	2958	4315	8504	4735	11158	8962		
		Gabon	0	0	0	0	0	0	1	11	51	26	0	59	76	21	101	0	0	0	0	0	0		
		Ghana	24347	26597	22751	24251	25052	18967	20225	21258	18607	19602	26336	34183	40216	28974	42489	30499	24597	25727	44671	30236	45709		
		Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6389	5162			
		Japan	1982	3200	2243	2566	4792	2378	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0		
		Korea Rep.	6	3	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Maroc Mixed flags (FR+ES)	1028	428	295	1197	254	559	310	248	4981	675	4509	2481	848	1198	268	280	523	807	1893	3779			
		Namibia	4663	4660	4125	5280	11101	12273	13750	9492	5862	5831	4905	5621	6845	9461	7137	2995	4959	5262	4666	5313	3275		
		NEI (ETRO) Netherlands	0	0	0	0	0	0	0	2	15	0	1	0	0	8	0	0	0	0	0	0	0		
		Antilles	791	2994	2263	10516	11335	12409	20291	17418	16235	16211	6161	6748	8893	7127	8122	8550	9688	11137	9740	7629	11247		
		Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Panama	581	738	0	0	0	0	8312	8719	13027	12978	14853	5855	1300	572	1308	1559	281	342	0	7126	11490	13468	18821
		Rumania Russian Federation S. Tomé e Príncipe	0	0	0	0	0	0	1175	1110	540	1471	1450	381	1146	2086	1426	374	0	0	0	0	392	1130	
		Senegal	88	157	96	17	15	7	6	4	4	1	6	2	1	0	1	0	2	1	0	0	0		
		South Africa St. Vincent and	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0		

Grenadines																						
U.S.A.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
U.S.S.R.	547	1822	1915	3635	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
UK.Sta Helena	139	158	397	171	24	16	65	55	115	86	294	298	13	64	205	63	63	63	63	88		
Venezuela	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
ATW	Argentina	90	7	111	106	272	123	50	1	0	1	0	2	0	1	0	0	0	30	0	0	
	Barbados	21	3	9	11	14	5	6	6	6	5	5	10	3	3	0	0	0	0	0	0	
	Brasil	16286	17316	20750	20130	20548	18535	17771	20588	16560	22528	26564	23789	23188	25164	24146	18338	20416	23037	26388	23270	
	Canada Chinese	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Taipei	2	7	19	0	32	26	9	7	2	10	1	2	1	0	1	16	14	27	28	30	
	Colombia	0	0	0	0	0	0	2074	789	1583	0	0	0	0	0	0	0	0	0	0	0	
	Cuba	1101	1631	1449	1443	1596	1638	1017	1268	886	1000	1000	651	651	651	0	0	624	545	514	536	
	Dominica Dominican Republic	0	0	0	60	38	41	24	43	33	33	33	85	86	45	55	51	30	20	28	32	
	EC.España	0	0	0	0	1592	1120	397	0	0	0	0	0	1	1	0	0	0	0	0	0	
	EC.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	EC.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	3	3	5	21	
	Grenada	5	22	11	23	25	30	25	11	12	11	15	23	23	23	15	14	16	21	22	15	
	Jamaica	0	0	0	0	0	0	0	0	0	62	0	0	0	0	0	0	0	0	0	0	
	Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
	Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Mexico Netherlands	13	10	14	4	9	8	1	1	0	2	3	6	51	13	54	71	75	9	7	10	
	Antilles	40	40	40	40	40	40	45	40	35	30	30	30	30	30	0	0	0	0	0	0	
	Panama St. Vincent and Grenadines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Sta.Lucia Trinidad and Tobago	60	53	38	37	51	39	53	86	72	38	100	263	153	216	151	106	132	137	159	120	
	U.S.A.	734	57	73	304	858	560	367	99	81	85	84	106	152	44	70	88	79	103	30	61	
	UK.Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	
	Venezuela	5750	4509	3723	3813	8146	7834	11172	6697	2387	3574	3834	4114	2981	3003	6870	2554	3247	3270	1093	2008	
MED	Algerie	0	0	0	0	0	0	0	0	0	0	0	171	43	89	77	0	0	0	0	0	
	EC.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	26	10	15	
	EC.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	
	EC.Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102	99	99	0	
	EC.Italy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	29	34	17	0		
	Maroc	13	0	0	0	0	0	0	2	0	43	9	4	5	10	1	0	1	1	2	1	
Discards	ATW	Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 3. Breakdown of Task I yellowfin “unclassified” Atlantic catches into eastern and western management units using Task II catch and effort geographic information.

Task-I	Stock	Flag	FleetCode	1962	1963	1964	1965	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2005	2006
Task-I before area breakdown (UNK = all Atlantic)	UNK	Chinese Taipei	TAI	278	399	396	183																						18	226
		EC.España	EC/ESP-ES-SWO																											
		NEI (Flag related)	NEI.007																											
			NEI.028																											
			NEI.040																											
			NEI.042																											
			NEI.071					754	406	526	956	1297	2324	2643	3938	4240	3768	2555	3626	2913	3970	4155	4057	3453	2646	332				
			NEI.079																											
			NEI.081																											
			NEI.094																											
			NEI.105																											
			NEI.111																											
			NEI.134																											
			NEI.144																											
			NEI.166																											
		Panama	PAN																											
		TOTAL		278	399	396	183	754	406	526	8178	6444	5755	5276	8249	7837	7430	5805	7826	6790	7916	7256	8697	7794	5269	2883	175	578		
Task-I Atlantic catches broken down into ATE and ATW management units	ATE	Chinese Taipei	TAI	66	95	94	44																					18	226	
		EC.España	EC/ESP-ES-SWO																											
		NEI (Flag related)	NEI.007																											
			NEI.028																											
			NEI.040																											
			NEI.042																											
			NEI.071					103	54	76	150	285	206	266	1071	2268	1292	1106	2078	2063	2389	2294	2658	2647	1543	241				
			NEI.079																											
			NEI.081																											
			NEI.094																											
			NEI.105																											
			NEI.111																											
			NEI.134																											
			NEI.144																											
			NEI.166																											
		Panama	PAN																											
		TOTAL		278	399	396	183	754	406	526	8178	6444	5755	5276	8249	7837	7430	5805	7826	6790	7916	7256	8697	7794	5269	2883	175	578		

Table 4. Task II size data catalog of yellowfin tuna in the ICCAT database.

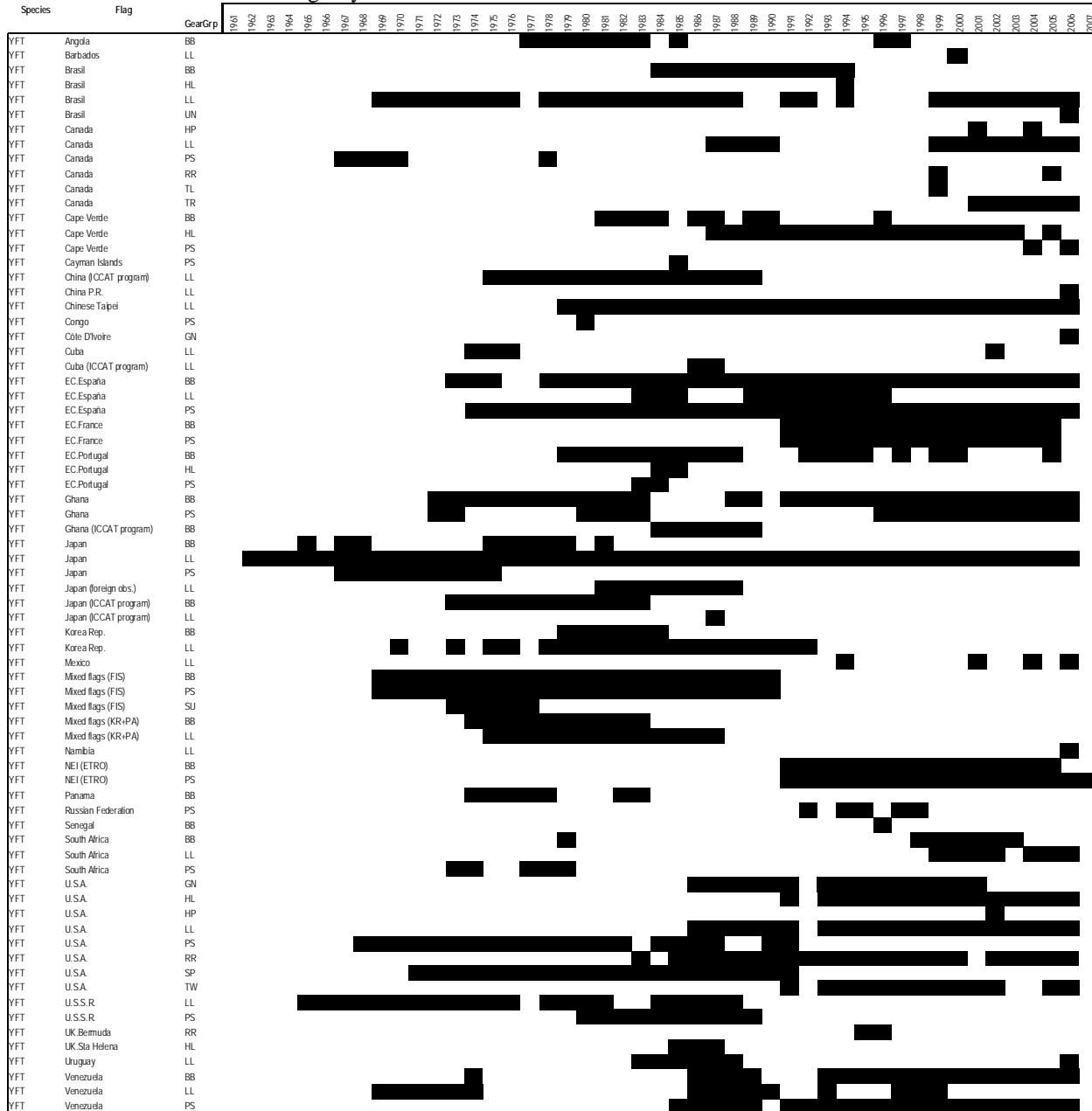


Table 5. Task II size data catalog of skipjack tuna in the ICCAT database.

Table 6. Overall yellowfin catch-at-size matrix (number of fish) obtained for the overall Atlantic.

Table 7. Overall skipjack catch-at-size matrix (number of fish) obtained for the eastern stock.

Li (cm)	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
<24	215	651	7353					67468																														
24	215	1952	19302	2661																																		
25	215	3903	14706	1330																																		
26	108	4554	14706	887																																		
27	1183	8457	30792	3548																																		
28	753	6505	25736	10643	810	7274	1016	803																														
29	1505	13661	72613	29712																																		
30	1183	7806	14247	1330	820	13395	1573	29651	3403	23918	13830	31717	88357	40244	38010	10924	8146	8822	49315	54584	47920	68393	130718	134587	165050	102982	68500	66095	86161	97011	100159	115519	104283	58412	81313	121637	81747	93072
31	2150	9758	10556	2661	5678	26430	9178	29651	4331	25389	12949	45463	102033	52428	60753	16247	13372	13950	86420	91312	80549	104051	217867	229857	271446	185083	116345	125545	162188	153814	159114	214961	178599	116050	147157	288778	131368	148881
32	1720	9107	25722	17295	3970	23276	9016	39353	24461	26859	60064	91970	128264	95531	116757	29954	20251	29456	184519	192586	173768	227881	463268	491629	554791	407252	261726	269704	317989	323549	351418	446530	398003	204834	309964	517430	279714	302107
33	1183	7333	2298	887	5934	39261	6984	34592	42843	29361	142801	31395	18705	124025	16185	51692	33328	38995	239518	23882	311483	619813	51886	556748	374795	390435	461902	413808	508333	61703	508418	277037	467625	851820	377008	459710		
34	15836	28344	44316	50158	49338	103702	22124	65293	92538	62721	13218	234260	325235	227792	247857	91380	71662	74627	369726	409983	369605	439093	901036	946104	1102434	832537	563152	620058	645861	567314	776195	921663	797594	421452	479977	1132809	695295	626929
35	14976	28952	43489	42475	17472	174323	31021	100505	108680	138284	171113	424303	344246	355491	396385	149019	126441	544986	617198	572753	719366	1240586	1246256	1167667	1162833	762291	946007	8870	81438	1141463	1201522	982687	587701	933717	1425355	1110067	832036	
36	34005	41126	60101	71470	137249	348841	108370	327543	499280	248820	244608	248779	695020	812579	679233	854363	158189	1572283	1902174	1462078	1067968	1461493	1336745	1007278	1447546	1569777	1373417	821183	1244471	1671743	1343630	1033412						
37	39292	70244	100942	94459	221737	400316	14188	211683	292024	390308	462109	1210916	663326	916479	326202	391688	404940	751841	953020	1793783	1796534	1668939	1962217	1637611	2015421	1584421	151298	1145961	148428	189472	1649163	1031387	1916878	165571	1150452			
38	116523	169932	271248	389939	439474	886059	303255	50227	582204	673233	775304	1646355	1274781	111818	99102	494042	559024	615151	850115	124727	1076490	1417186	2366208	197716	2360206	210955	1743935	1854926	1842288	1534276	1984962	1259703	1870363	1885875	1910063	1551142		
39	12339	205986	435029	509485	574053	1198467	347786	806175	779808	902919	86871	156664	170733	154501	125103	702464	764038	703250	886003	2479451	198686	2608611	2163376	225188	1960101	187431	1455823	187843	221958	2310936	1609023	2060197	216209	2151424	1613629			
40	229600	406258	790001	85136	1197426	241626	656379	1377159	1459309	1581692	1299867	238624	2435689	271553	512548	1136404	1219576	909929	1300877	2154013	1746953	2139464	2866013	3670003	2741378	2743853	3121918	2562192	2339748	1836059	2850025	2909917	1992571	2683742	2695705	3048252	2268866	
41	23578	426866	976623	885528	1383229	3085153	743077	1729841	1548177	1885796	1374783	2365078	335163	2963166	2453382	1626215	1684327	1054874	1572421	2460663	1770983	2165791	3822612	3145404	4369470	3177872	4024828	3435433	3332945	2178825	2971823	2763531	3089321	2625145				
42	42390	753996	1509236	1528158	225428	4185033	1046304	1984934	205428	233048	1820482	2994350	3802800	3491992	3384854	2343835	2253957	1540576	2249740	3704093	2576689	3259902	5515881	5458821	4475586	3762455	2965294	4455032	3826021	4158522	2705833	3830842	3531355					
43	445291	927553	1743772	1580105	2564792	4365511	113428	1998015	2274317	267659	1804494	3059270	4785720	4114000	4315818	3859948	2612902	2141590	441160	2483902	4044580	2191156	3636074	2738092	4475597	3297226	205055	1725662	1401076	2091986	4401076	2926655	4455927	3276562	3040670	4233410		
44	711092	2658192	2445528	3659805	4818428	1401624	235004	2433419	3136131	4769117	4339963	4306553	2995842	2569564	2823283	297998	4793117	2763604	3366052	7230412	549907	6732409	1824653	323180	4842803	419737	327635	3535905	173622	1403204	1874310	142437	1184923	1453849				
45	78109	1803042	2489906	237361	3732101	4552430	133383	285969	2903619	352184	2602153	509470	477740	336097	6468504	4215240	5021871	7692540	8074929	7234097	5369582	5566626	4052057	4349680	5011620	4084200	4243310	3732023	3556063	5648823	5082409	4049120	4545526	4455457				
46	61367	1698826	2150198	1866827	3154657	4406804	287624	365786	317658	357548	286014	4265345	4279274	506514	4829912	4276118	437623	3762953	5360434	4625535	4254527	509133	373952	373952	373952	373952	373952	373952	373952	373952	373952	373952	373952					
47	661323	1439821	1637316	1774242	1991939	3242856	1072462	3057446	3214448	3165305	3214448	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446						
48	512536	1339821	1637316	1774242	1991939	3242856	1072462	3057446	3214448	3165305	3214448	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446						
49	50993	1209072	1959916	1663610	2813024	1057446	3214448	3165305	3214448	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446	2057446						
50	497806	497838	1713407	1729143	2111285	2215683	1802432	227682	2251691	2374641	2374038	2588861	1794240	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552	2647552						
51	474876	798912	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795	155795						
52	563143	928689	1700883	1590173	99790	1347907																																

Table 8. Overall skipjack catch-at-size matrix (number of fish) obtained for the western stock.

Table 9. Yellowfin catch-at-age matrix.

<i>Year</i>	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5+</i>
1970	361290	2229482	607301	650369	335068	85575
1971	344448	1977021	1287353	474486	293744	72602
1972	370595	2052767	1492978	786068	289931	91172
1973	243206	1577104	1251198	811921	370436	103603
1974	886952	2496615	1274896	897957	403301	115146
1975	1850686	2801854	1719568	842170	602660	162022
1976	2183572	3635133	1388487	867883	547868	148267
1977	1488116	4057058	1711726	970685	504842	105140
1978	1592943	3664928	1963323	1155362	441937	60903
1979	2028285	3775358	1022740	1156845	537482	73775
1980	3200008	4016663	1247358	972350	532110	83719
1981	6758071	4062149	1479983	926044	810154	139639
1982	2657563	6800765	1379253	1214320	710570	142131
1983	4323476	4680819	1680974	1290371	704840	128569
1984	2901125	6946804	1953147	861417	211065	30274
1985	4268983	4165569	2143130	957578	738008	69106
1986	3706439	4362541	1306129	1351567	586169	68951
1987	6280192	4318997	1513905	1055188	652139	65881
1988	5045170	5018133	1138051	1362108	479093	44092
1989	5844442	4139343	946698	1212904	945449	121843
1990	6840077	5910204	977104	1354542	1052048	177816
1991	6313402	5500947	1181880	1108701	832673	126849
1992	6170239	5029419	1236534	1294467	780051	124612
1993	8654594	5382283	1528458	1371075	745384	81507
1994	4983084	6443400	2198100	1089902	762615	100493
1995	5210909	4889679	1543835	1000446	724878	82982
1996	5415623	5453178	1306456	1144517	699652	77460
1997	5109588	6051401	1090160	805058	697640	81796
1998	5261746	7237372	1260581	828678	716679	132870
1999	6104314	11684800	1722161	797909	524019	96085
2000	8362333	5878954	1274923	1133947	475691	100301
2001	7465211	10065910	1576328	1271341	534448	117632
2002	7175201	8115388	952183	882558	613958	76429
2003	6879341	7202107	1008228	764832	507098	107459
2004	7118910	5801751	1149694	874474	360014	114175
2005	5792990	6796869	895413	573610	446518	86079
2006	4628314	3926747	1232116	759365	382044	98240

Table 10. Yellowfin upper size limits used for slicing.

<i>Upper Slicing limits</i>					
<i>Age</i>	<i>Quarter</i>				Current and past
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	
0	42	45	48	53	
1	60	69	78	89	
2	100	110	120	128	
3	136	143	148	153	
4	157	161	163	166	
0	30	44	58	71	Shuford <i>et al.</i>
1	83	100	104	114	
2	122	131	139	146	
3	153	159	165	170	
4	175	180	185	189	

Table 11. Fishery definitions used for skipjack MFCL analyses preparations.

<i>Definition of fisheries</i>						
<i>Region</i>	<i>Fishery</i>	<i>Nation/Gear</i>		<i>Years</i>	<i>Fishery #</i>	
#East	1E	EC-France, EC-Spain and Others	PS	1956-1979	1	
#East	2E	EC-France, EC-Spain and Others	PS	1980-1990	2	
#East	3E	EC-France, EC-Spain and Others-Free School	PS	1991-2005	3	
#East	4E	EC-France, EC-Spain and Others-FADs	PS	1991-2005	4	
#East	5E	Ghana	PS & BB	1973-2005	5	
#East	6E	EC-France, EC-Spain (Dakar Based), Senegal	BB	1956-1983	6	
#East	7E	EC-France, EC-Spain (Dakar Based), Senegal	BB	1984-2005	7	
#East	8E	Azores, Madeira, Canaries	BB	1956-2005	8	
#East	9E	Others	BB	1956-2005	9	
#East	10E	Others	Others	1956-2005	10	
#West	1W	Brazil	BB	1956-2005	11	
#West	2W	Venezuela	PS+BB	1956-2005	12	
#West	3W	All	Others	1956-2005	13	

Table 12. Fishery definitions used for yellowfin MFCL analyses preparations.

	<i>Fishery</i>	<i>Gear</i>	<i>Nation</i>	<i>Years</i>	<i>Region</i>
#	1	PS	EC-France, EC-Spain, Others	1956-1979	E
#	2	PS	EC-France, EC-Spain, Others	1980-1990	E
#	3	PS	EC-France, EC Spain, Others, free schools Qtr 2-4	1991 - 2006	E
#	4	PS	EC-France, EC-Spain, Others, FADS	1991 - 2006	E
#	5	PS&BB	Ghana (1973 - 2005)	1956 - 2006	E
#	6	BB	EC-France, EC-Spain (Dakar based), Senegal	1965 - 1983	E
#	7	BB	EC-France, EC-Spain (Dakar based), Senegal	1984 - 2006	E
#	8	BB	Azores, Madeira, Canaries	1956 - 2005	E
#	9	BB	Others	1956 - 2006	E
#	10	LL	ALL	1956 - 1975	E
#	11	LL	ALL	1976 - 2006	E
#	12	OTH	Others	1956 - 2006	E
#	13	PS	EC-France, EC-Spain, Others, free schools Qtr 1	1991 - 2006	E
#	14	BB	Brazil	1956 - 2006	W
#	15	PS&BB	Venezuela	1956 - 2006	W
#	16	LL	All	1956 - 1975	W
#	17	LL	All	1976 - 2006	W
#	18	Others	Others	1956 - 2006	W

Table 13. Estimated yellowfin and skipjack weighted and unweighted combined indexes. Refer to text for explanation of the fleets used in the GLM procedure.

Year	YELLOWFIN		SKIPJACK - ATE		SKIPJACK - ATW	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
1965	2.5708	2.5708	0.1476	0.220		
1966	1.7311	1.7311	0.1985	0.142		
1967	3.4049	3.4049	0.3608	0.582		
1968	3.2299	3.2299	0.3063	0.438		
1969	1.9136	1.9136	0.2339	0.279		
1970	1.5549	1.5549	0.2681	0.226		
1971	1.2247	1.2247	0.1230	0.102		
1972	1.3862	1.3862	0.2730	0.345		
1973	1.2904	1.2904	0.3052	0.492		
1974	1.2970	1.2970	0.4099	0.593		
1975	0.9611	0.9611	0.5716	0.752		
1976	1.0211	1.0211	0.4586	0.594		
1977	1.0334	1.0334	0.7638	0.994		
1978	0.8556	0.8556	0.7091	1.067		
1979	1.0593	1.0593	0.2645	0.227		
1980	0.5871	0.5871	0.5238	0.694		
1981	1.1711	1.1711	0.4980	0.674	1.1371	1.160
1982	1.0718	1.0718	0.7100	0.677	2.5823	2.420
1983	1.3095	1.3095	0.8498	0.956	1.0104	0.934
1984	1.1961	1.1961	1.1888	1.344	0.8831	0.918
1985	1.1660	1.1660	0.7824	0.953	1.1639	1.170
1986	1.2742	1.2742	0.8196	0.685	1.0632	1.152
1987	1.3523	1.3523	1.1653	0.667	0.7874	0.719
1988	1.4114	1.4114	0.8892	0.532	0.8940	0.929
1989	1.1496	1.1496	1.1556	0.651	0.9410	0.930
1990	1.4176	1.4176	1.0684	0.890	1.0947	1.064
1991	1.2238	1.2238	0.8047	0.387	1.0400	0.992
1992	1.1837	1.1837	1.1339	1.283	0.7074	0.636
1993	0.9902	0.9902	0.9468	1.458	1.2769	1.315
1994	1.0952	1.0952	0.9560	1.548	0.7491	0.763
1995	0.7577	0.7577	0.9832	1.097	0.6162	0.597
1996	1.1553	1.1553	1.0552	0.884	0.8227	0.733
1997	0.7201	0.7201	0.8262	0.643	1.2126	1.073
1998	0.8519	0.8519	0.8533	0.484	1.1828	1.141
1999	0.8140	0.8140	1.2205	1.255	0.8910	1.200
2000	0.6015	0.6015	1.3322	1.161	0.5497	0.532
2001	0.5274	0.5274	1.2468	0.956	1.2446	1.297
2002	0.8007	0.8007	1.1831	1.305	0.8448	0.937
2003	0.8928	0.8928	0.1476	0.220	1.0310	1.202
2004	0.7589	0.7589	0.1985	0.142	0.7431	0.769
2005	0.5288	0.5288	0.3608	0.582	0.3078	0.449
2006	0.6980	0.6980	0.3063	0.438	0.6849	0.592

Table 14. Control file specifications used for VPA model runs.

SEARCH ALGORITHM CONTROLS (USED FOR ALL RUNS)	
-911	RANDOM NUMBER SEED
50	MAXIMUM NUMBER OF AMOEBA SIMPLEX SEARCH RESTARTS
3	NUMBER OF CONSECUTIVE RESTARTS THAT MUST VARY BY LESS THAN 1% TO STOP SEARCH
0.4	PDEV (standard deviation controlling vertices for Initial simplex of each restart)
INDEX WEIGHTING CONTROLS (USED FOR ALL RUNS)	
1	SCALE (DIVIDE INDEX VALUES BY THEIR MEAN)- ANY VALUE > 0 = YES
1.0	INDEX WEIGHTING:(0)INPUT CV's, (+)DEFAULT CV, (-)DEFAULT STD. DEV., (999)MLE
0	(0) MULTIPLICATIVE VARIANCE SCALING FACTOR or (1) ADDITIVE VARIANCE SCALING FACTOR
CONSTRAINT ON VULNERABILITY (PARTIAL RECRUITMENT) - LINKS THE VULNERABILITIES IN THE LAST N YEARS. (Number of years affected, Standard Deviation, First Age, Last Age)	
0 0.4 0 5	(CONTINUITY RUN) – NO PENALTY USED
3 0.4 0 5	(BASE RUNS 5 and 10) – PENALTY APPLIED
CONSTRAINTS ON RECRUITMENT - LINKS THE RECRUITMENTS IN THE LAST N YEARS (N Years,	
4 0.4	(CONTINUITY AND BASE RUNS 5 and 10) – PENALTY APPLIED
PARAMETER ESTIMATION OPTIONS	
1	USE F'S AS TERMINAL YEAR PARAMETERS (ALL RUNS)
-1	ESTIMATE Q BY CONCENTRATED MLE's (ALL RUNS)

Table 15. Parameter file specifications used for VPA model Runs.

```

# TERMINAL F PARAMETERS: (lower bound, best estimate, upper bound, indicator, reference age)
#(USED FOR CONTINUITY AND BASE RUNS 5 and 10)
#                  X
$ 1 0 0.2 2 1 0.1 first age (AGE 0 in this case)
$ 1 0 0.8 2 1 0.1
$ 1 0 0.3 2 1 0.1
$ 1 0 0.3 2 1 0.1
$ 1 0 0.5 2 1 0.1 next to last age
#                  X

# F-RATIO PARAMETERS F{oldest}/F{oldest-1} (lower bound, best estimate, upper bound, indicator, std. dev. of prior)
# one parameter (set of specifications) for each year
#(USED FOR CONTINUITY AND BASE RUNS 5 and 10)
#                  X
$ 1 0.1 0.2 5 1 0.2 1970 estimated
$ 36 0.1 0.2 5 3 0.2 1971-2006 random walk
#                  X

# NATURAL MORTALITY PARAMETERS: (lower bound, best estimate, upper bound, indicator, std. dev. of prior)
# one parameter (set of specifications) for each age
#(USED FOR CONTINUITY AND BASE RUNS 5 and 10)
#                  X
$ 1 0 0.8 1 0 0.1
$ 1 0 0.8 1 0 0.1
$ 1 0 0.6 1 0 0.1
$ 1 0 0.6 1 0 0.1
$ 1 0 0.6 1 0 0.1
$ 1 0 0.6 1 0 0.1
#                  X

# MIXING PARAMETERS: (lower bound, best estimate, upper bound, indicator, std. dev. of prior)
# one parameter (set of specifications) for each age :not used here!
#(NO MIXING WAS USED FOR ANY 2008 YFT VPA RUN)
#                  X
$ 6 0 0 0 0 0
#                  X

# STOCK-RECRUITMENT PARAMETERS: (lower bound, best estimate, upper bound, indicator, std. dev. of prior)
# five parameters so 5 sets of specifications : not used here!
#(THESE SETTINGS ARE USED TO CONSTRAINT ON THE ESTIMATED S-R RELATIONSHIP. THIS WAS NOT DONE FOR ANY 2008 YFT VPA RUN)
#                  X
0 0 0 0 0 maximum recruitment
0 0 0 0 0 spawning biomass scaling parameter
0 0 0 0 0 extra parameter (not used yet)
0 0 0 0 0 autocorrelation parameter
0 0 0 0 0 variance for penalty function
#                  X

# VARIANCE SCALING PARAMETER (lower bound, best estimate, upper bound, indicator, std. dev.)
#(USED FOR CONTINUITY AND BASE RUNS 5 and 10. THESE SETTINGS ESTIMATE A SINGLE VARIANCE SCALAR FOR ALL INDICES. THE SAME SCALAR IS USED FOR THE INTERANNUAL VARIANCE OF EACH INDEX. (EQUAL WEIGHTING ACROSS YEARS AND INDICES).
#                  X
$ 1 0 0.5 1.0 1 0.1
$ 17 0 1.0 1.0 -0.1 0.1

```

Table 16. Indices of abundance used for VPA model runs.

<i>Index</i>	<i>Continuity Run</i>	<i>Runs 5 & 10</i>
Brazilian Bait Boat	Used	Used
Brazilian Longline	Used	Used
Japanese Longline	Used	Used
USA-Mexico Longline (GOM)	Used	Used
USA Rod and Reel	Not Used	Used
USA Pelagic Longline (ATL)	Used	Used
Venezuela Longline	Used	Used
Venezuela Purse Seine	Used	Used
EU FAD Purse Seine	Not Available in 2003	Used
EU PS 3% Annual Increase in Q	Used 1970-2006	Used (1970-1979) ***
EU TROP Purse Seine	Not Available in 2003	Used
EU Dakar Purse Seine	Not Available in 2003	Used
Uruguay Longline	Not Available in 2003	Used
Chinese Taipei Longline	Not Available in 2003	Used
Canary Islands Bait Boat	Not Available in 2003	Used

*** No increase in catchability was applied during this period. The EU indices for juveniles (EU-FAD_PS) and adults (EU-TROP-PS) were used when available. They cannot be used with the EU-PS 3% index during overlapping time periods because they were developing using the same datasets.

Table 17. Methods used to estimate index selectivities for VPA models. (B&G = Butterworth and Geromont, 1999).

Index	Estimation of Index Selectivities		
	Continuity Run	Run 5	Run 10
Brazilian Bait Boat	Partial Catches (B&G) Ages 0-4	Partial Catches (B&G) Ages 0-4	Identical to Run 5 except that for all <i>LONGLINE INDICES</i> , the selectivity was estimated as in Run 5, then for all ages older than the first fully selected age, the selectivity was fixed at 1.0. Using this method, the selectivity vectors of the longline fleets were assumed to be logistic (flat-topped) rather than dome shaped (as in Run 5).
Brazilian Longline	Partial Catches (B&G) Ages 0-5	Partial Catches (B&G) Ages 0-5	
Japanese Longline	Partial Catches (B&G) Ages 0-5	Partial Catches (B&G) Ages 0-5	
USA-Mexico Longline (GOM)	Partial Catches (B&G) Ages 0-5	Partial Catches (B&G) Ages 0-5	
USA Rod and Reel	Not Used	Partial Catches (B&G) Ages 0-5	
USA Pelagic Longline (ATL)	Partial Catches (B&G) Ages 0-5	Partial Catches (B&G) Ages 0-5	
Venezuela Longline	Partial Catches (B&G) Ages 0-5	Partial Catches (B&G) Ages 0-5	
Venezuela Purse Seine	Partial Catches (B&G) Ages 0-4	Partial Catches (B&G) Ages 0-4	
EU FAD Purse Seine	Not Used	Partial Catches EU- PS (B&G) Ages 0-1	
EU PS 3% Annual Increase in Q	Partial Catches (B&G) Ages 0-5	Partial Catches EU- PS (B&G) Ages 0-5	
EU TROP Purse Seine	Not Used	Fixed at Fecundity Proxy Ages 3-5	
EU Dakar Purse Seine	Not Used	Partial Catches (B&G) Ages 0-4	
Uruguay Longline	Not Used	Partial Catches (B&G) Ages 0-5	
Chinese Taipei Longline	Not Used	Partial Catches (B&G) Ages 0-5	
Canary Islands Bait Boat	Not Used	Partial Catches (B&G) Ages 0-4	

Table 18. Estimated indexes of abundance used in ASPIC runs.

YEAR	<i>YFT-JPN-LL(w)</i>	<i>YFT-USA-RR(n)</i>	<i>YFT-BRZ-LL(n)</i>	<i>YFT-USA-LL(w)</i>	<i>YFT-URU-LL(n)</i>	<i>YFT-VEN-PS(w)</i>	<i>YFT-BRZ-BB(w)</i>	<i>YFT-EUDKR-BB(w)</i>	<i>EU PS 3% incQ</i>	<i>combined index (from 1965 to 2006)</i>	<i>combined index (from 1956 to 2006)</i>
1950											
1951											
1952											
1953											
1954											
1955											
1956										72.909	
1957										43.752	
1958										31.410	
1959										32.821	
1960										20.334	
1961										12.884	
1962										4.283	
1963										4.027	
1964										2.367	
1965	2.355								2.537	1.222	
1966	1.586								1.708	0.823	
1967	3.119								3.360	1.618	
1968	2.580								3.128	1.507	
1969	2.270					0.659			2.715	1.308	
1970	1.690						0.644	5.061	2.099	1.011	
1971	1.357						0.636	4.318	1.469	0.707	
1972	1.834						0.640	4.795	1.776	0.856	
1973	1.288						0.589	4.833	1.560	0.751	
1974	1.778						0.925	4.405	1.367	0.658	
1975	1.321						0.405	4.744	1.121	0.540	
1976	1.297						0.448	4.693	1.169	0.563	
1977	1.006						0.684	4.610	1.026	0.494	
1978	1.478						0.264	4.195	1.084	0.522	
1979	1.783						0.498	4.171	1.246	0.600	
1980	1.102							3.457	0.965	0.465	
1981	1.390			144.960		1.391	1.024	3.709	1.133	0.546	
1982	1.228			196.750		0.212	0.976	3.166	0.915	0.441	
1983	1.222			84.811	13.589	0.576	0.994	2.748	1.068	0.514	
1984	1.315			42.077	6.027	0.280	1.420	2.172	1.021	0.492	
1985	0.840			75.434	10.170	0.209	1.091	3.732	0.909	0.438	
1986	1.053	32.756	5.035	116.428	5.977	0.209	1.647	4.026	1.098	0.529	
1987	1.110	15.564	6.355	1.766	112.292	4.574	0.295	1.858	3.527	1.141	0.549
1988	1.102	7.789	5.276	1.861	142.612	6.304	0.327	1.798	3.340	1.341	0.646
1989	0.863	12.821	5.342	1.626	56.755	13.656	0.299	0.433	4.162	1.091	0.525
1990	1.169	5.746	9.045	1.371	51.864	7.002	0.620	1.658	4.531	1.323	0.637

1991	0.891	9.236	4.962	1.053	186.624	7.151	0.187	1.200	3.605	1.020	0.491
1992	1.003	6.298	2.069	1.257	293.019	4.812	0.295	2.340	3.290	0.935	0.450
1993	0.478	14.332	2.402	0.716	55.948	5.511	0.350	1.899	3.256	0.766	0.369
1994	0.813	34.744	2.668	0.695	214.310	6.720	0.210	1.414	3.123	0.951	0.458
1995	0.560	47.164	1.810	0.835	88.011	3.025	0.104	0.845	3.192	0.796	0.383
1996	0.613	14.731	4.648	0.824	166.935	6.777	0.289	1.381	3.116	0.864	0.416
1997	0.465	6.324	3.678	0.888	54.748	4.569	0.422	0.586	2.887	0.703	0.339
1998	0.557	10.750	4.685	0.650	62.019	3.704	0.323	0.223	2.589	0.730	0.351
1999	0.563	21.224	4.392	0.982	125.597	5.434	0.112	0.639	2.329	0.729	0.351
2000	0.625	22.736	4.583	0.853	165.542	6.624		0.301	2.983	0.765	0.368
2001	0.421	24.172	3.676	0.771	0.000	13.243	0.681	0.482	3.290	0.621	0.299
2002	0.430	19.716	2.908	0.606	100.350	8.181	0.291	0.731	3.723	0.707	0.340
2003	0.507	17.978	6.166	0.513	152.398	3.999	0.238	0.835	3.175	0.882	0.425
2004	0.657	17.585	7.536	0.868	109.591	2.393	0.091	0.636	2.906	0.905	0.436
2005	0.499	13.211	0.918	0.869	231.081	1.226	0.103	0.519	3.146	0.636	0.306
2006	0.693	19.888	2.305	0.891	90.832		0.376	0.588	3.838	0.749	0.361

Table 19. Series of catches used in ASPIC runs.

YEAR	<i>YFT-JPN-LL(w)</i>	<i>YFT-USA-RR(n)</i>	<i>YFT-BRZ-LL(n)</i>	<i>YFT-USA-LL(w)</i>	<i>YFT-URU-LL(n)</i>	<i>YFT-VEN-PS(w)</i>	<i>YFT-BRZ-BB(w)</i>	<i>YFT-EUDKR-BB(w)</i>	<i>EU PS (PILAR) 3% incQ</i>	<i>others</i>	<i>Total</i>
1950	0	0	0	0	0	0	0	0	0	1200	1200
1951	0	0	0	0	0	0	0	0	0	1358	1358
1952	0	0	0	0	0	0	0	0	0	2787	2787
1953	0	0	0	0	0	0	0	0	0	3600	3600
1954	0	0	0	0	0	0	0	0	0	3407	3407
1955	0	0	0	0	0	0	0	0	0	4300	4300
1956	612	0	0	0	0	0	0	0	0	5985	6597
1957	13198	0	0	0	0	0	0	0	0	10500	23698
1958	27159	0	1740	0	0	0	0	0	0	11682	40581
1959	44071	0	5920	111	0	0	0	0	0	7667	57769
1960	50822	0	4700	0	0	0	0	0	0	12971	68493
1961	42609	0	4400	0	0	0	0	0	0	11794	58803
1962	41973	0	1400	17	0	0	0	0	0	14133	57523
1963	37717	0	2400	8	0	0	0	0	0	88	24384
1964	35106	0	1624	0	0	0	0	0	637	31561	68928
1965	36918	0	696	0	0	0	0	0	718	29390	67721
1966	22354	0	464	0	0	0	0	0	983	34639	58439
1967	12824	0	812	0	0	0	0	0	994	45163	59793
1968	13913	0	812	0	0	0	0	0	0	1402	68196
1969	9966	0	464	0	0	0	0	14269	1595	68277	94571
1970	6809	0	812	0	0	0	0	0	7556	4309	54969
1971	10629	0	347	0	0	0	0	0	7570	3014	52887
1972	6497	0	233	0	0	0	0	0	7539	5017	75342
1973	3803	0	153	0	0	0	0	0	5542	5297	80332
1974	3475	0	232	0	0	0	0	0	6353	12498	84583
1975	4192	0	260	0	0	0	0	0	2881	27309	90154
1976	3366	0	681	0	0	0	0	0	3718	17720	99475
1977	1467	0	928	0	0	0	0	0	3380	22329	102909
1978	1923	0	795	0	0	0	0	0	2783	24669	103874
1979	1986	0	1076	0	0	0	117	2141	22199	99998	127517
1980	2839	0	521	52	0	4397	392	0	22398	100097	130696
1981	4145	1275	1159	45	67	2500	917	2766	40976	102287	156137
1982	6062	912	935	65	214	12030	1036	2907	35639	105542	165342
1983	2069	2196	887	165	357	23503	1778	2690	39808	92404	165857
1984	3967	404	484	593	368	17814	1298	3460	10972	74690	114050
1985	5308	3393	515	738	354	16241	2176	2874	32339	92680	156619
1986	3405	4836	1057	3975	270	9175	751	3797	32462	86945	146673
1987	3365	3952	653	4888	109	6583	1560	3778	31498	88975	145361
1988	5982	1899	898	8644	177	5992	1596	4420	28618	78039	136265
1989	6970	1930	1126	6247	64	11612	1376	2809	47539	82574	162247

1990	5919	545	661	4474	18	6533	953	3805	50053	120487	193448
1991	4718	1418	582	4141	62	11967	1169	4824	30805	107214	166901
1992	3715	957	1248	5337	74	9693	2660	3359	30426	106290	163760
1993	3096	1898	1518	3886	20	12659	3087	3002	26500	107088	162753
1994	4783	4523	1084	3246	59	19587	2744	3155	30473	102896	172551
1995	5227	4053	1312	3645	53	6338	2613	2152	28324	99529	153246
1996	5250	4032	734	3320	171	10777	1956	2190	26181	98428	153040
1997	3539	3569	849	3773	53	11653	1643	1478	26761	83893	137211
1998	5173	2927	1014	2449	88	9157	1229	569	27255	98703	148564
1999	3405	3967	2930	3541	45	6523	1197	1857	19442	97459	140366
2000	4061	3862	2754	2901	45	7572	3093	872	15627	95447	136235
2001	2691	4185	4883	2200	90	13064	1276	1172	18756	116333	164650
2002	2105	2887	3323	2573	91	7961	2843	2242	23166	93088	140279
2003	2754	5328	1941	2164	95	4607	1289	1963	14816	90558	125515
2004	6260	3759	1968	2492	204	3185	2838	1664	14077	83488	119936
2005	4488	3657	4695	1746	644	2634	2236	1288	10077	75857	107322
2006	5334	4908	1329	2010	218	0	1214	2483	4430	86697	108623

Table 20. Summarized scenarios for yellowfin ASPIC runs.

Run	Model	Abundance indicators	Weighting of indexes	B1/K	Time period			
1	GENFIT	combined (from 1965 - 2006)	none	fix as 1	1950 -2006			
2	LOGISTIC							
3	GENFIT		estimate					
4	LOGISTIC							
5	GENFIT	10 separate series	equal	fix as 1				
6	LOGISTIC							
7	GENFIT		weighting by ratio of area convergence					
8	LOGISTIC							
9	GENFIT	combined (from 1956 – 2006)	none					
10	LOGISTIC							

Table 21. Western skipjack BSP starting parameter inputs and technical inputs for all runs.

param.out file		Techinputs file	
parameter	starting guess	Comment	
K	100000	close to mode	
B1950/K	1	close to mode	
r	1.2	close to mode	
		Fmin	0.0000001
		stepsize	0.000001
		eps	0.0000001
		maxlikefunc	10000

Table 22. Eastern skipjack BSP starting parameter inputs and technical inputs for all runs.

Low variance on r prior Runs 1-3			High variance on r prior Runs 1-3			Same for all runs Techinputs file		
param.out file			param.out file			Techinputs file		
parameter starting guess Comment			parameter starting guess Comment			Fmin 1.00E-07		
K 1500000 close to mode			K 1500000 close to mode			stepsize 1.00E-06		
B1950/K 1 close to mode			B1950/K 1 close to mode			eps 1.00E-07		
r 1.1 close to mode			r 1.1 close to mode			maxlikefunc 1.00E+04		
Run 4			Run 4					
param.out file			param.out file					
parameter starting guess Comment			parameter starting guess Comment					
K 700000 close to mode			K 700000 close to mode					
B1950/K 1 close to mode			B1950/K 1 close to mode					
r 1.1 close to mode			r 1.1 close to mode					
Runs 5-8			Runs 5-8			Run 5B		
param.out file			param.out file			param.out file		
parameter starting guess Comment			parameter starting guess Comment			parameter starting guess Comment		
K 700000 close to mode			K 700000 close to mode			K 600000 close to mode		
B1950/K 1 close to mode			B1950/K 1 close to mode			B1950/K 1 close to mode		
r 1.3 close to mode			r 1.3 close to mode			r 1.2 close to mode		

Table 23. Western skipjack BSP indices.

year	Brazilian Baitboat	VZ curse seine	US rod and reel	Combined Weighted by area	Combined unweighted
1981	1.171	NA	NA	1.160	1.137
1982	1.577	4.083	NA	2.420	2.582
1983	0.624	1.581	NA	0.934	1.010
1984	0.646	1.167	NA	0.918	0.883
1985	0.928	1.409	1.516	1.170	1.164
1986	0.935	0.848	0.652	1.152	1.063
1987	0.716	1.046	1.018	0.719	0.787
1988	0.827	0.849	0.957	0.929	0.894
1989	0.763	1.142	0.947	0.930	0.941
1990	1.341	1.033	1.090	1.064	1.095
1991	0.834	1.237	0.434	0.992	1.040
1992	0.935	0.872	1.640	0.636	0.707
1993	1.334	0.952	0.795	1.315	1.277
1994	0.822	0.643	0.439	0.763	0.749
1995	1.063	0.501	0.528	0.597	0.616
1996	0.923	1.144	0.710	0.733	0.823
1997	1.257	1.999	1.380	1.073	1.213
1998	0.807	1.487	2.209	1.141	1.183
1999	0.624	0.514	0.525	1.200	0.891
2000	NA	0.559	1.602	0.532	0.550
2001	0.927	1.298	1.289	1.297	1.245
2002	0.777	0.602	1.623	0.937	0.845
2003	1.372	0.492	0.827	1.202	1.031
2004	0.967	0.514	0.455	0.769	0.743
2005	1.409	0.046	0.366	0.449	0.308
2006	1.368	NA	NA	0.592	0.685

Table 24. Eastern skipjack - Eight indices used in the BSP model. Weights are determined by the inverse of the fraction of the total fished area that the index accounts for in each year¹. Weights are used in the BSP model as CVs so that the higher the value, the lower its influence.

year	SKJ-GHN-BB Weight	Area	SKJ-CAN1-BB Weight	Area	SKJ-CAN2-BB Weight	Area	SKJ-POR-BB(w) Weight	Area	SKJ-EUDK R1-BB Weight	Area	SKJ-EUDK R2-BB Weight	Area	SKJ-EC-PS-FAD Weight	Area	SKJ-EUDK R-PS Weight	Area	Total area		
1969	1.138	4.75	4				0.121	1.27	15									19	
1970	1.612	6	4				0.0188	12.0	2	0.213	1.33	18						24	
1971	1.865	5.75	4				0.793	11.5	2	0.299	1.35	17						23	
1972	1.581	5.25	4				0.4535	10.5	2	0.263	1.40	15						21	
1973	1.138	4.5	4				0.1962	9.0	2	0.219	1.50	12						18	
1974	1.233	4.25	4				0.0655	8.5	2	0.319	1.55	11						17	
1975	0.664	4	3				0.0205	6.0	2	0.175	1.71	7						12	
1976	0.917	4	3				0.3899	6.0	2	0.257	1.71	7						12	
1977	1.201	2.13	8				0.9981	8.5	2	0.224	2.43	7						17	
1978	1.296	3.33	3				1.2161	5.0	2	0.296	2.00	5						10	
1979	2.308	4.33	3				0.8233	6.5	2	0.503	1.63	8						13	
1980	1.771	4	5	1.439	20.0	1	0.6778	10.0	2	0.518	2.50	8				0.147	5.0	4	20
1981	2.340	4.75	4	2.035	19.0	1	0.9066	9.5	2	0.651	2.37	8				0.612	4.7	4	19
1982	2.055	2.87	8	2.105	23.0	1	1.4974	11.5	2	0.620	2.87	8				0.610	5.8	4	23
1983	0.265	16.0	1				0.1333	8.0	2	0.376	1.78	9				0.098	4.0	4	16
1984	0.883	15.0	1				1.5574	7.5	2	0.273	1.88	8				0.363	3.7	4	15
1985	2.471	13.0	1				0.6045	6.5	2	0.311	2.17	6				0.260	3.2	4	13
1986	0.405	13.0	1				1.1491	6.5	2	0.380	2.17	6				0.696	3.2	4	13
1987	1.191	12.0	1				1.8142	6.0	2	0.576	2.40	5				0.395	3.0	4	12
1988	1.260	18.0	1				3.2581	6.0	3	0.663	2.00	9				0.704	3.6	5	18
1989	1.105	15.0	1				1.8214	7.5	2	0.444	1.88	8				0.541	3.7	4	15
1990	0.811	3.8	5				0.2639	9.5	2	0.790	2.37	8				0.765	4.7	4	19
1991	0.146	29.0	1				0.693	14.5	2	0.505	4.14	7	1.2985	1.81	16	1.061	9.7	3	29
1992				0.160	33.0	1	0.2577	16.5	2	0.516	5.50	6	0.8376	1.65	20	0.688	8.3	4	33
1993				0.153	27.0	1	0.2547	13.5	2	1.028	5.40	5	1.0758	1.59	17	0.786	13.5	2	27
1994				0.676	33.0	1	0.4754	16.5	2	0.966	6.60	5	0.8534	1.65	20	0.608	6.6	5	33
1995				0.379	35.0	1	0.0295	17.5	2	0.381	5.00	7	0.9468	1.67	21	0.622	8.8	4	35
1996				1.376	32.0	1	1.5686	16.0	2	2.118	6.40	5	0.7653	1.60	20	0.286	8.0	4	32
1997				3.208	34.0	1	1.3652	17.0	2	1.037	5.67	6	0.5449	1.62	21	0.767	8.5	4	34
1998				4.821	34.0	1	0.7329	17.0	2	1.732	4.86	7	0.474	1.62	21	0.883	11.3	3	34
1999				0.808	37.0	1	0.6019	18.5	2	1.260	5.29	7	0.5722	1.61	23	1.307	9.3	4	37
2000				0.901	35.0	1	0.2085	11.7	3	1.198	4.37	8	0.8031	1.84	19	0.861	8.8	4	35
2001				0.263	32.0	1	0.2975	10.7	3	1.100	8.00	4	0.6577	1.60	20	0.558	8.0	4	32
2002				0.041	33.0	1	0.827	11.0	3	1.230	5.50	6	0.6683	1.65	20	0.272	11.0	3	33
2003				1.232	34.0	1	0.9712	17.0	2	1.169	5.67	6	0.864	1.62	21	0.742	8.5	4	34
2004				0.605	37.0	1	1.0496	18.5	2	1.148	6.17	6	1.0084	1.54	24	0.825	9.3	4	37
2005				0.555	33.0	1	0.6505	16.5	2	1.383	5.50	6	0.9809	1.57	21	0.469	11.0	3	33
2006				0.904	28.0	1	2.7102	14.0	2	1.376	5.60	5	0.8057	1.75	16	0.401	7.0	4	28

¹ For 1960, weight for SKJ-GHN-BB = 1% total area fished=1/(4/19)=4.75

Table 25. Eastern skipjack combined indices and EU-PS indices constructed with variable q or a 3% increase in q by year. used for BSP model.

year	Combined, Weighted by area	Combined unweighted	EU-PS CPUE variable q	EU-PS CPUE 3% change in q
1969	0.220	0.148	4.568	
1970	0.142	0.198	4.953	3.253
1971	0.582	0.361	4.249	4.473
1972	0.438	0.306	2.891	3.791
1973	0.279	0.234	3.760	3.835
1974	0.226	0.268	2.641	4.679
1975	0.102	0.123	2.339	1.994
1976	0.345	0.273	2.755	2.463
1977	0.492	0.305	2.658	3.773
1978	0.593	0.410	2.453	3.158
1979	0.752	0.572	2.931	2.719
1980	0.594	0.459	2.490	2.607
1981	0.994	0.764	2.263	2.608
1982	1.067	0.709	2.171	2.381
1983	0.227	0.265	NA	1.752
1984	0.694	0.524	NA	1.749
1985	0.674	0.498	2.202	1.878
1986	0.677	0.710	2.075	2.492
1987	0.956	0.850	2.434	2.321
1988	1.344	1.189	2.254	2.990
1989	0.953	0.782	2.448	2.426
1990	0.685	0.820	1.935	2.778
1991	0.667	1.165	1.458	4.025
1992	0.532	0.889	1.419	2.823
1993	0.651	1.156	1.152	3.450
1994	0.890	1.068	1.142	2.806
1995	0.387	0.805	1.116	3.032
1996	1.283	1.134	1.174	2.577
1997	1.458	0.947	1.576	2.407
1998	1.548	0.956	1.898	2.137
1999	1.097	0.983	1.623	2.308
2000	0.884	1.055	1.594	2.612
2001	0.643	0.826	1.862	2.484
2002	0.484	0.853	1.912	2.526
2003	1.255	1.220	1.640	3.050
2004	1.161	1.332	1.677	3.180
2005	0.956	1.247	2.206	3.919
2006	1.305	1.183	2.252	4.089

Table 26. Summary results from the analyses of catchability trends in the purse seine fishery. The regression slope values can be used to infer average annual percent change in catchability for different time periods.

	MSY	k	Bmsy	B/k	B/Bmsy	q Regression slopes			
						1969-79	1980-90	1991-06	2002-06
SKJ	150000	700000	257516	0.61	1.66	0.04	0.10	0.01	0.13
YFT	150000	644588	237131	0.37	1.00	0.09	0.11	0.05	-0.07
BET	90000	839523	308843	0.33	0.90	0.07	0.06	0.08	0.03
All	390000	2184112	803490	0.55	1.50	0.07	0.10	0.03	0.03

Table 27. Time series of nominal EC-purse seine fishing effort, estimates of catchability trends by species (and species combined), and effort adjusted for catchability changes estimated by year. The last column shows adjusted yellowfin effort assuming a 3% change per year following the method applied in 2000.

Year	Effort Nominal	Catchability				Adjusted Effort				Adj. Effort 3%/year
		SKJ	YFT	BET	All	SKJ	YFT	BET	All	
1969	6010	2.3E-06	6.6E-06	3.5E-07	2.7E-06	6010	6010	6010	6010	--
1970	8970	2.4E-06	5.2E-06	4.4E-07	2.4E-06	9647	7063	11308	8060	14686
1971	11708	3.5E-06	4.4E-06	3.7E-07	2.5E-06	17990	7875	12234	11155	17091
1972	13322	4.4E-06	5.3E-06	4.1E-07	3.1E-06	25736	10869	15699	15586	19624
1973	15041	3.0E-06	5.6E-06	4.4E-07	2.8E-06	20076	12961	18768	15566	19683
1974	17491	5.6E-06	5.6E-06	4.8E-07	3.6E-06	43084	15015	23994	23665	24322
1975	19179	2.7E-06	8.0E-06	4.2E-07	3.3E-06	22432	23385	23092	23450	26305
1976	19726	2.7E-06	9.6E-06	5.4E-07	3.7E-06	23797	29052	30327	27424	26624
1977	17065	5.4E-06	1.2E-05	1.0E-06	5.3E-06	40346	30575	49899	33874	28420
1978	19950	4.7E-06	1.1E-05	6.6E-07	4.7E-06	41134	33857	37439	35156	31950
1979	21138	3.1E-06	1.1E-05	5.7E-07	3.9E-06	28357	34101	34399	31223	30570
1980	24732	3.7E-06	9.6E-06	5.2E-07	3.9E-06	39676	36302	36932	36008	37884
1981	25660	4.3E-06	1.1E-05	8.4E-07	4.6E-06	48412	43247	61599	43894	42010
1982	27674	4.7E-06	1.1E-05	7.8E-07	4.5E-06	57154	45305	61622	46823	52118
1983										60175
1984										52468
1985	14362	5.7E-06	1.6E-05	7.2E-07	6.1E-06	35788	35561	29479	32877	41949
1986	11397	8.7E-06	2.1E-05	1.3E-06	8.5E-06	43727	36563	42421	36319	36401
1987	13390	6.6E-06	1.9E-05	8.6E-07	7.1E-06	39055	39317	32772	35475	40951
1988	11647	1.0E-05	1.9E-05	1.1E-06	8.4E-06	53716	33406	35072	36829	40486
1989	13050	6.7E-06	2.4E-05	8.4E-07	8.1E-06	38409	47275	31284	39481	38756
1990	12006	1.2E-05	3.7E-05	1.4E-06	1.3E-05	60990	67900	47327	56488	42480
1991	12109	2.4E-05	3.2E-05	2.2E-06	1.6E-05	127784	60056	77349	72834	46291
1992	12700	1.8E-05	3.5E-05	2.9E-06	1.4E-05	99020	67029	103537	67849	49781
1993	12462	2.7E-05	3.5E-05	5.2E-06	1.9E-05	149726	66026	186500	86770	49990
1994	11679	2.6E-05	4.0E-05	6.5E-06	2.0E-05	135785	70805	215071	86298	55253
1995	10969	2.7E-05	4.4E-05	6.0E-06	2.1E-05	130382	73872	187096	84939	48003
1996	10544	2.3E-05	4.7E-05	6.9E-06	2.0E-05	107790	75714	206154	80148	49115
1997	8506	1.9E-05	4.9E-05	5.8E-06	1.9E-05	72590	63849	141217	60017	47521
1998	8581	1.7E-05	5.3E-05	4.9E-06	1.8E-05	64594	68904	119406	58124	57373
1999	7909	2.5E-05	4.6E-05	6.8E-06	2.1E-05	85731	56112	154479	61369	60271
2000	7337	2.3E-05	5.5E-05	7.8E-06	2.2E-05	74841	61312	163285	59859	45663
2001	7661	2.0E-05	6.6E-05	7.7E-06	2.1E-05	66769	77093	168851	61472	50044
2002	6397	1.8E-05	8.3E-05	9.3E-06	2.2E-05	49771	81084	169902	52767	37675
2003	6366	2.6E-05	7.3E-05	9.3E-06	2.4E-05	73525	71136	168495	56257	39529
2004	5430	3.3E-05	6.3E-05	9.4E-06	2.5E-05	78281	52485	146129	50267	41268
2005	4600	3.0E-05	5.9E-05	8.4E-06	2.3E-05	60619	41337	109729	39417	34118
2006	3675	3.2E-05	6.5E-05	1.1E-05	2.6E-05	51387	36505	117368	35942	28299

Table 28. Management benchmarks and references calculated from the joint distribution of yellowfin VPA Runs 5 and 10.

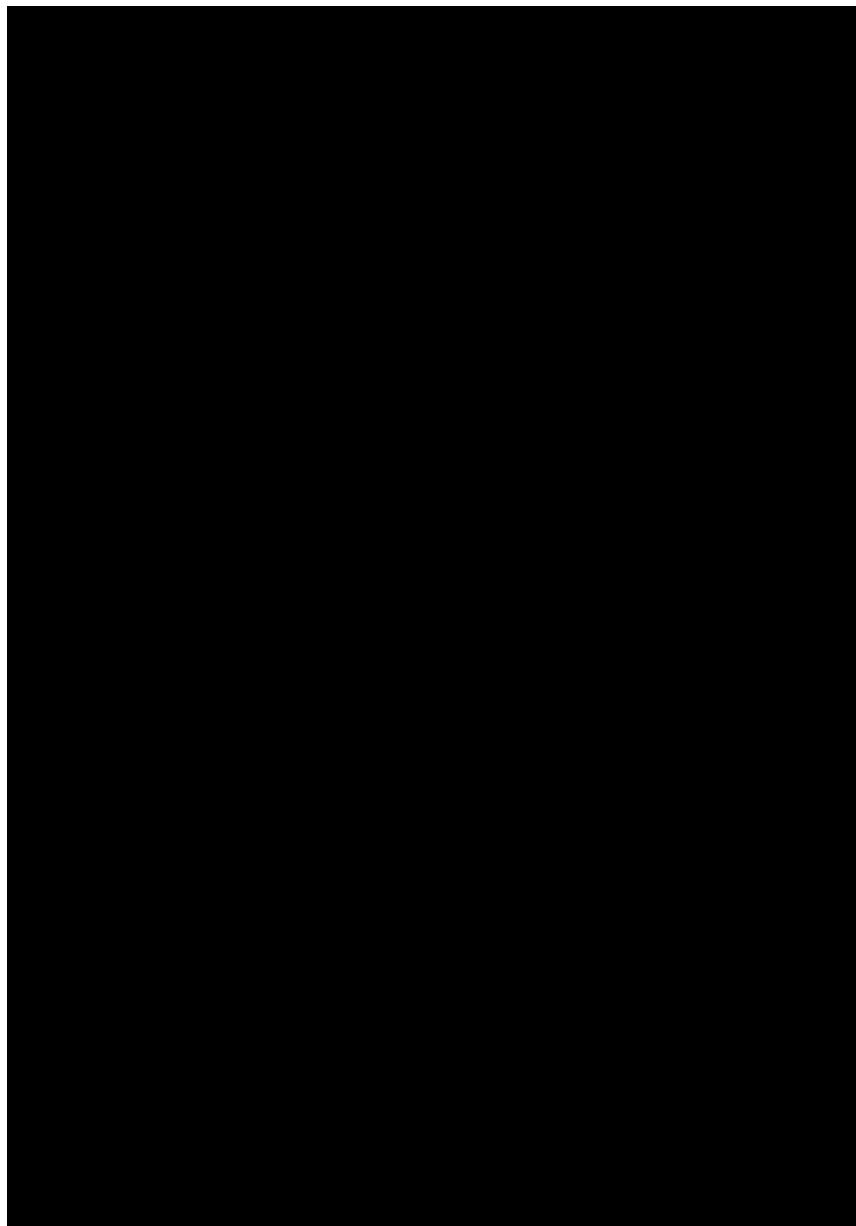


Table 29. Non-bootstrap results of initial ASPIC runs.

Run	MSY (mt)	K (mt)	B _{MSY} (mt)	F _{MSY}	B ₂₀₀₆ /B _{MSY}	F ₂₀₀₆ /F _{MSY}	Equilibrium yield (mt)
1	170,200	2,151,00	215,100	0.792	3.581	0.175	135,700
2	146,600	852,700	426,400	0.344	0.834	0.845	145,600
3	1,173,000	39,120,0	13,270,000	0.088	3.034	0.031	-73,060
4	146,600	853,000	426,400	0.344	0.834	0.845	145,600
5	111,900	4,027,00	2,014,000	0.056	0.957	1.013	111,700
6	119,800	3,320,00	1,667,000	0.072	0.944	0.955	119,500
7	137,100	1,521,00	459,300	0.299	0.940	0.815	137,100
8	150,400	631,500	315,800	0.476	0.707	0.948	145,100
9	69,460	4,377,00	547,100	0.127	0.811	2.022	68,940
10	8,723	6,179,00	3,089,000	0.003	0.216	62.800	2,882

Table 30. ASPIC bootstraps results of cases 2, 4, 6, and 8.

		<i>run02</i>	<i>run04</i>	<i>run06</i>	<i>run08</i>
MSY (MT)	point estimate	1.47E+05	1.47E+05	1.20E+05	1.50E+05
	80% lower	1.20E+05	9.62E+04	9.88E+04	1.44E+05
	80% upper	1.54E+05	1.53E+05	1.42E+05	1.54E+05
K (MT)	point estimate	8.53E+05	8.53E+05	3.32E+06	6.32E+05
	80% lower	4.60E+05	5.17E+05	1.20E+06	4.65E+05
	80% upper	2.63E+06	3.99E+06	4.63E+06	9.82E+05
B _{MSY} (MT)	point estimate	4.26E+05	4.26E+05	1.67E+06	3.16E+05
	80% lower	2.30E+05	2.58E+05	5.99E+05	2.32E+05
	80% upper	1.31E+06	2.00E+06	2.31E+06	4.91E+05
F _{MSY}	point estimate	0.344	0.344	0.072	0.476
	80% lower	0.089	0.049	0.040	0.292
	80% upper	0.671	0.590	2.205	0.664
B _{current} /B _{MSY}	point estimate	0.834	0.834	0.944	0.707
	80% lower	0.745	0.733	0.871	0.669
	80% upper	0.965	0.963	1.044	0.764
F _{current} /F _{MSY}	point estimate	0.845	0.845	0.955	0.948
	80% lower	0.615	0.631	0.749	0.828
	80% upper	1.149	1.206	1.308	1.105
Equilibrium yield (MT)	point estimate	1.46E+05	1.46E+05	1.20E+05	1.45E+05
	80% lower	1.31E+05	1.25E+05	9.64E+04	1.33E+05
	80% upper	1.54E+05	1.53E+05	1.42E+05	1.53E+05

Table 31. BSP model runs, convergence criteria and model results for western skipjack.

RUN	Indices	prior on r	limits of uniform prior on ln(K) in 1000 MT		parameter settings for importance function width		status results (marginal posterior distributions of each parameter)						convergence criteria good convergence is achieved if CV(wts)/CV(ip) <2	
			Kmin	Kmax	degf	expand imp	K	r	MSY	F(2006)/Fmsy	B(2006)/Bmsy	Bmsy	(ip)	cv(wts)/cv
RUN1	3 equal	-N(1.17,.5)	ln(500)	ln(2500)	1E-05	2	159,322 (55,374)	1.372 (0.372)	52,064 (14,488)	0.381 (0.461)	1.625 (0.208)	79,661 (27,687)	18.74	CV(wts)/CV(ip)>2
RUN2	combined eq wt	-N(1.17,.5)	ln(500)	ln(2500)	1E-05	2	164,549 (48,812)	1.392 (0.361)	54,159 (10,465)	0.304 (0.08)	1.69 (0.08)	82,274 (24,406)	60.46	CV(wts)/CV(ip)>2
RUN3	combined sep wt	-N(1.17,.5)	ln(500)	ln(2500)	1E-05	2	187,037 (48,041)	1.328 (0.329)	59,334 (10,548)	0.271 (0.07)	1.724 (0.071)	93,519 (24,020)	58.51	CV(wts)/CV(ip)>2
RUN4	3 equal	-U(0.01, 3)	ln(500)	ln(2500)	1E-05	2	159,322 (55,374)	1.372 (0.372)	52,064 (14,488)	0.381 (0.461)	1.625 (0.208)	79,661 (27,687)	18.74	CV(wts)/CV(ip)>2
RUN5	3 equal	-N(1.17,.5)	ln(500)	ln(2500)	1E-05	4	147,037 (53,860)	1.342 (0.341)	47,596 (15,286)	0.449 (0.615)	1.565 (0.232)	73,519 (26,930)	12.95	CV(wts)/CV(ip)>2
RUN6	3 equal	-N(1.17,.5)	ln(500)	ln(2500)	1E-05	10	132,316 (34,320)	1.19 (0.344)	38,471 (11,216)	0.596 (0.663)	1.427 (0.271)	66,158 (17,160)	3.79	CV(wts)/CV(ip)>2
RUN7	3 equal	-N(1.17,.5)	ln(500)	ln(2500)	1E-08	15	124,907 (14,181)	1.097 (0.154)	33,972 (4607)	0.664 (0.798)	1.369 (0.249)	62,453 (7,090)	1.66	marginal
RUN8	3 equal	-N(1.17,.5)	ln(500)	ln(2500)	1E-09	20	127,373 (14,677)	1.107 (0.172)	34,912 (6037)	0.624 (0.662)	1.395 (0.244)	63,686 (7,338)	1.56	marginal
RUN9	3 equal	-N(1.17,.25)	ln(500)	ln(2500)	1E-09	20	200104 (35297)	1.159 (0.278)	57815 (17229)	0.326 (0.262)	1.672 (0.189)	100052 (17649)	1.22	acceptable

Table 32. BSP model runs, convergence criteria and model results for eastern skipjack for priors on r with narrower standard deviations (0.3 or 0.25). Note that the only the sd= 0.25 was as originally specified from the demographic analysis.

RUN	Indices	prior on r	limits of uniform prior on K or ln(K) in 1000 MT		parameter settings for importance function width		status results (marginal posterior distributions of each parameter)						convergence criteria	
			Kmin	Kmax	degf	expand imp	K	r	MSY	F(2006)/Fmsy	B(2006)/Bmsy	Bmsy	cv(wt)/cv	v(l*p)
RUN1	8 equal	-normal (1.17,sd=.3)	200	2000	0.00001	2	1,393,053 (392,931)	1.351 (0.296)	465,834 (162,805)	0.159 (0.074)	1.834 (0.078)	696,527 (196,466)	1.1578	marginal
RUN2	8 equal	-normal (1.17,sd=.3)	ln(200)	ln(2000)	0.00001	2	1,293,317 (410,825)	1.285 (0.275)	465,834 (162,805)	0.183 (0.082)	1.808 (0.087)	646,658 (205,413)	0.9627	acceptable
RUN3	combined eq wt	-normal (1.17,sd=.3)	ln(200)	ln(2000)	0.00001	2	1,316,538 (406,767)	1.326 (0.332)	408,830 (148,173)	0.176 (0.081)	1.816 (0.086)	658,269 (203,383)	0.7832	acceptable
RUN4	combined sep wt	-normal (1.17,sd=.3)	ln(200)	ln(2000)	0.00001	2	1,278,930 (425,336)	1.305 (0.335)	428,418 (162,252)	0.19 (0.092)	1.801 (0.098)	639,465 (212,668)	0.7667	acceptable
RUN5	8 equal	-normal (1.17,sd=.3)	200	1000	0.00001	2	724,475 (146,955)	1.422 (0.281)	407,960 (161,318)	0.261 (0.081)	1.727 (0.087)	395,034 (73,477)	0.9344	acceptable
RUN5B	8 equal	-normal (1.17,sd=.3)	ln(200)	ln(1000)	0.00001	2	762,831 (154,416)	1.416 (0.263)	278,228 (69,645)	0.273 (0.083)	1.713 (0.089)	381,416 (77,208)	0.8815	acceptable
RUN6	8 separate weighting	-normal (1.17,sd=.3)	ln(200)	ln(1000)	0.00001	2	849,344 (115,140)	1.497 (0.316)	267,019 (66,345)	0.221 (0.064)	1.769 (0.069)	424,672 (57,570)	1.4983	marginal
RUN7	1 EU-PS, variable q	-normal (1.17,sd=.3)	ln(200)	ln(1000)	0.00001	2	543,400 (106,018)	1.237 (0.273)	316,192 (74,752)	0.523 (0.151)	1.443 (0.161)	271,700 (53,009)	1.3096	marginal
RUN8	1 EU-PS, 3% per year	-normal (1.17,sd=.3)	ln(200)	ln(1000)	0.00001	2	731,404 (175,105)	1.286 (0.312)	163,313 (31,388)	0.344 (0.13)	1.637 (0.14)	365,702 (87,553)	0.7225	acceptable
RUN8Z	1 EU-PS, 3% per year	-normal (1.17,sd=.25)	ln(200)	ln(1000)	0.00001	2	735,623 (169,249)	1.25 (0.269)	229,727 (66,596)	0.347 (0.125)	1.633 (0.135)	367,812 (84,624)	0.99	acceptable
RUN5BZ	8 equal	-normal (1.17,sd=.25)	ln(200)	ln(1000)	0.00001	2	768,318 (150,650)	1.371 (0.243)	225,796 (61,501)	0.279 (0.082)	1.707 (0.088)	384,159 (75,325)	0.8185	comments

Table 33. BSP model runs, convergence criteria and model results for eastern skipjack with wide standard deviations (0.5) on r prior.

RUN	Indices	prior on r	limits of uniform prior on K or ln(K) in 1000 MT		parameter settings for importance function width		status results (marginal posterior distributions of each parameter)						convergence criteria	
			Kmin	Kmax	degtf	expand imp	K	r	MSY	F(2006)/Fmsy	B(2006)/Bmsy	Bmsy	cv(wt)/cv(l*p)	comments
RUN1	8 equal	~normal (1.17,sd=.5)	200	2000	0.00001	2	1,382,655 (408,971)	1.487 (0.444)	504,319 (207,639)	0.153 (0.078)	1.84 (0.083)	691,327 (204,486)	1.1058	marginal
RUN2	8 equal	~normal (1.17,sd=.5)	ln(200)	ln(2000)	0.00001	2	1,248,077 (449,897)	1.538 (0.483)	461,961 (206,136)	0.172 (0.089)	1.821 (0.094)	624,038 (224,949)	0.9333	acceptable
RUN3	combined eq wt	~normal (1.17,sd=.5)	ln(200)	ln(2000)	0.00001	2	1,266,776 (435,154)	1.581 (0.502)	485,205 (216,089)	0.163 (0.085)	1.83 (0.09)	633,388 (217,577)	0.8496	acceptable
RUN4	combined sep wt	~normal (1.17,sd=.5)	ln(200)	ln(2000)	0.00001	2	1,243,952 (451,127)	1.518 (0.499)	453,691 (207,983)	0.178 (0.096)	1.814 (0.102)	621,976 (225,563)	0.932	acceptable
RUN5	8 equal	~normal (1.17,sd=.5)	200	1000	0.00001	2	790,069 (146,955)	1.422 (0.281)	278,228 (69,645)	0.261 (0.081)	1.727 (0.087)	395,034 (73,477)	0.852	acceptable
RUN5B	8 equal	~normal (1.17,sd=.5)	ln(200)	ln(2000)	0.00001	2	724,475 (174,418)	1.685 (0.369)	300,485 (90,125)	0.246 (0.089)	1.743 (0.095)	362,238 (87,209)	1.0382	marginal
RUN6	8 separate weighting	~normal (1.17,sd=.5)	ln(200)	ln(2000)	0.00001	2	827,685 (127,400)	1.681 (0.352)	345,673 (84,803)	0.201 (0.061)	1.79 (0.065)	413,843 (63,700)	1.2219	marginal
RUN7	1 EU-PS, variable q	~normal (1.17,sd=.5)	ln(200)	ln(2000)	0.00001	2	577,890 (157,188)	1.309 (0.434)	177,892 (52,233)	0.495 (0.197)	1.475 (0.194)	288,945 (78,594)	1.1259	marginal
RUN8	1 EU-PS, 3% per year	~normal (1.17,sd=.5)	ln(200)	ln(2000)	0.00001	2	661,461 (195,584)	1.516 (0.454)	241,380 (89,412)	0.343 (0.145)	1.639 (0.156)	330,730 (97,792)	0.7676	acceptable

Table 34. Summary table of the model runs for the catch-only model for SKJ-W. Abbreviations: lnK is $\ln(K) \sim U(\ln(100), \ln(1000))$, U is $K \sim U(100, 1000)$, logN is $K \sim \text{logN}(\text{mean}=350000, \text{CV}=0.5)$, u is $r \sim U(0.4, 2.0)$, D is $r \sim \text{demographic}$, L is $x \sim U(0, 10)$, s is $x \sim U(0, 1.1)$. The catch data used ranged from 1976 to 2006.

