REPORT OF THE 2008 ATLANTIC BLUEFIN TUNA STOCK ASSESSMENT SESSION

(Madrid, Spain – June 23 to July 4, 2008)

1. Opening, adoption of the Agenda and meeting arrangements

The meeting was held at the ICCAT Secretariat in Madrid. Mr. Driss Meski, ICCAT Executive Secretary, opened the meeting and welcomed participants.

Dr. G. Scott (USA) served as overall meeting Coordinator on behalf the General Coordinator, Dr. J. Powers. Drs. C. Porch (USA) and J-M. Fromentin (EC-France) served as co-Chairmen for the western and eastern stocks, respectively. Dr. Scott welcomed meeting participants (“the Group”) and proceeded to review the Agenda, which was adopted with minor changes **(Appendix 1)**. In reviewing the Agenda, Dr. Scott reminded participants that the meeting responded to the request from the Commission contained in the *Recommendation by ICCAT to Establish a Multi-annual Recovery Plan for Bluefin Tuna in the Eastern Atlantic and Mediterranean* [Rec. 06-05] and that it had been prepared in the Bluefin Workplan for 2008 **(Appendix 2)**.

A List of Meeting Participants is attached as **Appendix 3** and the List of Scientific Documents presented at the meeting is attached as **Appendix 4**.

The following participants served as Rapporteurs for various sections of the report:

Section	*Rapporteurs*
1, 13	P. Pallarés
2, 12	G. Scott
3	E. Rodríguez-Marín
4	J. Neilson, A. Boustany, E. Rodríguez-Marín
5	P. Kebe, C. Palma, C. Brown, J-M. Fromentin, V. Restrepo
6	N. Miyabe, W. Ingram, G. Diaz, M. Ortiz
7	H. Arrizabalaga, V. Restrepo, S. Cass-Calay, M. McAllister, C. Porch, N. Taylor, J. Neilson, G. Scott
8	H. Arrizabalaga, V. Restrepo, S. Cass-Calay, C. Porch, M. Ortiz, M. McAllister, N. Taylor
9	J. Ortiz de Urbina, G. Diaz
10	J-M. Fromentin, V. Restrepo, S. Cass-Calay, C. Porch, M. Ortiz, M. McAllister, N. Taylor
11	J-M. Fromentin, V. Restrepo, G. Scott, Y. Takeuchi

2. Review of the Rebuilding Plans for Atlantic and Mediterranean bluefin tuna and previous SCRS advice

The Commission’s Rebuilding Plans for Atlantic and Mediterranean bluefin were reviewed.

Recommendation 06-05 calls for a 15-year rebuilding period, starting in 2007, with the objective of recovering the stock to B_{MSY} with greater than 50% probability. A number of technical measures, including minimum size, fishery closures, and TACs were implemented in the Plan, which also calls for SCRS to monitor and advise the Commission on the odds of the Plan’s objectives being met based upon available data. Based upon information available in 2007, the SCRS advised that overall, preliminary results indicate that the measures adopted in the Plan were a step in the right direction, but were unlikely to fully fulfill the objective of the plan to rebuild to the MSY level in 15 years with greater than 50% probability. The SCRS advised that this depends on several factors, particularly how well regulations are implemented (including a severe reduction in fishing effort by 2023) and future recruitment. If implementation is perfect and if future recruitment is at about the 1990s level and is unaffected by recent spawning biomass level, there is about 50% probability of rebuilding by 2023 under the current regulations. The SCRS advised, however, perfect implementation is unlikely because, even with perfect enforcement, the Committee thinks that it is not feasible to avoid totally discard mortality of small fish (in excess of tolerance) and while continually and severely reducing fishing effort to very low levels to achieve the objectives of the Rebuilding Plan. With other plausible assumptions (either imperfect implementation or recruitment that decreases from recent levels as spawning biomass decreases, or both) the objectives of the Rebuilding Plan will not be met without further adjustments.

The *Supplemental Recommendation by ICCAT Concerning the Western Atlantic Bluefin Tuna Rebuilding Program* [Rec. 06-06] calls for a 20-year rebuilding period starting in 1999 with the objective of recovering the stock to B_{MSY} with at least a 50% probability by the end of the Plan's time frame (through 2018). A number of technical measures, including TACs, were implemented in this Plan which also calls for SCRS to monitor and advise the Commission on the odds of the Plan's objectives being met based upon available data. Based upon an assessment of western stock status conducted in 2006, the SCRS advised Rec. [06-06] was expected to result in a rebuilding of the stock towards the Convention objective with fishing mortality rates at about the estimated MSY level. The SCRS also cautioned that new evidence suggested that current regulations may be insufficient to achieve the objectives. However, the Committee would be unable to further evaluate this until the next assessment. The ability to achieve the Convention objectives would be further hampered by future use of accumulated unused quota, particularly given the large amount involved for western bluefin tuna.

3. Consideration of the findings and recommendations of the World Symposium for the Study into the Stock Fluctuation of Northern Bluefin Tunas (*Thunnus thynnus* and *Thunnus orientalis*), including the Historic Periods

The SCRS Chairman summarized the Symposium held in Santander in April 2008. The aim of the Symposium was to provide a deeper investigation into the historical events that took place decades ago in various bluefin tuna fisheries and to use this information to improve the_current management of Atlantic bluefin tuna. The Symposium was organized into various sessions in relation to different geographic areas, fisheries and time periods. In addition to the Atlantic bluefin tuna biology and history of the fisheries, the Pacific and southern bluefin tuna historical changes in distribution and abundance were also considered (*T. orientalis* and *T. maccoyii*). As a general conclusion, it was agreed that there are important dynamics in the Atlantic bluefin fisheries that took place prior to 1970, which should be incorporated into our overall analysis and be utilized to shape our scientific advice to the Commission. It was also concluded that the incorporation of more historical information could better inform us about stock productivity and abundance levels.

The historical analysis of Atlantic bluefin fisheries showed that its captures date back to ancient times. The species has been exploited for centuries in the Mediterranean Sea and at the entrance of the Gibraltar Straits. Since the 1920s, it has been increasingly exploited in the northeast Atlantic. Large changes have been observed since then and there were several extinctions/discoveries of important fishing grounds in the Mediterranean as well as in the East Atlantic during the 20th century. Bluefin tuna are now absent or rare from formerly occupied habitats, such as the North Sea, Norwegian Sea, Black Sea, Sea of Marmara, off the coast of Brazil and Bermuda and certain locations off the northeastern American coasts, while high catches have been recently made_in new areas, such as the eastern Mediterranean, the Gulf of Syrta and the central North Atlantic. The reasons for these changes in spatial and temporal patterns remain unclear and are likely to result from interactions between biological, environmental, trophic and fishing processes.

Strong connection was found between the Nordic fisheries and the northeast Atlantic traps, based on catch-at-length and catch-at-age analysis. The abundance of exceptionally large cohorts could also be found concurrently in some juvenile fisheries located in different areas. The role of learning of migration patterns by young tuna from older tuna was discussed, as well as the necessity for overlap of spatial distributions of young and old tuna. However, the mechanisms by which learning is accomplished are unclear. Atlantic bluefin tuna might be seen as a metapopulation constituted by sub-populations that have varied in size in response to environmental changes and overfishing.

Pacific bluefin tuna populations have also had large fluctuations in the past 50 years, both in recruitment and spawning stock size. Information was also provided during the Symposium about experience with captive Pacific bluefin tuna, which indicate spawning does not always take place annually, that egg quality is likely the same between young and medium-old adult Pacific bluefin tuna, and that a rapid increase of sea surface temperature to 24ºC triggers spawning. In the late 1970s, southern bluefin tuna suffered a fishery collapse along with a considerable reduction in the juvenile component of the stock, which was attributed to high exploitation rates. Changes in the distribution and movement patterns of juveniles have also been documented.

The Group recognized that there were very important Atlantic bluefin tuna fisheries before the reference period used in previous population analysis (1970). In consequence, it was decided to investigate, in a preliminary manner, the inclusion of historical data into the population analysis. Specifically, the Group included catch and size data from the middle 1950s for the East and Mediterranean stock and from 1960s for the west stock as an exploratory analysis to obtain improved estimation of stock productivity. However, appropriate methodologies for incorporating historical information with different statistical characteristics into our stock assessment can only be achieved over a much longer period. It is furthermore of key importance for SCRS to have full access to all historical fishery data collected on bluefin tuna, especially those from the early years of the 20th century. This data mining should, for instance, target the recovery of all the historical data collected (published and unpublished) on the North Sea fisheries, from the various traps active in the Atlantic and the Mediterranean Sea and the various bluefin fisheries that have been active during the period, but not recorded in the ICCAT database. In addition, it is necessary to move away from using VPA models and use instead integrated statistical models that can make direct use of sparse data.

4. New biological information, including results from tagging, microconstituent analysis, growth and reproductive studies, and other studies pertinent to the assessment

The Group received four working papers, which included contributions pertaining to growth (both in the wild and in captivity), information on the consequences of different growth models on management advice, and electronic tagging results. The Group also received a presentation on natal origin as indicated from otolith microchemistry. Apart from these new contributions, a summary of the current assumptions concerning life history attributes as used in the assessment is provided in the table below for the West Atlantic and East Atlantic and Mediterranean stocks:

Life history attribute	*Assumption used by the SCRS*	*Source (ICCAT Manual)*	*Notes*
Growth (length at age)	von Bertalanffy growth West: K=0.079; L_∞=382; t_0= -0.707 East & Med: K= 0.093; L_∞=319; t_0=-0.093	Turner and Restrepo[1] (1994) ICCAT (2006) Cort (1991)	Research in progress will likely refine the current growth model (see Section 4.1).
Growth (length-weight)	West: Area and season specific conversions are used, East & Med. < 101 cm: $W=2.95.10^{-5}*FL^{2.899}$ East & Med. >100 cm: $W=1.96.10^{-5}*FL^{3.009}$	ICCAT conversion factors ICCAT (2006)	Trend of declining condition noted in southern Gulf of St. Lawrence (SCRS/ 2008/083) and the Gulf of Maine implies a need for updated conversions in the west.
Natural mortality	West - M assumed age-independent (=0.14yr^{-1}) East & Med. Starting at age 1: 0.49, 0.24, 0.24, 0.24, 0.24, 0.20, 0.175, 0.15, 0.125, 0.10	ICCAT (1997)	ICCAT 1997. An age-specific vector for M is applied for ages 1 to 10+, (ICCAT 1997).
Longevity	East: > 20 yr West: 32 yr	Fromentin and Fonteneau (2001) Neilson and Campana (in press)	Based on tagging data. Based on radiocarbon traces.

[1] For the central North Atlantic, either the east or west growth model has been used to construct the catch at age in that area.

Maturity	West 50% maturity: Age 8 (190 cm / 120 kg). East & Med. 50% maturity: Age 4 (115 cm / 30 kg).	Baglin (1982) ICCAT 1997 (being confirmed by more recent studies)	Diaz and Turner (2007) and others suggest later age at 50% maturity (age 11-12), but Goldstein *et al.* (2007) suggest for the west asynchronous reproductive schedule and smaller size at maturity.
Spawning Area	West: Gulf of Mexico. East & Med.: Around Balearic Islands, Tyrrhenian Sea, central Mediterranean and Levantine Sea.	Multiple sources, see Rooker *et al.* (2007) and Fromentin and Powers (2005) or Mather *et al.* (1995) for reviews.	Other spawning areas have been hypothesized, but not yet demonstrated.
Spawning season	West: mid-April to mid-June. East & Med.: mid-May to mid-July.	As above.	

4.1 Growth

SCRS/2008/084 presented models fitted to recent samples of Atlantic bluefin tuna on the basis of annulus interpretations in otoliths. Samples were aggregated based upon whether individuals originated in western or eastern nursery systems using otolith stable isotope analysis. A model fit to recent year-classes (after 1970) for western captured, western-origin Atlantic bluefin tuna yielded von Bertalanffy coefficients of K=0.20; L_∞=257; and t_0=0.83. These coefficients are substantially different than those from the Turner and Restrepo model based on conventional tagging and modal progression data (K=0.08; L_∞=382; t_0= -0.71), and the corresponding growth curve predicts very different lengths at age for fish younger than age 4 or older than age12. Growth models were also fit for the eastern population, but coefficients were probably biased due to the small sample size and the truncated size range in the samples. Given the established accuracy of direct age estimates from otoliths and the feasibility of complementary age and natal assignment determinations using the same prepared otoliths, the authors recommended that future assessments be based upon direct ageing of otoliths over other approaches. For the current assessment, they recommended use of the western capture - western origin subset as being the most representative of western bluefin tuna growth patterns.

The Group requested more information on the computational details, which was subsequently provided by the authors, along with the original data. It was recommended that the new information from direct ageing be combined with length-frequency samples, to better describe growth over a more complete age range. The Group also expressed concern that the estimates of L_∞ appeared too small, and would not be able to accommodate occurrences of large bluefin tuna, as have occurred historically. It was noted that in the context of rebuilding efforts, it is important to characterize productivity correctly. Finally, it was asked what birth date convention was used by the authors.

The presenting author consulted by email with some of the co-authors to attempt to address some of the concerns raised above. Concerning the value of L_∞ appearing too small, the authors noted that the current description of growth may have been limited by the absence of older fish. Preliminary von Bertalanffy fits conducted by the authors with larger, older Canadian samples yielded an L_∞ of 280 cm. The authors also noted that there is a view that L_∞ should reflect the average largest fish, not the largest fish ever seen. Concerning the birthdate convention, the authors assumed a spring-summer birthdate. Fish included in the analyses were samples captured during summer-fall months.

The Group saw the benefit of basing growth models on otolith data, as these samples could more reliably be assigned to a stock than can conventional tag data used in Turner and Restrepo (1994). The major concern was that it appeared as though the largest and smallest size classes were under-represented in the sampling. Additional otolith samples from large fish have been collected and are being analysed. These new data will be incorporated into the growth model. In addition, the authors will attempt to collect and analyse otolith samples from fish throughout the size ranges in the future. The Group decided to explore the results of combining different data sets and using different error assumptions to estimate growth curves (see **Appendix 5**).

SCRS/2008/091 examined the implications of the growth curve presented in SCRS/2008/084 to the stock assessment of western Atlantic bluefin tuna and its corresponding management advice. The new growth curve was used to convert the catch-at-size matrix from the 2006 assessment (Anon. 2007) into an alternative catch-at-age matrix through application of the SCRS age-slicing algorithm. The base-case VPA model and associated projections from the 2006 assessment were then repeated with this alternative catch-at-age. The results suggest a more optimistic appraisal of stock status, but are dependent on VPA parameter specifications that were based on the results from the current growth curve. It is recommended that (1) the otolith data used to estimate the new growth curve parameters be augmented with samples from small fish and (2) the terminal-year, F-ratio, natural mortality and maturity specifications be re-examined if the proposed otolith-based growth curve is to be adopted.

The Group agreed that significant progress has been made in updating the growth curve used by the SCRS. Given the expected changes in the growth model, there will likely be a need to revise the current benchmark calculations. Having direct age estimates throughout the age range would also be helpful for the estimation of the von Bertalanffy parameters, rather than the explorations presented here, which necessitated the combination of data sets with disparate error structure.

The Group strongly encouraged further age and growth work based on direct ages from otoliths, including incorporation of both younger and older ages. It was further noted that given the considerable consequences of variations in growth on management advice as demonstrated in SCRS/2008/091, a program of biological sampling of the catch and routine age determinations is urgently needed to provide more realistic estimates of stock productivity.

4.2 Movement and migrations

SCRS/2008/092 presented information from 15 bluefin tuna that were satellite and archival tagged in the Gulf of St. Lawrence, Canada, during October 2007. The objective was to examine the movements and spawning migrations of bluefin tuna from this late summer/autumn foraging assemblage. Preliminary results from this experiment were presented. All bluefin tuna were brought onboard the vessel, irrigated, tagged, measured and released. Bluefin tuna ranged in size from 235 to 302 cm curved fork length. Three tags were programmed to pop-up shortly post-release, after 3, 30, and 60 day intervals, to demonstrate survivorship and short-term success of the tagging operations. The remaining tags were set for longer durations in order to examine where the tuna were during the breeding season. To date, of the six tags that remained on fish beyond the onset of the breeding season, three have popped up in the Gulf of Mexico and three in the western North Atlantic. A single fish that carried a long-term tag had a premature release program activated suggesting the fish died shortly after release. The tagging data support the hypothesis that strong linkages exist between the Gulf of St. Lawrence fish, the North Carolina foraging grounds and the Gulf of Mexico spawning grounds. To date, none of the fish has a geoposition in the eastern Atlantic management unit.

The Group enquired about size-related aspects of transatlantic migration. It was noted that all marked fish were large and of presumed spawning age, so there were limited possibilities for addressing size-related aspects of migration within this particular study. The Group noted for the Pacific congener there is evidence of skipped spawning from studies of captive fish, and enquired if any evidence was available for Atlantic bluefin tuna from satellite and archival tagging efforts to date. In response, it was noted that there was evidence (fish of the right size in the right location that exhibited behaviour indicative of spawning) of repeated annual spawning for up to five years in the Mediterranean, and three years in the Gulf of Mexico. Skipped spawning was not observed in any of these fish for which multi-year tracks were obtained. The Group asked if there were prospects of a physiological tag (eg. measuring hormone level) that could measure spawning activity. In response, it was noted that such technology was not yet available, and inferences of spawning were made from behavioural observations obtained from the electronic tags, as well as examining the tracks of fish with respect to known spawning areas and environmental conditions (sea surface temperatures >24ºC). The Group noted that observations from bluefin in captivity could help refine the characterization of spawning activity. It was noted that researchers involved in the tagging program had been in contact with Japanese, Australian and American colleagues regarding spawning behaviour of tunas observed in captivity.

4.3 Stock structure

The Group also received a presentation that showed how otolith microchemistry can be used to determine natal origin. The results demonstrated otolith $\delta^{13}C$ and $\delta^{18}O$ values of yearling bluefin tuna from eastern (Mediterranean Sea) and western (Gulf of Mexico) spawning areas were distinct and served as natal tags to assess population origin. Analysis of otolith cores for adults on spawning grounds supported philopatry to both eastern and western spawning areas. Adolescent and adult bluefin tuna collected from the U.S. Mid-Atlantic were comprised of both populations with the percent of fish originating in the Mediterranean Sea decreasing with increasing size or age. In contrast, large adults foraging areas in the northwest Atlantic (Gulf of Maine and Gulf of St. Lawrence) waters were almost entirely from the western population. Findings support natal homing to both spawning areas, and highlight the substantial subsidy of adolescents from the eastern population to most of the foraging and fishing regions in the western Atlantic.

The Group requested more information on the precision of the estimates of natal origin. In particular, they noted that the apparent movement of a significant fraction of the western stock into the Mediterranean has considerable implications. A potential problem is that the maximum likelihood composition estimator can be biased when the stocks differ greatly in local abundance, with the near-zero contributor tending to be overestimated (Millar 1987). By correspondence, the lead author provided information that indicated the range of actual western contribution to the Mediterranean could be as low as nil, which is more consistent with genetic investigations (Carlsson *et al.* 2007, Boustany *et al.* 2007). The Group asked if otoliths from larvae or post-larvae could be used for this type of analyses. The authors responded that with current methods, this would necessitate pooling of otoliths from individual fish.

For the analyses of mixing, the following information (determined from samples collected opportunistically from 1995-2005) was used:

Western samples (Mid-Atlantic bight)						*Eastern samples (Mediterranean)*					
Location	*CFL (cm)/age*	*n*	*East*	*West*	*Std*	*Location*	*Age*	*n*	*East*	*West*	*std*
MAB	69-119	46	0.62	0.38	0.12	Med	age 10	94	0.957	0.043	0.032
MAB	120-151	50	0.56	0.44	0.10	Med	age 5-9	38	0.955	0.045	0.045
MAB	185+	34	0.17	0.83	0.12						
GOM	age 10+	42	0.01	0.99	0.02						
Gulf Maine	age 10+	72	0.02	0.98	0.03						
Gulf SL	age 10+	39	0.00	1.00	0.00						

4.4 Summary of bluefin biology

Atlantic bluefin tuna (BFT) mainly live in the pelagic ecosystem of the entire North Atlantic and its adjacent seas, primarily the Mediterranean Sea. BFT have a wide geographic distribution and live permanently in temperate Atlantic waters. Archival tagging and tracking information confirmed that BFT can sustain cold as well as warm temperatures while maintaining stable internal body temperature. Until recently, it was assumed that BFT preferentially occupy the surface and sub-surface waters of the coastal and open-sea areas, but archival tagging and ultrasonic telemetry show that BFT frequently dive to depths of 500 m to 1000 m. BFT is also a highly migratory species that seems to display a homing behaviour and spawning site fidelity in both the Mediterranean Sea and Gulf of Mexico, which constitute the two main spawning areas being clearly identified today. Less is known about feeding migrations within the Mediterranean and the North Atlantic, but results from electronic tagging indicated that BFT movement patterns vary considerably between individuals, years and areas. The appearance and disappearance of important past fisheries further suggest that important changes in the spatial dynamics of BFT may also have resulted from interactions between biological factors, environmental variations and fishing. Although the Atlantic BFT population is managed as two stocks, separated by the 45°W meridian, its population structure remains poorly understood and needs to be further investigated. Recent genetic and microchemistry studies as well as work based on historical fisheries tend to indicate that BFT population structure is complex.