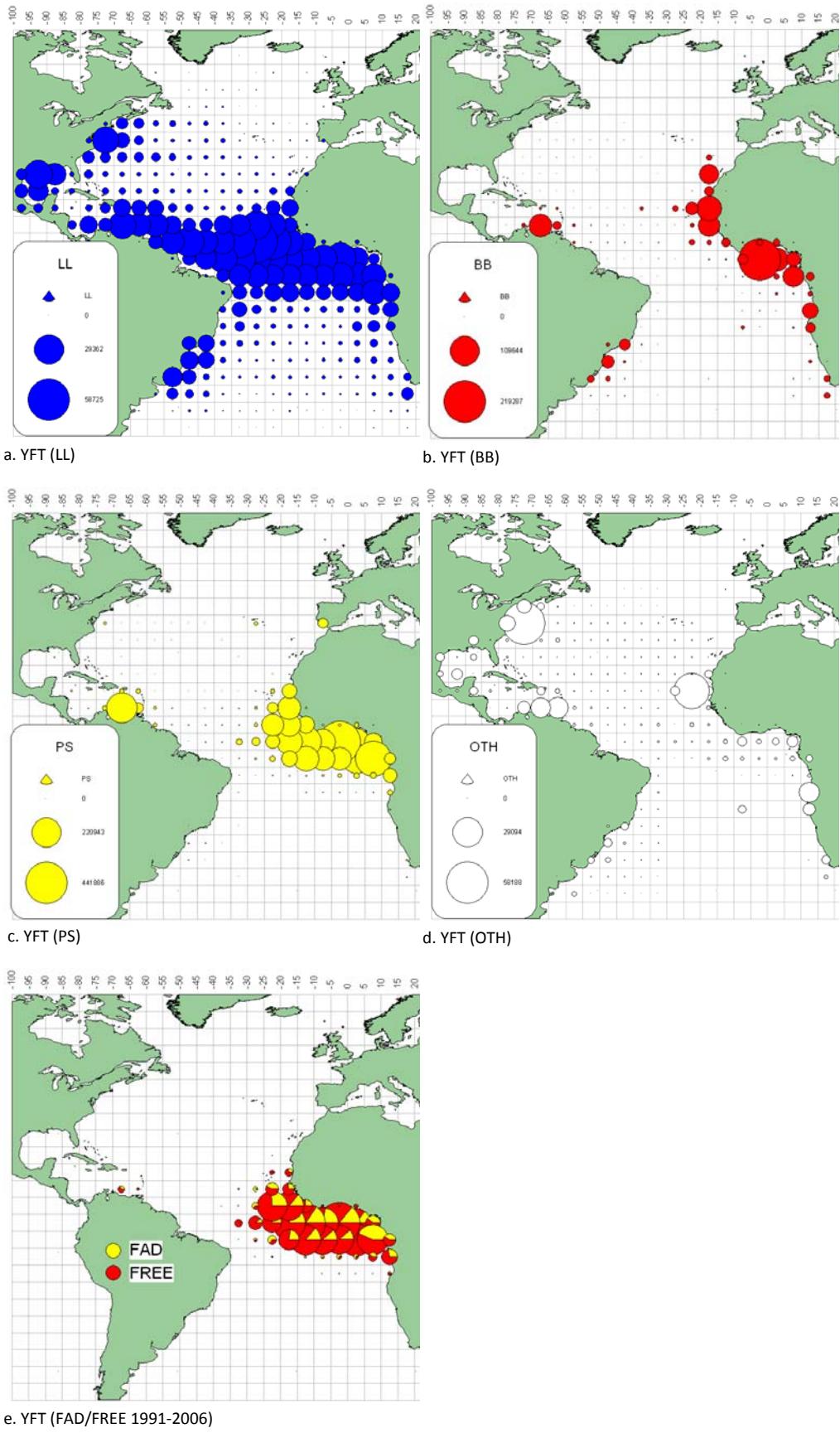
Model	Priors				Posteriors				Obs			
	K	r	x	K	r	MSY	F_{2006}/F_{MSY}	B_{2006}/B_{MSY}	B_{MSY}	$P(MSY < C_{2006})$		
A. 1	lnK	u	L	239 193	0.97	58 234	0.31	1.71	119 596	0.01	Wide posterior on x	
A. 2	logN	u	L	316 597	0.89	69 561	0.25	1.77	158 299	0.00		
A. 3	U	u	L	399 328	0.82	83 646	0.20	1.81	199 664	0.00		
A. 4	lnK	D	L	202 204	1.09	54 887	0.34	1.69	101 102	0.01		
A. 5	logN	D	L	295 618	1.05	77 250	0.22	1.79	147 809	0.00		
A. 6	U	D	L	312 610	1.04	83 012	0.21	1.80	156 305	0.00		
B. 1	lnK	u	s	129 023	0.93	30 520	0.98	1.22	64 512	0.08		
B. 2	logN	u	s	165 843	0.75	31 069	0.86	1.26	82 921	0.06		
B. 3	U	u	s	140 755	0.85	30 702	0.93	1.24	70 377	0.07		
B. 4	lnK	D	s	116 808	1.04	30 601	1.02	1.20	58 404	0.06	Posterior probability increasing	
B. 5	logN	D	s	127 264	0.98	30 986	0.97	1.23	63 632	0.05	towards the upper limit of	
B. 6	U	D	s	120 434	1.02	30 892	0.99	1.22	60 217	0.05	of the prior	

Table 35. Summary table of the model runs for the catch-only model for eastern skipjack. Abbreviations: lnK is $\ln(K) \sim U(\ln(200), \ln(2000))$, U is $K \sim U(200, 2000)$, logN is $K \sim \text{logN}(\text{mean}=350000, \text{CV}=0.5)$, u is $r \sim U(0.4, 2.0)$, D is $r \sim \text{demographic}$, L is $x \sim U(0, 10)$, s is $x \sim U(0, 1.1)$. The runs were fit to the following catch series: A- 1950 to 2006, B – 1965 to 1984, C- 1985 to 2006.

Mode l	Priors			Results – median of the posteriors					Obs		
	K	r	x	K	r	MSY	F_{2006}/F_{MSY}	B_{2006}/B_{MSY}	B_{MSY}	$P(MS Y < C_2^{006})$	
A. 1	lnK	u	L	827 839	1.37	223 930	0.37	1.66	413 919	0.03	The fishery
A. 2	log N	u	L	722 445	1.27	204 349	0.43	1.62	361 222	0.02	was not homogeneo
A. 3	U	u	L	1 187 158	1.20	275 904	0.28	1.74	593 579	0.01	us over the whole time
A. 4	lnK	D	L	759 226	1.15	204 510	0.42	1.62	295 061	0.03	series
A. 5	log N	D	L	698 803	1.17	198 995	0.45	1.60	349 401	0.03	
A. 6	U	D	L	1 121 772	1.15	308 717	0.24	1.77	560 886	0.02	
B. 1	lnK	u	s	229 516	1.51	88 195			114 758	1.00	The
B. 2	log N	u	s	231 966	1.52	87 194			115 983	1.00	posterior
B. 3	U	u	s	234 421	1.49	89 199			117 210	1.00	for K were
B. 4	lnK	D	s	255 996	1.32	85 573			127 998	1.00	concentrate
B. 5	log N	D	s	288 006	1.21	87 830			144 003	1.00	on the lower
B. 6	U	D	s	266 596	1.28	86 827			133 298	1.00	bound
C. 1	lnK	u	s	618 746	1.05	143 632	0.94	1.20	309 373	0.06	
C. 2	log N	u	s	663 628	0.95	145 004	0.92	1.24	331 814	0.06	
C. 3	U	u	s	871 930	0.81	155 552	0.71	1.37	435 965	0.05	
C. 4	lnK	D	s	534 309	1.12	142 865	1.10	1.17	267 155	0.06	
C. 5	log N	D	s	569 172	1.09	146 103	1.01	1.21	284 586	0.04	
C. 6	U	D	s	629 915	1.09	156 326	0.82	1.32	314 957	0.04	

Table 36. Maximum posterior estimates of the parameters and reference points based on the different runs conducted with PROCEAN. SD = standard deviation; q = catchability.

	m	r	B0/K	K	MSY	F_{MSY}
Standard run	1.2	1.169	0.9	2173530	170200	0.19
Sensitivity m	1.7	1.174	0.9	740914	167798	0.48
Sensitivity B0/K	1.2	1.114	0.7	2265240	169055	0.19
Sensitivity mean prior MSY = 130,000	1.2	1.164	0.9	2020000	157090	0.19
Sensitivity mean prior MSY = 170,000	1.2	1.172	0.9	2360080	185192	0.20
Sensitivity SD prior r = 0.7	1.2	1.161	0.9	2189580	170195	0.19
Combined abundance index	1.2	1.212	0.9	1978800	160653	0.20
Standard run with random walk on q	1.2	1.234	0.9	1860000	153986	0.21



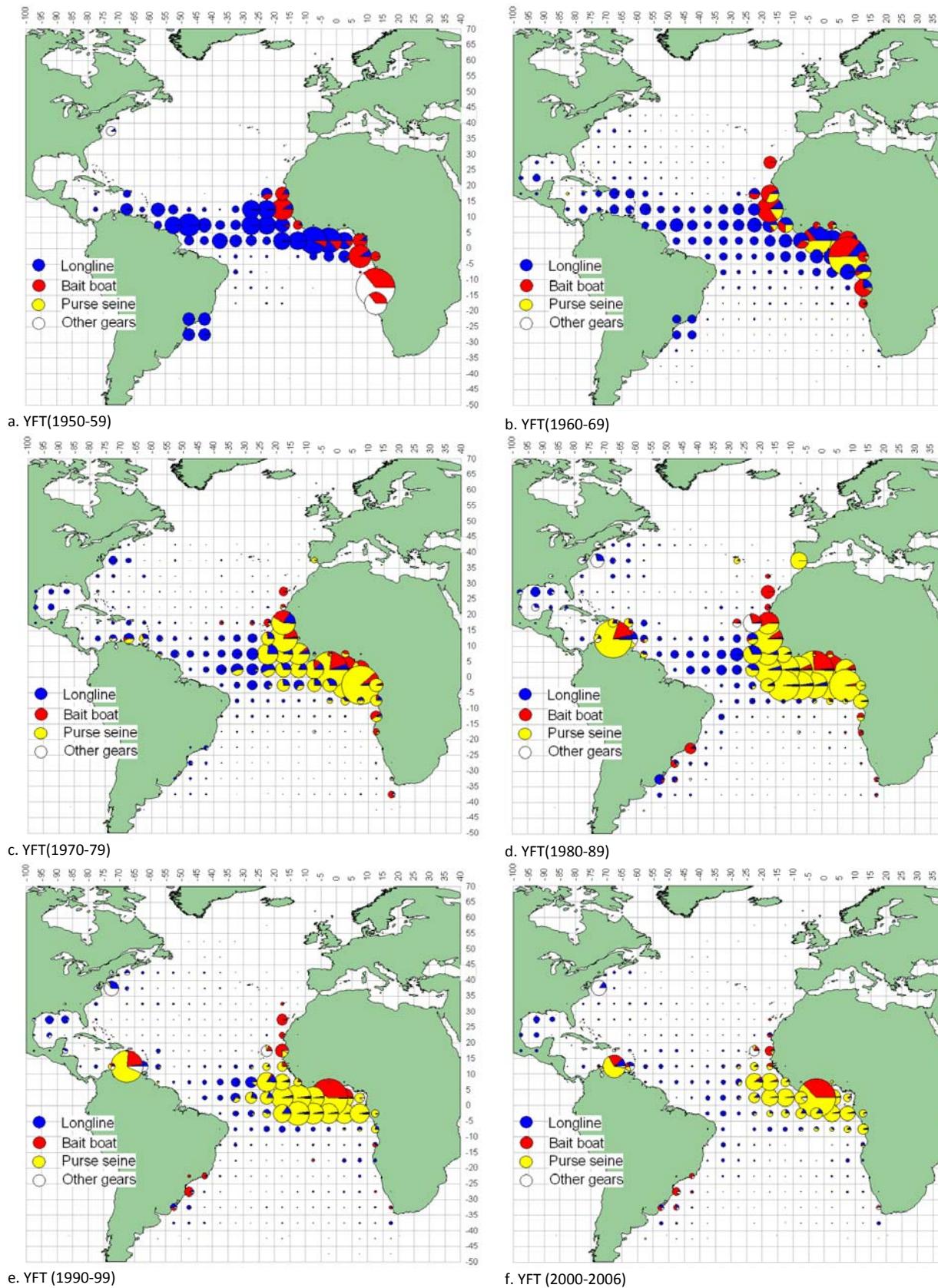
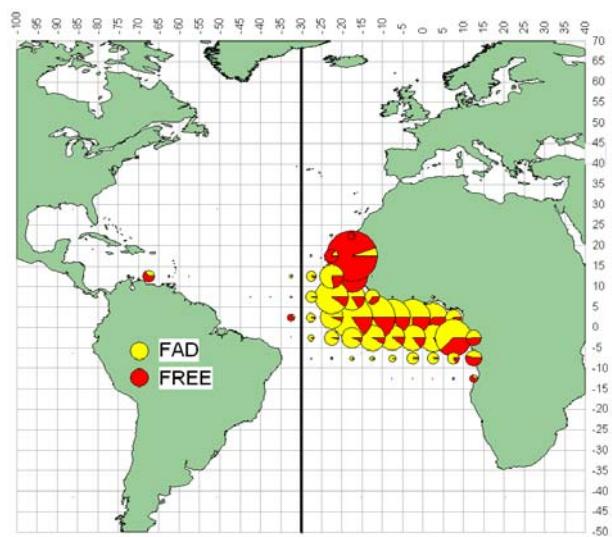
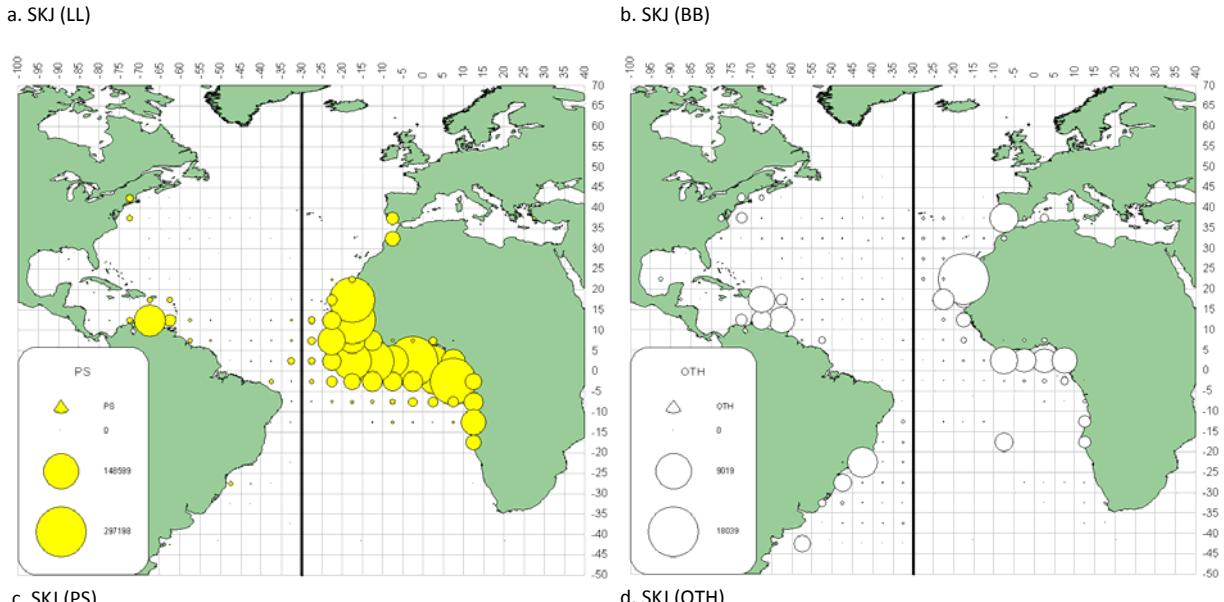
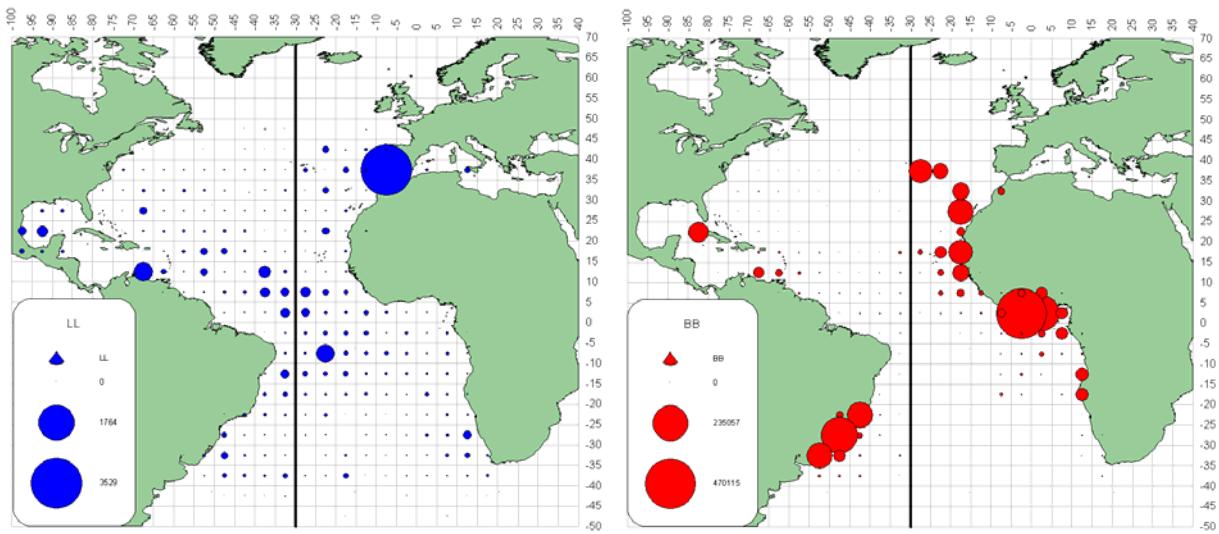


Figure 1. Geographic distribution of yellowfin catch by gear and decade.



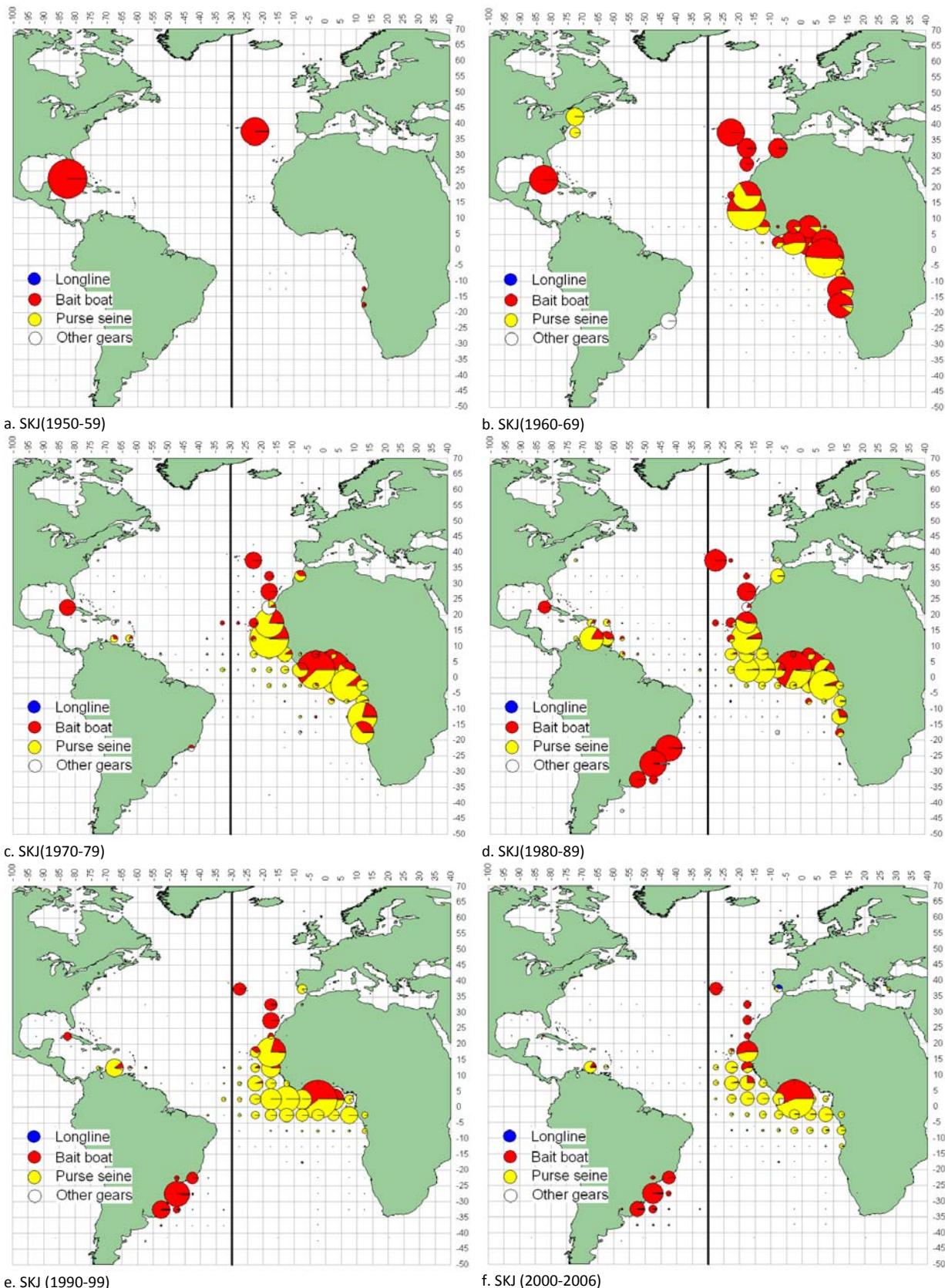


Figure 2. Geographic distribution of skipjack catch by gear and decade.

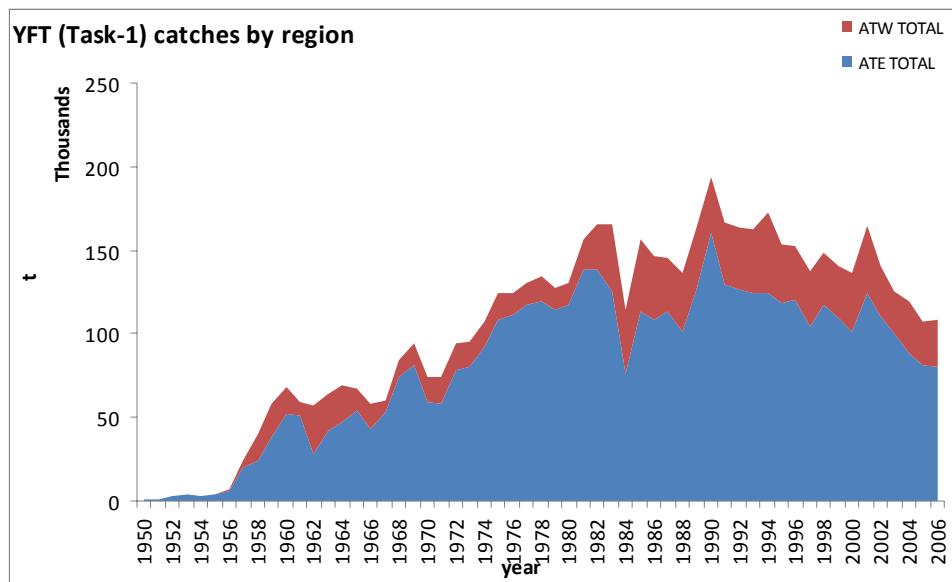


Figure 3. Atlantic yellowfin tuna catch by area.

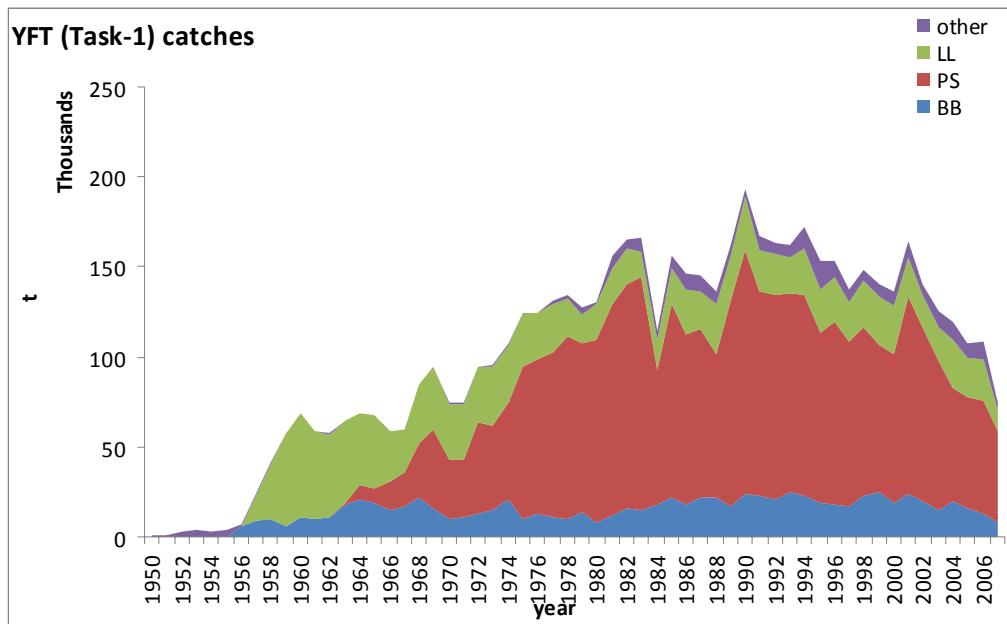


Figure 4. Atlantic yellowfin tuna catch by gear.

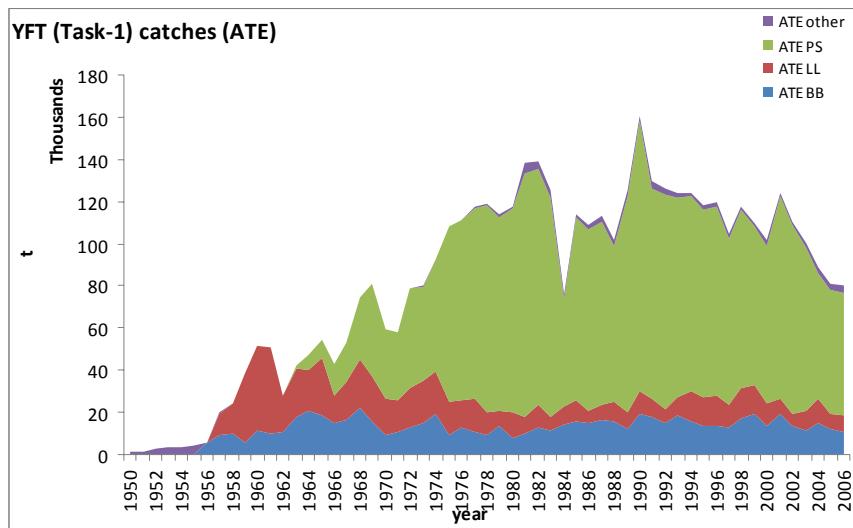


Figure 5. Yellowfin catch by gear – east.

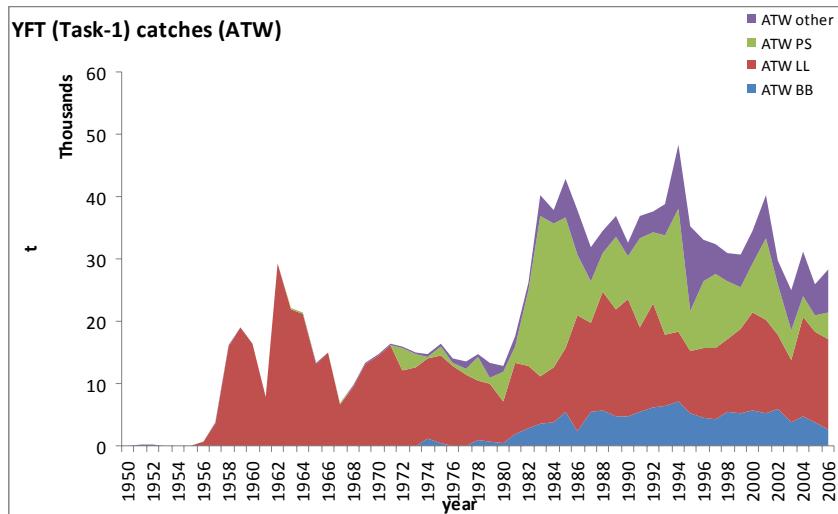


Figure 6. Yellowfin catch by gear – west.

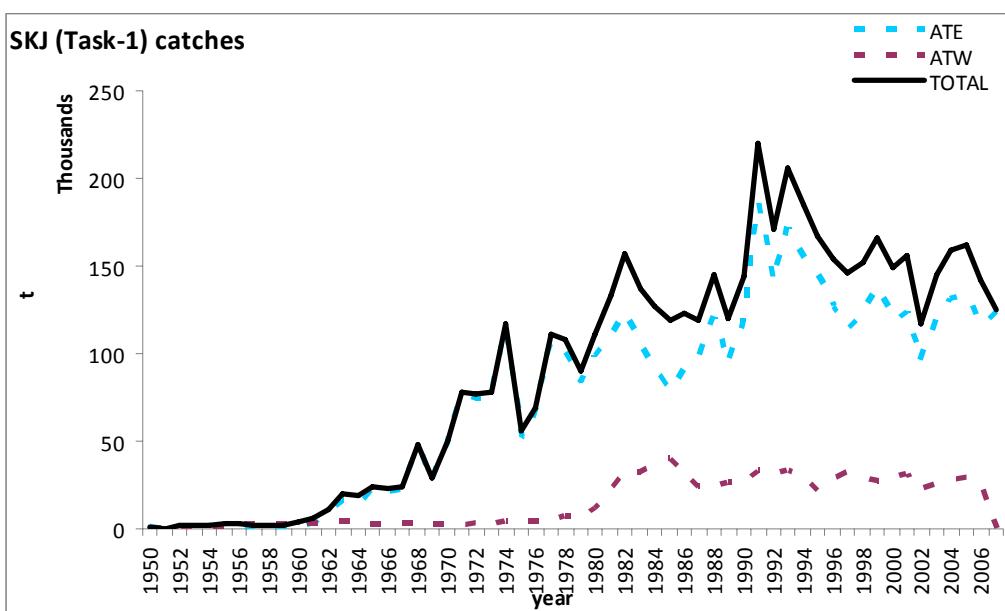


Figure 7. Atlantic skipjack catch by area.

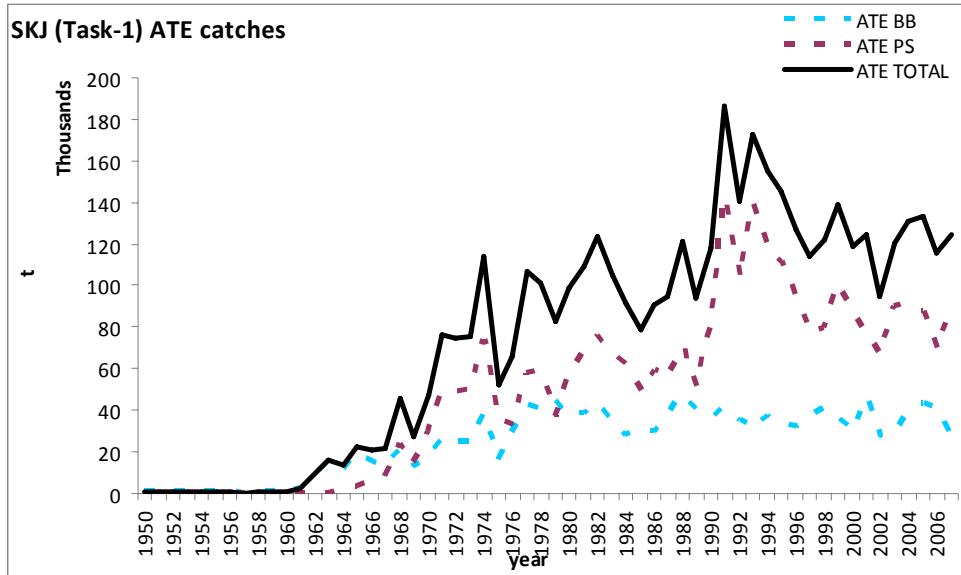


Figure 8. Skipjack catch by gear in the eastern Atlantic.

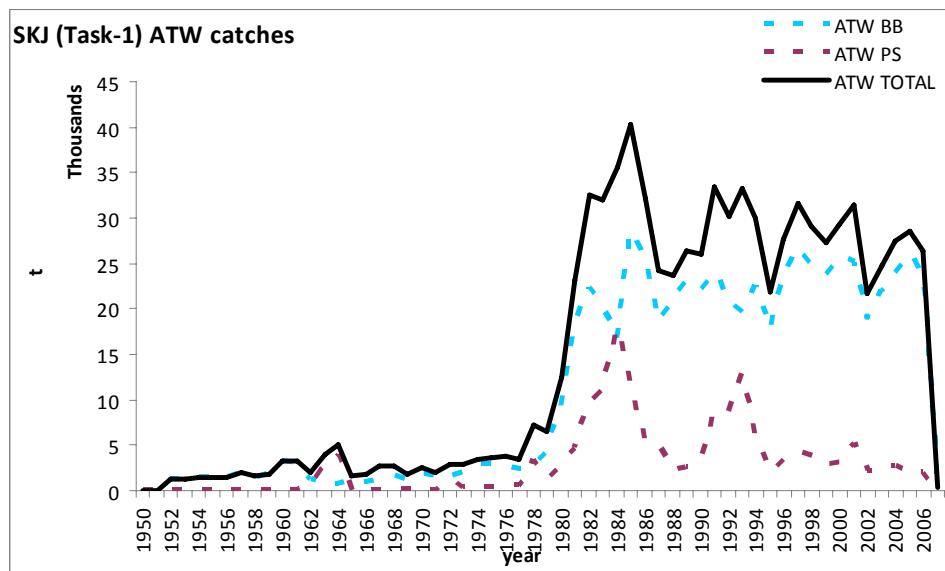


Figure 9. Skipjack catch by gear in the western Atlantic.

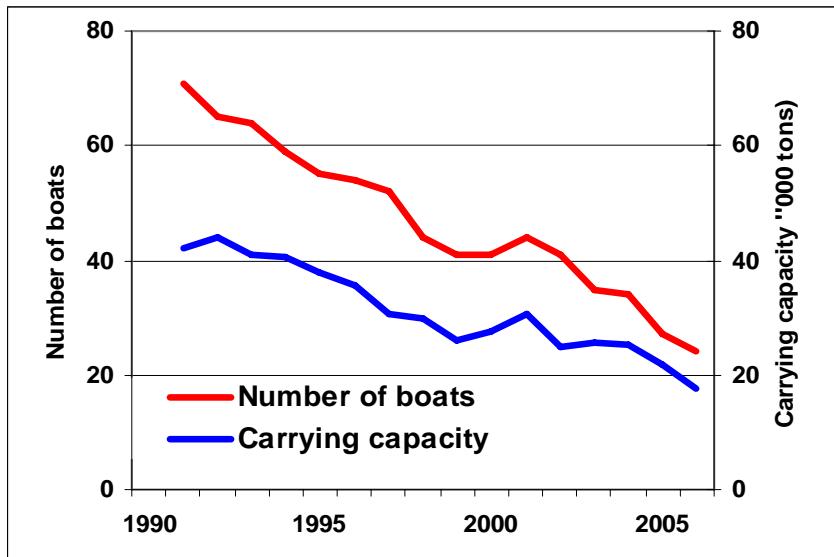


Figure 10. Change over time of the carrying capacity of the European and associated purse seine fleet.

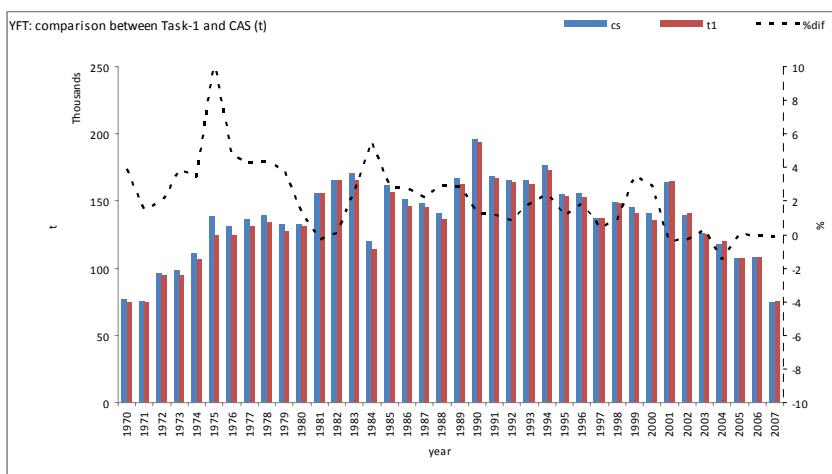


Figure 11. Comparison of Task II catch at size and Task I (t) for Atlantic yellowfin.

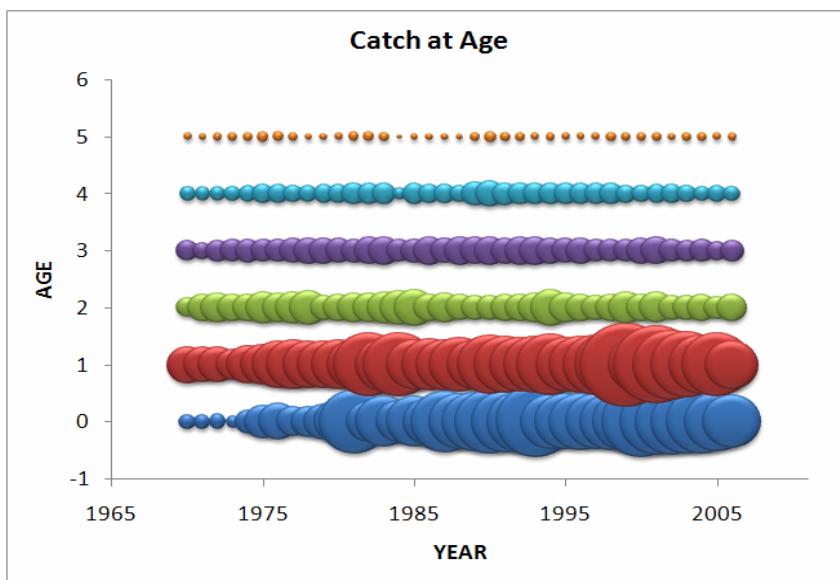


Figure 12. Relative distribution of Atlantic yellowfin catches by age (0-5+) and year (bubble size is proportional to total catches).

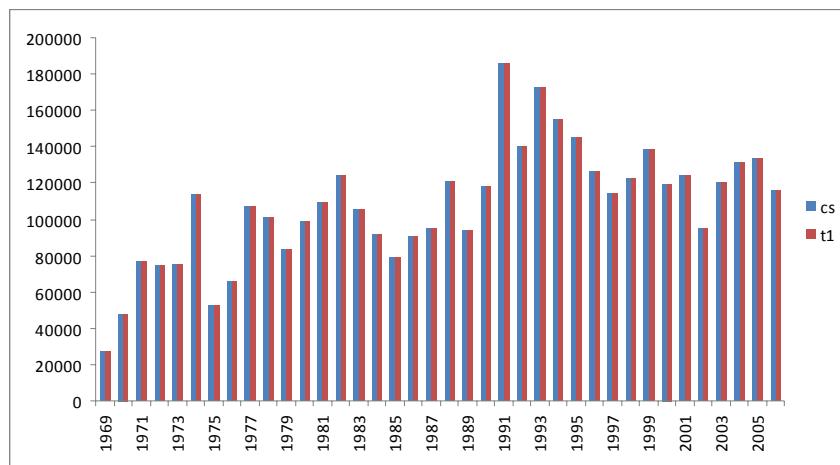


Figure 13. Comparison of Task II catch at size and Task I (t.) for skipjack.

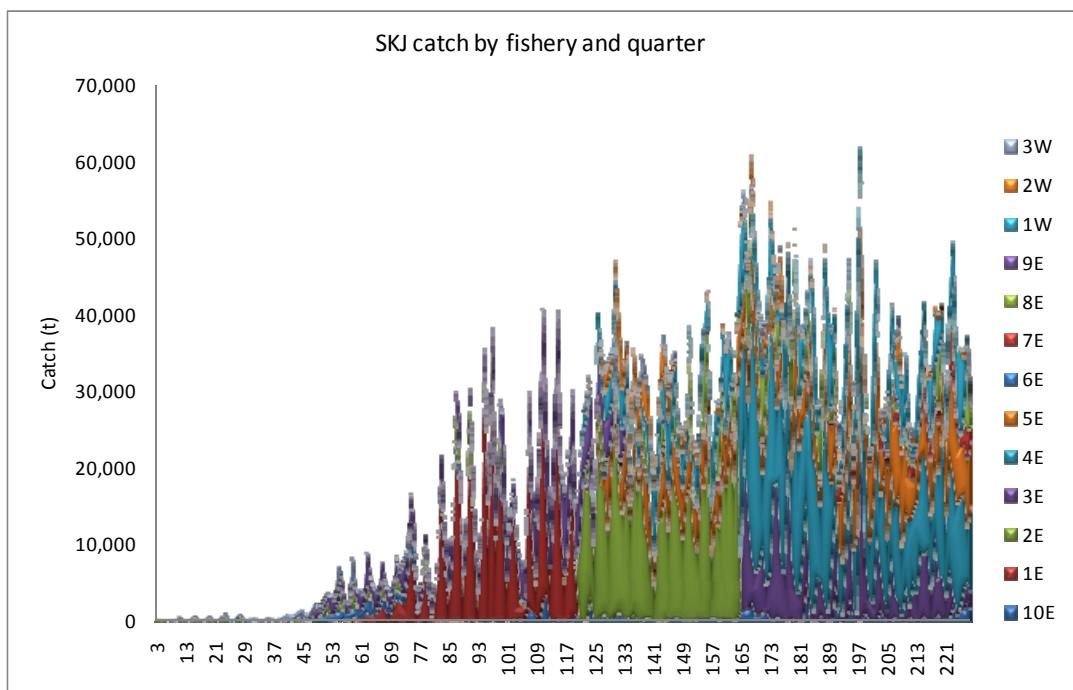


Figure 14. Skipjack quarterly catch by cumulative quarter starting in 1956 through 2006, by MFCL fishery definitions (Table 11).

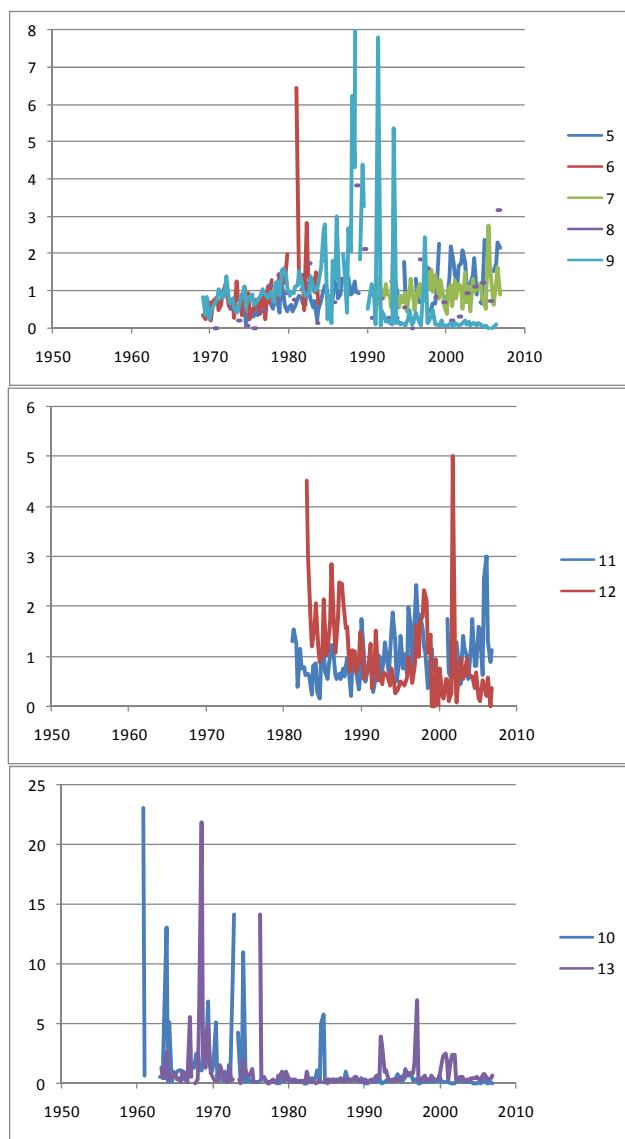


Figure 15. Quarterly catch rate patterns by fishery prepared for skipjack (**Table 11**).

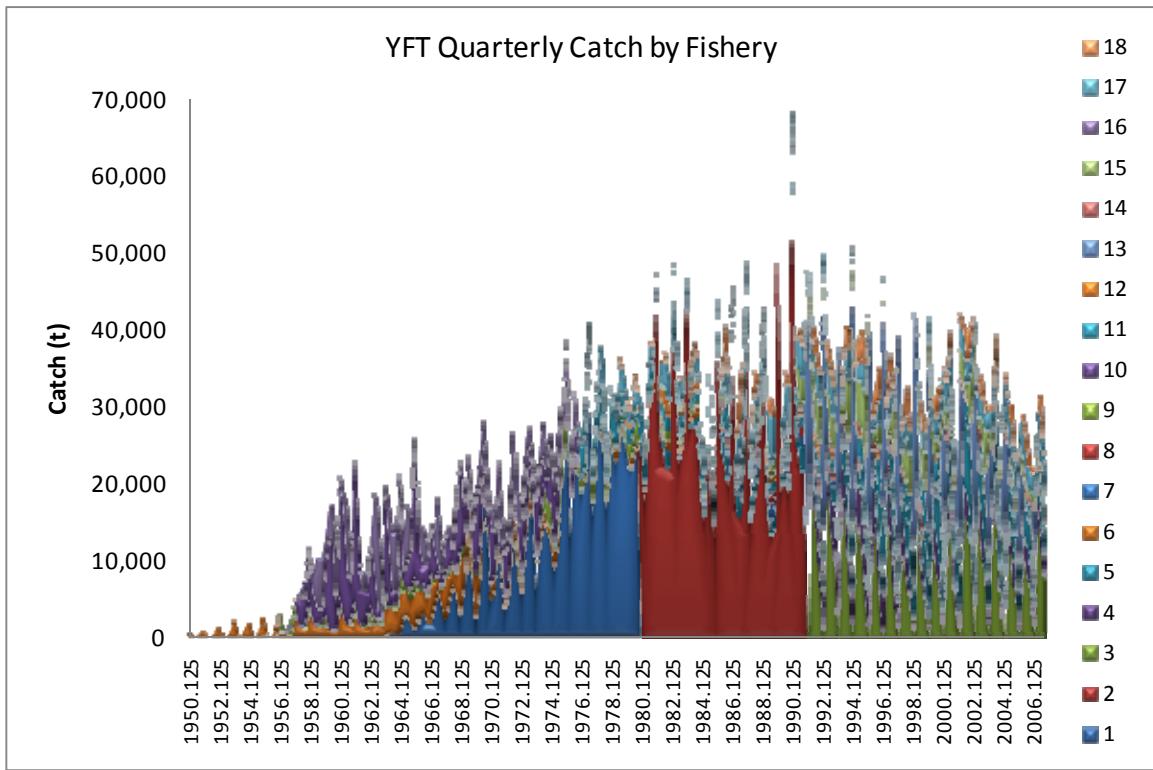


Figure 16. Yellowfin quarterly catch by cumulative quarter starting in 1956 through 2006, by MFCL fishery definitions (**Table 12**).

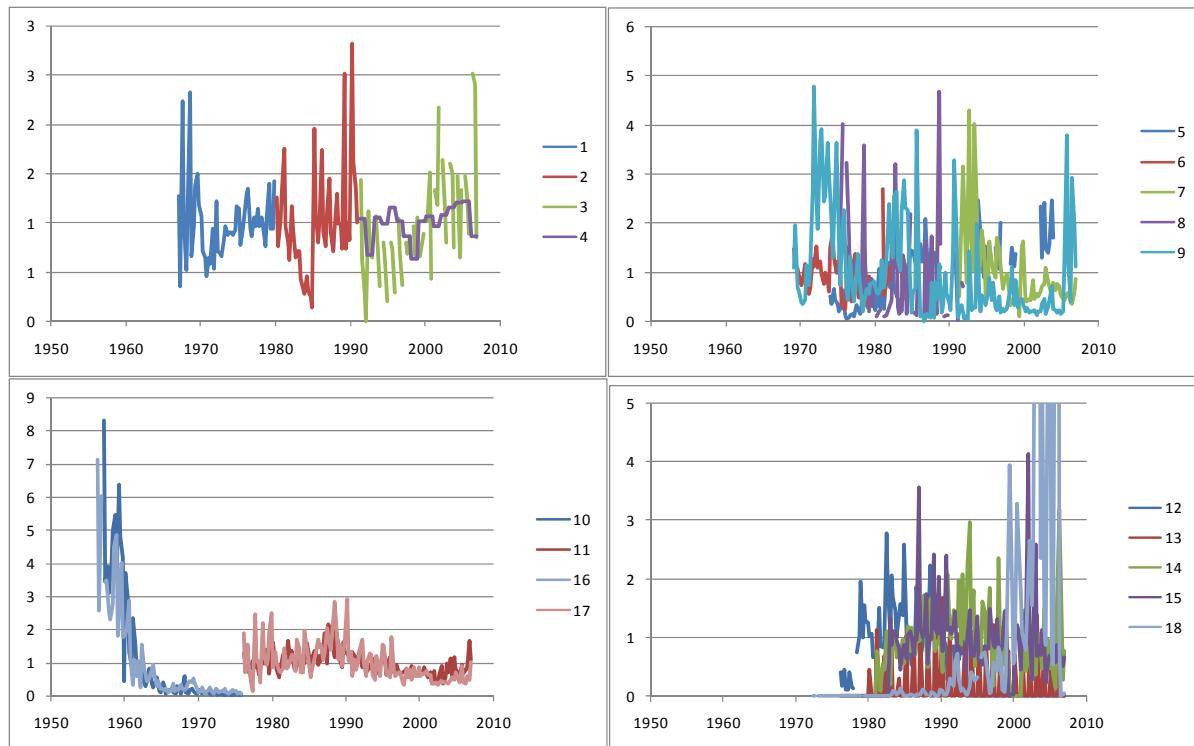


Figure 17. Quarterly catch rate patterns by fishery prepared for yellowfin (**Table 12**).

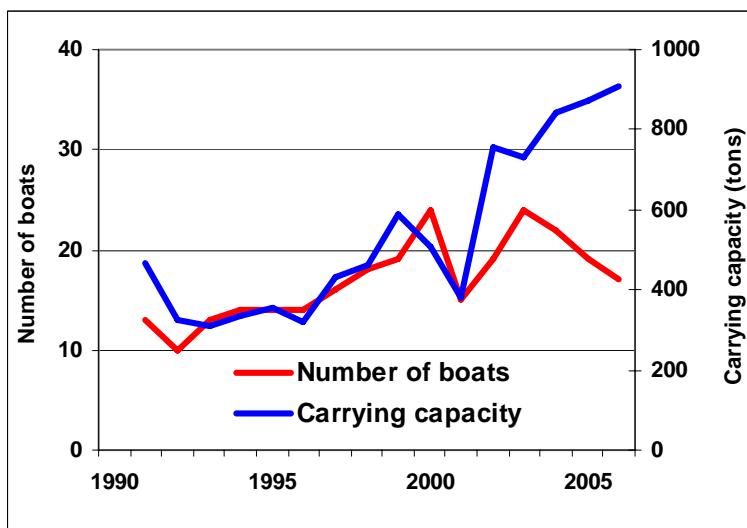


Figure 18. Change over time of the carrying capacity of the Dakar based baitboats.

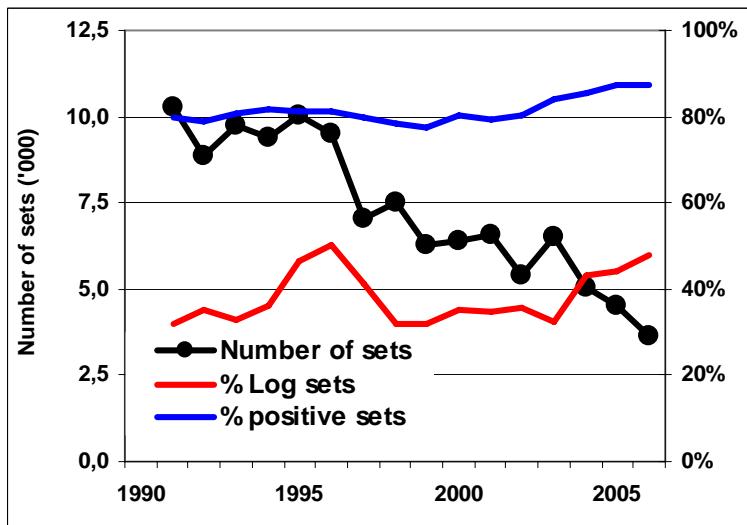


Figure 19. Proportion of FADs sets, % of successful sets and total number of sets for the EC-purse seiners in the eastern Atlantic.

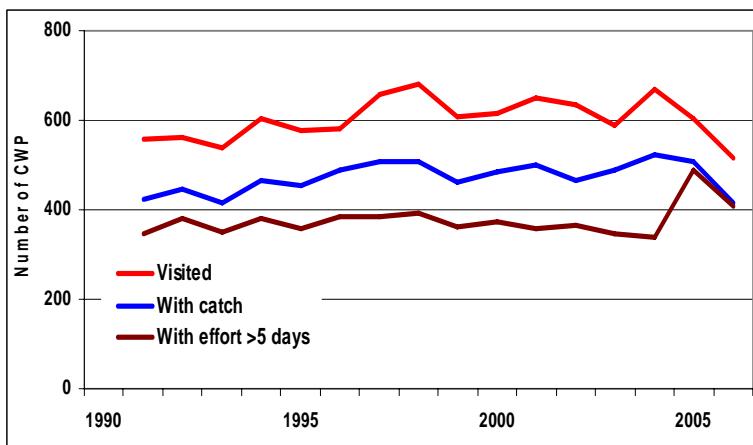


Figure 20. Change over time of the total area visited and fished by the EC purse seiners.

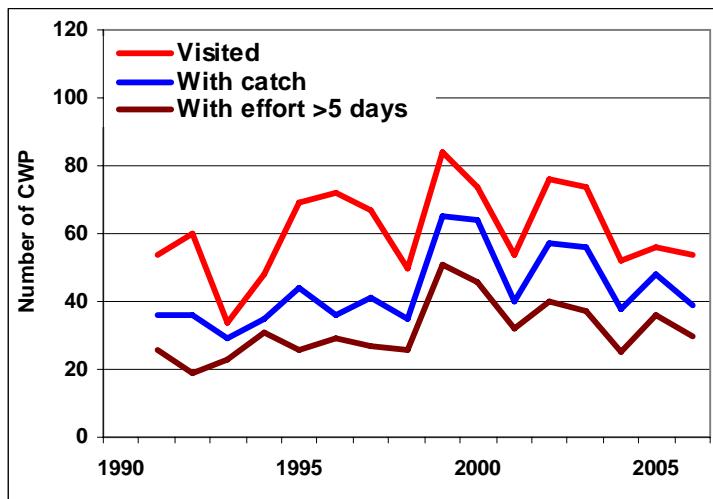


Figure 21. Change over time of the total area visited and fished by the Dakar based baitboats.

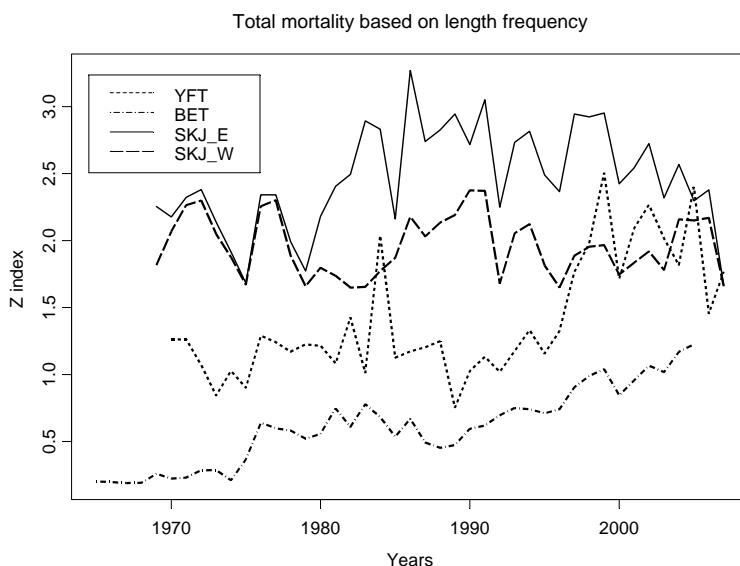


Figure 22. Changes over the years in the apparent total mortality Z , based on Beverton and Holt's equation, for the three tropical tuna species in the Atlantic Ocean. YFT = yellowfin, BET = bigeye, SKJ = skipjack (eastern and western stock). The size of full recruitment was fixed at 50 cm (FL).

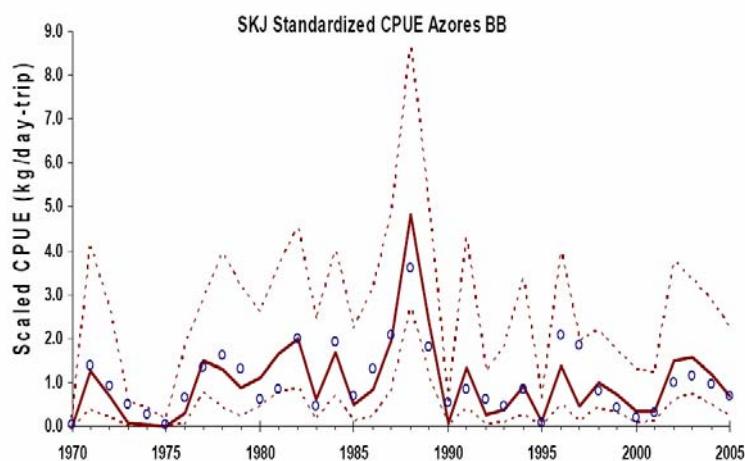


Figure 23. Standardized CPUE for skipjack for the Azorean baitboat fishery. The index was obtained by fitting a delta-lognormal GLM to daily catch records. Open symbols: observed CPUE. Lines: predicted CPUE and approximate 95% confidence intervals.

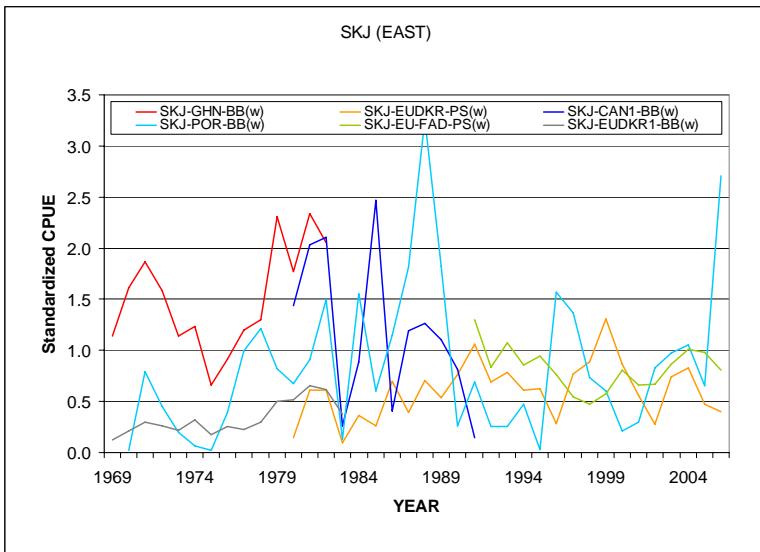


Figure 24. Standardized CPUEs for the east Atlantic stock (1969-2006).

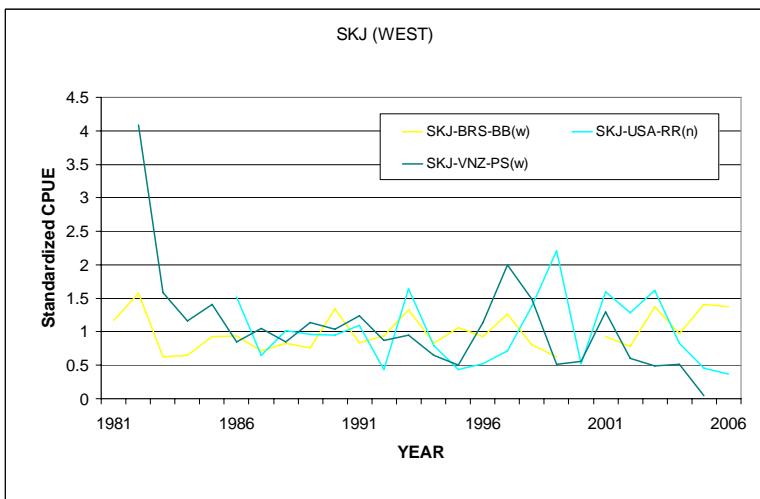


Figure 25. Standardized CPUEs for the western Atlantic stock (1981-2006). Letters w and n indicate estimations gathered in analysis of catch in weight and number, respectively.

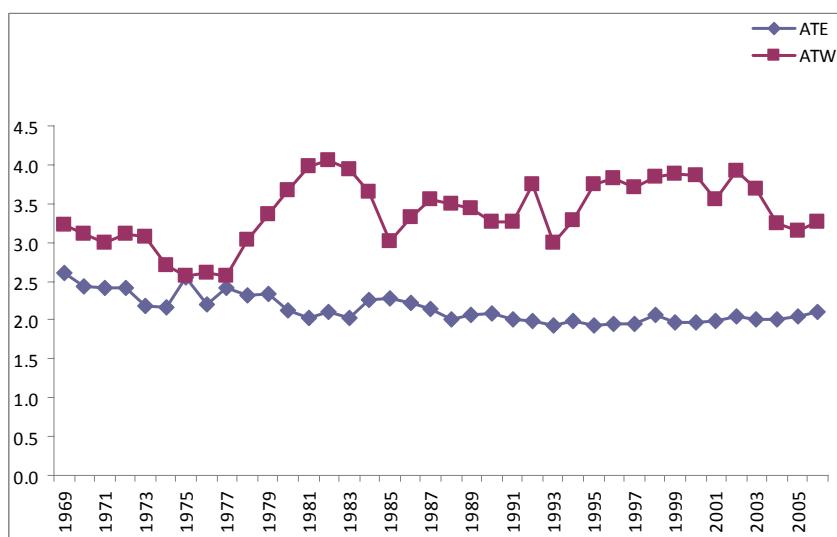


Figure 26. Average weight of skipjack landed in the East and West Atlantic Ocean.

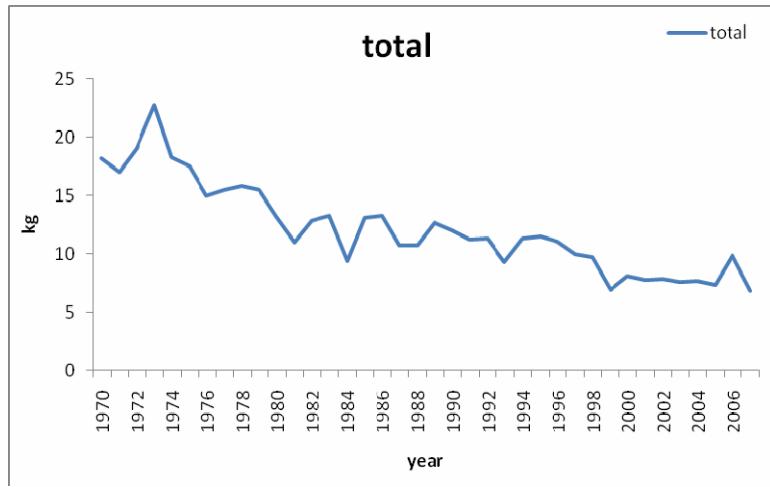


Figure 27. Average weight of yellowfin landed in the Atlantic Ocean.

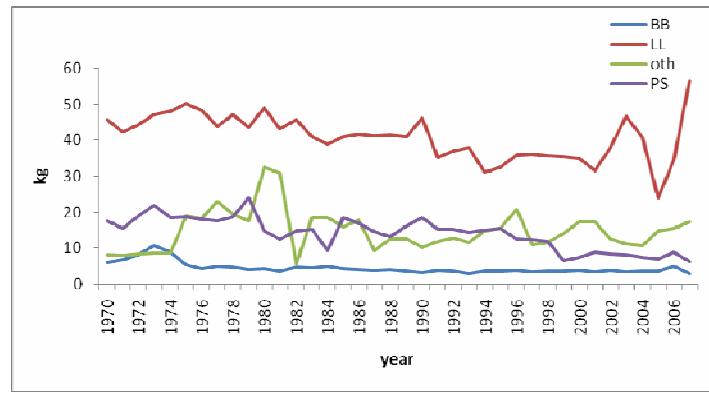


Figure 28. Average weight of yellowfin landed by fishing fleet.

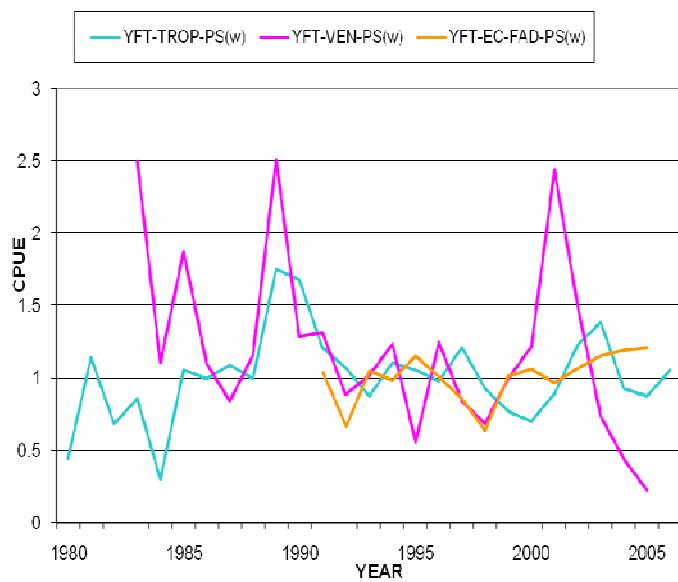


Figure 29. Standardized CPUE for yellowfin tuna caught by purse seine fleets.

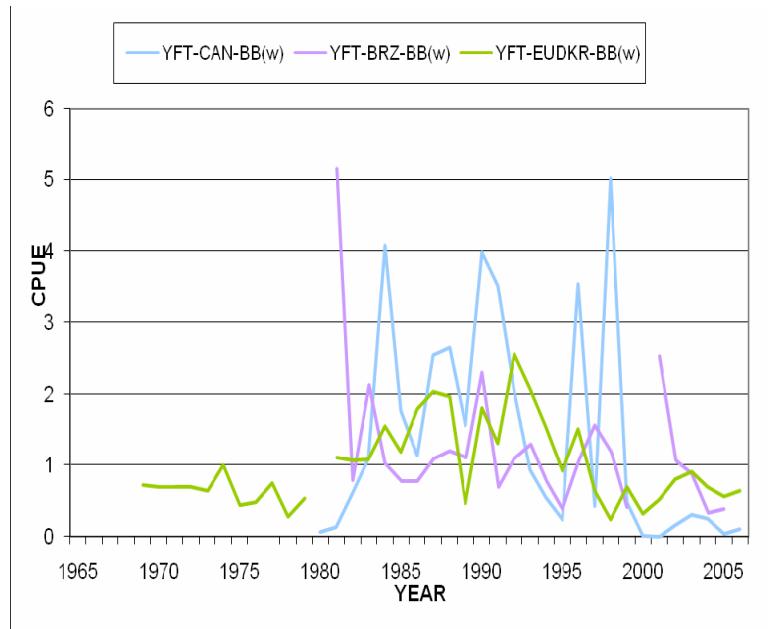


Figure 30. Nominal CPUE for yellowfin tuna caught by baitboat fleets.

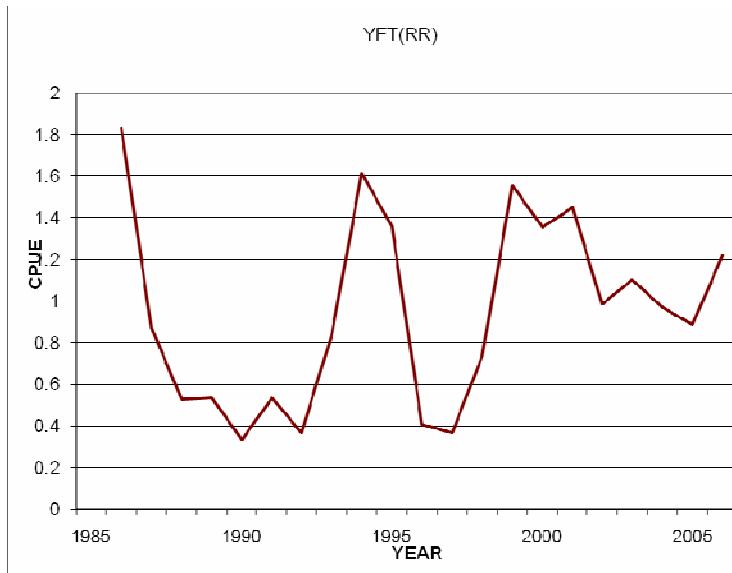


Figure 31. Standardized CPUE for yellowfin tuna caught by the U.S. rod and reel fleet.

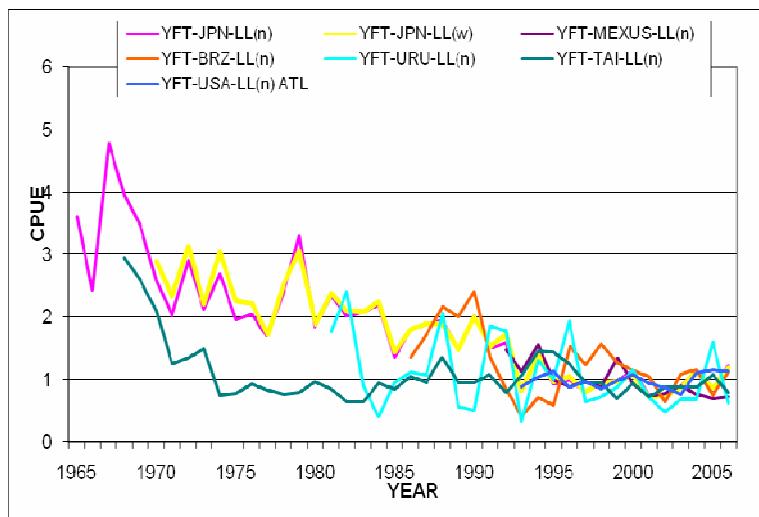


Figure 32. Standardized CPUE for yellowfin tuna caught by longline fleets.