Currently, our understanding is that BFT in the Mediterranean mature at 4-5 years of age (approximately 25 kg) and at about 8 years of age (approximately 140 kg) in the Gulf of Mexico (albeit age-at-maturity is still debated in the West). Juvenile and adult BFT are opportunistic feeders (as are most predators) and their diet can include jellyfish and salps, as well as demersal and sessile species such as, octopus, crabs and sponges. However, in general, juveniles feed on crustaceans, fish and cephalopods, while adults primarily feed on fish such as herring, anchovy, sand lance, sardine, sprat, bluefish and mackerel. Juvenile growth is rapid for a teleost fish (about 30 cm/year), but slower than other tuna and billfish species. Fish born in June attain a length of about 30-40 cm and a weight of about 1 kg by October. After one year, fish reach about 4 kg and 60 cm long. Growth in length tends to be lower for adults than juveniles, but growth in weight increases. At 10 years old, a BFT is about 200 cm and 150 kg and reaches about 300 cm and 400 kg at 20 years. However, there remain large uncertainties about BFT growth curves.

In the 2006 stock assessment conducted by the SCRS, there was noted a need to integrate recent and anticipated advances in otolith microconstituent analyses, age determination, archival tagging and genetics into the next assessment and management evaluation processes. While more work needs to be completed, the SCRS has achieved important progress towards that goal. Concerning age determination, the SCRS received new information that presented a novel approach for determining age and area of natal origin from the same otolith, allowing construction of area-specific growth curves. The preliminary results diverge considerably from the age-length relationship used by the SCRS for the western stock, and could have significant impacts for estimates of stock productivity.

The information on natal origin derived from otolith microchemistry received by the SCRS indicated that there is an increasing contribution of eastern origin fish to the western fisheries with decreasing average size of the fish in the catch (*i.e.* up to 62% for fish in the 69-119 cm size class). In contrast, other western fisheries supported by the largest size classes had minimal or no eastern component in the catch.

5. Catch data, including size frequencies and fisheries trends

Annual bluefin nominal catches (Task I) from 1950 to 2007 were presented by the Secretariat and summarized in **Table 1** and **Figures 1** and **2**. **Figures 3** and **4** show the spatial distribution of bluefin catches (1950-2006) by gear and decade. **Figure 5** shows the reported annual bluefin catches by area and main gear.

The catch-at-size data set for the western and eastern stock prepared in advance by the Secretariat was reviewed by the Group. Substitution rules tabulated in SCRS/2008/102 contain the detailed procedures used for the substitution and the extrapolation made when no size sample was submitted.

In the case of the western stock, the available data included catch, effort and size statistics through 2007, while for the eastern stock, data for 2007 were unavailable for analysis during the assessment session (see the letter of the SCRS Chair dated 27/06/2008, ICCAT Circular 1226/08, attached to this report as **Appendix 6**). There are considerable data limitations for the eastern stock for the recent period. These include poor temporal and spatial coverage for detailed size and catch-effort statistics for many fisheries, especially in the Mediterranean. Substantial under-reporting of total catches is also evident.

5.1 *Fishery trends – East*

Several papers about fishery, fishery data and CPUEs were presented at the meeting. Summaries of documents relative to fishery trends are presented below.

Document SCRS/2008/096 deals with the reconstruction of the size composition of bluefin tuna caught by the Moroccan Atlantic traps from biological scraps (mainly heads), using a linear relationship between the fork length and the head length established for this species. In 2006, scraps from 209 individuals were sampled to estimate the size structure of BFT catches. Results show that there is a strong correlation between the head length and the length between the tip of the snout and the posterior limit of the pre-operculum, as well as between the fork length and the head length. A comparison of the same relationship in the other trap fisheries was also provided. On the basis of these studies, the Group discussed the possible enhancement of this type of data collection especially in the Mediterranean Sea (Section 11.1 includes a recommendation reflecting this discussion).

SCRS/2008/104 presented information on the total catch, timing of harvest and size composition of bluefin tuna caught in Tunisian pens between 2005 and 2007. Wild tuna caught by Tunisian purse seiners are used in the fattening operations. The study reported that 5,665 were fish sampled, of which 3,275 had both weight and length data from the same fish. Annual length-weight relationships for fattened fish are reported, and size composition information presented. It is demonstrated that Tunisian farms are targeting spawning fish, with more than 98% of the total sampled fish which are larger than the length at first maturity.

Considering that only about 15% of the 2007 Task I data were reported in due time to the Secretariat, **Figure 1** shows patterns of bluefin catch by main areas based on Task I data for the 1970-2006. From 1950 until the early 1960s, catches of bluefin tuna mostly took place in the northeast Atlantic and then in the Mediterranean Sea. In the mid-1960s, a new fishing ground was found in the tropical West Atlantic while the northeast Atlantic fisheries strongly declined (especially in the North Sea and Norwegian Sea, see SCRS/2008/Santander). From the mid-1960s until the mid-1970s, the catches were about 6,000 to 9,000 t/year in the three areas. Since 1982, the West Atlantic catches were limited to around 2,500 t/year, while the catches in the East Atlantic remained at the same level of about 9,000 t/year. From the early 1980s until the mid-1990s, the catches in the Mediterranean Sea have steadily increased, from about 10,000 t/year to almost 40,000 t/year. Although, there is a substantial decrease in the reported catch of the Mediterranean Sea over the last decade (at about 24,000 t/year), the SCRS strongly believes that these lower catches mostly reflect underreporting and that current catches are probably more than 43,000 t/year (see below “trade statistics” section, Section 9 and Anon. 2007).

Figures 1 and 5 show patterns of bluefin catch by main gears. Since 1950, the baitboat fisheries that mostly catch juvenile fish in the northeast Atlantic appear to be rather stable. The longlines displayed two peaks, the former in the tropical West Atlantic (especially offshore Brazil) and the latter in the Mediterranean Sea and secondarily in the central Atlantic. Catches have, however, slowly declined over the last decade. The trap that was the major gear in the East Atlantic and Mediterranean Sea steadily declined during the 1960s. From the 1970s to nowadays, trap catches mostly varied between 2,000 and 4,500t/year and have almost completely disappeared from the Mediterranean Sea. Catches from purse-seiners were mostly coming from the Northeast Atlantic during the 1950s and early 1960s. While these fisheries declined in the following years, this gear arose in the Mediterranean Sea and has become the major gear used for harvesting bluefin tuna in the Mediterranean (up to 85% of the reported catches in the Mediterranean Sea).

Regarding seasonality, estimates of temporal pattern in monthly catches of spawning size (> 130 cm FL) and juvenile (< 130 cm FL) bluefin tuna in the East Atlantic and Mediterranean fisheries were updated based on the 2005 and 2006 catches **(Figure 6)**.

In general, monthly catch patterns are very similar to those previously estimated. For the Mediterranean, juvenile bluefin tuna catches occur throughout the year, with a peak at the beginning of the second quarter. As regards spawning size fish, the bulk of the catch occurs during the second quarter.

East Atlantic juveniles are caught from May to November with two peaks around June and September. For the spawning size fish, the bulk of the catch is made in the second quarter of the year although there is still a significant amount of catch during the last quarter.

The tremendous recent expansion of the purse seine (PS) fleet in the Mediterranean is related to the farming activity, a feature that is not obviously reflected by the reported catch of that gear. In 1997, only 200 t of Mediterranean BFT were put into cages, whereas previously the SCRS estimated that up to 20,000 to 25,000 t were farmed each year since 2003 (some estimates being conservative in comparison to those of WWF, which reach 30,000 t in 2004 and 2005, and which also appear to be possible). This tremendous development of farming activity in the Mediterranean over the last few years has induced a concomitant development of new PS fisheries and a considerable modernization of the traditional PS fleets. This worrying development in a context of overexploitation potential has further led to a quick and spatial expansion of the PS fleets in the Mediterranean, especially in the central and eastern Mediterranean **(Figure 3)**. Consequently, the vast area of the Mediterranean nowadays were covered by BFT fishing over its entire surface, a situation that has never been encountered in the past and that is of high concern since there appears to no longer exist any refuge for BFT in the Mediterranean during the spawning season.

Summarizing, it is very well known that introduction of farming activities in the Mediterranean in 1997 and good market conditions resulted in rapid changes in the Mediterranean fisheries for bluefin tuna, mainly due to increasing purse seine catches. In the last few years, nearly all of the declared Mediterranean bluefin fishery production is exported overseas. Declared catches in the East Atlantic and Mediterranean reached a peak of over 50,000 t in 1996 and, then decreased substantially, stabilizing around TAC levels established by ICCAT for the most recent period. Both the increase and the subsequent decrease in declared production occurred mainly for the Mediterranean. In 2006, declared catch was about 30,650 t for the East Atlantic and Mediterranean, of which about 23,100 t were declared for the Mediterranean (2007 catch reports were unavailable at the time of the meeting). Information available reinforces our belief that catches of bluefin tuna from the eastern Atlantic and Mediterranean have been seriously under-reported in recent years (see Sections 5.3.3 and 9.1).

5.2 Fishery trends – West

The total catch for the West Atlantic including discards has generally been relatively stable since 1982 due to the imposition of quotas. However, since a total catch level of 3,319 t in 2002 (the highest since 1981), total catch in the West Atlantic has declined steadily to a level of 1,624 t in 2007 **(Figure 7)**. This decline is primarily due to considerable reductions in catch levels for U.S. fisheries. It is noted that several additional CPCs have reported at least some West Atlantic bluefin tuna catches during the previous five years, but did not report in 2007. However, the total reported from these flags has averaged only 44 t during this period.

CANADA: Canadian bluefin tuna fisheries currently operate in several geographic areas off the Atlantic coast from July to November, when bluefin tuna have migrated into Canadian waters. The spatial distribution of the Canadian fisheries has not changed significantly, but there were anecdotal reports of tuna occurring in areas where they have not been observed in many years (for example, the Baie des Chaleurs in the western Gulf of St. Lawrence). The size composition of the catch in the southern Gulf of St. Lawrence over the past 5-6 years has generally followed a declining trend that has recently stabilized, and is now increasing. The condition (Fulton's K) of individual fish in the southern Gulf of St. Lawrence has been following a declining trend and is now at the lowest value in the series. The Canadian bluefin tuna catches (landings and discards) in 2002 were 641 t, the highest level since 1978 at the time. Catches for 2003-2007 totaled 571, 552, 600, 735 and 491 t, respectively. The 2006 catch was the highest recorded since 1977. The 2007 landings by gear were: 17 t by harpoon, 58 t by longline, 389 t by rod and reel, 23 t by tended line and 4 t by trap.

UNITED STATES: The U.S. bluefin fishery continues to be regulated by quotas, seasons, gear restrictions, limits on catches per trip, and size limits designed, to varying degrees, to conform to ICCAT recommendations. The catches (landings and discards) of U.S. vessels fishing in the northwest Atlantic (including the Gulf of Mexico) in 2002 reached 2014 t of bluefin tuna, the highest level since 1979. However, catches in 2003-2007 declined precipitously, to 1644, 1066, 848, 615, and 849 t, respectively. The 2007 catches, including dead discards, by gear were: 28 t by purse seine, 23 t by harpoon, 164 t by longline (of which 81 t were incidental catches from the Gulf of Mexico), and 634 t by rod and reel (of which, 399 t was the preliminary estimate for bluefin less than 145 cm SFL from off the northeastern United States).

JAPAN: Japan uses longline gear to catch bluefin tuna in the Atlantic Ocean. The overall number of boats engaged in bluefin fishing has declined from more than 100 boats in recent years to about 50 boats in 2007, of which about 20 boats were operated in the West Atlantic. Recent catches in the west (about 300-600 t) have fluctuated mostly due to the quota adjustment. Operational pattern did not change much in the West Atlantic. Fishing starts in August but in the east Atlantic in the waters off Iceland to Ireland. Thereafter, they move westward and reach the West Atlantic at around late November to early December. The fishing usually stops in January but in some years it extends to February. The West Atlantic bluefin tuna catch (landings and discards) of the Japanese longline fleet in 2007 was 277 t, the lowest level since 1981 with the exception of 57 t in 2003.

5.3 Catch and size data – East

5.3.1 Nominal catches

It was noted that the ICCAT Task I for the years 1950-1979 contain important catch for EC-Greece with an average of 710 t by year. The Group felt that for those years there were no fisheries in Greece targeting bluefin and decided to remove those time series from the scientific calculation and asked the Secretariat to flag the information in its database and try to find the origin of this data.

New catch figures for Denmark for the years 1938-1988, Sweden for 1937-1962, Germany for 1947-1962 and Norway for 1927-1974 were made available during the session (see BFT Symposium Report) and the Group approved the decision to revise the historical catch time series for those countries. The Japanese catches reported in two different longline fisheries (mother boat and single boat operation) were aggregated into only one gear.

On the first day of the meeting, only 3,816 t of the 2007 nominal catches (Task I) were reported to the Secretariat by the following three Contracting Parties: Japan, Croatia and Turkey. According to the low level of catches reported in the eastern Atlantic and Mediterranean area for the year 2007, the Group expressed grave concern about the compliance of reporting statistical data by the contracting parties. n particular, the Group considered that these scarce data did not allow evaluation of the progress of the 2006 Recovery Plan for Bluefin Tuna in the astern Atlantic and Mediterranean, as was requested by the Commission. The concern of the Group was expressed through a letter addressed to the Commission Chairman (see **Appendix 6**). Nevertheless, to make up for the lack of data in 2007 it was decided to examine 2007 catch levels reported to the Compliance Committee during the 2007 Commission meeting to compare with other sources of information.

5.3.2 Size frequencies

During the session, six important historical size sampling data sets were submitted to the Group for the first time: Germany for years 1952 to 1962, EC-Italy/Trap for 1956 to 1984, Norway/PS for 1956 to 1981, Morocco/Hand for 2000 to 2006 and Morocco/Trap for 2006 to 2007, Turkey/PS for 1992 to 2003 and a new sample from Spanish BB in 1956. The availability of those new data influenced the Group to create the catch at size and catch at age for the eastern stock starting in 1955. After examination of the catch size distribution, it was decided to remove all the time series from Moroccan PS and Tunisian trap of Monastir which showed an unusually large amount of small fish and to substitute it by Spanish baitboat and Italian trap, respectively, which the Group believes better reflects the actual size distribution of these catches. Catch at age generated from this catch at size is shown in **Figure 8**.

In addition to the analyses of size data submitted as Task II, the Group estimated the coverage of the bluefin farming sampling scheme established by the *Recommendation by ICCAT on Bluefin tuna Farming* [Rec. 06-07]. Results are shown in **Appendix 7** as well as the procedure used.

5.3.3 Trade statistics evaluations

The Committee has previously observed that in spite of declared levels in official statistics, the volume of catch taken in recent years likely significantly exceeded TAC levels and probably was close to the levels reported in the mid-1990s. As only about 15% of the 2007 AC for eastern Atlantic and Mediterranean bluefin was officially submitted in time to be considered in the assessment, our belief that catches of bluefin tuna from the eastern Atlantic and Mediterranean have been seriously under-reported in recent years has been reinforced. It has been observed that nearly all of the declared Mediterranean bluefin fishery production is exported overseas, leaving little of the declared volumes for domestic consumption, which are believed to be substantial.

Although the Japanese market remains a primary recipient for Atlantic bluefin tuna production, it is no longer the only available market for bluefin and tracking trade through the various markets is difficult to accomplish. Nonetheless, the Group examined the information reported through various market data sources in an attempt to further refine estimates of the volume of bluefin exported from the Mediterranean and eastern Atlantic fisheries. We examined the BFT statistical documents held at ICCAT for the most recent period to compare against Task I official reports available for the assessment. Due to the lag between the time of export/import and the time of capture because of farming practices, only a portion of the 2007 capture volumes can be estimated from this comparison, since import statistics for the first part of 2008 are not yet available at ICCAT. To estimate the live-weight of bluefin being exported from the Mediterranean to the Japanese and U.S. markets, the average gain for fish held in cages for six months needs to be known. In the past, the SCRS has used a 25% gain in weight for fish held in cages for six months (taking into account that a small proportion of fish coming from the Adriatic were of small size and proportionally gained much more weight than large fish). During the present meeting, the Group was able to reestimate the gain, using samples of farmed fish for which both weight and length are available (see Section 5.3). As this estimate was significantly different, i.e. 14.5%, the estimates of live weight were computed under the two assumptions, gains of 14.5% and 25%, respectively **(Table 2)**. Estimates of live-weight bluefin from farms varied between 27,148 and 34,198 t/year depending on the assumption and year. Task I data for 2004 to 2006 (2007 being unavailable) ranged from 23,154 t to 26,697 t, so that the differences between the two estimates would indicate an underreporting of 1,000 to 7,000 t/year.

Japanese and U.S. market import statistics were also examined independently. In the Japanese market case, the import volumes from May 2007 to April 2008 were taken to represent catches made in the eastern Atlantic and Mediterranean. As above, two assumptions about the average growth of bluefin held in cages were applied. In this case, the Japanese market statistics support a range of 24,000-27,000 t of estimated live weight of bluefin caught in the eastern Atlantic and Mediterranean during 2007. Likewise, U.S. import statistics were examined and in 2007 it is estimated that on the order of 600 t live weight of bluefin were imported from catches made in the eastern management zone and not re-exported to other markets. No information was yet available for 2008 and so a complete view of 2007 catches imported cannot be made from the available data. In total, taking into account the Japanese catch in the eastern Atlantic and Mediterranean but not accounting for domestic consumption by exporting countries, indicates the 2007 catch level from the eastern Atlantic and Mediterranean was in excess of TAC, although the amount in excess could not be estimated without additional information and assumption.

Scientists from the World Wildlife Fund (WWF) attended the meeting as observers. Information pertinent to estimating potential recent catch levels in the Mediterranean held within a document prepared by WWF, entitled “Race for the Last Bluefin Tuna” (March 2008) was presented by the authors. In 2006, WWF estimated total catches on the eastern Atlantic stock of bluefin tuna in 2005 at more than 50,000 t. A new assessment produced by Advanced Tuna Ranching Technologies (ATRT) and supported by WWF and Greenpeace in 2007 confirmed this figure for the following years of 2006 and 2007. For 2006, the study relied on complete official statistics on international trade for the year, including ICCAT statistical documents supplemented with Eurostat trade data. Trade figures inferred were crosschecked against databases from national trade and custom agencies in Spain, France, Malta, Italy, United States, Japan, Korea and Tunisia, and fine tuned with reliable catch and caging data when appropriate. Total estimated catches of BFT (wild round weight) in the east Atlantic and the Mediterranean from this WWF and Greenpeace study amounted to 58,681 t for the year 2006. For 2007, this study was based on direct field assessments of Mediterranean tuna farms in 2006 and 2007, supplemented with Eurostat trade data (from January to July 2007) and official reports of catches and industry estimates collected until August 30, 2007. Total estimated catches of BFT (wild round weight) in the East Atlantic and Mediterranean amounted to 56,149 t for the year 2007.

Discussion of the methods applied and results given in the document was mostly devoted to checking the sources of information and methodologies used for estimating catch potentials. In the 2006 and the current bluefin tuna assessment (see Section 9), the SCRS had already considered misreporting of about the same magnitude identified in the WWF report for somewhat earlier periods. The Group has asked to WWF scientists to consider different scenarios about domestic consumption, conversion factors, different approaches (all being based on the same source of information coming from ICCAT, Japanese and U.S. trade data and Eurostat) to avoid double counting due to simultaneous exports of belly meat together with filets. The comparison results in estimates of the 2007 catch level in the eastern Atlantic and Mediterranean was on the order of 39,000 to 56,000 t, i.e. values that largely exceed the TAC. Spreadsheets supporting these calculations are held at the ICCAT Secretariat as part of the record of the 2008 bluefin tuna stock assessment.

The WWF estimates of 2006 and 2007 catches coincided in general with those made by the Group on the basis of active capacity (see Section 9). They are substantially higher than the Group estimates when summing estimated catches from **Table 2** (i.e. farmed bluefin tuna in the Mediterranean) with East Atlantic catch (i.e. 7,493 t in 2006) which results in a total catch of estimate of between 36,584 and 41,691 t. Note, however, the Group assumed that all catches from the Mediterranean Sea go into cages, which is a very conservative assumption.

In conclusion, the Group still believes that significant underreporting has occurred in 2006 and 2007 (note that the EU has reported a 4,400 t quota overshoot in 2007). Consequently, the Group estimates that the 2006 and 2007 catches were more likely at a comparable level of those of previous years, i.e. 50,000 t, or even higher (see Section 9 and Anon. 2007). As has been expressed several times in past SCRS Reports, this is particularly worrying since such large under-reporting partially impairs our ability to assess the stock with methods that do not assume observation errors. This does not prevent development of scientific advice, but this development has to be supplemented with different indicators and methodological approaches (including more robust ones, such the yield-per-recruit, year-class curves, etc.) It is imperative that CPCs provide accurate Task I and Task II data to the SCRS if they want to have improved and more precise stock status evaluations and advice.

5.4 Catch data – West

5.4.1 Nominal catches

The 2005-2007 reported catches (including estimated discards) for the West Atlantic were 1,869, 1,811, and 1624 t, respectively. Catches for each of these last three years are lower than for any prior year since 1982, and each is considerably lower than the average catches of about 2,500 t that have been reported during 1983-2004. The Untied States, Canada, Mexico and Japan reported catches for 2007 in the West Atlantic. After reviewing information presented by the Secretariat, it was decided to move the Portuguese baitboat catch in 2005 and 2006 from the western to the eastern stock. Catches reported in unclassified gear for Canada during the years 1960 to 1969 was reclassified as trap gear and U.S. longline discards for 1987-1991 were revised by U.S. national scientists. The Task I catch data, as reported in **Table 1** and **Figures 1** and **2**, were approved.