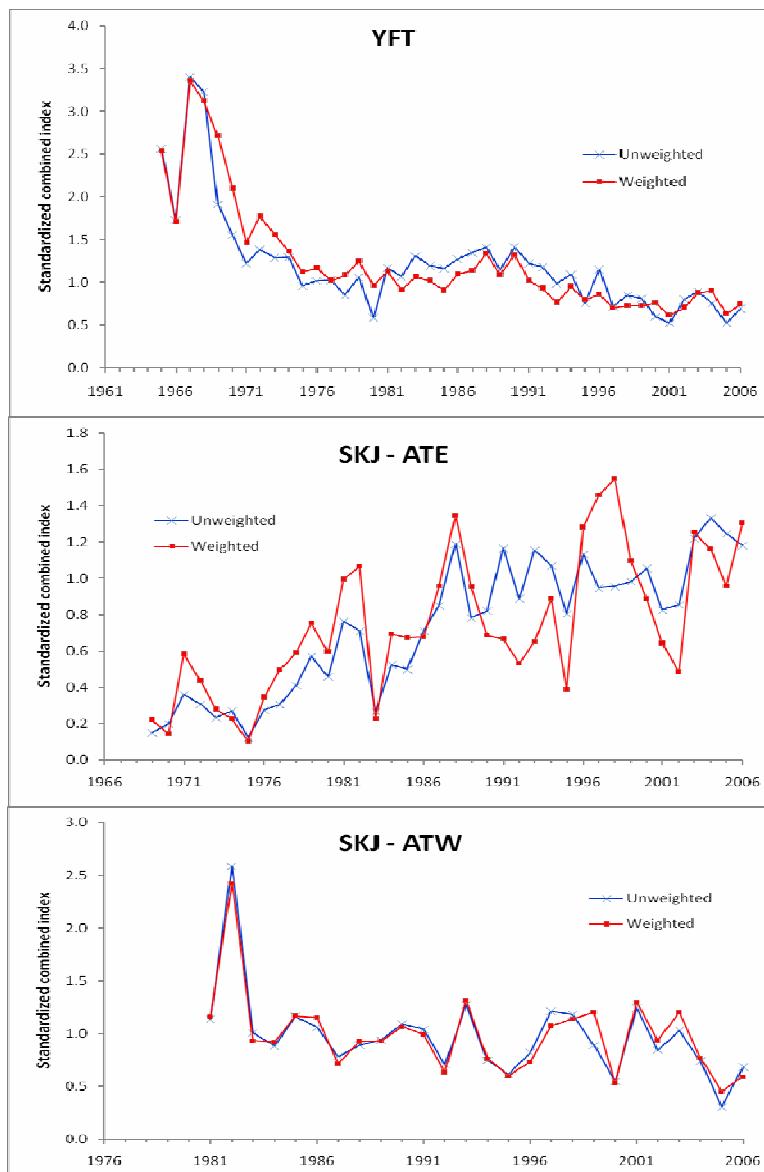


Figure 33. Estimated combined weighted and unweighted indexes of abundances for yellowfin and the two skipjack stocks.

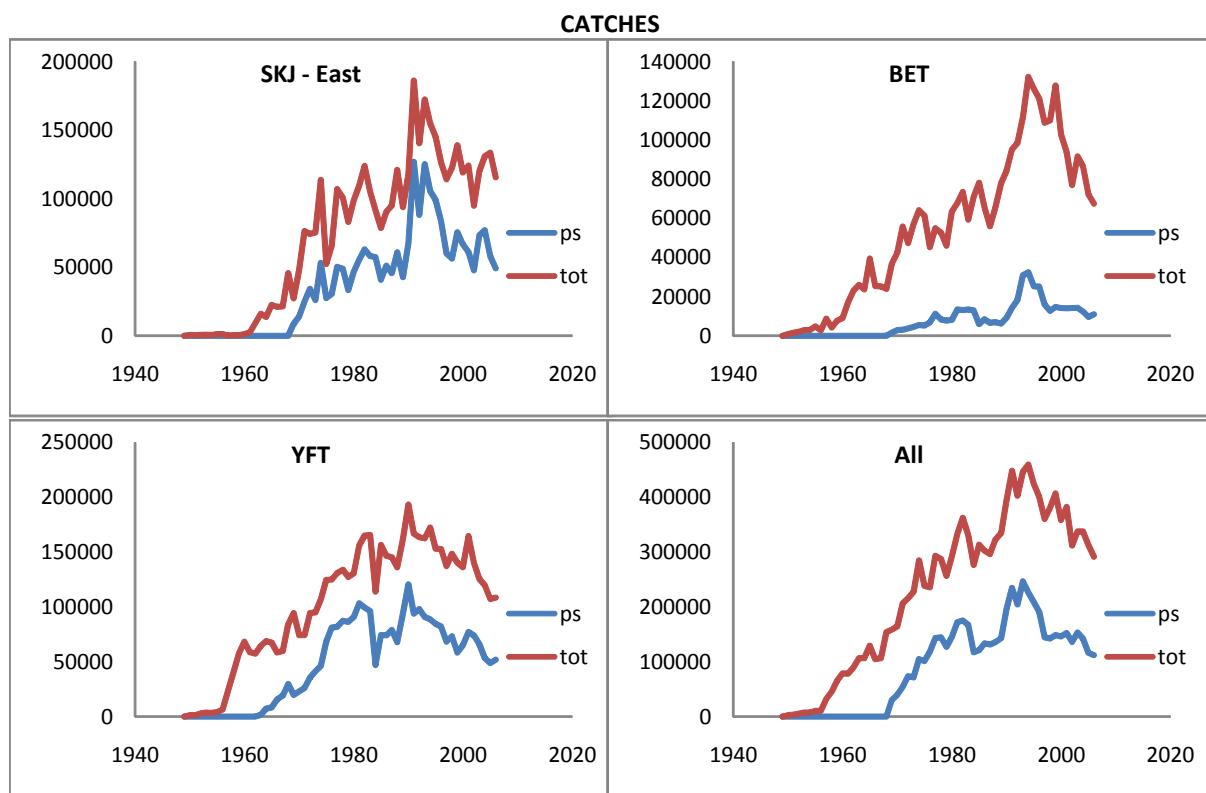


Figure 34. Input catch series used in the analyses of catchability trends.

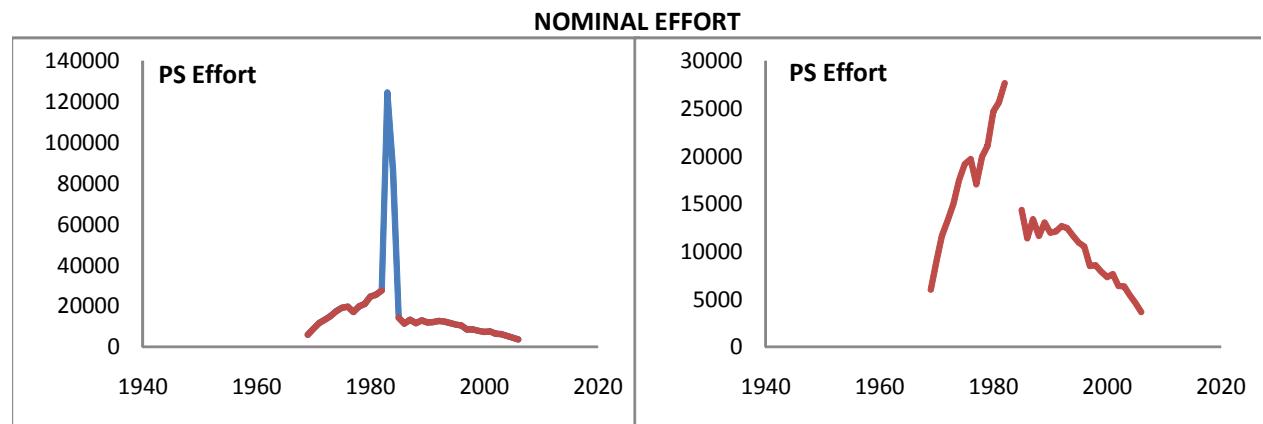


Figure 35. Input nominal effort series used in the analysis of catchability trends. The figure on the right excludes the 1983 and 1984 data points.

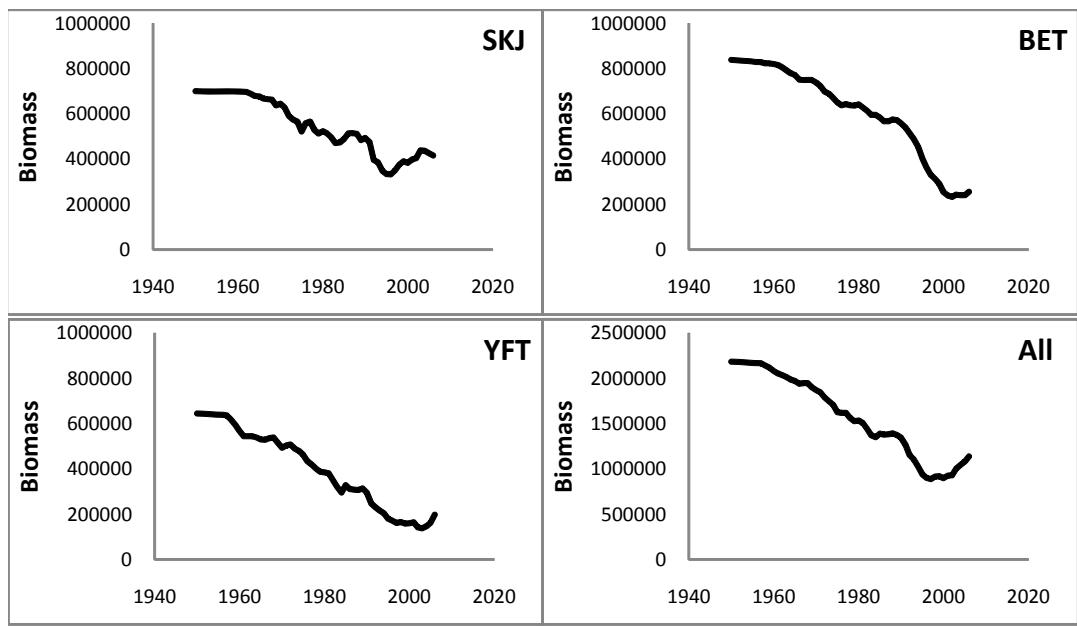


Figure 36. Biomass trajectories that result from the catchability trend analyses.

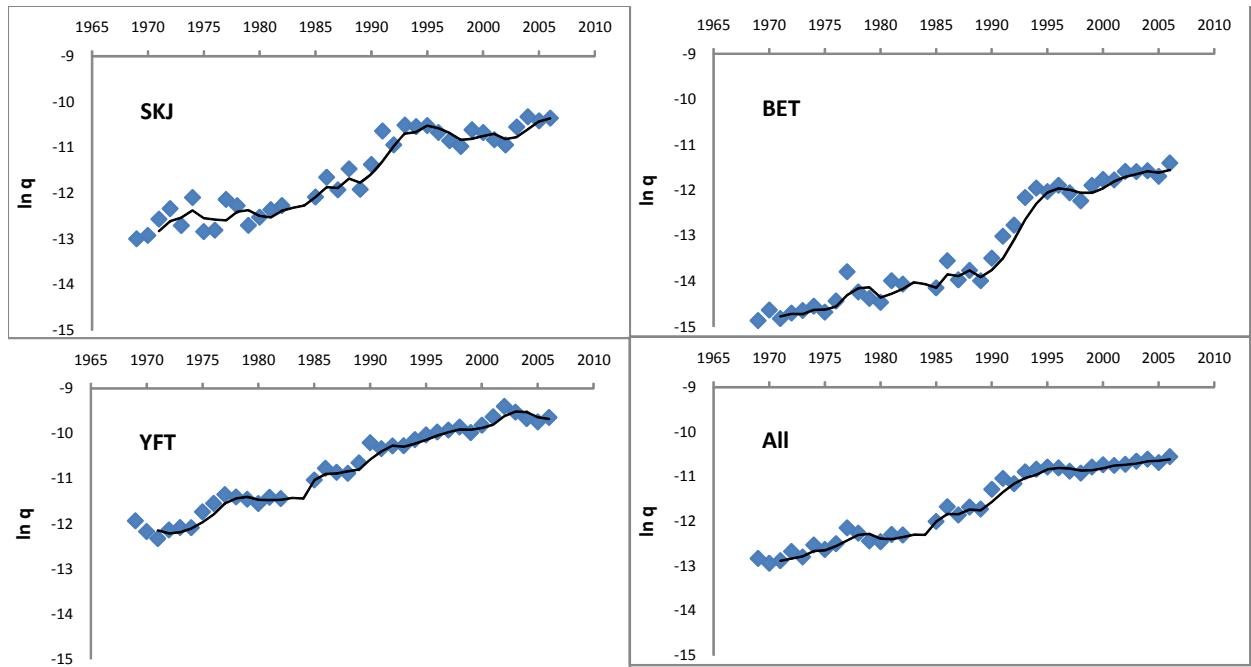


Figure 37. Trends in estimated catchability (in logarithmic units) for the three stocks individually and combined. The solid line is a running average.

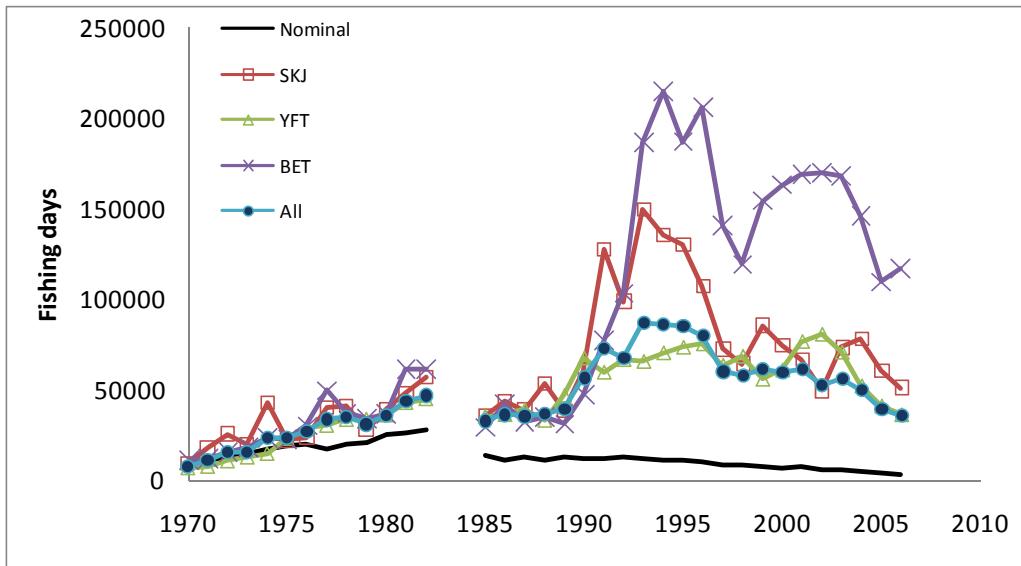


Figure 38. EC and associated purse seine fishing effort (fishing days). The solid black line is the nominal series. The lines with symbols represent fishing effort adjusted for potential catchability changes. All series are scaled so that they start at the same value in 1969.

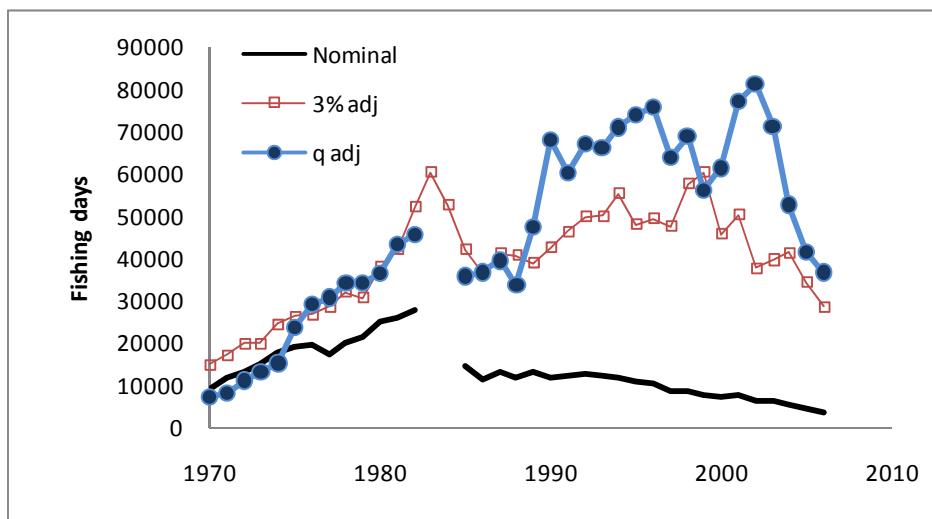


Figure 39. EC and associated purse seine fishing effort (fishing days). The solid black line is the nominal series. The lines with symbols represent fishing effort adjusted for potential catchability changes for yellowfin tuna: The red line with open squares assumes a 3% per year change in q starting in 1980; the blue line with solid circles is adjusted for catchability changes estimated in the present analysis.

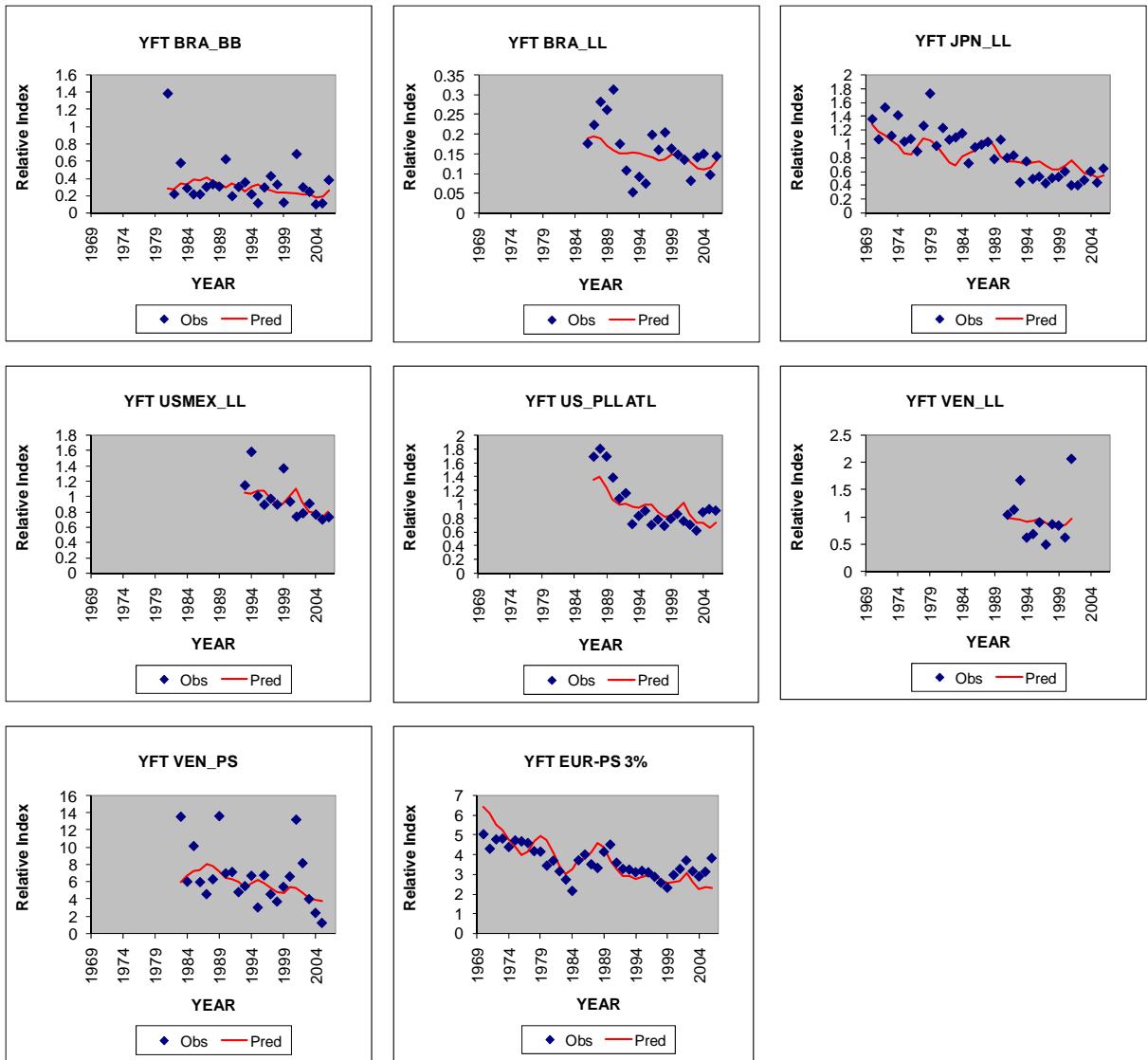


Figure 40. Fits to the CPUE indices for yellowfin VPA continuity model.

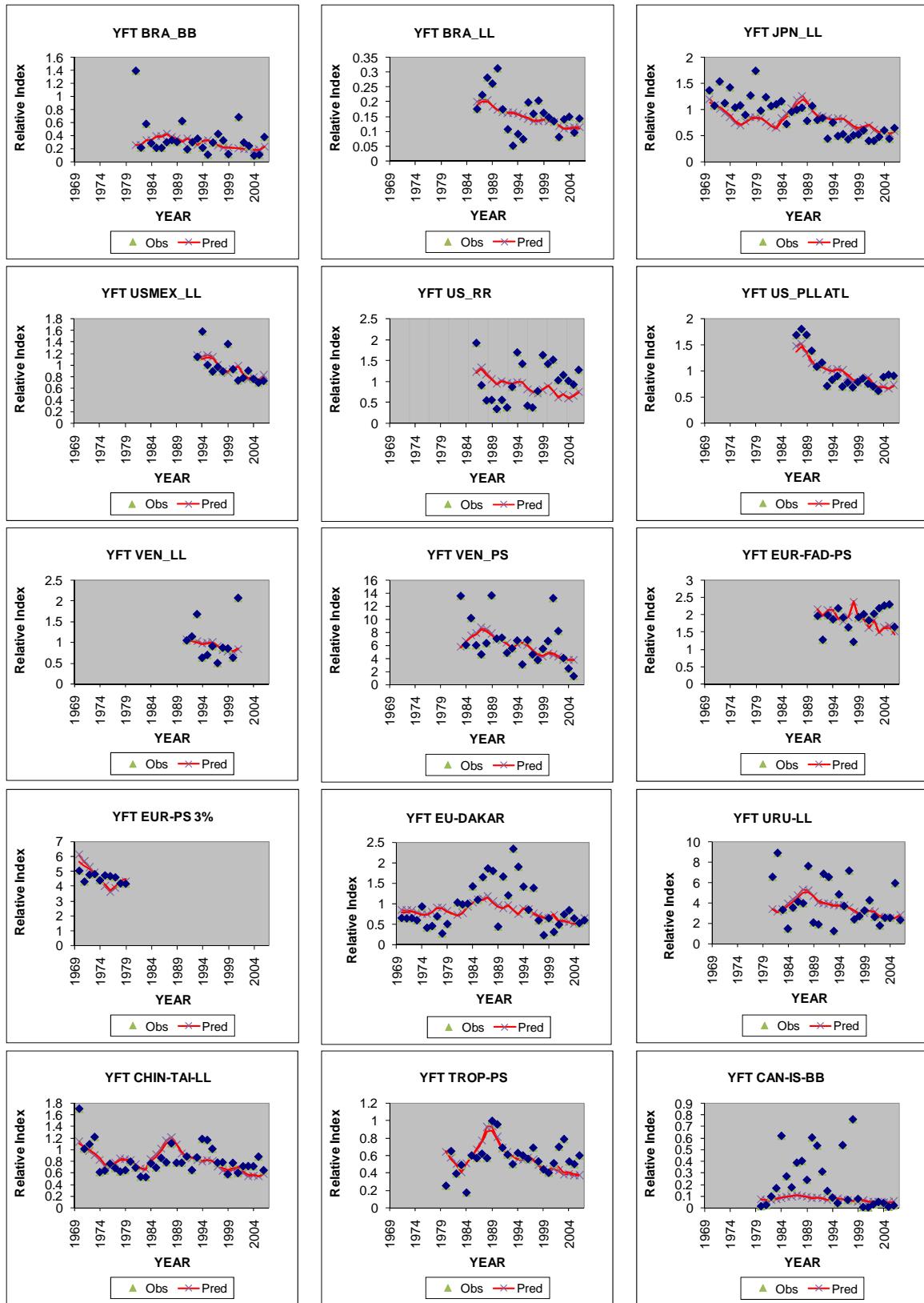
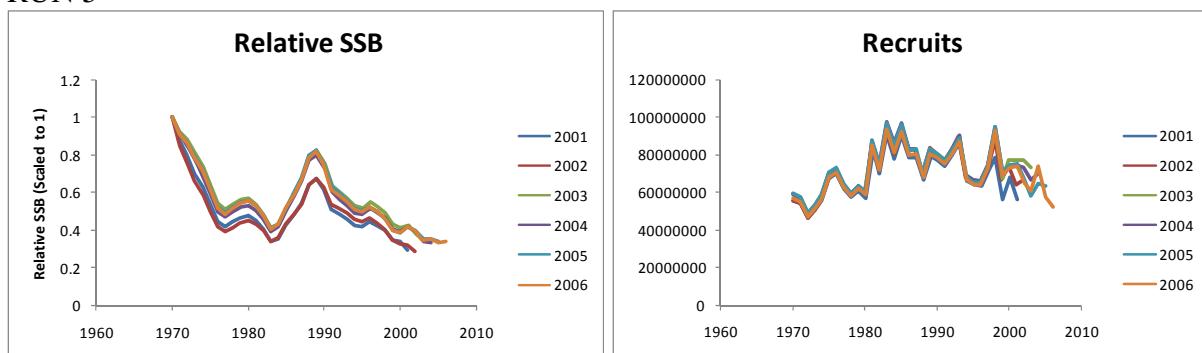


Figure 41. Fits to the CPUE indices for YFT VPA Runs 5 and 8. The blue diamonds are the observed values. The red line and the “X” symbol are the predicted values from Run 5 and Run 10, respectively.

RUN 5



RUN 10

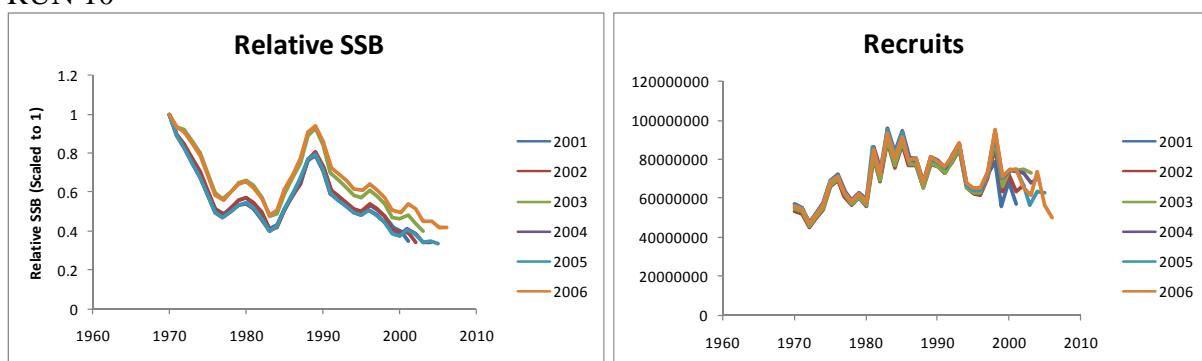


Figure 42. Retrospective trends of spawning biomass (mt) and recruits (numbers at Age 0) from the yellowfin VPA base cases. The legend indicates the terminal year of the analysis.

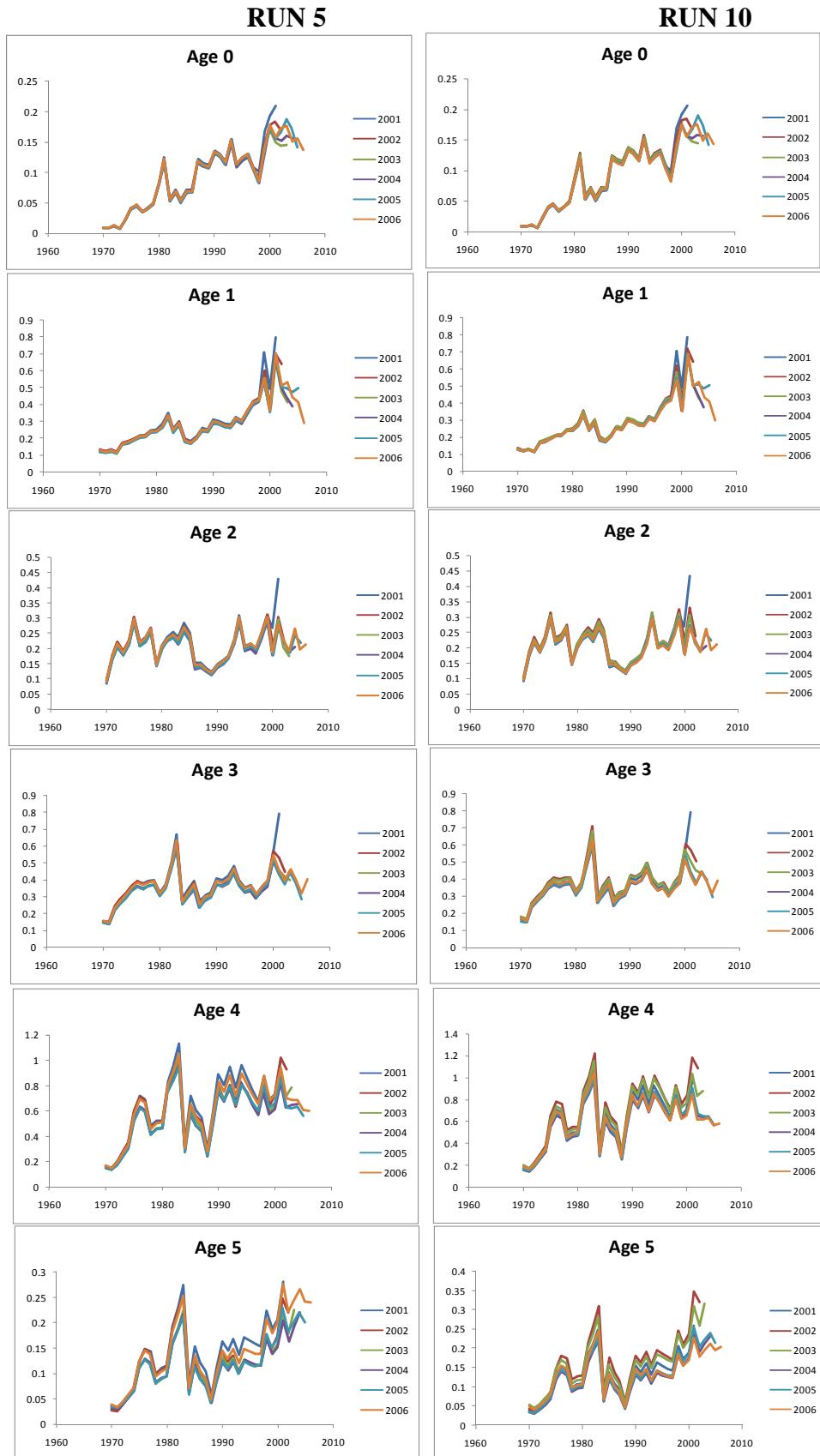
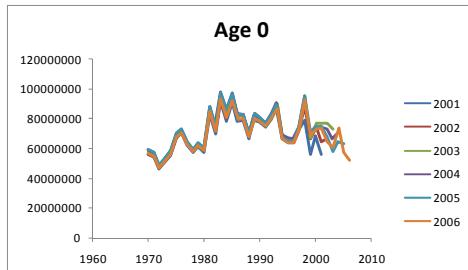
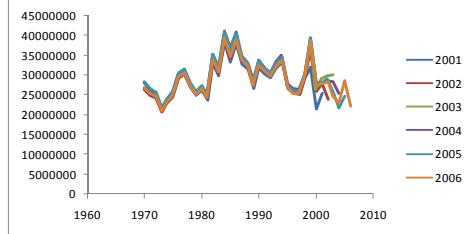


Figure 43. Retrospective patterns in fishing mortality at age (FAA) from the yellowfin base models. The legend indicates the terminal year of the analysis.

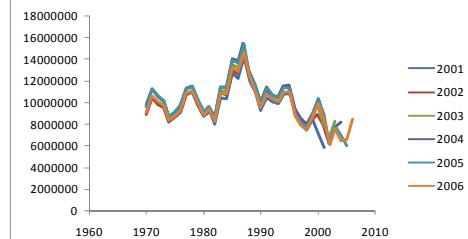
RUN 5



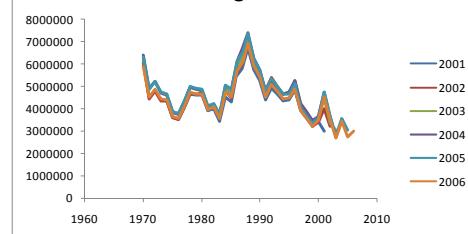
Age 1



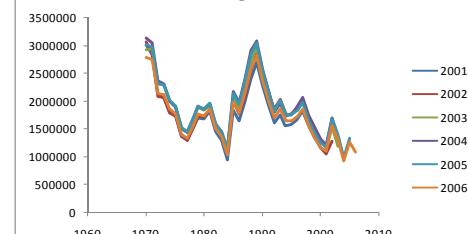
Age 2



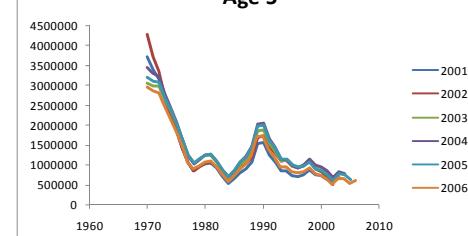
Age 3



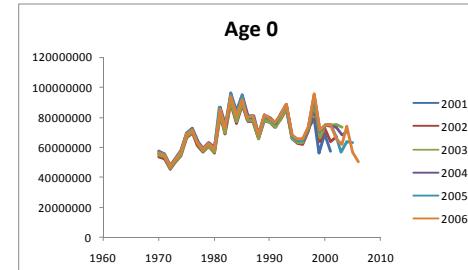
Age 4



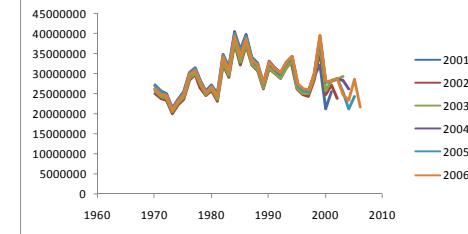
Age 5



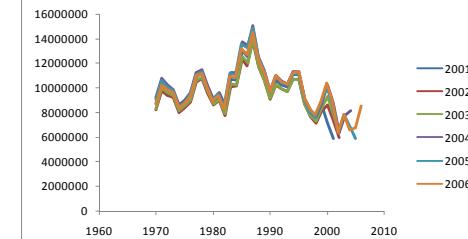
RUN 10



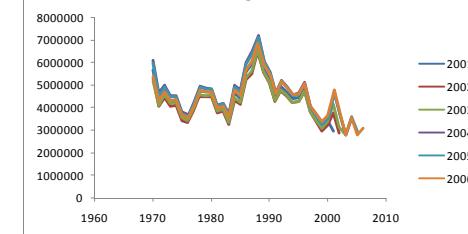
Age 1



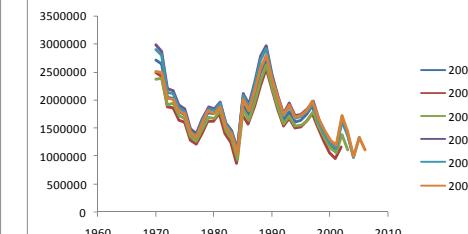
Age 2



Age 3



Age 4



Age 5

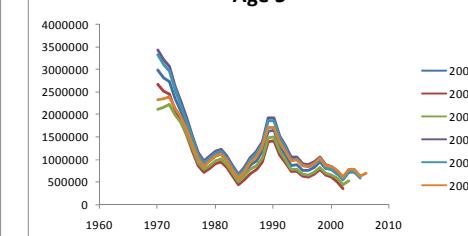


Figure 44. Retrospective patterns in numbers at age (NAA) from the yellowfin base models. The legend indicates the terminal year of the analysis.

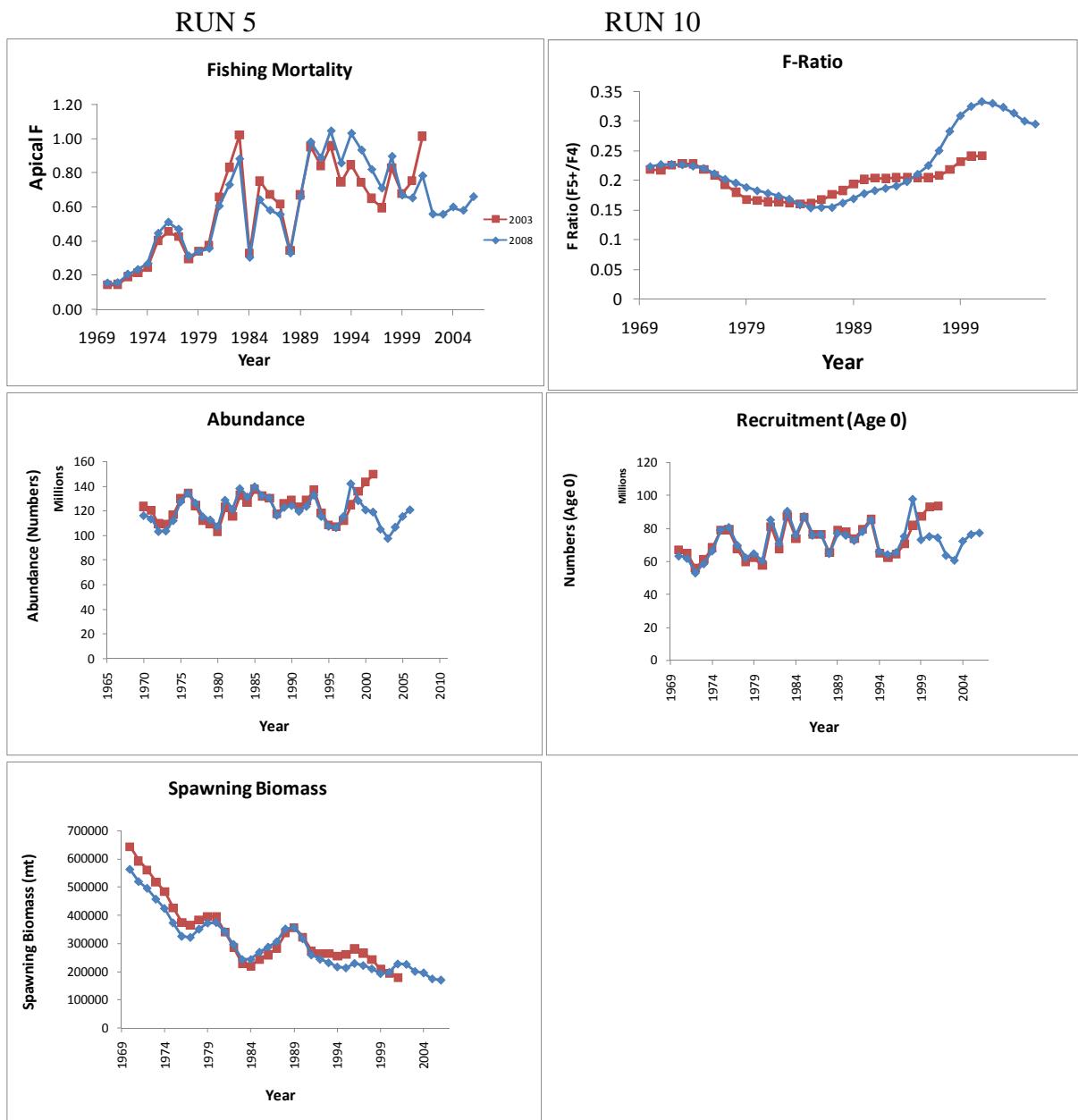


Figure 45. Annual estimates of average fishing mortality by age group, spawning stock biomass (SSB), recruitment and F-Ratio for the 2003 base (red line) and 2008 continuity (blue line) VPA runs.

RUN 5

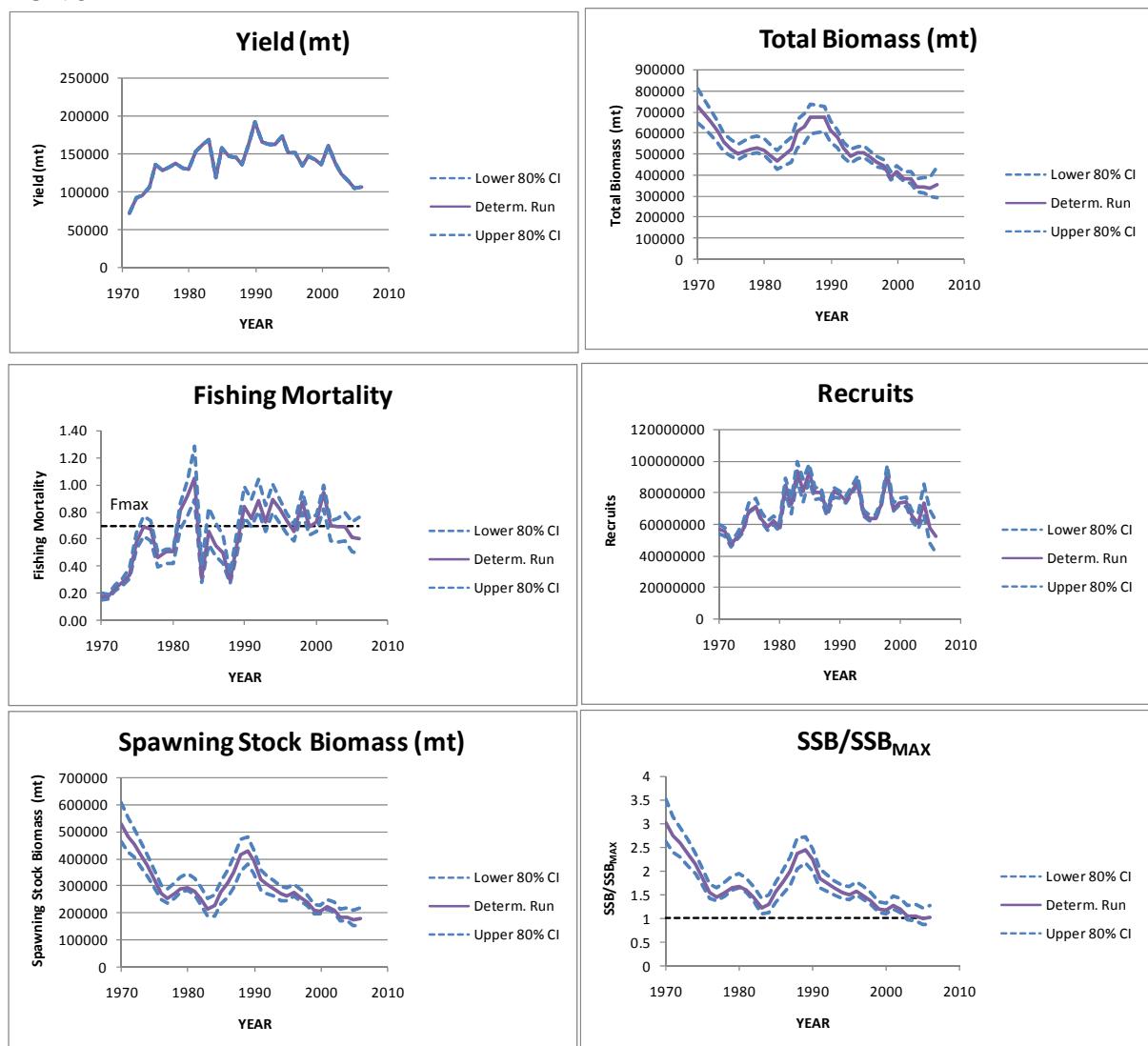


Figure 46. Run 5 - Annual estimates of yield, total biomass, apical fishing mortality, recruits (Age 0), spawning stock biomass (SSB) and SSB relative to SSB at F_{MAX} . The dashed lines are the 80% confidence intervals obtained from 500 bootstrap runs.

RUN 10

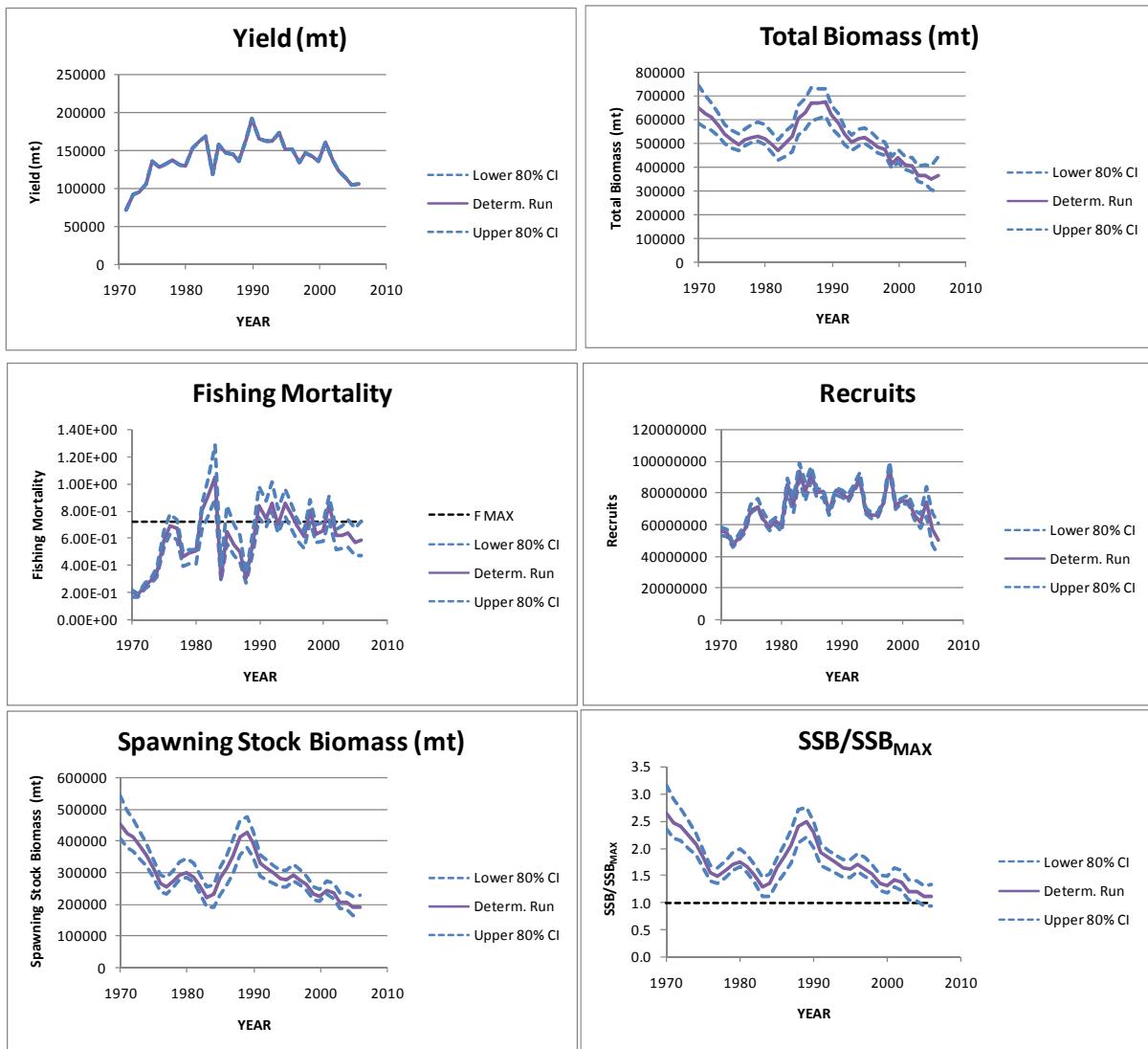


Figure 47. Run 10 - Annual estimates of yield, total biomass, apical fishing mortality, recruits (Age 0), spawning stock biomass (SSB) and SSB relative to SSB at F_{MAX} . The dashed lines are the 80% confidence intervals obtained from 500 bootstrap runs.

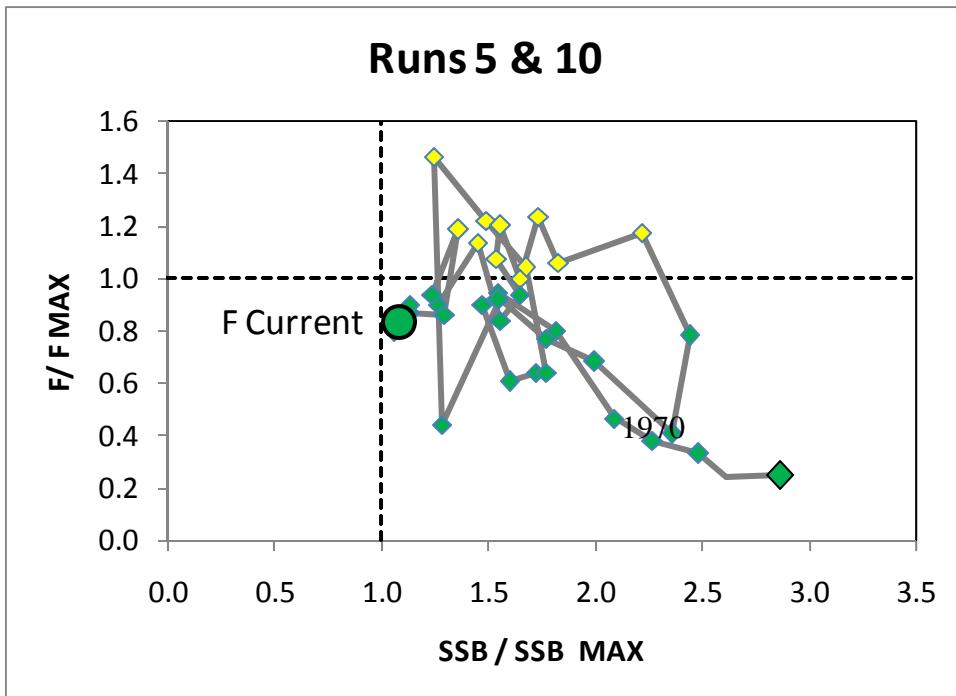


Figure 48. Trajectory of stock status from 1970 to 2006. Stock status in 2006 (large circle) was estimated using SSB_{2006}/SSB_{MAX} and $F_{Current}/F_{MAX}$. Yellow points indicate that overfishing was occurring. Green points indicate that the population is neither overfished nor undergoing overfishing.

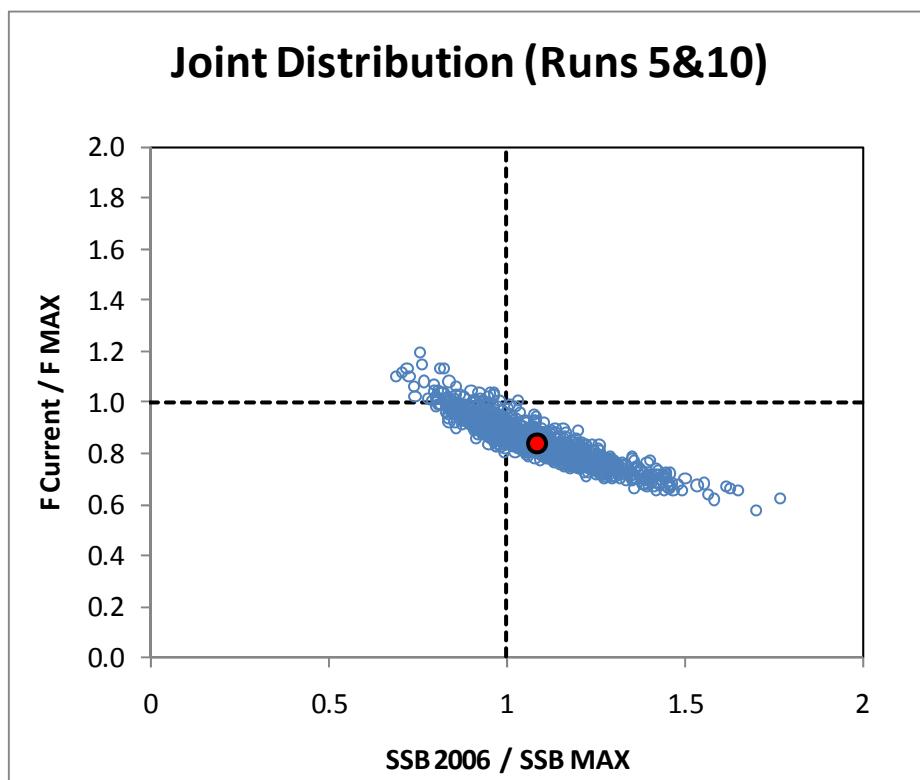


Figure 49. Phase plot showing the 2006 stock status (filled symbol) obtained using the median of the joint distribution of VPA models 5 and 10. The open circles show 500 bootstrap runs of each VPA model.

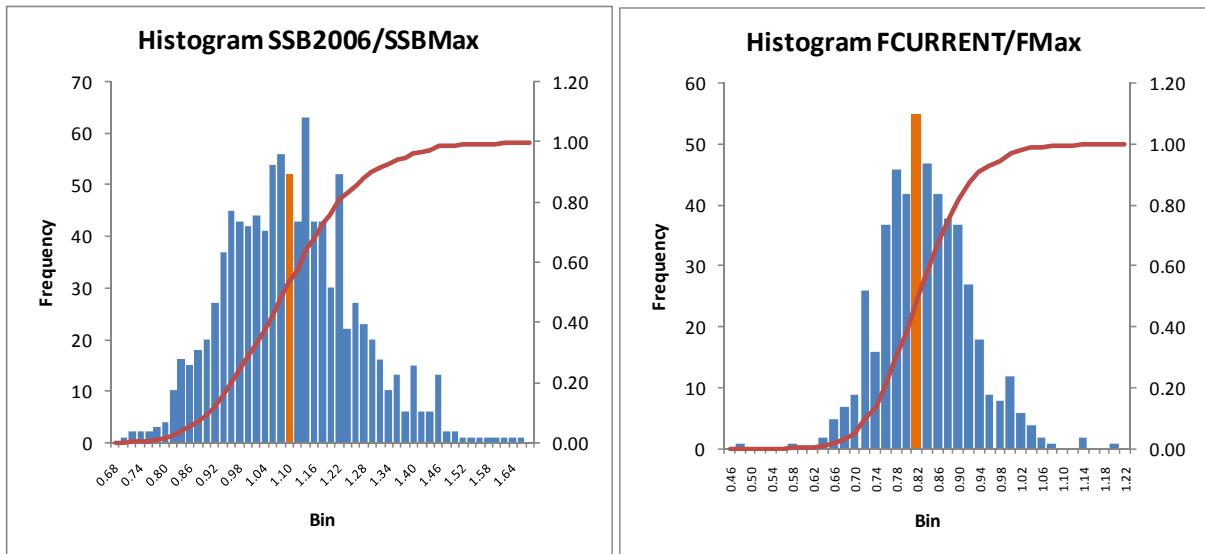


Figure 50. Histograms of bootstrap estimates of 2006 stock status. These were constructed to examine bias and normality.

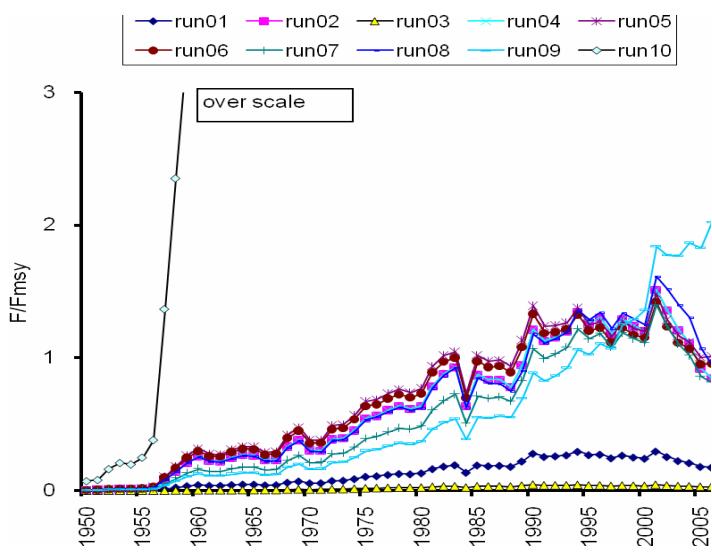
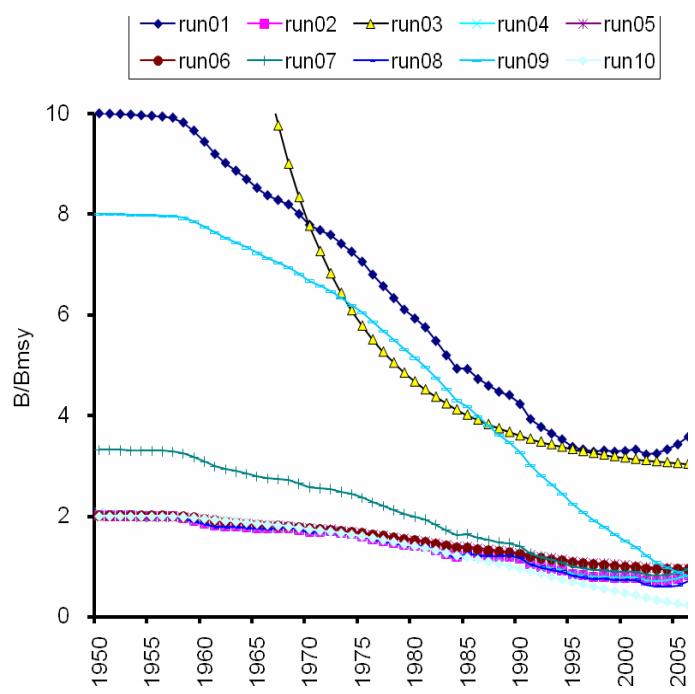


Figure 51. Estimated relative biomass (B/B_{msy}) and relative fishing mortality (F/F_{msy}) for 10 ASPIC runs. Refer to text for detail explanation of each run setting.

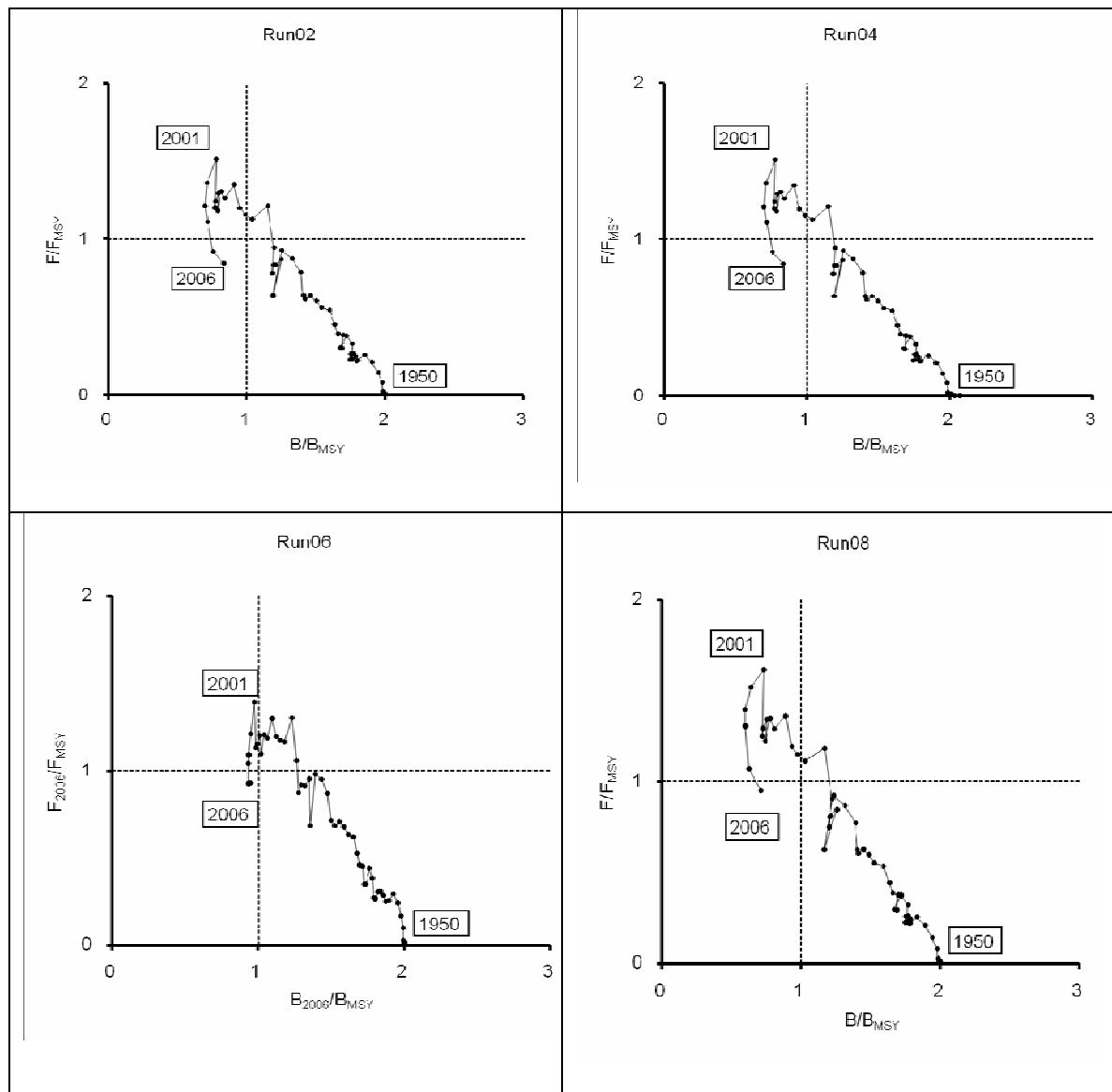


Figure 52. Relative Biomass – Relative F trajectories ('snail tracks') for 4 cases of ASPIC.

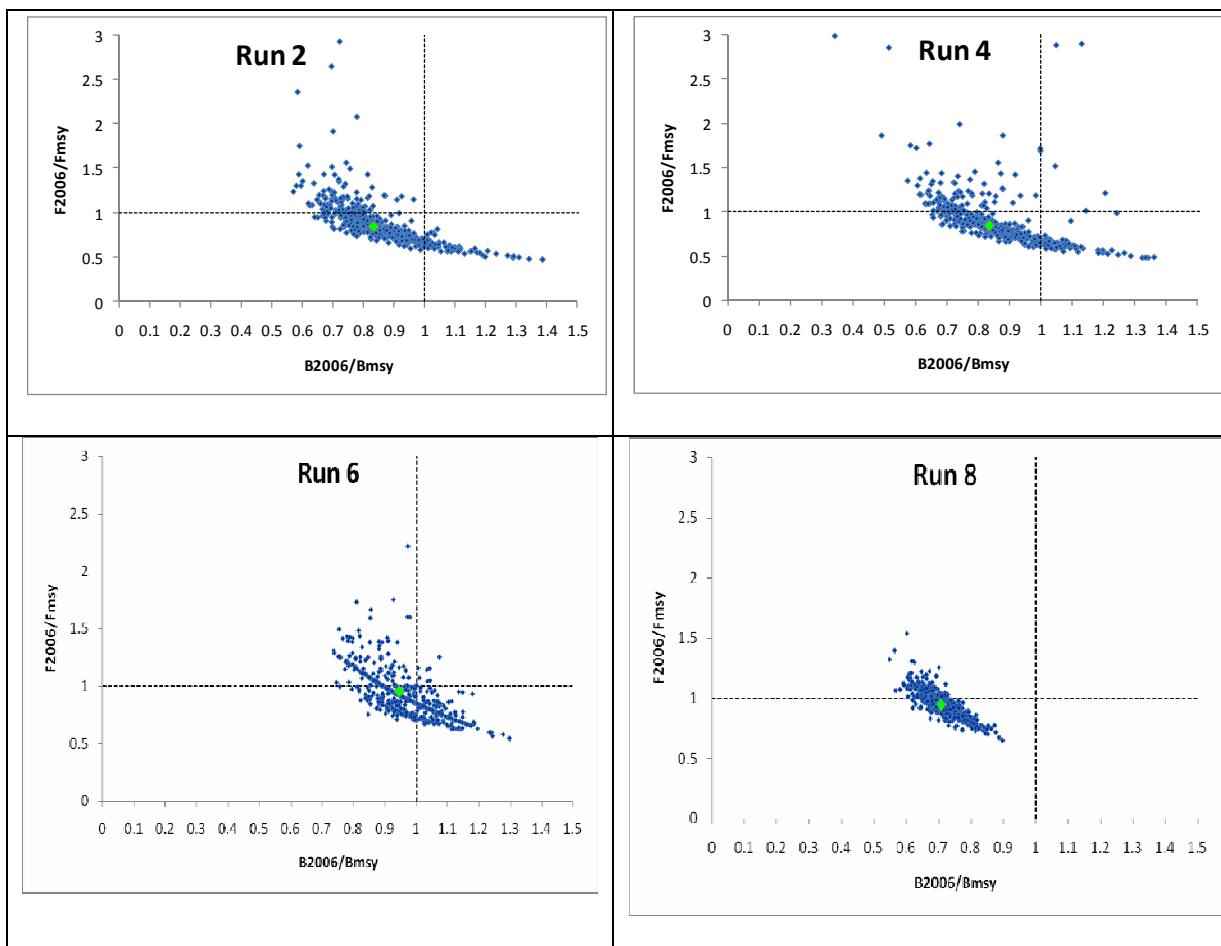


Figure 53. Phase plots of 2006 conditions from bootstraps runs for 4 runs of ASPIC. Green diamond indicates deterministic results.

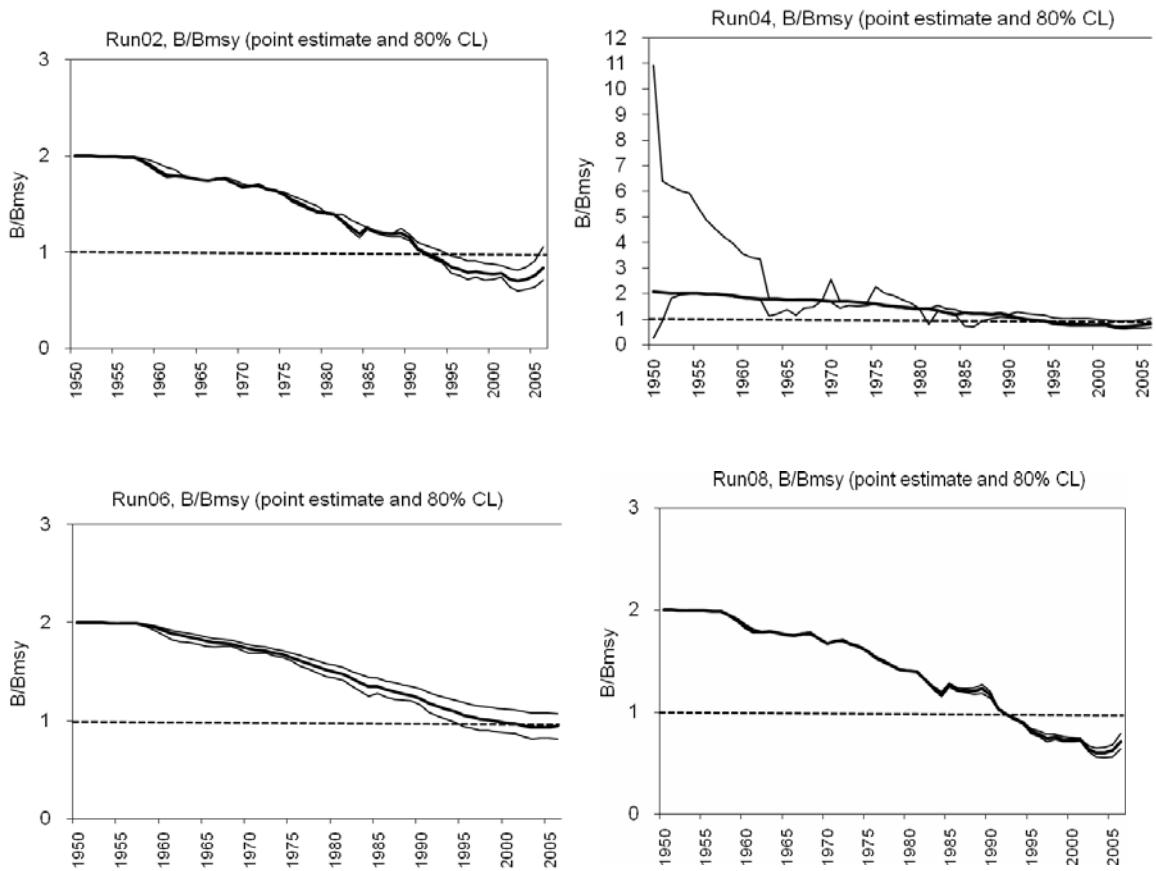


Figure 54. Estimated relative biomass trajectories and 80% confidence intervals estimated from 500 bootstraps.

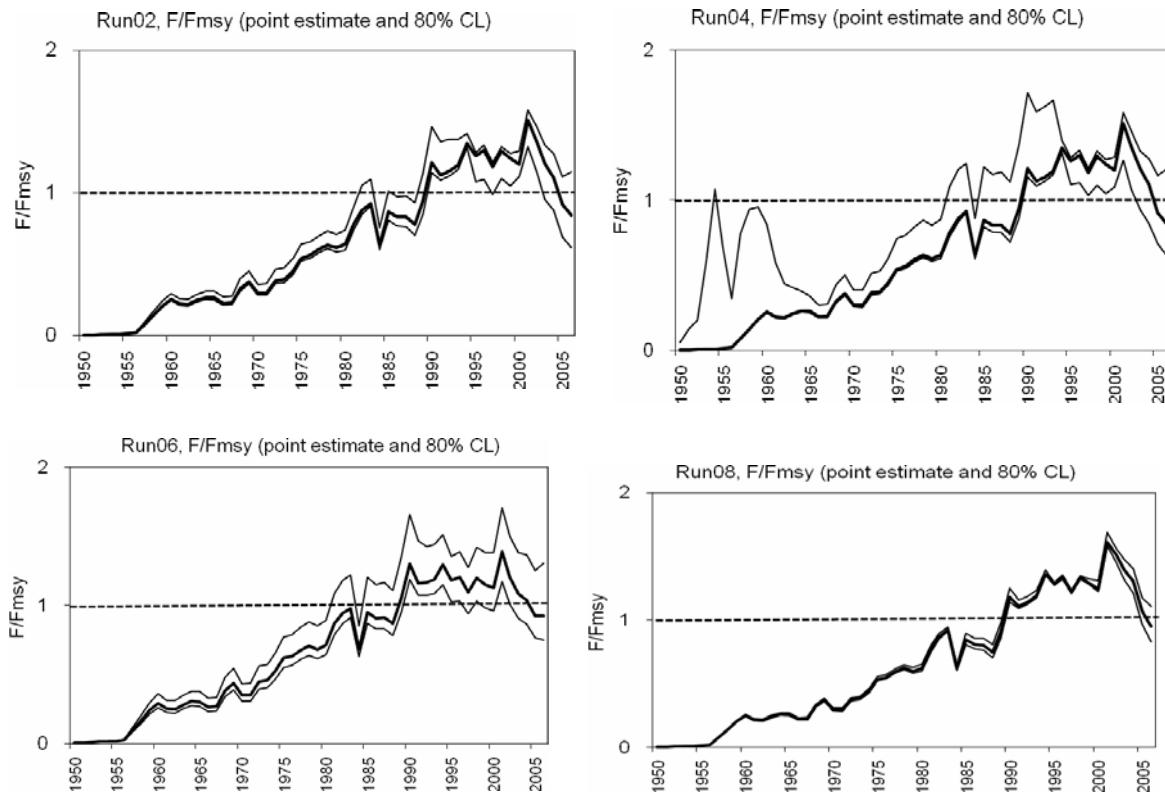


Figure 55. Estimated relative F trajectories and 80% confidence intervals estimated from 500 bootstraps.

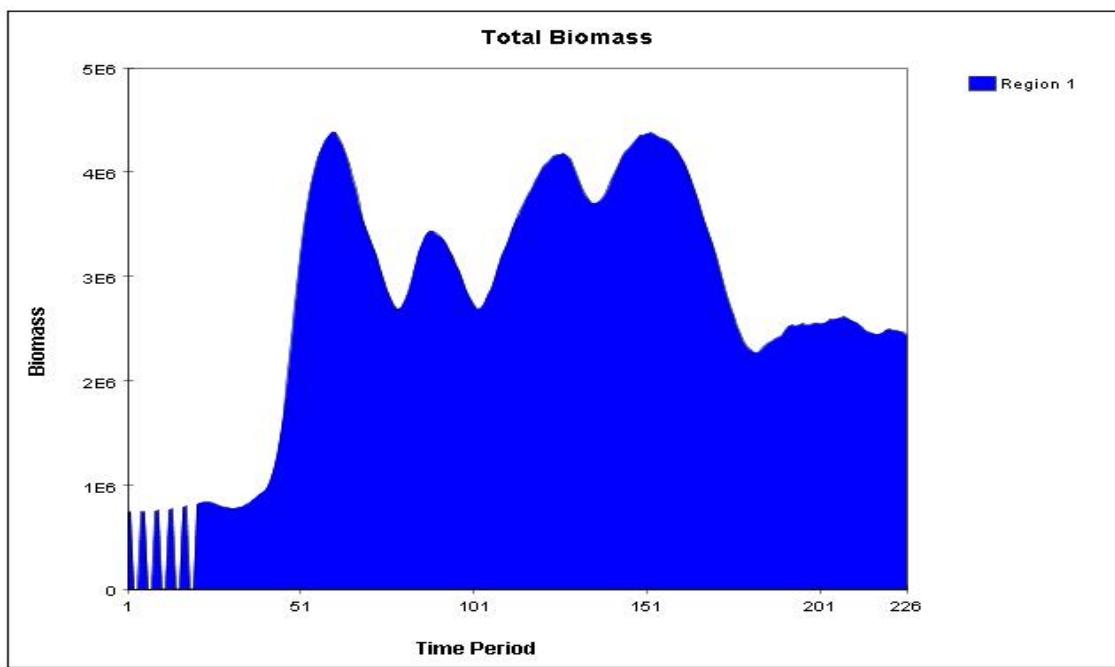


Figure 56. Multifan-CL biomass estimates for the eastern Atlantic region using data from 1950 to 2006.