5.4.2 Catch-at-size (CAS) and catch-at-age (CAA)

The substitution scheme proposed by the Secretariat for western Atlantic bluefin tuna to update the CAS used at the 2000 assessment session, up to and including 2001 is detailed in SCRS/2008/102. A few changes were proposed to western catch-at-size data. The modifications affected U.S. longline (2004), U.S. rod and reel (1992), and U.S. longline discard (1986). Fleets which had been defined in earlier catch at size data sets as unclassified were broken down into the following countries: Argentina, Uruguay, Brazil, Cuba, Chinese Taipei and Korea.

Following a careful scrutiny of the data in both stocks, and with the availability of new size sample data presented during the first day of the meeting, the Group decided to undertake an important revision in the nominal catch data and, consequently, in the catch at size. The overall catch at size for the west is shown in **Figure 9**.

The same age slicing procedure used for several years was again employed to convert CAS to CAA. That procedure uses the growth curve from Turner and Restrepo (1994) and empirical modal separation for ages 1-3, where appropriate. A summary of the results is shown in **Table 3** for the West Atlantic (Areas 1+2) and in **Figures 10 and 11**. Weights at age from the age-slicing for the west are shown in **Table 4**. Three scenarios for boundaries were defined using the areas defined in the Report of the ICCAT Workshop on Bluefin Mixing (Anon. 2002). The CAA was defined separately for Area 3 **(Table 5)** using the CAS for Japanese LL, which represents nearly all the catch in that area. The eastern stock age slicing procedures were applied to the Area 3 CAS data provided by national scientists for years 2002-2007. The resulting CAA data were appended to CAA data for 1970-2001 that were available for the 2006 bluefin tuna stock assessment. It should be noted that the CAA data for Japanese longline in Area 3 2002-2007 were updated by the Secretariat based on the CAS submitted to the Secretariat from Japan before the meeting. CAA data for Japanese longline in Area 3 until 2001 was carried over from the CAA used at the 2006 assessment. The Group noted that there were major discrepancies between the Area 3 CAA carried over from the 2006 assessment and that used for the 2002 assessment. The reasons for this were unclear, but a possible explanation is that differing decisions were made on the geographic separation of catches between areas.

5.5 Mixing variants

The Group discussed the implications of the otolith microconstituent study reviewed in Section 4.3, which estimated that a substantial proportion of the bluefin sampled from western catches were of eastern origin. Unfortunately, the available samples were insufficient to determine the relative proportions of eastern and western fish in the catches for each year, so it was not possible to adjust the CAA directly. Instead, the Group agreed that it was more appropriate to examine the implications of the proportion estimates within the context of a mixing analysis (e.g., the two-box overlap VPA).

6. Relative abundance indices and other fishery indicators

6.1 Relative abundance indices – East

6.1.1 Primary indices

The Group reviewed the available information on abundance indices. The indices that were presented at the last assessment meeting were all updated. Those are indices from Spanish trap, Moroccan trap, Spanish baitboat fishery in Bay of Biscay and Japanese longline fishery in the east Atlantic and Mediterranean. Original CPUE and scaled CPUE to its mean value and CVs, when they are calculated, are given in **Table 6** and **Figure 12**.

SCRS/2008/099 derived GLM-standardized indices of abundance for large bluefin tuna (6+) in the Spanish traps close to the Strait of Gibraltar from 1981 to 2007. This index was discussed since the 2002 Atlantic Bluefin Tuna Stock Assessment Session (Anon, 2003). At the last assessment in 2006, it was standardized with a GLM with a negative binomial error assumption and included variables of trap, year and season (May and total duration). Discussion was made similarly on the possible inclusion of the environmental information such as water temperature because the movements of the fish are often triggered by the changes in oceanographic conditions. Finally accepted model includes only factors of year and trap with aggregated catches for whole season.

SCRS/2008/098 provided a CPUE series from 1986 to 2006 from the Moroccan trap fishery for fish over 10 years old at the mouth of the Strait of Gibraltar. This is resulted from the recommendation made in 2006, and was extended back to 1986 (last time it covered only to 1998). As agreed at the 2006 meeting, this index was also standardized using a negative binomial error assumption. The model includes the same variables as for Spanish study. When compared, both series showed a complementary pattern which might be interpreted as resulting from bluefin tuna migration closer to the Spanish or the Moroccan coasts. In combination, though, the Spanish and Moroccan trap CPUEs showed lower abundance during 1992-1996 and after 2002, although the latter years are slightly higher than 1992-1996. The Group also agreed to combine both two indices into a single trap CPUE index, using a negative binomial error assumption. The results being satisfactory, the group decided to use this index for the tuning of the VPA.

SCRS/2008/100 updated standardized CPUE indices from Spanish baitboat fishery in the Bay of Biscay for 1975 to 2007. Standardization was carried out using generalized linear mixed models. Catch and effort data on bluefin tuna were prepared on trip basis; catches that are classified by commercial category were converted to ages by applying seasonal age length keys to the length distribution of commercial category. In this update the age was assigned to each commercial category so that the indices should represent the year class strength. This is because the fishery takes a variety of fish size from age 1 to over age 5. On the other hand, there are many zero catch observations, and therefore a delta-lognormal model was applied. The model finally selected following explanatory factors: Year, Age, Month and Year × Age fixed factors, plus a selection of other factors that significantly contributed for reducing deviance in the aggregated model. All Year interactions besides the Year × Age factor were considered as random variable. CVs of the standardized index are less variable than the previous one (from 1975 to 2004), but still some variability are found for the last years when the larger vessels were built and were included in the analysis. The revised age length keys seem to be reducing variability in CVs during the study period. The standardized indices indicated large annual fluctuation without a strong tendency, although the most recent peaks are relatively lower than the previous peaks.

SCRS/2008/103 provided standardized CPUE from the Japanese longline fishery in the East Atlantic (Area 5) and the Mediterranean Sea, from 1975 to 2006. Set by set data from longline boats including available chartering activities are used. Due to the short fishing season in these two areas, data were limited to April and May. Other factors included are geographic area, materials for main and branch lines and number of hooks between floats. The Group also developed the index for Mediterranean Sea (Area 6). The age of fish assigned are 4 years old and older, as the occurrence of fish of ages 5 to 7 is not rare, and in the VPA fishes older than 4 years old were used as partial catches of this fishery. The indices were standardized by delta-lognormal models with random effects for month × area interactions. The relative abundance index for the East Atlantic and Mediterranean showed relatively large fluctuations until the mid-1980s, and then exhibited a regular decline, reaching its lowest level in the late-1990s. After that it reached somewhat low peak in 2002 and higher peak in 2006 that is slightly lower than the highest peak. Getting the overall abundance index from the Japanese longline fishery for the total eastern Atlantic and Mediterranean Sea was suggested. However, the fishing seasons are different depending on the area, and the years of the fishing are also different. Giving these situations, it would require some ways of combining all information, such as area-season weighting for the total East Atlantic. The Group did not have enough time to conduct this analysis and it is left for future consideration.

6.1.2 Historical indices

The Group also reproduced two historical nominal CPUEs for the purpose of conducting an historical VPA going back to 1955. French and Spanish baitboat indices were calculated from the ICCAT Task II data for 1952-1977. Also, Norwegian purse seine CPUE (yields divided by the number of vessels) for 1955-86 given in Fromentin and Restrepo (SCRS/2008/093, Figure 1c) was used. Therefore, these two indices are considered to be nominal CPUE. With regard to the PS CPUE for 1963, Norwegian scientist pointed out that this data point should not be used because fishing effort (number of boat) for that year did not reflect the actual effort.

6.1.3 Needs of information from the purse seine fishery and from the Mediterranean Sea

In the Mediterranean, more than 85% of the total catches were made by the purse seine fishery during the recent years. The nominal CPUE index from the French PS fleet that has been used until 1998 has not been updated due to various severe limitations (see Anon. 2007, Section 5.1), so that the Group has no catch rate information on the PS fisheries. To conduct more precise and reliable assessments, it is necessary to obtain information about the catch composition, effort (e.g. day-at-sea, day of active fishing, etc.), the spatial distribution (e.g. VMS) and the technological equipments of the PS fisheries operating in the Mediterranean Sea. This issue was already pointed out many years ago and repeatedly raised in various ICCAT reports without success.

In addition to this information, the Group also stressed the strong need for fisheries-independent indices (especially in the Mediterranean Sea), as this is currently available for many stocks assessed by ICES or GFCM. European and Mediterranean scientists have recently conducted over several years and with success aerial surveys (see Fromentin, *et al.* 2003) or larval surveys (see García *et al,* 2005). These surveys have been stopped due to a lack of funding which is really unfortunate and the Group recommended that such monitoring be more strongly supported by ICCAT and/or CPCs.

6.1.4 Abundance indices used in the VPA runs

Abundance indices used in VPA analyses were shown in **Figure 13 East**. Spanish baitboat indices for both ages 2 and 3 indicate relatively large fluctuation between 1 to 5 years. The first nine years and the last five years of the two indices were lower than remaining part. Japanese longline index and combined trap index were similar between 1981 and 1996 as well as the most recent five years. However, they are quite different between 1997 and 2001.

CPUE indices starting in the early-1950s (Norwegian PS CPUE and French baitboat CPUE) were simple (nominal) CPUE because they were obtained by total catches divided by the total effort. They exhibit considerable fluctuations and there was no strong tendency except that the Norwegian CPUE declined by nearly 50% after 1975. These two indices were used in the VPA runs that start since 1955 in addition to the previous Indices.

In summary, available indicators from small fish fisheries in the Bay of Biscay did not show any consistent trend since the mid-1970s. This result is not particularly surprising because of strong inter-annual variation in year class strength. Indicators from longliners and traps targeting large fish (spawners) in the East Atlantic and the Mediterranean Sea displayed a recent increase after a general decline since the mid-1970s. The Group found it difficult to derive any clear conclusion from fisheries indicators in the absence of more precise information about the catch composition, effort and spatial distribution of the Purse Seine fisheries (which represent more than 60% of the total recent reported catch). Fisheries-independent indicators and a large scale tagging program in the Mediterranean Sea are also strongly needed to fill major gaps of scientific information.

6.2 Relative abundance indices – West

The indices used in the previous assessment of western Atlantic bluefin (Table 9, Figure 20 in the Report of the 2006 ICCAT SCRS Bluefin Tuna Stock Assessment Session in Anon. 2007) were updated, where possible, for the current assessment (**Table 7, Figure 14**). Several indices were revised using data and methods that were believed to be more appropriate. In addition, several new indices were developed from Japanese longline CPUE including two that extended back into the 1960s (one for Brazil and one for Florida and the Bahamas).

Document SCRS/2008/083 provided standardized relative abundance indices for Canadian bluefin tuna fisheries in the Gulf of St. Lawrence (1981-2007) and off southwest Nova Scotia (1988-2007) based on data from commercial log records. Methods used were as in the 2006 bluefin tuna stock assessment. CPUEs in the Gulf of St. Lawrence have increased slightly from 1997 to 2003, rapidly increased in 2004 and have remained high since then. The catch rates in 2007 are the highest in the time series, almost three times larger than the series average (**Figure 14**). The southwest Nova Scotia series has had a fairly stable trend through the mid- to late-1990s. While year 2000 showed the lowest value on record, catch rates have been following a slightly increasing trend since then. The 2007 catch rates are close (0.98) to the series average (**Figure 14**).

The Group asked if there were recent technological developments in this fishery, but there was no information of such changes. However, it was noted that the management system changed from a competitive quota to a fleet quota in 2004. The possible consequences for the catch rate series were not clear. The Group observed that the good catch rates in the Gulf of St. Lawrence may reflect the passage of a single year-class. The Group commented that there was considerable interest in bluefin tuna population declines and recoveries, and should the early signs of recovery of bluefin tuna in the western Gulf of St. Lawrence continue, it would be desirable to carefully document the event if possible. The possibility of combining Canadian indices with U.S. indices was considered but not accepted due to differing age composition among the different fisheries supporting the indices, and the desire to retain the ability to examine finer-scale spatial dynamics.

During the meeting, the Group compared an age-length key constructed from fish > 200 cm as reported in Hurley and Iles (1983) to the length-frequency information for the southern Gulf of St. Lawrence (SCRS/

2008/083). While the year-classes documented in Hurley and Iles (1983) are from earlier years, the data give information on expected variation in length at age for that fishery. The Group concluded that the data are not inconsistent with the possibility that the current fishery (and high catch rates) is supported by only a few (or even one) year classes/class, given the observed variation in length at age.

Document SCRS/2008/103 presented Generalized Linear Model analyses of catch rates for the Japanese longline fishery using different combinations of data from the western, central, and eastern Atlantic and the Mediterranean areas. The Group requested that the Area 2 index (see SCRS/2008/103, Figures 2 and 3) be redeveloped without including 2007 data because these data were considered not to be representative of the entire fleet (e.g., very few 2007 observations were available for the assessment; only few of the traditional fishing areas were represented; the data possibly corresponded to a non-random sample of vessels that fished in previous years; the data included only one of two types of branch line and one of two types of main line used by the Japanese fleet; most of the fishing effort in 2007 was in the month of February whereas most effort in other years was not). The Group also requested the development of:

1) An alternative index for fishing Area 3 including data only from (sub) Areas 31+32.
2) An alternative index for (sub) Areas 17 and 18, which was considered to be primarily a WBFT index.
3) Two historical indices, one based on Japanese longline catch and effort data from Brazil and the other based on data from the east coast of Florida (U.S.) and the Bahamas.

In response to the request from the Group, indices for Area 3 (Areas 31 and 32) and off Nova Scotia (Areas 17 and 18) were estimated using a delta-lognormal approach and including the interactions Month*Area as random effects. All estimated indices are shown in **Figure 14**. The indices in Area 3 showed a similar annual trend to the index for the central Atlantic. The index off Nova Scotia fluctuated without a discernible trend and it showed large coefficients of variation after 2000 due to a low number of observations. The West Atlantic index (Area 2) exhibited considerable fluctuations also without any trend. The abundance index for the central Atlantic was high in 1996, decreased in 1997 and 1998, and then recovered to an average level from 1999 through 2006. Historical abundance indices for off the Brazilian coast and off Florida/Bahamas were estimated for the periods 1960-1970 and 1964-1971, respectively, also using a delta-lognormal approach. The index off the Brazilian coast exhibited a sudden increase in 1962 and peaked in 1963. The abundance index off Florida/Bahamas reached its highest value in 1965 and showed thereafter a gradual decrease until the end of the time series in 1970.

Miller (2007) presented larval indices standardized in terms of the abundance of day-old larvae per 100 m^2 of water sampled. Due to the large frequency of zero catches during ichthyoplankton surveys, especially in later years, this index was developed using a zero-inflated delta-lognormal model. This model is a mathematical combination of yearly catch estimates from two distinct generalized linear models: a zero-inflated binomial model which describes the proportion of positive catch values and a lognormal model which describes the variability in nonzero catch data. Covariates, including time of day, time of month, area sampled and year, were tested for inclusion in both sub-models. The results of this approach indicated a strong decrease in larval catch rates from the beginning of the time series with the lowest value in 2005 (**Figure 14**). The Group agreed to use the indices resulting from this zero inflated delta lognormal model in the continuity and base case assessment scenarios.

Document SCRS/2008/085 presented relative indexes of abundance for the U.S. pelagic longline fleet in the Gulf of Mexico using self reported logbook data. All indexes were standardized using the delta-lognormal method. These indexes included one index that extended the time series of the index used in the 2006 BFT assessment (‘continuity’ index). The variables considered in this index were Year, Month and Zone. The four other indices presented (‘alternative’ indices) differed from the ‘continuity’ case in that they were constructed using different temporal and spatial restrictions. These ‘alternative’ indices were restricted to the Gulf of Mexico and only included data for the months of March-June, while the ‘continuity’ index included both the Gulf of Mexico and the Florida East coast and used data for the months of January to May. The ‘alternative’ indexes also tested two additional variables named (1) ‘Observed’ and (2) ‘Technology’. The variable ‘observed’ indicated if the longline fishing set was ‘observed’ by a scientific observer onboard of the fishing vessels, and the variable ‘Technology’ (levels ‘High’, ‘Low’, ‘Unknown’) assigned categories to fishing vessels based on information collected by observers. The four alternative indices were: (1) index estimated using only sets that were observed by scientific observes onboard of fishing vessels, (2) index estimated using sets that were not observed, (3) index estimated using all sets (observed and non-observed), and (4) index estimated by splitting the time series between 1987-1998 and 1999 and 2007. Diagnostic plots showed for all indices that the assumptions of normality were not fully met. Except for the index that only used the observed sets, the other indices show similar trends and values. Generally, standardized catch rates were high and variable between 1987 and 1991 and showed a sharp decline in 1992. Lowest values were observed in 1995 followed by an increasing trend that peaked in 2004. The years 2005 and 2006 showed new declines followed by a recovery in 2007. The index that only used observer data showed lower levels than the other indexes between 1992 and 1997, and relatively higher values after 1999. All five indices were within the 95% confidence interval of any of the indexes.

The testing for inclusion in the models of the variables 'Observed' and 'Technology' raised some concerns with the Group. First, the proportion of observations in each level of the variable 'Technology' is far from constant among years and some years are dominated by the level 'unknown', secondly the proportion of 'observed' sets is, in almost all years, very low resulting in an unbalanced design. The final model adopted by the Group for the assessment used only data from the Gulf of Mexico during months 1-6 and included only the variables Year, Month, and Zone. The final models for this index were:

Prop. Pos. = Year + Month + Zone + Year*Month + Year*Zone
Positive Catch rates = Year + Zone + Month

A second index was also produced using the same area (Gulf of Mexico) and months as the previous index, but including the variable 'Observed' and splitting the series between 1987-1998 and 1999-2007. This second index was used in a VPA sensitivity run. The final models for this index were:

1987-1998
Prop. Pos. = Year + Month + Zone + Year*Month + Year*Zone
Positive Catch rates = Year + Zone

1999-2007
Prop. Pos. = Year + Month + Observed + Year*Month + Year*Observed
Positive Catch rates = Year + Month + Zone + Year*Month

All first term interactions with the factor Year were modeled as random effects.

SCRS/2008/088 presented indices of abundance of bluefin tuna from the U.S. rod and real/handline fisheries off the northeast United States. Individual trip rod and reel/handline catch per unit effort data, collected through interviews with fishermen, were used to estimate standardized catch rates considering factors such as time of year, area fished, boat type, fishing method, fishery open/closed status, bag limits and target. Models were developed for all size categories of bluefin tuna (except for those <66 cm SFL), implementing a delta-Poisson approach in which catch rates are considered as a product of binomially distributed probabilities of a positive catch and Poisson distributed positive catch rates. Seven indices of abundance of bluefin tuna from the U.S. rod and reel fishery are presented. These indices are calculated separately by size category and for two distinct time periods 1980-1992 and 1993-2007. The indices for the early period include a series for small bluefin (<145 cm SFL) for 1980-1992 and for large bluefin (>195 cm SFL) for 1983-1992; these are presented unchanged from previous analyses. Also presented unchanged are the indices for 145-177 cm SFL bluefin and large bluefin (>195 cm SFL, 1983-2001). For the period 1993-2007, indices are updated for 66-114 cm, 115-144 cm, and >177 cm SFL bluefin. The distinct periods were defined because changes in survey data collection implemented in 1993 permitted separation of the catches into the smaller size intervals and because regulatory and management changes imposed different daily limits and fishery closures for those size categories.

It was pointed out that a modal progression pattern can be seen in recent years for the smaller size categories. Individuals in the 66-114 cm size range (generally ages 2-3) showed a local relative abundance peak during 2004-2005, while 115-144 cm individuals (generally ages 4-5) exhibited a local relative abundance peak during 2006-2007, a shift of 2 years which may be consistent with expectations of one (or possibly two) relatively larger cohorts. However, similar patterns are not consistently clear in other years or across other size categories. It was noted that modal progression patterns will be obscured by a large size range of individuals within a category.

Document SCRS/2008/088 also included an index for large bluefin (>195 cm) for the years 1983-2001. This index was available, but has not been used since the 2002 assessment because an important regulatory change occurred during the series: the large-medium (178-195 cm) and large (>195 cm) size classes were combined. This regulatory change appeared to have caused changes in the way size category and targeting was reported. Consequently, the 2002 working group (Anon. 2003) recommended the use of a substitute index, bluefin >177 cm for the years 1993 and later. This decision was discussed and upheld by the 2006 working group and it was carried forward for this assessment.

The Group noted that the otolith microchemistry results (reviewed in Section 4.3) suggest that the U.S. rod and reel indices for fish under 150 cm CFL may be confounded by trends in the eastern population. The same may also be true of the Japanese longline index for the NW Atlantic. Unfortunately, the available information was insufficient to determine the relative proportions of eastern and western fish in the catches by year, so it was not possible to adjust the catch at age or the affected indices of abundance. The Group therefore suggested a sensitivity analysis where these indices were excluded from the analysis.

There were two other CPUE indices that were used in the last two assessments but that were not update for this assessment. These included Japanese longline CPUE indices for the Gulf of Mexico (SCRS/2002/012) and tagging indices (Anon. 2003). The Group decided to incorporate these indices to the assessment.

7. Methods and other data relevant to the assessment

7.1 Methods – East

For reasons of continuity, the Group decided to run again a VPA ("VPA-2BOX v. 3.01", available from www.iccat.int) as was done in the 2002 and 2006 assessments.

VPA specifications

Notwithstanding the uncertainties in the catch at age and abundance index data, described elsewhere, the Group decided to run ADAPT VPA (as implemented in VPA-2box) again as it did for the 2002 assessment. The primary purpose of this exercise was to develop a recent selectivity pattern for use in further projections.

Following trials 1 and 2 in the 2006 assessment, the baitboat ages 2 and 3, combined index for Spanish and Moroccan traps and Japanese longline indices (**Table 6**) were used to tune the VPA, for the period of 1970-2006 data, with equal weighting of the indices. In all cases, terminal year Fs were estimated for ages 2 to 9, and F at age 1 was set to 0.75*F2. Penalties were imposed so that the selectivities for ages 2-9 did not vary too much in an unconstrained fashion during the last few years (see SCRS/2008/089 and text below).

Different model specifications were made (see below). RUN 1 used an F-ratio fixed to 1.0 (run 2 of the 2006 assessment). RUN 2 used a penalty for changes in selectivity in the likelihood for the last two years (sd=0.4). In RUN 3, a slightly less severe constraint was applied to the selectivity of the last 4 years (sd=0.5). Based on inspection of older fish catch at age, as well as the F-ratio pattern (F_{10+}/F_9) coming out of preliminary runs allowing for a random walk in the F-ratio, RUN 4 considered 3 periods with different F- ratios (1.0 for the 1970-1984 period, 0.6 for the 1985-1994 period and 1.2 for 1995-2006 period), as well as a constraint on the last four years' selectivities (sd=0.75). RUN 5 was equal to RUN 4, except that the 1998-2006 purse seine catch at age was adjusted so that the total catch equaled 50,000 t, to take account of underreporting. This was achieved by finding the constant γ for each year so that

$$\gamma \sum PS_a w_a + \sum O_a w_a = 50000$$

where PS and O are the catches of purse seine and all other gears combined, respectively.

The Group noted that some of the preliminary outcomes estimated lower biomass levels than the ones that would allow the high catch levels estimated for 2007. In order to fix that inconsistency, the Group added two additional runs: RUN 6 was exactly the same as RUN 4, with the exception that the CAA in 2006 was carried over to the CAA in 2007. RUN 7 was the same as RUN 5, but the CAA in 2007 was assumed to represent 60,000 t with the same age structure as 2005-2006. (Note that 2007 Task I and Task II were not available for the assessment).

An alternative dataset that dates back to 1955 was also constructed for the VPA, adding the historical French baitboat and Norwegian purse seine nominal CPUE indices for tuning. RUNS 8 to 14 were made similar to runs 1 to 7, except that they expanded back to 1955.

Model specifications for the VPA fits to eastern Atlantic and Mediterranean bluefin.

	RUN 1	*RUN 2*	*RUN 3*	*RUN 4*	*RUN 5*	*RUN 6*	*RUN 7*
Time period	*70-06*	*70-06*	*70-06*	*70-06*	*70-06*	*70-07*	*70-07*
F-ratio	70-06:1	70-06:1	70-06:1	70-84:1; 85-94: 0.6; 95-06: 1.2	70-84: 1; 85-94: 0.6; 95-06: 1.2	70-84: 1; 85-94: 0.6; 95-06: 1.2	70-84: 1; 85-94: 0.6; 95-06: 1.2
Selectivity penalty	no	2 years, sd=0.4	4 years, sd=0.5	4 years, sd=0.75	4 years, sd=0.75	4 years, sd=0.75	4 years, sd=0.75
CAA 1998-2006	reported	reported	reported	reported	50,000 t	reported	50,000 t
CAA 2007						CAA2006	60,000 t

	RUN 8	*RUN 9*	*RUN 10*	*RUN 11*	*RUN 12*	*RUN 13*	*RUN 14*
Time period	*55-06*	*55-06*	*55-06*	*55-06*	*55-06*	*55-07*	*55-07*
F-ratio	70-06:1	70-06:1	70-06:1	70-84: 1; 85-94: 0.6; 95-06: 1.2	70-84: 1; 85-94: 0.6; 95-06: 1.2	70-84: 1; 85-94: 0.6; 95-06: 1.2	70-84: 1; 85-94: 0.6; 95-06: 1.2
Selectivity penalty	no	2 years, sd=0.4	4 years, sd=0.5	4 years, sd=0.75	4 years, sd=0.75	4 years, sd=0.75	4 years, sd=0.75
CAA 1998-2006	reported	reported	reported	reported	50,000 t	reported	50,000 t
CAA 2007						CAA2006	60,000t

It should be noted that in all cases examined, the fit to the available CPUE indices was relatively poor (similar to the past assessments). However, the fit to the Japanese longline index improved under time varying F ratio assumptions (in comparison to fixed F ratio, **Figure 15**), and the retrospective patterns were improved when the F of the last 4 years was constrained. Based on these criteria, the group selected RUNs 6, 7, 13 and 14 as most satisfactory.

In addition to the VPA runs, the Group also decided to update the year-class-curve analyses to estimate total mortality with another methodological approach (see Anon. 2007 and Fromentin *et al.* 2007). The analyses have been performed on 1975-2006 Japanese CPUE data, but have not been updated on trap fisheries as the catch-at-size for 2006 and 2007 were unavailable.

7.2 Methods – West

ADAPT-VPA applied to the West Atlantic

The parameter specifications used in the 2008 VPA base model were generally the same as those used in the 2006 base-case assessment with the exception of the specification of terminal year fishing mortality rates, and the accommodation of the increased number of years. A general description of the model parameters appears below and in **Table 8**.

Virtual population analyses (VPA) require the estimation or assumption of terminal year fishing mortality rates (F). Assessments conducted since 1994 have all assumed the following relative vulnerability (partial recruitment) schedule for the terminal year:

$$F_{age\ 1} = 0.318*F_{age\ 2};\ F_{age\ 3} = F_{age\ 2};\ F_{age\ 5} = F_{age\ 4};\ F_{age\ 7} = F_{age\ 6};\ F_{age\ 9} = F_{age\ 8}$$

where $F_{age\ i}$ is the fishing mortality rate at a given age and only F_{age2}, F_{age4}, F_{age6} and F_{age8} are estimated. For this assessment, the Group preferred instead to apply the method examined in document SCRS/2008/089, wherein the terminal Fs for ages 1-9 are all estimated subject to a constraint that restricts the amount of change in the vulnerability pattern during the most recent three years (with a standard deviation of 0.5).

The oldest age class represents a plus group (ages 10 and older) and the corresponding terminal fishing mortality rate is specified as the product of $F_{age\ 9}$ and an estimated 'F-ratio' parameter that represents the ratio of $F_{age\ 10}$ to $F_{age\ 9}$ (assumed to be invariant since 1981). For the 2006 base model, the F-ratio was pre-specified at 1.0 for the period 1970-1973, estimated by a single parameter for the period 1974-1981 then estimated using a second parameter during the most recent period (1982-2007) subject to a penalty term included in the likelihood function:

$$-\ell n L = \frac{(\ell n \tilde{r}_y - \ell n \hat{r}_y)^2}{2(\sigma_r)^2}$$

where $\tilde{r}_y$ is the expected F-ratio for the most recent period (taken to be the value assumed for the 1996 base case assessment, 1.14), $\hat{r}_y$ is the corresponding model estimate, and σ_r is the standard deviation of the "prior" distribution (assumed to be 0.25).

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 (except as indicated otherwise below).

The natural mortality rate was assumed age-independent (=0.14 yr^{-1}) as in previous assessments.

Runs for the West Atlantic

The indices included in the various model runs are summarized in **Table 9**. A general description of the model settings follows:

- Continuity Run: To facilitate comparison of the 2008 assessment results to the 2006 assessment, a run was specified which used essentially the same abundance indices (Section 6.2) and model specifications as selected in 2006. Note that the continuity run was the only run that applied the assumed terminal-year vulnerability schedule of the 2006 assessment.

- Base Run: This run used the same indices and model specifications as the continuity run with the exception of the vulnerability schedule which was estimated subject to a penalty term (SCRS/2008/089).

- Case 2: To examine the implications of removing western indices thought to include catches of eastern origin bluefin, Case 2 eliminated three U.S. rod and reel indices that reference bluefin tuna <145 cm FL. In addition, the western Atlantic Japanese longline index (Area 2) was replaced by the Japanese longline index from the northwest Atlantic (Areas 17 and 18). All other settings were unchanged from the base run.

- Case 3: To consider the implications of bluefin in the Central Area (see SCRS/2008/103) belonging to the western stock, the Group decided to rerun the base case assessment for the situation where catches in Area 3 (essentially the area between 45 and 30^{o}W - see **Figure 3**) were treated as coming entirely from the western stock, and accordingly aged by means of the growth curve for bluefin in the west. For this run, the Japanese standardized LL index for Area 3 (Areas 31 and 32) was used in addition to the corresponding index for Area 2. All other settings were unchanged from the base run.

- Case 4: This run examined the effect of extending the time series back to 1960. The other models begin in 1970. To facilitate this effort, two historical indices were constructed at the 2008 BFT assessment meeting, one of Japanese longline catches off Florida (USA) and a second from Japanese longline catches off Brazil. The selectivity-at-age of these indices was estimated using the fleet specific catch-at-age from the western Atlantic Japanese longline catches. Inasmuch as the catch at size information is sparse prior to 1970, the F-ratio specifications were modified somewhat; being fixed at 1.0 for years 1960-1969 estimated by a single parameter for years 1970-1981, and estimated by a second parameter for years 1982-2007. All other settings were unchanged from the base run.

- Case 5: This case examined the effect of splitting the U.S. Gulf of Mexico pelagic longline index into two series (SCRS/2008/085). The first (1987-1998) corresponds to catch rates before the initiation of the observer program, the second (1999-2007) corresponds to the higher catch rates typically observed during the observer program. All other settings were unchanged from the base run.

- Case 6: To determine the effect of allowing the F-ratio ($F_{y,10+}$ / $F_{y,9}$) to vary in recent years, the F-ratio was estimated by a single parameter for 1982-1990 using the same Bayesian prior as was used for the base case (μ = 1.14, SD=0.25), but then allowed to vary annually using a random walk from the 1990 estimate (SD = 0.1). All other settings were unchanged from the base run.

- Case 7: This case examined the effect of estimating index selectivities from partial catches using the Powers and Restrepo approach rather than the Butterworth and Geromont method. The Powers and Restrepo approach allows index selectivity to vary annually, but assumes that fleet specific catches-at-age are known precisely. In that formulation, the selectivities can change by year, therefore it was necessary to allow the catchability coefficients to vary by year as well (in this case a random walk with low standard deviation of 0.05).

- Case 8: This case examines the effect of estimating an additional F-ratio as a frequentist parameter (initial estimate = 1.14) during recent years (2002-2007). All other settings were unchanged from the base run.

- Case 9: The Canadian Gulf of St. Lawrence catch rate series was developed to index the abundance of bluefin age 13+. The trends for this index are far more optimistic than any of the other indices for recent years. Since the VPA includes ages 1-10+ only, the index was adjusted to age 10+ and used an annually varying vulnerability for Age 10+ that was calculated using the total catch of Ages 13+ divided by the total catch of Ages 10+. This specification may have different implications than the time-invariant vulnerability vectors estimated (or assumed) for all other indices. More importantly, the index represents a small area located near the northern tip of the range of western bluefin tuna, and concern was expressed that it may represent local changes in availability of older fish more than the overall abundance of those age classes. It was noted that the trends of this index are very different from other indices that older, predominantly western fish (U.S. longline and larval surveys in the Gulf of Mexico). To examine the influence of this index, and the potential impact of a misspecification, this run eliminated the Canadian GSL index from the model. ll other settings were unchanged from the base run.

7.3 Methods – mixing variants

ADAPT-VPA applied to the East and West Atlantic to account for mixing

As a sensitivity analysis, several two-box VPA models were run estimating the levels of migration of eastern origin fish to the west and western origin fish to the east. The boundary between the two areas was assumed to be 45°W. The catch and index data used for the east box were the same as the eastern run with catches adjusted to account for under-reporting. The catch and index data used for the western box were the same as for the West Atlantic area Base case. Note that fish caught in the East Atlantic (i.e., in the eastern management area) were assigned to age categories according to the eastern growth curve, while fish caught in the West Atlantic (i.e., in the western management area) were assigned to age categories according to the western growth curve. Thus, under a mixing hypothesis, some fish are incorrectly aged.

The specifications of the two-box model were the same as the eastern adjusted-catch case and the western base-case with the exception that the vulnerability constraint was applied over four years using a standard deviation of 0.75 (consistent with the eastern base-case as opposed to 3 years with standard deviation 0.5 used for the western base-case). This change was found to make little difference to the estimates for the west (without migration). Migration was assumed to follow the overlap model, meaning that fish return to their natal area to spawn, and a specified percentage of the fish from each stock are in the other area each year.

Two types of data were used to estimate the movement coefficients (overlap fractions) in the two-box VPA: the mixing proportion estimates described in Section 4.1, (based on otolith microconstituent analyses) and conventional tagging data. The mixing proportion estimates were fit by the two-box model assuming they were approximately lognormal distributed with standard deviations equal to the values given in Section 4.3. Several of the proportion estimates were based on samples collected over several years. To reflect this in the two-box model, the same proportion values were input for each of the sampled years, but the input for each year was down weighted commensurate with the number of years (by increasing the standard deviation so that the weight given to the likelihood for the combined years was the same as for the actual point estimate).

Additional runs were made using the conventional tagging data described in **Appendix 8**. The tagging data were assumed to be approximately multinomial distributed. Tags at liberty less than 30 days were ignored. The use of tagging data necessitates specifying a number of additional parameters such as mis-reporting, tag shedding, and incomplete mixing of tags. The specifications used here were similar to those outlined in Porch *et al.* (2001), but were modified by a subgroup of scientists familiar with eastern and western BFT tagging programs to better account for recent and historical changes in tagging activities.

It was not possible to run projections with the 2-box model at the meeting. There were many analytical nuances associated with different data types, model configurations and CPUE series. Because of time limits, these nuances could not be evaluated with the exhaustive rigour that they merit. Therefore modeling results were not considered reliable enough to include in stock- assessment projections and reconstructions. Nevertheless, preliminary results indicate that considering mixing in our analyses has significant effects on perceived western-stock status (as was previously thought) and possibly now also for eastern-stock status.

Alternative mixing models

SCRS/2008/097 presented a preliminary version of a spatial, Multi-stock Age-Structured Tag-integrated stock assessment model (MAST) of Atlantic bluefin tuna. The model is not yet considered reliable enough to include fitting results or projections but a brief description of it is included here to illustrate what it can do. Readers can consult SCRS/2008/097 for details of the models assumptions, data sources, and fitting procedures. MAST models eastern and western Atlantic bluefin tuna stocks simultaneously in four areas, with quarterly time steps. MAST estimates F_{MSY} and MSY as leading parameters. Each stock is modeled as having specific growth, movement, maturity and natural mortality parameters.

Building and attempting to fit MAST to data have helped to identify research priorities for ICCAT's assessment of Atlantic bluefin tuna if it intends to undertake assessments at fine temporal and spatial resolution. These include: obtaining of stock composition data for tagged fish and for catches on a more regular basis; longer and finer temporal and spatial scale time series of CPUE indices, and generally more data of all types from the East. Being able to designate mark-recapture observations by stock with genetic techniques is a high priority. MAST reaches back to 1950 to do its stock reconstructions and operates at quarterly time steps by area. These stock reconstructions would be facilitated by CPUE series at this same level of resolution that also reach back to the 1950s.

The use of a model of this type requires a thorough analysis of potential biases produced by the non-random sampling properties of existing tagging programs but also of how model areas are designated. Even without having done such an analysis it can be said that more tag and stock-composition data are needed in the East. In the multi-stock context, uncertainties about one stock, be they stock size, movement rates or fishing mortalities will propagate to the other. The Group looks forward to these simulation studies being done in order to evaluate this model's performance but also, to guide data collection and research recommendations with particular respect to the value of different kinds of information such as different tag types, stock composition and CPUE data in resolving key uncertainties. In discussions following, the Group noted that best measure of model performance should focus on how well fishing mortality, not other nuisance parameters can be determined.

On the whole, the Group felt that the approach appeared to address a number of issues that have been raised in the past concerning stock mixing (Anon. 2002) and a more appropriate biological description of the system. The spatial and temporal resolution that will be possible with this model will be limited by the resolution of the available data.

7.4 Methods – Regulatory analyses

Comparisons of size frequency distributions with existing minimum size regulations were carried out at the meeting.

7.5 Methods for integration of management advice across multiple hypotheses

Due to gaps in and sparseness of available data for stock assessment and the high dimensionality of fisheries for and the biology of Atlantic bluefin tuna, there remains considerable uncertainty over hypotheses concerning stock dynamics, interpretations of available data and fleet behaviors (e.g., SCRS/2008/094; SCRS/2008/097; SCRS/2008/101). While it has long been considered a requirement for stock assessments to account for such uncertainties, the integration of management advice across multiple hypotheses is not a straightforward matter.

And while there has been much discourse concerning uncertainties in past stock assessments of Atlantic bluefin tuna (e.g., McAllister *et al.* 2001; Anon. 2002), this issue remains deserving of further close attention by Atlantic bluefin tuna stock assessment scientists and managers.

SCRS/2008/101 explored, using computer simulations, the importance of stock-recruitment assumptions in evaluations of the potential biological outcomes of management regulations for eastern Atlantic bluefin tuna. Alternative hypotheses for the steepness of the Beverton-Holt (BH) stock-recruit model, the form of recruitment variability and parental effects regarding the relative contribution to spawning stock of different age groups of adult bluefin tuna over and above their mass-at-age were considered. Depending on the assumption about BH steepness, the stock was computed to be at 20-60% of unfished spawning stock biomass (SSB) in 1970 after the model had reached a long-term equilibrium before incorporating the annual catch-at-age data from 1970 onwards. The potential future stock trajectories under the recently adopted ICCAT [Rec. 06-05] were investigated under various combinations of these alternative hypotheses. It was found that the simulated stock trajectories were highly sensitive to the assumed recruitment hypotheses with the stock trajectories ranging from rapid severe depletion to rapid recovery to Bmsy. It was concluded that due to potential large unaccounted for historic shifts in fishery selectivity-at-age and potential biases in VPA stock reconstructions "we are unable to properly estimate the stock-recruitment relationship for the East Atlantic and Mediterranean bluefin tuna stock. Consequently, it is crucial to clearly state recruitment assumptions when an advice is given and to consider a significant range of contrasting and realistic stock-recruitment relationships".

Interest was expressed in extending the VPA back to the 1950s to add to the time series of stock-recruit data for the estimation of stock-recruit model parameters. It was mentioned that catch-at-length data from 1950s and 1960s fisheries, e.g., off of Norway were likely to be of high quality since many fish captured from this fishery were sampled. While summary results demonstrated high contrasts in the simulated potential outcomes under the different hypotheses, there were requests for some further comparisons to be shown, e.g., keeping steepness and stochasticity assumptions constant and showing results with and without the parental effects on reproductive output. The potential for there to exist parental effects on reproductive potential was considered to be of concern due to the recent increased targeting on very large-sized fish presumably as a response to the recently implemented ICCAT [Rec. 06-05]. The failure to find any parental effects in captive Pacific bluefin tuna was mentioned but the extent to which this finding could be generalized was questioned since it was only limited observations made over relatively few years. Due to the paucity of data and research on potential parental effects in wild bluefin tuna, further interest was expressed in the establishment of new research programs on bluefin tuna reproductive biology to test hypotheses on parental effects. In summary, the paper provided strong support for the current and future stock assessments to carry out and present projection results under a set of "contrasting and realistic" hypotheses about the stock-recruit function. A summary of discussions on approaches to provide weights on and present as a basis for management advice results from model runs based on alternative hypotheses is provided further below.

SCRS/2008/094 presented results from computer simulations that evaluated the performance of alternative management methods under alternative hypothesis for the apparent long-term fluctuations in Mediterranean trap landings that have gone on for centuries. The authors used a management strategy evaluation approach. The two alternative hypotheses included either long-term cycles in the carrying capacity of the stock-recruit function or long-term cycles in migration patterns and availability to the fishery. The alternative management reference points considered included MSY, $F_{0.1}$, F_{MAX}, $F_{x\%SPR}$, F_{MSY}. The management control procedures considered included ones using $F_{0.1}$ and a minimum size limit.

ADAPT VPA estimates of abundance (N) and fishing mortality rates (Fs) were unbiased under the carrying capacity fluctuation (CCF) hypothesis but showed marked biases in the trends and magnitudes of estimates of F and N under the migration fluctuation (MF) hypothesis. The estimates of yield and stock biomass reference points showed considerably more bias than the F-based reference points. Among the F-based reference points, the $F_{0.1}$ reference point appeared to provide the most precise and least biased proxy for the true F_{MSY}. The average ratio of F to $F_{0.1}$reference points were relatively stable under the CCF hypotheses but depended strongly on the phase under the MF hypothesis. Management strategies based on $F_{0.1}$ tended to provide higher stock biomass than other policies under the different hypotheses for the phase and cause of long-term catch fluctuation. The minimum size limit policy tended to provide slightly lower stock biomass than the $F_{0.1}$ policy but higher yields. The status quo policy appeared to perform poorly compared with other policies in both respects. The performance of all three policies was strongly affected by about the current phase of the historic cycle under the two hypotheses for the cause of historic cycling of trap catches. The paper also indicated that policy performance was highly sensitive to implementation error but less so to misreporting of commercial fishery statistics.