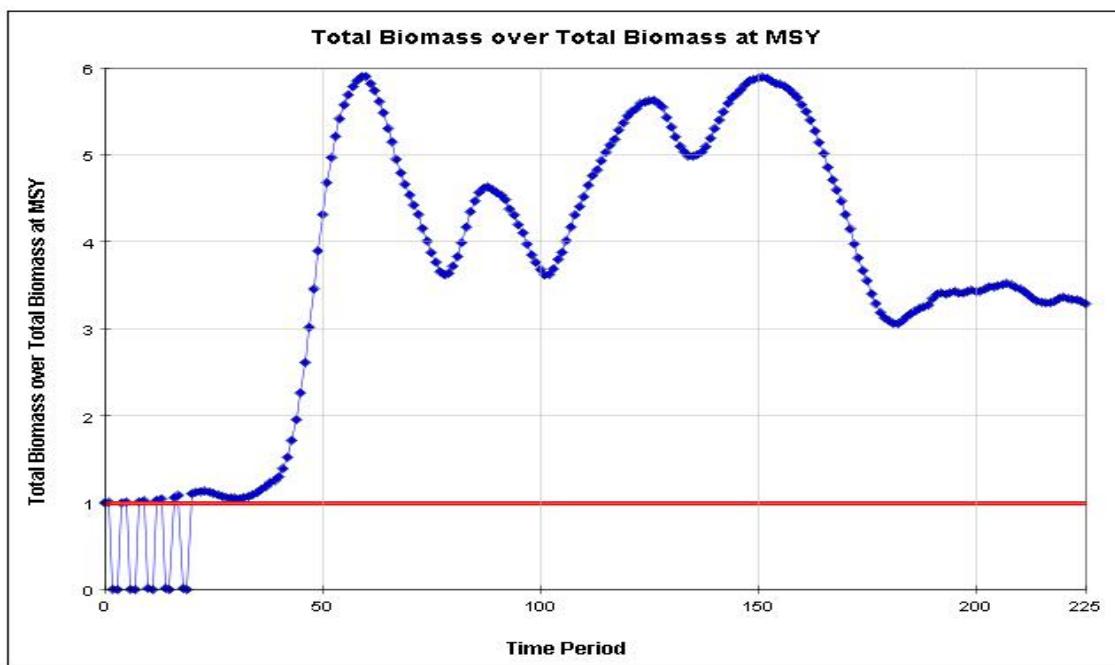


Figure 57. Multifan-CL biomass over MSY estimates for the eastern Atlantic region using data from 1950 to 2006.

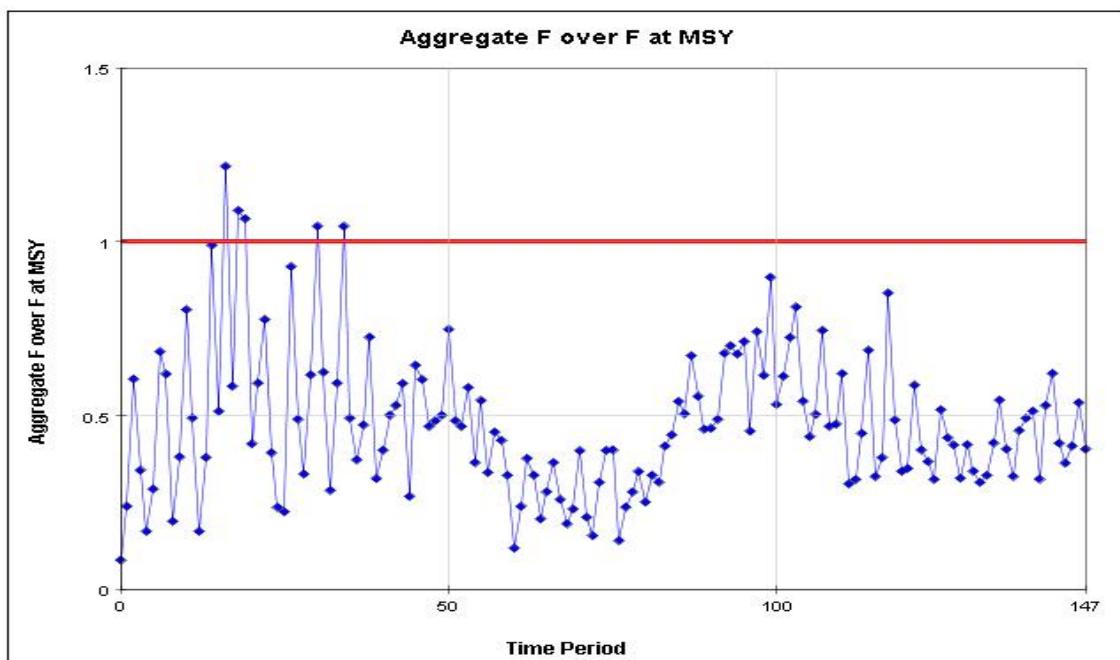


Figure 58. Multifan-CL F over F_{MSY} estimates for the eastern Atlantic region using data from 1950 to 2006.

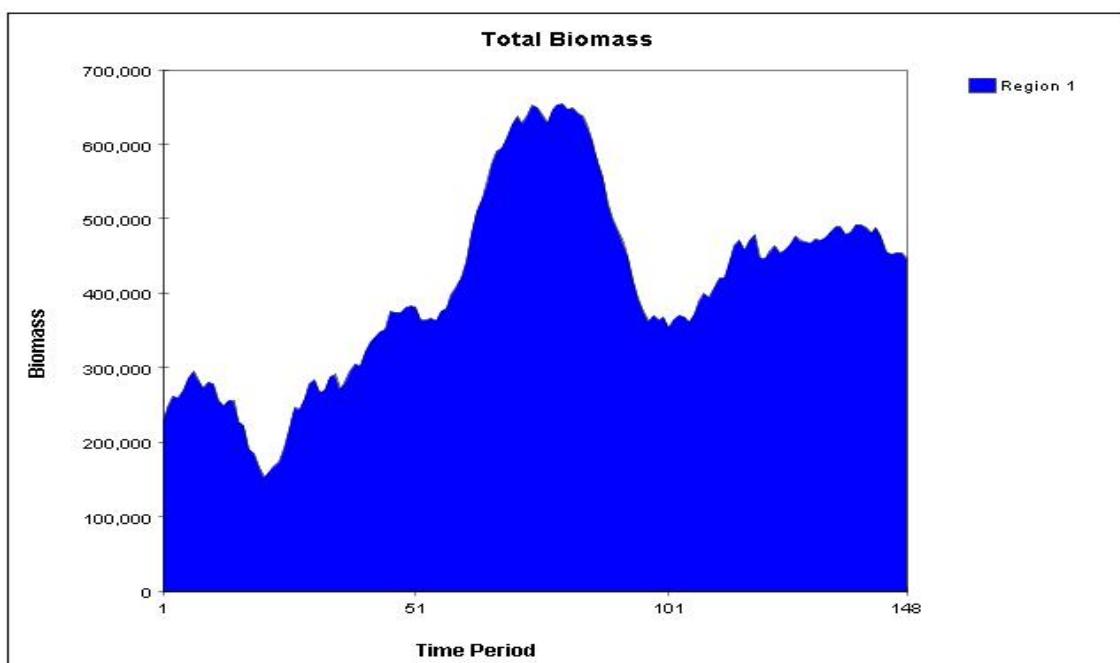


Figure 59. Multifan-CL biomass estimation for the eastern Atlantic region using data from 1970 to 2006.

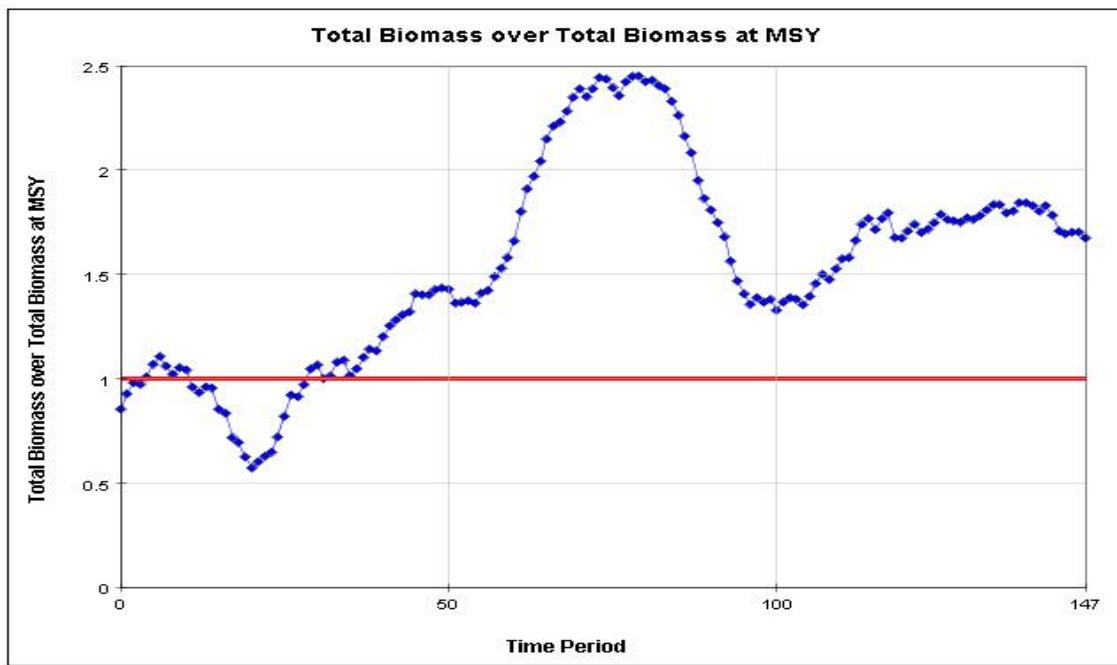


Figure 60. Multifan-CL biomass over MSY estimates for the eastern Atlantic region using data from 1970 to 2006.

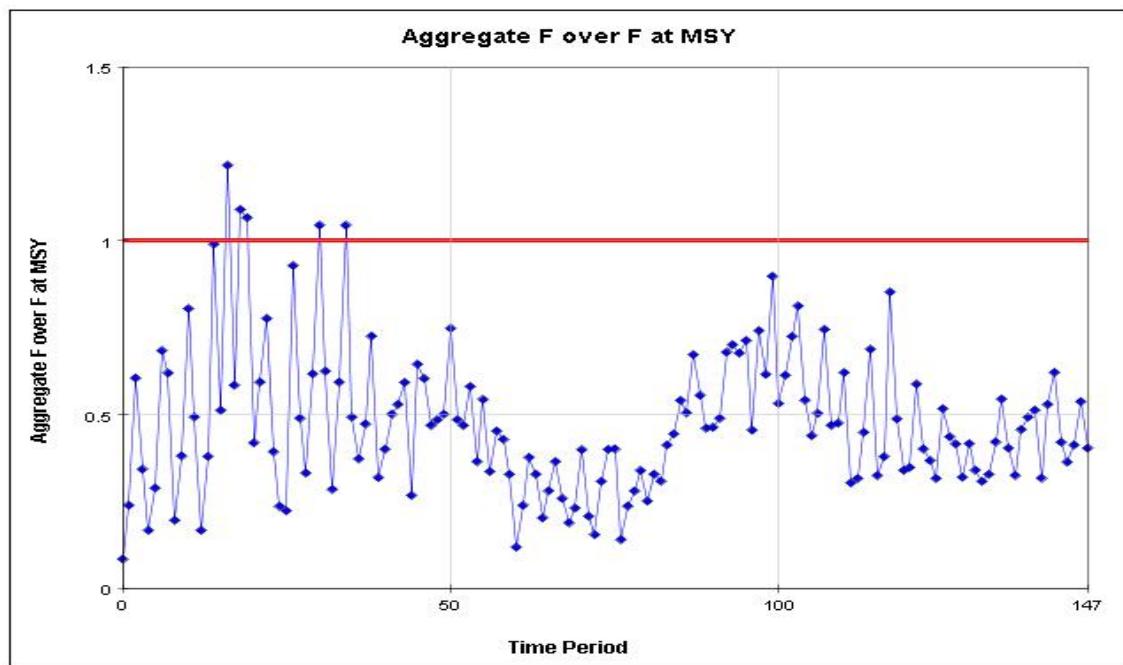


Figure 61. Multifan-CL F over F_{MSY} estimates for the eastern Atlantic region using data from 1970 to 2006.

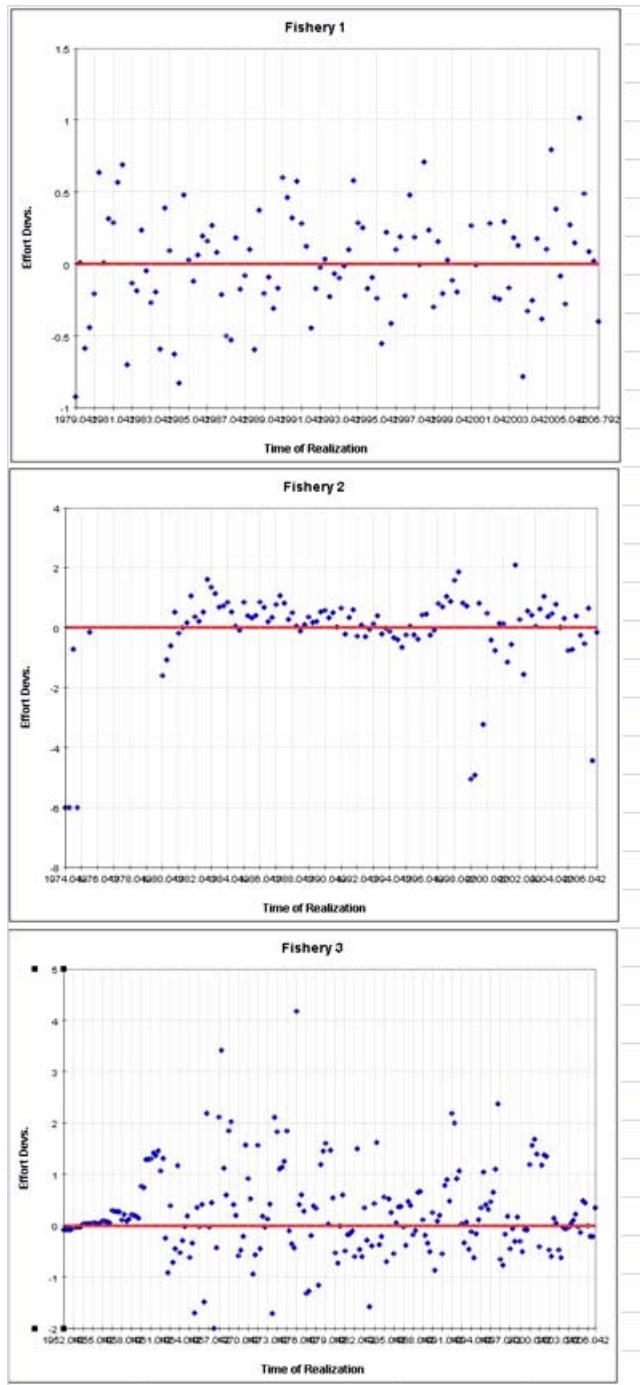


Figure 62a. Effort deviations estimated from the Multifan-CL application to western skipjack for the three fisheries.

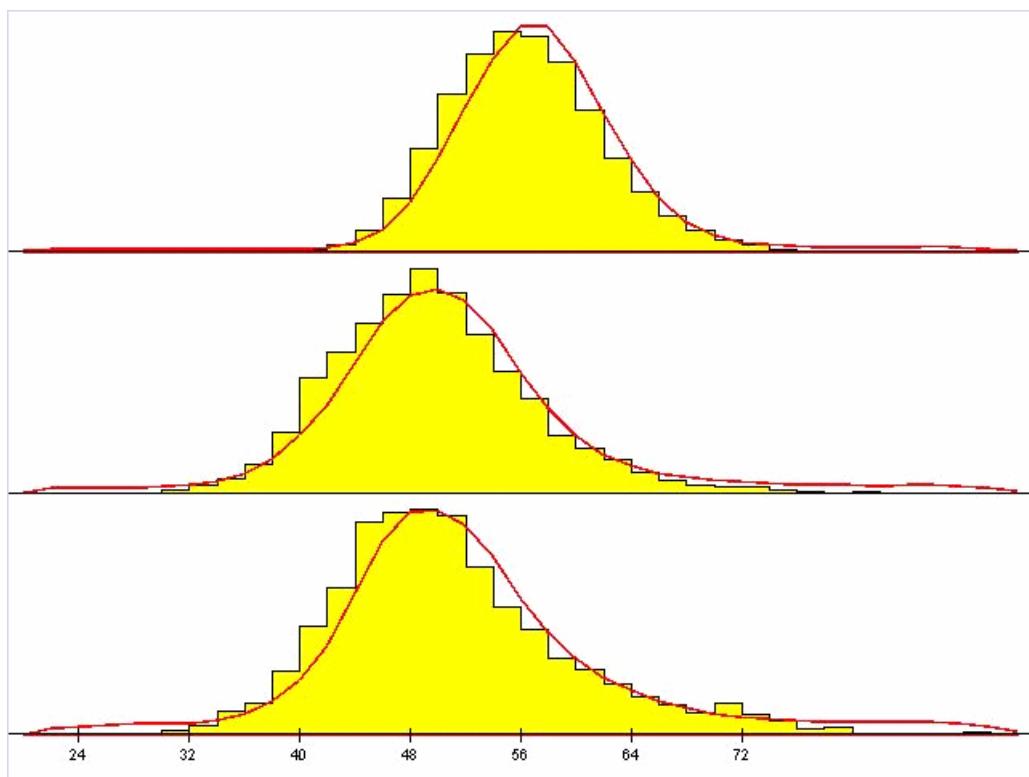


Figure 62b. Overall size frequencies fitted in the Multifan-CL application to western skipjack for the three fisheries.

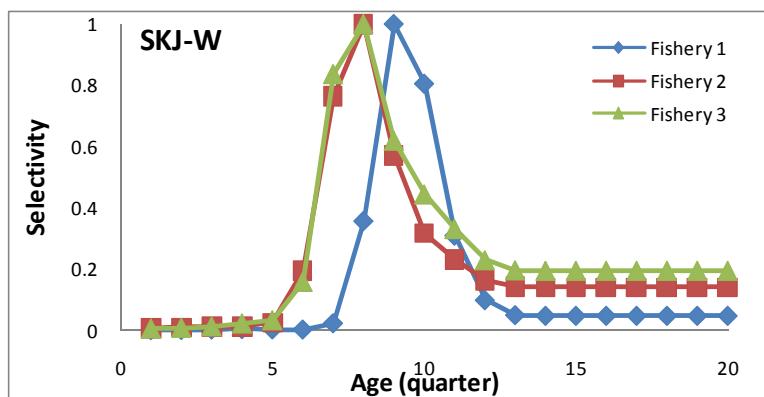


Figure 63. Selectivities estimated by the Multifan-CL application to western skipjack for the three fisheries.

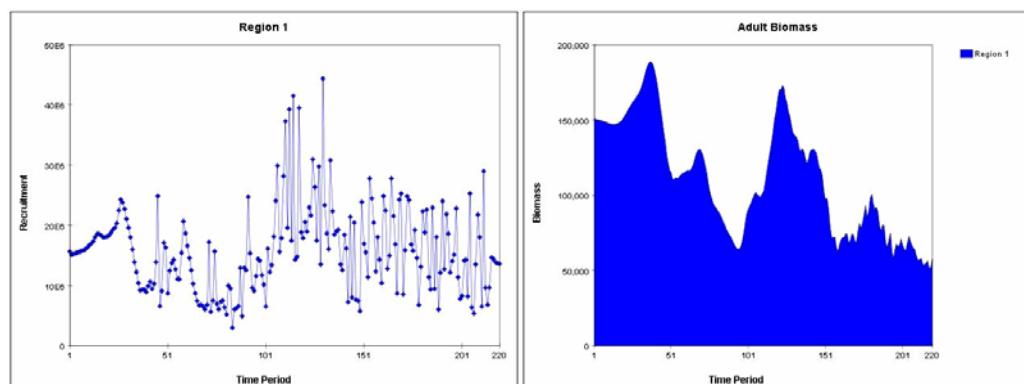


Figure 64. Recruitment and spawning biomass trends estimated by the Multifan-CL application to western skipjack.

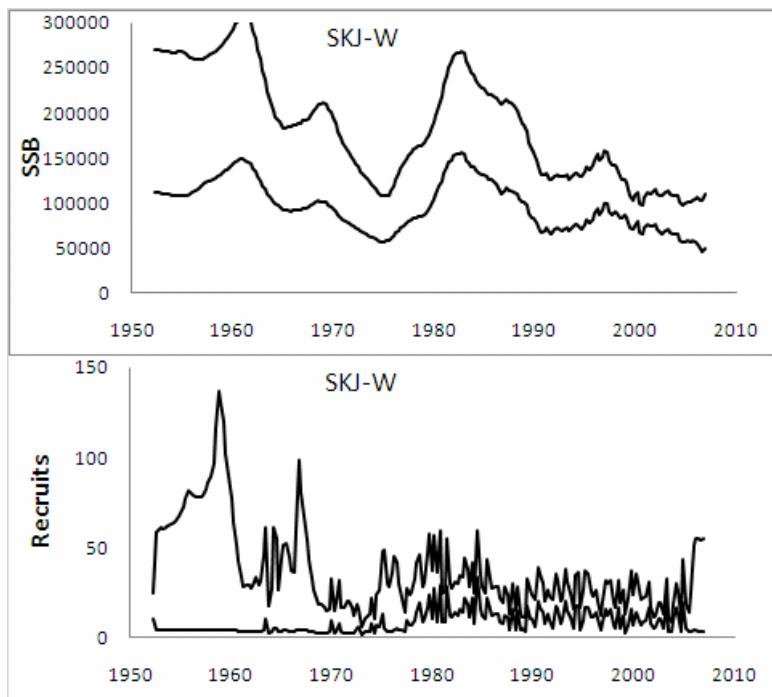


Figure 65. Approximate 95% confidence intervals for SSB and recruitment estimated by the Multifan-CL application to western skipjack.

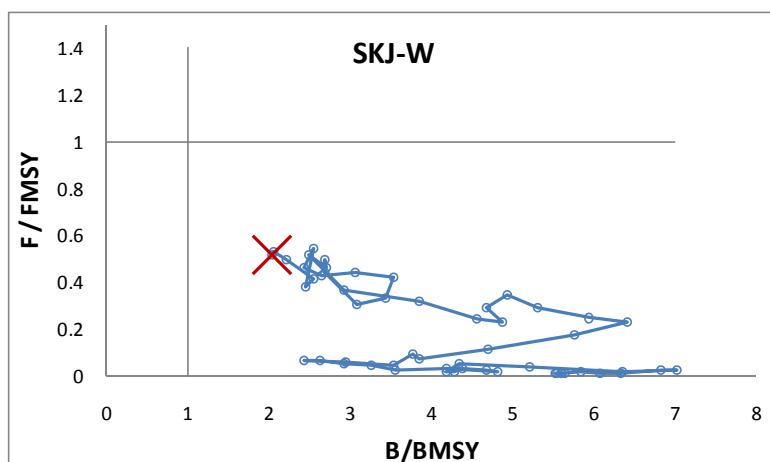


Figure 66. Joint trajectory of biomass and fishing mortality relative to MSY levels, estimated by the Multifan-CL application to western skipjack.

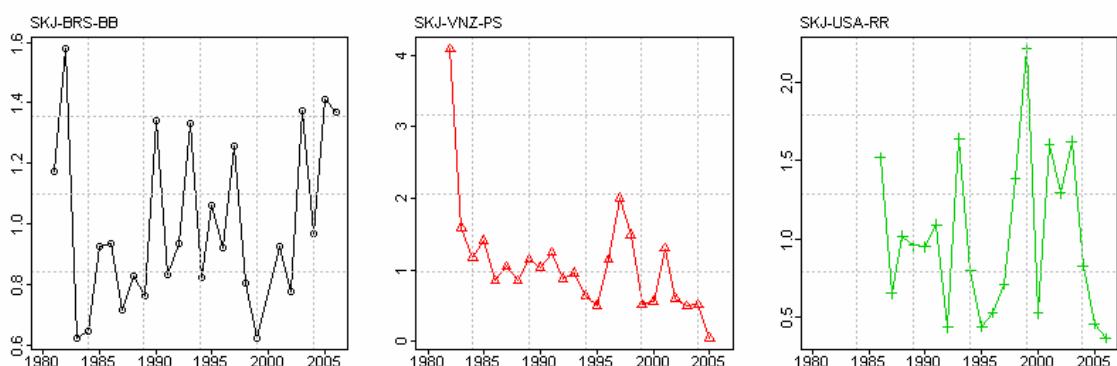


Figure 67. Plot of indices of abundance used for BSP projection models for western skipjack.

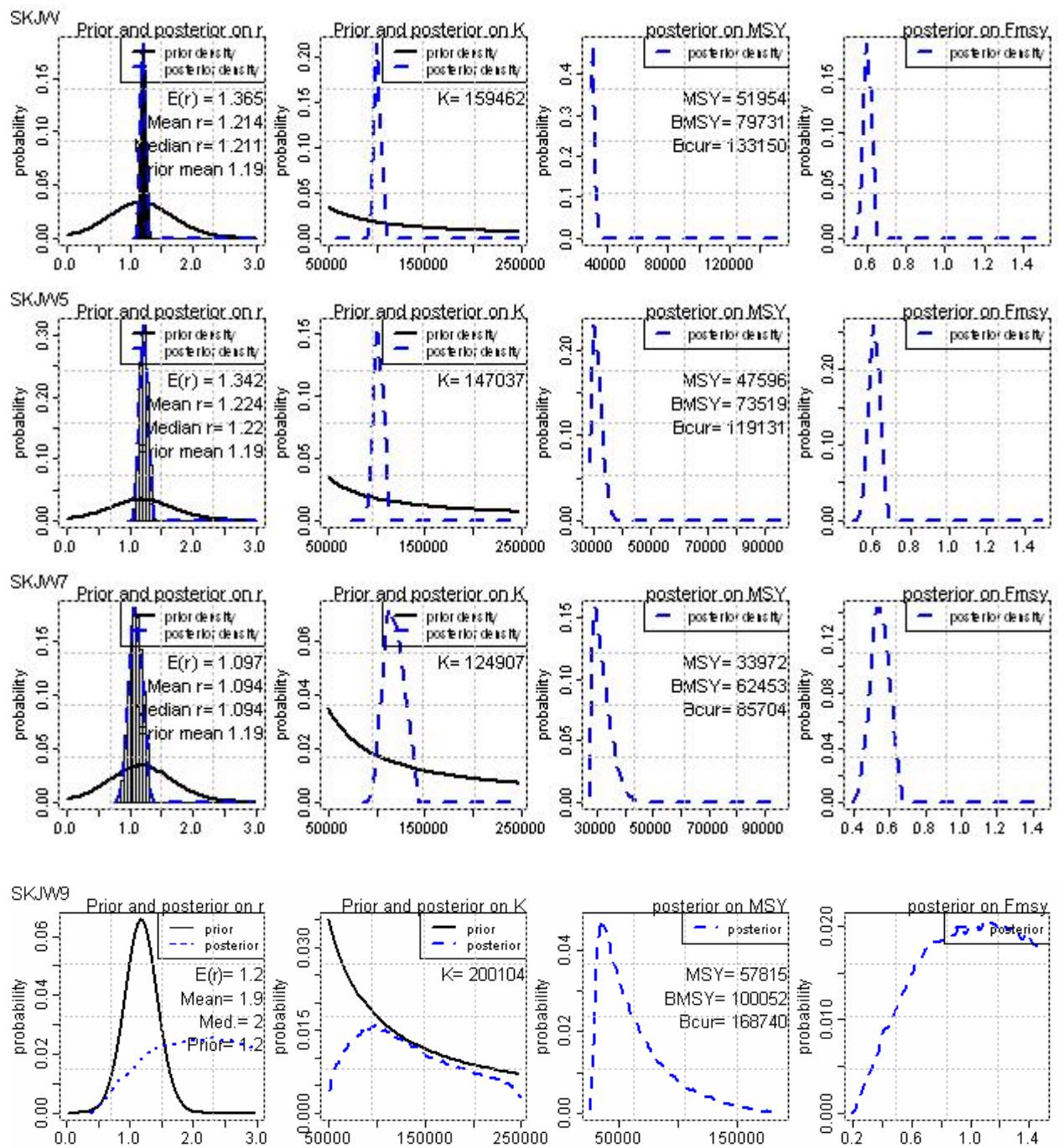


Figure 68. Prior and posteriors for r , K and posteriors for MSY and F_{MSY} for BSP runs 1, 5, 7 and 9 showing the expansion of the posterior for r and the migration of K to lower values. Note that for run 9 the prior for r was $N(1.17, 0.25)$ and $N(1.17, 0.5)$ for all others.

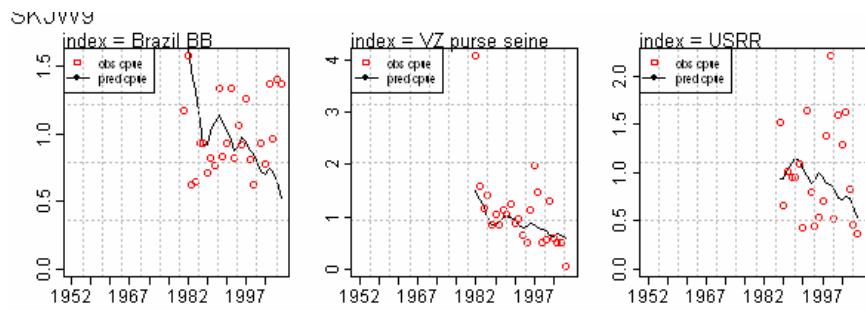


Figure 69. Fits to the indices for BSP SKJW-RUN9.

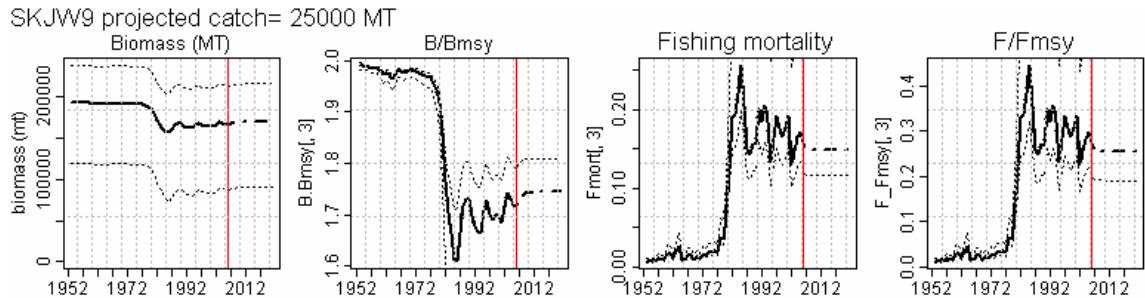


Figure 70. Biomass, B/B_{MSY}, F, and F/F_{MSY} trajectory with projections of 25,000 MT starting in 2007 for SKJW-RUN9. Dashed lines are 90% confidence intervals based on importance samples.

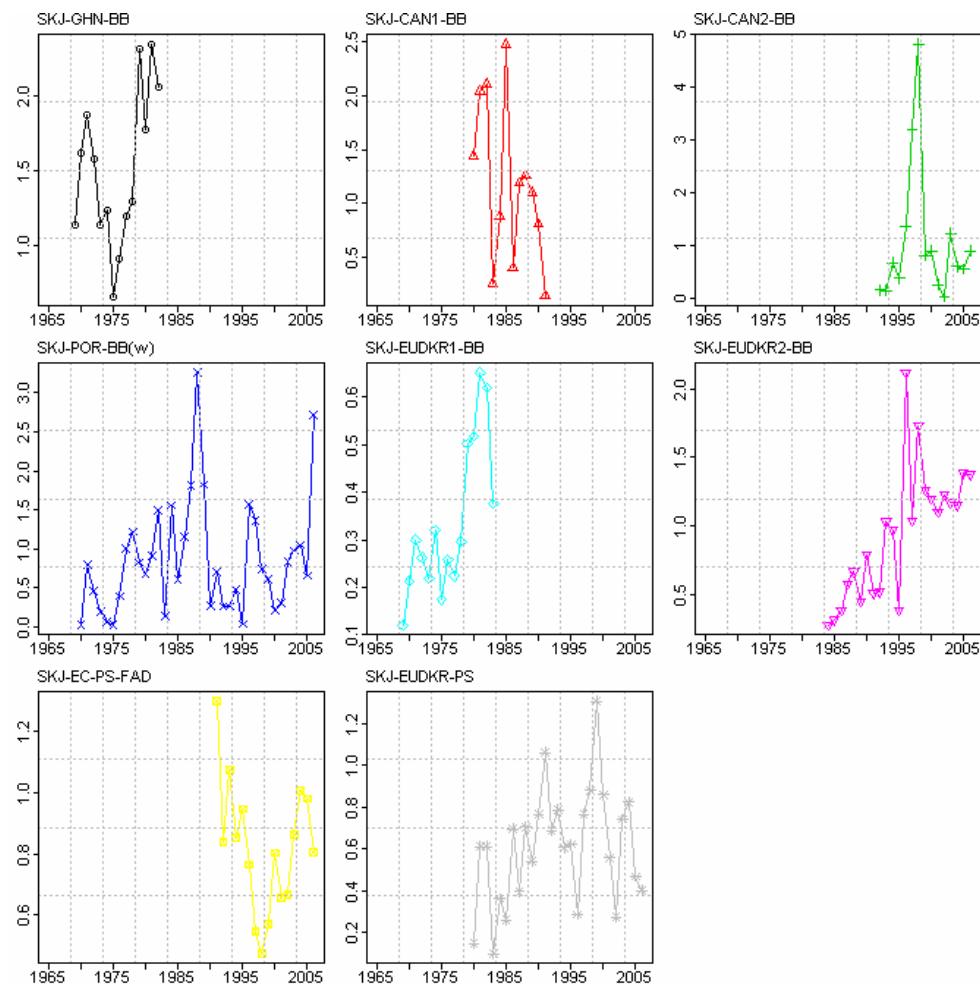


Figure 71. Plot of indices of abundance used for BSP projection models for eastern skipjack.

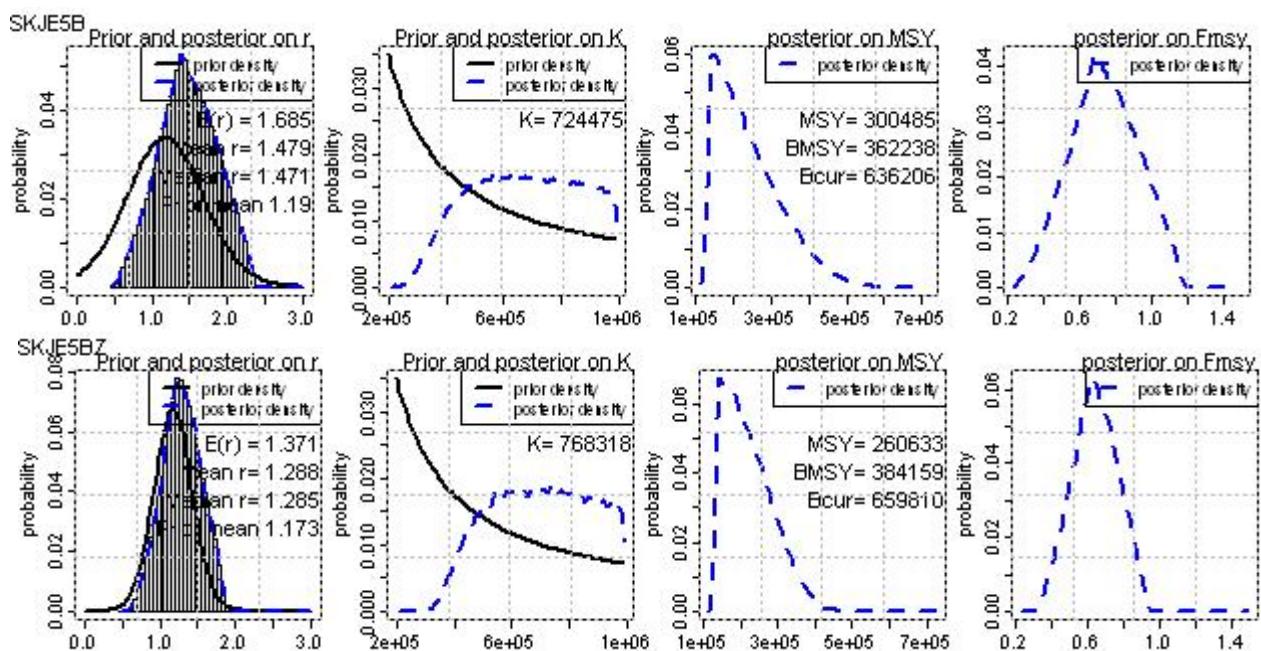


Figure 72. Comparison of SKJE A. Run 5B with a loose prior on r ($sd=0.5$) and B. Run 5BZ with a tight prior on r ($sd = 0.25$).

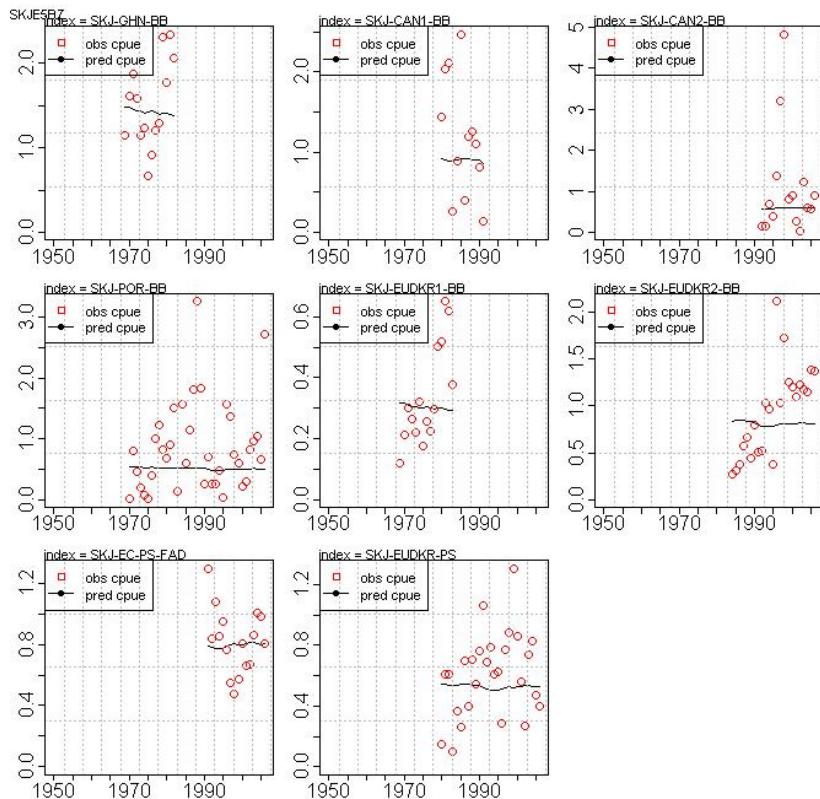


Figure 73. Fits to the indices for BSP RUN5BZ for with low variance r prior.

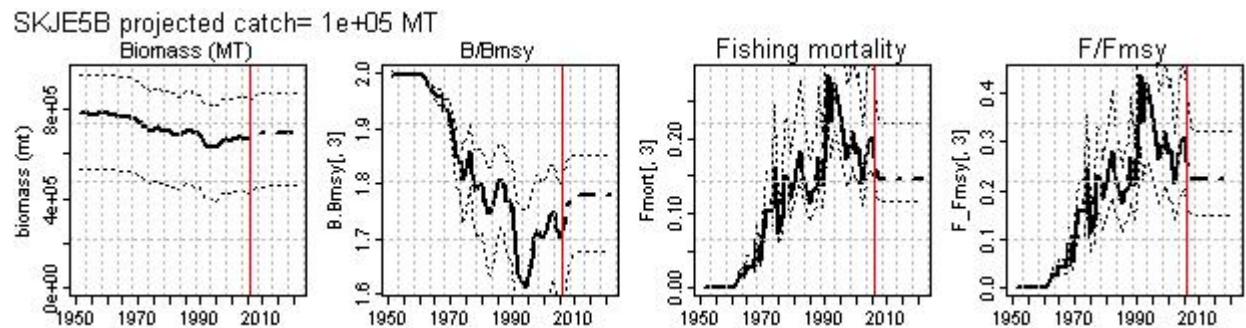


Figure 74. Biomass, B/B_{MSY} , F , and F/F_{MSY} trajectory with projections of 100,000 MT starting in 2007 for SKJE-RUN5BZ, low variance on r . Dashed lines are 90% confidence intervals based on importance samples.

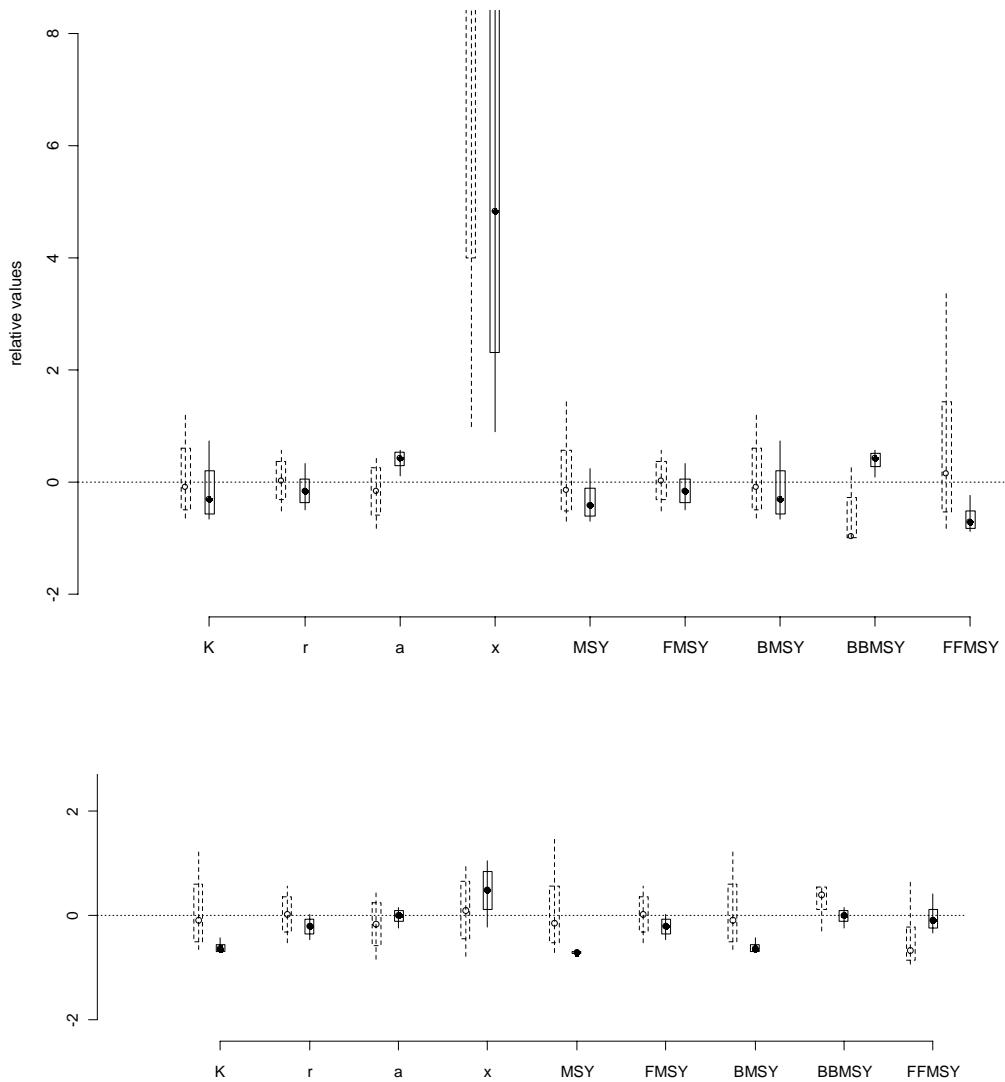


Figure 75. Priors and posteriors for runs A.1 and B.1 for the western skipjack stock. The priors (dashed boxes) and posteriors (solid boxes) were relativised to be in the same scale. The dashed boxes for management quantities are the values obtained by running the model only with the priors.

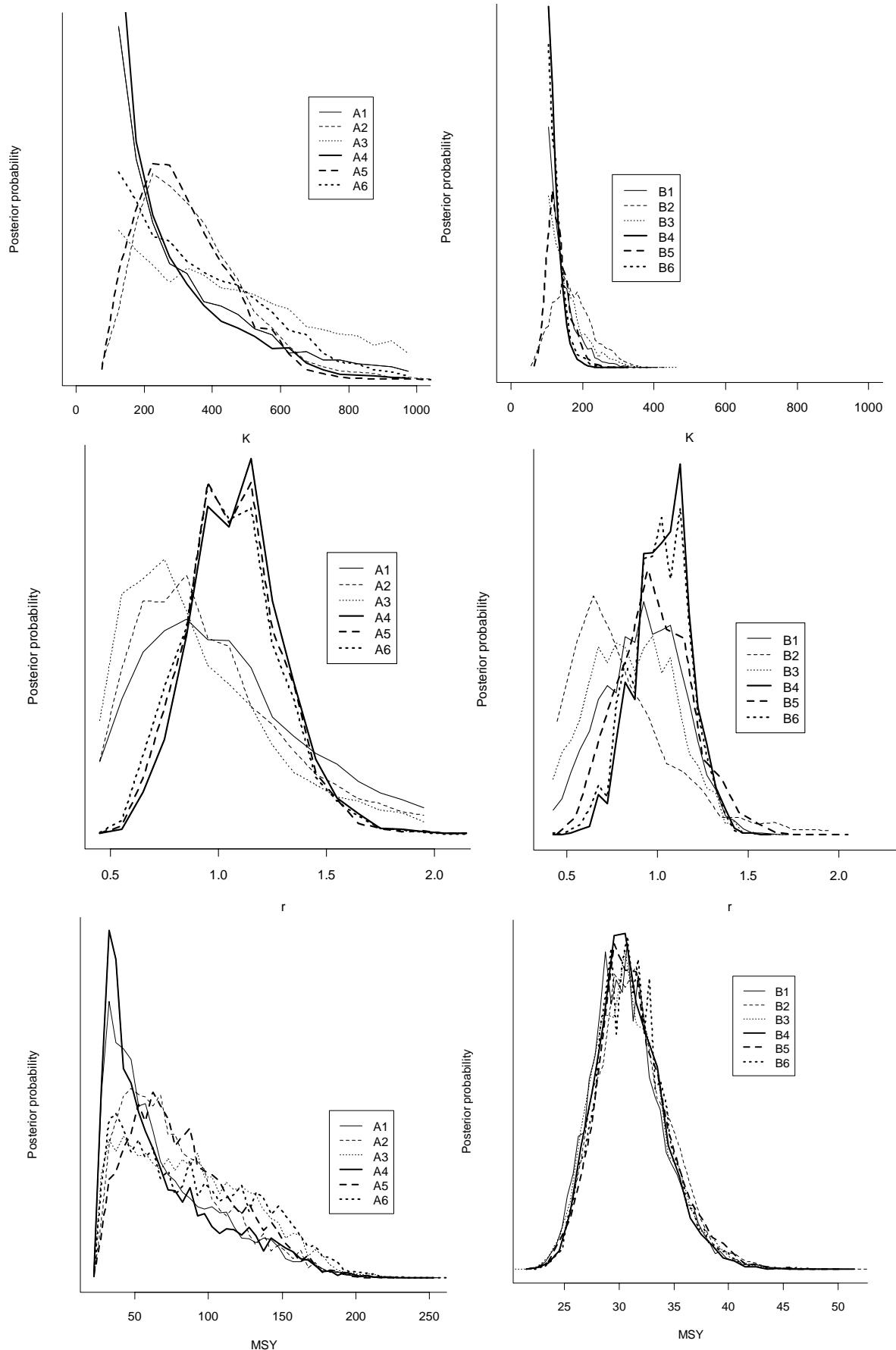


Figure 76. Posteriors for K , r and MSY for runs A1 to A6 (left) and B1 to B6 (right) for the western skipjack stock. (Units for K and MSY are in 1,000 t).

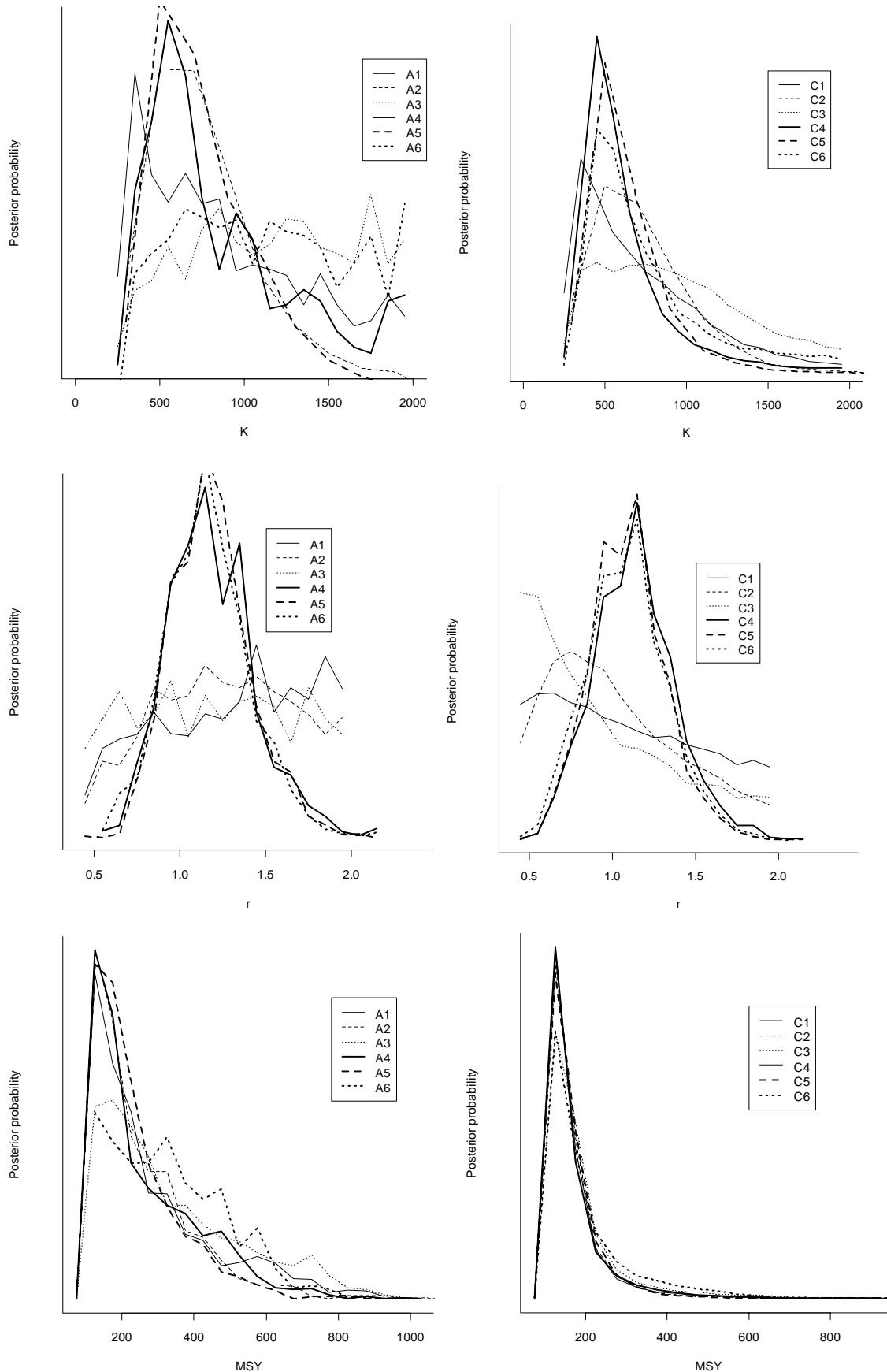


Figure 77. Posteriors for K , r and MSY for runs A1 to A6 (left) and C1 to C6 (right) for the eastern SKJ stock (units for K and MSY are in 1000 t).

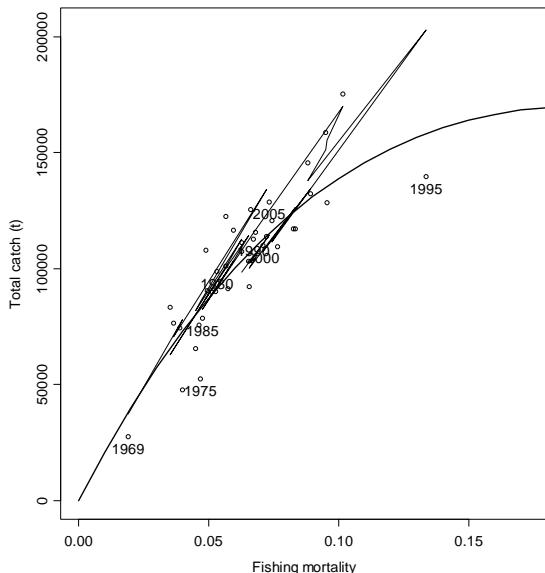


Figure 78. Total catches observed (circles), predicted (solid line) and equilibrium production curve estimated in the standard run.

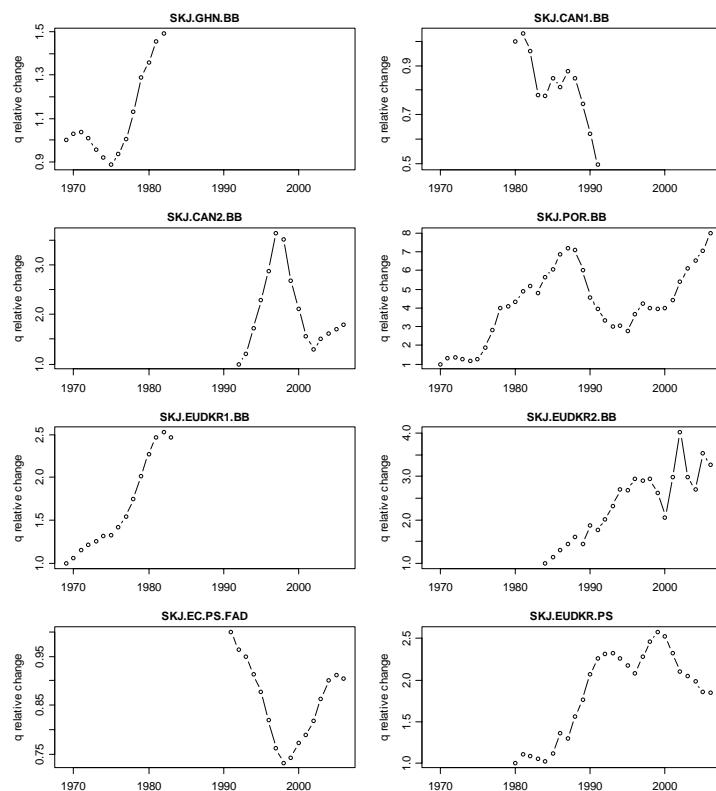


Figure 79. Relative changes in catchability estimated with a process error on catchability for the 8 fishing fleets considered in the standard run. GHN.BB = Ghanean baitboats; CAN.BB = Canarian baitboats; POR.BB = Azorean baitboats; EUDKR.BB = European and Senegalese baitboats; EC.PS.FAD = European purse seiners fishing on fishing aggregating devices; EUDKR.PS = Spanish purse seiners fishing off Senegal.

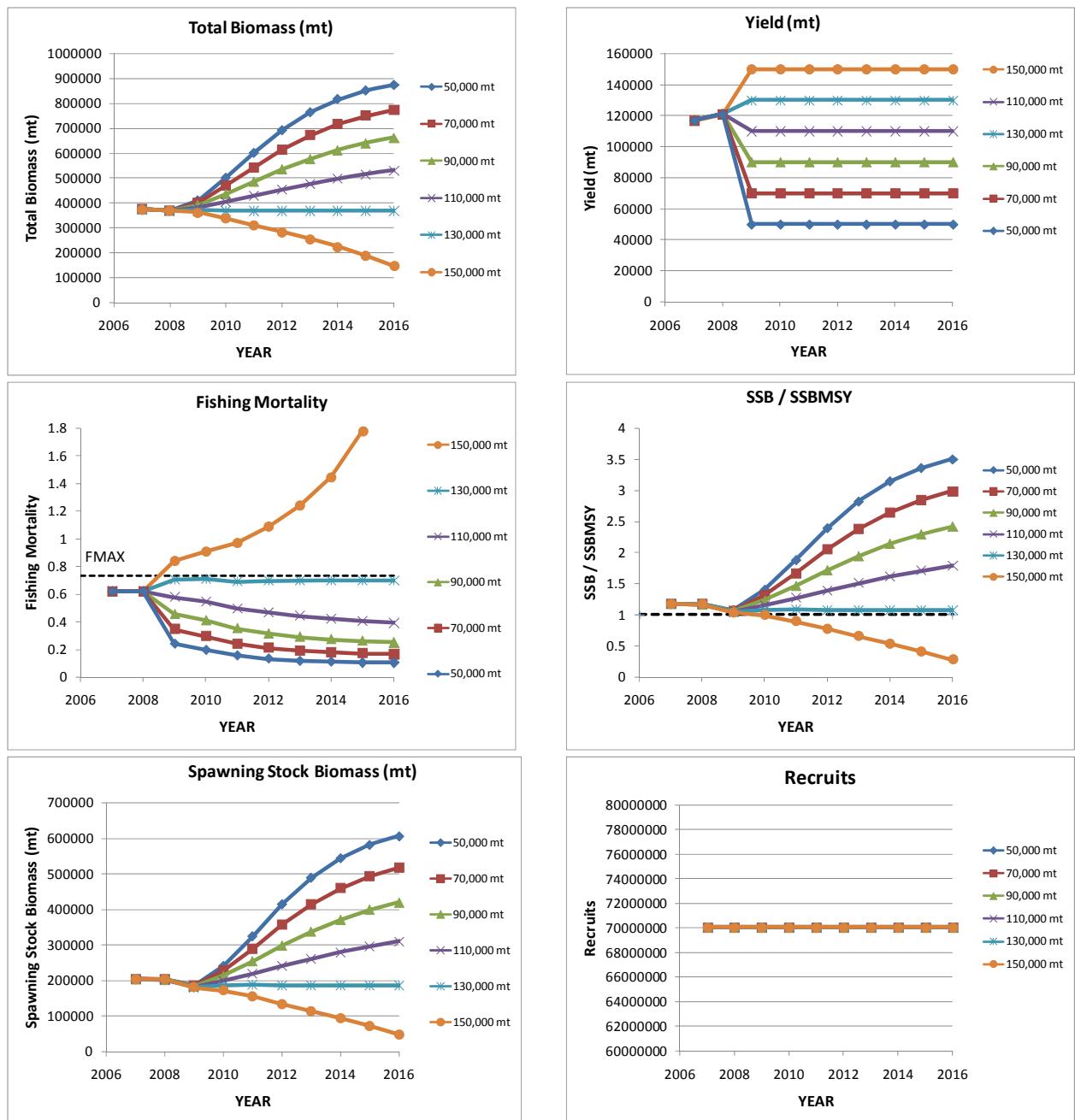


Figure 80. Constant catch projection results using the joint distribution of YFT VPA runs 5 and 10.

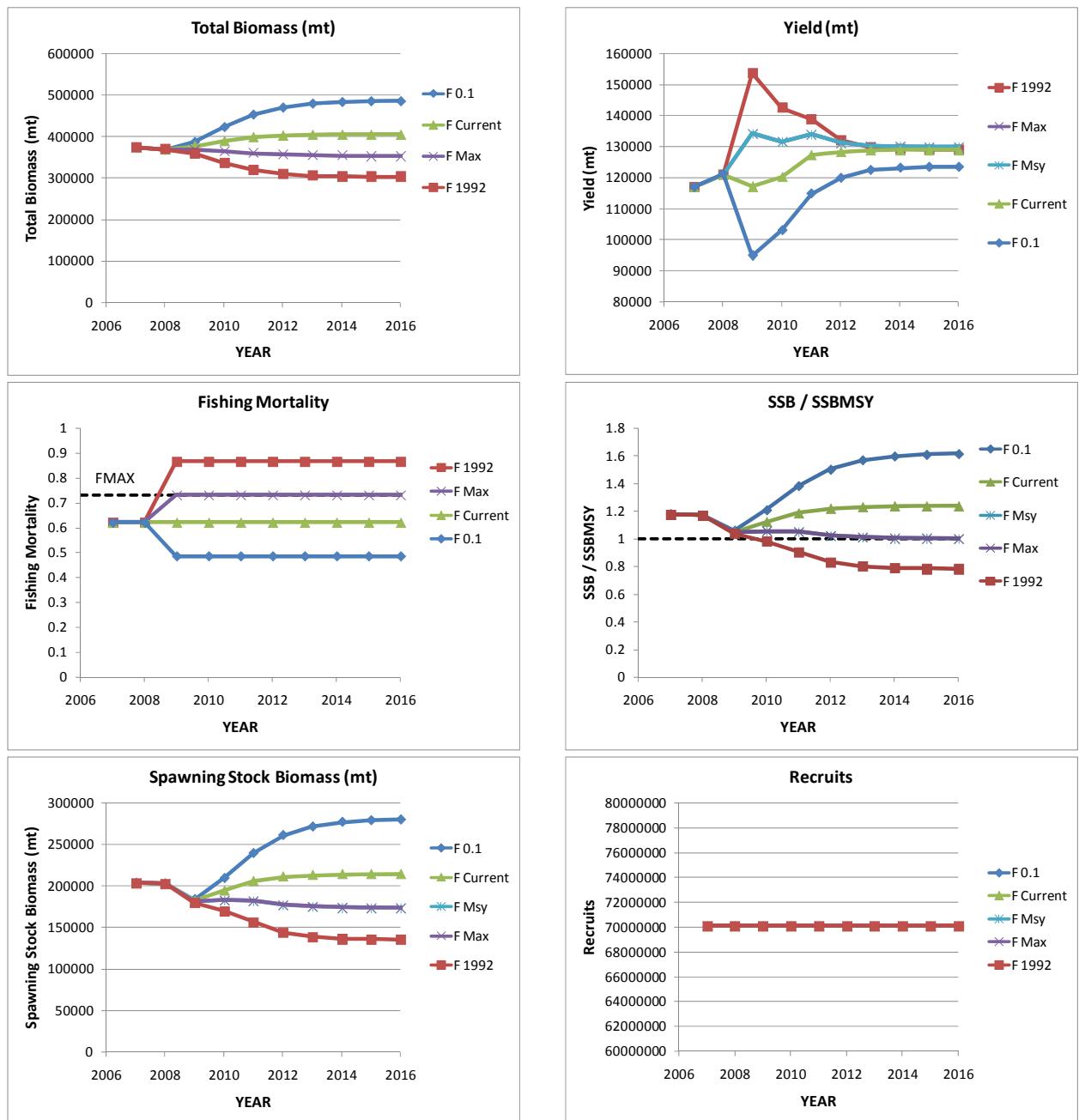


Figure 81. Constant F projection results using the joint distribution of YFT VPA runs 5 and 10.

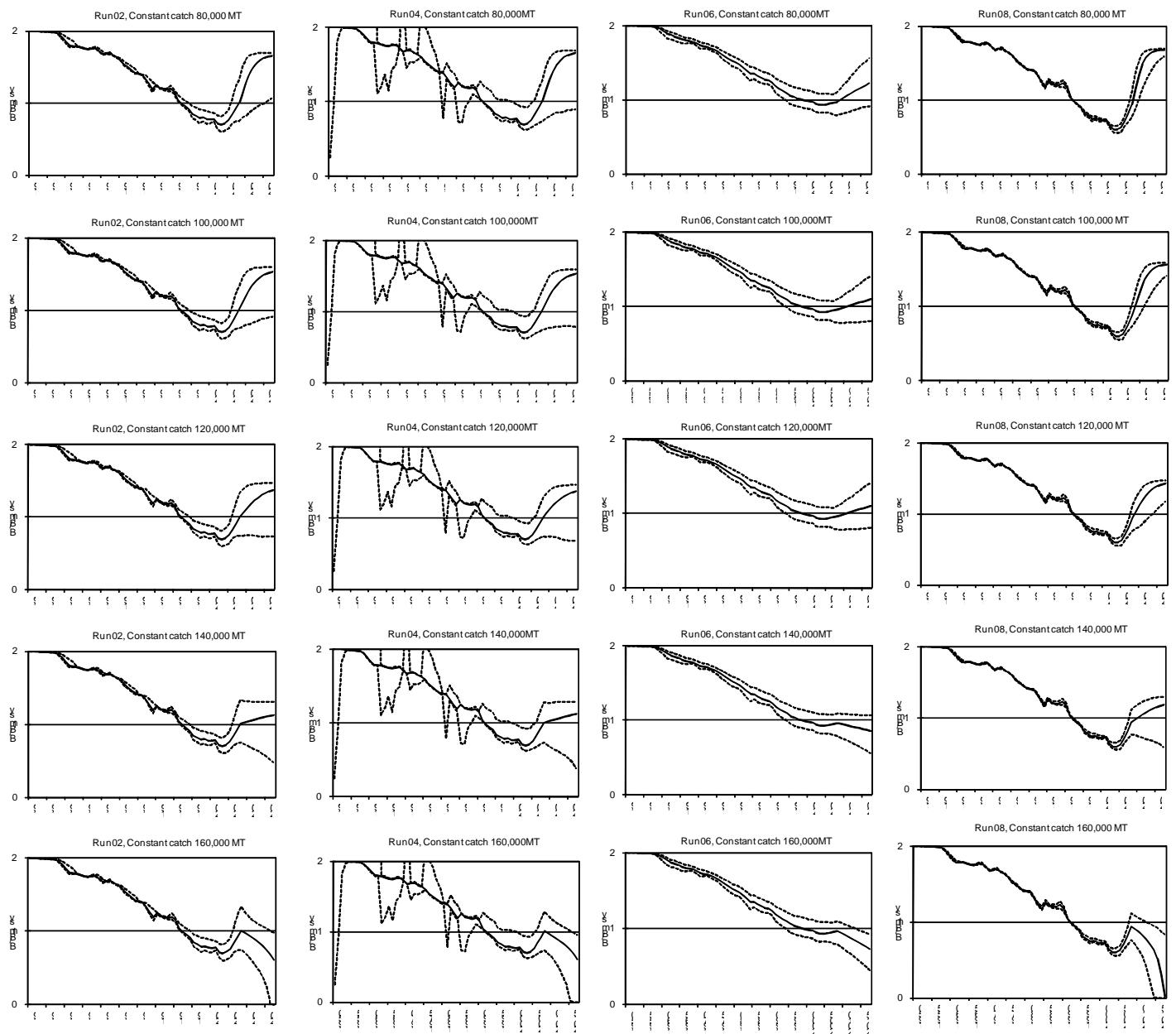


Figure 82. Biomass projections for catch levels of 80,000 t, 100,000 t, 120,000 t, 140,000 t and 160,000 t for each of the 4 ASPIC cases.

Appendix 1

Agenda

1. Opening, adoption of the Agenda and meeting arrangements.
2. Review of Biological Information, including results from tagging, growth & reproductive studies, and other studies pertinent to the assessment
3. Review of fishery statistics: Effort and Catch data, including size frequencies and fisheries trends
4. Relative abundance indices and other fishery indicators
5. Methods and other data relevant to the assessment
 - 5.1 Methods – Yellowfin
 - 5.2 Methods – Skipjack
6. Stock status results
 - 6.1 Stock status – Yellowfin
 - 6.2 Stock status – Skipjack
7. Projections
 - 7.1 Projections – Yellowfin
 - 7.2 Projections – Skipjack
8. Recommendations
 - 8.1 Research and Statistics – Yellowfin
 - 8.2 Research and Statistics – Skipjack
 - 8.3 Management – Yellowfin
 - 8.4 Management – Skipjack
9. Other matters
10. Adoption of the report and closure

Appendix 2

List of Participants

CONTRACTING PARTIES

SCRS Chairman

Scott, Gerald P.

NOAA Fisheries, Southeast Fisheries Science Center Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami, Florida 33149-1099

Tel: +1 305 361 4220, Fax: +1 305 361 4219, E-Mail: gerry.scott@noaa.gov

ANGOLA

Airosa Ferreira, Júlia

Ministério das Pescas. Av. Marginal, Luanda, Angola

Tel: + 244 924 822254, E-Mail: fjairosar@hotmail.com

Lutuba Nsilulu, Henriette

INIP-MIN PESCAS. Rua Martala Mohamed. Ilha do Caba. C.P. 2601, Luanda, Angola

Tel: + 244 92334 7560, E-Mail: henrim60@hotmail.com; henrim60@yahoo.com

BRAZIL

Agrelli Andrade, Humber

Universidade Federal de Santa Catarina - UFSC Depto. Informática e Estatística, INE/CTC Caixa Postal 476, Florianópolis, Santa Catarina 88010-970,

Tel: +55 48 3721 9942, Fax: +55 48 3721 9566, E-Mail: humber@inf.ufsc.br

de Lima, Luis Henrique

Esplanada dos Ministerios - Edificio Sede, 2º andar, Sala 236, Brasilia D.F.