It was suggested that this paper might provide further justification for utilizing $F_{0.1}$as a proxy for F_{MSY} in harvest control procedures. However, not all members of the Group agreed that this paper provided sufficient evidence for a general recommendation to be made to ICCAT to use $F_{0.1}$as a proxy for ICCAT's F_{MSY} reference points. This was partly because there may still be some room for improvement in the estimation of MSY based reference points (e.g., via Bayesian estimation methods and the implications of uncertainty over growth and natural mortality rates could also be further explored).

Some also pointed out that while uncertainty over explanations for historic fluctuations in trap catches might never be resolved, current and recent fisheries data and scientific research methods and possibly new spatially structured assessment models could help to test whether recent (e.g., past few decades) migration patterns varied such that they could affect recent availability of bluefin tuna to fishing gear in the Mediterranean Sea. Therefore, it may be possible in the near future to reduce or eliminate this historic source of uncertainty in the evaluation of the performance of candidate management methods. It was commented that long-term variation in catches or apparent abundance in a given fishery could be caused by other factors than external driving forces on migration and carrying capacity and, for example, could potentially be explained by interactions between fisheries exploitation and density-dependent properties of dome-shaped stock-recruit functions such as the Ricker model. It was also mentioned that while minimum size limits or other types of size limit restrictions could be found to perform well in simulation evaluations, there has been a history of imperfect implementation of minimum size regulations and that strict enforcement of such regulations has in the past been very difficult to achieve in bluefin tuna and numerous other fisheries and in some instances have failed due to this (e.g., Kuikka *et al.* 1999).

SCRS/2008/013 reported on the Joint Canada-ICCAT 2008 Workshop on the Precautionary Approach for Western Bluefin Tuna (Halifax, Nova Scotia, 17-20). The objectives of the meeting were to review the production dynamics of western bluefin tuna as determined from the 2006 assessment, as a case study. For this stock, the meeting reviewed generic harvest strategies consistent with the ICCAT Convention and the Precautionary Approach. The meeting also considered alternative fishing mortality and biomass references, and documented the advantages of the Precautionary Approach for this stock. The meeting first focused on identifying possible systematic biases in the assessment. As noted in previous meetings, the stock assessments for western bluefin tuna tend to underestimate the terminal year biomass, yet retrospective comparison of projections indicate that the forecasts were overly optimistic. Some potential reasons for this were explored at the meeting, and subsequently (see, for example, SCRS/2008/089). The meeting considered alternative harvest strategies, and illustrated some that included varying F reference levels as biomass declines. An example is shown in **Figure 16**, along with the current trajectory for the stock. The meeting also noted that estimates of proxies for F reference points were much less sensitive to assumptions about recruitment than were estimates of proxies for B_{ref} and B_{lim} (see also SCRS/2008/094). This relative insensitivity of F reference points to indeterminacy of the S-R relationship can be used to advantage to devise harvest strategies that may permit rebuilding to historical biomass for a modest level of foregone yield. A further important conclusion of the Workshop was that the current F_{ref} proxy used by the SCRS for advising the Commission (F_{MAX}) approximated the F-level which, given the available information about spawning stock size and recruitment levels for western bluefin tuna, was expected to keep the stock at recent levels, on average, and was not likely to promote rebuilding to biomass levels considered to be consistent with the Convention Objective. The Workshop concluded that an F_{MAX} based fishery management strategy for western bluefin tuna was not consistent with the rebuilding intention of the Precautionary Approach. Alternative proxies, such as $F_{0.1}$ or $F_{95\%MSY}$, which result in only slightly lower yields, would provide higher odds of rebuilding western bluefin tuna and could be considered to be consistent with the Precautionary Approach. FAO (2001) which has addressed "*Research Implications of Adopting the Precautionary Approach to Management of Tuna Fisheries*" was recommended for further reading on this topic.

It was generally agreed that efforts to develop methods to integrate management advice across multiple hypotheses on stock-mixing should continue through the development and application of stock assessment models that explicitly model spatial structure and mixing and are fitted to tagging data and stock ID data (e.g., Porch *et al.* 2001; Anon. 2002; SCRS/2008/097). It was agreed that scientists from both the eastern and western stock assessments should collaborate in developing and exploring the use of these models for stock assessment, management strategy evaluation and the evaluation of the potential future data requirements for future stock assessment and management approaches that more explicitly account for stock mixing.

General discussion on the integration of management advice across multiple hypotheses

It has long been recognized that an important source of uncertainty in the assessments of eastern and western Atlantic bluefin tuna has been over how to model future recruitment and determine stock rebuilding reference points such as B_{MSY} (e.g., McAllister *et al.* 2001; SCRS/2008/101). The stock-recruit models considered for the stock of interest underpin these choices. For the eastern stock, SCRS/2008/101 demonstrates the marked influence of alternative "realistic" models for recruitment on projection results. In the western assessment, the recruitment estimates prior to the early 1980s were the highest and estimates since then have been on average relatively low. In assessments up to 2002, stock projections from two alternative stock-recruit models had been reported in management advice. One model fitted a Beverton-Holt function to the full time series of stock-recruit data (i.e., starting in 1970) and provided a relatively high B_{MSY} reference point. The alternative model presumed that a "regime-shift" had occurred circa the late 1970s which has since resulted in low recruitment and that future recruitment could be most accurately represented using a "hockey stick" or "two-line" stock-recruit model that was fitted to the stock-recruit data since 1976. This model has provided much lower B_{MSY} reference points and stock status estimates much closer to B_{MSY}, and suggested for the same TAC policies, more rapid stock-rebuilding than the "high recruitment" model.

It was emphasized that for the western stock (and also the eastern stock), there still remains high scientific uncertainty over the various alternative recruitment hypotheses and associated biological reference points. Yet for the western stock in recent years, i.e., since 2002, the high uncertainty concerning recruitment hypotheses has not been conveyed in the provision of management advice. Despite the equivocal nature of the data and interpretations of them, the regime-shift (or "low recruitment") hypothesis has since been emphasized in management advice. It is understood that the decision to emphasize the regime shift hypothesis was made by the Commissioners but that the failure to communicate the uncertainty concerning recruitment was the responsibility of the scientists. The group therefore recommended that management advice provided in this and future stock assessments for both east and western stock components should continue to explicitly account for and convey the management implications of the uncertainty over the alternative recruitment hypotheses. Thus, for the western stock, it was agreed that stock status and projection results computed from both the high recruitment and regime-shift (or "low") recruitment hypotheses should continue to be reported and conveyed in the provision of management advice. Similarly, for the eastern stock, projection results from different recruitment hypotheses should also continue to be conveyed in the management advice provided.

In order to quantify and communicate uncertainty concerning alternative recruitment hypotheses in the provision of management advice, it was suggested that scientists collectively assign to the alternative hypotheses probability weightings for them and communicate these probabilities in the provision of management advice. The probabilities should reflect a consensus of the overall scientific credibility of each alternative hypothesis given all available evidence and scientific judgment concerning the evidence. Should the alternative hypotheses remain equally credible, equal probabilities should be assigned to the alternative hypotheses. When evidence is judged to support some hypotheses more strongly than others, the probability weightings should reflect this. Guidance should also be provided on how to interpret the probability weightings (e.g., see Kass and Raftery 1995).

It was noted that the computation of probabilities for alternative models based on how well they fit the data has received considerable attention in the fisheries scientific and statistical literature, but that the computation of such probabilities has remained technically difficult to achieve (e.g., Kass and Raftery 1995; Butterworth *et al.* 1996; Patterson 1999; Parma 2001; McAllister and Kirchner 2002; Hill *et al.* 2007). Due to current software configurations in ICCAT's catalogued assessment software, such computations cannot easily be achieved using the stock assessment models currently applied for the eastern and western stock components. Some suggested that AICC values calculated for the alternative models could be transformed into probabilities and it was agreed that methodologies concerning this issue this warranted further exploration.

In some recent assessments, bootstrapping had been carried out with different recruitment models included in a single bootstrap run and the Monte Carlo results from the different recruitment models summarized into single statistics (e.g., probability of stock rebuilding to B_{MSY} and median values of By/SSB). It was agreed that this approach appropriately accounts for uncertainty in recruitment hypotheses and parameter values under each hypothesis for computing the probability of various management outcomes of interest. However, it was recommended that diagnostics should be checked prior to computing means and median results from such model averaging type analyses. If distributions for quantities of interest (e.g., projections of SSB) from the different models do not overlap or only scarcely overlap, medians or means from model averaging computations may have very low or no credibility and may lead to advice that is inconsistent with the alternative recruitment hypotheses. In such instances, it may be appropriate to compute and present median or mean results from the different recruitment hypotheses separately and present these together with probability weightings for each of the alternative hypotheses (e.g., McAllister and Kirchner 2002).

7.6 Other methods

SCRS/2008/089 presented three different strategies for modeling the terminal-year fishing mortality rates (F_{term}) in virtual population analyses of western bluefin tuna: retrospective patterns and consequences for projections. The method for modeling F_{term} in past western Atlantic bluefin tuna assessments was recently identified as a possible reason for the observed tendency of previous assessments to under-estimate the most recent SSB but over-predict projected future SSB (see for example SCRS/2008/013). The paper evaluated the F_{term} method that had been applied in previous assessments (e.g., for the 2002 assessment, $F_{2001,1}$ =0.318, $F_{2001,2}$ =0.318 $F_{2001,3}$, $F_{2001,4}$ = $F_{2001,5}$, $F_{2001,6}$ = $F_{2001,7}$ and $F_{2001,8}$ = $F_{2001,9}$) a method that estimated F_{term} for all ages up to age 9 with no constraints, and a method that estimated F_{term} for all ages up to age 9 "subject to a penalty that constrains the amount of annual change in relative vulnerability of each age class". In the third method (called below the "constraint" method), the vulnerabilities for ages 1-9 were linked over three years with a standard deviation (SD) of 0.5.

It was found that the "constraint" method provided in all evaluations similar or better performance than the status quo and no-constraints methods. In the 2006 retrospective analysis that was performed, the estimated ratios of F_{term} for adjacent age classes were found to be quite different than assumed. For example the assumed ratio of 0.318 for F_1/F_2 was found to be lower and past estimates of F_3/F_2 were found to be higher than the assumed value of 1. It was found that "the current status quo method creates erratic retrospective patterns and may have led to overly optimistic projections of SSB" and that this method and the no vulnerability constraint method "erratically overestimate age 1 recruitment in the most recent years, including years prior to the last 3". In contrast, "the method of constraining changes in vulnerabilities appears to mute erratic retrospective patterns in abundance at age and result in projections of SSB that are less prone to initial leaps."

The Group questioned why an SD of 0.5 was selected. It was replied that previous experience had found that setting the SD too small (below 0.1) can sometimes force the VPA to settle on solutions that provide a poor fit to the indices owing to the need to simultaneously match the catch at age exactly. Values of the SD on the order of 0.5 generally were sufficient to damp the erratic behavior in the estimates of F for recent years while having little impact on the ability of the model to fit to the indices. The group accepted a proposal to replace the status quo F_{term} method for the west and east VPA stock assessments with the constraint method that has the SD in vulnerability set at 0.5.

8. Stock status results

8.1 Stock status – East

ADAPT VPA runs were made as explained in Section 7.1. The report file for the VPA runs including the whole data series (Runs 13 and 14) is included as **Appendix 9**. This appendix includes complete description of the model results corresponding to these two runs, 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

Overall, the VPA fits to the available data for eastern Atlantic bluefin continue to be poor, as they were in previous assessments. The fits to different indices showed residual trends in all cases, especially for the trap and longline indices **(Figure 15)**.

Figures 17, 18, 19 and **20** summarize the abundance and fishing mortality estimates for Runs 6, 7, 13 and 14, respectively, resulting from a retrospective pattern analysis. Some bias in the estimates is indicated for F1-5 and F_{8+}, which was believed to be driven by the change in selectivity pattern towards larger fish that occurred in the latest years.

Summary VPA results

The results suggest that since 2000 there has been a rapid increase in fishing mortality especially for large (ages 8+) fish and a rapid decline in spawning stock biomass. Inclusion of the 1955-1969 data allowed estimating biomass and fishing mortality trajectories for this historical period that was not considered in earlier assessments. The 8+ fishing mortality pattern for this historical period showed a U-shape, the initial decline corresponding to the decline of the Norwegian purse seine fishery in the 1950s and 1960s, and the latter increase to the development of purse seine fisheries in the 1990s and 2000s. Under Runs 6 and 13 (based on reported catch), the spawning stock biomass over the last five years of the time series was only 38.33% and 37.79% of the one in the first five years of the time series (1970-1974 and 1955-1959, respectively). The scenarios that considered underreporting showed similar SSB reductions (40.44% and 39.50% for runs 7 and 14, respectively) although the SSB decline after the year 2000 was relatively steeper than scenarios with unadjusted catch.

The average (geometric mean) fishing mortality pattern for 2003-2006 estimated with the four model runs is shown in **Figure 21**. The scenarios with adjusted catch to 50,000 t since 1998 showed somewhat higher fishing mortality on average and slightly higher selectivity on ages 5 and older. The Group decided to consider both selectivity patterns for projections.

Year-class curve analyses

Using a year-class curve analysis on the Norwegian CPUE, document SCRS/2008/093 presented the first estimates of mortality rates of Atlantic bluefin tuna that migrated north from the mid-1950s to the late 1970s. The results indicated that bluefin tuna would have experienced a total mortality rate (Z) of 0.2 to 0.4 yr-1 (i.e. F at around 0.3 yr-1) during the late 1950s, 0.2 yr-1 during the 1960s and 0.1 yr-1afterwards (assuming M=0.1 yr-1). This F trend is consistent with VPA findings from the historical period (**Figures 19 and 20**), although absolute values are slightly higher. The fishing mortality rates experienced by bluefin tuna in the North Sea and Norwegian Sea during the period 1956-1979 were thus significant (so that local overfishing may have occurred, especially during the 1950s). However, these estimates are lower than F estimated by year-class curve analysis in more recent years (i.e. 1992-2004 based on trap data, Fromentin *et al.* 2007).

The Group updated additional year class curve analyses using the Japanese longline CPUE data. Results are shown in **Table 10 and Figure 22**. Because the year-class estimates of mortality in **Table 10** are calculated within cohorts, they are not directly comparable to mortality time series estimated with VPA. However, they do provide estimates of average total mortality that successive cohorts experienced. The F 9-14 trend in **Figure 21** shows a continuous increase from around 0.2 to around 0.4 for cohorts exploited in the 1984-2005 period. The trend for F 8-14 is similar but absolute values were slightly lower and the increasing trend disappeared approximately after the year 2000. These trends are consistent with the increasing F8+ trends observed in the VPA during that period of time, although the VPA estimates show higher rates of increase in F8+ for that period.

Conclusions about state of the stock

There are considerable data limitations for the assessment of the stock. These include poor temporal and spatial coverage for detailed size and catch-effort statistics for many fisheries, especially in the Mediterranean. Substantial under-reporting of total catches is also evident. Unless substantial improvements are made in the catch and effort statistics, there is little scientific need to perform a stock assessment every two years because many results are based on equilibrium assumptions and because BFT is a long lived species. This explains why our diagnosis and advice is very similar to that of 2006.

The 2008 assessment results indicate that the spawning stock biomass (SSB) continues to decline while fishing mortality is increasing rapidly, especially for large bluefin.

The decline in SSB is evident from the results of an age-structured model (VPA) that used both reported and adjusted (for underreporting) catch and CPUE information, which estimates that recent (2003-2007) SSB is less than 40% of the highest estimated levels (at the start of the time series 1970-1974 or 1955-1958, depending on the analysis). The decline in SSB appears to be more pronounced during the more recent years, especially under the scenarios with adjusted catches, although model estimates for recent years should be judged with caution due to imprecision.

The increase in mortality estimated with the age-structured model for large bluefin is consistent with a shift in targeting towards larger individuals destined for farming.

The Group conducted equilibrium projections so as to determine the stock status relative to MSY and other benchmarks. Projections were made under the assumption that future selectivity will be similar to the one in 2003-2006, scaled to a fishing mortality equal to the geometric mean of the 2005-2006 as estimated by the VPA and that future recruitment levels will be equal to the mean recruitment observed in the 1990-2003 period. Given the uncertainty of the VPA estimates from which assumptions for the projections are taken, estimates of stock status with respect to MSY benchmarks can be considered highly uncertain but it is nonetheless apparent that recent F is too high and recent SSB too low to be consistent with the Convention objectives.

Benchmarks were computed assuming the fishing mortalities estimated under scenarios 13 (reported catch) and 14 (adjusted catch). In both cases, current fishing mortality was estimated to be more than three times F_{MAX}, more than four times F30%SPR, and around 7 times $F_{0.1}$. Spawning stock biomass in equilibrium was estimated to be far below desired levels (**Table 11**, **Figure 23 and Figure 24**). Depending on different assumed levels of resource productivity current F is most likely at least 3 times that which would result in MSY and SSB is most likely less than 20% of the level needed to sustainably support MSY. Even in our most optimistic evaluation, assuming recruitment will not decrease if SSB continues to decline, substantial overfishing is occurring and spawning biomass is well below levels needed to sustain MSY (**Figure 25**).

8.2 Stock status – West

This Section summarizes the results from VPA analyses explained in Section 7.2. The report files output by the VPA-2BOX software for the base VPA model and one of the sensitivity runs (Case 9) are included as **Appendix 9**. These reports contain 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

Table 12 provides a summary of the AIC, AIC_C, BIC information criteria, log likelihoods, number of parameters and the number of data points for the various VPA model runs. The information, however, is not comparable unless the data inputs (and constraints) are identical. Therefore, only the base model and cases 6 and 8 can be compared.

Fits to the CPUE series for the base model are summarized in **Figure 26-28**. The fits to the indices were nearly identical for the continuity and base VPA runs **(Figure 26.)**. In fact, the model fits were virtually unchanged for all model runs except Case 7, and are therefore not shown in detail. The Case 7 fits are compared to the base model in **Figure 27**. The fits were not improved by estimating yearly variation in index selectivity (Powers and Restrepo, 1999) and allowing catchability to vary with a random walk (Case 7). Moreover, the annual selectivity estimates for all of the indices varied erratically with no apparent trend. Thus, there was deemed to be no advantage to using this approach and the model was not considered further. The fits to the indices that were used only in sensitivity runs (Cases 2-5) are shown in **Figure 28**.

Histograms of the bootstrap estimates of 2007 stock status from the VPA base and Case 9 (remove Canadian GSL index) model runs were constructed to examine the bias and normality of the distribution. In each case, there is no evidence of a strong bias in the results (**Figure 29**).

A retrospective analysis was conducted by sequentially removing inputs of catch and abundance indices in annual increments from the 2008 base case model, back to 2003. **Figure 30** shows the trends of spawning biomass and age 1 recruits for the base case. The estimated recruitment is not sensitive to the retrospective removal of data except for the most recent two years, which are uncertain and have generally been disregarded in past assessments. The overall magnitude of SSB decreases as more years of data are added suggesting that SSB tends to be over-estimated, however the recent downward trends also become less appreciable. These results are similar to what was apparent in earlier assessments (SCRS/1994/124). The retrospective results also indicate possible underestimation of fishing mortality for ages 9 and 10+ (**Figure 31**) and, conversely, overestimation of the abundance of ages 9 and 10 (**Figure 32)**. For other ages, the retrospective patterns are less evident (and much reduced relative to the 2006 assessment and 2008 continuity run).

Comparison of 2006 and 2008 VPA base model results

The base-case assessment is consistent with previous analyses in that spawning stock biomass (SSB) declined steadily between the early 1970s and 1992. Since then, SSB has fluctuated between 18% and 27% of the 1975 level (**Figure 33**). The stock has experienced different levels of fishing mortality (F) over time, depending on the size of fish targeted by various fleets (**Figure 34**). Fishing mortality on spawners (ages 8 and older) declined markedly between 2002 and 2007. Estimates of recruitment were very high for the early 1970s, but varied without trend since 1977.

The results from the 2008 base VPA model are compared to the 2006 base model (Anon. 2007) and corresponding 2008 continuity run in **Figure 34**. The trends in average fishing mortality by age group, spawning stock biomass (SSB), recruitment (Age 1) and the annual F-ratio (F10+/F9) are very similar.

Sensitivity Runs

Comparisons between the 2008 base and sensitivity runs are summarized in **Figure 35**. The SSB trends are very similar between all model runs, particularly when the series are expressed relative to the maximum value (i.e., scaled to a maximum of 1.0). The recruitment estimates are also nearly identical for all model runs. F-ratio outputs, from fixed assumptions or estimation procedures, are also summarized in **Figure 35.** Between 1974 and 1982, the estimated F-ratio varies substantially between models (1.0 to 2.5). Between 1983 and 2007, the model estimates are more similar (0.9 to 1.5).

The influence of the various indices of abundance on the base case model results was examined by removing one index at a time, running the VPA with the same model specifications, and computing the following quantities: SSB in 1970 and 2007, $F_{current}$ (the apical value of the vector of geometric mean F values for 2004-2006), and F_{max} (the multiplier of the geometric mean selectivity that maximizes yield-per-recruit). The results are given in **Table 13**. In terms of spawning biomass depletion (SSB_{2007}/SSB_{1970}), removing either the Canadian Gulf of St. Lawrence index or the early Japanese longline index in the Gulf of Mexico results in more pessimistic results (depletions of 0.10, compared to 0.18 in the base case). In terms of current F compared to F_{MAX}, removing the Canadian Gulf of St. Lawrence index also results in more pessimistic (higher relative F) results. On the other side of the spectrum, removing the fishery-independent larval index results in lower estimates of depletion (0.35) and relative F (0.83).