Tel: +55 61 321 83891, E-Mail: luislima@seap.gov.br

Hazin, Humberto

UFRPE/DEPAq, Laboratorio de Oceanografia Pesqueira (LOP), Rua Dom Manuel de Medeiros, s/n, Dois Irmaos, Recife-PE

Tel: +55 44 326 14622, E-Mail: hghazin@hotmail.com

Minte-Vera, Carolina V.
Universidade Estadual de Maringá – Av. Colombo nº 5790 Bloco H90. Maringá-PR
Tel: +55 48 3721 9942, Fax: + 55 48 3721 9566, E-Mail: cminte@nupelia.uem.br

Sheidt de Souza, Guilherme
Esplanada dos Ministérios –Bloco D, 2 andar, Sala 244. 70043-900 Brasília/DF
Tel: +55 61 3218 3881, Fax: +55 61 3226 9980, E-Mail: scheidt@seap.gov.br

Travassos, Paulo
Universidade Federal Rural de Pernambuco - UFRPE, Laboratorio de Ecologia Marinha - LEMAR, Departamento de Pesca e Aquicultura - DEPAq, Avenida Dom Manoel Medeiros s/n - Dois Irmãos, CEP 52171-900, Recife, Pernambuco
Tel: +55 81 3320 6511, Fax: +55 81 3320 6512, E-Mail: paulotr@ufrpe.br;p.travassos@depaq.ufrpe.br

Velasco, Gonzalo
Secretaría Especial de Aquicultura e Pesca (SEAP/PR). Esplanada dos Ministérios, Bloco D, 2 andar, Sala 238, 70043-900 Brasilia/DF
Tel: +55 61 3218 3893, Fax: +55 61 3218 3886, E-Mail: gonzalovelasco@seap.gov.br

EUROPEAN COMMUNITY

Ariz Telleria, Javier
Instituto Español de Oceanografía, C.O. de Canarias, Apartado 1373, 38080, Santa Cruz de Tenerife, Islas Canarias, Spain
Tel: +34 922 549 400, Fax: +34 922 549 554, E-Mail: javier.ariz@ca.ieo.es

Chassot, Emmanuel
I.R.D. UR nº 109 Centre de Recherche Halieutique Méditerranéenne et Tropicale, Avenue Jean Monnet - B.P. 171, 34203 Sète Cedex, France
Tel: +33 4 99 57 32 24, Fax: +33 4 99 57 32 95, E-Mail: Emmanuel.Chassot@ird.fr

De Bruyn, Paul
AZTI - Tecnalia, , Herrera Kaia Portualdea z/g, 20110 Pasaia, Gipuzkoa, Spain
Tel: +34 943 004800, Fax: +34 943 004801, E-Mail: debruyn@pas.azti.es

Delgado de Molina Acevedo, Alicia
Instituto Español de Oceanografía, C.O. de Canarias, Apartado 1373, 38080 Santa Cruz de Tenerife, Spain
Tel: +34 922 549 400, Fax: +34 922 549 554, E-Mail: alicia.delgado@ca.ieo.es

Gaertner, Daniel
I.R.D. UR nº 109 Centre de Recherche Halieutique Méditerranéenne et Tropicale, Avenue Jean Monnet - B.P. 171, 34203 Sète Cedex, France
Tel: +33 4 99 57 32 31, Fax: +33 4 99 57 32 95, E-Mail: gaertner@ird.fr

Monteagudo, Juan Pedro
Asesor Científico, ANABAC/OPTUC, c/ Txibitxiaga, 24 - entreplanta, 48370 Bermeo, Vizcaya, Spain
Tel: +34 94 688 2806, Fax: +34 94 688 5017, E-Mail: monteagudog@yahoo.es

Murua, Hilario
AZTI - Tecnalia /Itsas Ikerketa Saila, Herrera Kaia Portualde z/g, 20110 Pasaia, Gipuzkoa, Spain
Tel: +34 943 004800 ext. 821, Fax: +34 943 004801, E-Mail: hmurua@pas.azti.es

Pereira, Joao Gil
Universidade dos Açores, Departamento de Oceanografia e Pescas, 9900 Horta, Portugal
Tel: +351 292 200 431, Fax: +351 292 200 411, E-Mail: pereira@uac.pt

Pereira, Juan Antonio
OPAGAC c/ Ayala 54, 2 A. 28001 Madrid, Spain
Tel: +34 91 431 4857, Fax: +34 91 576 1222, E-Mail: opagac@arrakis.es

GHANA
Bannerman, Paul
Ministry of Food and Agriculture, Fisheries Department, P.O. Box BT 62, Tema
Tel: +233 222 02346, Fax: +233 222 06627, E-Mail: paulbann@hotmail.com

JAPAN
Satoh, Keisuke
Tropical Tuna Section, National Research Institute of Far Seas Fisheries, Fisheries Research Agency of Japan, 7-1, 5 Chome Orido, Shizuoka-Shi, Shimizu-Ku , 424-8633
Tel: +81 543 36 6044, Fax: +81 543 35 9642, E-Mail: kstu21@fra.affrc.go.jp

MEXICO**González Anía, Luis V.**

Instituto Nacional de la Pesca, Pitágoras 1320 Col. Santa Cruz Atoyac

Tel: +52 54 22 30 49, Fax: +52 56 04 48 87, E-Mail: lgonzalez@inp.semarnap.gob.mx

Ramírez López, Karina

Instituto Nacional de la Pesca - SAGARPA, Av. Ejército Mexicano No.106 - Colonia Exhacienda, Ylang Ylang, 94298 Boca de Río, Veracruz

Tel: +52 22 9130 4518, Fax: +52 22 9130 4519, E-Mail: kramirez_inp@yahoo.com; kramirez_lopez@yahoo.com.mx

UNITED STATES**Brown, Craig A.**

NOAA Fisheries Southeast Fisheries Center Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami, Florida 33149-1099

Tel: +1 305 361 4590, Fax: +1 305 361 4562, E-Mail: craig.brown@noaa.gov

Cass-Calay, Shannon

NOAA Fisheries, Southeast Fisheries Center, Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami, Florida 33149

Tel: +1 305 361 4231, Fax: +1 305 361 4562, E-Mail: shannon.calay@noaa.gov

Díaz, Guillermo

Office of Science and Technology, National Marine Fisheries Service NOAA, 1315 East-West Highway, Silver Spring, Maryland 20910

Tel: +1 301 713 2363, Fax: +1 301 713 1875, E-Mail: guillermo.diaz@noaa.gov

Restrepo, Victor

NOAA Fisheries, Southeast Fisheries Center, Sustainable Fisheries Division, 75 Virginia Beach Dr., Miami, Florida 33149

Tel: +1 305 361 4484, E-Mail: victor.restrepo@noaa.gov

Walter, John

NOAA Fisheries, Southeast Fisheries Center, Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami, Florida 33149-1099

Tel: +1 305 365 4114, Fax: +1 305 361 4562, E-Mail: john.f.walter@noaa.gov

URUGUAY**Domingo, Andres**

DINARA , 75 Constituyente 1497, Montevideo

Tel: +598 400 4689, E-Mail: adomingo@adinet.com.uy; adomingo@dinara.gub.uy

Pons, Maite

DINARA , 75 Constituyente 1497, Montevideo

Tel: +598 400 4689, E-Mail: pons.maite@gmail.com

ICCAT SECRETARIAT

C/ Corazón de María, 8-6th floor, 28002 Madrid – Spain

Tel: +34 91 416 5600; Fax: +34 91 415 2612; E-Mail: info@iccat.int

Kebe, Papa**Pallarés, Pilar****Palma, Carlos****Appendix 3****List of Documents**

- SCRS/2008/105 Estadísticas españolas de la pesquería atunera tropical, en el Océano Atlántico, hasta 2007.
DELGADO DE MOLINA, A., J.C. Santana and J. Ariz.
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Appendix 4

Appendices MFCL

Available from the ICCAT Secretariat upon request.

Appendix 5

Estimation of Combined Indices for Yellowfin and Skipjack

Combined indexes were estimated for both species using a GLM approach with the following model formulation:

$$\text{Log(index)} = \text{Year} + \text{Source} + \varepsilon$$

Where ‘Source’ identifies the index (fleet) included in the model and ε is the error term. Indexes expressed as number of fish per unit of effort were transformed into biomass by multiplying the index value times the average weight of the fish. Average weights were estimated from the yield-at-age and weight at age matrices for each specific fishery:

$$\bar{W}_{y,g} = \frac{\sum_a C_{y,a,g} * W_{y,a}}{\sum_a C_{y,a,g}}$$

Where y , a , and g identify the year, age, and fishery, respectively. Prior to estimating the combined indexes, individual indexes were scaled to their mean value of the overlapping years. Annual weighting factors were estimated for each fleet by counting the number of $5^\circ \times 5^\circ$ squares where each fishery operated and estimating the proportion to the total number of squares fished for each year. This approach allowed to capture the spatial expansion/contraction experienced by different fleets over time. The index weights were re-scaled so that they would add up to 1.0 each year.

$$\phi_{y,g} = \frac{Y_{y,g}}{\sum_g Y_{y,g}}$$

Yellowfin tuna

Table Appendix 5.1 shows the values of the indexes used in the GLM to estimate the combined index. The fleets included in the model were the Japanese longline, the combined Mexico and US longline in the Gulf of Mexico, the US rod and reel, the Brazilian longline, the Chinese-Taipei longline, the Canadian baitboat, the Venezuelan purse seine, the Brazilian baitboat, the EC-Dakar baitboat, the Venezuelan longline, and the EC-purse seine assuming a constant annual increase in catchability of 3%. The estimated weighting factors are shown in **Table Appendix 5.2** and the estimated unweighted and weighted combined indexes are presented in **Table Appendix 5.5** and **Figure Appendix 5.1**. Both the unweighted and weighted index showed similar trends with a sharp decrease in the late 1960s followed by a relatively stable period until about 1990. From 1990 onward both indexes showed a continuous declining trend.

Skipjack tuna

Table Appendix 5.3 presents the values of the indexes used in the GLM to estimated combined indexes for each skipjack stock. The fisheries used to estimate the combined index for the ATE stock were the EC-Dakar and EC-FAD purse seine fisheries and the Ghana, Canarian, Portugal and EC-Dakar baitboat fisheries. In the case of the ATW stock they were the Venezuelan purse seine, the US rod and reel and the Brazilian baitboat. The combined index for the skipjack eastern Atlantic stock (ATE) showed a variable but constant increasing trend from the beginning of the time series in 1965 to the end in 2006. The western Atlantic stock (ATW) series

started in 1981 and also showed a series with highly variable values but with a relatively constant trend. The weighting factors for each fishery/year are shown in the **Table Appendix 5.4**. Values of the estimated combined indexes for each stocks and matrices of weighting factors are shown in **Table Appendix 5.5** and **Figure Appendix 5.1**.

Table Appendix 5.1 Yellowfin scaled indexes of abundance used in the GLM to estimate a combined index. The indexes included were the Japanese longline (jp_ll), the combined Mexico and US longline in the Gulf of Mexico (mxus_ll), the US rod and reel (us_rr), the Brazilian longline (br_ll), the Chinese-Taipei longline (tai_ll), the Canarian baitboat (ca_bb), the Venezuelan purse seine (ve_ps), the Brazilian baitboat (br_bb), the EC-Dakar baitboat (eudkr_bb), the Venezuelan longline (ven_ll) and the EC-purse seine assuming an constant annual increase in catchability of 3% (ec_ps_3perc).

YEAR	jp_ll	mx_ll	us_rr	br_ll	uru_ll	tai_ll	ca_bb	ve_ps	br_bb	us_ll_atl	Eudkr_bb	ven_ll	ec_ps_3perc
1965	4.16												
1966	2.801												
1967	5.509												
1968	4.557					4.303							
1969	4.01					3.787					0.763		
1970	2.985					3.066					0.746		1.702
1971	2.396					1.745					0.737		1.452
1972	3.24					1.895					0.741		1.612
1973	2.275					2.185					0.682		1.625
1974	3.141					1.128					1.071		1.481
1975	2.334					0.971					0.469		1.595
1976	2.291					1.152					0.519		1.578
1977	1.778					1.038					0.792		1.55
1978	2.611					0.946					0.306		1.411
1979	3.149					0.982					0.577		1.403
1980	1.946					0.918	0.051						1.162
1981	2.456					1.256	0.953	0.103		4.468		1.186	1.247
1982	2.169					1.705	0.716	0.499		0.68		1.131	1.065
1983	2.158					0.735	0.917	0.878	2.199	1.85		1.151	0.924
1984	2.322					0.365	0.916	3.274	0.975	0.9		1.645	0.73
1985	1.484					0.654	0.901	1.422	1.646	0.673		1.264	1.255
1986	1.86	1.503	1.392	1.009	1.046	0.915	0.967	0.673			1.908		1.354
1987	1.961	0.714	1.758	0.973	0.953	2.043	0.74	0.947	2.567		2.152		1.186
1988	1.947	0.357	1.459	1.236	1.835	2.126	1.02	1.05	2.799		2.083		1.123
1989	1.524	0.588	1.477	0.492	1.328	1.257	2.21	0.96	2.218		0.502		1.4
1990	2.064	0.264	2.502	0.449	1.468	3.199	1.133	1.993	1.897		1.92		1.523
1991	1.573	0.424	1.373	1.617	1.233	2.827	1.157	0.602	1.41		1.39	1.114	1.212
1992	1.773	0.289	0.572	2.539	0.925	1.638	0.779	0.947	1.569		2.71	1.634	1.106
1993	0.845	1.124	0.658	0.664	0.485	1.082	0.748	0.892	1.124	0.953	2.2	2.352	1.095
1994	1.437	1.44	1.594	0.738	1.857	1.158	0.445	1.088	0.673	0.995	1.638	1.118	1.05
1995	0.99	0.92	2.164	0.501	0.763	1.283	0.189	0.49	0.333	1.134	0.979	0.765	1.073
1996	1.082	0.868	0.676	1.285	1.446	1.249	2.851	1.097	0.929	0.932	1.6	0.976	1.048
1997	0.821	0.936	0.29	1.017	0.474	0.971	0.341	0.74	1.355	0.999	0.679	0.597	0.971
1998	0.984	0.789	0.493	1.296	0.537	0.978	4.03	0.6	1.038	0.829	0.258	1.021	0.871
1999	0.995	1.198	0.974	1.215	1.088	0.721	0.384	0.879	0.359	0.949	0.74	0.932	0.783
2000	1.104	0.899	1.043	1.268	1.434	0.936	0.012	1.072		1.137	0.349	0.289	1.003
2001	0.743	0.825	1.109	1.017	0.916	0.623	0	2.143	2.189	1.072	0.558	0.95	1.106
2002	0.759	0.817	0.905	0.804	0.869	0.949	0.13	1.324	0.934	1.005	0.847		1.252
2003	0.895	1.02	0.825	1.705	1.32	1.283	0.244	0.647	0.764	0.868	0.967		1.068
2004	1.16	0.809	0.807	2.084	0.95	1.178	0.201	0.387	0.291	1.163	0.737		0.977
2005	0.881	0.766	0.606	0.254	2.002	1.475	0.027	0.198	0.332	1.252	0.601		1.058
2006	1.224	0.738	0.912	0.638	0.787	1.411	0.085		0.376	1.121	0.681		1.291

Table Appendix 5.2 Weighting factors (by fleet and year) used to estimate the yellowfin weighted combined index.

YEAR	jp_ll	mxus_ll	us_rr	br_ll	usu_ll	tai_ll	ve_ps	br_bb	us_ll_atl	ven_ll	ec_ps_3perc	can_bb	eudkr_bb
1965	1	0	0	0	0	0	0	0	0	0	0	0	0
1966	1	0	0	0	0	0	0	0	0	0	0	0	0
1967	1	0	0	0	0	0	0	0	0	0	0	0	0
1968	0.65	0	0	0	0	0.35	0	0	0	0	0	0	0
1969	0.47	0	0	0	0	0.46	0	0	0	0	0	0	0.07
1970	0.46	0	0	0	0	0.43	0	0	0	0	0.04	0	0.06
1971	0.53	0	0	0	0	0.37	0	0	0	0	0.04	0	0.06
1972	0.49	0	0	0	0	0.41	0	0	0	0	0.03	0	0.06
1973	0.47	0	0	0	0	0.4	0	0	0	0	0.05	0	0.08
1974	0.4	0	0	0	0	0.48	0	0	0	0	0.05	0	0.06
1975	0.48	0	0	0	0	0.42	0	0	0	0	0.06	0	0.05
1976	0.37	0	0	0	0	0.52	0	0	0	0	0.07	0	0.04
1977	0.34	0	0	0	0	0.53	0	0	0	0	0.09	0	0.04
1978	0.35	0	0	0	0	0.52	0	0	0	0	0.1	0	0.02
1979	0.41	0	0	0	0	0.47	0	0	0	0	0.08	0	0.04
1980	0.41	0	0	0	0	0.5	0	0	0	0	0.08	0	
1981	0.44	0	0	0	0.01	0.46	0	0.01	0	0	0.08	0	0
1982	0.43	0	0	0	0	0.47	0	0.02	0	0	0.07	0	0
1983	0.38	0	0	0	0.01	0.42	0.03	0.02	0	0	0.09	0	0.04
1984	0.37	0	0	0	0.03	0.39	0.06	0.03	0	0	0.08	0	0.03
1985	0.43	0	0	0	0.03	0.39	0.04	0.02	0	0	0.06	0	0.02
1986	0.36	0	0.03	0.06	0.03	0.4	0.02	0.02	0	0	0.06	0	0.02
1987	0.33	0	0.03	0.06	0.01	0.32	0.01	0.02	0.15	0	0.05	0	0.02
1988	0.4	0	0.03	0.06	0.01	0.16	0.01	0.01	0.19	0	0.08	0	0.03
1989	0.43	0	0.04	0.04	0	0.16	0.01	0.01	0.22	0	0.05	0	0.03
1990	0.4	0	0.03	0.05	0	0.2	0.02	0.02	0.19	0	0.05	0.02	0.03
1991	0.37	0	0.03	0.05	0	0.31	0.01	0.02	0.14	0.01	0.05	0	0.02
1992	0.35	0	0.03	0.1	0	0.23	0.01	0.02	0.16	0.01	0.06	0	0.03
1993	0.28	0.02	0.03	0.09	0	0.35	0.02	0.02	0.12	0.01	0.05	0	0.01
1994	0.31	0.02	0.03	0.07	0	0.37	0.01	0.01	0.11	0.01	0.04	0	0.01
1995	0.33	0.01	0.02	0.07	0	0.32	0.01	0.02	0.13	0	0.05	0	0.02
1996	0.28	0.02	0.03	0.11	0	0.33	0.02	0.01	0.13	0.01	0.06	0	0.02
1997	0.3	0.02	0.03	0.11	0	0.31	0.01	0.01	0.14	0.01	0.04	0	0.02
1998	0.3	0.02	0.03	0.1	0	0.33	0.01	0.02	0.13	0.01	0.05	0	0.01
1999	0.27	0.01	0.02	0.13	0	0.36	0.01	0.01	0.1	0.02	0.04	0	0.01
2000	0.31	0.01	0.02	0.07	0	0.38	0.01	0.01	0.09	0.03	0.05	0	0.01
2001	0.3	0.01	0.02	0.11	0	0.34	0.01	0.01	0.09	0.03	0.05	0	0.01
2002	0.27	0.01	0.02	0.12	0	0.4	0.01	0.02	0.09	0	0.04	0	0.01
2003	0.3	0.02	0.03	0.12	0	0.37	0.01	0.01	0.07	0	0.06	0	0.02
2004	0.3	0.01	0.02	0.11	0	0.38	0.01	0.01	0.07	0	0.07	0	0.01
2005	0.3	0.02	0.03	0.15	0	0.29	0.02	0.04	0.08	0	0.05	0	0.01
2006	0.41	0.02	0.04	0.19	0	0.11	0	0.03	0.1	0	0.07	0	0.02

Table Appendix 5.3 Skipjack indices of abundance values used in the GLM to estimate a combined indexes. The indexes used included for the Eastern Atlantic stock (ATE) the baitboat fisheries from Ghana (ghn_bb), Canary Islands (can1_bb and can2_bb), Portugal (por_bb), and EC-Dakar (eudkr1_bb and eudkr2_bb) and the purse seine fisheries from EC-Dakar (eudkr_ps) and the EC on FADs (ec_ps_fad). In the case of the western stock (ATW) the fisheries were the Brazilian baitboat (br_bb), the Venezuelan purse seine (ven_ps) and the US rod and reel (us_rr).

Year	ghn	can1_b	can2_b	por_b	SKJ - ATE				SKJ - ATW		
					eudkr1_b	eudkr2_b	ec_ps_fa	eudkr_p	br_b	ven_p	us_r
1969	1.13				0.121						
	1.61										
1970	2			0.019	0.213						
	1.86										
1971	5			0.793	0.299						
	1.58										
1972	1			0.453	0.263						
	1.13										
1973	8			0.196	0.219						
	1.23										
1974	3			0.066	0.319						
	0.66										
1975	4			0.02	0.175						
	0.91										
1976	7			0.39	0.257						
	1.20										
1977	1			0.998	0.224						
	1.29										
1978	6			1.216	0.296						
	2.30										
1979	8			0.823	0.503						
	1.77										
1980	1	1.439		0.678	0.518			0.147			
	2.34	2.035		0.907	0.651			0.612	1.17		
	2.05										
1982	5	2.105		1.497	0.62			0.61	1.58	4.08	
	0.265			0.133	0.376			0.098	0.62	1.58	
1984	0.883			1.557		0.273		0.363	0.65	1.17	
1985	2.471			0.605		0.311		0.26	0.93	1.41	
1986	0.405			1.149		0.38		0.696	0.94	0.85	1.52
1987	1.191			1.814		0.576		0.395	0.72	1.05	0.65
1988	1.26			3.258		0.663		0.704	0.83	0.85	1.02
1989	1.105			1.821		0.444		0.541	0.76	1.14	0.96
1990	0.811			0.264		0.79		0.765	1.34	1.03	0.95
1991	0.146			0.693		0.505	1.298	1.061	0.83	1.24	1.09
	0.16			0.258		0.516	0.838	0.688	0.94	0.87	0.43
1993	0.153			0.255		1.028	1.076	0.786	1.33	0.95	1.64
1994	0.676			0.475		0.966	0.853	0.608	0.82	0.64	0.8
1995	0.379			0.029		0.381	0.947	0.622	1.06	0.5	0.44
1996	1.376			1.569		2.118	0.765	0.286	0.92	1.14	0.53
1997	3.208			1.365		1.037	0.545	0.767	1.26	2	0.71
1998	4.821			0.733		1.732	0.474	0.883	0.81	1.49	1.38
1999	0.808			0.602		1.26	0.572	1.307	0.62	0.51	2.21
2000	0.901			0.208		1.198	0.803	0.861		0.56	0.52
2001	0.263			0.298		1.1	0.658	0.558	0.93	1.3	1.6
2002	0.041			0.827		1.23	0.668	0.272	0.78	0.6	1.29
2003	1.232			0.971		1.169	0.864	0.742	1.37	0.49	1.62
2004	0.605			1.05		1.148	1.008	0.825	0.97	0.51	0.83
2005	0.555			0.651		1.383	0.981	0.469	1.41	0.05	0.45
2006	0.904			2.71		1.376	0.806	0.401	1.37		0.37

Table Appendix 5.4 Weighting factors (by fleet and year) used to estimate the skipjack weighted combined indexes.

Year	SKJ - ATE								SKJ - ATW		
	ghn_bb	can1_bb	can2_bb	por_bb	eudkr1_bb	eudkr2_bb	ec_ps_fad	eudkr_ps	br_bb	ven_ps	us_rr
1969	0.21	0.00	0.00	0.00	0.79	0.00	0.00	0.00			
1970	0.17	0.00	0.00	0.08	0.75	0.00	0.00	0.00			
1971	0.17	0.00	0.00	0.09	0.74	0.00	0.00	0.00			
1972	0.19	0.00	0.00	0.10	0.71	0.00	0.00	0.00			
1973	0.22	0.00	0.00	0.11	0.67	0.00	0.00	0.00			
1974	0.24	0.00	0.00	0.12	0.65	0.00	0.00	0.00			
1975	0.25	0.00	0.00	0.17	0.58	0.00	0.00	0.00			
1976	0.25	0.00	0.00	0.17	0.58	0.00	0.00	0.00			
1977	0.47	0.00	0.00	0.12	0.41	0.00	0.00	0.00			
1978	0.30	0.00	0.00	0.20	0.50	0.00	0.00	0.00			
1979	0.23	0.00	0.00	0.15	0.62	0.00	0.00	0.00			
1980	0.25	0.05	0.00	0.10	0.40	0.00	0.00	0.20			
1981	0.21	0.05	0.00	0.11	0.42	0.00	0.00	0.21	1.00	0.00	0.00
1982	0.35	0.04	0.00	0.09	0.35	0.00	0.00	0.17	0.56	0.44	0.00
1983	0.00	0.06	0.00	0.13	0.56	0.00	0.00	0.25	0.57	0.43	0.00
1984	0.00	0.07	0.00	0.13	0.00	0.53	0.00	0.27	0.42	0.58	0.00
1985	0.00	0.08	0.00	0.15	0.00	0.46	0.00	0.31	0.47	0.53	0.00
1986	0.00	0.08	0.00	0.15	0.00	0.46	0.00	0.31	0.38	0.14	0.48
1987	0.00	0.08	0.00	0.17	0.00	0.42	0.00	0.33	0.32	0.16	0.53
1988	0.00	0.06	0.00	0.17	0.00	0.50	0.00	0.28	0.22	0.22	0.56
1989	0.00	0.07	0.00	0.13	0.00	0.53	0.00	0.27	0.24	0.18	0.59
1990	0.00	0.26	0.00	0.11	0.00	0.42	0.00	0.21	0.29	0.24	0.48
1991	0.00	0.03	0.00	0.07	0.00	0.24	0.55	0.10	0.37	0.11	0.53
1992	0.00	0.00	0.03	0.06	0.00	0.18	0.61	0.12	0.29	0.24	0.48
1993	0.00	0.00	0.04	0.07	0.00	0.19	0.63	0.07	0.32	0.28	0.40
1994	0.00	0.00	0.03	0.06	0.00	0.15	0.61	0.15	0.26	0.21	0.53
1995	0.00	0.00	0.03	0.06	0.00	0.20	0.60	0.11	0.32	0.23	0.45
1996	0.00	0.00	0.03	0.06	0.00	0.16	0.63	0.13	0.33	0.19	0.48
1997	0.00	0.00	0.03	0.06	0.00	0.18	0.62	0.12	0.32	0.23	0.45
1998	0.00	0.00	0.03	0.06	0.00	0.21	0.62	0.09	0.38	0.21	0.42
1999	0.00	0.00	0.03	0.05	0.00	0.19	0.62	0.11	0.22	0.22	0.56
2000	0.00	0.00	0.03	0.09	0.00	0.23	0.54	0.11	0.22	0.22	0.56
2001	0.00	0.00	0.03	0.09	0.00	0.13	0.63	0.13	0.30	0.20	0.50
2002	0.00	0.00	0.03	0.09	0.00	0.18	0.61	0.09	0.33	0.19	0.48
2003	0.00	0.00	0.03	0.06	0.00	0.18	0.62	0.12	0.26	0.21	0.53
2004	0.00	0.00	0.03	0.05	0.00	0.16	0.65	0.11	0.29	0.24	0.48
2005	0.00	0.00	0.03	0.06	0.00	0.18	0.64	0.09	0.47	0.24	0.29
2006	0.00	0.00	0.04	0.07	0.00	0.18	0.57	0.14	0.38	0.00	0.63

Table Appendix 5.5 Estimated yellowfin and skipjack weighted and unweighted combined indexes. Refer to text for explanation of the fleets used in the GLM procedure.

Year	<i>Yellowfin</i>		<i>Skipjack - ATE</i>		<i>Skipjack - ATW</i>	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
1965	2.5708	2.5708	0.1476	0.220		
1966	1.7311	1.7311	0.1985	0.142		
1967	3.4049	3.4049	0.3608	0.582		
1968	3.2299	3.2299	0.3063	0.438		
1969	1.9136	1.9136	0.2339	0.279		
1970	1.5549	1.5549	0.2681	0.226		
1971	1.2247	1.2247	0.1230	0.102		
1972	1.3862	1.3862	0.2730	0.345		
1973	1.2904	1.2904	0.3052	0.492		
1974	1.2970	1.2970	0.4099	0.593		
1975	0.9611	0.9611	0.5716	0.752		
1976	1.0211	1.0211	0.4586	0.594		
1977	1.0334	1.0334	0.7638	0.994		
1978	0.8556	0.8556	0.7091	1.067		
1979	1.0593	1.0593	0.2645	0.227		
1980	0.5871	0.5871	0.5238	0.694		
1981	1.1711	1.1711	0.4980	0.674	1.1371	1.160
1982	1.0718	1.0718	0.7100	0.677	2.5823	2.420
1983	1.3095	1.3095	0.8498	0.956	1.0104	0.934
1984	1.1961	1.1961	1.1888	1.344	0.8831	0.918
1985	1.1660	1.1660	0.7824	0.953	1.1639	1.170
1986	1.2742	1.2742	0.8196	0.685	1.0632	1.152
1987	1.3523	1.3523	1.1653	0.667	0.7874	0.719
1988	1.4114	1.4114	0.8892	0.532	0.8940	0.929
1989	1.1496	1.1496	1.1556	0.651	0.9410	0.930
1990	1.4176	1.4176	1.0684	0.890	1.0947	1.064
1991	1.2238	1.2238	0.8047	0.387	1.0400	0.992
1992	1.1837	1.1837	1.1339	1.283	0.7074	0.636
1993	0.9902	0.9902	0.9468	1.458	1.2769	1.315
1994	1.0952	1.0952	0.9560	1.548	0.7491	0.763
1995	0.7577	0.7577	0.9832	1.097	0.6162	0.597
1996	1.1553	1.1553	1.0552	0.884	0.8227	0.733
1997	0.7201	0.7201	0.8262	0.643	1.2126	1.073
1998	0.8519	0.8519	0.8533	0.484	1.1828	1.141
1999	0.8140	0.8140	1.2205	1.255	0.8910	1.200
2000	0.6015	0.6015	1.3322	1.161	0.5497	0.532
2001	0.5274	0.5274	1.2468	0.956	1.2446	1.297
2002	0.8007	0.8007	1.1831	1.305	0.8448	0.937
2003	0.8928	0.8928	0.1476	0.220	1.0310	1.202
2004	0.7589	0.7589	0.1985	0.142	0.7431	0.769
2005	0.5288	0.5288	0.3608	0.582	0.3078	0.449
2006	0.6980	0.6980	0.3063	0.438	0.6849	0.592

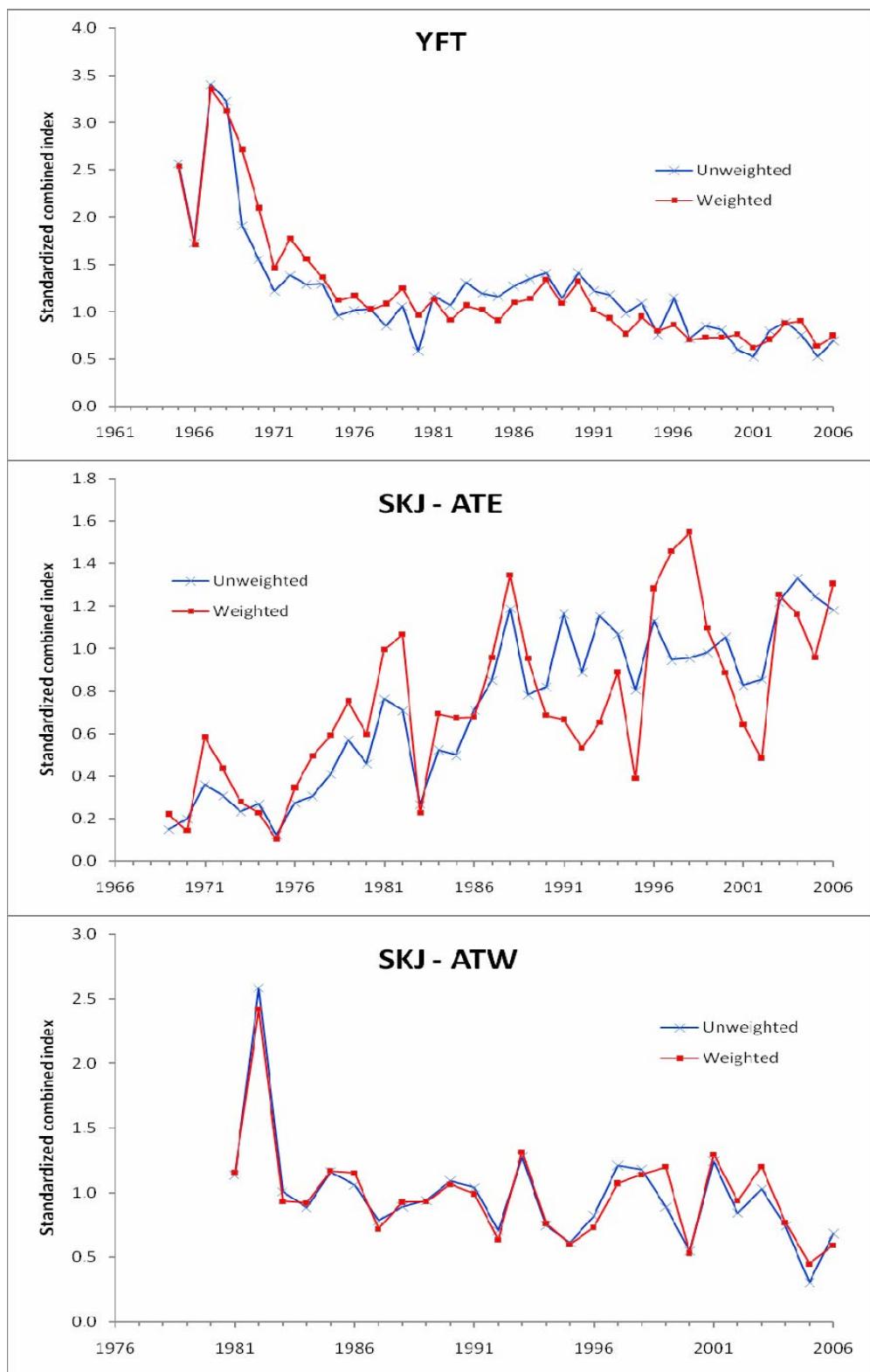


Figure Appendix 5.1 Estimated combined weighted and unweighted indexes of abundances for yellowfin and the two stocks of skipjack.

Appendix 6

Developing Demographic Priors for Yellowfin and Skipjack Tuna

Demographic priors for \mathbf{r} for both yellowfin and skipjack tuna were obtained using methods described in McAllister *et al* (2001) whereby estimates of \mathbf{r} are obtained by repeatedly sampling from distributions of basic life history inputs. This method operates by recasting the intrinsic rate of population increase into component parts for which we either have greater knowledge of than \mathbf{r} or for which we can place reasonable distributions around. Prior distributions for \mathbf{r} were obtained through Monte Carlo sampling of inputs and then numerically solving the Euler-Lotka population growth equation using methods outlined in originally in McAllister (2001) and McAllister & Carruthers (2007). The method proceeds by numerically solving for \mathbf{r} from the Euler-Lotka equation (Lotka 1907) with the integration over ages starting at age 0:

$$1 = \int_{a=0}^{\infty} l_a m_a \exp(-a \times r) da \quad (a1)$$

where l_a is the fraction of animals surviving from age 0 to age a where the fraction is set at 1 for l_0 , and m_a is the number of age 0 offspring expected to be produced by an individual of age a . Equation (a1) can be approximated by the discrete equation below:

$$1 = \sum_{a=0}^{\infty} l_a m_a \exp(-a \times r) \quad (a2)$$

Survivorship (l_a) or the fraction of the initial population surviving to age a can be obtained as follows:

$$l_a = l_0 \exp\left(-\sum_{i=0}^{a-1} M_i\right) \quad (a3)$$

Where M_i is natural mortality at age. McAllister & Carruthers (2008) make a particularly useful advancement by starting the integration (or summation if using (a2)) of equation (a1) at age 1 and setting l_1 equal to 1. What follows is a description of this method. Provided that there is no reproduction in the first year of the life ($m_0=0$) and m_a can be specified in terms of age 1 recruits, this bypasses the need to obtain estimates of larval survival and production of larval fish per spawner, making the solution of equation (a1) or (a2) far more tractable.

Estimates of the expected number of recruits produced per adult female of age a , m_a , were obtained by:

$$m_a = \tilde{R}_S W_a G_a \quad (a4)$$

where \tilde{R}_S is the number of age 1 recruits produced per unit of spawning potential at spawner abundance approaching zero (\tilde{R}_S), W_a is the mass per fish of age a in grams, and G_a is the fraction of animals of age a that are mature. (\tilde{R}_S) was computed using an assumed Beverton-Holt stock recruitment relationship for both skipjack and yellowfin tuna:

$$\tilde{R}_S = \frac{4h}{S(1-h)} \quad (a5)$$

Where steepness (h) was obtained from a sample from the beta() distributions indicated below in Inputs. Estimates of the spawner biomass produced per single age 1 recruit (\tilde{S}) were obtained as follows:

$$\tilde{S} = \left(\sum_{a=1}^{a_p-1} (W_a G_a \exp(-(a-1) M_a)) \right) + W_{a_p} G_{a_p} \frac{\exp(-a_p M_a)}{1 - \exp(-M_a)} \quad (a6)$$

Where W_a and G_a were defined as above, M_a is natural mortality at age, a_p is the age of the plus group. However, as no plus group was used for either species the right side equation (a6) was dropped and a_p equals the last age (10). It is likely more correct to include a plus group on the last age, however, given the high mortality rates for both species including a plus group likely would have little impact upon the resulting r values.

Inputs

Inputs into the Euler-Lotka equation take the form of a standard life table representing survivorship, or a natural mortality at age schedule, a fecundity and maturity schedule, lengths at age and weights at age derived from lengths (**Table Appendix 6.1 and Table Appendix 6.2**) (Gotelli & Ellison, 2001). Inputs into the life tables are maturity, survival, weight and reproductive output. Weights at age were computed from lengths using ICCAT length-weight conversions (skipjack: $RWT = 7.480 \times 10^{-6} (FL)^{3.2526}$ (Cayré-Laloe, 1986); yellowfin: $RWT = 2.1527 \times 10^{-5} * FL^{2.976}$ (Caveriviere, 1976)) where the lengths at age were determined from sampling from distributions of Von Bertalanffy growth equation parameters as shown below. Maturity at age for skipjack was assumed to be 50% at age 2 and 100% at age 3 based on an assumed size at first maturity of either 41 cm (Entire Atlantic: Cayré & Farrugio, 1986), or 51 cm (Southwestern Atlantic: Vilela & Castello, 1993). For yellowfin maturity was assumed to be knife-edged at age 3 (Anon 2003).

1. prior distribution on steepness (h) was chosen to be distributed according to a beta() function with a mode of 0.9. This is based upon examination of the prior distribution for h used in the western Pacific skipjack and yellowfin tuna assessments (Hampton, 2002; Langley *et al.* 2003) but allowing a greater density towards lower values of steepness. This chosen beta(18, 4) distribution was used for both yellowfin and skipjack tuna.

2. prior distributions of mortality at age The vector of mortality at age for skipjack was assumed to be constant at 0.8 for all ages (Anon. 1984) which is close to the value (0.77) estimated Vilela & Castello (1993) using the equation of Rikhter and Efanov (1976). Each mortality at age value was assumed to be distributed as a normal (u , 0.04) random variable and a single value for mortality at age was chosen from these distributions for each Monte Carlo simulation. For yellowfin tuna mortality natural mortality was assumed to be 0.8 for ages 1 and 2, and 0.6 for ages 3-10. The life tables were extended out to a maximum age of 10 with no plus group for both yellowfin and skipjack tuna.

3. prior distributions on growth rate paramters. For skipjack prior values of K and L_{inf} were chosen from von Bertalannfy K and L_{inf} pairs obtained from a meta-analysis (Gaertner *et al.* 2008) of skipjack growth rates. For each iteration a single pair of K and L_{inf} was chosen. For yellowfin tuna, an empirical bivariate normal distribution (R code: `rmvnorm (n, mean = c(191.30,0.47), sigma= matrix(c(617.4366667, -3.683830769, -3.683830769, 0.033582936), ncol=2)`) was constructed from the set of 26 Von Bertalannfy K and L_{inf} values found in FISH-BASE. From this distribution a random set of von Bertalannfy K and L_{inf} pairs was chosen for each Monto Carlo run. For all samples for yellowfin t_o was set to zero.

For both species 1000 estimates of r were obtained by numerically solving for r from random combinations of h , M_i , and the von Bertalannfy growth rate parameters using the R function “nlminb”. Histograms of the prior distributions are shown in **Figure Appendix 6.1** for both yellowfin and skipjack tunas with mean values equal to 0.76 and 1.17, respectively. For input into the catch-free models the empirical histogram values were input into as prior distributions for r . For the BSP and PROCEAN model a $N(1.17, 0.25)$ distribution was used as a prior for r . While the BSP model was not applied to yellowfin tuna during this assessment, the construction of demographic priors for the species will facilitate further analyses that require or can benefit from demographic priors.

Table Appendix 6.1. Life table analysis for skipjack tuna. Description of inputs are given in the text.

<i>Age</i>	<i>Maturity</i> (G_a)	<i>Mortality</i> (M_a)	<i>Survival</i> ($\exp(-M_a)$)	<i>Survivor-</i> <i>ship</i> (l_a)	<i>length</i> <i>from</i> <i>Von</i> <i>Bert.</i> $K = .294$ $L_{inf} = 91$	<i>Weight (kg) =</i> $0.00000748 *$ $length^{3.2526}$ <i>Cayré & Laloë,</i> 1983
1	0	0.8	0.449	1.000	23.180	0.2061
2	0.5	0.8	0.449	0.449	40.455	1.2611
3	1	0.8	0.449	0.202	53.330	3.0978
4	1	0.8	0.449	0.091	62.926	5.3060
5	1	0.8	0.449	0.041	70.077	7.5304
6	1	0.8	0.449	0.018	75.406	9.5578
7	1	0.8	0.449	0.008	79.378	11.2947
8	1	0.8	0.449	0.004	82.339	12.7232
9	1	0.8	0.449	0.002	84.545	13.8659
10	1	0.8	0.449	0.001	86.189	14.7624

Table Appendix 6.2 Life table analysis for yellowfin tuna. Description of inputs are given in the text. Note that the Von Bertalanffy parameters for this table are from Lessa & Duarte-Neto (2004) but for the Monte-Carlo sampling are chosen from the bivariate normal distribution.

Age	Maturity (G_a)	Mortality (M_a)	Survival ($\exp(-M_a)$)	Survivor- ship (l_a)	length from Von Bert. $t_o = 0.042, K =$.281 $L_{inf} = 245$	Weight (kg) = $2.153 \cdot 10^{-5} \cdot FL^{2.98}$ (Caveriviere, 1976)
1	0	0.8	0.449	1.000	57.66	3.74
2	0	0.8	0.449	0.449	98.05	18.18
3	1	0.6	0.549	0.247	128.97	41.09
4	1	0.6	0.549	0.135	152.64	67.86
5	1	0.6	0.549	0.074	170.77	94.76
6	1	0.6	0.549	0.041	184.65	119.57
7	1	0.6	0.549	0.022	195.28	141.24
8	1	0.6	0.549	0.012	203.41	159.48
9	1	0.6	0.549	0.007	209.64	174.46
10	1	0.6	0.549	0.004	214.41	186.55

Table Appendix 6.3 Compilation if L_{inf} and K pairs randomly chosen to obtain lengths at age obtained from a metanalysis of skipjack tuna growth (Gaertner 2008). For each Monte Carlo simulation, a single L_{inf} and K pair was chosen randomly. Rows indicated with an asterisk were not used in the simulations as they were deemed to be outliers.

L_{inf}	K	PhiPrime	Method
62	2.08	3.903	Tagging*
66.5	1.806	3.902	Tagging*
60	1.537	3.743	Tagging*
61.3	1.25	3.672	Tagging
80	0.95	3.784	Length
65.5	0.945	3.608	Tagging
60.6	0.93	3.533	Length
73	0.82	3.64	Tagging
75.5	0.77	3.642	Tagging
60	0.75	3.431	Length
79	0.64	3.601	Tagging
85	0.62	3.651	Length
80	0.601	3.585	Tagging
76.6	0.6	3.547	Length
64.3	0.55	3.357	Tagging
102.2	0.55	3.759	Reading
77	0.52	3.489	Length
96.3	0.515	3.679	Tagging
74.8	0.515	3.46	Length
90	0.49	3.599	Length
82	0.45	3.481	Length
93.6	0.43	3.576	Reading
107	0.42	3.682	Length
94.9	0.34	3.486	Length
80	0.322	3.314	Tagging
86.7	0.307	3.363	Reading
103.6	0.302	3.511	Reading
97.26	0.251	3.376	Tagging
87.12	0.219	3.221	Reading

*Not used

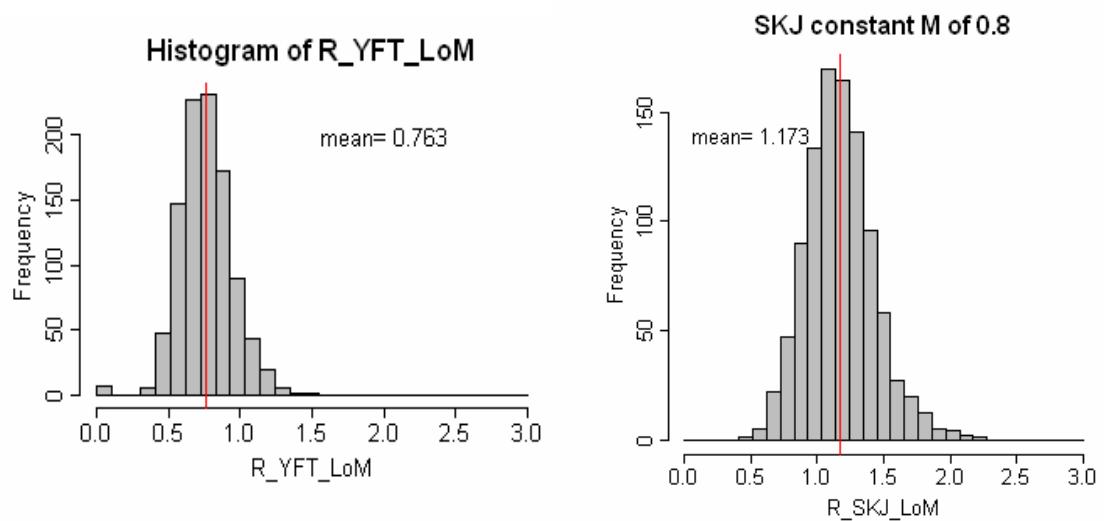


Figure Appendix 6.1 Histograms of prior distributions for r for yellowfin and skipjack obtained from demographic analysis.

Appendix 7

VPA Results. Report Files for YFT VPA Base Runs 5 and 10

Run 5. This file contains basic model inputs and results.

```
*****
      VPA-2BOX
  SUMMARY STATISTICS AND DIAGNOSTIC OUTPUT
*****  

YFT 1970-2006 RUN 5
12:48, 26 July 2008  

=====  

Total objective function = -25.06
  (with constants) = 297.49
Number of parameters (P) = 58
Number of data points (D)= 351
AIC : 2*objective+2P = 710.98
AICc: 2*objective+2P(..)= 734.42
BIC : 2*objective+Plog(D)= 934.91
Chi-square discrepancy = 421.37  

Loglikelihoods (deviance)= -44.11 ( 350.36)
effort data = -44.11 ( 350.36)  

Log-posteriors = 56.58
  catchability = 0.00
  f-ratio = 56.58
  natural mortality = 0.00
  mixing coeff. = 0.00  

Constraints = 12.59
  terminal F = 10.17
  stock-rec./sex ratio = 2.42  

Out of bounds penalty = 0.00
=====
```

TABLE 1. FISHING MORTALITY RATE FOR Yellowfin Tuna 2008

	0	1	2	3	4	5
1970	0.009	0.128	0.093	0.158	0.172	0.039
1971	0.009	0.120	0.174	0.149	0.151	0.034
1972	0.012	0.128	0.217	0.237	0.196	0.044
1973	0.007	0.115	0.186	0.273	0.261	0.058
1974	0.023	0.169	0.224	0.310	0.333	0.073
1975	0.040	0.178	0.298	0.356	0.576	0.124
1976	0.046	0.195	0.219	0.383	0.691	0.146
1977	0.035	0.212	0.232	0.370	0.669	0.139
1978	0.040	0.214	0.265	0.384	0.461	0.095
1979	0.048	0.242	0.147	0.391	0.502	0.105
1980	0.082	0.243	0.205	0.318	0.508	0.109
1981	0.122	0.273	0.233	0.364	0.810	0.183
1982	0.055	0.337	0.247	0.489	0.912	0.217
1983	0.069	0.246	0.228	0.632	1.047	0.253
1984	0.053	0.291	0.271	0.272	0.310	0.071
1985	0.069	0.190	0.240	0.325	0.654	0.136
1986	0.069	0.176	0.144	0.371	0.550	0.106
1987	0.119	0.204	0.147	0.258	0.498	0.090
1988	0.113	0.253	0.131	0.298	0.279	0.049
1989	0.110	0.245	0.119	0.312	0.567	0.099
1990	0.134	0.300	0.145	0.392	0.833	0.146
1991	0.129	0.293	0.156	0.384	0.750	0.129
1992	0.117	0.277	0.172	0.404	0.881	0.148
1993	0.154	0.273	0.222	0.467	0.723	0.120
1994	0.114	0.319	0.303	0.386	0.894	0.149
1995	0.125	0.303	0.205	0.347	0.820	0.143
1996	0.130	0.365	0.216	0.364	0.731	0.138
1997	0.107	0.415	0.201	0.315	0.657	0.138
1998	0.085	0.427	0.250	0.364	0.876	0.208
1999	0.135	0.556	0.303	0.394	0.690	0.179
2000	0.178	0.365	0.186	0.545	0.726	0.201
2001	0.157	0.703	0.278	0.456	0.944	0.276
2002	0.173	0.514	0.228	0.393	0.699	0.222
2003	0.177	0.530	0.192	0.462	0.688	0.245
2004	0.150	0.442	0.264	0.401	0.688	0.266
2005	0.156	0.412	0.196	0.320	0.606	0.242
2006	0.137	0.290	0.212	0.402	0.602	0.240

TABLE 2. ABUNDANCE AT THE BEGINNING OF THE YEAR [BY AREA] FOR Yellowfin Tuna 2008

	0	1	2	3	4	5
1970	56827076.	26816375.	9071802.	5884865.	2793144.	2966660.
1971	55106729.	25298304.	10606195.	4537515.	2758725.	2856222.
1972	47054028.	24536455.	10086825.	4889354.	2146497.	2815868.
1973	51632776.	20900939.	9696256.	4457788.	2116338.	2447425.
1974	56299245.	23041404.	8369699.	4416666.	1861879.	2162395.
1975	68100480.	24718895.	8741493.	3673188.	1778511.	1835313.
1976	70980976.	29394694.	9299178.	3560807.	1411955.	1438214.
1977	62688538.	30472596.	10865238.	4101046.	1332649.	1070197.
1978	58214208.	27198591.	11080421.	4727969.	1555082.	885900.

1979	62168958.	25120192.	9862202.	4666806.	1767372.	980099.
1980	58551869.	26614566.	8861610.	4671485.	1733012.	1071574.
1981	84969788.	24231497.	9378199.	3962195.	1865189.	1099634.
1982	72220041.	33803026.	8283350.	4079113.	1510692.	957699.
1983	93618531.	30722104.	10846076.	3551608.	1373457.	755870.
1984	81032660.	39255938.	10797621.	4739407.	1036099.	586785.
1985	92594770.	34523286.	13189634.	4519391.	1980767.	716953.
1986	80000485.	38831521.	12826872.	5693023.	1792549.	908768.
1987	80414113.	33537951.	14633132.	6093126.	2155891.	1016047.
1988	67810039.	32064870.	12287775.	6933962.	2583632.	1228496.
1989	80687185.	27200090.	11185917.	5918445.	2825847.	1715199.
1990	78485573.	32467672.	9562891.	5452106.	2376462.	1732600.
1991	75078726.	30840093.	10805767.	4540212.	2022515.	1388887.
1992	80528069.	29648712.	10334831.	5074422.	1697735.	1194334.
1993	87100552.	32186810.	10098026.	4777056.	1858795.	951405.
1994	66443625.	33544313.	11011292.	4438584.	1643773.	957994.
1995	63832247.	26626621.	10953309.	4462745.	1655519.	822078.
1996	63898099.	25308041.	8835028.	4895966.	1731451.	791223.
1997	72830487.	25206331.	7895838.	3905446.	1866539.	835581.
1998	93078749.	29412868.	7481199.	3545574.	1564866.	930587.
1999	69538085.	38407535.	8621467.	3197076.	1351838.	772262.
2000	73582135.	27295975.	9900397.	3493399.	1183460.	726455.
2001	73830946.	27667459.	8517649.	4511530.	1111479.	640601.
2002	64995513.	28351317.	6152743.	3539845.	1568726.	504214.
2003	60926366.	24573507.	7615827.	2689564.	1310971.	649440.
2004	73658093.	22937269.	6499403.	3450777.	930406.	640551.
2005	57823827.	28495271.	6626683.	2738768.	1268101.	525862.
2006	52099904.	22238924.	8484458.	2989618.	1091007.	606128.
2007		20415829.	7477540.	3766537.	1097412.	589827.

TABLE 3. CATCH OF Yellowfin Tuna 2008

	0	1	2	3	4	5
1970	361290.	2229482.	607301.	650369.	335068.	85575.
1971	344448.	1977021.	1287353.	474486.	293744.	72602.
1972	370595.	2052767.	1492978.	786068.	289931.	91172.
1973	243206.	1577104.	1251198.	811921.	370436.	103603.
1974	886952.	2496615.	1274896.	897957.	403301.	115146.
1975	1850686.	2801854.	1719568.	842170.	602660.	162022.
1976	2183572.	3635133.	1388487.	867883.	547868.	148267.
1977	1488116.	4057058.	1711726.	970685.	504842.	105140.
1978	1592943.	3664928.	1963323.	1155362.	441937.	60903.
1979	2028285.	3775358.	1022740.	1156845.	537482.	73775.
1980	3200008.	4016663.	1247358.	972350.	532110.	83719.
1981	6758071.	4062149.	1479983.	926044.	810154.	139639.
1982	2657563.	6800765.	1379253.	1214320.	710570.	142131.
1983	4323476.	4680819.	1680974.	1290371.	704840.	128569.
1984	2901125.	6946804.	1953147.	861417.	211065.	30274.
1985	4268983.	4165569.	2143130.	957578.	738008.	69106.
1986	3706439.	4362541.	1306129.	1351567.	586169.	68951.
1987	6280192.	4318997.	1513905.	1055188.	652139.	65881.
1988	5045170.	5018133.	1138051.	1362108.	479093.	44092.
1989	5844442.	4139343.	946698.	1212904.	945449.	121843.
1990	6840077.	5910204.	977104.	1354542.	1052048.	177816.
1991	6313402.	5500947.	1181880.	1108701.	832673.	126849.
1992	6170239.	5029419.	1236534.	1294467.	780051.	124612.
1993	8654594.	5382283.	1528458.	1371075.	745384.	81507.
1994	4983084.	6443400.	2198100.	1089902.	762615.	100493.
1995	5210909.	4889679.	1543835.	1000446.	724878.	82982.
1996	5415623.	5453178.	1306456.	1144517.	699652.	77460.
1997	5109588.	6051401.	1090160.	805058.	697640.	81796.
1998	5261746.	7237372.	1260581.	828678.	716679.	132870.
1999	6104314.	11684800.	1722161.	797909.	524019.	96085.
2000	8362333.	5878954.	1274923.	1133947.	475691.	100301.
2001	7465211.	10065910.	1576328.	1271341.	534448.	117632.
2002	7175201.	8115388.	952183.	882558.	613958.	76429.
2003	6879341.	7202107.	1008228.	764832.	507098.	107459.
2004	7118910.	5801751.	1149694.	874474.	360014.	114175.
2005	5792990.	6796869.	895413.	573610.	446518.	86079.
2006	4628314.	3926747.	1232116.	759365.	382044.	98240.

TABLE 4. SPAWNING STOCK FECUNDITY AND RECRUITMENT OF Yellowfin Tuna 2008

year	spawning biomass	recruits from VPA
1970	527927.	56827076.
1971	481016.	55106729.
1972	454589.	47054028.
1973	412567.	51632776.
1974	376086.	56299245.
1975	324436.	68100480.
1976	272667.	70980976.
1977	256577.	62688538.
1978	272458.	58214208.
1979	288027.	62168958.
1980	293904.	58551869.
1981	279967.	84969788.
1982	253417.	72220041.
1983	215698.	93618531.
1984	226445.	81032660.
1985	274518.	92594770.
1986	311782.	80000485.
1987	350898.	80414113.
1988	413286.	67810039.
1989	429900.	80687185.
1990	391943.	78485573.
1991	325441.	75078726.

1992	308360.	80528069.
1993	290867.	87100552.
1994	271127.	66443625.
1995	263249.	63832247.
1996	276953.	63898099.
1997	260906.	72830487.
1998	240945.	93078749.
1999	210427.	69538085.
2000	205339.	73582135.
2001	222426.	73830946.
2002	210526.	64995513.
2003	184918.	60926366.
2004	186435.	73658093.
2005	176398.	57823827.
2006	179806.	52099904.

TABLE 5. FITS TO INDEX DATA FOR Yellowfin Tuna 2008

5.1 BRA_BB

Lognormal dist.
month 6 biomass
Ages 0 - 4
log-likelihood = -1.51
deviance = 21.69
Chi-sq. discrepancy= 29.46

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1981	1.614	-0.079	1.693	0.688	0.163E-08	1.391	0.256	17.865
1982	-0.269	-0.076	-0.193	0.688	0.163E-08	0.212	0.257	0.201
1983	0.732	0.185	0.547	0.688	0.163E-08	0.576	0.333	0.218
1984	0.012	0.185	-0.173	0.688	0.163E-08	0.280	0.333	0.187
1985	-0.279	0.359	-0.638	0.688	0.163E-08	0.209	0.396	0.561
1986	-0.279	0.347	-0.626	0.688	0.163E-08	0.209	0.392	0.551
1987	0.063	0.444	-0.381	0.688	0.163E-08	0.295	0.432	0.351
1988	0.165	0.327	-0.162	0.688	0.163E-08	0.327	0.384	0.178
1989	0.076	0.265	-0.189	0.688	0.163E-08	0.299	0.361	0.199
1990	0.807	0.121	0.686	0.688	0.163E-08	0.620	0.312	0.530
1991	-0.390	0.245	-0.635	0.688	0.163E-08	0.187	0.354	0.558
1992	0.062	0.120	-0.058	0.688	0.163E-08	0.295	0.312	0.107
1993	0.234	-0.093	0.327	0.688	0.163E-08	0.350	0.252	0.015
1994	-0.278	0.131	-0.410	0.688	0.163E-08	0.210	0.316	0.374
1995	-0.983	0.172	-1.155	0.688	0.163E-08	0.104	0.329	0.931
1996	0.044	-0.002	0.045	0.688	0.163E-08	0.289	0.276	0.050
1997	0.421	-0.113	0.533	0.688	0.163E-08	0.422	0.247	0.196
1998	0.154	-0.247	0.401	0.688	0.163E-08	0.323	0.216	0.052
1999	-0.906	-0.256	-0.650	0.688	0.163E-08	0.112	0.214	0.570
2001	0.900	-0.310	1.210	0.688	0.163E-08	0.681	0.203	4.475
2002	0.049	-0.362	0.411	0.688	0.163E-08	0.291	0.193	0.060
2003	-0.151	-0.338	0.187	0.688	0.163E-08	0.238	0.197	0.004
2004	-1.118	-0.444	-0.674	0.688	0.163E-08	0.091	0.178	0.589
2005	-0.985	-0.408	-0.577	0.688	0.163E-08	0.103	0.184	0.511
2006	0.305	-0.174	0.479	0.688	0.163E-08	0.376	0.233	0.124

Selectivities by age

Year	0	1	2	3	4
1981	0.007	0.621	1.000	0.196	0.011
1982	0.007	0.621	1.000	0.196	0.011
1983	0.007	0.621	1.000	0.196	0.011
1984	0.007	0.621	1.000	0.196	0.011
1985	0.007	0.621	1.000	0.196	0.011
1986	0.007	0.621	1.000	0.196	0.011
1987	0.007	0.621	1.000	0.196	0.011
1988	0.007	0.621	1.000	0.196	0.011
1989	0.007	0.621	1.000	0.196	0.011
1990	0.007	0.621	1.000	0.196	0.011
1991	0.007	0.621	1.000	0.196	0.011
1992	0.007	0.621	1.000	0.196	0.011
1993	0.007	0.621	1.000	0.196	0.011
1994	0.007	0.621	1.000	0.196	0.011
1995	0.007	0.621	1.000	0.196	0.011
1996	0.007	0.621	1.000	0.196	0.011
1997	0.007	0.621	1.000	0.196	0.011
1998	0.007	0.621	1.000	0.196	0.011
1999	0.007	0.621	1.000	0.196	0.011
2001	0.007	0.621	1.000	0.196	0.011
2002	0.007	0.621	1.000	0.196	0.011
2003	0.007	0.621	1.000	0.196	0.011
2004	0.007	0.621	1.000	0.196	0.011
2005	0.007	0.621	1.000	0.196	0.011
2006	0.007	0.621	1.000	0.196	0.011

5.2 BRA_LL

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 4.15
deviance = 7.39
Chi-sq. discrepancy= 3.63

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
-----	-----	-----	-----	-----	-----	-----	-----	-----

1986	0.178	0.310	-0.132	0.688	0.156E-07	0.177	0.201	0.157
1987	0.416	0.348	0.068	0.688	0.156E-07	0.224	0.209	0.040
1988	0.645	0.330	0.315	0.688	0.156E-07	0.282	0.206	0.011
1989	0.571	0.227	0.344	0.688	0.156E-07	0.262	0.185	0.021
1990	0.752	0.159	0.592	0.688	0.156E-07	0.313	0.173	0.301
1991	0.177	0.110	0.067	0.688	0.156E-07	0.176	0.165	0.040
1992	-0.300	0.104	-0.405	0.688	0.156E-07	0.109	0.164	0.370
1993	-1.013	0.102	-1.115	0.688	0.156E-07	0.054	0.164	0.906
1994	-0.468	0.079	-0.548	0.688	0.156E-07	0.093	0.160	0.488
1995	-0.661	0.030	-0.690	0.688	0.156E-07	0.076	0.152	0.603
1996	0.299	-0.024	0.323	0.688	0.156E-07	0.199	0.144	0.013
1997	0.085	-0.100	0.185	0.688	0.156E-07	0.161	0.134	0.004
1998	0.327	-0.097	0.424	0.688	0.156E-07	0.205	0.134	0.070
1999	0.104	-0.065	0.169	0.688	0.156E-07	0.164	0.139	0.007
2000	0.008	-0.095	0.103	0.688	0.156E-07	0.149	0.134	0.026
2001	-0.086	-0.123	0.037	0.688	0.156E-07	0.136	0.131	0.054
2002	-0.573	-0.215	-0.358	0.688	0.156E-07	0.083	0.119	0.332
2003	-0.043	-0.297	0.254	0.688	0.156E-07	0.142	0.110	0.000
2004	0.020	-0.282	0.302	0.688	0.156E-07	0.151	0.112	0.007
2005	-0.415	-0.251	-0.164	0.688	0.156E-07	0.098	0.115	0.180
2006	-0.022	-0.250	0.228	0.688	0.156E-07	0.145	0.115	0.000

Selectivities by age						
Year	0	1	2	3	4	
1986	0.018	0.172	0.407	1.000	0.624	0.237
1987	0.018	0.172	0.407	1.000	0.624	0.237
1988	0.018	0.172	0.407	1.000	0.624	0.237
1989	0.018	0.172	0.407	1.000	0.624	0.237
1990	0.018	0.172	0.407	1.000	0.624	0.237
1991	0.018	0.172	0.407	1.000	0.624	0.237
1992	0.018	0.172	0.407	1.000	0.624	0.237
1993	0.018	0.172	0.407	1.000	0.624	0.237
1994	0.018	0.172	0.407	1.000	0.624	0.237
1995	0.018	0.172	0.407	1.000	0.624	0.237
1996	0.018	0.172	0.407	1.000	0.624	0.237
1997	0.018	0.172	0.407	1.000	0.624	0.237
1998	0.018	0.172	0.407	1.000	0.624	0.237
1999	0.018	0.172	0.407	1.000	0.624	0.237
2000	0.018	0.172	0.407	1.000	0.624	0.237
2001	0.018	0.172	0.407	1.000	0.624	0.237
2002	0.018	0.172	0.407	1.000	0.624	0.237
2003	0.018	0.172	0.407	1.000	0.624	0.237
2004	0.018	0.172	0.407	1.000	0.624	0.237
2005	0.018	0.172	0.407	1.000	0.624	0.237
2006	0.018	0.172	0.407	1.000	0.624	0.237

5.3 JPN_LL

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 9.12
deviance = 9.39
Chi-sq. discrepancy = 6.80

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1970	0.526	0.399	0.127	0.688	0.153E-06	1.364	1.201	0.018
1971	0.283	0.299	-0.016	0.688	0.153E-06	1.069	1.087	0.083
1972	0.643	0.231	0.411	0.688	0.153E-06	1.533	1.016	0.060
1973	0.329	0.153	0.176	0.688	0.153E-06	1.119	0.939	0.006
1974	0.566	0.058	0.508	0.688	0.153E-06	1.420	0.854	0.160
1975	0.250	-0.085	0.334	0.688	0.153E-06	1.034	0.740	0.017
1976	0.288	-0.138	0.426	0.688	0.153E-06	1.075	0.702	0.071
1977	0.103	-0.036	0.139	0.688	0.153E-06	0.893	0.777	0.014
1978	0.452	0.065	0.387	0.688	0.153E-06	1.266	0.860	0.043
1979	0.768	0.059	0.709	0.688	0.153E-06	1.737	0.855	0.600
1980	0.190	0.042	0.148	0.688	0.153E-06	0.974	0.840	0.012
1981	0.426	-0.058	0.485	0.688	0.153E-06	1.234	0.760	0.130
1982	0.278	-0.157	0.434	0.688	0.153E-06	1.063	0.689	0.079
1983	0.308	-0.198	0.506	0.688	0.153E-06	1.096	0.661	0.157
1984	0.361	0.039	0.322	0.688	0.153E-06	1.156	0.838	0.013
1985	-0.115	0.138	-0.253	0.688	0.153E-06	0.718	0.925	0.247
1986	0.167	0.246	-0.079	0.688	0.153E-06	0.952	1.030	0.121
1987	0.207	0.382	-0.175	0.688	0.153E-06	0.991	1.180	0.188
1988	0.246	0.449	-0.203	0.688	0.153E-06	1.030	1.262	0.209
1989	-0.032	0.338	-0.370	0.688	0.153E-06	0.780	1.130	0.342
1990	0.277	0.175	0.102	0.688	0.153E-06	1.063	0.960	0.026
1991	-0.011	0.087	-0.098	0.688	0.153E-06	0.797	0.879	0.133
1992	0.034	0.080	-0.046	0.688	0.153E-06	0.833	0.873	0.100
1993	-0.608	0.039	-0.647	0.688	0.153E-06	0.439	0.838	0.568
1994	-0.076	0.003	-0.079	0.688	0.153E-06	0.747	0.808	0.121
1995	-0.500	0.030	-0.530	0.688	0.153E-06	0.489	0.830	0.473
1996	-0.430	0.025	-0.455	0.688	0.153E-06	0.524	0.826	0.411
1997	-0.636	-0.088	-0.548	0.688	0.153E-06	0.426	0.738	0.488
1998	-0.470	-0.220	-0.250	0.688	0.153E-06	0.503	0.646	0.245
1999	-0.440	-0.257	-0.183	0.688	0.153E-06	0.519	0.623	0.194
2000	-0.296	-0.213	-0.083	0.688	0.153E-06	0.599	0.651	0.124
2001	-0.708	-0.145	-0.562	0.688	0.153E-06	0.397	0.697	0.500
2002	-0.708	-0.274	-0.434	0.688	0.153E-06	0.397	0.612	0.394
2003	-0.533	-0.391	-0.142	0.688	0.153E-06	0.473	0.545	0.164
2004	-0.298	-0.362	0.065	0.688	0.153E-06	0.598	0.561	0.041
2005	-0.614	-0.394	-0.219	0.688	0.153E-06	0.436	0.543	0.221
2006	-0.226	-0.321	0.095	0.688	0.153E-06	0.643	0.585	0.029

Selectivities by age						
Year	0	1	2	3	4	
1970	0.000	0.003	0.231	1.000	0.964	0.212

1971	0.000	0.003	0.231	1.000	0.964	0.212
1972	0.000	0.003	0.231	1.000	0.964	0.212
1973	0.000	0.003	0.231	1.000	0.964	0.212
1974	0.000	0.003	0.231	1.000	0.964	0.212
1975	0.000	0.003	0.231	1.000	0.964	0.212
1976	0.000	0.003	0.231	1.000	0.964	0.212
1977	0.000	0.003	0.231	1.000	0.964	0.212
1978	0.000	0.003	0.231	1.000	0.964	0.212
1979	0.000	0.003	0.231	1.000	0.964	0.212
1980	0.000	0.003	0.231	1.000	0.964	0.212
1981	0.000	0.003	0.231	1.000	0.964	0.212
1982	0.000	0.003	0.231	1.000	0.964	0.212
1983	0.000	0.003	0.231	1.000	0.964	0.212
1984	0.000	0.003	0.231	1.000	0.964	0.212
1985	0.000	0.003	0.231	1.000	0.964	0.212
1986	0.000	0.003	0.231	1.000	0.964	0.212
1987	0.000	0.003	0.231	1.000	0.964	0.212
1988	0.000	0.003	0.231	1.000	0.964	0.212
1989	0.000	0.003	0.231	1.000	0.964	0.212
1990	0.000	0.003	0.231	1.000	0.964	0.212
1991	0.000	0.003	0.231	1.000	0.964	0.212
1992	0.000	0.003	0.231	1.000	0.964	0.212
1993	0.000	0.003	0.231	1.000	0.964	0.212
1994	0.000	0.003	0.231	1.000	0.964	0.212
1995	0.000	0.003	0.231	1.000	0.964	0.212
1996	0.000	0.003	0.231	1.000	0.964	0.212
1997	0.000	0.003	0.231	1.000	0.964	0.212
1998	0.000	0.003	0.231	1.000	0.964	0.212
1999	0.000	0.003	0.231	1.000	0.964	0.212
2000	0.000	0.003	0.231	1.000	0.964	0.212
2001	0.000	0.003	0.231	1.000	0.964	0.212
2002	0.000	0.003	0.231	1.000	0.964	0.212
2003	0.000	0.003	0.231	1.000	0.964	0.212
2004	0.000	0.003	0.231	1.000	0.964	0.212
2005	0.000	0.003	0.231	1.000	0.964	0.212
2006	0.000	0.003	0.231	1.000	0.964	0.212

5.4 USMEX_LL

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 4.66
deviance = 1.13
Chi-sq. discrepancy= 1.56

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1993	0.205	0.216	-0.011	0.688	0.213E-06	1.151	1.164	0.080
1994	0.528	0.194	0.334	0.688	0.213E-06	1.589	1.138	0.017
1995	0.077	0.222	-0.145	0.688	0.213E-06	1.012	1.170	0.167
1996	-0.043	0.200	-0.242	0.688	0.213E-06	0.898	1.144	0.239
1997	0.042	0.072	-0.030	0.688	0.213E-06	0.977	1.007	0.091
1998	-0.039	-0.050	0.011	0.688	0.213E-06	0.901	0.891	0.068
1999	0.382	-0.071	0.452	0.688	0.213E-06	1.373	0.873	0.095
2000	0.001	-0.007	0.008	0.688	0.213E-06	0.938	0.930	0.069
2001	-0.232	0.054	-0.286	0.688	0.213E-06	0.743	0.989	0.273
2002	-0.175	-0.110	-0.065	0.688	0.213E-06	0.787	0.840	0.112
2003	-0.025	-0.208	0.183	0.688	0.213E-06	0.914	0.761	0.005
2004	-0.195	-0.174	-0.021	0.688	0.213E-06	0.771	0.787	0.085
2005	-0.285	-0.215	-0.070	0.688	0.213E-06	0.705	0.756	0.115
2006	-0.240	-0.123	-0.118	0.688	0.213E-06	0.737	0.829	0.147

Selectivities by age

Year	0	1	2	3	4	5
1993	0.000	0.006	0.281	1.000	0.656	0.052
1994	0.000	0.006	0.281	1.000	0.656	0.052
1995	0.000	0.006	0.281	1.000	0.656	0.052
1996	0.000	0.006	0.281	1.000	0.656	0.052
1997	0.000	0.006	0.281	1.000	0.656	0.052
1998	0.000	0.006	0.281	1.000	0.656	0.052
1999	0.000	0.006	0.281	1.000	0.656	0.052
2000	0.000	0.006	0.281	1.000	0.656	0.052
2001	0.000	0.006	0.281	1.000	0.656	0.052
2002	0.000	0.006	0.281	1.000	0.656	0.052
2003	0.000	0.006	0.281	1.000	0.656	0.052
2004	0.000	0.006	0.281	1.000	0.656	0.052
2005	0.000	0.006	0.281	1.000	0.656	0.052
2006	0.000	0.006	0.281	1.000	0.656	0.052

5.5 US_RR

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 0.24
deviance = 15.20
Chi-sq. discrepancy= 7.28

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1986	0.789	0.349	0.441	0.688	0.104E-06	1.939	1.248	0.084
1987	0.046	0.429	-0.383	0.688	0.104E-06	0.922	1.352	0.352
1988	-0.456	0.300	-0.757	0.688	0.104E-06	0.558	1.189	0.654
1989	-0.437	0.197	-0.634	0.688	0.104E-06	0.569	1.073	0.558
1990	-0.911	0.086	-0.998	0.688	0.104E-06	0.354	0.960	0.829

1991	-0.437	0.151	-0.587	0.688	0.104E-06	0.569	1.024	0.520
1992	-0.820	0.109	-0.929	0.688	0.104E-06	0.388	0.982	0.781
1993	0.003	0.085	-0.082	0.688	0.104E-06	0.883	0.959	0.123
1994	0.665	0.119	0.546	0.688	0.104E-06	1.712	0.991	0.217
1995	0.490	0.113	0.377	0.688	0.104E-06	1.438	0.986	0.037
1996	-0.717	-0.062	-0.655	0.688	0.104E-06	0.430	0.828	0.575
1997	-0.822	-0.156	-0.666	0.688	0.104E-06	0.387	0.753	0.583
1998	-0.121	-0.191	0.070	0.688	0.104E-06	0.780	0.727	0.039
1999	0.627	-0.071	0.699	0.688	0.104E-06	1.649	0.820	0.568
2000	0.489	0.023	0.466	0.688	0.104E-06	1.436	0.901	0.110
2001	0.556	-0.139	0.695	0.688	0.104E-06	1.536	0.766	0.558
2002	0.168	-0.340	0.508	0.688	0.104E-06	1.042	0.627	0.160
2003	0.283	-0.224	0.507	0.688	0.104E-06	1.169	0.704	0.159
2004	0.156	-0.359	0.515	0.688	0.104E-06	1.029	0.615	0.169
2005	0.063	-0.279	0.342	0.688	0.104E-06	0.938	0.666	0.020
2006	0.383	-0.140	0.523	0.688	0.104E-06	1.291	0.765	0.181

Selectivities by age

Year	0	1	2	3	4	5
1986	0.000	0.098	1.000	0.188	0.080	0.027
1987	0.000	0.098	1.000	0.188	0.080	0.027
1988	0.000	0.098	1.000	0.188	0.080	0.027
1989	0.000	0.098	1.000	0.188	0.080	0.027
1990	0.000	0.098	1.000	0.188	0.080	0.027
1991	0.000	0.098	1.000	0.188	0.080	0.027
1992	0.000	0.098	1.000	0.188	0.080	0.027
1993	0.000	0.098	1.000	0.188	0.080	0.027
1994	0.000	0.098	1.000	0.188	0.080	0.027
1995	0.000	0.098	1.000	0.188	0.080	0.027
1996	0.000	0.098	1.000	0.188	0.080	0.027
1997	0.000	0.098	1.000	0.188	0.080	0.027
1998	0.000	0.098	1.000	0.188	0.080	0.027
1999	0.000	0.098	1.000	0.188	0.080	0.027
2000	0.000	0.098	1.000	0.188	0.080	0.027
2001	0.000	0.098	1.000	0.188	0.080	0.027
2002	0.000	0.098	1.000	0.188	0.080	0.027
2003	0.000	0.098	1.000	0.188	0.080	0.027
2004	0.000	0.098	1.000	0.188	0.080	0.027
2005	0.000	0.098	1.000	0.188	0.080	0.027
2006	0.000	0.098	1.000	0.188	0.080	0.027

----- 5.6 US_PLL ATL

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 6.66
deviance = 1.61
Chi-sq. discrepancy= 2.04

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1987	0.587	0.446	0.140	0.688	0.200E-06	1.696	1.474	0.014
1988	0.652	0.479	0.174	0.688	0.200E-06	1.811	1.523	0.006
1989	0.588	0.351	0.238	0.688	0.200E-06	1.699	1.339	0.000
1990	0.388	0.200	0.188	0.688	0.200E-06	1.391	1.152	0.004
1991	0.140	0.128	0.012	0.688	0.200E-06	1.085	1.072	0.067
1992	0.210	0.143	0.067	0.688	0.200E-06	1.164	1.088	0.040
1993	-0.279	0.090	-0.369	0.688	0.200E-06	0.713	1.032	0.341
1994	-0.125	0.072	-0.197	0.688	0.200E-06	0.832	1.014	0.205
1995	-0.040	0.100	-0.141	0.688	0.200E-06	0.906	1.043	0.163
1996	-0.298	0.078	-0.376	0.688	0.200E-06	0.700	1.020	0.346
1997	-0.191	-0.059	-0.131	0.688	0.200E-06	0.780	0.889	0.156
1998	-0.316	-0.177	-0.139	0.688	0.200E-06	0.687	0.790	0.162
1999	-0.178	-0.199	0.020	0.688	0.200E-06	0.789	0.773	0.063
2000	-0.091	-0.131	0.040	0.688	0.200E-06	0.861	0.827	0.053
2001	-0.218	-0.059	-0.160	0.688	0.200E-06	0.758	0.889	0.177
2002	-0.293	-0.238	-0.055	0.688	0.200E-06	0.703	0.743	0.106
2003	-0.423	-0.340	-0.082	0.688	0.200E-06	0.618	0.671	0.123
2004	-0.063	-0.291	0.228	0.688	0.200E-06	0.886	0.705	0.000
2005	-0.013	-0.345	0.332	0.688	0.200E-06	0.931	0.668	0.016
2006	-0.036	-0.248	0.211	0.688	0.200E-06	0.910	0.736	0.001

Selectivities by age

Year	0	1	2	3	4	5
1987	0.000	0.006	0.267	1.000	0.477	0.026
1988	0.000	0.006	0.267	1.000	0.477	0.026
1989	0.000	0.006	0.267	1.000	0.477	0.026
1990	0.000	0.006	0.267	1.000	0.477	0.026
1991	0.000	0.006	0.267	1.000	0.477	0.026
1992	0.000	0.006	0.267	1.000	0.477	0.026
1993	0.000	0.006	0.267	1.000	0.477	0.026
1994	0.000	0.006	0.267	1.000	0.477	0.026
1995	0.000	0.006	0.267	1.000	0.477	0.026
1996	0.000	0.006	0.267	1.000	0.477	0.026
1997	0.000	0.006	0.267	1.000	0.477	0.026
1998	0.000	0.006	0.267	1.000	0.477	0.026
1999	0.000	0.006	0.267	1.000	0.477	0.026
2000	0.000	0.006	0.267	1.000	0.477	0.026
2001	0.000	0.006	0.267	1.000	0.477	0.026
2002	0.000	0.006	0.267	1.000	0.477	0.026
2003	0.000	0.006	0.267	1.000	0.477	0.026
2004	0.000	0.006	0.267	1.000	0.477	0.026
2005	0.000	0.006	0.267	1.000	0.477	0.026
2006	0.000	0.006	0.267	1.000	0.477	0.026

5.7 VEN_LL

Lognormal dist.

month 6 numbers

Ages 0 - 5

log-likelihood = 2.19

deviance = 3.83

Chi-sq. discrepancy= 3.45

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1991	0.132	0.150	-0.017	0.688	0.206E-06	1.045	1.063	0.083
1992	0.218	0.138	0.080	0.688	0.206E-06	1.138	1.051	0.035
1993	0.605	0.106	0.499	0.688	0.206E-06	1.676	1.018	0.148
1994	-0.378	0.061	-0.439	0.688	0.206E-06	0.627	0.972	0.398
1995	-0.277	0.070	-0.346	0.688	0.206E-06	0.694	0.981	0.322
1996	-0.011	0.086	-0.097	0.688	0.206E-06	0.905	0.997	0.133
1997	-0.604	-0.016	-0.588	0.688	0.206E-06	0.500	0.901	0.521
1998	-0.051	-0.138	0.087	0.688	0.206E-06	0.870	0.797	0.032
1999	-0.075	-0.178	0.103	0.688	0.206E-06	0.849	0.766	0.026
2000	-0.375	-0.179	-0.196	0.688	0.206E-06	0.629	0.765	0.204
2001	0.815	-0.099	0.914	0.688	0.206E-06	2.067	0.829	1.547

Selectivities by age

Year	0	1	2	3	4	5
1991	0.000	0.018	0.132	0.906	1.000	0.322
1992	0.000	0.018	0.132	0.906	1.000	0.322
1993	0.000	0.018	0.132	0.906	1.000	0.322
1994	0.000	0.018	0.132	0.906	1.000	0.322
1995	0.000	0.018	0.132	0.906	1.000	0.322
1996	0.000	0.018	0.132	0.906	1.000	0.322
1997	0.000	0.018	0.132	0.906	1.000	0.322
1998	0.000	0.018	0.132	0.906	1.000	0.322
1999	0.000	0.018	0.132	0.906	1.000	0.322
2000	0.000	0.018	0.132	0.906	1.000	0.322
2001	0.000	0.018	0.132	0.906	1.000	0.322

5.8 VEN_PS

Lognormal dist.

month 6 biomass

Ages 0 - 4

log-likelihood = 2.60

deviance = 11.97

Chi-sq. discrepancy= 8.72

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1983	0.863	0.003	0.860	0.688	0.222E-07	13.589	5.750	1.233
1984	0.050	0.144	-0.094	0.688	0.222E-07	6.027	6.618	0.131
1985	0.573	0.269	0.304	0.688	0.222E-07	10.170	7.505	0.008
1986	0.042	0.321	-0.279	0.688	0.222E-07	5.977	7.901	0.268
1987	-0.226	0.421	-0.646	0.688	0.222E-07	4.574	8.731	0.568
1988	0.095	0.395	-0.300	0.688	0.222E-07	6.304	8.511	0.285
1989	0.868	0.312	0.556	0.688	0.222E-07	13.656	7.831	0.233
1990	0.200	0.187	0.013	0.688	0.222E-07	7.002	6.915	0.067
1991	0.221	0.169	0.052	0.688	0.222E-07	7.151	6.790	0.047
1992	-0.175	0.109	-0.284	0.688	0.222E-07	4.812	6.395	0.272
1993	-0.040	-0.037	-0.002	0.688	0.222E-07	5.511	5.523	0.075
1994	0.159	0.071	0.088	0.688	0.222E-07	6.720	6.156	0.032
1995	-0.639	0.113	-0.752	0.688	0.222E-07	3.025	6.416	0.650
1996	0.167	0.045	0.122	0.688	0.222E-07	6.777	5.998	0.019
1997	-0.227	-0.103	-0.124	0.688	0.222E-07	4.569	5.173	0.151
1998	-0.437	-0.227	-0.209	0.688	0.222E-07	3.704	4.567	0.214
1999	-0.054	-0.288	0.235	0.688	0.222E-07	5.434	4.297	0.000
2000	0.144	-0.174	0.318	0.688	0.222E-07	6.624	4.818	0.012
2001	0.837	-0.215	1.052	0.688	0.222E-07	13.243	4.623	2.621
2002	0.356	-0.297	0.653	0.688	0.222E-07	8.181	4.259	0.439
2003	-0.360	-0.405	0.045	0.688	0.222E-07	3.999	3.822	0.050
2004	-0.874	-0.405	-0.469	0.688	0.222E-07	2.393	3.824	0.423
2005	-1.543	-0.405	-1.138	0.688	0.222E-07	1.226	3.824	0.921

Selectivities by age

Year	0	1	2	3	4
1983	0.014	0.622	0.865	1.000	0.204
1984	0.014	0.622	0.865	1.000	0.204
1985	0.014	0.622	0.865	1.000	0.204
1986	0.014	0.622	0.865	1.000	0.204
1987	0.014	0.622	0.865	1.000	0.204
1988	0.014	0.622	0.865	1.000	0.204
1989	0.014	0.622	0.865	1.000	0.204
1990	0.014	0.622	0.865	1.000	0.204
1991	0.014	0.622	0.865	1.000	0.204
1992	0.014	0.622	0.865	1.000	0.204
1993	0.014	0.622	0.865	1.000	0.204
1994	0.014	0.622	0.865	1.000	0.204
1995	0.014	0.622	0.865	1.000	0.204
1996	0.014	0.622	0.865	1.000	0.204
1997	0.014	0.622	0.865	1.000	0.204
1998	0.014	0.622	0.865	1.000	0.204
1999	0.014	0.622	0.865	1.000	0.204
2000	0.014	0.622	0.865	1.000	0.204
2001	0.014	0.622	0.865	1.000	0.204
2002	0.014	0.622	0.865	1.000	0.204
2003	0.014	0.622	0.865	1.000	0.204
2004	0.014	0.622	0.865	1.000	0.204
2005	0.014	0.622	0.865	1.000	0.204

5.9 EUR-FAD-PS

Lognormal dist.
month 6 biomass
Ages 0 - 1
log-likelihood = 4.80
deviance = 2.35
Chi-sq. discrepancy= 1.90

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1991	0.054	0.154	-0.100	0.688	0.173E-07	1.960	2.166	0.135
1992	-0.380	0.059	-0.438	0.688	0.173E-07	1.270	1.969	0.398
1993	0.065	0.143	-0.078	0.688	0.173E-07	1.980	2.141	0.120
1994	0.002	0.135	-0.133	0.688	0.173E-07	1.860	2.125	0.158
1995	0.161	0.008	0.153	0.688	0.173E-07	2.180	1.871	0.011
1996	0.029	-0.026	0.055	0.688	0.173E-07	1.910	1.808	0.046
1997	-0.130	0.040	-0.170	0.688	0.173E-07	1.630	1.933	0.185
1998	-0.428	0.245	-0.673	0.688	0.173E-07	1.210	2.372	0.589
1999	0.034	0.022	0.011	0.688	0.173E-07	1.920	1.898	0.067
2000	0.080	0.013	0.067	0.688	0.173E-07	2.010	1.880	0.040
2001	-0.014	-0.135	0.121	0.688	0.173E-07	1.830	1.622	0.020
2002	0.085	-0.009	0.094	0.688	0.173E-07	2.020	1.839	0.029
2003	0.161	-0.217	0.378	0.688	0.173E-07	2.180	1.494	0.038
2004	0.197	-0.128	0.325	0.688	0.173E-07	2.260	1.633	0.014
2005	0.210	-0.101	0.311	0.688	0.173E-07	2.290	1.677	0.010
2006	-0.124	-0.202	0.078	0.688	0.173E-07	1.640	1.516	0.035

Selectivities by age

Year 0 1

1991	0.788	1.000
1992	0.788	1.000
1993	0.788	1.000
1994	0.788	1.000
1995	0.788	1.000
1996	0.788	1.000
1997	0.788	1.000
1998	0.788	1.000
1999	0.788	1.000
2000	0.788	1.000
2001	0.788	1.000
2002	0.788	1.000
2003	0.788	1.000
2004	0.788	1.000
2005	0.788	1.000
2006	0.788	1.000

5.10 EUR-PS 3%

Lognormal dist.
month 6 biomass
Ages 0 - 5
log-likelihood = 3.47
deviance = 0.53
Chi-sq. discrepancy= 0.93

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1970	0.101	0.290	-0.188	0.688	0.187E-07	5.061	6.111	0.198
1971	-0.057	0.215	-0.273	0.688	0.187E-07	4.318	5.672	0.263
1972	0.047	0.141	-0.094	0.688	0.187E-07	4.795	5.266	0.131
1973	0.055	0.068	-0.013	0.688	0.187E-07	4.833	4.894	0.080
1974	-0.038	-0.033	-0.004	0.688	0.187E-07	4.405	4.424	0.076
1975	0.037	-0.135	0.171	0.688	0.187E-07	4.744	3.997	0.007
1976	0.026	-0.238	0.264	0.688	0.187E-07	4.693	3.604	0.001
1977	0.008	-0.169	0.177	0.688	0.187E-07	4.610	3.863	0.006
1978	-0.086	-0.080	-0.007	0.688	0.187E-07	4.195	4.223	0.077
1979	-0.092	-0.058	-0.034	0.688	0.187E-07	4.171	4.314	0.093

Selectivities by age

Year 0 1 2 3 4 5

1970	0.040	0.273	0.422	0.632	1.000	0.227
1971	0.040	0.273	0.422	0.632	1.000	0.227
1972	0.040	0.273	0.422	0.632	1.000	0.227
1973	0.040	0.273	0.422	0.632	1.000	0.227
1974	0.040	0.273	0.422	0.632	1.000	0.227
1975	0.040	0.273	0.422	0.632	1.000	0.227
1976	0.040	0.273	0.422	0.632	1.000	0.227
1977	0.040	0.273	0.422	0.632	1.000	0.227
1978	0.040	0.273	0.422	0.632	1.000	0.227
1979	0.040	0.273	0.422	0.632	1.000	0.227

5.11 EU-DAKAR

Lognormal dist.
month 6 biomass
Ages 0 - 4
log-likelihood = 3.24
deviance = 20.41
Chi-sq. discrepancy= 12.29

Residuals Standard Q Untransfrmd Untransfrmd Chi-square

Year	Observed	Predicted	(Obs-pred)	Deviation	Catchabil.	Observed	Predicted	Discrepancy
1970	-0.200	0.070	-0.271	0.688	0.477E-08	0.644	0.844	0.261
1971	-0.213	0.051	-0.264	0.688	0.477E-08	0.636	0.828	0.256
1972	-0.207	0.053	-0.260	0.688	0.477E-08	0.640	0.830	0.253
1973	-0.290	-0.008	-0.282	0.688	0.477E-08	0.589	0.781	0.270
1974	0.162	-0.068	0.229	0.688	0.477E-08	0.925	0.735	0.000
1975	-0.664	-0.057	-0.608	0.688	0.477E-08	0.405	0.744	0.536
1976	-0.563	0.004	-0.567	0.688	0.477E-08	0.448	0.790	0.503
1977	-0.140	0.137	-0.277	0.688	0.477E-08	0.684	0.902	0.266
1978	-1.092	0.130	-1.222	0.688	0.477E-08	0.264	0.896	0.972
1979	-0.457	0.047	-0.505	0.688	0.477E-08	0.498	0.825	0.452
1981	0.263	-0.097	0.361	0.688	0.477E-08	1.024	0.714	0.029
1982	0.215	-0.026	0.241	0.688	0.477E-08	0.976	0.767	0.000
1983	0.234	0.153	0.081	0.688	0.477E-08	0.994	0.917	0.034
1984	0.590	0.253	0.338	0.688	0.477E-08	1.420	1.013	0.019
1985	0.327	0.334	-0.007	0.688	0.477E-08	1.091	1.099	0.077
1986	0.739	0.350	0.389	0.688	0.477E-08	1.647	1.117	0.044
1987	0.859	0.400	0.459	0.688	0.477E-08	1.858	1.174	0.102
1988	0.826	0.286	0.541	0.688	0.477E-08	1.798	1.047	0.208
1989	-0.597	0.183	-0.781	0.688	0.477E-08	0.433	0.945	0.673
1990	0.745	0.118	0.627	0.688	0.477E-08	1.658	0.886	0.375
1991	0.422	0.196	0.226	0.688	0.477E-08	1.200	0.957	0.000
1992	1.090	0.074	1.015	0.688	0.477E-08	2.340	0.848	2.289
1993	0.881	-0.070	0.951	0.688	0.477E-08	1.899	0.734	1.791
1994	0.586	0.111	0.476	0.688	0.477E-08	1.414	0.879	0.120
1995	0.071	0.094	-0.023	0.688	0.477E-08	0.845	0.864	0.086
1996	0.562	-0.046	0.609	0.688	0.477E-08	1.381	0.751	0.334
1997	-0.295	-0.131	-0.164	0.688	0.477E-08	0.586	0.690	0.180
1998	-1.261	-0.187	-1.074	0.688	0.477E-08	0.223	0.653	0.880
1999	-0.208	-0.222	0.013	0.688	0.477E-08	0.639	0.630	0.066
2000	-0.961	-0.096	-0.865	0.688	0.477E-08	0.301	0.715	0.736
2001	-0.490	-0.317	-0.173	0.688	0.477E-08	0.482	0.573	0.187
2002	-0.074	-0.322	0.248	0.688	0.477E-08	0.731	0.570	0.000
2003	0.059	-0.366	0.425	0.688	0.477E-08	0.835	0.546	0.071
2004	-0.213	-0.448	0.235	0.688	0.477E-08	0.636	0.503	0.000
2005	-0.416	-0.359	-0.057	0.688	0.477E-08	0.519	0.550	0.107
2006	-0.291	-0.226	-0.066	0.688	0.477E-08	0.588	0.628	0.113

Selectivities by age

Year	0	1	2	3	4
1970	0.062	1.000	0.665	0.201	0.047
1971	0.062	1.000	0.665	0.201	0.047
1972	0.062	1.000	0.665	0.201	0.047
1973	0.062	1.000	0.665	0.201	0.047
1974	0.062	1.000	0.665	0.201	0.047
1975	0.062	1.000	0.665	0.201	0.047
1976	0.062	1.000	0.665	0.201	0.047
1977	0.062	1.000	0.665	0.201	0.047
1978	0.062	1.000	0.665	0.201	0.047
1979	0.062	1.000	0.665	0.201	0.047
1981	0.062	1.000	0.665	0.201	0.047
1982	0.062	1.000	0.665	0.201	0.047
1983	0.062	1.000	0.665	0.201	0.047
1984	0.062	1.000	0.665	0.201	0.047
1985	0.062	1.000	0.665	0.201	0.047
1986	0.062	1.000	0.665	0.201	0.047
1987	0.062	1.000	0.665	0.201	0.047
1988	0.062	1.000	0.665	0.201	0.047
1989	0.062	1.000	0.665	0.201	0.047
1990	0.062	1.000	0.665	0.201	0.047
1991	0.062	1.000	0.665	0.201	0.047
1992	0.062	1.000	0.665	0.201	0.047
1993	0.062	1.000	0.665	0.201	0.047
1994	0.062	1.000	0.665	0.201	0.047
1995	0.062	1.000	0.665	0.201	0.047
1996	0.062	1.000	0.665	0.201	0.047
1997	0.062	1.000	0.665	0.201	0.047
1998	0.062	1.000	0.665	0.201	0.047
1999	0.062	1.000	0.665	0.201	0.047
2000	0.062	1.000	0.665	0.201	0.047
2001	0.062	1.000	0.665	0.201	0.047
2002	0.062	1.000	0.665	0.201	0.047
2003	0.062	1.000	0.665	0.201	0.047
2004	0.062	1.000	0.665	0.201	0.047
2005	0.062	1.000	0.665	0.201	0.047
2006	0.062	1.000	0.665	0.201	0.047

5.12 URU-LL

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 1.86
deviance = 15.70
Chi-sq. discrepancy= 10.38

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1981	0.627	-0.040	0.667	0.688	0.470E-06	6.554	3.365	0.475
1982	0.932	-0.106	1.038	0.688	0.470E-06	8.896	3.149	2.490
1983	-0.050	-0.043	-0.007	0.688	0.470E-06	3.330	3.353	0.077
1984	-0.858	0.117	-0.975	0.688	0.470E-06	1.485	3.936	0.814
1985	0.012	0.221	-0.209	0.688	0.470E-06	3.546	4.368	0.213
1986	0.164	0.309	-0.145	0.688	0.470E-06	4.124	4.769	0.166
1987	0.127	0.419	-0.292	0.688	0.470E-06	3.976	5.324	0.278
1988	0.777	0.400	0.376	0.688	0.470E-06	7.613	5.225	0.037
1989	-0.519	0.285	-0.804	0.688	0.470E-06	2.085	4.657	0.690
1990	-0.609	0.148	-0.757	0.688	0.470E-06	1.904	4.059	0.654

1991	0.672	0.122	0.549	0.688	0.470E-06	6.854	3.957	0.222
1992	0.626	0.112	0.514	0.688	0.470E-06	6.545	3.915	0.168
1993	-1.028	0.071	-1.100	0.688	0.470E-06	1.252	3.760	0.897
1994	0.325	0.071	0.254	0.688	0.470E-06	4.845	3.758	0.000
1995	0.058	0.084	-0.026	0.688	0.470E-06	3.711	3.809	0.088
1996	0.715	0.009	0.707	0.688	0.470E-06	7.159	3.532	0.593
1997	-0.379	-0.109	-0.270	0.688	0.470E-06	2.396	3.140	0.261
1998	-0.255	-0.198	-0.057	0.688	0.470E-06	2.715	2.874	0.107
1999	-0.073	-0.165	0.092	0.688	0.470E-06	3.255	2.969	0.030
2000	0.198	-0.092	0.290	0.688	0.470E-06	4.268	3.195	0.005
2001	-0.283	-0.113	-0.170	0.688	0.470E-06	2.638	3.128	0.185
2002	-0.667	-0.291	-0.376	0.688	0.470E-06	1.796	2.617	0.347
2003	-0.314	-0.311	-0.002	0.688	0.470E-06	2.558	2.564	0.075
2004	-0.318	-0.337	0.019	0.688	0.470E-06	2.547	2.499	0.063
2005	0.528	-0.336	0.864	0.688	0.470E-06	5.937	2.502	1.255
2006	-0.406	-0.226	-0.179	0.688	0.470E-06	2.333	2.792	0.191

Selectivities by age

Year	0	1	2	3	4	5
1981	0.000	0.039	0.572	1.000	0.586	0.120
1982	0.000	0.039	0.572	1.000	0.586	0.120
1983	0.000	0.039	0.572	1.000	0.586	0.120
1984	0.000	0.039	0.572	1.000	0.586	0.120
1985	0.000	0.039	0.572	1.000	0.586	0.120
1986	0.000	0.039	0.572	1.000	0.586	0.120
1987	0.000	0.039	0.572	1.000	0.586	0.120
1988	0.000	0.039	0.572	1.000	0.586	0.120
1989	0.000	0.039	0.572	1.000	0.586	0.120
1990	0.000	0.039	0.572	1.000	0.586	0.120
1991	0.000	0.039	0.572	1.000	0.586	0.120
1992	0.000	0.039	0.572	1.000	0.586	0.120
1993	0.000	0.039	0.572	1.000	0.586	0.120
1994	0.000	0.039	0.572	1.000	0.586	0.120
1995	0.000	0.039	0.572	1.000	0.586	0.120
1996	0.000	0.039	0.572	1.000	0.586	0.120
1997	0.000	0.039	0.572	1.000	0.586	0.120
1998	0.000	0.039	0.572	1.000	0.586	0.120
1999	0.000	0.039	0.572	1.000	0.586	0.120
2000	0.000	0.039	0.572	1.000	0.586	0.120
2001	0.000	0.039	0.572	1.000	0.586	0.120
2002	0.000	0.039	0.572	1.000	0.586	0.120
2003	0.000	0.039	0.572	1.000	0.586	0.120
2004	0.000	0.039	0.572	1.000	0.586	0.120
2005	0.000	0.039	0.572	1.000	0.586	0.120
2006	0.000	0.039	0.572	1.000	0.586	0.120

5.13 BRA-URU-LL

Not used

5.14 CHIN-TAI-LL

Lognormal dist.

month 6 numbers

Ages 0 5

log-likelihood = 11.65

deviance = 4.33

Chi-sq. discrepancy= 4.53

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1970	0.772	0.369	0.403	0.688	0.141E-06	1.712	1.145	0.054
1971	0.251	0.275	-0.024	0.688	0.141E-06	1.017	1.042	0.087
1972	0.328	0.211	0.116	0.688	0.141E-06	1.098	0.978	0.021
1973	0.435	0.133	0.302	0.688	0.141E-06	1.223	0.904	0.008
1974	-0.252	0.041	-0.293	0.688	0.141E-06	0.615	0.824	0.279
1975	-0.212	-0.090	-0.121	0.688	0.141E-06	0.641	0.723	0.149
1976	-0.041	-0.126	0.085	0.688	0.141E-06	0.760	0.698	0.033
1977	-0.145	-0.022	-0.122	0.688	0.141E-06	0.685	0.774	0.150
1978	-0.238	0.066	-0.304	0.688	0.141E-06	0.624	0.846	0.288
1979	-0.200	0.054	-0.255	0.688	0.141E-06	0.648	0.836	0.249
1980	0.006	0.033	-0.027	0.688	0.141E-06	0.796	0.818	0.089
1981	-0.133	-0.061	-0.072	0.688	0.141E-06	0.693	0.745	0.117
1982	-0.394	-0.147	-0.248	0.688	0.141E-06	0.534	0.684	0.244
1983	-0.403	-0.169	-0.234	0.688	0.141E-06	0.529	0.668	0.233
1984	-0.033	0.054	-0.088	0.688	0.141E-06	0.766	0.836	0.127
1985	-0.133	0.149	-0.282	0.688	0.141E-06	0.693	0.919	0.270
1986	0.083	0.254	-0.171	0.688	0.141E-06	0.860	1.021	0.185
1987	-0.009	0.381	-0.391	0.688	0.141E-06	0.784	1.159	0.358
1988	0.342	0.432	-0.091	0.688	0.141E-06	1.114	1.220	0.129
1989	-0.020	0.320	-0.340	0.688	0.141E-06	0.776	1.090	0.317
1990	-0.020	0.166	-0.186	0.688	0.141E-06	0.776	0.935	0.196
1991	0.110	0.088	0.022	0.688	0.141E-06	0.884	0.865	0.062
1992	-0.199	0.082	-0.280	0.688	0.141E-06	0.649	0.859	0.269
1993	0.092	0.042	0.050	0.688	0.141E-06	0.868	0.825	0.048
1994	0.407	0.013	0.394	0.688	0.141E-06	1.189	0.802	0.047
1995	0.391	0.034	0.357	0.688	0.141E-06	1.170	0.819	0.027
1996	0.251	0.016	0.235	0.688	0.141E-06	1.017	0.804	0.000
1997	-0.018	-0.098	0.080	0.688	0.141E-06	0.778	0.718	0.035
1998	-0.010	-0.217	0.207	0.688	0.141E-06	0.783	0.637	0.001
1999	-0.315	-0.238	-0.077	0.688	0.141E-06	0.578	0.624	0.120
2000	-0.023	-0.194	0.170	0.688	0.141E-06	0.773	0.652	0.007
2001	-0.277	-0.144	-0.134	0.688	0.141E-06	0.600	0.686	0.158
2002	-0.101	-0.279	0.178	0.688	0.141E-06	0.715	0.599	0.005
2003	-0.096	-0.380	0.284	0.688	0.141E-06	0.719	0.541	0.004
2004	-0.099	-0.360	0.261	0.688	0.141E-06	0.717	0.552	0.001
2005	0.108	-0.383	0.491	0.688	0.141E-06	0.882	0.540	0.138
2006	-0.201	-0.308	0.106	0.688	0.141E-06	0.647	0.582	0.025

Selectivities by age

Year	0	1	2	3	4	5
1970	0.000	0.013	0.272	1.000	0.890	0.204
1971	0.000	0.013	0.272	1.000	0.890	0.204
1972	0.000	0.013	0.272	1.000	0.890	0.204
1973	0.000	0.013	0.272	1.000	0.890	0.204
1974	0.000	0.013	0.272	1.000	0.890	0.204
1975	0.000	0.013	0.272	1.000	0.890	0.204
1976	0.000	0.013	0.272	1.000	0.890	0.204
1977	0.000	0.013	0.272	1.000	0.890	0.204
1978	0.000	0.013	0.272	1.000	0.890	0.204
1979	0.000	0.013	0.272	1.000	0.890	0.204
1980	0.000	0.013	0.272	1.000	0.890	0.204
1981	0.000	0.013	0.272	1.000	0.890	0.204
1982	0.000	0.013	0.272	1.000	0.890	0.204
1983	0.000	0.013	0.272	1.000	0.890	0.204
1984	0.000	0.013	0.272	1.000	0.890	0.204
1985	0.000	0.013	0.272	1.000	0.890	0.204
1986	0.000	0.013	0.272	1.000	0.890	0.204
1987	0.000	0.013	0.272	1.000	0.890	0.204
1988	0.000	0.013	0.272	1.000	0.890	0.204
1989	0.000	0.013	0.272	1.000	0.890	0.204
1990	0.000	0.013	0.272	1.000	0.890	0.204
1991	0.000	0.013	0.272	1.000	0.890	0.204
1992	0.000	0.013	0.272	1.000	0.890	0.204
1993	0.000	0.013	0.272	1.000	0.890	0.204
1994	0.000	0.013	0.272	1.000	0.890	0.204
1995	0.000	0.013	0.272	1.000	0.890	0.204
1996	0.000	0.013	0.272	1.000	0.890	0.204
1997	0.000	0.013	0.272	1.000	0.890	0.204
1998	0.000	0.013	0.272	1.000	0.890	0.204
1999	0.000	0.013	0.272	1.000	0.890	0.204
2000	0.000	0.013	0.272	1.000	0.890	0.204
2001	0.000	0.013	0.272	1.000	0.890	0.204
2002	0.000	0.013	0.272	1.000	0.890	0.204
2003	0.000	0.013	0.272	1.000	0.890	0.204
2004	0.000	0.013	0.272	1.000	0.890	0.204
2005	0.000	0.013	0.272	1.000	0.890	0.204
2006	0.000	0.013	0.272	1.000	0.890	0.204

----- 5.15 TROP-PS

Lognormal dist.
month 6 numbers
Ages 3 - 5
log-likelihood = 5.99
deviance = 8.19
Chi-sq. discrepancy= 4.61

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1980	-0.780	0.164	-0.945	0.688	0.320E-08	0.250	0.643	0.793
1981	0.175	0.061	0.114	0.688	0.320E-08	0.650	0.580	0.022
1982	-0.336	-0.071	-0.265	0.688	0.320E-08	0.390	0.508	0.257
1983	-0.108	-0.283	0.175	0.688	0.320E-08	0.490	0.411	0.006
1984	-1.166	-0.067	-1.100	0.688	0.320E-08	0.170	0.510	0.897
1985	0.095	0.061	0.034	0.688	0.320E-08	0.600	0.580	0.055
1986	0.044	0.204	-0.160	0.688	0.320E-08	0.570	0.669	0.177
1987	0.128	0.350	-0.223	0.688	0.320E-08	0.620	0.775	0.224
1988	0.044	0.538	-0.494	0.688	0.320E-08	0.570	0.934	0.444
1989	0.606	0.539	0.067	0.688	0.320E-08	1.000	0.936	0.040
1990	0.565	0.405	0.160	0.688	0.320E-08	0.960	0.818	0.009
1991	0.235	0.229	0.006	0.688	0.320E-08	0.690	0.686	0.070
1992	0.112	0.158	-0.046	0.688	0.320E-08	0.610	0.639	0.100
1993	-0.087	0.095	-0.183	0.688	0.320E-08	0.500	0.600	0.194
1994	0.144	0.024	0.120	0.688	0.320E-08	0.630	0.559	0.020
1995	0.095	0.005	0.090	0.688	0.320E-08	0.600	0.548	0.031
1996	0.026	0.060	-0.034	0.688	0.320E-08	0.560	0.580	0.093
1997	0.235	0.015	0.220	0.688	0.320E-08	0.690	0.554	0.000
1998	-0.029	-0.098	0.069	0.688	0.320E-08	0.530	0.494	0.039
1999	-0.215	-0.215	0.000	0.688	0.320E-08	0.440	0.440	0.073
2000	-0.310	-0.272	-0.039	0.688	0.320E-08	0.400	0.416	0.096
2001	-0.068	-0.203	0.135	0.688	0.320E-08	0.510	0.446	0.015
2002	0.249	-0.234	0.484	0.688	0.320E-08	0.700	0.432	0.129
2003	0.370	-0.368	0.738	0.688	0.320E-08	0.790	0.377	0.700
2004	-0.029	-0.341	0.312	0.688	0.320E-08	0.530	0.388	0.010
2005	-0.087	-0.383	0.296	0.688	0.320E-08	0.500	0.372	0.006
2006	0.095	-0.371	0.466	0.688	0.320E-08	0.600	0.376	0.110

Selectivities by age

Year	3	4	5
1980	29.518	54.953	78.542
1981	29.518	54.953	78.542
1982	29.518	54.953	78.542
1983	29.518	54.953	78.542
1984	29.518	54.953	78.542
1985	29.518	54.953	78.542
1986	29.518	54.953	78.542
1987	29.518	54.953	78.542
1988	29.518	54.953	78.542
1989	29.518	54.953	78.542
1990	29.518	54.953	78.542
1991	29.518	54.953	78.542
1992	29.518	54.953	78.542
1993	29.518	54.953	78.542
1994	29.518	54.953	78.542
1995	29.518	54.953	78.542

1996	29.518	54.953	78.542
1997	29.518	54.953	78.542
1998	29.518	54.953	78.542
1999	29.518	54.953	78.542
2000	29.518	54.953	78.542
2001	29.518	54.953	78.542
2002	29.518	54.953	78.542
2003	29.518	54.953	78.542
2004	29.518	54.953	78.542
2005	29.518	54.953	78.542
2006	29.518	54.953	78.542

5.16 CAN-IS-BB

Lognormal dist.
month 6 biomass
Ages 0 - 4
log-likelihood = -103.24
deviance = 226.64
Chi-sq. discrepancy= 323.79

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1980	-1.991	0.078	-2.070	0.688	0.282E-09	0.010	0.076	1.337
1981	-1.284	-0.066	-1.218	0.688	0.282E-09	0.020	0.066	0.969
1982	0.289	-0.061	0.350	0.688	0.282E-09	0.094	0.066	0.024
1983	0.855	0.086	0.769	0.688	0.282E-09	0.166	0.077	0.814
1984	2.171	0.176	1.995	0.688	0.282E-09	0.620	0.084	38.064
1985	1.338	0.316	1.022	0.688	0.282E-09	0.269	0.097	2.344
1986	0.896	0.335	0.561	0.688	0.282E-09	0.173	0.099	0.241
1987	1.700	0.426	1.274	0.688	0.282E-09	0.387	0.108	5.468
1988	1.740	0.376	1.363	0.688	0.282E-09	0.402	0.103	7.169
1989	1.214	0.295	0.920	0.688	0.282E-09	0.238	0.095	1.582
1990	2.148	0.167	1.981	0.688	0.282E-09	0.605	0.084	36.747
1991	2.025	0.209	1.815	0.688	0.282E-09	0.535	0.087	24.419
1992	1.479	0.099	1.380	0.688	0.282E-09	0.310	0.078	7.531
1993	0.695	-0.040	0.735	0.688	0.282E-09	0.142	0.068	0.688
1994	0.176	0.098	0.078	0.688	0.282E-09	0.084	0.078	0.036
1995	-0.679	0.119	-0.797	0.688	0.282E-09	0.036	0.080	0.685
1996	2.033	0.010	2.022	0.688	0.282E-09	0.539	0.071	40.634
1997	-0.092	-0.087	-0.005	0.688	0.282E-09	0.064	0.065	0.076
1998	2.379	-0.208	2.587	0.688	0.282E-09	0.763	0.057	148.409
1999	0.029	-0.243	0.271	0.688	0.282E-09	0.073	0.055	0.002
2000	-3.439	-0.118	-3.321	0.688	0.282E-09	0.002	0.063	1.557
2001	-7.484	-0.286	-7.198	0.688	0.282E-09	0.000	0.053	1.648
2002	-1.054	-0.294	-0.760	0.688	0.282E-09	0.025	0.053	0.657
2003	-0.426	-0.353	-0.073	0.688	0.282E-09	0.046	0.050	0.117
2004	-0.618	-0.436	-0.182	0.688	0.282E-09	0.038	0.046	0.193
2005	2.617	-0.366	-2.250	0.688	0.282E-09	0.005	0.049	1.387
2006	-1.481	-0.233	-1.249	0.688	0.282E-09	0.016	0.056	0.987

Selectivities by age

Year	0	1	2	3	4
1980	0.006	0.971	1.000	0.519	0.457
1981	0.006	0.971	1.000	0.519	0.457
1982	0.006	0.971	1.000	0.519	0.457
1983	0.006	0.971	1.000	0.519	0.457
1984	0.006	0.971	1.000	0.519	0.457
1985	0.006	0.971	1.000	0.519	0.457
1986	0.006	0.971	1.000	0.519	0.457
1987	0.006	0.971	1.000	0.519	0.457
1988	0.006	0.971	1.000	0.519	0.457
1989	0.006	0.971	1.000	0.519	0.457
1990	0.006	0.971	1.000	0.519	0.457
1991	0.006	0.971	1.000	0.519	0.457
1992	0.006	0.971	1.000	0.519	0.457
1993	0.006	0.971	1.000	0.519	0.457
1994	0.006	0.971	1.000	0.519	0.457
1995	0.006	0.971	1.000	0.519	0.457
1996	0.006	0.971	1.000	0.519	0.457
1997	0.006	0.971	1.000	0.519	0.457
1998	0.006	0.971	1.000	0.519	0.457
1999	0.006	0.971	1.000	0.519	0.457
2000	0.006	0.971	1.000	0.519	0.457
2001	0.006	0.971	1.000	0.519	0.457
2002	0.006	0.971	1.000	0.519	0.457
2003	0.006	0.971	1.000	0.519	0.457
2004	0.006	0.971	1.000	0.519	0.457
2005	0.006	0.971	1.000	0.519	0.457
2006	0.006	0.971	1.000	0.519	0.457

5.17 NOT-USED

Not used

5.18 NOT-USED

Not used

TOTAL NUMBER OF FUNCTION EVALUATIONS = 11363

Run 10.This file contains basic model inputs and results.

VPA-2BOX

SUMMARY STATISTICS AND DIAGNOSTIC OUTPUT

YFT 1970-2006 RUN 10
12:55, 27 July 2008

```
=====
Total objective function = -25.19
(with constants) = 297.36
Number of parameters (P) = 58
Number of data points (D)= 351
AIC : 2*objective+2P = 710.72
AICc: 2*objective+2P(...)= 734.16
BIC : 2*objective+Plog(D)= 934.65
Chi-square discrepancy = 418.18

Loglikelihoods (deviance)= -44.16 ( 352.21)
effort data = -44.16 ( 352.21)

Log-posteriors = 56.79
catchability = 0.00
f-ratio = 56.79
natural mortality = 0.00
mixing coeff. = 0.00

Constraints = 12.56
terminal F = 10.19
stock-rec./sex ratio = 2.37

Out of bounds penalty = 0.00
=====
```

TABLE 1. FISHING MORTALITY RATE FOR Yellowfin Tuna 2008

	0	1	2	3	4	5
1970	0.009	0.131	0.097	0.173	0.194	0.050
1971	0.009	0.122	0.181	0.157	0.169	0.042
1972	0.012	0.129	0.222	0.248	0.209	0.052
1973	0.007	0.115	0.188	0.282	0.276	0.066
1974	0.023	0.169	0.224	0.312	0.347	0.082
1975	0.040	0.177	0.298	0.356	0.585	0.136
1976	0.045	0.193	0.218	0.383	0.692	0.157
1977	0.035	0.210	0.229	0.368	0.670	0.147
1978	0.040	0.213	0.263	0.378	0.458	0.099
1979	0.048	0.241	0.146	0.387	0.489	0.106
1980	0.082	0.243	0.204	0.316	0.500	0.108
1981	0.121	0.272	0.232	0.362	0.800	0.180
1982	0.055	0.334	0.245	0.488	0.904	0.213
1983	0.069	0.245	0.226	0.626	1.046	0.247
1984	0.053	0.290	0.270	0.269	0.306	0.070
1985	0.069	0.191	0.240	0.323	0.640	0.134
1986	0.070	0.177	0.145	0.371	0.546	0.103
1987	0.119	0.205	0.148	0.260	0.497	0.088
1988	0.112	0.252	0.131	0.301	0.281	0.048
1989	0.109	0.243	0.118	0.314	0.576	0.099
1990	0.133	0.296	0.143	0.389	0.839	0.147
1991	0.127	0.289	0.153	0.377	0.741	0.130
1992	0.115	0.272	0.169	0.395	0.852	0.148
1993	0.151	0.267	0.217	0.456	0.695	0.118
1994	0.112	0.311	0.295	0.374	0.854	0.143
1995	0.122	0.294	0.198	0.333	0.774	0.135
1996	0.127	0.352	0.208	0.348	0.685	0.128
1997	0.105	0.401	0.191	0.299	0.609	0.126
1998	0.083	0.416	0.239	0.342	0.804	0.186
1999	0.131	0.535	0.292	0.370	0.623	0.156
2000	0.175	0.352	0.176	0.516	0.652	0.171
2001	0.155	0.687	0.265	0.424	0.846	0.229
2002	0.171	0.503	0.219	0.367	0.616	0.180
2003	0.175	0.525	0.186	0.439	0.615	0.197
2004	0.149	0.435	0.260	0.385	0.631	0.214
2005	0.160	0.410	0.192	0.314	0.567	0.197
2006	0.143	0.299	0.211	0.391	0.584	0.204

TABLE 2. ABUNDANCE AT THE BEGINNING OF THE YEAR [BY AREA] FOR Yellowfin Tuna 2008

	0	1	2	3	4	5
1970	55754410.	26075935.	8662439.	5399353.	2498986.	2339937.
1971	54790348.	24816407.	10273896.	4312957.	2492624.	2351162.
1972	47032848.	24394085.	9870486.	4707253.	2023399.	2392913.
1973	51598339.	20891423.	9632340.	4339346.	2016684.	2147944.
1974	56438414.	23025933.	8365393.	4381645.	1797126.	1943515.
1975	68711754.	24781423.	8734544.	3670825.	1759384.	1679888.
1976	71327404.	29669227.	9327187.	3557013.	1410672.	1342659.
1977	62955983.	30628402.	10988247.	4116392.	1330592.	1017118.
1978	58377594.	27318799.	11150183.	4795328.	1563444.	855697.
1979	62184709.	25193650.	9916057.	4704961.	1804084.	968079.
1980	58772998.	26621652.	8894440.	4701033.	1753795.	1084888.
1981	85481877.	24330807.	9381395.	3980181.	1881324.	1118207.
1982	72408502.	34032890.	8327789.	4080841.	1520495.	976462.
1983	93679565.	30806698.	10948583.	3575910.	1374388.	771317.
1984	80672423.	39283432.	10835469.	4795516.	1049181.	595718.
1985	92044266.	34361419.	13201992.	4540072.	2011466.	728987.
1986	79828955.	38584252.	12754302.	5699738.	1803848.	931880.
1987	80704010.	33460991.	14522197.	6053296.	2159538.	1034850.
1988	68444054.	32195035.	12253292.	6873186.	2561852.	1240796.
1989	81583256.	27484742.	11244101.	5899569.	2792645.	1709998.
1990	79323441.	32869875.	9690246.	5484003.	2366162.	1711798.

1991	76193992.	31215988.	10985457.	4610022.	2039879.	1372014.
1992	81923536.	30149307.	10502783.	5172922.	1735774.	1194360.
1993	88889455.	32813290.	10321825.	4869105.	1912447.	971569.
1994	68017359.	34346748.	11291498.	4561154.	1693772.	997793.
1995	65603142.	27333214.	11311567.	4615868.	1722308.	870360.
1996	65500438.	26103018.	9150664.	5092199.	1815019.	853260.
1997	74239906.	25925386.	8250134.	4078295.	1973589.	914371.
1998	95693809.	30045552.	7800932.	3739637.	1659292.	1031432.
1999	71457060.	39581840.	8902601.	3372047.	1457695.	877607.
2000	74638276.	28157126.	10418232.	3647024.	1278811.	841102.
2001	74939431.	28141072.	8901403.	4795272.	1194655.	754572.
2002	65424217.	28848665.	6359189.	3749685.	1723013.	610520.
2003	61595949.	24765699.	7835700.	2802582.	1425323.	790609.
2004	73837594.	23237480.	6584292.	3571242.	991828.	779340.
2005	56463887.	28575638.	6759904.	2785189.	1333723.	634829.
2006	49948365.	21628769.	8520186.	3062598.	1116358.	701217.
2007		19450311.	7204902.	3786102.	1137160.	655569.

TABLE 3. CATCH OF Yellowfin Tuna 2008

	0	1	2	3	4	5
1970	361290.	2229482.	607301.	650369.	335068.	85575.
1971	344448.	1977021.	1287353.	474486.	293744.	72602.
1972	370595.	2052767.	1492978.	786068.	289931.	91172.
1973	243206.	1577104.	1251198.	811921.	370436.	103603.
1974	886952.	2496615.	1274896.	897957.	403301.	115146.
1975	1850686.	2801854.	1719568.	842170.	602660.	162022.
1976	2183572.	3635133.	1388487.	867883.	547868.	148267.
1977	1488116.	4057058.	1711726.	970685.	504842.	105140.
1978	1592943.	3664928.	1963323.	1155362.	441937.	60903.
1979	2028285.	3775358.	1022740.	1156845.	537482.	73775.
1980	3200008.	4016663.	1247358.	972350.	532110.	83719.
1981	6758071.	4062149.	1479983.	926044.	810154.	139639.
1982	2657563.	6800765.	1379253.	1214320.	710570.	142131.
1983	4323476.	4680819.	1680974.	1290371.	704840.	128569.
1984	2901125.	6946804.	1953147.	861417.	211065.	30274.
1985	4268983.	4165569.	2143130.	957578.	738008.	69106.
1986	3706439.	4362541.	1306129.	1351567.	586169.	68951.
1987	6280192.	4318997.	1513905.	1055188.	652139.	65881.
1988	5045170.	5018133.	1138051.	1362108.	479093.	44092.
1989	5844442.	4139343.	946698.	1212904.	945449.	121843.
1990	6840077.	5910204.	977104.	1354542.	1052048.	177816.
1991	6313402.	5500947.	1181880.	1108701.	832673.	126849.
1992	6170239.	5029419.	1236534.	1294467.	780051.	124612.
1993	8654594.	5382283.	1528458.	1371075.	745384.	81507.
1994	4983084.	6443400.	2198100.	1089902.	762615.	100493.
1995	5210909.	4889679.	1543835.	1000446.	724878.	82982.
1996	5415623.	5453178.	1306456.	1144517.	699652.	77460.
1997	5109588.	6051401.	1090160.	805058.	697640.	81796.
1998	5261746.	7237372.	1260581.	828678.	716679.	132870.
1999	6104314.	11684800.	1722161.	797909.	524019.	96085.
2000	8362333.	5878954.	1274923.	1133947.	475691.	100301.
2001	7465211.	10065910.	1576328.	1271341.	534448.	117632.
2002	7175201.	8115388.	952183.	882558.	613958.	76429.
2003	6879341.	7202107.	1008228.	764832.	507098.	107459.
2004	7118910.	5801751.	1149694.	874474.	360014.	114175.
2005	5792990.	6796869.	895413.	573610.	446518.	86079.
2006	4628314.	3926747.	1232116.	759365.	382044.	98240.

TABLE 4. SPAWNING STOCK FECUNDITY AND RECRUITMENT OF Yellowfin Tuna 2008

year	spawning biomass	recruits from VPA
1970	452061.	55754410.
1971	423048.	54790348.
1972	411420.	47032848.
1973	381632.	51598339.
1974	355344.	56438414.
1975	311738.	68711754.
1976	265347.	71327404.
1977	252932.	62955983.
1978	272542.	58377594.
1979	290143.	62184709.
1980	296829.	58772998.
1981	282729.	85481877.
1982	255400.	72408502.
1983	217599.	93679565.
1984	229378.	80672423.
1985	277632.	92044266.
1986	314297.	79828955.
1987	351375.	80704010.
1988	411351.	68444054.
1989	427222.	81583256.
1990	390735.	79323441.
1991	327078.	76193992.
1992	313194.	81923536.
1993	297839.	88889455.
1994	280258.	68017359.
1995	274757.	65603142.
1996	291581.	65500438.
1997	277349.	74239906.
1998	259041.	95693809.
1999	228871.	71457060.
2000	223352.	74638276.
2001	243476.	74939431.
2002	232604.	65424217.
2003	204756.	61595949.

2004 203493. 73837594.
 2005 189337. 56463887.
 2006 190327. 49948365.

TABLE 5. FITS TO INDEX DATA FOR Yellowfin Tuna 2008

 5.1 BRA_BB

Lognormal dist.
 month 6 biomass
 Ages 0 - 4
 log-likelihood = -1.43
 deviance = 21.65
 Chi-sq. discrepancy= 30.04

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1981	1.614	-0.096	1.711	0.687	0.160E-08	1.391	0.251	18.855
1982	-0.269	-0.089	-0.180	0.687	0.160E-08	0.212	0.253	0.192
1983	0.732	0.176	0.556	0.687	0.160E-08	0.576	0.330	0.237
1984	0.012	0.171	-0.159	0.687	0.160E-08	0.280	0.328	0.177
1985	-0.279	0.340	-0.619	0.687	0.160E-08	0.209	0.389	0.548
1986	-0.279	0.323	-0.602	0.687	0.160E-08	0.209	0.382	0.534
1987	0.063	0.418	-0.355	0.687	0.160E-08	0.295	0.421	0.331
1988	0.165	0.305	-0.139	0.687	0.160E-08	0.327	0.375	0.162
1989	0.076	0.251	-0.174	0.687	0.160E-08	0.299	0.356	0.188
1990	0.807	0.115	0.692	0.687	0.160E-08	0.620	0.310	0.555
1991	-0.390	0.243	-0.633	0.687	0.160E-08	0.187	0.353	0.560
1992	0.062	0.120	-0.057	0.687	0.160E-08	0.295	0.312	0.107
1993	0.234	-0.088	0.322	0.687	0.160E-08	0.350	0.253	0.013
1994	-0.278	0.142	-0.420	0.687	0.160E-08	0.210	0.319	0.384
1995	-0.983	0.188	-1.171	0.687	0.160E-08	0.104	0.334	0.947
1996	0.044	0.019	0.025	0.687	0.160E-08	0.289	0.282	0.060
1997	0.421	-0.086	0.506	0.687	0.160E-08	0.422	0.254	0.160
1998	0.154	-0.221	0.376	0.687	0.160E-08	0.323	0.222	0.037
1999	-0.906	-0.233	-0.673	0.687	0.160E-08	0.112	0.219	0.591
2001	0.900	-0.279	1.180	0.687	0.160E-08	0.681	0.209	4.094
2002	0.049	-0.343	0.391	0.687	0.160E-08	0.291	0.197	0.047
2003	-0.151	-0.328	0.176	0.687	0.160E-08	0.238	0.200	0.006
2004	-1.118	-0.444	-0.674	0.687	0.160E-08	0.091	0.178	0.592
2005	-0.985	-0.410	-0.575	0.687	0.160E-08	0.103	0.184	0.512
2006	0.305	-0.193	0.498	0.687	0.160E-08	0.376	0.228	0.149

Selectivities by age

Year	0	1	2	3	4
1981	0.007	0.624	1.000	0.194	0.010
1982	0.007	0.624	1.000	0.194	0.010
1983	0.007	0.624	1.000	0.194	0.010
1984	0.007	0.624	1.000	0.194	0.010
1985	0.007	0.624	1.000	0.194	0.010
1986	0.007	0.624	1.000	0.194	0.010
1987	0.007	0.624	1.000	0.194	0.010
1988	0.007	0.624	1.000	0.194	0.010
1989	0.007	0.624	1.000	0.194	0.010
1990	0.007	0.624	1.000	0.194	0.010
1991	0.007	0.624	1.000	0.194	0.010
1992	0.007	0.624	1.000	0.194	0.010
1993	0.007	0.624	1.000	0.194	0.010
1994	0.007	0.624	1.000	0.194	0.010
1995	0.007	0.624	1.000	0.194	0.010
1996	0.007	0.624	1.000	0.194	0.010
1997	0.007	0.624	1.000	0.194	0.010
1998	0.007	0.624	1.000	0.194	0.010
1999	0.007	0.624	1.000	0.194	0.010
2001	0.007	0.624	1.000	0.194	0.010
2002	0.007	0.624	1.000	0.194	0.010
2003	0.007	0.624	1.000	0.194	0.010
2004	0.007	0.624	1.000	0.194	0.010
2005	0.007	0.624	1.000	0.194	0.010
2006	0.007	0.624	1.000	0.194	0.010

 5.2 BRA_LL

Lognormal dist.
 month 6 numbers
 Ages 0 - 5
 log-likelihood = 4.25
 deviance = 7.29
 Chi-sq. discrepancy= 3.57

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1986	0.178	0.262	-0.084	0.687	0.140E-07	0.177	0.192	0.125
1987	0.416	0.307	0.109	0.687	0.140E-07	0.224	0.201	0.024
1988	0.645	0.311	0.334	0.687	0.140E-07	0.282	0.202	0.018
1989	0.571	0.238	0.333	0.687	0.140E-07	0.262	0.188	0.017
1990	0.752	0.171	0.581	0.687	0.140E-07	0.313	0.175	0.281
1991	0.177	0.115	0.062	0.687	0.140E-07	0.176	0.166	0.042
1992	-0.300	0.099	-0.399	0.687	0.140E-07	0.109	0.163	0.367
1993	-1.013	0.096	-1.109	0.687	0.140E-07	0.054	0.163	0.908
1994	-0.468	0.076	-0.544	0.687	0.140E-07	0.093	0.159	0.487
1995	-0.661	0.031	-0.692	0.687	0.140E-07	0.076	0.152	0.607
1996	0.299	-0.011	0.310	0.687	0.140E-07	0.199	0.146	0.010
1997	0.085	-0.070	0.155	0.687	0.140E-07	0.161	0.138	0.010

1998	0.327	-0.071	0.398	0.687	0.140E-07	0.205	0.138	0.052
1999	0.104	-0.048	0.152	0.687	0.140E-07	0.164	0.141	0.011
2000	0.008	-0.080	0.088	0.687	0.140E-07	0.149	0.136	0.031
2001	-0.086	-0.114	0.028	0.687	0.140E-07	0.136	0.132	0.058
2002	-0.573	-0.197	-0.376	0.687	0.140E-07	0.083	0.121	0.348
2003	-0.043	-0.279	0.236	0.687	0.140E-07	0.142	0.112	0.000
2004	0.020	-0.285	0.305	0.687	0.140E-07	0.151	0.111	0.009
2005	-0.415	-0.268	-0.147	0.687	0.140E-07	0.098	0.113	0.168
2006	-0.022	-0.283	0.261	0.687	0.140E-07	0.145	0.111	0.001

Selectivities by age

Year	0	1	2	3	4	5
1986	0.018	0.172	0.407	1.000	1.000	1.000
1987	0.018	0.172	0.407	1.000	1.000	1.000
1988	0.018	0.172	0.407	1.000	1.000	1.000
1989	0.018	0.172	0.407	1.000	1.000	1.000
1990	0.018	0.172	0.407	1.000	1.000	1.000
1991	0.018	0.172	0.407	1.000	1.000	1.000
1992	0.018	0.172	0.407	1.000	1.000	1.000
1993	0.018	0.172	0.407	1.000	1.000	1.000
1994	0.018	0.172	0.407	1.000	1.000	1.000
1995	0.018	0.172	0.407	1.000	1.000	1.000
1996	0.018	0.172	0.407	1.000	1.000	1.000
1997	0.018	0.172	0.407	1.000	1.000	1.000
1998	0.018	0.172	0.407	1.000	1.000	1.000
1999	0.018	0.172	0.407	1.000	1.000	1.000
2000	0.018	0.172	0.407	1.000	1.000	1.000
2001	0.018	0.172	0.407	1.000	1.000	1.000
2002	0.018	0.172	0.407	1.000	1.000	1.000
2003	0.018	0.172	0.407	1.000	1.000	1.000
2004	0.018	0.172	0.407	1.000	1.000	1.000
2005	0.018	0.172	0.407	1.000	1.000	1.000
2006	0.018	0.172	0.407	1.000	1.000	1.000

5.3 JPN_LL

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 9.03
deviance = 9.75
Chi-sq. discrepancy= 6.99

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1970	0.526	0.350	0.176	0.687	0.134E-06	1.364	1.143	0.006
1971	0.283	0.290	-0.007	0.687	0.134E-06	1.069	1.077	0.077
1972	0.643	0.253	0.390	0.687	0.134E-06	1.533	1.038	0.046
1973	0.329	0.180	0.149	0.687	0.134E-06	1.119	0.965	0.012
1974	0.566	0.097	0.470	0.687	0.134E-06	1.420	0.888	0.115
1975	0.250	-0.042	0.292	0.687	0.134E-06	1.034	0.773	0.006
1976	0.288	-0.119	0.407	0.687	0.134E-06	1.075	0.715	0.058
1977	0.103	-0.054	0.157	0.687	0.134E-06	0.893	0.763	0.009
1978	0.452	0.032	0.419	0.687	0.134E-06	1.266	0.832	0.067
1979	0.768	0.038	0.731	0.687	0.134E-06	1.737	0.837	0.680
1980	0.190	0.029	0.161	0.687	0.134E-06	0.974	0.830	0.009
1981	0.426	-0.063	0.490	0.687	0.134E-06	1.234	0.756	0.139
1982	0.278	-0.170	0.448	0.687	0.134E-06	1.063	0.680	0.092
1983	0.308	-0.227	0.535	0.687	0.134E-06	1.096	0.642	0.202
1984	0.361	-0.017	0.378	0.687	0.134E-06	1.156	0.792	0.039
1985	-0.115	0.084	-0.199	0.687	0.134E-06	0.718	0.876	0.206
1986	0.167	0.195	-0.029	0.687	0.134E-06	0.952	0.979	0.090
1987	0.207	0.324	-0.118	0.687	0.134E-06	0.991	1.115	0.147
1988	0.246	0.401	-0.155	0.687	0.134E-06	1.030	1.203	0.174
1989	-0.032	0.333	-0.365	0.687	0.134E-06	0.780	1.124	0.339
1990	0.277	0.194	0.083	0.687	0.134E-06	1.063	0.979	0.033
1991	-0.011	0.100	-0.111	0.687	0.134E-06	0.797	0.890	0.142
1992	0.034	0.083	-0.050	0.687	0.134E-06	0.833	0.876	0.102
1993	-0.608	0.033	-0.641	0.687	0.134E-06	0.439	0.833	0.566
1994	-0.076	0.008	-0.084	0.687	0.134E-06	0.747	0.812	0.124
1995	-0.500	0.028	-0.528	0.687	0.134E-06	0.489	0.829	0.474
1996	-0.430	0.030	-0.460	0.687	0.134E-06	0.524	0.830	0.417
1997	-0.636	-0.060	-0.576	0.687	0.134E-06	0.426	0.759	0.513
1998	-0.470	-0.164	-0.307	0.687	0.134E-06	0.503	0.684	0.291
1999	-0.440	-0.212	-0.228	0.687	0.134E-06	0.519	0.652	0.229
2000	-0.296	-0.176	-0.120	0.687	0.134E-06	0.599	0.676	0.149
2001	-0.708	-0.117	-0.590	0.687	0.134E-06	0.397	0.716	0.525
2002	-0.708	-0.246	-0.462	0.687	0.134E-06	0.397	0.630	0.419
2003	-0.533	-0.347	-0.186	0.687	0.134E-06	0.473	0.570	0.196
2004	-0.298	-0.340	0.042	0.687	0.134E-06	0.598	0.573	0.051
2005	-0.614	-0.396	-0.218	0.687	0.134E-06	0.436	0.542	0.220
2006	-0.226	-0.331	0.105	0.687	0.134E-06	0.643	0.579	0.025

Selectivities by age

Year	0	1	2	3	4	5
1970	0.000	0.003	0.231	1.000	1.000	1.000
1971	0.000	0.003	0.231	1.000	1.000	1.000
1972	0.000	0.003	0.231	1.000	1.000	1.000
1973	0.000	0.003	0.231	1.000	1.000	1.000
1974	0.000	0.003	0.231	1.000	1.000	1.000
1975	0.000	0.003	0.231	1.000	1.000	1.000
1976	0.000	0.003	0.231	1.000	1.000	1.000
1977	0.000	0.003	0.231	1.000	1.000	1.000
1978	0.000	0.003	0.231	1.000	1.000	1.000
1979	0.000	0.003	0.231	1.000	1.000	1.000
1980	0.000	0.003	0.231	1.000	1.000	1.000
1981	0.000	0.003	0.231	1.000	1.000	1.000
1982	0.000	0.003	0.231	1.000	1.000	1.000

1983	0.000	0.003	0.231	1.000	1.000	1.000
1984	0.000	0.003	0.231	1.000	1.000	1.000
1985	0.000	0.003	0.231	1.000	1.000	1.000
1986	0.000	0.003	0.231	1.000	1.000	1.000
1987	0.000	0.003	0.231	1.000	1.000	1.000
1988	0.000	0.003	0.231	1.000	1.000	1.000
1989	0.000	0.003	0.231	1.000	1.000	1.000
1990	0.000	0.003	0.231	1.000	1.000	1.000
1991	0.000	0.003	0.231	1.000	1.000	1.000
1992	0.000	0.003	0.231	1.000	1.000	1.000
1993	0.000	0.003	0.231	1.000	1.000	1.000
1994	0.000	0.003	0.231	1.000	1.000	1.000
1995	0.000	0.003	0.231	1.000	1.000	1.000
1996	0.000	0.003	0.231	1.000	1.000	1.000
1997	0.000	0.003	0.231	1.000	1.000	1.000
1998	0.000	0.003	0.231	1.000	1.000	1.000
1999	0.000	0.003	0.231	1.000	1.000	1.000
2000	0.000	0.003	0.231	1.000	1.000	1.000
2001	0.000	0.003	0.231	1.000	1.000	1.000
2002	0.000	0.003	0.231	1.000	1.000	1.000
2003	0.000	0.003	0.231	1.000	1.000	1.000
2004	0.000	0.003	0.231	1.000	1.000	1.000
2005	0.000	0.003	0.231	1.000	1.000	1.000
2006	0.000	0.003	0.231	1.000	1.000	1.000

5.4 USMEX_LL

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 4.74
deviance = 1.04
Chi-sq. discrepancy= 1.52

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1993	0.205	0.196	0.009	0.687	0.173E-06	1.151	1.140	0.068
1994	0.528	0.175	0.353	0.687	0.173E-06	1.589	1.116	0.026
1995	0.077	0.196	-0.119	0.687	0.173E-06	1.012	1.140	0.148
1996	-0.043	0.185	-0.228	0.687	0.173E-06	0.898	1.128	0.228
1997	0.042	0.095	-0.054	0.687	0.173E-06	0.977	1.031	0.105
1998	-0.039	-0.005	-0.034	0.687	0.173E-06	0.901	0.932	0.093
1999	0.382	-0.043	0.425	0.687	0.173E-06	1.373	0.898	0.072
2000	0.001	0.001	0.000	0.687	0.173E-06	0.938	0.938	0.073
2001	-0.232	0.043	-0.275	0.687	0.173E-06	0.743	0.978	0.265
2002	-0.175	-0.093	-0.082	0.687	0.173E-06	0.787	0.854	0.123
2003	-0.025	-0.178	0.153	0.687	0.173E-06	0.914	0.785	0.011
2004	-0.195	-0.183	-0.013	0.687	0.173E-06	0.771	0.781	0.080
2005	0.285	-0.230	-0.055	0.687	0.173E-06	0.705	0.745	0.105
2006	-0.240	-0.159	-0.081	0.687	0.173E-06	0.737	0.800	0.123

Selectivities by age

Year	0	1	2	3	4	5
1993	0.000	0.006	0.281	1.000	1.000	1.000
1994	0.000	0.006	0.281	1.000	1.000	1.000
1995	0.000	0.006	0.281	1.000	1.000	1.000
1996	0.000	0.006	0.281	1.000	1.000	1.000
1997	0.000	0.006	0.281	1.000	1.000	1.000
1998	0.000	0.006	0.281	1.000	1.000	1.000
1999	0.000	0.006	0.281	1.000	1.000	1.000
2000	0.000	0.006	0.281	1.000	1.000	1.000
2001	0.000	0.006	0.281	1.000	1.000	1.000
2002	0.000	0.006	0.281	1.000	1.000	1.000
2003	0.000	0.006	0.281	1.000	1.000	1.000
2004	0.000	0.006	0.281	1.000	1.000	1.000
2005	0.000	0.006	0.281	1.000	1.000	1.000
2006	0.000	0.006	0.281	1.000	1.000	1.000

5.5 US_RR

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 0.40
deviance = 14.99
Chi-sq. discrepancy= 7.18

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1986	0.789	0.319	0.470	0.687	0.102E-06	1.939	1.212	0.116
1987	0.046	0.397	-0.351	0.687	0.102E-06	0.922	1.310	0.327
1988	-0.456	0.273	-0.730	0.687	0.102E-06	0.558	1.157	0.636
1989	-0.437	0.178	-0.615	0.687	0.102E-06	0.569	1.052	0.544
1990	-0.911	0.076	-0.987	0.687	0.102E-06	0.354	0.950	0.826
1991	-0.437	0.143	-0.580	0.687	0.102E-06	0.569	1.016	0.516
1992	-0.820	0.103	-0.923	0.687	0.102E-06	0.388	0.976	0.781
1993	0.003	0.086	-0.083	0.687	0.102E-06	0.883	0.959	0.124
1994	0.665	0.124	0.541	0.687	0.102E-06	1.712	0.997	0.211
1995	0.490	0.124	0.366	0.687	0.102E-06	1.438	0.997	0.032
1996	-0.717	-0.046	-0.670	0.687	0.102E-06	0.430	0.841	0.590
1997	-0.822	-0.134	-0.688	0.687	0.102E-06	0.387	0.770	0.604
1998	-0.121	-0.171	0.049	0.687	0.102E-06	0.780	0.742	0.048
1999	0.627	-0.054	0.681	0.687	0.102E-06	1.649	0.834	0.523
2000	0.489	0.052	0.437	0.687	0.102E-06	1.436	0.928	0.083
2001	0.556	-0.114	0.671	0.687	0.102E-06	1.536	0.785	0.493
2002	0.168	-0.326	0.494	0.687	0.102E-06	1.042	0.636	0.144

2003	0.283	-0.218	0.501	0.687	0.102E-06	1.169	0.708	0.154
2004	0.156	-0.365	0.521	0.687	0.102E-06	1.029	0.611	0.180
2005	0.063	-0.284	0.347	0.687	0.102E-06	0.938	0.663	0.023
2006	0.383	-0.165	0.547	0.687	0.102E-06	1.291	0.747	0.222

Selectivities by age						
Year	0	1	2	3	4	5
1986	0.000	0.100	1.000	0.186	0.076	0.025
1987	0.000	0.100	1.000	0.186	0.076	0.025
1988	0.000	0.100	1.000	0.186	0.076	0.025
1989	0.000	0.100	1.000	0.186	0.076	0.025
1990	0.000	0.100	1.000	0.186	0.076	0.025
1991	0.000	0.100	1.000	0.186	0.076	0.025
1992	0.000	0.100	1.000	0.186	0.076	0.025
1993	0.000	0.100	1.000	0.186	0.076	0.025
1994	0.000	0.100	1.000	0.186	0.076	0.025
1995	0.000	0.100	1.000	0.186	0.076	0.025
1996	0.000	0.100	1.000	0.186	0.076	0.025
1997	0.000	0.100	1.000	0.186	0.076	0.025
1998	0.000	0.100	1.000	0.186	0.076	0.025
1999	0.000	0.100	1.000	0.186	0.076	0.025
2000	0.000	0.100	1.000	0.186	0.076	0.025
2001	0.000	0.100	1.000	0.186	0.076	0.025
2002	0.000	0.100	1.000	0.186	0.076	0.025
2003	0.000	0.100	1.000	0.186	0.076	0.025
2004	0.000	0.100	1.000	0.186	0.076	0.025
2005	0.000	0.100	1.000	0.186	0.076	0.025
2006	0.000	0.100	1.000	0.186	0.076	0.025

5.6 US_PLL ATL

Lognormal dist.

month 6 numbers

Ages 0 - 5

log-likelihood = 6.65

deviance = 1.74

Chi-sq. discrepancy= 2.11

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1987	0.587	0.370	0.217	0.687	0.156E-06	1.696	1.365	0.001
1988	0.652	0.436	0.216	0.687	0.156E-06	1.811	1.459	0.001
1989	0.588	0.367	0.221	0.687	0.156E-06	1.699	1.361	0.000
1990	0.388	0.230	0.159	0.687	0.156E-06	1.391	1.187	0.009
1991	0.140	0.144	-0.003	0.687	0.156E-06	1.085	1.089	0.075
1992	0.210	0.125	0.085	0.687	0.156E-06	1.164	1.069	0.033
1993	-0.279	0.077	-0.356	0.687	0.156E-06	0.713	1.019	0.331
1994	0.125	0.055	-0.180	0.687	0.156E-06	0.832	0.997	0.192
1995	-0.040	0.075	-0.115	0.687	0.156E-06	0.906	1.017	0.146
1996	-0.298	0.067	-0.365	0.687	0.156E-06	0.700	1.009	0.338
1997	-0.191	-0.023	-0.168	0.687	0.156E-06	0.780	0.922	0.183
1998	-0.316	-0.123	-0.193	0.687	0.156E-06	0.687	0.834	0.202
1999	-0.178	-0.163	-0.015	0.687	0.156E-06	0.789	0.801	0.082
2000	-0.091	-0.121	0.030	0.687	0.156E-06	0.861	0.835	0.057
2001	-0.218	-0.076	-0.142	0.687	0.156E-06	0.758	0.874	0.164
2002	-0.293	-0.210	-0.084	0.687	0.156E-06	0.703	0.765	0.124
2003	-0.423	-0.298	-0.124	0.687	0.156E-06	0.618	0.700	0.152
2004	-0.063	-0.301	0.238	0.687	0.156E-06	0.886	0.698	0.000
2005	-0.013	-0.350	0.336	0.687	0.156E-06	0.931	0.665	0.019
2006	-0.036	-0.280	0.244	0.687	0.156E-06	0.910	0.713	0.000

Year	0	1	2	3	4	5
1987	0.000	0.006	0.270	1.000	1.000	1.000
1988	0.000	0.006	0.270	1.000	1.000	1.000
1989	0.000	0.006	0.270	1.000	1.000	1.000
1990	0.000	0.006	0.270	1.000	1.000	1.000
1991	0.000	0.006	0.270	1.000	1.000	1.000
1992	0.000	0.006	0.270	1.000	1.000	1.000
1993	0.000	0.006	0.270	1.000	1.000	1.000
1994	0.000	0.006	0.270	1.000	1.000	1.000
1995	0.000	0.006	0.270	1.000	1.000	1.000
1996	0.000	0.006	0.270	1.000	1.000	1.000
1997	0.000	0.006	0.270	1.000	1.000	1.000
1998	0.000	0.006	0.270	1.000	1.000	1.000
1999	0.000	0.006	0.270	1.000	1.000	1.000
2000	0.000	0.006	0.270	1.000	1.000	1.000
2001	0.000	0.006	0.270	1.000	1.000	1.000
2002	0.000	0.006	0.270	1.000	1.000	1.000
2003	0.000	0.006	0.270	1.000	1.000	1.000
2004	0.000	0.006	0.270	1.000	1.000	1.000
2005	0.000	0.006	0.270	1.000	1.000	1.000
2006	0.000	0.006	0.270	1.000	1.000	1.000

5.7 VEN_LL

Lognormal dist.