Of the quantities examined, the value of initial SSB is very sensitive to the exclusion of various indices. The range between the highest and lowest SSB_{1970} estimates is more than two-fold. On the other hand, the estimate of current SSB is less sensitive to the choice of index (**Table 13**).

Stocks status

A key factor in determining stock status is the estimation of the MSY-related benchmarks against which the current condition of the stock will be measured. These benchmarks depend to a large extent on the relationship between spawning biomass and recruitment. This year, the Group reexamined the two alternative spawner-recruit hypotheses explored in several prior assessments: two-line (hockey stick) and Beverton and Holt formulation. The two-line model assumes recruitment increase linearly with SSB from zero with no spawners to a maximum value (R_{MAX}) when SSB reaches a certain threshold. Here the SSB threshold (hinge) was set at the average SSB during 1989-1994 (a period of generally low estimated SSB), and R_{MAX} was calculated as the geometric mean recruitment during 1976-2004. The Beverton and Holt function was fit to the SSB and recruitment estimates corresponding to the period 1970-2004. The two curves are shown in **Figure 36**.

Stock status was determined under the two-line and Beverton-Holt scenarios for the base model from 1970 to current **(Figure 38)**. The results under the two-line (low recruitment) scenario suggest that the stock has been below convention objectives since the mid 1970s and that fishing mortality rates have been above convention objectives throughout the time series (note however the ‘current’ fishing mortality rate represented by the square in the graph is actually the 2004-2006 geometric mean and does not include 2007 when the 2100 t quota went into effect). The results under the Beverton-Holt (high recruitment) scenario are even more pessimistic, suggesting the convention objectives for SSB and fishing mortality rate have not been meant since 1970.

The estimated status of the stock in 2007 is summarized for the two recruitment levels in **Figures 37 and Figure 38. Figure 38** shows the results for the base case and case 9 (the VPA model that removes the Canadian GSL index where catch rates have increased rapidly in recent years and it was hypothesized that such an increase could be due to primarily changes in availability/catchability). With the two-line model, recent F is 30% to 50% higher than the MSY level and SSB is about half of the MSY level. Estimates of stock status are more pessimistic with the Beverton and Holt model ($F/F_{MSY} > 2$, $B/B_{MSY} < 0.2$). The estimated median trajectories of stock status since 1970 are shown in **Figure 37** for the two-line and Beverton and Holt models.

One important factor in the recent decline of fishing mortality on large bluefin (**Figure 34**) is that the TAC has not been taken during this time period, due primarily to a shortfall by the U.S. fisheries that target large bluefin. Two plausible explanations for the shortfall were put forward previously by the SCRS: (1) that availability of fish to the United States fishery has been abnormally low, and/or (2) the overall size of the population in the

Western Atlantic declined substantially from the level of recent years. While there is no overwhelming evidence to favor either explanation over the other, the base case assessment implicitly favors the notion of regional changes in availability (in the sense that the indices used to tune the model, and therefore the model estimates, do not indicate a recent decline). Nevertheless, there remains substantial uncertainty on this issue and more research needs to be done.

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 mixing between fish of eastern and western origin. Limited analyses were conducted of the two stocks with mixing (see below). Depending on the types of data used (conventional tagging or samples of stock origin in the catches) and modeling assumptions made, the estimates of stock status varied considerably. These analyses are preliminary and more research needs to be done before mixing models can be used operationally for management advice. 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 (the "low" vs "high" recruitment hypotheses which affect management benchmarks). Finally, the growth curve assumed in the analyses may be revised based on new information that is being collected. If the curve changes substantially, it may impact the assessment results as well as management benchmarks.

8.3 Stock status – variants considering mixing

Five variations of the overlap VPA were run using the western base case and eastern adjusted-catch case. Two runs estimated mixing using the proportion data (otolith microconstituents); one specifying the fixed F-ratios for the eastern case (see Section 7.1) and one estimating them. Three runs estimated mixing using the conventional tagging data; two specifying the fixed F-ratios indicated (the full model and a reduced model that estimates fewer reporting rates and other tagging-related parameters) and one that estimates the eastern F-ratios (using the reduced tagging model). The resulting estimates of mixing are summarized in **Table 14** and the estimates of recruitment, spawning biomass, and recent fishing mortality rates are summarized in **Figures 39-41**.

The estimates of the fraction of the eastern-origin population that sojourns in the west (eastern overlap) depended strongly on the type of data used. Fitting to the tagging data suggested the overlap was very low for ages 1-3 and on the order of two or three percent for older ages, whilst fitting to the proportion data suggested overlap rates of 2-3 percent for ages 1-3, 5.5 percent for ages 4-7, and 0.01-.04 percent for ages 8-10. The estimated overlap of western-origin fish into the eastern management zone was even more sensitive. Fitting to the tagging data produced estimates on the order of 10 percent for ages 1-3, 50 percent for ages 4-7 and 30 percent for ages 8-10. Fitting to the proportion data on the other hand produced estimates of very low overlap for every age class (except ages 8-10 when the eastern F-ratio parameters were estimated).

The abundance trends and absolute estimates for both the east and the west are sensitive to the use of the tagging and proportion data. When the proportion data were used and the F-ratios were fixed for the east, the estimates of spawning biomass for the east were similar to the no-mixing result. On the other hand, the estimates of spawning biomass were much higher when the F-ratios were estimated. The estimates of eastern SSB with the tagging data were similar to the no-mixing case except more optimistic in recent years (whether or not the F-ratio was estimated). The western estimates of SSB and recruitment fell into two groups; the estimates with the proportion data were very similar to the base case whereas the estimates with the tagging data were much higher in magnitude (although similar in trend).

In summary, the proportion (otolith microconstituent) and conventional tagging data lead to very different perceptions of the degree of overlap of each population. However, it should be kept in mind that both data sets are incomplete in the sense that they do not represent random samples of the overall population. Accordingly, the Group believes that the analyses of mixing have not yet reached the stage where they are reliable enough to be used as the basis for the advice called for in the Commission's rebuilding plans for the eastern and western Atlantic bluefin tuna. However, progress is being made in terms the information that is available about mixing and models that are flexible enough to utilize diverse types of data (conventional tagging, electronic tagging, otolith micro-chemistry and genetics). The modeling results considered by the Group this year confirm its previous conclusion that the state of the population in the western Atlantic is sensitive to mixing, and that the fishery in the eastern Atlantic potentially has an important impact on the western Atlantic. While the results are only preliminary, this year's modeling also gives the impression that the population in the eastern Atlantic may be more sensitive to mixing than previously thought. This new impression about mixing and the eastern Atlantic requires further investigation.

9. Evaluation of fishing capacity relative to the ICCAT Convention objectives

The current stock assessment indicates that there is overcapacity for both eastern and western bluefin tuna, because current levels of fishing mortality exceed F_{MSY}. The sections below analyze the available information on the sizes of the fleets targeting these two stocks.

9.1 East bluefin tuna stock

9.1.1 Fishing capacity

The Commission's Working Group on Capacity met in July 2007 and decided to focus on eastern Atlantic and Mediterranean bluefin (BFT-E) as the primary stock of concern, and asked for more refined quantitative estimates of capacity for the stock. Information presented below represents an updated view of fishing capacity for BFT-E held by the participants of the 2008 stock assessment session.

The fishing capacity table of the various fleets involved in the eastern bluefin fishery was updated during the meeting. The information used came from the ICCAT list of bluefin vessels and the scientists present at the meeting, on the basis of their knowledge of the fisheries, who provided additional information about bluefin tuna fleets of their own countries. The resulting estimates of vessel numbers were discussed by the group and adjusted when needed. They were finally grouped by main gears, by size categories and by main areas for the purse seiners (PS), longline (LL) and other fishing gears targeting bluefin tuna in the Mediterranean.

The comparison between the present table and that prepared during the 2006 assessment shows an important increase in the number of PS vessels targeting bluefin tuna in the Mediterranean between 2005 and 2007 due to newly developed fisheries or reflagged vessels. The present estimation of large and medium size purse seiners in the Mediterranean Sea alone is double that estimated for 2004-2005 (**Table 15**). In 2004 and 2005, the purse seine fleet was estimated as comprised of 41 large and 103 medium vessels, while for the 2007 fishing season the estimates grew to 83 large and 205 medium purse seiners. However the estimated number of small/multispecies purse seiners involved in the BFT fishery in the Mediterranean Sea has considerably decreased. In the case of the longliners in the Mediterranean Sea, a decrease in the estimated number of vessels is observed for all the size categories, with the estimated current fleet of 43 large LL vessels (compared to 56 in 2004-2005).

The Group further evaluated active capacity in the East Atlantic (which has not been done in 2006) which was dominated in 2007 (in number of units) by longliners, trawlers and baitboats (**Table 16**.). The joined active capacity in the Mediterranean Sea and East Atlantic is depicted in **Figure 42** (upper panel).

Estimates of catch-per-unit fishing category (CPU) were revised according to the new size categories used and then raised to get an estimate of the total catch in the Mediterranean and in the East Atlantic by the overall fleet (**Tables 15 and 16**). The mean CPU by gear type and vessel size over all areas during the recent period was used to construct this estimate. As CPU may vary between fleets, the Group decided to also calculate lower values to give a range by presuming that older PS vessels have a probable annual catch half of new PS vessels of the same size. Those assumptions lead to an estimated 2007 catch of about 47,800 t. for the Mediterranean alone and about 61,100 t for both the Mediterranean and East Atlantic and bluefin tuna stock. These values are much larger than the reported Task I, but fit much better with the collective expert opinion of the various national scientists attending the meeting (see also **Figure 42**, lower panel).

If the same premises are applied to the *total potential* fleet operating in the stock area (*i.e.* vessels that are not currently targeting BFT but that could shift from other large pelagics species to BFT), the estimated *potential catch* in the Mediterranean would be about 56,000 t in the Mediterranean and about 17,000 t in the East Atlantic, resulting in an estimated *total potential* catch for the entire East stock of about 73,000 t (**Table 17 and 18**).

The values obtained are considered as the best estimates available among the scientists at the meeting. If further and new information, such as VMS data, would be provided to the SCRS, more precise estimates might be obtained in the future.

In view of the assessment of stock status, this level of *active* capacity, leading to estimates of 2007 catch level on the order of 60,000 t, is at least 3 times the level needed to fish at a level consistent with the Convention objective. Estimates of *potential* capacity lead to even higher estimates of potential catch and would require much larger reductions in fleet size to achieve the Convention objective, if capacity control were the primary management measure of choice.

9.1.2. Farming capacity

As regards farming capacity for bluefin tuna in the Mediterranean, according to the ICCAT record of farming facilities (July 2008), it has grown to about 64,000 t, which would represent approximately 51,000-57,000 t round weight of (large) fish at time of capture (**Figure 43)**. This estimated farming capacity is as much as twice the 2008 TAC agreed by the Commission [Rec. 06-05] and represents a capacity excess of more than 32,000 t above the predicted short-term catch level consistent with the effort level implied by the Convention objective. As indicated above, the estimates of fleet size indicate there is sufficient active fishing capacity to fully supply the farms to their indicated limits.

In summary, information available reinforces our belief that catches of bluefin tuna from the eastern Atlantic and Mediterranean have been seriously under-reported in recent years. An estimate made by the Working Group in 2006 based on the number of vessels operating in the Mediterranean Sea and their respective catch rates, indicates that the volume of catch taken in recent years likely significantly exceeded TAC levels and probably was close to 43,000 t in the Mediterranean during the early 2000s. Our careful evaluation in 2008 using the information from the ICCAT list of bluefin vessels and the knowledge of the national scientists present at the meeting, led to a 2007 probable catch of 47,800 t for the Mediterranean and about 61,100 t for the eastern Atlantic and Mediterranean bluefin stock. Our belief in significant underreporting is further supported by examination of the information reported through various market data sources (see Section 5.3) and which all leads us to conclude that the exports to the Japanese and US markets largely exceed the reported catches. This apparent lack of compliance with the TAC and underreporting of the catch will undermine conservation of the stock.

9.2 West

The status of the WBFT stock indicated that overcapacity of the western fleet might be one of the contributing factors to the overfished condition of this stock. Reductions in the capacity of this fleet might be required to comply with the ICCAT Convention objectives of reducing fishing mortality rate F below F_{MSY} and increase stock biomass B to levels above B_{MSY}. To support the efforts of the SCRS Methods Working Group aimed at estimating fishing capacity for all tuna fleets in the Convention Area, the Group reviewed the available information needed to estimate capacity, catch rates per vessel type, and total catch in the WBFT fishery. Two documents were presented to the group with information on fleet size/characteristics.

Document SCRS/2008/087 provided a characterization of the U.S. tuna fleets. The number of fishing permits issued for catching Atlantic tunas was used as an estimate of fleet size. The U.S. Atlantic tuna fishery does not have a specific permit for BFT. In the case of the recreational fishery, there are two categories of permits: Angling and Charter/Headboat. The permit for the recreational sector is a Highly Migratory Species permit that allows the landing of all Atlantic tunas (including BFT), sharks, swordfish and billfish. The commercial sector has five permit categories: General (all hand gear), Harpoon, Trap, Longline, and Purse Seine. All permits (recreational and commercial) are 'open access' except for the Longline and Purse Seine categories which are of 'limited access'. The total number of permits that were valid during 2007 was 46,068 of which 40,088 were recreational permits. Of the 5,980 commercial permits the majority corresponded to the General category (5,652 permits), followed by longline (275 permits), Harpoon (37 permits), Trap (11 permits) and Purse Seine (5 permits). Information on length (LOA) of commercial and recreational vessels showed that the majority of the U.S. vessels are relatively small in size with the highest proportion of them in the '<20 m' category. Because during 2007 the U.S. tuna fisheries were managed on a fishing year cycle (June-May) instead of a calendar year cycle (January-December), the expiration of permits and the issue of new permits followed the fishing year cycle. Therefore, not all the 46,068 permits described above were valid at the same time during 2007. Due to reporting requirements and data confidentiality issues it was not possible to estimate the proportion of permits that were active for most of the fleets. It was possible, however, to do it for the longline fleet (44% active). The proportion of vessels with tuna permits that landed BFT was very low. The document described the problems to estimate BFT fleet capacity for the U.S. due to several factors such as, for example, the difficulty to identify vessels that target BFT, the incidental catches by the longline fleet in the Gulf of Mexico, the unknown proportion of active vessels compared to the number of valid permits.

Document SCRS/2008/083 provided some information on the Canadian fleet size. The document indicated that the number of license holders eligible to land bluefin tuna was 776 from 1999-2003, and increased to 777 in 2004 and has remained constant since then. The number of vessels active in the fishery has varied from year to year. In the Gulf of St. Lawrence, the dominant gear type was rod and reel, and the tended line component has become less significant. The highest number of active vessels in this area was observed in 2004 with over 350 vessels. The number of active vessels in 2007 was about 250. In the southwest Nova Scotia fishery, rod and reel is also dominant followed by the tended line fishery. The highest number of vessels in this fishery was observed in the late 1990s. The number of active vessels in 2007 was on the order of 150 vessels.

The Group was unable to estimate catch rates per vessel similar to those prepared for the eastern Atlantic and Mediterranean BFT fisheries (see Section 9.1). The main reasons that precluded the Group from performing this task were that, unlike in the EBFT fishery, ICCAT does not have a complete list of BFT vessels operating in the western fishery or information on the BFT catch of individual vessels. Therefore, information as basic as the number of vessels directly participating in the WBFT fishery was not available. It was clear to the Group that without more detailed information the process of estimating catch rates per vessel type and total catch would produce meaningless results.

10. Projections

10.1 Projections – East

Document SCRS/2008/101 relates to projections for the East stock was presented at the 2008 working group. The aim of this study is to investigate the implications of different stock-recruitment assumptions when examining the potential of the *Recommendation by ICCAT to Establish a Multi-Annual Recovery Plan for Bluefin Tuna in the Eastern Atlantic and Mediterranean* [Rec. 06-05]. To do so, some Beverton and Holt relationships displaying contrasting steepness of 0.99, 0.90, 0.75 and 0.50 were applied within a simulation model. In addition to these four stock-recruitment scenarios, parental effects and stochastic variations were also considered. The main conclusion is that our ability to evaluate the consequences of [Rec. 06-05] (as any set of management measures) relies on our capacity to predict future recruitment levels in an accurate way. Assuming a Beverton and Holt relationship with different steepness, with or without parental effects and with or without stochastic variations led to contrasting outputs, i.e. from a significant rebuilding of the simulated population within 15 years to the crash of this same simulated population. This outcome is somewhat problematic, as we are unable to properly estimate the stock-recruitment relationship for the East Atlantic and Mediterranean bluefin tuna stock. Consequently, it is crucial to clearly state recruitment assumptions when an advice is given and to consider a significant range of contrasting and plausible stock-recruitment relationships.

Besides this, a Management Strategy Evaluation (MSE) for Atlantic bluefin tuna using the FLR open source software framework (Fisheries Library for R, http://www.flr-project.org, Kell *et al.* 2007) was presented to the Group. The three main elements of a MSE are the:

i) Operating Model (OM), that represents alternative plausible hypotheses about stock and fishery dynamics, allowing integration of a higher level of complexity and knowledge than is generally used within stock assessment models;

ii) the Management Procedure (MP) or management strategy which is the combination of the available pseudo-data, the stock assessment used to derive estimates of stock status and the management model or Harvest Control Rule (HCR) that generates the management outcomes, such as a target fishing mortality rate or Total Allowable Catch; and

iii) Observation Error Model (OEM) that describes how simulated fisheries data, or pseudo-data, are sampled from the Operating Model.

This MSE has been applied to BFT in a preliminary exercise to illustrative the types of evaluations that can be conducting. Several important points are clearly evident these are:

- A TAC management strategy based upon reducing fishing mortality to $F_{0.1}$, a proxy for F_{MSY}, alone will not recover the stocks to the B_{MSY} level within a generation time
- Additional measures such as a reducing fishing on immature fish will help in the recover stocks but again the stocks will not recover to the B_{MSY} level with a high probability within a generation time
- Recovery will be enhanced if recruitment is not affected by low SSBs; however, at current low SSB levels estimated recruitment has been low.
- Even with recent misreporting of 50% the conclusions are not changed.

The results are consistent with the SCRS conclusions that the only scenarios which have potential to address the declines and initiate recovery are those which (in combination) close the Mediterranean to fishing during spawning season and decrease mortality on small fish through fully enforced increases in minimum size.

Based on these two documents and following discussions, the Group agreed on conducting non-equilibrium projections using the FLR open source software framework while considering different recruitment scenario and catch levels to reflect various sources of uncertainties (see **Table 19**). Four management strategies were evaluated corresponding to (i) perfect implementation [Rec. 06-05]; (ii) as i but with a 20% implementation error; (iii) as i) but with a fishing mortality equal to $F_{0.1}$ from 2009 onwards; (iv) as i) but with a fishing mortality equal to F_{max} from 2009 onwards (**Table 20**). These were evaluated by running stock projections for alternative plausible hypotheses about historical stock status and stock dynamics. The simulations conducted by the group did not use an operating model and management procedure with feedback. Instead the population was projected ignoring the stock assessment, monitoring and implementation feedback processes.

The framework for these projections were agreed by the Group, but due to the time required for their implementation, it was decided to complete the work needed in time for Species Group discussions in September 2008, and to append a complete description of the methods and results to the detailed report of the assessment after further review in September. Projections conducted in September are included as **Appendix 12**.

In view of the information available at the meeting, the Committee's previous evaluation of the current regulatory scheme thus remains unaltered. Unless the Plan is adjusted to impose greater control over the fisheries by improving compliance and to further reduce fishing mortality rates (especially on larger fish), it will most likely lead to further reduction in spawning stock biomass with an increasing risk of fisheries and stock collapse. As the selectivity pattern and the fishing mortality rates are similar as those of the 2006 stock assessment, the Committee further stresses that the main conclusions from the "Report of the 2006 Atlantic BluefinTuna Stock Assessment Session" (Anon. 2007) still hold, i.e. only the management scenarios which have potential to address the declines and initiate recovery are those which (in combination) close the Mediterranean to fishing during spawning season and decrease mortality on small fish through minimum size of 20 or 30 kg.

10.2 Projections – West

Specifications

The projections for the western stock (Base Case and Case 9) were based on the bootstrap replicates of the fishing mortality-at-age and numbers-at-age matrices produced by the VPA-2BOX software. The current rebuilding plan has been designed implicitly on a low recruitment scenario that assumes the future recruitment will never exceed the values observed since 1976 (when spawning biomass is estimated to have been depleted). The short-term projections conducted in 2006 made a similar assumption on the basis that it would take several years for spawning biomass to increase sufficiently to have an appreciable impact on recruitment. However, in several past assessments an alternative recruitment scenario was examined for longer-term projections that allowed the level of recruitment to increase as a Beverton and Holt function of spawning biomass. The Group agreed that it had no strong evidence to favor one scenario over the other and noted that they provide reasonable (but not extreme) lower and upper bounds on rebuilding potential.

The Group agreed that projections and benchmarks should be computed for the Beverton and Holt (high) and two-line scenarios (low) to account for the uncertainty regarding the true form of the stock-recruitment relationship, consistent with the approach used during the 2002 assessment (see **Figure 36**). The 2-line stock-recruitment relationship involves a linear increase in recruitment from the origin to a "pivot" level of spawning stock size above which recruitment is independent of spawning stock size. The "pivot" spawning stock size is defined as the mean spawning stock size over 1989-94 (the period that includes the lowest estimates of spawning biomass). The constant level of recruitment is defined as the geometric mean recruitment over the years 1976-2004, a period over which recruitment was relatively constant. The Group agreed to set the extent of recruitment variability, σ_R, for each bootstrap replicate equal to the maximum likelihood estimate (~0.39).