month 6 numbers

Ages 0 - 5

log-likelihood = 2.22

deviance = 3.82

Chi-sq. discrepancy= 3.43

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy

1991	0.132	0.140	-0.008	0.687	0.179E-06	1.045	1.053	0.078
1992	0.218	0.122	0.096	0.687	0.179E-06	1.138	1.034	0.028
1993	0.605	0.079	0.526	0.687	0.179E-06	1.676	0.991	0.188
1994	-0.378	0.046	-0.424	0.687	0.179E-06	0.627	0.959	0.388
1995	-0.277	0.051	-0.328	0.687	0.179E-06	0.694	0.963	0.308
1996	-0.011	0.072	-0.083	0.687	0.179E-06	0.905	0.983	0.124
1997	-0.604	-0.010	-0.594	0.687	0.179E-06	0.500	0.906	0.528
1998	-0.051	-0.104	0.054	0.687	0.179E-06	0.870	0.825	0.046
1999	-0.075	-0.152	0.077	0.687	0.179E-06	0.849	0.786	0.036
2000	-0.375	-0.158	-0.218	0.687	0.179E-06	0.629	0.782	0.221
2001	0.815	-0.087	0.902	0.687	0.179E-06	2.067	0.839	1.486

Selectivities by age

Year	0	1	2	3	4	5
1991	0.000	0.018	0.132	0.906	1.000	1.000
1992	0.000	0.018	0.132	0.906	1.000	1.000
1993	0.000	0.018	0.132	0.906	1.000	1.000
1994	0.000	0.018	0.132	0.906	1.000	1.000
1995	0.000	0.018	0.132	0.906	1.000	1.000
1996	0.000	0.018	0.132	0.906	1.000	1.000
1997	0.000	0.018	0.132	0.906	1.000	1.000
1998	0.000	0.018	0.132	0.906	1.000	1.000
1999	0.000	0.018	0.132	0.906	1.000	1.000
2000	0.000	0.018	0.132	0.906	1.000	1.000
2001	0.000	0.018	0.132	0.906	1.000	1.000

----- 5.8 VEN_PS

Lognormal dist.

month 6 biomass

Ages 0 - 4

log-likelihood = 2.77

deviance = 11.76

Chi-sq. discrepancy= 8.48

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1983	0.863	-0.014	0.877	0.687	0.216E-07	13.589	5.654	1.341
1984	0.050	0.125	-0.075	0.687	0.216E-07	6.027	6.499	0.119
1985	0.573	0.246	0.328	0.687	0.216E-07	10.170	7.329	0.015
1986	0.042	0.292	-0.250	0.687	0.216E-07	5.977	7.676	0.246
1987	-0.226	0.387	-0.613	0.687	0.216E-07	4.574	8.444	0.543
1988	0.095	0.362	-0.267	0.687	0.216E-07	6.304	8.231	0.259
1989	0.868	0.285	0.583	0.687	0.216E-07	13.656	7.621	0.286
1990	0.200	0.170	0.030	0.687	0.216E-07	7.002	6.796	0.058
1991	0.221	0.160	0.061	0.687	0.216E-07	7.151	6.728	0.043
1992	-0.175	0.104	-0.279	0.687	0.216E-07	4.812	6.360	0.269
1993	0.040	-0.039	0.000	0.687	0.216E-07	5.511	5.512	0.073
1994	0.159	0.076	0.082	0.687	0.216E-07	6.720	6.188	0.034
1995	-0.639	0.124	-0.763	0.687	0.216E-07	3.025	6.489	0.662
1996	0.167	0.062	0.105	0.687	0.216E-07	6.777	6.101	0.025
1997	-0.227	-0.081	-0.146	0.687	0.216E-07	4.569	5.289	0.167
1998	-0.437	-0.201	-0.236	0.687	0.216E-07	3.704	4.691	0.235
1999	-0.054	-0.262	0.208	0.687	0.216E-07	5.434	4.412	0.001
2000	0.144	-0.144	0.289	0.687	0.216E-07	6.624	4.963	0.005
2001	0.837	-0.179	1.016	0.687	0.216E-07	13.243	4.795	2.318
2002	0.356	-0.269	0.624	0.687	0.216E-07	8.181	4.383	0.374
2003	-0.360	-0.391	0.031	0.687	0.216E-07	3.999	3.877	0.057
2004	-0.874	-0.401	-0.473	0.687	0.216E-07	2.393	3.839	0.428
2005	-1.543	-0.412	-1.131	0.687	0.216E-07	1.226	3.798	0.922

Selectivities by age

Year	0	1	2	3	4
1983	0.015	0.629	0.869	1.000	0.198
1984	0.015	0.629	0.869	1.000	0.198
1985	0.015	0.629	0.869	1.000	0.198
1986	0.015	0.629	0.869	1.000	0.198
1987	0.015	0.629	0.869	1.000	0.198
1988	0.015	0.629	0.869	1.000	0.198
1989	0.015	0.629	0.869	1.000	0.198
1990	0.015	0.629	0.869	1.000	0.198
1991	0.015	0.629	0.869	1.000	0.198
1992	0.015	0.629	0.869	1.000	0.198
1993	0.015	0.629	0.869	1.000	0.198
1994	0.015	0.629	0.869	1.000	0.198
1995	0.015	0.629	0.869	1.000	0.198
1996	0.015	0.629	0.869	1.000	0.198
1997	0.015	0.629	0.869	1.000	0.198
1998	0.015	0.629	0.869	1.000	0.198
1999	0.015	0.629	0.869	1.000	0.198
2000	0.015	0.629	0.869	1.000	0.198
2001	0.015	0.629	0.869	1.000	0.198
2002	0.015	0.629	0.869	1.000	0.198
2003	0.015	0.629	0.869	1.000	0.198
2004	0.015	0.629	0.869	1.000	0.198
2005	0.015	0.629	0.869	1.000	0.198

----- 5.9 EUR-FAD-PS

Lognormal dist.

month 6 biomass

Ages 0 - 1

log-likelihood = 4.77

deviance = 2.48

Chi-sq. discrepancy= 1.95

Residuals	Standard	Q	Untransfrmd	Untransfrmd	Chi-square
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Year	Observed	Predicted	(Obs-pred)	Deviation	Catchabil.	Observed	Predicted	Discrepancy
1991	0.054	0.152	-0.098	0.687	0.170E-07	1.960	2.161	0.133
1992	-0.380	0.061	-0.440	0.687	0.170E-07	1.270	1.973	0.401
1993	0.065	0.148	-0.084	0.687	0.170E-07	1.980	2.153	0.124
1994	0.002	0.145	-0.143	0.687	0.170E-07	1.860	2.145	0.165
1995	0.161	0.021	0.140	0.687	0.170E-07	2.180	1.896	0.014
1996	0.029	-0.011	0.040	0.687	0.170E-07	1.910	1.836	0.053
1997	-0.130	0.051	-0.181	0.687	0.170E-07	1.630	1.953	0.193
1998	-0.428	0.257	-0.685	0.687	0.170E-07	1.210	2.401	0.601
1999	0.034	0.041	-0.007	0.687	0.170E-07	1.920	1.933	0.077
2000	0.080	0.022	0.058	0.687	0.170E-07	2.010	1.898	0.044
2001	-0.014	-0.131	0.117	0.687	0.170E-07	1.830	1.628	0.021
2002	0.085	-0.011	0.096	0.687	0.170E-07	2.020	1.836	0.028
2003	0.161	-0.223	0.383	0.687	0.170E-07	2.180	1.486	0.042
2004	0.197	-0.136	0.333	0.687	0.170E-07	2.260	1.620	0.017
2005	0.210	-0.129	0.339	0.687	0.170E-07	2.290	1.632	0.019
2006	-0.124	-0.258	0.134	0.687	0.170E-07	1.640	1.435	0.016

Selectivities by age

Year	0	1
1991	0.795	1.000
1992	0.795	1.000
1993	0.795	1.000
1994	0.795	1.000
1995	0.795	1.000
1996	0.795	1.000
1997	0.795	1.000
1998	0.795	1.000
1999	0.795	1.000
2000	0.795	1.000
2001	0.795	1.000
2002	0.795	1.000
2003	0.795	1.000
2004	0.795	1.000
2005	0.795	1.000
2006	0.795	1.000

5.10 EUR-PS 3%

Lognormal dist.
month 6 biomass
Ages 0 - 5
log-likelihood = 3.57
deviance = 0.37
Chi-sq. discrepancy= 0.88

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1970	0.101	0.213	-0.112	0.687	0.192E-07	5.061	5.662	0.143
1971	-0.057	0.162	-0.220	0.687	0.192E-07	4.318	5.379	0.222
1972	0.047	0.116	-0.069	0.687	0.192E-07	4.795	5.135	0.114
1973	0.055	0.058	-0.002	0.687	0.192E-07	4.833	4.845	0.075
1974	-0.038	-0.028	-0.010	0.687	0.192E-07	4.405	4.448	0.079
1975	0.037	-0.116	0.152	0.687	0.192E-07	4.744	4.075	0.011
1976	0.026	-0.211	0.237	0.687	0.192E-07	4.693	3.702	0.000
1977	0.008	-0.137	0.145	0.687	0.192E-07	4.610	3.990	0.013
1978	-0.086	-0.042	-0.045	0.687	0.192E-07	4.195	4.388	0.099
1979	-0.092	-0.016	-0.076	0.687	0.192E-07	4.171	4.503	0.119

Selectivities by age

Year	0	1	2	3	4	5
1970	0.040	0.271	0.420	0.631	1.000	0.243
1971	0.040	0.271	0.420	0.631	1.000	0.243
1972	0.040	0.271	0.420	0.631	1.000	0.243
1973	0.040	0.271	0.420	0.631	1.000	0.243
1974	0.040	0.271	0.420	0.631	1.000	0.243
1975	0.040	0.271	0.420	0.631	1.000	0.243
1976	0.040	0.271	0.420	0.631	1.000	0.243
1977	0.040	0.271	0.420	0.631	1.000	0.243
1978	0.040	0.271	0.420	0.631	1.000	0.243
1979	0.040	0.271	0.420	0.631	1.000	0.243

5.11 EU-DAKAR

Lognormal dist.
month 6 biomass
Ages 0 - 4
log-likelihood = 3.31
deviance = 20.45
Chi-sq. discrepancy= 12.16

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1970	-0.200	0.007	-0.208	0.687	0.472E-08	0.644	0.793	0.213
1971	-0.213	0.006	-0.219	0.687	0.472E-08	0.636	0.791	0.221
1972	-0.207	0.020	-0.227	0.687	0.472E-08	0.640	0.803	0.228
1973	-0.290	-0.029	-0.261	0.687	0.472E-08	0.589	0.764	0.254
1974	0.162	-0.082	0.244	0.687	0.472E-08	0.925	0.725	0.000
1975	-0.664	-0.068	-0.597	0.687	0.472E-08	0.405	0.735	0.530
1976	-0.563	-0.002	-0.561	0.687	0.472E-08	0.448	0.785	0.501
1977	-0.140	0.134	-0.274	0.687	0.472E-08	0.684	0.900	0.265
1978	-1.092	0.126	-1.218	0.687	0.472E-08	0.264	0.892	0.975
1979	-0.457	0.041	-0.499	0.687	0.472E-08	0.498	0.820	0.449
1981	0.263	-0.106	0.369	0.687	0.472E-08	1.024	0.708	0.034

1982	0.215	-0.031	0.247	0.687	0.472E-08	0.976	0.763	0.000
1983	0.234	0.149	0.085	0.687	0.472E-08	0.994	0.913	0.033
1984	0.590	0.245	0.346	0.687	0.472E-08	1.420	1.005	0.022
1985	0.327	0.322	0.005	0.687	0.472E-08	1.091	1.086	0.070
1986	0.739	0.333	0.405	0.687	0.472E-08	1.647	1.098	0.057
1987	0.859	0.383	0.477	0.687	0.472E-08	1.858	1.154	0.123
1988	0.826	0.272	0.554	0.687	0.472E-08	1.798	1.033	0.233
1989	-0.597	0.177	-0.774	0.687	0.472E-08	0.433	0.939	0.671
1990	0.745	0.119	0.626	0.687	0.472E-08	1.658	0.887	0.378
1991	0.422	0.201	0.221	0.687	0.472E-08	1.200	0.962	0.000
1992	1.090	0.082	1.008	0.687	0.472E-08	2.340	0.854	2.248
1993	0.881	-0.058	0.939	0.687	0.472E-08	1.899	0.743	1.725
1994	0.586	0.129	0.457	0.687	0.472E-08	1.414	0.895	0.102
1995	0.071	0.117	-0.046	0.687	0.472E-08	0.845	0.885	0.100
1996	0.562	-0.018	0.580	0.687	0.472E-08	1.381	0.773	0.281
1997	-0.295	-0.099	-0.196	0.687	0.472E-08	0.586	0.713	0.204
1998	-1.261	-0.158	-1.103	0.687	0.472E-08	0.223	0.672	0.904
1999	-0.208	-0.190	-0.018	0.687	0.472E-08	0.639	0.651	0.084
2000	-0.961	-0.057	-0.904	0.687	0.472E-08	0.301	0.743	0.768
2001	-0.490	-0.282	-0.208	0.687	0.472E-08	0.482	0.593	0.213
2002	-0.074	-0.296	0.223	0.687	0.472E-08	0.731	0.585	0.000
2003	0.059	-0.350	0.409	0.687	0.472E-08	0.835	0.555	0.059
2004	-0.213	-0.439	0.226	0.687	0.472E-08	0.636	0.507	0.000
2005	-0.416	-0.357	-0.059	0.687	0.472E-08	0.519	0.550	0.108
2006	-0.291	-0.243	-0.048	0.687	0.472E-08	0.588	0.617	0.101

Selectivities by age

Year	0	1	2	3	4
1970	0.062	1.000	0.666	0.200	0.047
1971	0.062	1.000	0.666	0.200	0.047
1972	0.062	1.000	0.666	0.200	0.047
1973	0.062	1.000	0.666	0.200	0.047
1974	0.062	1.000	0.666	0.200	0.047
1975	0.062	1.000	0.666	0.200	0.047
1976	0.062	1.000	0.666	0.200	0.047
1977	0.062	1.000	0.666	0.200	0.047
1978	0.062	1.000	0.666	0.200	0.047
1979	0.062	1.000	0.666	0.200	0.047
1981	0.062	1.000	0.666	0.200	0.047
1982	0.062	1.000	0.666	0.200	0.047
1983	0.062	1.000	0.666	0.200	0.047
1984	0.062	1.000	0.666	0.200	0.047
1985	0.062	1.000	0.666	0.200	0.047
1986	0.062	1.000	0.666	0.200	0.047
1987	0.062	1.000	0.666	0.200	0.047
1988	0.062	1.000	0.666	0.200	0.047
1989	0.062	1.000	0.666	0.200	0.047
1990	0.062	1.000	0.666	0.200	0.047
1991	0.062	1.000	0.666	0.200	0.047
1992	0.062	1.000	0.666	0.200	0.047
1993	0.062	1.000	0.666	0.200	0.047
1994	0.062	1.000	0.666	0.200	0.047
1995	0.062	1.000	0.666	0.200	0.047
1996	0.062	1.000	0.666	0.200	0.047
1997	0.062	1.000	0.666	0.200	0.047
1998	0.062	1.000	0.666	0.200	0.047
1999	0.062	1.000	0.666	0.200	0.047
2000	0.062	1.000	0.666	0.200	0.047
2001	0.062	1.000	0.666	0.200	0.047
2002	0.062	1.000	0.666	0.200	0.047
2003	0.062	1.000	0.666	0.200	0.047
2004	0.062	1.000	0.666	0.200	0.047
2005	0.062	1.000	0.666	0.200	0.047
2006	0.062	1.000	0.666	0.200	0.047

5.12 URU-LL

Lognormal dist.
month 6 numbers
Ages 0 - 5
log-likelihood = 1.92
deviance = 15.71
Chi-sq. discrepancy= 10.54

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1981	0.627	-0.041	0.668	0.687	0.408E-06	6.554	3.361	0.484
1982	0.932	-0.121	1.053	0.687	0.408E-06	8.896	3.102	2.658
1983	-0.050	-0.083	0.033	0.687	0.408E-06	3.330	3.222	0.056
1984	-0.858	0.058	-0.916	0.687	0.408E-06	1.485	3.709	0.776
1985	0.012	0.174	-0.162	0.687	0.408E-06	3.546	4.169	0.179
1986	0.164	0.259	-0.095	0.687	0.408E-06	4.124	4.537	0.132
1987	0.127	0.369	-0.242	0.687	0.408E-06	3.976	5.064	0.240
1988	0.777	0.378	0.399	0.687	0.408E-06	7.613	5.109	0.052
1989	-0.519	0.302	-0.821	0.687	0.408E-06	2.085	4.737	0.707
1990	-0.609	0.176	-0.785	0.687	0.408E-06	1.904	4.174	0.679
1991	0.672	0.136	0.536	0.687	0.408E-06	6.854	4.012	0.203
1992	0.626	0.110	0.516	0.687	0.408E-06	6.545	3.907	0.173
1993	-1.028	0.072	-1.100	0.687	0.408E-06	1.252	3.761	0.902
1994	0.325	0.069	0.255	0.687	0.408E-06	4.845	3.754	0.001
1995	0.058	0.082	-0.024	0.687	0.408E-06	3.711	3.800	0.087
1996	0.715	0.022	0.693	0.687	0.408E-06	7.159	3.581	0.557
1997	-0.379	-0.065	-0.314	0.687	0.408E-06	2.396	3.280	0.297
1998	-0.255	-0.146	-0.109	0.687	0.408E-06	2.715	3.027	0.141
1999	-0.073	-0.133	0.060	0.687	0.408E-06	3.255	3.066	0.043
2000	0.198	-0.071	0.269	0.687	0.408E-06	4.268	3.263	0.002
2001	-0.283	-0.099	-0.184	0.687	0.408E-06	2.638	3.171	0.195
2002	-0.667	-0.254	-0.414	0.687	0.408E-06	1.796	2.717	0.379
2003	-0.314	-0.279	-0.035	0.687	0.408E-06	2.558	2.649	0.093

2004	-0.318	-0.330	0.012	0.687	0.408E-06	2.547	2.517	0.067
2005	0.528	-0.335	0.863	0.687	0.408E-06	5.937	2.505	1.263
2006	-0.406	-0.250	-0.156	0.687	0.408E-06	2.333	2.727	0.174

Selectivities by age

Year	0	1	2	3	4	5
1981	0.000	0.039	0.572	1.000	1.000	1.000
1982	0.000	0.039	0.572	1.000	1.000	1.000
1983	0.000	0.039	0.572	1.000	1.000	1.000
1984	0.000	0.039	0.572	1.000	1.000	1.000
1985	0.000	0.039	0.572	1.000	1.000	1.000
1986	0.000	0.039	0.572	1.000	1.000	1.000
1987	0.000	0.039	0.572	1.000	1.000	1.000
1988	0.000	0.039	0.572	1.000	1.000	1.000
1989	0.000	0.039	0.572	1.000	1.000	1.000
1990	0.000	0.039	0.572	1.000	1.000	1.000
1991	0.000	0.039	0.572	1.000	1.000	1.000
1992	0.000	0.039	0.572	1.000	1.000	1.000
1993	0.000	0.039	0.572	1.000	1.000	1.000
1994	0.000	0.039	0.572	1.000	1.000	1.000
1995	0.000	0.039	0.572	1.000	1.000	1.000
1996	0.000	0.039	0.572	1.000	1.000	1.000
1997	0.000	0.039	0.572	1.000	1.000	1.000
1998	0.000	0.039	0.572	1.000	1.000	1.000
1999	0.000	0.039	0.572	1.000	1.000	1.000
2000	0.000	0.039	0.572	1.000	1.000	1.000
2001	0.000	0.039	0.572	1.000	1.000	1.000
2002	0.000	0.039	0.572	1.000	1.000	1.000
2003	0.000	0.039	0.572	1.000	1.000	1.000
2004	0.000	0.039	0.572	1.000	1.000	1.000
2005	0.000	0.039	0.572	1.000	1.000	1.000
2006	0.000	0.039	0.572	1.000	1.000	1.000

5.13 BRA-URU-LL

Not used

5.14 CHIN-TAI-LL

Lognormal dist.

month 6 numbers

Ages 0 - 5

log-likelihood = 11.89

deviance = 4.03

Chi-sq. discrepancy= 4.45

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1970	0.772	0.327	0.445	0.687	0.123E-06	1.712	1.098	0.089
1971	0.251	0.274	-0.023	0.687	0.123E-06	1.017	1.041	0.086
1972	0.328	0.236	0.092	0.687	0.123E-06	1.098	1.002	0.030
1973	0.435	0.164	0.272	0.687	0.123E-06	1.223	0.933	0.002
1974	-0.252	0.081	-0.333	0.687	0.123E-06	0.615	0.858	0.312
1975	-0.212	-0.048	-0.163	0.687	0.123E-06	0.641	0.754	0.180
1976	-0.041	-0.111	0.070	0.687	0.123E-06	0.760	0.709	0.039
1977	-0.145	-0.043	-0.102	0.687	0.123E-06	0.685	0.758	0.136
1978	-0.238	0.034	-0.272	0.687	0.123E-06	0.624	0.819	0.263
1979	-0.200	0.034	-0.234	0.687	0.123E-06	0.648	0.819	0.233
1980	0.006	0.022	-0.016	0.687	0.123E-06	0.796	0.809	0.082
1981	-0.133	-0.066	-0.067	0.687	0.123E-06	0.693	0.741	0.113
1982	-0.394	-0.161	-0.233	0.687	0.123E-06	0.534	0.674	0.233
1983	-0.403	-0.202	-0.202	0.687	0.123E-06	0.529	0.647	0.208
1984	-0.033	-0.004	-0.030	0.687	0.123E-06	0.766	0.789	0.090
1985	-0.133	0.097	-0.230	0.687	0.123E-06	0.693	0.872	0.230
1986	0.083	0.204	-0.121	0.687	0.123E-06	0.860	0.970	0.149
1987	-0.009	0.325	-0.334	0.687	0.123E-06	0.784	1.096	0.314
1988	0.342	0.389	-0.048	0.687	0.123E-06	1.114	1.168	0.101
1989	-0.020	0.319	-0.339	0.687	0.123E-06	0.776	1.089	0.317
1990	-0.020	0.186	-0.206	0.687	0.123E-06	0.776	0.953	0.211
1991	0.110	0.101	0.009	0.687	0.123E-06	0.884	0.876	0.068
1992	-0.199	0.083	-0.281	0.687	0.123E-06	0.649	0.860	0.271
1993	0.092	0.037	0.055	0.687	0.123E-06	0.868	0.821	0.045
1994	0.407	0.016	0.391	0.687	0.123E-06	1.189	0.804	0.047
1995	0.391	0.031	0.360	0.687	0.123E-06	1.170	0.817	0.029
1996	0.251	0.022	0.229	0.687	0.123E-06	1.017	0.809	0.000
1997	-0.018	-0.067	0.049	0.687	0.123E-06	0.778	0.740	0.048
1998	-0.010	-0.163	0.153	0.687	0.123E-06	0.783	0.673	0.011
1999	-0.315	-0.196	-0.119	0.687	0.123E-06	0.578	0.651	0.148
2000	-0.023	-0.161	0.138	0.687	0.123E-06	0.773	0.674	0.014
2001	-0.277	-0.121	-0.157	0.687	0.123E-06	0.600	0.702	0.175
2002	-0.101	-0.250	0.149	0.687	0.123E-06	0.715	0.617	0.012
2003	-0.096	-0.339	0.243	0.687	0.123E-06	0.719	0.564	0.000
2004	-0.099	-0.342	0.243	0.687	0.123E-06	0.717	0.562	0.000
2005	-0.108	-0.385	0.493	0.687	0.123E-06	0.882	0.539	0.143
2006	-0.201	-0.322	0.120	0.687	0.123E-06	0.647	0.574	0.020

Selectivities by age

Year	0	1	2	3	4	5
1970	0.000	0.013	0.272	1.000	1.000	1.000
1971	0.000	0.013	0.272	1.000	1.000	1.000
1972	0.000	0.013	0.272	1.000	1.000	1.000
1973	0.000	0.013	0.272	1.000	1.000	1.000
1974	0.000	0.013	0.272	1.000	1.000	1.000
1975	0.000	0.013	0.272	1.000	1.000	1.000
1976	0.000	0.013	0.272	1.000	1.000	1.000
1977	0.000	0.013	0.272	1.000	1.000	1.000
1978	0.000	0.013	0.272	1.000	1.000	1.000

1979	0.000	0.013	0.272	1.000	1.000	1.000
1980	0.000	0.013	0.272	1.000	1.000	1.000
1981	0.000	0.013	0.272	1.000	1.000	1.000
1982	0.000	0.013	0.272	1.000	1.000	1.000
1983	0.000	0.013	0.272	1.000	1.000	1.000
1984	0.000	0.013	0.272	1.000	1.000	1.000
1985	0.000	0.013	0.272	1.000	1.000	1.000
1986	0.000	0.013	0.272	1.000	1.000	1.000
1987	0.000	0.013	0.272	1.000	1.000	1.000
1988	0.000	0.013	0.272	1.000	1.000	1.000
1989	0.000	0.013	0.272	1.000	1.000	1.000
1990	0.000	0.013	0.272	1.000	1.000	1.000
1991	0.000	0.013	0.272	1.000	1.000	1.000
1992	0.000	0.013	0.272	1.000	1.000	1.000
1993	0.000	0.013	0.272	1.000	1.000	1.000
1994	0.000	0.013	0.272	1.000	1.000	1.000
1995	0.000	0.013	0.272	1.000	1.000	1.000
1996	0.000	0.013	0.272	1.000	1.000	1.000
1997	0.000	0.013	0.272	1.000	1.000	1.000
1998	0.000	0.013	0.272	1.000	1.000	1.000
1999	0.000	0.013	0.272	1.000	1.000	1.000
2000	0.000	0.013	0.272	1.000	1.000	1.000
2001	0.000	0.013	0.272	1.000	1.000	1.000
2002	0.000	0.013	0.272	1.000	1.000	1.000
2003	0.000	0.013	0.272	1.000	1.000	1.000
2004	0.000	0.013	0.272	1.000	1.000	1.000
2005	0.000	0.013	0.272	1.000	1.000	1.000
2006	0.000	0.013	0.272	1.000	1.000	1.000

5.15 TROP-PS

Lognormal dist.
month 6 biomass
Ages 3 - 5
log-likelihood = 6.38
deviance = 7.55
Chi-sq. discrepancy= 4.21

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1980	-0.780	0.167	-0.948	0.687	0.245E-08	0.250	0.645	0.799
1981	0.175	0.023	0.152	0.687	0.245E-08	0.650	0.558	0.011
1982	-0.336	-0.092	-0.244	0.687	0.245E-08	0.390	0.498	0.241
1983	-0.108	-0.315	0.207	0.687	0.245E-08	0.490	0.398	0.001
1984	-1.166	-0.093	-1.073	0.687	0.245E-08	0.170	0.497	0.884
1985	0.095	0.059	0.036	0.687	0.245E-08	0.600	0.579	0.054
1986	0.044	0.194	-0.150	0.687	0.245E-08	0.570	0.662	0.170
1987	0.128	0.318	-0.190	0.687	0.245E-08	0.620	0.750	0.200
1988	0.044	0.470	-0.426	0.687	0.245E-08	0.570	0.873	0.389
1989	0.606	0.485	0.121	0.687	0.245E-08	1.000	0.886	0.020
1990	0.565	0.369	0.196	0.687	0.245E-08	0.960	0.789	0.002
1991	0.235	0.190	0.045	0.687	0.245E-08	0.690	0.659	0.050
1992	0.112	0.129	-0.018	0.687	0.245E-08	0.610	0.621	0.083
1993	-0.087	0.080	-0.167	0.687	0.245E-08	0.500	0.591	0.183
1994	0.144	0.011	0.133	0.687	0.245E-08	0.630	0.552	0.016
1995	0.095	0.025	0.070	0.687	0.245E-08	0.600	0.560	0.039
1996	0.026	0.088	-0.062	0.687	0.245E-08	0.560	0.596	0.110
1997	0.235	0.018	0.217	0.687	0.245E-08	0.690	0.555	0.001
1998	-0.029	-0.072	0.043	0.687	0.245E-08	0.530	0.508	0.051
1999	-0.215	-0.192	-0.023	0.687	0.245E-08	0.440	0.450	0.086
2000	-0.310	-0.272	-0.038	0.687	0.245E-08	0.400	0.416	0.095
2001	-0.068	-0.107	0.040	0.687	0.245E-08	0.510	0.490	0.053
2002	0.249	-0.160	0.409	0.687	0.245E-08	0.700	0.465	0.060
2003	0.370	-0.300	0.670	0.687	0.245E-08	0.790	0.404	0.492
2004	-0.029	-0.295	0.266	0.687	0.245E-08	0.530	0.406	0.002
2005	-0.087	-0.345	0.258	0.687	0.245E-08	0.500	0.386	0.001
2006	0.095	-0.380	0.475	0.687	0.245E-08	0.600	0.373	0.121

Selectivities by age

Year	3	4	5
1980	1.000	1.000	1.000
1981	1.000	1.000	1.000
1982	1.000	1.000	1.000
1983	1.000	1.000	1.000
1984	1.000	1.000	1.000
1985	1.000	1.000	1.000
1986	1.000	1.000	1.000
1987	1.000	1.000	1.000
1988	1.000	1.000	1.000
1989	1.000	1.000	1.000
1990	1.000	1.000	1.000
1991	1.000	1.000	1.000
1992	1.000	1.000	1.000
1993	1.000	1.000	1.000
1994	1.000	1.000	1.000
1995	1.000	1.000	1.000
1996	1.000	1.000	1.000
1997	1.000	1.000	1.000
1998	1.000	1.000	1.000
1999	1.000	1.000	1.000
2000	1.000	1.000	1.000
2001	1.000	1.000	1.000
2002	1.000	1.000	1.000
2003	1.000	1.000	1.000
2004	1.000	1.000	1.000
2005	1.000	1.000	1.000
2006	1.000	1.000	1.000

5.16 CAN-IS-BB

Lognormal dist.

month 6 biomass

Ages 0 - 4

log-likelihood = -104.64

deviance = 229.58

Chi-sq. discrepancy= 320.68

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1980	-1.991	0.060	-2.052	0.687	0.275E-09	0.010	0.075	1.340
1981	-1.284	-0.085	-1.199	0.687	0.275E-09	0.020	0.065	0.963
1982	0.289	-0.078	0.368	0.687	0.275E-09	0.094	0.065	0.033
1983	0.855	0.071	0.784	0.687	0.275E-09	0.166	0.076	0.886
1984	2.171	0.159	2.013	0.687	0.275E-09	0.620	0.083	40.044
1985	1.338	0.295	1.043	0.687	0.275E-09	0.269	0.095	2.556
1986	0.896	0.309	0.587	0.687	0.275E-09	0.173	0.096	0.294
1987	1.700	0.397	1.303	0.687	0.275E-09	0.387	0.105	6.037
1988	1.740	0.349	1.391	0.687	0.275E-09	0.402	0.100	7.851
1989	1.214	0.273	0.942	0.687	0.275E-09	0.238	0.093	1.747
1990	2.148	0.154	1.994	0.687	0.275E-09	0.605	0.082	38.279
1991	2.025	0.203	1.822	0.687	0.275E-09	0.535	0.087	25.050
1992	1.479	0.097	1.382	0.687	0.275E-09	0.310	0.078	7.650
1993	0.695	-0.037	0.732	0.687	0.275E-09	0.142	0.068	0.686
1994	0.176	0.107	0.069	0.687	0.275E-09	0.084	0.079	0.039
1995	-0.679	0.133	-0.812	0.687	0.275E-09	0.036	0.081	0.700
1996	2.033	0.031	2.001	0.687	0.275E-09	0.539	0.073	38.979
1997	-0.092	-0.060	-0.032	0.687	0.275E-09	0.064	0.067	0.092
1998	2.379	-0.180	2.559	0.687	0.275E-09	0.763	0.059	140.841
1999	0.029	-0.214	0.243	0.687	0.275E-09	0.073	0.057	0.000
2000	-3.439	-0.084	-3.355	0.687	0.275E-09	0.002	0.065	1.570
2001	-7.484	-0.250	-7.234	0.687	0.275E-09	0.000	0.055	1.658
2002	-1.054	-0.263	-0.792	0.687	0.275E-09	0.025	0.054	0.684
2003	-0.426	-0.335	-0.091	0.687	0.275E-09	0.046	0.051	0.129
2004	-0.618	-0.430	-0.188	0.687	0.275E-09	0.038	0.046	0.198
2005	-2.617	-0.368	-2.249	0.687	0.275E-09	0.005	0.049	1.395
2006	-1.481	-0.252	-1.229	0.687	0.275E-09	0.016	0.055	0.981

Selectivities by age

Year	0	1	2	3	4
1980	0.006	0.971	1.000	0.520	0.455
1981	0.006	0.971	1.000	0.520	0.455
1982	0.006	0.971	1.000	0.520	0.455
1983	0.006	0.971	1.000	0.520	0.455
1984	0.006	0.971	1.000	0.520	0.455
1985	0.006	0.971	1.000	0.520	0.455
1986	0.006	0.971	1.000	0.520	0.455
1987	0.006	0.971	1.000	0.520	0.455
1988	0.006	0.971	1.000	0.520	0.455
1989	0.006	0.971	1.000	0.520	0.455
1990	0.006	0.971	1.000	0.520	0.455
1991	0.006	0.971	1.000	0.520	0.455
1992	0.006	0.971	1.000	0.520	0.455
1993	0.006	0.971	1.000	0.520	0.455
1994	0.006	0.971	1.000	0.520	0.455
1995	0.006	0.971	1.000	0.520	0.455
1996	0.006	0.971	1.000	0.520	0.455
1997	0.006	0.971	1.000	0.520	0.455
1998	0.006	0.971	1.000	0.520	0.455
1999	0.006	0.971	1.000	0.520	0.455
2000	0.006	0.971	1.000	0.520	0.455
2001	0.006	0.971	1.000	0.520	0.455
2002	0.006	0.971	1.000	0.520	0.455
2003	0.006	0.971	1.000	0.520	0.455
2004	0.006	0.971	1.000	0.520	0.455
2005	0.006	0.971	1.000	0.520	0.455
2006	0.006	0.971	1.000	0.520	0.455

5.17 NOT-USED

Not used

5.18 NOT-USED

Not used

TOTAL NUMBER OF FUNCTION EVALUATIONS = 9774

Appendix 8

Detailed Results of the Application of the Catch Only Model to the Assessment of the Atlantic Skipjack Tuna

Table Appendix 8.1. Quantiles for the posterior distributions for MSY for COM runs C.1 to C.6 fitted to catch data from 1985 to 2006 for SKJ-E.

<i>Quantile</i>	<i>RUN C.1</i>	<i>RUN C.2</i>	<i>RUN C.3</i>	<i>RUN C.4</i>	<i>RUN C.5</i>	<i>RUN C.6</i>
5%	114 351	114 042	115 711	114 422	116 969	117 642
10%	119 585	119 402	121 736	119 598	121 763	122 714
25%	129 206	129 400	133 617	128 595	131 181	133 591
50%	143 633	145 005	155 552	142 865	146 103	156 326
75%	174 250	176 562	201 661	175 652	178 324	223 066
80%	188 831	189 313	219 754	192 134	191 662	247 780
95%	314 115	294 163	414 574	331 800	283 543	437 924

Table Appendix 8.2 Quantiles for the posterior distributions for B/B_{MSY} for COM runs C.1 to C.6 fitted to catch data from 1985 to 2006 for SKJ-E.

<i>Quantile</i>	<i>RUN 1</i>	<i>RUN 2</i>	<i>RUN 3</i>	<i>RUN 4</i>	<i>RUN 5</i>	<i>RUN 6</i>
5%	0.64	0.65	0.70	0.64	0.64	0.67
10%	0.74	0.76	0.82	0.74	0.75	0.78
25%	0.94	0.98	1.07	0.92	0.96	1.01
50%	1.20	1.24	1.37	1.17	1.21	1.32
75%	1.47	1.47	1.57	1.45	1.47	1.60
80%	1.52	1.52	1.61	1.52	1.52	1.65
95%	1.74	1.71	1.80	1.75	1.70	1.81

Skipjack western stock

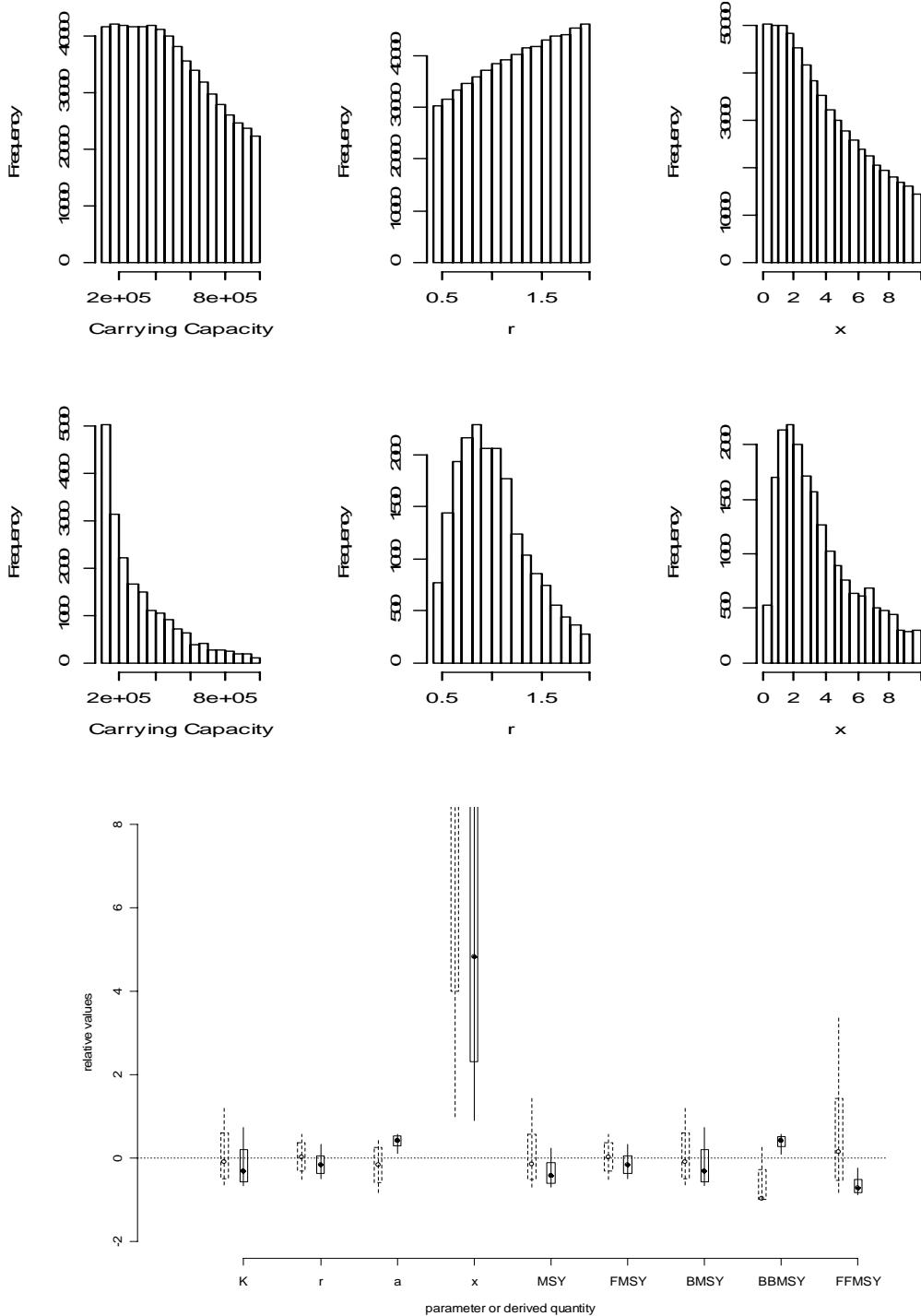


Figure Appendix 8.1 Pre-data, post-model priors (top row) and posteriors (middle row) and relative priors and posteriors (bottom row) for the COM run A.1 fitted to catch data from 1976 to 2006 for western skipjack. The priors (dashed boxes) and posteriors (solid boxes) were relativised to be in the same scale. The dashed boxes for management quantities are the values obtained by running the model only with the priors. The combinations of parameters from the priors that do not cause extinction of the population are called pre-data post-model priors.

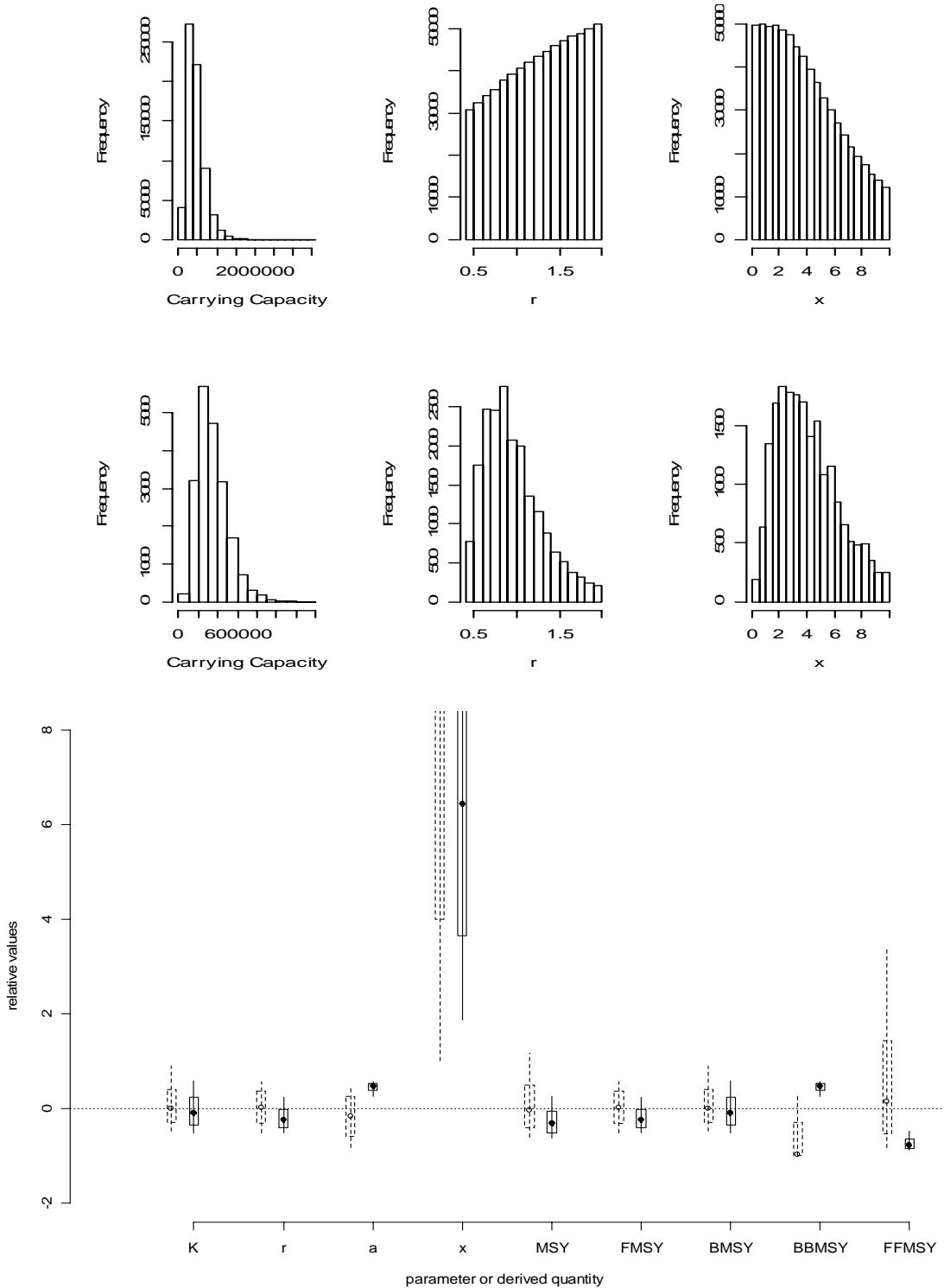


Figure Appendix 8.2 Pre-data, post-model priors (top row) and posteriors (middle row) and relative priors and posteriors (bottom row) for the COM run A.2 fitted to catch data from 1976 to 2006 for western skipjack. See **Figure Appendix 5.1** for explanations.

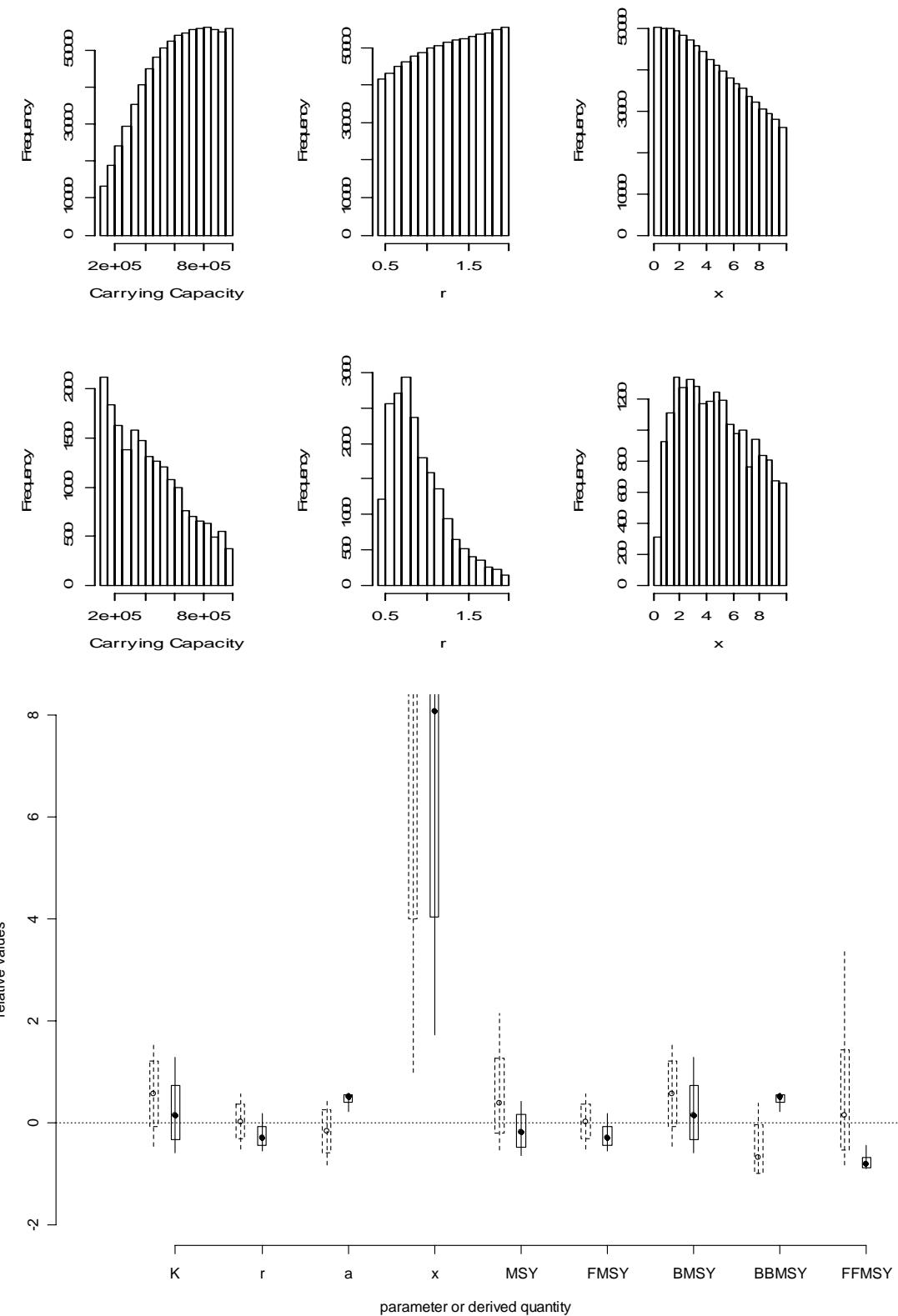


Figure Appendix 8.3 Pre-data, post-model priors (top row) and posteriors (middle row) and relative priors and posteriors (bottom row) for the COM run A.3 fitted to catch data from 1976 to 2006 for SKJ-W. See **Figure Appendix 5.1** for explanations.

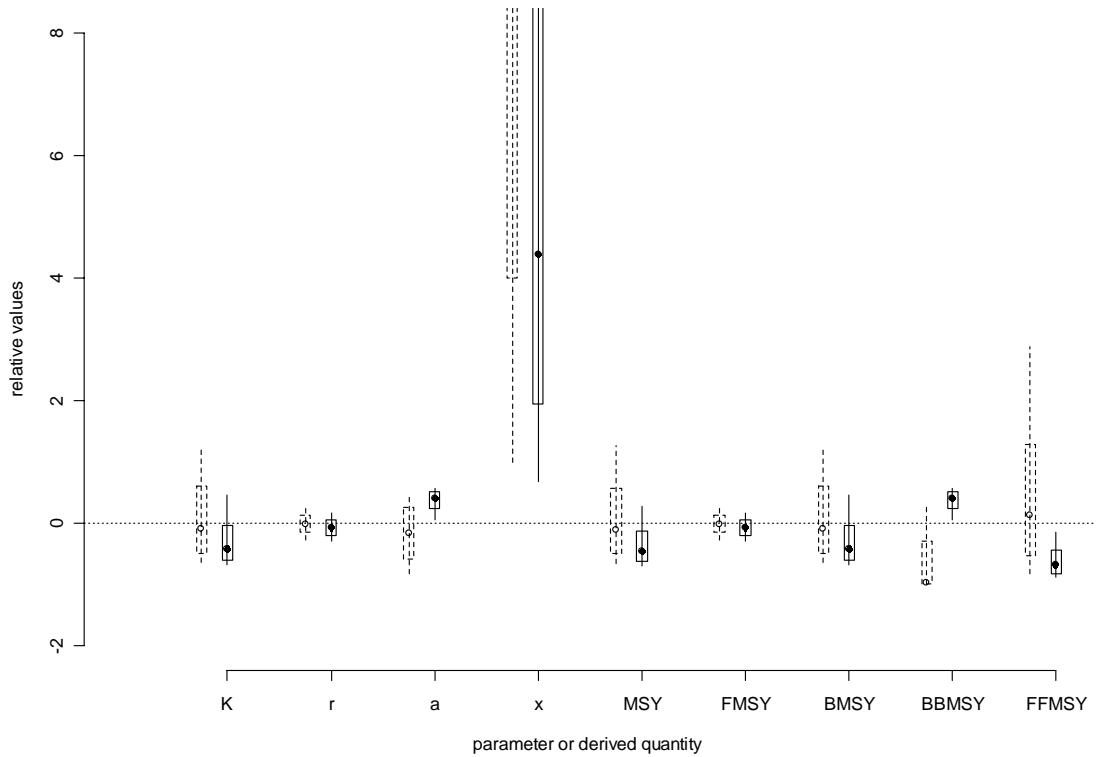
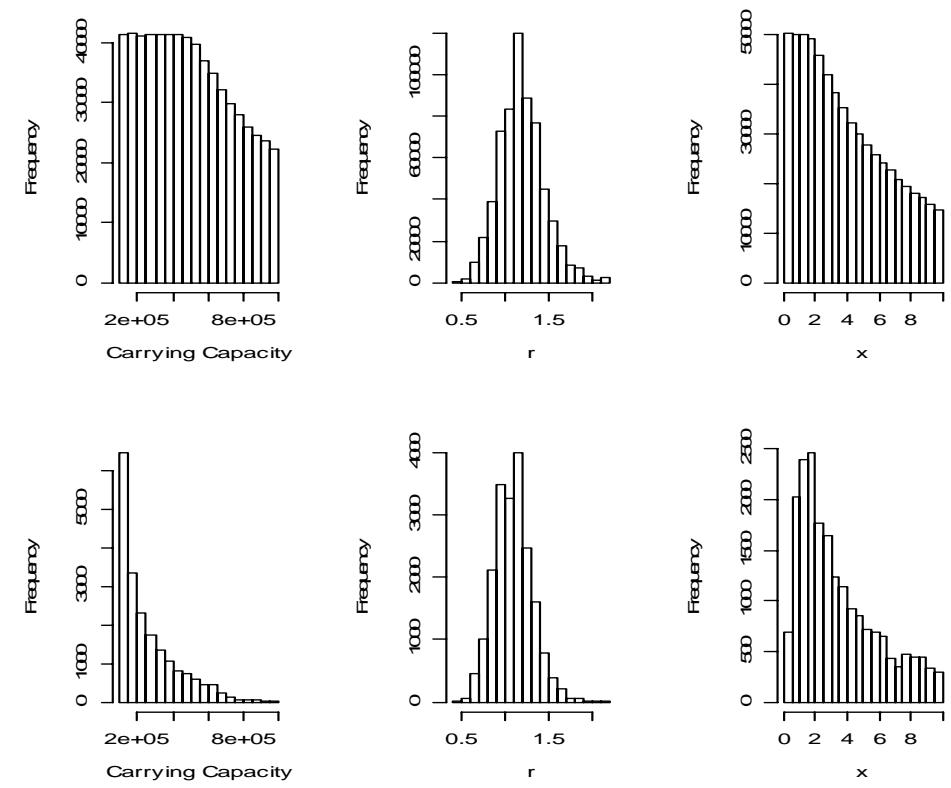


Figure Appendix 8.4. Pre-data, post-model priors (top row) and posteriors (middle row) and relative priors and posteriors (bottom row) for the COM run A.4 fitted to catch data from 1976 to 2006 for SKJ-W. See **Figure Appendix 5.1** for explanations.

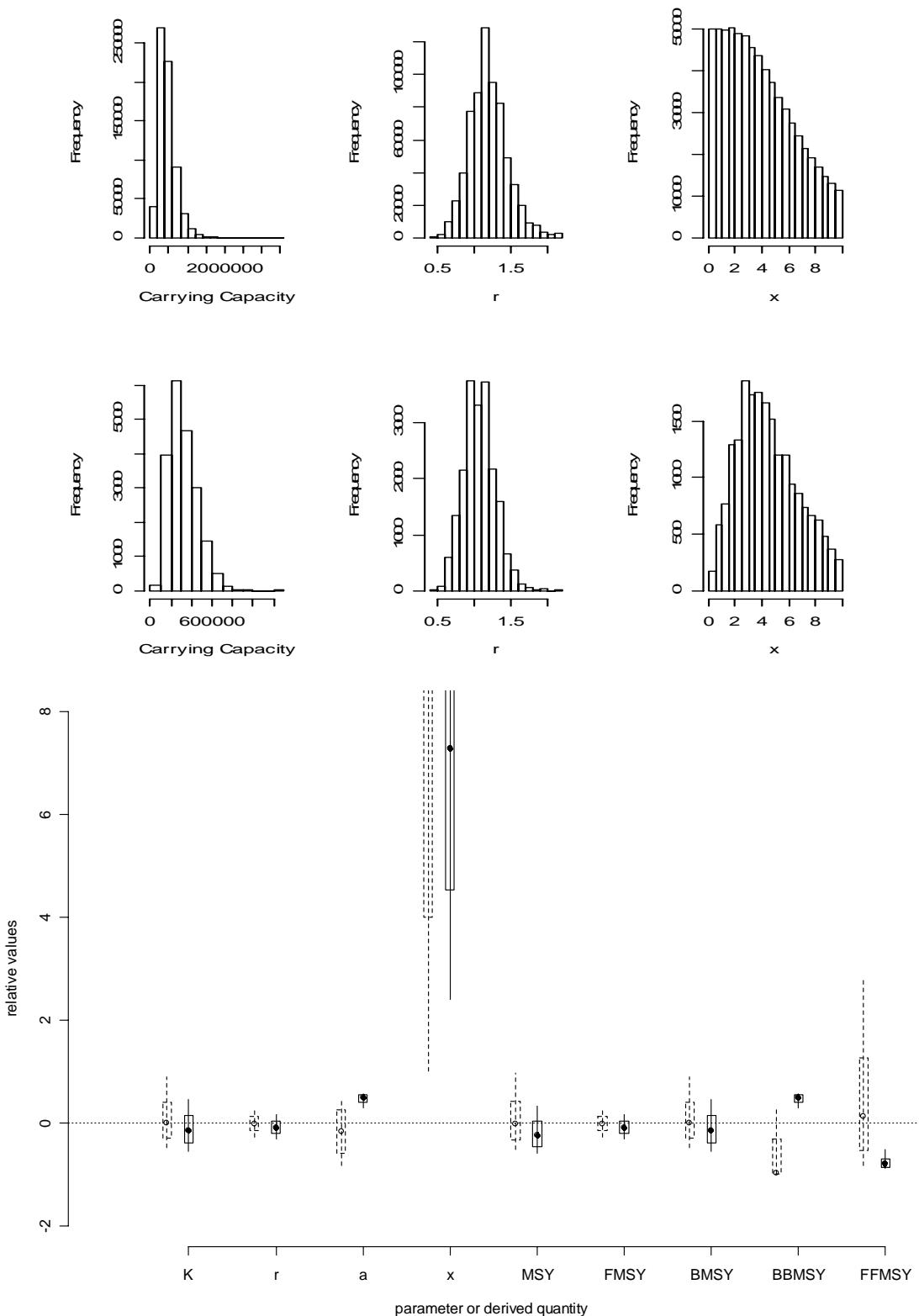


Figure Appendix 8.5 Pre-data, post-model priors (top row) and posteriors (middle row) and relative priors and posteriors (bottom row) for the COM run A.5 fitted to catch data from 1976 to 2006 for SKJ-W. See **Figure Appendix 5.1** for explanations.

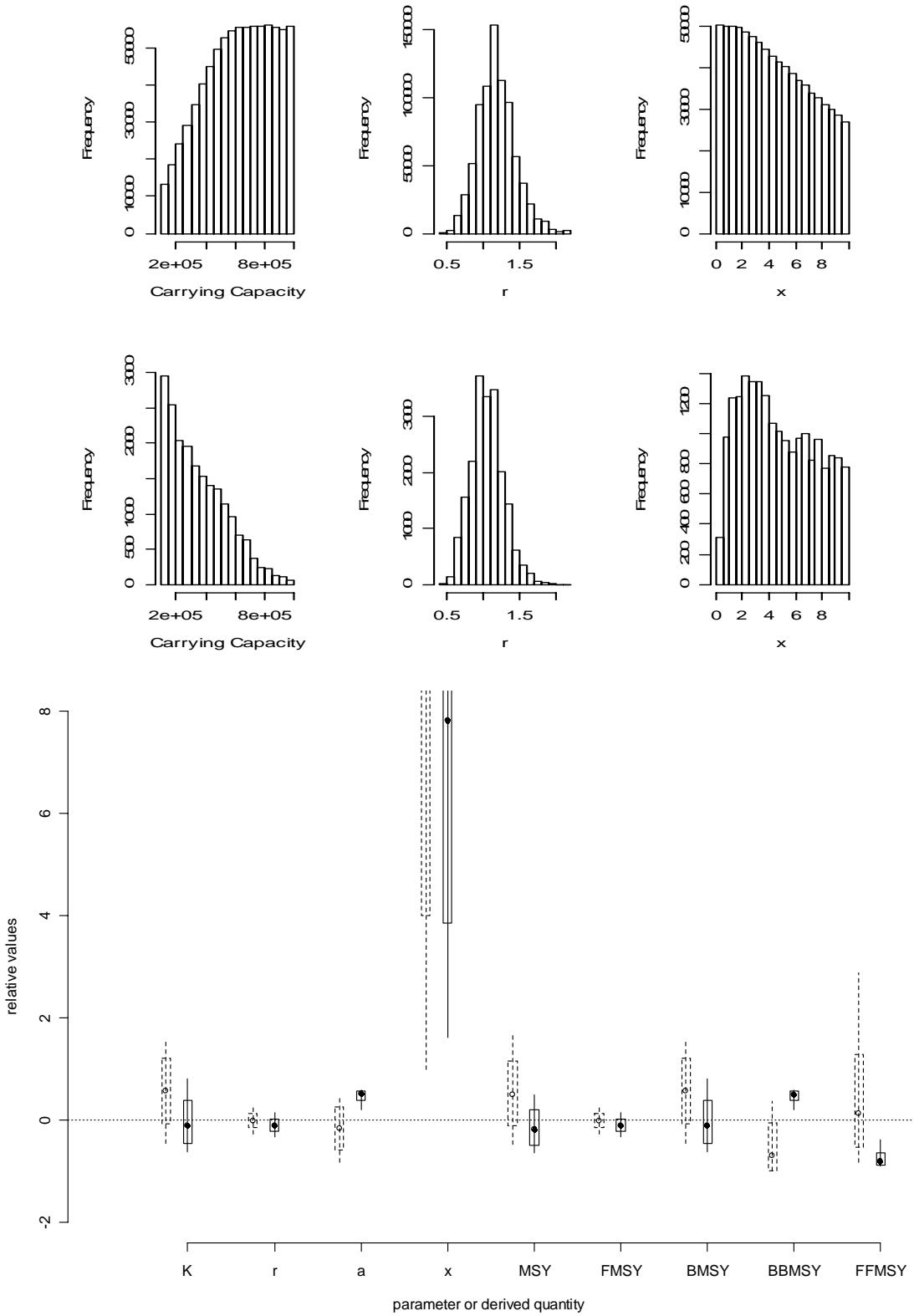


Figure Appendix 8.6 Pre-data, post-model priors (top row) and posteriors (middle row) and relative priors and posteriors (bottom row) for the COM run A.6 fitted to catch data from 1976 to 2006 for SKJ-W. See **Figure Appendix 5.1** for explanations.

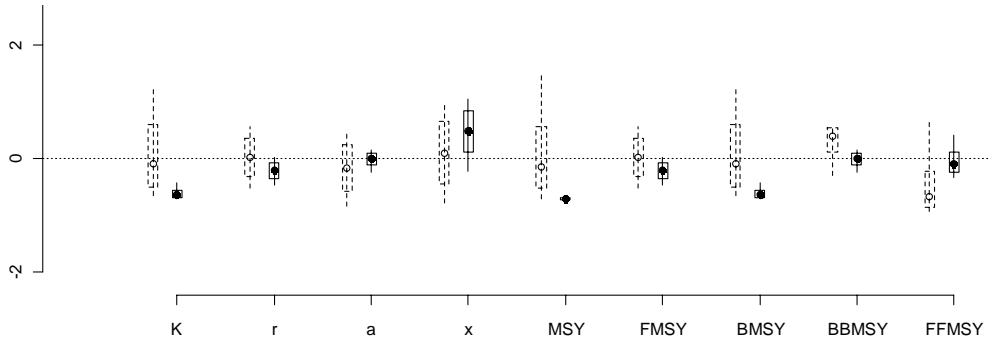


Figure Appendix 8.7 Relative priors and posteriors for the COM run B.1 fitted to catch data from 1976 to 2006 for SKJ-W. See **Figure Appendix 5.1** for explanations.

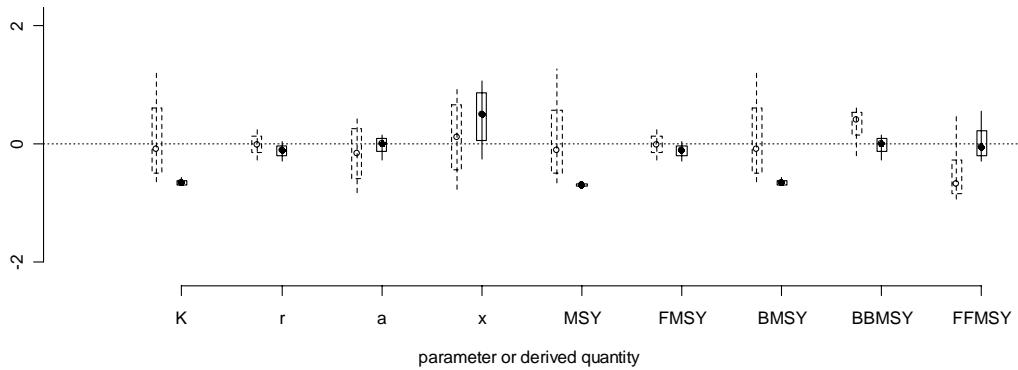


Figure Appendix 8.8 Relative priors and posteriors for the COM run B.4 fitted to catch data from 1976 to 2006 for SKJ-W. See **Figure Appendix 5.1** for explanations.

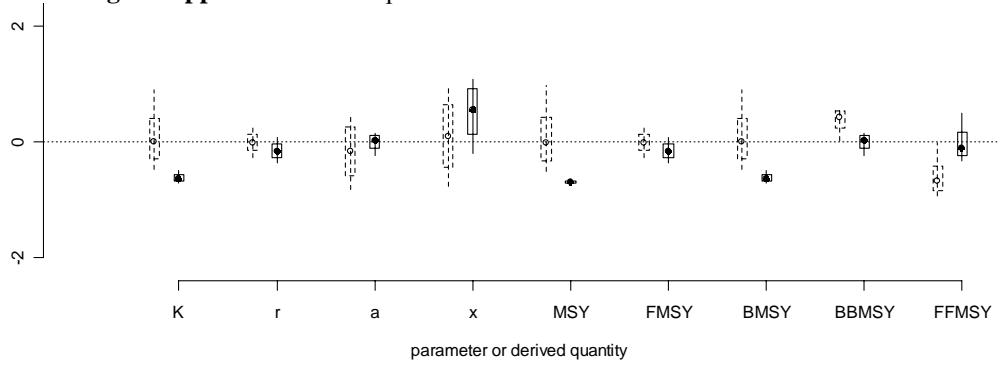


Figure Appendix 8.9 Relative priors and posteriors for the COM run B.5 fitted to catch data from 1976 to 2006 for SKJ-W. See **Figure Appendix 5.1** for explanations.

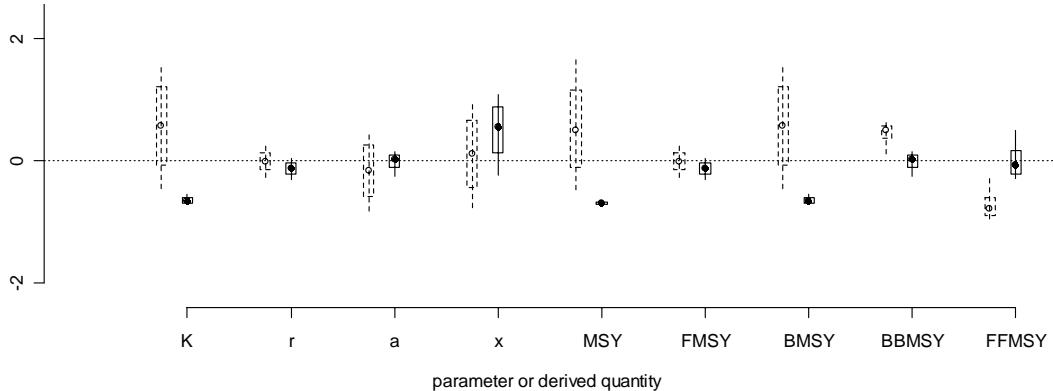


Figure Appendix 8.10 Relative priors and posteriors for the COM run B.6 fitted to catch data from 1976 to 2006 for SKJ-W. See **Figure Appendix 5.1** for explanations.

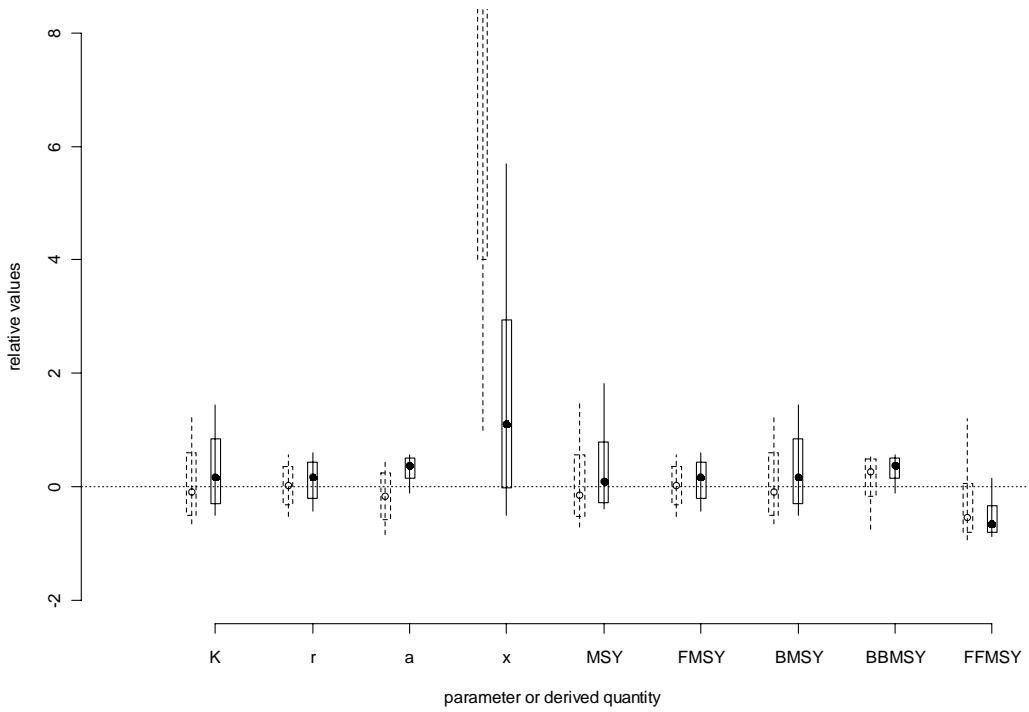


Figure Appendix 8.11 Relative priors and posteriors for the COM run A.1 fitted to catch data from 1950 to 2006 for SKJ-E. See **Figure Appendix 5.1** for explanations.

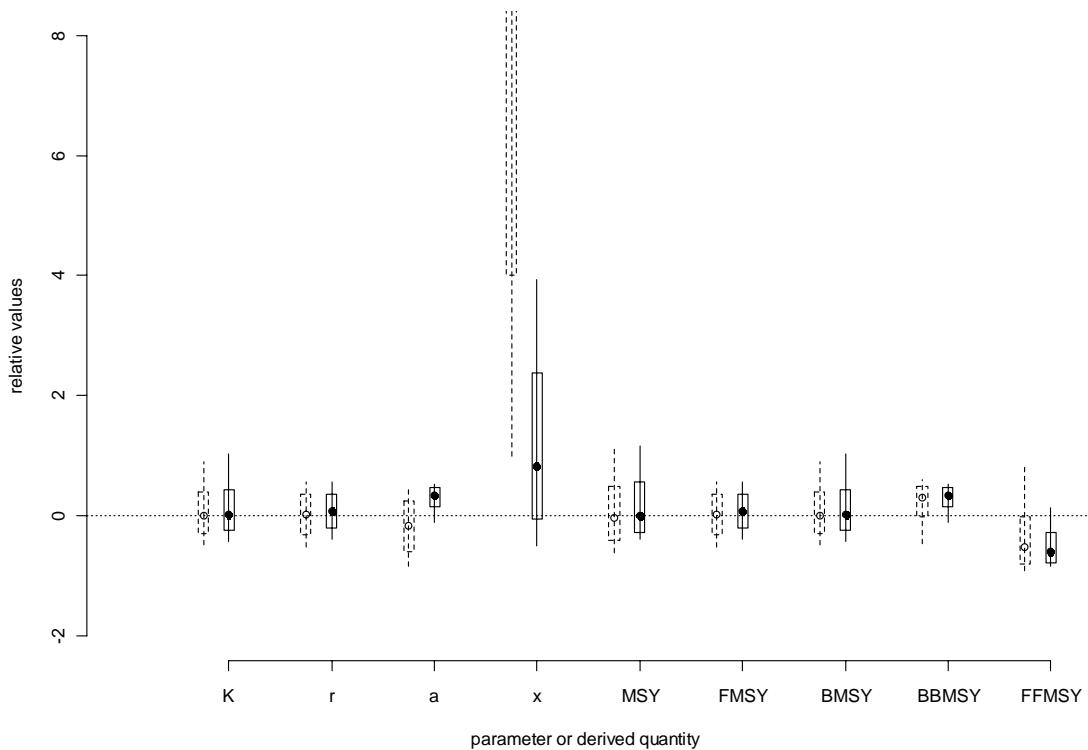


Figure Appendix 8.12. Relative priors and posteriors for the COM run A.2 fitted to catch data from 1950 to 2006 for SKJ-E. See **Figure Appendix 5.1** for explanations.