The Beverton-Holt stock-recruitment relationship was fitted to the estimates of spawning stock size and recruitment for the 1970-2003 year-classes[2] by means of maximum likelihood (lognormal error). The Group agreed to set the extent of recruitment variability, σ_R, for each bootstrap replicate equal to the maximum

[2] Common convention has been to define "recruitment" as the number of age 1 fish and "year-class strength" as the number of age 0 fish. The "recruitment" for year *y* is therefore the same cohort as the year-class for year *y*-1.

likelihood estimate (~0.39). The fits of the stock-recruitment relationships for the Base and Case 9 assessments show evidence of significant auto-correlation in recent years (see **Appendix 10**). Therefore, future recruitment was allowed to deviate from its expectation as a first-order multiplicative (lognormal) autocorrelated process Generally the lognormal structure is preferred because it does not admit negative recruitments and because it allows the variance in recruitment to increase with its expectation. The autocorrelation parameter (ρ) was estimated to be equal to 0.52 for the VPA base case and 0.35 for the Case 9 (Remove CAN GSL Index).

The recruitment values from the VPA for 2005-2007 were replaced with values generated from the estimated stock-recruitment relationship underlying the projection (for both low and high recruitment scenarios). Numbers- and fishing mortality-at-age for ages 1-3 at the start of 2005 were therefore re-calculated by projecting these generated recruitments forward under the known catches-at-age. Partial recruitment (which combines the effects of gear selectivity and availability of fish by age) was calculated from the normalized (re-scaled) geometric mean values of fishing mortality-at-age for the years 2004-2006.

The projected catch for 2008 was assumed to be equal to the 2008 TAC of 2,100 t. For years beyond 2008, projections were continued using various levels of constant catch with the restriction that the fully-selected *F* was constrained not to exceed 2 yr^{-1}.

Medium-term (12-year) projections were conducted to cover the time of the rebuilding plan. Projected spawning stock size was expressed relative to the spawning stock size associated with *MSY* (i.e., B_{MSY}) for the appropriate recruitment scenario and the 1975 SSB. B_{MSY} was used as a reference level for rebuilding because it is the target of the current Rebuilding Program. The 1975 SSB was used as a reference level for this because it has been assumed as the rebuilding target in several previous assessments, where it had been suggested as a proxy for B_{MSY}.

Results

Projections of SSB from the base VPA and case 9 were made through 2019 under constant catches of 0, 500, 1,000, 1,500, 2,100, 2,300, 2,500, 2,700 or 3,000 t (**Figure 44**). The associated benchmarks for the base case and case 9 are given in **Tables 21** and **22,** respectively.

The Group noted that the recruitment expected when spawning biomass reached B_{MSY} was much lower with the two-line scenario (70,000) than with the Beverton-Holt scenario (160,000), with a correspondingly lower estimates of MSY and B_{MSY}. On the other hand, that the two-line (low) recruitment scenario actually predicts slightly higher levels of recruitment than the Beverton-Holt (high) scenario early in the projections when spawning stock sizes are low (between 5,000 and 8,500 t). For this reason, the early projections with the two-line model tend to increase slightly more rapidly than those with the high recruitment scenario (**Figure 45**). Nevertheless, the projections with the low recruitment scenario are more optimistic primarily because the rebuilding target (B_{MSY}) is presumed to be so much lower than with the high recruitment scenario.

The results with the low recruitment scenario (**Figure 44**) are similar to those from the 2006 assessment (Anon. 2007). A total catch of 2,100 t is predicted to have at least a 50% chance of achieving the convention objectives of preventing overfishing and rebuilding the stock to MSY levels by 2019, the target rebuilding time. The outlook under the high recruitment scenario (**Figure 44**) is more pessimistic since the rebuilding target would be higher; a total catch of less than 1.500 t is predicted to stop overfishing within the next few years by 2011-2012, but the stock would not be expected to rebuild by 2019 even with no fishing.

Table 23 summarizes the chance that various constant catch policies will allow rebuilding under the high and low recruitment scenarios for the base-case model as well as for an alternative model that does not use the optimistic Gulf of St. Lawrence index. **Table 24** similarly summarizes the chance that various constant catch policies will end overfishing. The base model with the low recruitment scenario suggests that catch levels of 2400 t will have about a 50% chance of rebuilding the stock by 2019 and catches of 2,000 t or lower will have greater than a 75% chance of rebuilding. The levels of catch that lead to rebuilding with the alternative model (remove GSL index) are lower; 1800 t will have about a 50% chance and 1,500 t will have a 75% chance. If the high recruitment scenario is correct, then the western stock will not rebuild by 2019 even with no catch, although catches of 1,500 t or less are expected to end overfishing and initiate rebuilding.

Subsequent to the June assessment meeting, the Group agreed that it would be useful to present the projection results in the form of surface plots that would allows inferences about the future status of the stock to be made for any TAC or probability levels. It was also agreed that it would be useful to present the results for the high and low recruitment scenarios combined to better reflect the Groups contention that there is no strong evidence to support one recruitment hypothesis over the other. These plots are included in **Appendix 11**.

The Group noted that considerable uncertainties remain for the outlook of the western stock, particularly with regards to mixing and the effectiveness of management measures on the eastern stock.

11. Recommendations

11.1 Research and statistics – East

It is imperative that CPCs provide accurate Task I and Task II data to the SCRS if they want to have improved and more precise stock status diagnoses and advice. Continuing failure to meet obligations results in very high uncertainty in the scientific advice and may lead to a catastrophic failure of the management systems envisaged to rebuild the stock to the Convention objectives, depending on how the Commission chooses to react to this high uncertainty.

11.1.1 Recommendations fisheries independent indices and information on purse seine fleets

The 80% to 85% of yields are currently made by the purse seine fishery in the Mediterranean Sea. However, little information is available on these fisheries and the Task I data of these fisheries are likely to be strongly underreported since a decade ago. To conduct more precise and reliable assessment, it is necessary to obtain information about the catch composition, effort (e.g. days-at-sea, days of active fishing, etc.), the spatial distribution (e.g. VMS) and the technological equipments of the PS fisheries operating in the Mediterranean Sea, so that an accurate CPUE index might be computed.

In addition to this information, the group also stresses the strong need for fisheries-independent indices (especially in the Mediterranean Sea), as this is currently available for many stocks assessed by ICES or GFCM. European and Mediterranean scientists have recently conducted over several years and with success aerial surveys or larval surveys. These surveys have been stopped and the group recommends that such monitoring be more strongly supported and restated.

Large-scale, well planned conventional tagging experiments cross-Atlantic and Mediterranean are needed to significantly improve the status of BFT resource.

11.1.2 Recommendation for data mining

Data mining made by individual scientists has allowed the SCRS and ICCAT Secretariat to reconstruct total catch and size composition of bluefin in the northeast Atlantic and Mediterranean Sea back to 1955. There is, however, still highly valuable historical information on past BFT fisheries that are not used by the SCRS because they are not directly accessible nor validated. The BFT Working Group thus recommends that data mining continues, so that future stock assessment could include past major BFT fisheries and thus be performed on a wider period, such as 1920 to the 2000s.

11.1.3 Observation recommendations for tuna farming and holding operations

Holding tuna in fattening farms introduces additional uncertainties to estimates of total catch, catch-at-age and catch by area. These quantities are essential to properly conduct stock assessments. The conversion of total catch into catch-at-age requires that there be size or size-at-age samples at time of capture. For farmed fish, fish-size data are currently only available at time of sale. In addition, because fish grow in farms, apparent fish age based on size conversions are biased higher. Therefore, reliable fish-growth measures in farms are still needed. These can be achieved by conducting regular size-sampling in each farm; tracking size and weight changes from entry to departure; and by conducting mark-recapture studies on fish inside the farms to better estimate growth. In order to properly determine total numbers, observers need to record number of fish transferred and collect data on deaths occurring in pens and during the transfer process. Observers also need to collect otolith and genetic samples from harvested fish. Finally original set locations of each purse seine used to transfer fish should be recorded to determine original catch areas. To resolve these issues, the Group recommends that additional data be collected by observers now having farm access.

11.2 Research and statistics – West

- Otolith microconstituent data can be very useful to determine stock origin with relatively high accuracy, and thus could be a key factor to improve our ability to conduct mixing analyses. The available samples have been collected primarily in recent years and from fisheries off North America. It is essential that representative samples be collected from all major fisheries, in all areas[3]. Added value would be obtained if genetic samples were also collected from the same fish, which could potentially result in more accurate and less expensive tests for stock origin. In terms of the mixing analyses, it is also important to identify existing collections of otoliths collected in historical time periods (1970s, 1980s) in order to understand how the stock origin proportions in the catch may have changed.

- Recent studies based on direct age readings of otoliths suggest that the growth curve assumed for western bluefin may be biased particularly for old (greater than 12-13) fish. The group recommends that more direct age reading samples be collected, from both old fish and young (ages 1-4) fish and that the resulting growth curve be considered by SCRS. In addition, Archived otoliths from the 1970s should be examined in order to determine if growth patterns may have changed. Contingent on the results of this investigation, a regular program of fishery sampling should be considered by national scientists, to allow the SCRS to better characterize the age structure of the catch.

- It is recommended that the historical catch and effort for the West Atlantic data from the Japanese longline fleet be analyzed by main areas and groups of years that show a consistent effort distribution, rather than considering only catches of bluefin reports. The main areas of interest are the Gulf of Mexico, the waters off Brazil and the Florida-Bahamas areas from 1960 through the 1980s.

- It took an inordinate amount of time during this assessment meeting to prepare the basic inputs to the assessment, such as catch-at-age. The use of time during the assessment needs to be more efficient and this can only be achieved through better preparation before the meeting. 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 revisited in the SCRS Plenaries and we should consider the use of modern web conferencing techniques.

- Research should continue to assess the significance of differences in life history parameters (maturity, fecundity, growth) between eastern and western bluefin tuna.

- The Group recommended that alternate assessment approaches, such as CATCHEM (Porch *et al.*, 2001), MULTIFAN-CL or MAST that allow for errors in the catch at age, be further developed for more extensive use at meetings in the near future. This has broad implications (not just for assessment results) in the way data are reported by national scientists and retained by ICCAT and this should be addressed (e.g., the actual size frequency observations used to estimate the catch at size for the various fleets). It is recommended that this work be advanced during 2009 in an inter-sessional meeting.

11.3 Management – East, including advice on the odds of achieving the current Rebuilding Plan objectives without further adjustment

The available information indicates that the current fishing mortality rate (under the current overall fishing pattern) may be more than three times the level which would permit the stock to stabilize at the MSY level. Previously SCRS advised that although [Rec. 06-05] is seen as a step in the right direction, it is unlikely to fully fulfill the objective of the plan to rebuild to the MSY level in 15 years with 50% probability. Although projections of the current assessment have not yet been fully implemented, the outcome of the status evaluation is very similar to that previously conducted which indicated the need for additional management measures if the

[3] The Group identified the following, *inter alia*: Japanese longline fisheries in the Atlantic and Mediterranean; Moroccan and Spanish trap fisheries in the Atlantic; Tunisian trap fisheries in the Mediterranean; Spanish baitboat fisheries in the Cantabrian; purse seine fisheries throughout the Mediterranean. It was recommended that industry and trade association groups be contacted by National Scientists for supporting these efforts. Past meetings of the SCRS have also identified the importance of obtaining samples in the ventral North Atlantic.

Recovery Plan objectives are to be met. In order to reverse SSB decline and to initiate rebuilding with a degree of confidence, additional reductions in fishing mortality and catch need to be implemented.

SCRS has evaluated a number of alternative management scenarios which might be used to achieve the recovery of this stock with a higher probability. All these scenarios involve a time-area closure including partial or full closure during the spawning season as well as much lower catches (TAC including all sources of fishing mortality) during the next few years (~15,000 t). The long-term gain resulting from these actions could lead to catches of 50,000 t or more with substantial increases in spawning biomass. For a long lived species such as bluefin tuna, it will take some time (> 10 years) to realize the benefit.

Clearly, an overall reduction in fishing effort and mortality is needed to reverse current trends. Current fishing capacity largely exceeds the current TAC and has even increased over the last two years. Therefore, management actions are also needed to mitigate the impacts of overcapacity as well as to eliminate illegal fishing. Deferring effective management measures will likely result in even more stringent measures being necessary in the future.

11.4 Management – West, including advice on the odds of achieving the current Rebuilding Plan objectives without further adjustment

In 1998, the Commission initiated a 20-year rebuilding plan designed to achieve B_{MSY} with 50% probability. The current assessment indicates that the stock is not rebuilding as rapidly as was projected under the plan initially. The 2007 SSB is estimated to be 7% below the level of the Plan's first year.

Based on a strict interpretation of the base case projections and the *Supplemental Recommendation by ICCAT Concerning the Western Atlantic Bluefin Tuna Rebuilding Program* [Rec. 06-06], the Commission is faced with a choice between TAC levels from 2,400 t to zero depending on its willingness to base management on the more risky low recruitment scenario. However, in light of the uncertainty about recruitment and other uncertainties not taken into account in the projections, the Group strongly advises against an increase in TAC. Instead, the Committee recommends that the Commission adopt more conservative catch levels that will result in a higher probability (75% chance) that B_{MSY} is achieved by the beginning of 2019. Under the more optimistic "low recruitment" scenario, this target could be achieved with a TAC of 2,000 t. However, if the assessment and estimates of future yield are positively biased or if there is implementation error (both of which have occurred in the past), the TAC should be lower. For instance, based on the assessment results without the Gulf of St. Lawrence CPUE index, the TAC would need to be reduced to 1,500 t in order to achieve B_{MSY} by 2019 with 75% probability.

Under the more pessimistic "high recruitment" scenario, B_{MSY} is very high and not achievable within the rebuilding time frame. However, some TAC levels that are projected to rebuild the stock under the optimistic scenario are also projected to end overfishing under the more pessimistic scenario. For instance, a TAC of 1,500 t is expected to end overfishing with 75% probability by 2015 under the high recruitment scenario.

As noted previously by the Committee, both the productivity of western Atlantic bluefin and western Atlantic bluefin fisheries are linked to the eastern Atlantic and Mediterranean stock. Therefore, management actions taken in the eastern Atlantic and Mediterranean are likely to impact the recovery in the western Atlantic, because even small rates of mixing from East to West can have significant effects on the West due to the fact that eastern plus Mediterranean resource is much larger than that of the West.

12. Other matters

12.1 Analyses of length frequencies and increases in weight in Mediterranean bluefin tuna farms

Harvest data from Mediterranean bluefin tuna farms were provided by Contracting Parties to the Secretariat. This data sometimes included various combinations of total weight harvested, histograms of harvested weights or histograms of harvested lengths. Only data with both harvested lengths and either total weight harvested or histograms of harvested weight could be used in this analysis. If it is deemed that growth and length frequency information is useful for future analyses it will be necessary to collect harvested lengths as well as the harvested weight, either by weight class and number or overall total.

The objectives of this analysis were to examine whether the length frequencies of fish harvested from the tuna pens matches the French purse seine catch at size for the same years and to determine whether the farm data could be used to calculate the percent increase in growth of fish during their tenure in the pens.

Results of the first objective (**Figure 46**) indicate that, in early years, the purse seine catch at size did not match harvested lengths from the farms. However, in more recent years, they appear to converge, particularly for Spain in 2007. It should be noted that purse seine catch usually occurs in May and June and that farms usually harvest in December and January so that sizes from the purse seine could be advanced by 6 months to match the farm sizes. However, this assumption is contrary to the assumption made to address the second objective of this analysis and, to date, remains untested.

To address the second objective we had to make several assumptions to address data limitation:

- We assumed that the length at harvest was the same as the length at capture, or that the tuna did not grow in length.
- Since there was no unique identifier for an individual farm harvest, we constructed a unique identifier based upon the flag, year, reported total catch, reported weight of sample and reported number of fish. We assumed that this unique identifier represents a farm harvest.
- Unique harvests for which no length frequency data and total catch (either in histogram or summed form) were removed from the analyses as we could not obtain initial weights.

This set of assumptions and data limitations provided 66 unique harvest sets (**Tables 25 and 26**). Unfortunately, it is difficult to cross reference these harvests with any other ancillary information and it is difficult to determine how long the fish were in the pens. It is likely that fish were captured and harvested at different times and these times are not always available. We assumed that all fish were placed in the pen and removed at the same time. Operating under these assumptions we used the ICCAT length-weight regression for Mediterranean bluefin tuna ($RWT = 1.9607 \cdot 10^{-5} (FL)^{3.0092}$, Arena), we obtained a putative weight at capture and then determined the percent increase in this value versus the harvest total weight (% increase= harvest weight- initial weight)/initial weight.

Of the 66 unique harvests, 34 showed positive growth and 32 indicated negative growth (**Tables 25 and 26**). For various reasons, listed in the table notes, we excluded 38 harvest sets that had either negative or anomalous growth or came from a flag for which similar harvests experienced anomalous growth. This resulted in keeping only all harvests from Turkey in 2004-2006 and most harvests from Spain. **Figures 47 and 48** show the length at harvest, implied weight at capture the actual weight distribution at harvest (when given) for the selected farms. A 'weighted' mean calculated as the % increase between the overall sum of the initial weights and the overall sum of the final weights was 14.5%.

Analysis of these putative increases in growth must be interpreted with caution. The method of estimating growth rate is likely to be a lower estimate as any increase in length will result in an underestimation of the difference between harvested and captured weight. This could explain the large numbers of landed weights that are less than 10% lower than the estimated initial weights. Furthermore, the anomalous estimates of growth must be explored in more detail before more conclusions can be made. In conclusion it appears that an initial estimate of growth rate in the pens may be around 14% but that this estimate appears to be highly variable and may be affected by many factors.

13. Adoption of the report and closure

The report was adopted by correspondence.

The Chairman thanked participants for their hard work.

The meeting was adjourned.

References

ANON. 2002. ICCAT Workshop on Bluefin Mixing (Madrid, Spain, September 3-7, 2001). Collect. Vol. Sci. Pap. ICCAT, 54(2): 262-352.

ANON. 2003. Report of the 2002 Atlantic Bluefin Tuna Stock Assessment Session (Madrid, Spain, July 22 to 30, 2002). Collect. Vol. Sci. Pap. ICCAT, 55(3): 710-937.

ANON. 2007. Report of the 2006 Atlantic Bluefin Tuna Stock Assessment Session (Madrid, Spain, June 12 to 18, 2006). Collect. Vol. Sci. Pap. ICCAT, 60(3): 652-880.

BAGLIN, R.E., Jr. 1982. Reproductive biology of western Atlantic bluefin tuna. *Fishery Bulletin*: Vol. 80 No. 1, pp. 121-134.

BOUSANY, A.M, C.A. Reeb, S.L.H. Teo, G. DeMetrio, B.A. Block. 2007. Genetic data and electronic tagging indicate that the Gulf of Mexico and Mediterranean Sea are reproductively isolated stocks of bluefin tuna (*Thunnus thynnus*). Collect. Vol. Vol. Sci. Pap., ICCAT 60(4): 1154-1159.

CARLSSON, J., J.R. McDowell, J.E.L. Carlsson, J.E. Graves. 2007. Genetic identity of YOY bluefin tuna from the eastern and western Atlantic spawning areas. Journal of Heredity 98(1): 23-28.

CORT, J.L. 1991. Age and Growth of the Bluefin Tuna, *Thunnus thynnus* (L.) of the Northwest Atlantic. SCRS/1990/66. Collect. Vol. Sci. Pap. ICCAT, 35(2): 213-230.

FROMENTIN, J.-M., Fonteneau, A. 2001. Fishing effects and life history traits: a case-study comparing tropical *versus* temperate tunas. *Fisheries Research* 53, 133-150.

FROMENTIN, J-M., H. Farrugio, M. Deflorio and G. De Metrio. 2003. Preliminary results of aerial surveys of bluefin tuna in the western Mediterranean Sea. Collect. Vol. Sci. Pap. ICCAT, 55(3): 1019-1027.

FROMENTIN, J.-M., Powers, J.E. 2005. Atlantic bluefin tuna: population dynamics, ecology, fisheries and management. *Fish and Fisheries* 6, 281-306.

FROMENTIN, J-M., H. Arrizabalaga, V.R. Restrepo and J. Ortiz de Urbina. Estimates of total mortality of eastern Atlantic bluefin tuna baased on year-class curves. Collect. Vol. Sci. Pap. ICCAT, 60(3): 928-936.

GARCÍA, A., F. Alemany, P. Velez-Belchi, J.L. López Jurado, D. Cortés, J.M. de la Serna, C. González Pola, J.M. Rodríguez, J. Jansa and T.Ramírez. Characterization of the bluefin tuna spawning habitat off the Balearic Archipelago in relation to key hydrographic features and associated environmental conditions. Collect. Vol. Sci. Pap. ICCAT, 58(2): 535-549.

GEROMONT, H.F. and D.S. Butterworth. 1997. Specifications for the Adapt VPA Code, September 1996 (Revised). Col. Vol. Sci. Pap. ICCAT, 46(2): 321-324.

GOLDSTEIN, J., S. Heppell, A. Cooper, S. Brault, and M. Lutcavage. 2007. Reproductive status and body condition of Atlantic bluefin tuna in the Gulf of Maine, 2000-2002. Marine Biology, 151: 2063-2075.