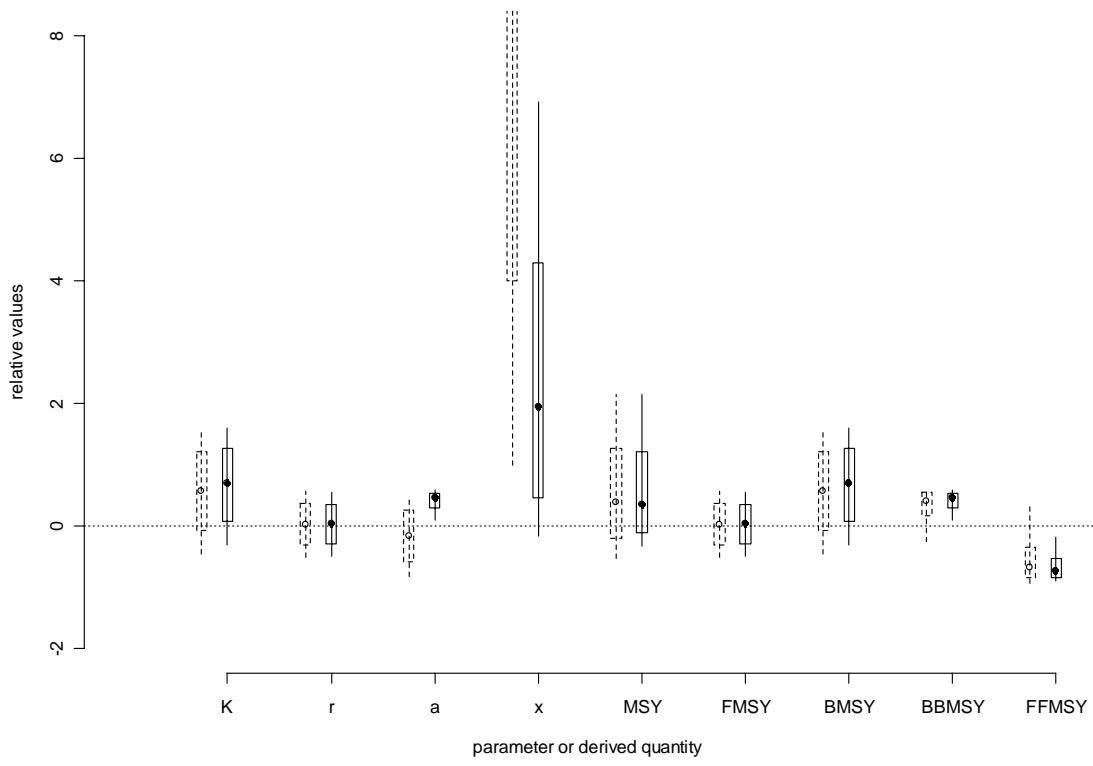


Figure Appendix 8.13 Relative priors and posteriors for the COM run A.3 fitted to catch data from 1950 to 2006 for SKJ-E. See **Figure Appendix 5.1** for explanations.

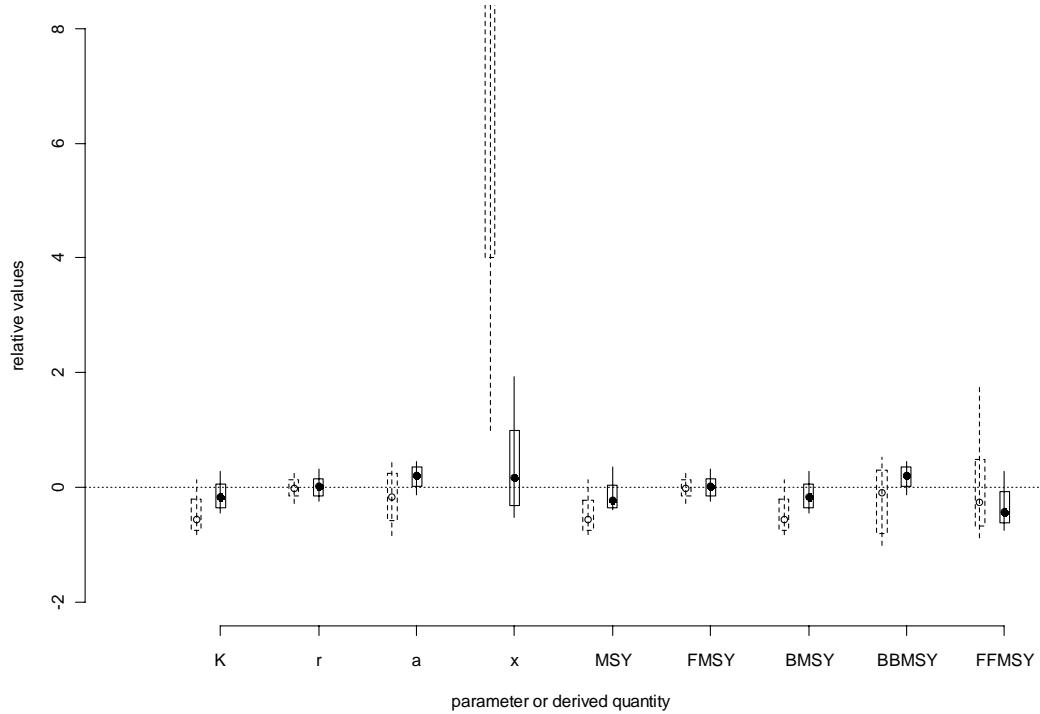


Figure Appendix 8.14 Relative priors and posteriors for the COM run A.4 fitted to catch data from 1950 to 2006 for SKJ-E. See **Figure Appendix 5.1** for explanations.

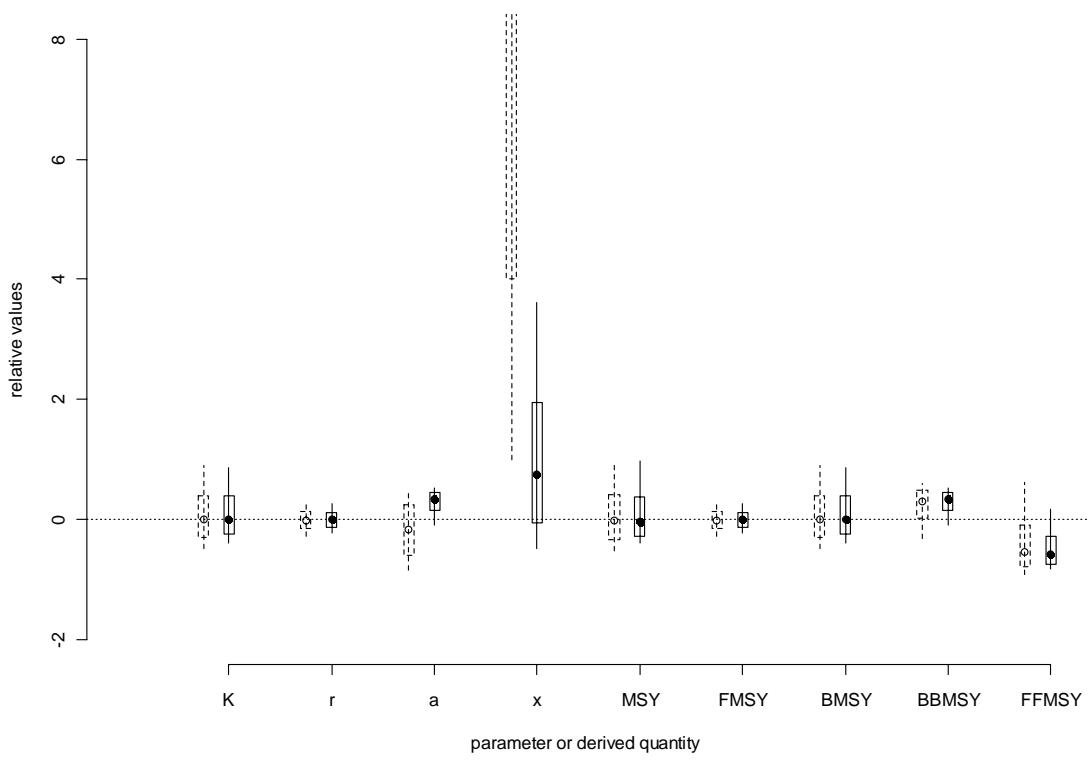


Figure Appendix 8.15 Relative priors and posteriors for the COM run A.5 fitted to catch data from 1950 to 2006 for SKJ-E. See **Figure Appendix 5.1** for explanations.

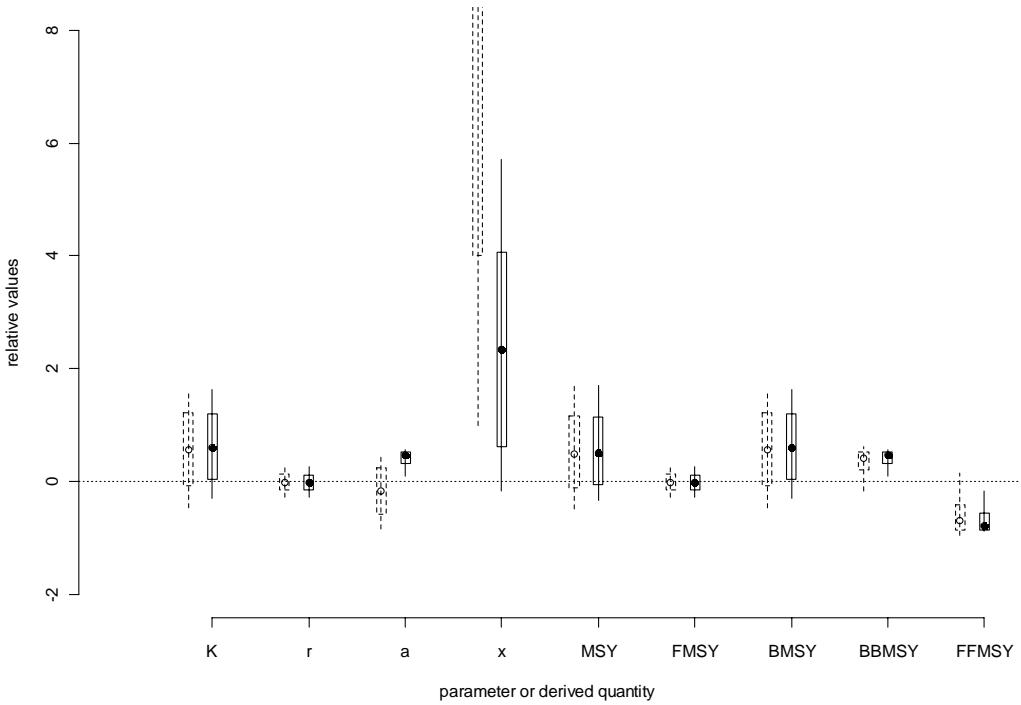


Figure Appendix 8.16 Relative priors and posteriors for the COM run A.6 fitted to catch data from 1950 to 2006 for SKJ-E. See **Figure Appendix 5.1** for explanations.

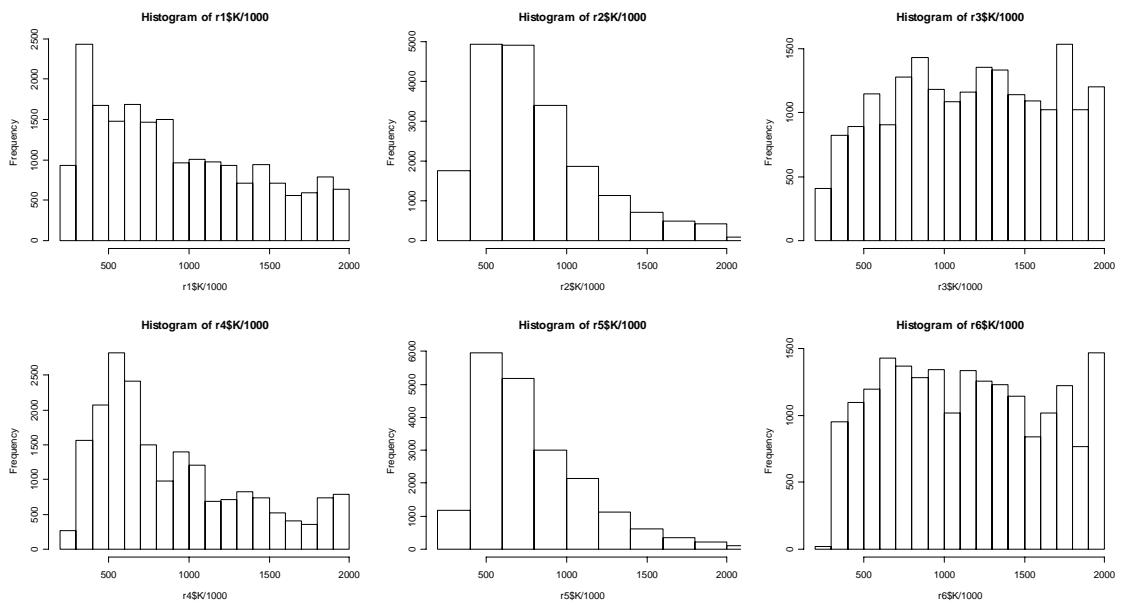


Figure Appendix 8.17 Posterior distributions for K for COM runs A.1 to A.6 fitted to catch data from 1950 to 2006 for SKJ-E.

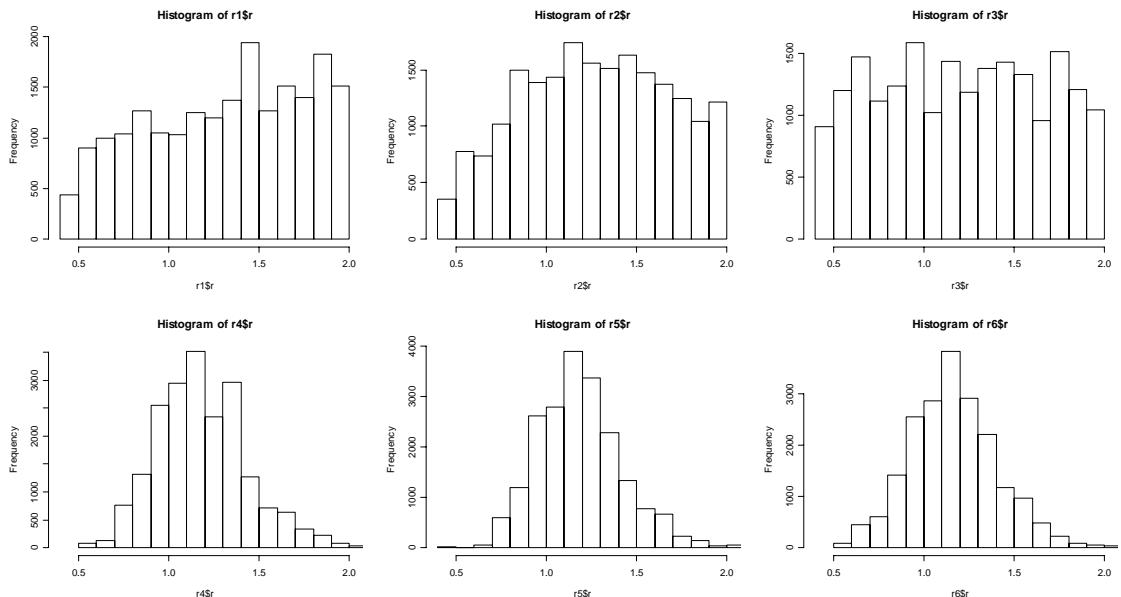


Figure Appendix 8.18. Posterior distributions for r for COM runs A.1 to A.6 fitted to catch data from 1950 to 2006 for SKJ-E.

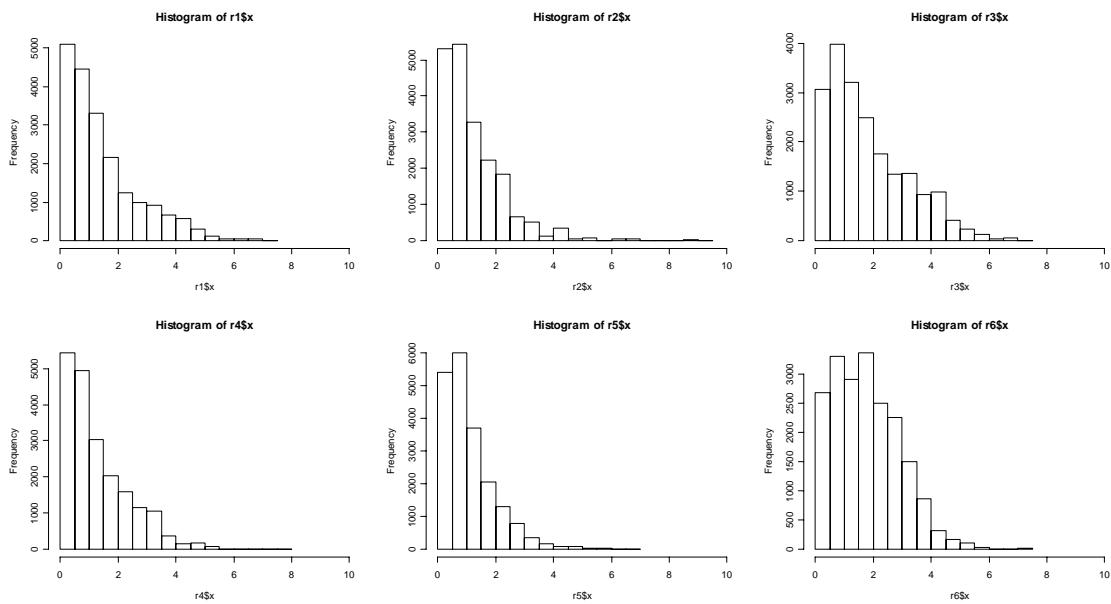


Figure Appendix 8.19 Posterior distributions for x for COM runs A.1 to A.6 fitted to catch data from 1950 to 2006 for SKJ-E.

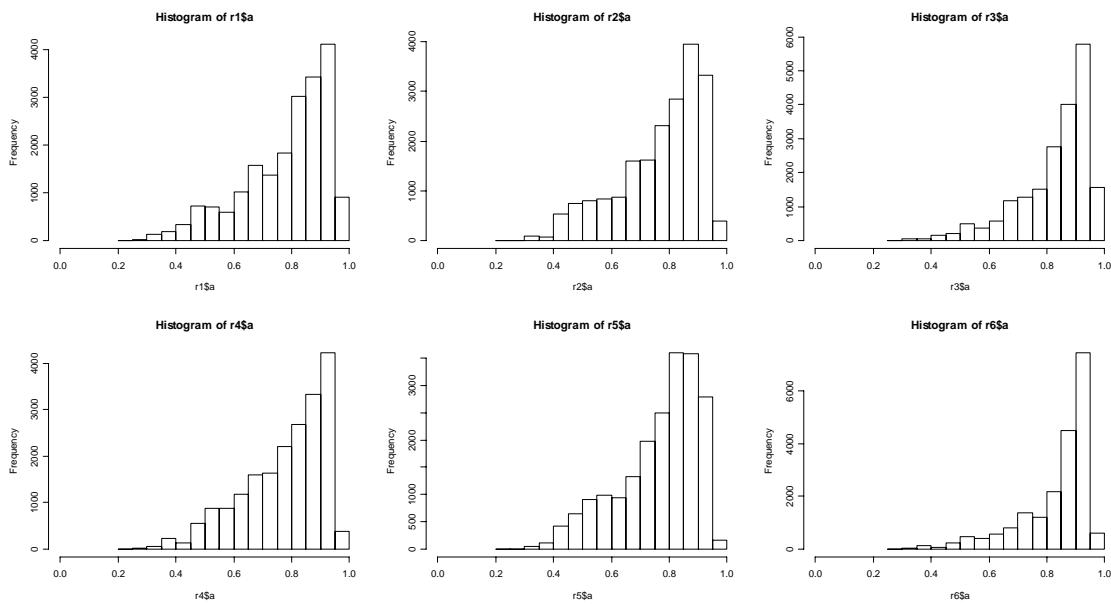


Figure Appendix 8.20 Posterior distributions for a for COM runs A.1 to A.6 fitted to catch data from 1950 to 2006 for SKJ-E.

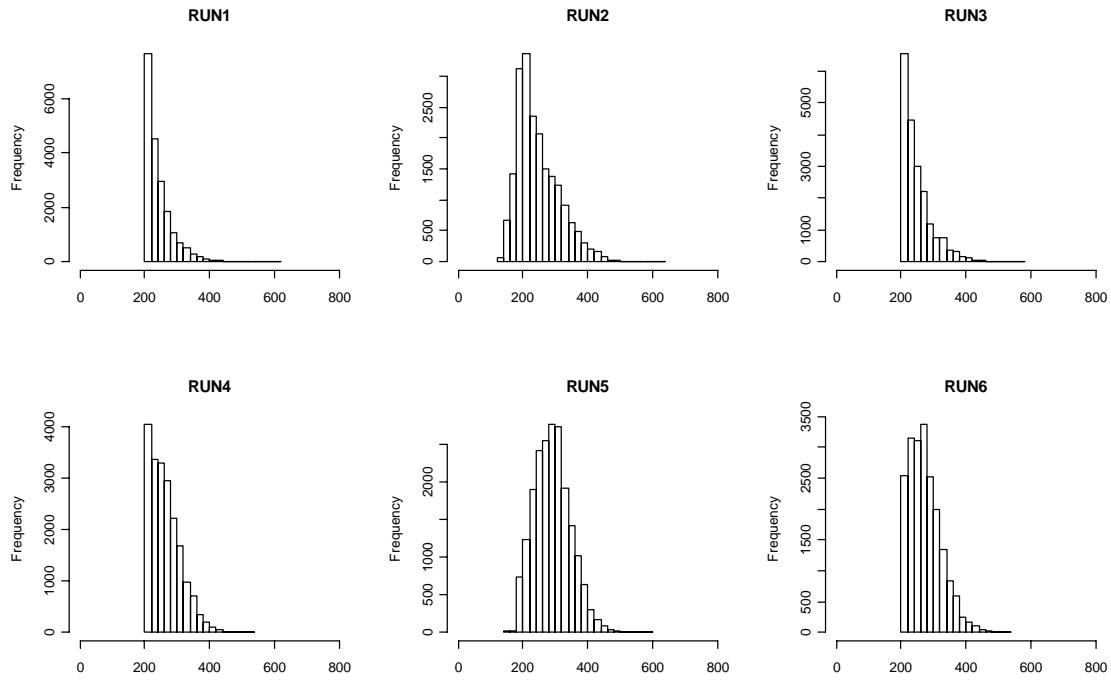


Figure Appendix 8.21 Posterior distributions for K for COM runs B.1 to B.6 fitted to catch data from 1965 to 1984 for SKJ-E.

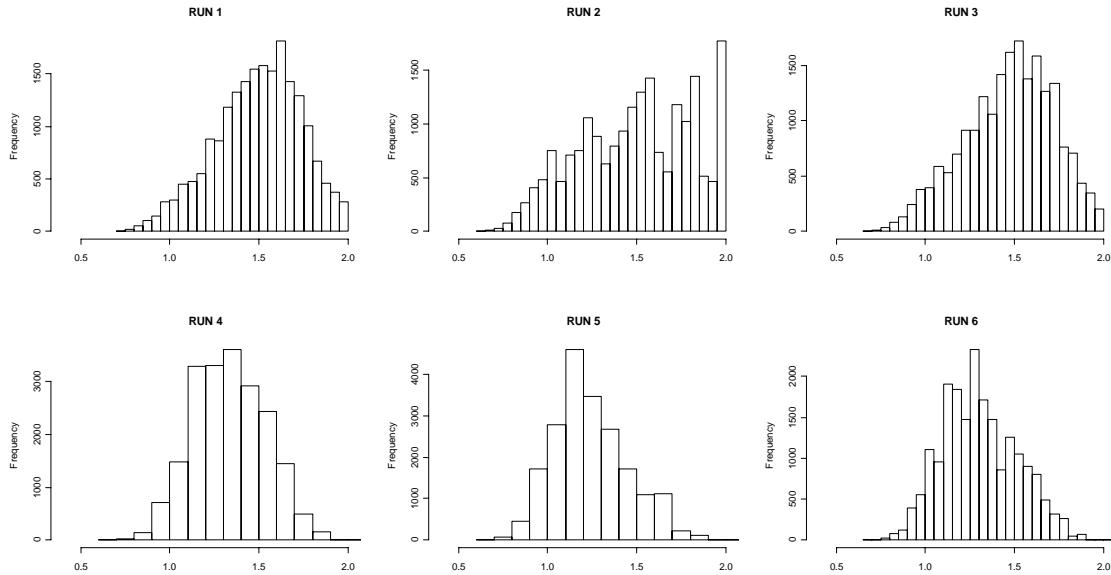


Figure Appendix 8.22 Posterior distributions for r for COM runs B.1 to B.6 fitted to catch data from 1965 to 1984 for SKJ-E.

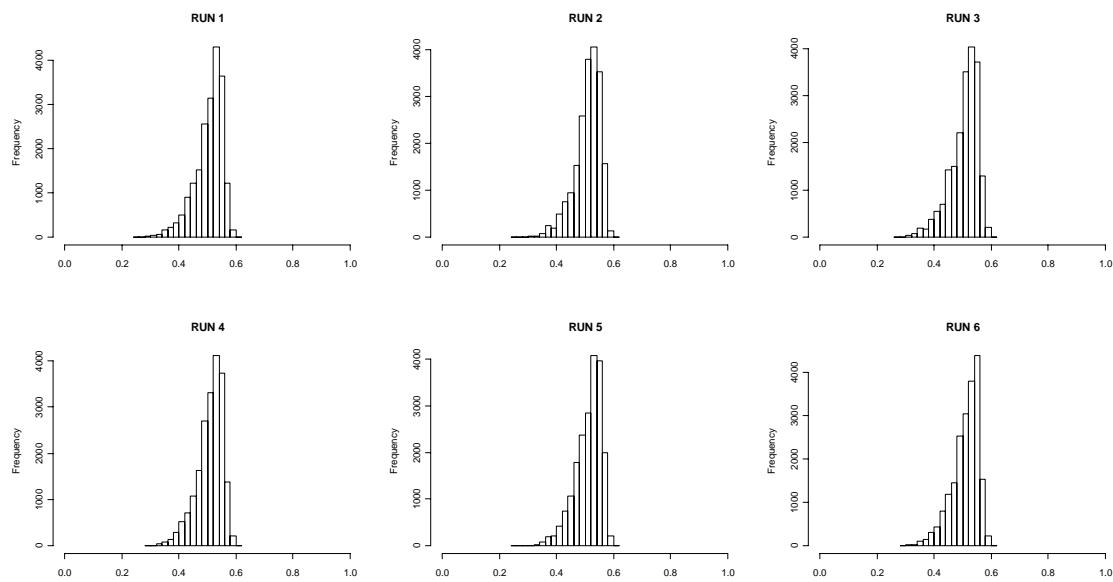


Figure Appendix 8.23 Posterior distributions for COM runs B.1 to B.6 fitted to catch data from 1965 to 1984 for SKJ-E.

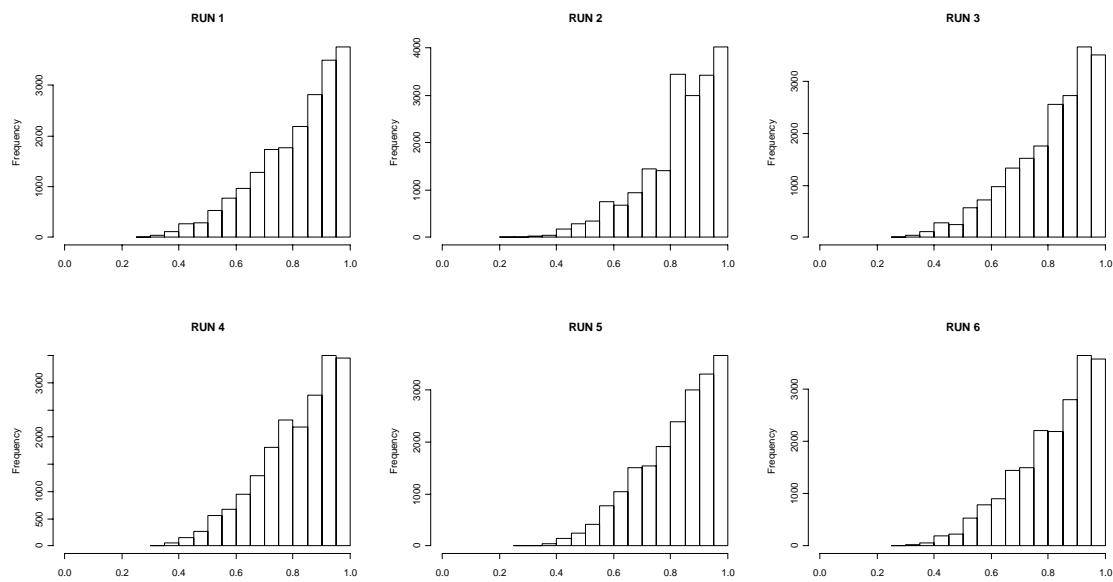


Figure Appendix 8.24 Posterior distributions for x for COM runs B.1 to B.6 fitted to catch data from 1965 to 1984 for SKJ-E.

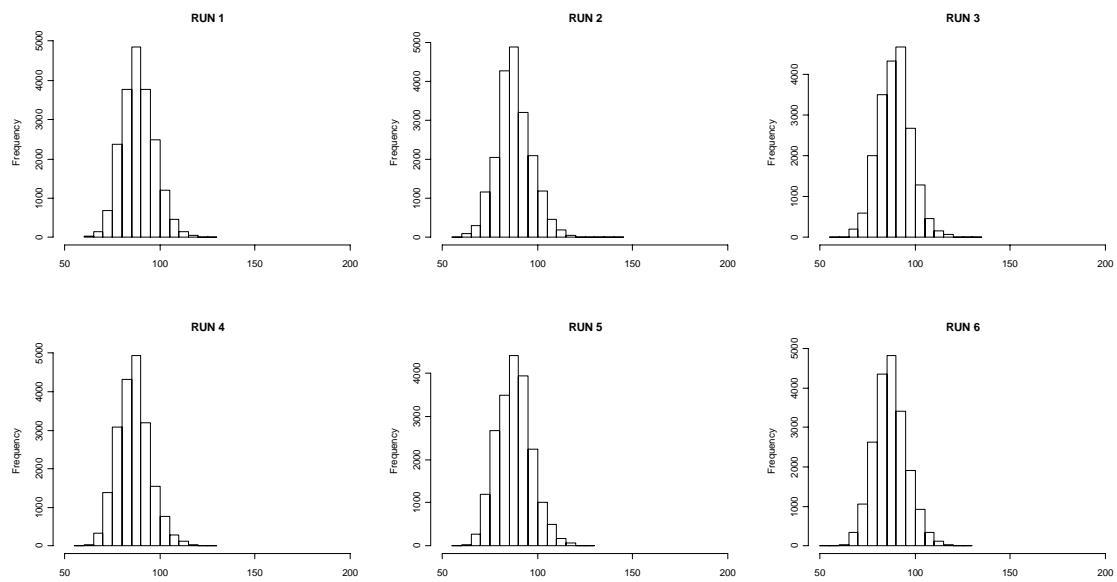
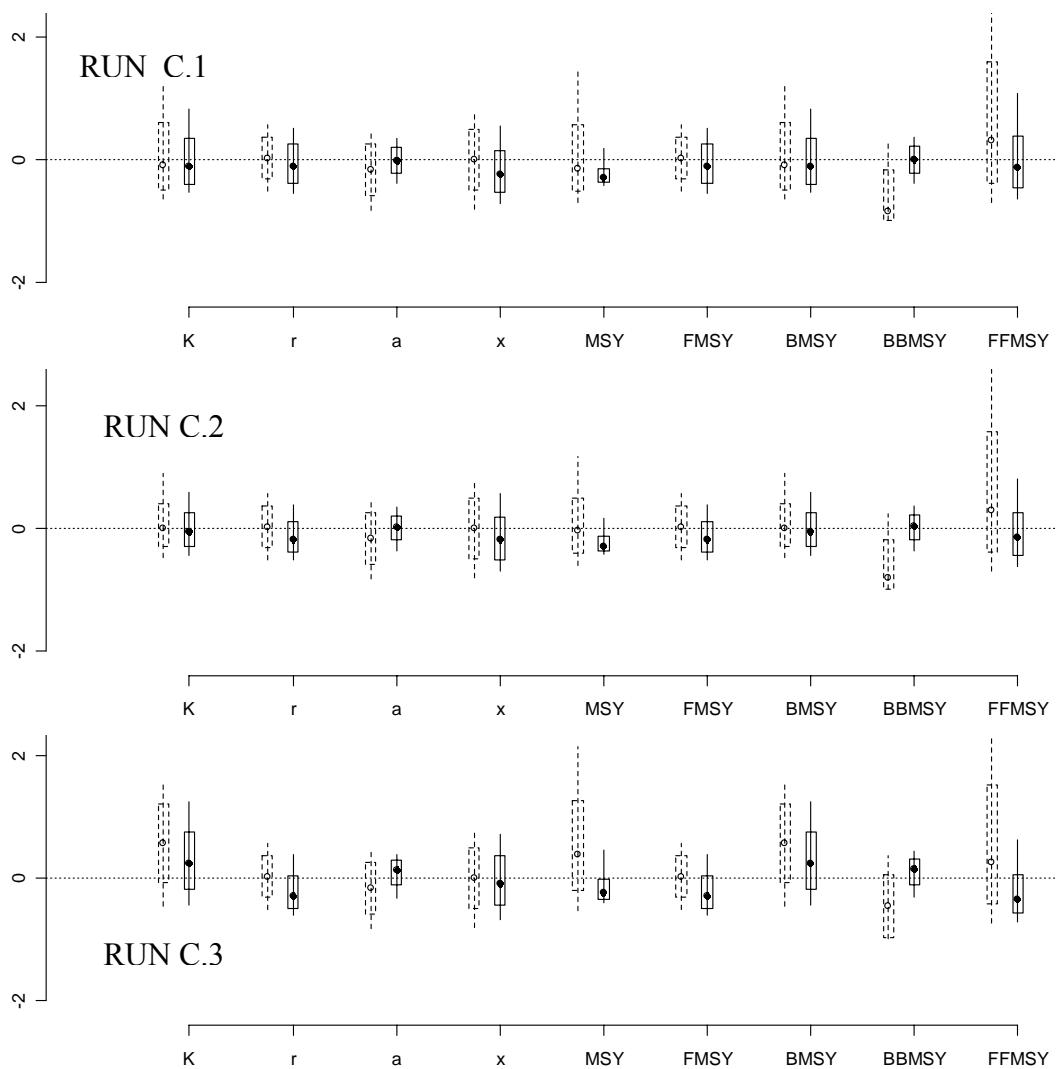


Figure Appendix 8.25 Posterior distributions for MSY for COM runs B.1 to B.6 fitted to catch data from 1965 to 1984 for SKJ-E.



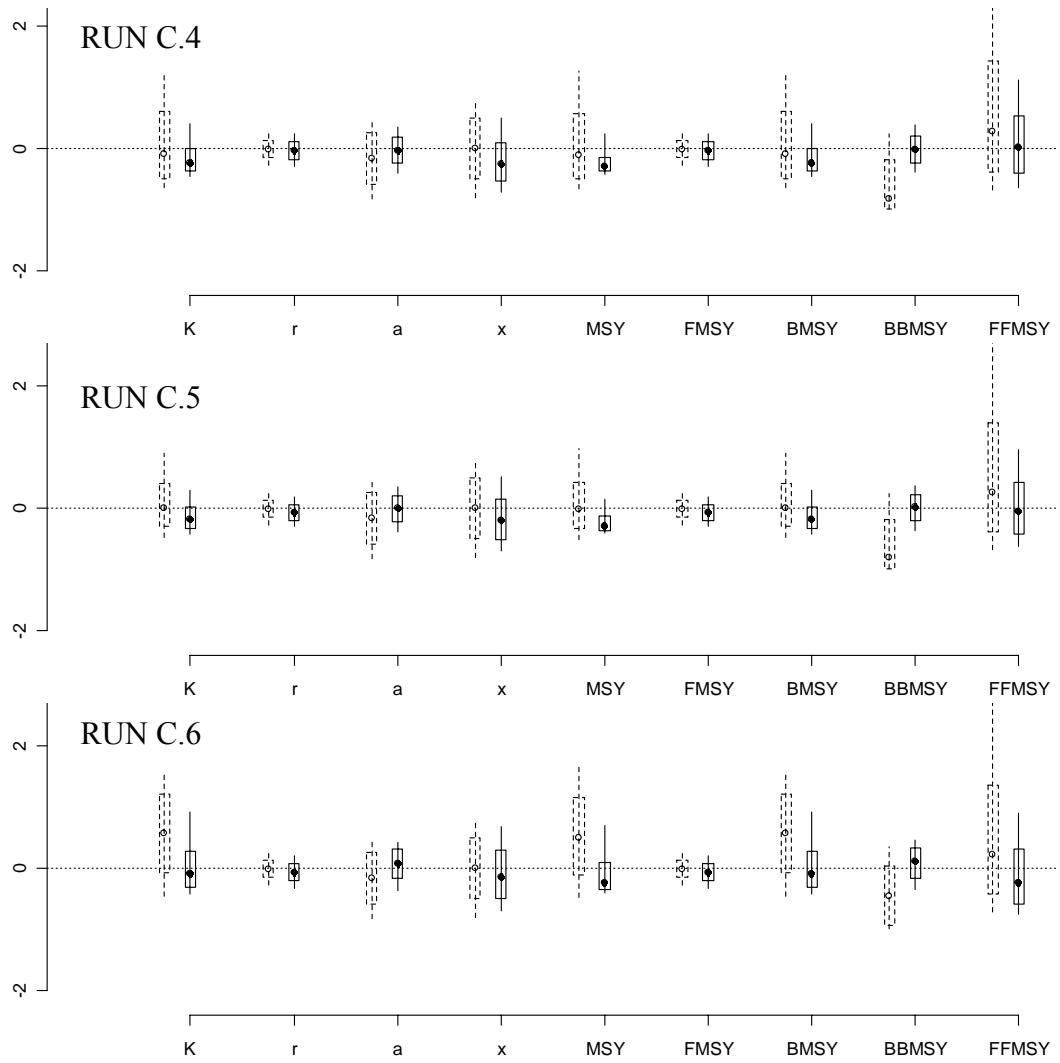


Figure Appendix 8.26 Relative priors and posteriors for the COM runs C.1 to C.6 fitted to catch data from 1985 to 2006 for SKJ-E. See **Figure Appendix 5.1** for explanations.

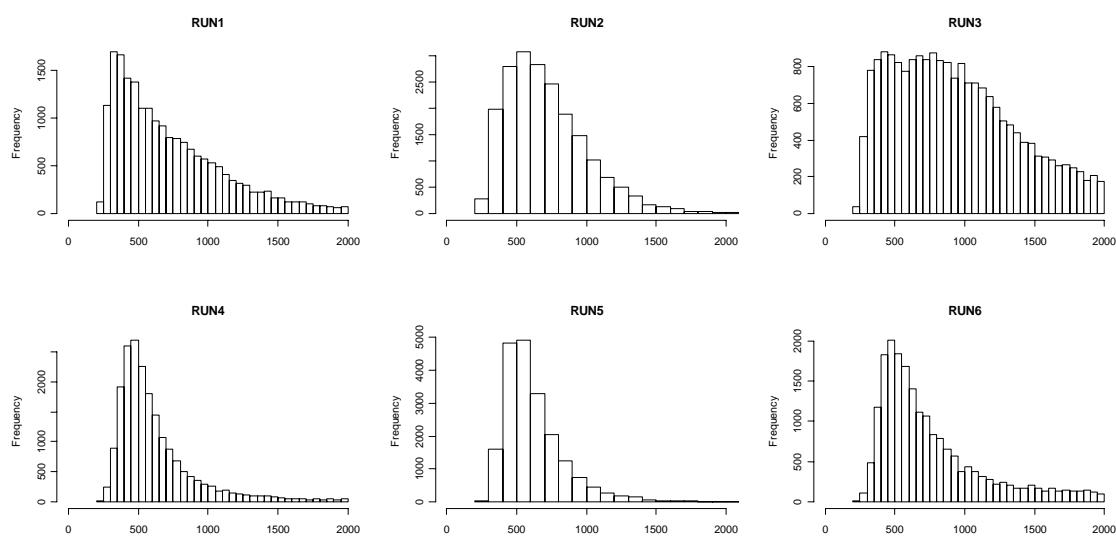


Figure Appendix 8.27 Posterior distributions for K for COM runs C.1 to C.6 fitted to catch data from 1985 to 2006 for SKJ-E.

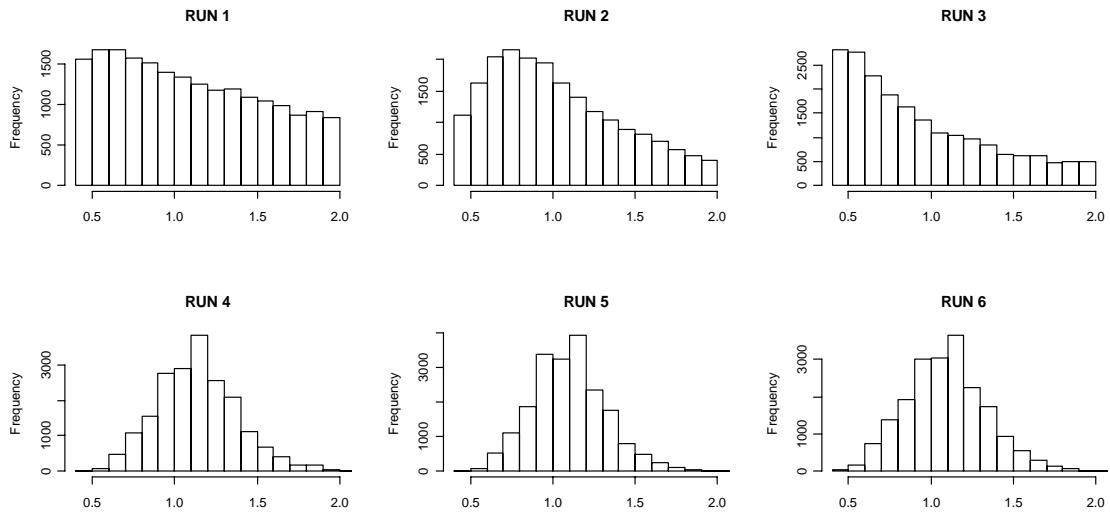


Figure Appendix 8.28 Posterior distributions for r for COM runs C.1 to C.6 fitted to catch data from 1985 to 2006 for SKJ-E.

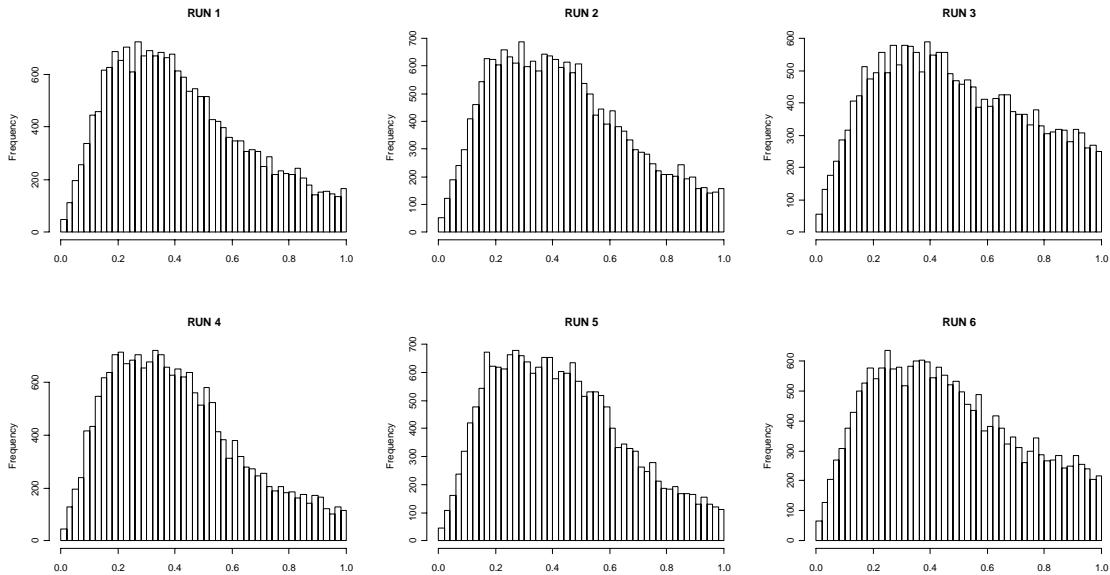


Figure Appendix 8.28 Posterior distributions for x for COM runs C.1 to C.6 fitted to catch data from 1985 to 2006 for SKJ-E.

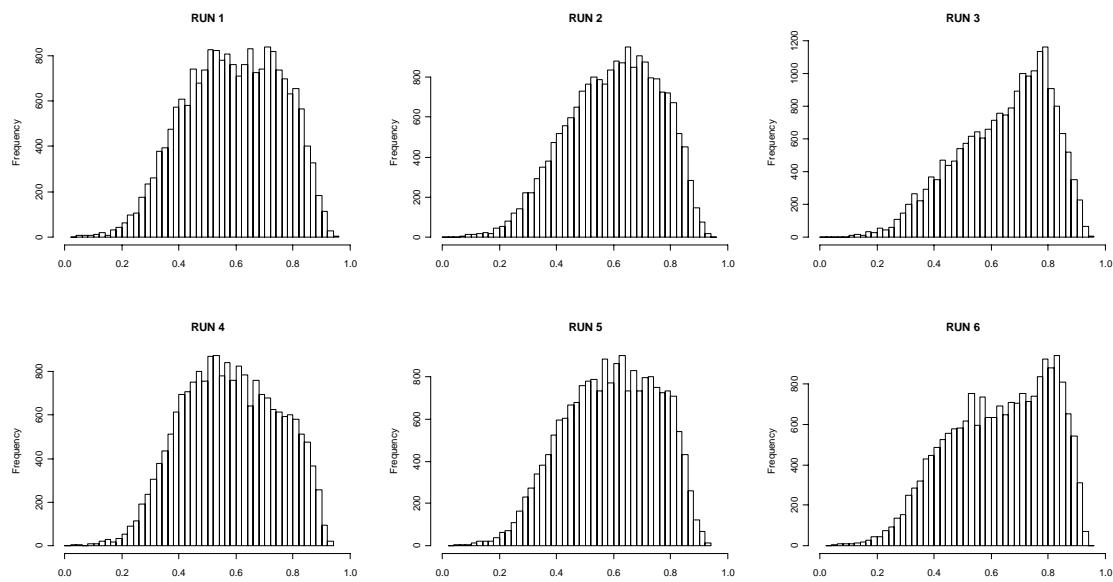


Figure Appendix 8.28 Posterior distributions for a for COM runs C.1 to C.6 fitted to catch data from 1985 to 2006 for SKJ-E.

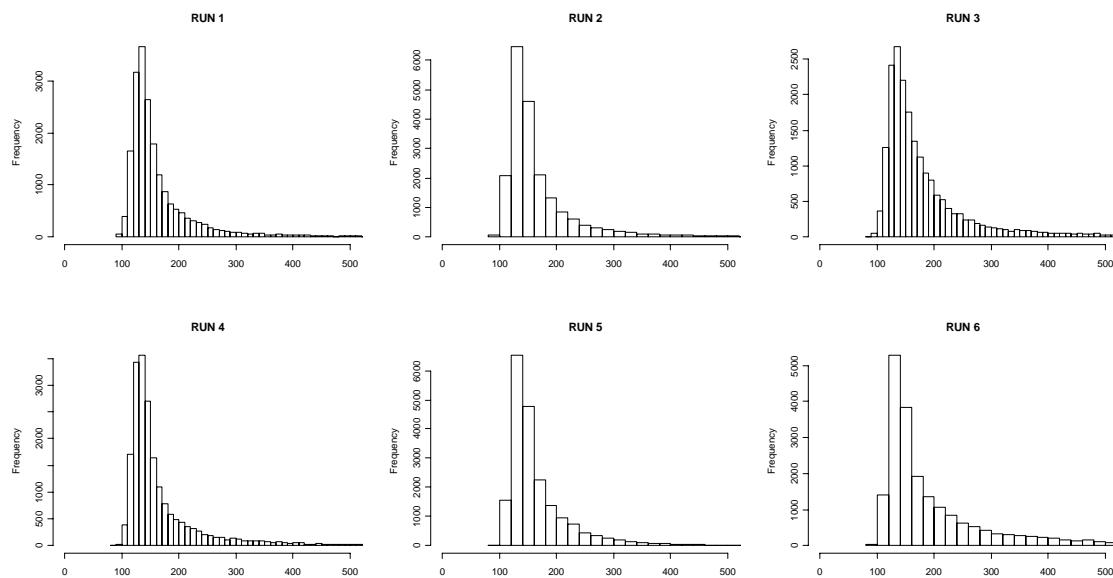


Figure Appendix 8.29. Posterior distributions for MSY for COM runs C.1 to C.6 fitted to catch data from 1985 to 2006 for SKJ-E.

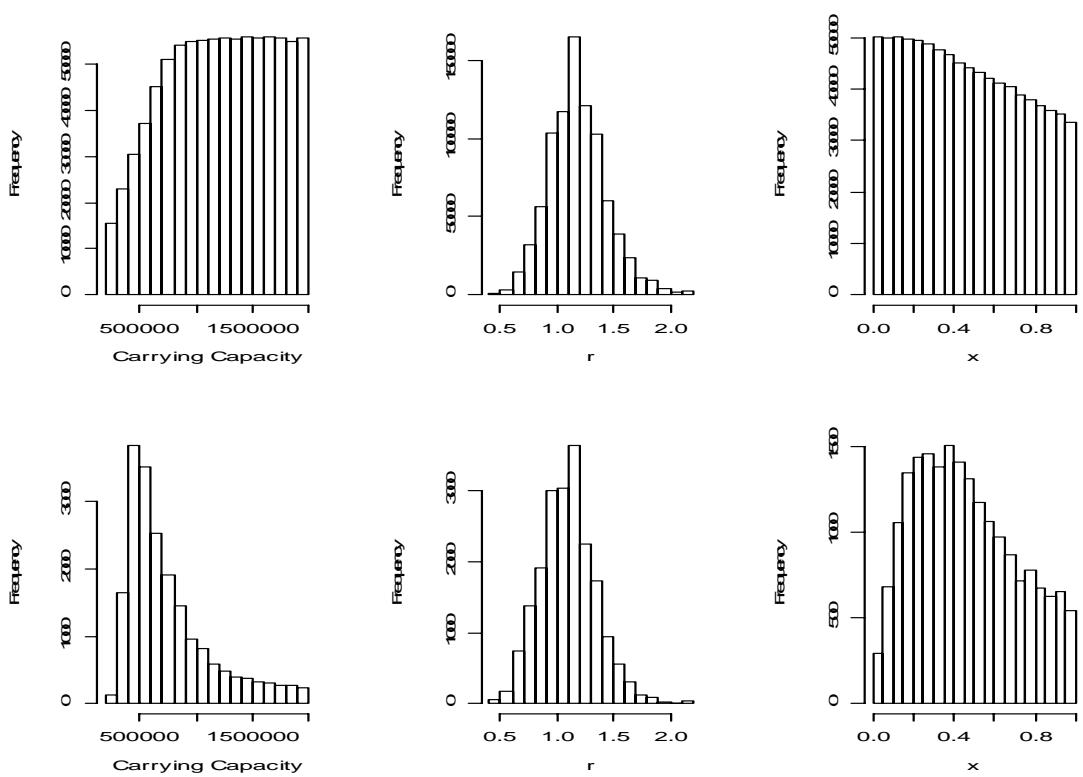


Figure Appendix 8.30. Pre-data, post-model priors (top row) and posteriors (bottom row) for run C.6 fitted to catch data from 1985 to 2006 for SKJ-E.

**Yield-Per-Recruit and Spawning Biomass-Per-Recruit
of the Tropical Tunas with Modification of Fleet-Specific Fishing Mortality**

TROPICAL TUNA SPECIES GROUP

1. Introduction

During the 2008 ICCAT Yellowfin and Skipjack Stock Assessments Meeting (Florianópolis, Brazil, July 21 to 29, 2008) The Tropical Species Group reviewed the 2007 Report of Panel 1, which included as part of the discussions, the suggestion that the SCRS analyze and present a range of options to the Commission, in time for consideration at the 2008 Special Meeting, to increase the yield per recruit and MSY of bigeye tuna by reducing mortality on small bigeye tuna through the use of such measures as closed areas (i.e. total closure of all surface fisheries) and moratoriums on the use of fish aggregating devices (FADs). In addition it was also suggested that the SCRS analyze the impacts of such measures on the catches of yellowfin tuna and skipjack tuna.

This report contains the results of one such analysis, as presented and discussed during the 2008 Tropical Tunas Species Group meeting (September 24 to 26, 2008) and described in document SCRS/2008/170. This report discusses the effect of reducing or increasing the effective fishing mortality of two fleets, the equatorial surface fleet and an aggregate fleet (all others) on the yield-per-recruit (YPR) and spawning stock biomass-per-recruit (SPR) of yellowfin and bigeye tunas.

2. Methods

The analyses presented in this report used a method developed in response to the Commissions' concerns, and described in SCRS/2008/170. This method can be used to estimate the effects of changes in fishing mortality (F) by age, fleet, gear and/or area on estimates of YPR and SPR. For this analysis, the effective fishing mortality of the equatorial surface fleet (EU PS + Ghana PS + Ghana BB) and an aggregated fleet (all others) was varied from 0% to 200% of recent values (YFT: 2003-2005; BET: 2002-2004). Age-specific biological inputs (weight of catch, weight of spawning stock, maturity and natural mortality at age) and the resulting fishing mortality at age from the most recent virtual population analysis models (YFT: 2008; BET: 2007) were used to parameterize the models.

3. Results

3.1 Yellowfin tuna

Two VPA base models were used to provide management advice during the 2008 assessment of yellowfin tuna, Runs 5 and 10. The results of the runs are quite similar. According to these runs, the recent YPR (kg) of yellowfin is 1.73 to 1.78 (**Table Appendix 9.1 and Table Appendix 9.2**, both F multipliers = 1.0). The greatest increases in YPR (>1.9) are achieved by reducing the equatorial surface fleet by 40-100% and increasing the effective F of the other fleets by a similar amount (**Table Appendix 9.1 and Table Appendix 9.2**). The current SPR (kg) of yellowfin is 3.11 to 3.22 (**Table Appendix 9.3 and 4**). Simultaneous increases in YPR and SPR can occur with certain fleet modifications. These cases are summarized in **Table Appendix 9.5**. YPR and SPR (expressed as a percentage of SPR_{MAX}) results are also illustrated in **Figure Appendix 9.1**.

3.2 Bigeye tuna

According to the base VPA run, the recent YPR (kg) of bigeye is 1.82 (**Table Appendix 9.6**, both F multipliers = 1.0). The greatest increases in YPR (>2.0) are achieved by reducing the equatorial surface fleet by 20-100% and increasing the effective F of the other fleets by a similar amount (**Table Appendix 9.6**). The current SPR (kg) of bigeye is 8.3 (**Table Appendix 9.7**). Simultaneous increases in YPR and SPR can occur with certain fleet modifications. These cases are summarized in **Table Appendix 9.8**. YPR and SPR (expressed as a percentage of SPR_{MAX}) results are also illustrated in **Figure Appendix 9.2**.

4. Discussion

The results of these analyses indicate that modest gains in yield-per-recruit for yellowfin and bigeye can be obtained by simultaneously decreasing considerably the surface fleet fishing mortality and noticeably increasing the fishing mortality exerted by the other fleets (**Table Appendix 9.5 and Table Appendix 9.8**). At this time, no analyses were attempted regarding skipjack tuna. The 2008 stock assessment models conducted for skipjack did not provide estimates of fishing mortality-at-age which are required for this analysis. The Tropical Species Group recommends that analyses of skipjack be conducted in the near future. The group also recommends the development of multi-species approaches.

The Tropical Species Group emphasizes that this analysis is a simplified treatment of the data. A more detailed analysis would separate surface fleet catches under floating aggregation devices (FADs) from those targeting free schools. The selectivity of the two fleet components differs substantially; FAD catches are dominated by the youngest animals. This may be particularly important for yellowfin because a substantial fraction of the equatorial catches of this species are older animals captured in free schools. Unfortunately, this analysis could not be accomplished since no estimates of catch-at-age for the free school and FAD components were available at the time of the meeting. The group recommends that this analysis be conducted in the near future.

The Tropical Species Group notes that these results are very sensitive to the assumed natural mortality vectors, which are quite high on ages 0 and 1 ($M=0.8$) and also poorly known. Also, changes in the method used by ICCAT to convert catch-at-size to catch-at-age may result in important differences in the fishing mortality-at-age vectors used for these analyses. Noting these concerns and the time constraints imposed by a three day meeting, the Tropical Species Group acknowledges that these results do not represent a full range of management options, and should be considered preliminary. Therefore, the group did not recommend any particular management measure. The Group suggested that this topic be explored in more detail at a future Intersessional Meeting.

Table Appendix 9.1. YFT VPA RUN 5: Yield per recruit (kg) with modification of fleet-specific fishing mortality. Current YPR (2003-2005) is highlighted.

YPR Run 5		<i>F Multiplier of Equatorial Surface Fleet</i>										
		0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
<i>F Multiplier of Other Fleets</i>	0	0.00	0.51	0.88	1.14	1.31	1.43	1.51	1.56	1.58	1.59	1.58
	0.2	0.47	0.86	1.14	1.33	1.46	1.54	1.59	1.61	1.62	1.62	1.60
	0.4	0.84	1.14	1.35	1.49	1.57	1.63	1.65	1.66	1.65	1.64	1.61
	0.6	1.15	1.37	1.51	1.61	1.66	1.69	1.70	1.69	1.67	1.65	1.62
	0.8	1.39	1.55	1.65	1.70	1.73	1.74	1.73	1.71	1.69	1.66	1.63
	1	1.58	1.69	1.75	1.78	1.78	1.78	1.75	1.73	1.69	1.66	1.63
	1.2	1.73	1.79	1.83	1.83	1.82	1.80	1.77	1.74	1.70	1.66	1.62
	1.4	1.84	1.88	1.89	1.87	1.85	1.82	1.78	1.74	1.70	1.66	1.62
	1.6	1.93	1.94	1.93	1.90	1.87	1.83	1.78	1.74	1.70	1.65	1.61
	1.8	2.00	1.99	1.96	1.92	1.88	1.83	1.78	1.74	1.69	1.65	1.60
	2	2.05	2.02	1.98	1.93	1.88	1.83	1.78	1.73	1.68	1.64	1.59

Table Appendix 9.2. YFT VPA RUN 10: Yield per recruit (kg) with modification of fleet-specific fishing mortality. Current YPR (2003-2005) is highlighted.

YPR Run 10		<i>F Multiplier of Equatorial Surface Fleet</i>										
		0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
<i>F Multiplier of Other Fleets</i>	0	0.00	0.47	0.82	1.06	1.24	1.37	1.45	1.50	1.53	1.54	1.55
	0.2	0.44	0.80	1.07	1.26	1.39	1.48	1.53	1.56	1.58	1.58	1.57
	0.4	0.79	1.08	1.28	1.42	1.51	1.57	1.60	1.61	1.61	1.60	1.59
	0.6	1.08	1.30	1.44	1.54	1.60	1.64	1.65	1.65	1.64	1.62	1.60
	0.8	1.32	1.47	1.58	1.64	1.68	1.69	1.69	1.68	1.66	1.63	1.60
	1	1.51	1.62	1.68	1.72	1.73	1.73	1.72	1.69	1.67	1.64	1.61
	1.2	1.66	1.73	1.77	1.78	1.78	1.76	1.74	1.71	1.68	1.64	1.61
	1.4	1.78	1.82	1.83	1.83	1.81	1.78	1.75	1.71	1.68	1.64	1.60
	1.6	1.87	1.89	1.88	1.86	1.83	1.80	1.76	1.72	1.68	1.64	1.60
	1.8	1.94	1.94	1.91	1.88	1.85	1.80	1.76	1.72	1.67	1.63	1.59
	2	2.00	1.97	1.94	1.90	1.85	1.81	1.76	1.71	1.67	1.63	1.59

Table Appendix 9.3. YFT VPA RUN 5: Spawning biomass per recruit (kg) with modification of fleet-specific fishing mortality. Current SPR (2003-2005) is highlighted.

SPR Run 5		<i>F Multiplier of Equatorial Surface Fleet</i>										
		0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
<i>F Multiplier of Other Fleets</i>	0	12.42	10.39	8.75	7.39	6.28	5.36	4.59	3.94	3.40	2.94	2.55
	0.2	10.89	9.15	7.72	6.55	5.58	4.78	4.10	3.54	3.06	2.65	2.30
	0.4	9.57	8.07	6.84	5.82	4.98	4.27	3.68	3.18	2.75	2.39	2.08
	0.6	8.44	7.14	6.08	5.19	4.45	3.83	3.31	2.86	2.49	2.17	1.89
	0.8	7.46	6.34	5.41	4.64	3.99	3.44	2.98	2.59	2.25	1.96	1.72
	1	6.62	5.64	4.83	4.15	3.58	3.10	2.69	2.34	2.04	1.78	1.56
	1.2	5.89	5.04	4.33	3.73	3.22	2.80	2.43	2.12	1.85	1.62	1.42
	1.4	5.25	4.51	3.88	3.36	2.91	2.53	2.20	1.92	1.69	1.48	1.30
	1.6	4.70	4.04	3.49	3.03	2.63	2.29	2.00	1.75	1.54	1.35	1.19
	1.8	4.21	3.64	3.15	2.74	2.38	2.08	1.82	1.60	1.40	1.23	1.09
	2	3.79	3.28	2.85	2.48	2.16	1.89	1.66	1.46	1.28	1.13	1.00

Table Appendix 9.4. YFT VPA RUN 10: Spawning biomass per recruit (kg) with modification of fleet-specific fishing mortality. Current SPR (2003-2005) is highlighted.

SPR Run 10		<i>F Multiplier of Equatorial Surface Fleet</i>										
		0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
<i>F Multiplier of Other Fleets</i>	0	12.42	10.47	8.87	7.54	6.43	5.51	4.73	4.07	3.52	3.05	2.65
	0.2	10.95	9.26	7.87	6.71	5.74	4.93	4.24	3.66	3.17	2.75	2.39
	0.4	9.68	8.21	7.00	5.98	5.13	4.41	3.81	3.30	2.86	2.49	2.17
	0.6	8.58	7.30	6.24	5.35	4.60	3.97	3.43	2.98	2.59	2.25	1.97
	0.8	7.62	6.50	5.57	4.79	4.13	3.57	3.09	2.69	2.34	2.05	1.79
	1	6.79	5.81	4.99	4.30	3.72	3.22	2.80	2.44	2.13	1.86	1.63
	1.2	6.06	5.20	4.48	3.87	3.35	2.91	2.53	2.21	1.93	1.69	1.49
	1.4	5.42	4.67	4.03	3.49	3.03	2.63	2.30	2.01	1.76	1.54	1.36
	1.6	4.86	4.20	3.63	3.15	2.74	2.39	2.09	1.83	1.60	1.41	1.24
	1.8	4.37	3.78	3.28	2.85	2.49	2.17	1.90	1.67	1.47	1.29	1.14
	2	3.94	3.41	2.97	2.59	2.26	1.98	1.73	1.52	1.34	1.18	1.04

Table Appendix 9.5. YFT: Fleet-specific multipliers that result in increases in YPR (medium grey with diagonal bar), SPR (light grey) and both YPR and SPR (black) over 2003-2005 levels.

Table Appendix 9.6. BET: Yield per recruit (kg) with modification of fleet-specific fishing mortality. Current SPR (2002-2004) is highlighted.

YPR		<i>F Multiplier of Equatorial Surface Fleet</i>										
		0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
<i>F Multiplier of Other Fleets</i>	0	0.00	0.16	0.31	0.44	0.56	0.67	0.77	0.86	0.93	1.01	1.07
	0.2	0.50	0.62	0.73	0.83	0.91	0.99	1.06	1.12	1.18	1.23	1.27
	0.4	0.92	1.00	1.08	1.15	1.21	1.26	1.31	1.35	1.38	1.42	1.44
	0.6	1.27	1.32	1.37	1.41	1.45	1.48	1.51	1.53	1.55	1.57	1.58
	0.8	1.55	1.58	1.61	1.63	1.65	1.66	1.68	1.69	1.69	1.70	1.70
	1	1.79	1.80	1.81	1.81	1.82	1.82	1.82	1.81	1.81	1.80	1.80
	1.2	1.99	1.98	1.97	1.97	1.95	1.94	1.93	1.92	1.91	1.89	1.88
	1.4	2.15	2.13	2.11	2.09	2.07	2.05	2.03	2.01	1.98	1.96	1.94
	1.6	2.29	2.26	2.22	2.19	2.16	2.13	2.10	2.08	2.05	2.02	2.00
	1.8	2.40	2.36	2.32	2.28	2.24	2.20	2.17	2.13	2.10	2.07	2.04
	2	2.49	2.44	2.39	2.35	2.30	2.26	2.22	2.18	2.15	2.11	2.08

Table Appendix 9.7. BET: Spawning biomass per recruit (kg) with modification of fleet-specific fishing mortality.

SPR		<i>F Multiplier of Equatorial Surface Fleet</i>										
		0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
<i>F Multiplier of Other Fleets</i>	0	22.0	20.2	18.5	17.0	15.6	14.3	13.1	12.0	11.0	10.1	9.3
	0.2	19.6	18.0	16.5	15.1	13.9	12.7	11.7	10.7	9.8	9.0	8.3
	0.4	17.5	16.0	14.7	13.5	12.4	11.4	10.4	9.6	8.8	8.1	7.4
	0.6	15.7	14.4	13.2	12.1	11.1	10.2	9.4	8.6	7.9	7.2	6.6
	0.8	14.1	12.9	11.9	10.9	10.0	9.2	8.4	7.7	7.1	6.5	6.0
	1	12.7	11.7	10.7	9.8	9.0	8.3	7.6	7.0	6.4	5.9	5.4
	1.2	11.5	10.6	9.7	8.9	8.2	7.5	6.9	6.3	5.8	5.3	4.9
	1.4	10.4	9.6	8.8	8.1	7.4	6.8	6.2	5.7	5.3	4.8	4.4
	1.6	9.5	8.7	8.0	7.3	6.7	6.2	5.7	5.2	4.8	4.4	4.0
	1.8	8.7	8.0	7.3	6.7	6.2	5.7	5.2	4.8	4.4	4.0	3.7
	2	7.9	7.3	6.7	6.1	5.6	5.2	4.8	4.4	4.0	3.7	3.4

Table Appendix 9.8. BET: Fleet-specific multipliers that result in increases in YPR (medium grey diagonal bar), SPR (light grey) and both YPR and SPR (black) over 2002-2004 levels.

BET		<i>F Multiplier of the Equatorial Surface Fleet</i>										
		0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
<i>F multiplier of the Other Fleets</i>	0											
	0.2											
	0.4											
	0.6											
	0.8											
	1											
	1.2											
	1.4											
	1.6											
	1.8											
	2											

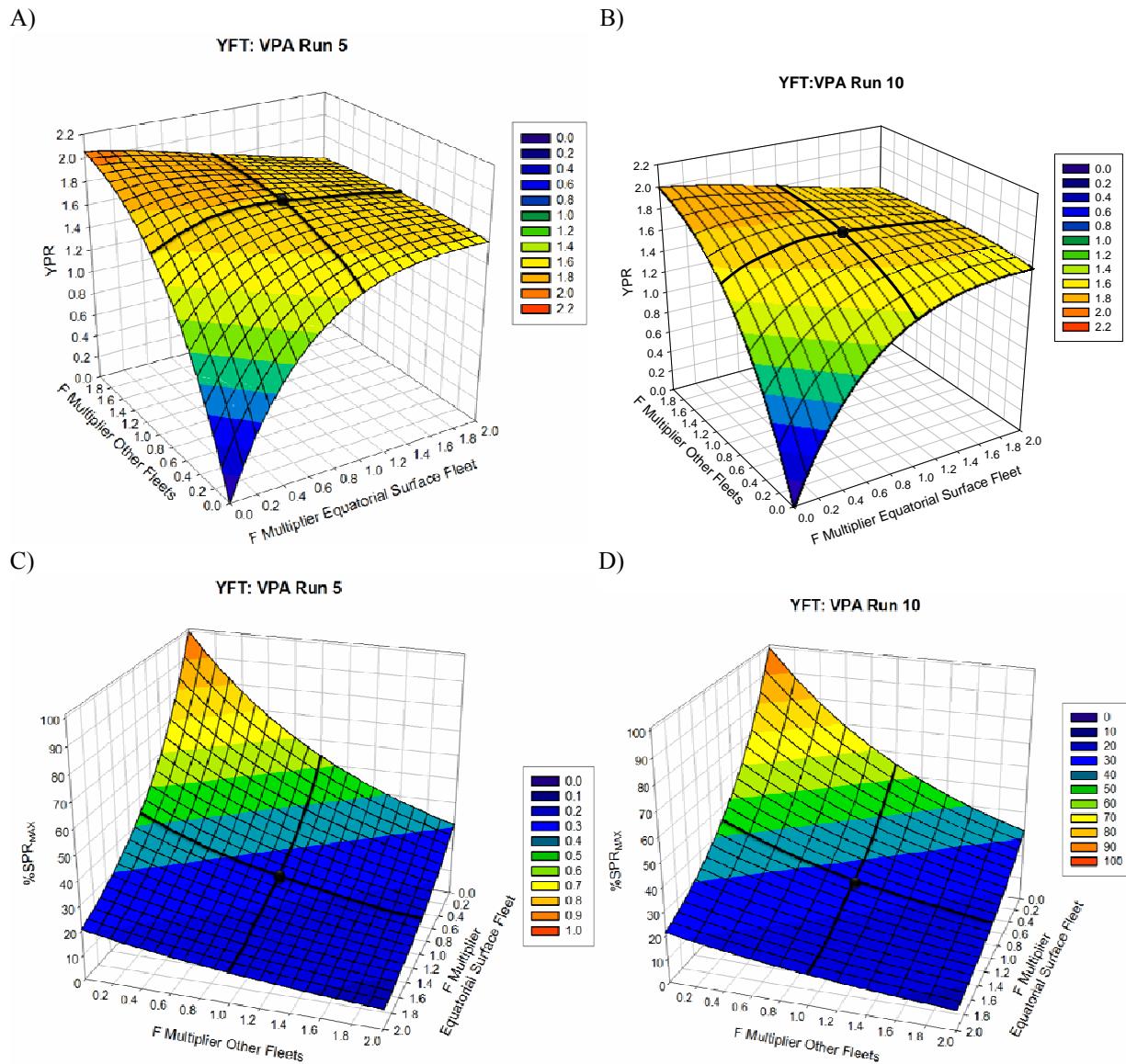


Figure Appendix 9.1. YFT: YPR and SPR with modification of fleet-specific F multipliers. (A) YPR VPA Run 5, (B) YPR VPA Run 10, (C) SPR VPA Run 5 and (D) SPR VPA Run 10. The solid lines are at F Multiplier = 1 (current F) for each fleet. The black circle is the current status quo.

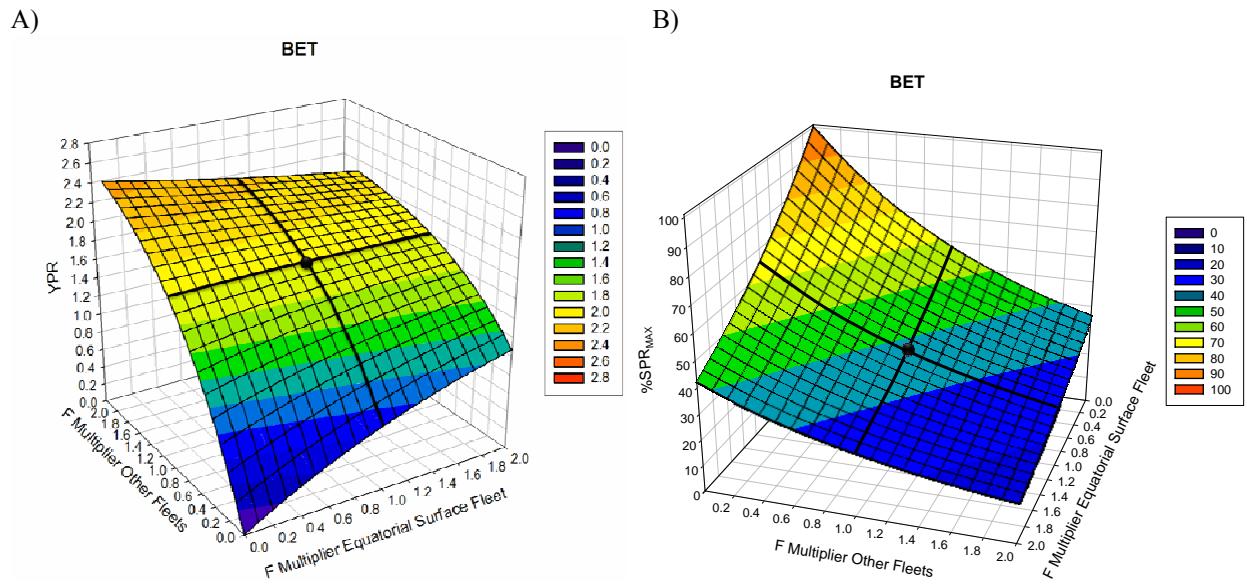


Figure Appendix 9.2. BET: YPR (A) and SPR (B) with modification of fleet-specific F multipliers. The solid lines are at F Multiplier = 1 (current F) for each fleet. The black circle is the current status quo.