HURLEY, P.C.F. and T.D. Iles. 1983. Age and growth estimation of Atlantic bluefin tuna *Thunnus thynnus* using otoliths. NOAA-NMFS Tech. Rep. 8 pp. 71-75.

ICCAT. 1997. 1996 SCRS Detailed Report on Bluefin Tuna. Collect. Vol. Sci. Pap. 46: 1-301.

ICCAT 2006. *ICCAT Manual*. Chapter 2.1.5: Atlantic bluefin tuna. http://iccat.es/Documents/ SCRS/Manual/CH2.

KASS, R.E. and A.E. Raftery. 1995. Bayes Factors. *Journal of the American Statistical Association*, Vol. 90, No. 430 (Jun. 1995), pp. 773-795.

KUIKKA, S., M. Hildén, H. Gislason, S. Hansson, H. Sparholt, H. and O. Varis. 1999. Modelling environmentally driven uncertainties in Baltic cod (*Gadus morhua*) management by Bayesian influence diagrams. *Can. J. Fish. Aquat. Sci.,* 56: 629-641.

MATHER, F.J., J.M. Mason. Jr. and A. Jones. 1995. Historical document: life history and fisheries of Atlantic bluefin tuna, Pages 165 pp. Miami, NOAA Technical Memorandum NMFS-SEFSC-370.

McALLISTER, M., E.A. Babcock, E.K. Pitich. 2001. Using Bayesian methods to improve stock assessment and management of stock rebuilding when there is uncertainty in processes affecting future recruitment. Collect. Vol. Sci. Pap. 52(3): 1078-1093.

McALLISTER, M. and C.K. Kirchner. 2002. Accounting for structural uncertainty to facilitate precautionary fishery management: Illustration with Namibian orange roughy. *Bulletin of Marinie Science*, Vol. 70, Issue 2 (March 2002), pp. 499-540.

MILLAR, R.B. 1987. Maximum likelihood estimation of mixed stock fishery composition. Can. J. Fish. Aquat. Sci. 44: 583-590.

MILLER, T.J. 2007. A finite-state continuous-time approach to inferring regional movement rates of Atlantic bluefin tuna using conventional tagging studies. Collect. Vol. Sci. Pap. ICCAT, 60(4): 1109-1131.

NEILSON, J.D. and S.E. Campana. A validated description of growth of bluefin tuna (*Thunnus thynnus*). Can. J. Fish. Aquat. Sci. *(In press)*.

PORCH, C.E., S.C. Turner, J.E. Powers. 2001. Virtual Population Analyses of Atlantic bluefin tuna with alternative models of transatlantic migration: 1970-1997. 2001. Collect. Vol. Sci. Pap. ICCAT, 52(3): 1022-1045.

POWERS, J. E., and V. R. Restrepo. 1992. Additional options for age-sequenced analysis. Col. Vol. Sci. Pap. ICCAT, 39(3): 540-553.

TURNER, S.C. and V.R. Restrepo. 1994. A review of the growth rate of West Atlantic bluefin tuna, *Thunnus thynnus*, estimated from marked and recaptured fish. Collect. Vol. Sci. Pap. ICCAT, 42: 170-172.

ROOKER, J.R., J.R. Alvarado Bremer, B.A. Block. G. de Metrio, A. Corriero, R.T. Krause, E.D. Prince, E. Rodriguez-Marin and D.H. Secor. 2007. Life history and stock structure of Atlantic bluefin tuna (*Thunnus thynnus*). Reviews in Fisheries Science, 15:265-310.

Table 1. Estimated catch (landings and discards) of BFT.

Stock	*Flag*	*GearGrp*	***1990***	***1991***	***1992***	***1993***	***1994***	***1995***	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2007****
*ATE	Cape Verde	BB																			
	China P.R.	LL									85	103	80	68	39	19	41	24			88
	Chinese Taipei	LL				6	20	8	61	226	350	222	144	304	158			10	4		
	EC.Denmark	UN	0	0		37		0	0		1										0
	EC.España	BB	1314	997	769	3281	1694	2386	4595	2940	2017	1217	1729	2168	2410	1239	1735	2012	1065		1187
		GN																			0
		HL								162	28	33	126	61	63	109	87	11	4		5
		LL	32	32							5	8	3	4	0	1	4	3	18		21
		SU																			0
		TP	1911	1040	1271	1244	1136	941	1207	2723	1525	2005	1416	1240	1548	750	862	880	820		914
		TR	300	204	277	553	305	492	373	376	226	94	192	151	68	39	112	195	125		139
		UN			2		2					3	8	9							0
	EC.France	BB	367	448	372	164	66	181	310	134	282	270	91	105	150	130	47		50		56
		GN	42	47	74	497	21	144	253	3	72	71	57	68	6						0
		LL			7												2		95		106
		PS															223		153		170
		TR				2															0
		TW	101	70	441	436	224	400		57	259	247	394	456	599	518	26		731		815
		UN					25			75							263	818	189		210
	EC.Germany	TW																			0
		UN																			0
	EC.Greece	TR																			0
	EC.Ireland	GN									3	1	0	1							0
		LL								14	2	1									0
		TR											2								0
		TW									16	50	20	6	15	3	1	1	2		3
	EC.Poland	UN																			0
	EC.Portugal	BB	12		0	2	219	34	80	447	252	5	2	2	7	1	8	6	0		0
		HL	1																		0
		LL		99	4	4	8		97	246	18	404	398	383	160	33	1	63	71	29	79
		PS					0									0			1		1
		SU	14	18	34	19	12	0			8	0	1	3	3						0

		TP						1	15	19	45	2	40	15	17	27	18	9	25		27
		TW							7												0
		UN					0														0
	EC.Sweden	UN		1																	0
	EC.United Kingdom	GN						1	0	0		0									0
		LL								0		10									0
		TW									1	2	0			0			0		0
	EC Total	All	4094	2955	3251	6202	3712	4580	6937	7197	4758	4423	4479	4673	5046	2851	3390	3999	3349		3733
	Faroe Islands	LL									67	104	118								
	Guinée Conakry	UN					330														
	Iceland	LL									1	27			1						
		TW									1										
	Japan	BB																			
		LL	1464	2981	3350	2484	2075	3971	3341	2905	3195	2690	2895	2425	2536	2695	2015	2598	1896	1612	1612
	Korea Rep.	LL					4	205	92	203			6	1					1		10
	Libya	LL			312				576	477	511	450							47		48
		PS											487								
	Maroc	GN	31	3	6	4	13	10	13		34	30	28	17	11						0
		LL														2	8	16	273	1	338
		PS	54	46	462	24	213	458	323	828	692	709	660	150	884	490	855	871	179		221
		SU																			0
		TP	323	482	94	387	494	210	699	1240	1615	852	1540	2330	1670	1305	1098	1518	1744	2417	2157
		UN																			
	NEI (ETRO)	UN	74	4																	
	NEI (Flag related)	LL		85	144	223	68	189	71	208	66										
	Norway	LL																			
		PS										5									
	Panama	LL					1	19	550	255		1									
		PS										12									
	Seychelles	LL													2						
	Sierra Leone	LL											93	118							
	U.S.A.	PS																			
ATE Total			6040	6556	7619	9367	6930	9650	12663	13539	11376	9628	10528	10086	10347	7362	7407	9036	7493	4059	11941
ATW	Argentina	LL																			

	TW										0									
	UN	2																		
Brasil	LL	1				0	0				13		0							
Canada	GN												0							
	HP				33	34	43	32	55	36	38	18	20	13	10	7	14	20	17	17
	LL	4	6	9	25	5	4	22	12	32	31	47	20	53	28	43	36	48	58	58
	PS																			
	RR	28	32	30	88	71	195	155	245	303	348	433	402	508	407	421	497	629	389	389
	TL	404	447	403	284	203	262	298	138	172	125	81	79	39	42	49	44	35	23	23
	TP	2		1	29	79	72	90	59	68	44	16	16	28	84	32	8	3	4	4
	UN																			
Chinese Taipei	LL								2											
Cuba	LL													74	11	19	27	19		
EC.Poland	UN																			
EC.United Kingdom	GN													0						
FR.St Pierre et Miquelon	LL													3	1	10	5			
	UN										1									
Japan	LL	550	688	512	581	427	387	436	330	691	365	492	506	575	57	470	378	376	277	277
Korea Rep.	LL																1	52		
Mexico	LL					4			2	8	14	29	10	12	22	9	10	14	7	7
	UN																			
NEI (ETRO)	LL	24	23	17																
NEI (Flag related)	LL							2			429	270	49							
Norway	LL																			
Panama	LL																	0	0	0
Sta. Lucia	HL	14	14	14	2	43	9													
	UN							3												
Trinidad and Tobago	LL																			
U.S.A.	GN			0		0	1	4					0							
	HL	210	341	218	224	228	66	33	17	29	15	3	9	4		1	2	0		
	HP	129	129	105	88	68	77	96	98	133	116	184	102	55	88	41	32	30	23	23
	LL	275	305	347	177	185	211	235	191	156	222	242	130	224	299	275	211	205	164	164
	PS	384	237	300	295	301	249	245	250	249	248	275	196	208	265	32	178	4	28	28
	RR	752	696	324	540	462	844	840	931	777	760	683	1244	1523	991	716	425	376	634	634

		TP																			
		TW																			
		UN	1	2	1	1	2	1	3	2	1	0	0	0							
	UK.Bermuda	LL											1								
		UN							1	2	2	1		1	1	0					
	Uruguay	LL		1	0	1	0	2							1	0					
ATW Total			2780	2921	2282	2368	2113	2423	2495	2334	2657	2772	2775	2785	3319	2306	2125	1869	1811	1624	1623
MED	Algerie	GN									200	158	214	312	287		186	165	75		108
		HL									180	208	159	163	129		39	27	21		30
		LL											700	109	186		167	712	88		127
		PS									900	1056	778	917	922		753	623	850		1228
		TL									93	174	88								0
		TP									399	367	290	366	41		5	3	4		6
		UN	782	800	1104	1097	1560	156	156	157	175	179	101	145	145	1586	58				0
	China P.R.	LL					97	137	93	49											
	Chinese Taipei	LL				328	709	494	411	278	106	27	169	329	508	445	51	267	5		
	Croatia	HL								6	1	39									
		LL								11	16	10		9	1					5	5
		PS		1418	1076	1058	1410	1220	1360	1088	889	921	930	890	975	1137	827	1017	1022	815	815
		SP												4	1	2					
	EC.Cyprus	HL				4															0
		LL	10	10	10	10	10	10	10	10	21	31	61	85	91	79	11	149	110		123
		PS															94				0
	EC.España	BB	25	148	158	48		206	5	4	11	4			1	9	17	5			0
		GN																			0
		HL	296	10	4	200	93	726	206	69	76	21	67	98	48	9	9	2			0
		LL	59	51	28	40	178	368	369	871	253	418	493	644	436	583	529	484	668		745
		PS	635	807	1366	1431	1725	2896	1657	1172	1573	1504	1676	1453	1686	1886	1778	2242	2013		2244
		SP									18	8	11	11	10	10	10	20	8		9
		SU	247	126	250	146	336		76	30	55	35	38	28	11	9	9				0
		TP	470	24	16	6		1	1	1	5	1	0	1	0	0	1	0			0
		TR					13	15			9	8			12						0
		UN	90	226	343	147	396	395	274	58		4	488		11	7	1	5			0
	EC.France	GN																			0

	PS	4663	4570	7346	6965	11803	9494	8547	7701	6800	5907	6780	6119	5810	5549	6339	8328	7438		8291
	SP	50	50	30	30	40	50	44	34	22	3	14	48	22	10	2	0			0
	UN						60	580	500	300	246				300	130	309	226		252
EC.Greece	HL	124	98	348	339	766	915	784	1127	279	233	597	341	394	245	73		6		7
	LL	37	37	67	68	88	57	58	58	3	10	15	12	36	152	209	162	48		54
	PS	40	40	32	32	32	32	32	32	4	5	10	8	8	25	107	156	200		223
	UN																			0
EC.Italy	BB										0	0								0
	GN	55	203	188	209	72	109	57	150		10	13	26							0
	HL	547	128	106	161	324	351	122	186	5	0	3	1	21	0					0
	HP	7	6	5	2	2	4	10	20		5	5	2				1			0
	LL	79	102	78	135	1018	2103	2100	1620	292	515	287	260	395	475	302	310	286		319
	PS	2651	2652	3846	4162	4654	3613	7060	7068	3334	1859	2801	3256	3246	3849	3752	3961	4006		4466
	RR	50	50	50	50	100	150			4	10	0	2		0	0				0
	SP	442	352	368	410	480	491	360	350	5	415	383	401	600	500	500	500	277		309
	TP	279	263	364	199	182	241	297	154	419	308	353	427	364	145	119	69	125		140
	UN		27			50					156	0	4	2	3	13		0		0
EC.Malta	LL	81	105	80	251	572	587	399	393	407	447	376	219	240	255	264	321	263		294
	PS																25			0
	UN																			0
EC.Portugal	LL		278	320	183	428	446	274	37	54	76	61	64		2		0	11		12
EC Total	All	10937	10363	15403	15228	23362	23320	23322	21645	13950	12240	14531	13507	13444	14102	14268	17050	15686		17486
Israel	UN							14												
Japan	LL	172	85	123	793	536	813	765	185	361	381	136	152	390	316	638	265	556	466	466
Korea Rep.	LL					684	458	591	410	66								26		266
	PS															700	1145			
Libya	LL	173	164	60	67	802	865	80	448	409	450	1002	1867	331	170	393	318	140		143
	PS	129	177	300	568	470	495	598	32	230	195	16		200	512	872	730	1140		1167
	TP	26	29	65		150	180	134	72	181	100	44	74	107	71	34	42			0
	UN																			0
Maroc	GN	31	13	4	6	16	92	30	17	18	6	6	9	14	20					0
	HL					373	816	541	455	634	600	650	195	407	570	597	80	187	19	231
	LL																		107	
	PS														170	222	12	3	515	4

	SU																			0
	TP	1118	912	201	73	703	127	15	63	35	30	39	307							0
NEI (combined)	UN					773	211		101	1030	1995	109	571	508	610	709				
NEI (ETRO)	LL	341	1750	1349																
NEI (Flag related)	HL									64	42									
	LL					427	639	171	1066	761	98	17								
NEI-2	PS	19	49	49																
Panama	LL	74	287	484	467	1499	1498	2850	236											
Serbia & Montenegro	PS						2	4												
	UN											4								
Tunisie	HL	43	50	45	43	81	57	92	113	48	43	37	58	15	46	109	4	3	4	4
	PS	114	1073	975	1997	2523	1617	2147	1992	1662	2263	2134	2432	2510	740	2266	3245	2542	2191	2191
	TP	249	243	175	92	169	223	154	95	35	46	13	3	3	5	1				0
Turkey	PS	2059	2459	2817	3084	3466	4219	4616	5093	5899	1200	1070	2100	2300	3300	1075	990	806	918	918
	TP																			
	UN						1													
Yugoslavia Fed.	PS	940																		
MED Total		17207	19872	24230	24901	39810	37640	38144	33612	28342	22828	23238	24519	23424	23801	23970	26697	23154	5040	25197

* 2007 catches for some fleets (shaded) not reported to the Secretariat were estimated from the 2007 Compliance Tables.

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Table 2. Live weights (in tonnes) of farmed bluefin tuna estimated using a gain of 14.5% and 25% in weight.

Year	*Average weight gain in farms of 25%*	*Average weight gain in farms 14.5%*
2004	27,148	28,695
2005	29,974	31,599
2006	32,467	34,198
2007	29,091	31,134

Table 3. Catch-at-age for the western Atlantic stock (Areas 1 + 2).

YEAR	*AGE*									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10+*
1960	485	588	652	2174	1269	1882	1132	1237	581	1167
1961	1279	1547	2130	6879	2513	2741	2360	1463	697	1278
1962	7252	14202	16316	69103	11003	1895	3781	4516	1996	2422
1963	33777	47982	47077	48206	35193	11997	5901	19685	12083	9357
1964	20855	32325	40284	26733	40776	11997	7292	43799	25329	9921
1965	70461	97740	30795	7610	18529	7196	7934	30600	16714	12139
1966	178396	74301	10351	136	116	662	1140	3648	6776	18730
1967	16018	100687	32743	9537	652	1122	795	3357	7253	8075
1968	5038	38310	16591	1004	1024	2220	297	1971	5355	3789
1969	10777	30235	28068	4637	2385	340	280	409	1596	5387
1970	61909	102549	126581	21101	3629	897	173	162	513	3656
1971	61511	150254	38184	45991	663	1646	2112	1351	1134	5980
1972	45326	97755	33545	3730	3856	118	568	574	261	5481
1973	4971	71796	29419	6964	2126	1450	951	1541	559	4535
1974	55834	19960	21028	6508	3164	681	913	914	1083	12401
1975	43341	146792	8323	11959	803	523	313	671	1650	9468
1976	5301	19357	71719	2911	2901	344	206	1168	558	14098
1977	1270	22341	9683	32004	4860	3629	957	513	1109	13568
1978	5103	10813	19800	6294	10482	4031	654	472	341	11996
1979	2745	10552	16287	14915	3447	3493	2611	598	557	12315
1980	3160	16182	11066	8879	2865	2981	5531	3453	1061	12240
1981	6046	9549	16496	5241	6019	3717	2882	3210	2763	10658
1982	3528	3729	1655	499	343	753	478	518	896	3114
1983	3600	2438	3243	891	880	918	1414	1287	957	5253
1984	868	7501	1845	2069	2068	1668	592	757	1087	4630
1985	568	5523	12308	2813	4329	4019	1024	612	696	5622
1986	563	5938	7129	3429	1115	1716	924	517	458	5226
1987	1534	13328	9162	5731	4378	2548	1725	1281	1063	3452
1988	4925	9282	12004	4123	3829	4267	2259	1438	1304	4005
1989	835	12925	1851	4243	1740	2184	2707	1840	1351	4772
1990	2400	4245	18073	2420	2567	1854	1727	2386	1543	4128
1991	3364	14542	10893	3470	1709	2293	2403	1967	1892	4136
1992	464	6015	2171	1383	1632	1207	2150	1880	1392	4583
1993	346	1134	5287	3494	2063	2050	1743	2500	1543	3084
1994	2015	691	1611	2619	2738	1743	2121	2363	1497	3030
1995	1088	1206	3685	4123	4394	2530	781	1598	1794	3523
1996	414	9473	1986	5754	2514	1720	2802	911	1360	4016
1997	219	994	6591	1320	1772	1639	2386	2276	1043	4130
1998	260	920	4013	3186	1162	1131	1921	3303	2625	4060

1999	73	589	2274	2038	1717	953	2158	2147	2699	5641
2000	98	278	1074	1854	4634	2825	1826	1760	1563	5045
2001	1398	323	2891	4424	1295	1984	2712	1089	1763	5770
2002	476	5807	4257	6259	3813	1035	3774	2953	1763	5691
2003	165	2748	5085	4013	2001	792	1731	2794	1392	3686
2004	306	3133	7084	3520	3088	2794	2063	1298	1215	2872
2005	369	5093	2863	2432	1470	891	1202	1126	1343	3695
2006	120	599	1380	2781	2228	1982	1429	1974	1453	3754
2007	65	253	8590	7335	2693	1582	806	700	614	2195

Table 4. Weights-at-age from slicing, west Atlantic.

	Weight-at-Age (kg)														
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1960	3.4	8.6	24.7	39.9	57.2	84.6	114.3	146.2	168.9	208.9	231.6	280.4	318.2	339.8	413.6
1961	3.4	8.6	24.8	39.8	55.1	85.2	113.5	146.3	173.7	214.9	239.1	276.8	309.3	356.3	-
1962	3.4	9.2	24.5	35.9	52.6	80.9	117.2	149.1	176.8	226.5	242.2	284.7	310.6		-
1963	3.7	10.0	19.5	38.7	58.4	78.3	116.8	138.0	162.4	209.5	231.1	282.4	309.8	343.4	-
1964	3.3	9.1	20.1	41.3	58.4	76.3	110.3	134.1	159.3	204.7	232.5	286.8	316.8	345.2	-
1965	3.4	9.0	19.1	43.4	56.7	82.0	109.6	133.8	159.5	200.8	227.6	286.2	319.9	345.0	375.4
1966	3.5	8.6	17.6	37.8	69.5	76.0	110.7	136.0	161.5	198.7	244.4	290.4	321.6	355.8	385.6
1967	5.0	10.0	20.5	38.0	53.0	75.5	108.2	138.3	160.7	194.6	236.2	283.1	307.8	356.7	389.5
1968	3.5	10.2	19.5	38.6	54.6	75.6	93.2	142.8	162.9	193.4	250.3	286.9	319.4	360.6	380.0
1969	3.9	8.5	22.0	38.0	56.2	76.9	104.6	144.7	168.3	202.3	244.7	282.9	321.3	371.3	411.9
1970	3.2	8.4	17.0	37.3	56.3	79.8	112.8	148.3	172.0	208.0	245.5	279.8	318.6	355.7	424.1
1971	3.5	8.4	21.2	32.0	60.3	82.0	108.5	135.1	169.2	208.6	248.2	283.2	322.1	355.3	411.9
1972	4.4	9.7	19.3	40.7	57.6	84.8	114.8	137.5	171.9	214.3	247.5	284.4	328.6	361.1	406.1
1973	3.7	8.9	20.9	39.9	62.4	77.5	119.5	142.7	172.9	217.6	250.5	292.5	329.6	366.2	407.4
1974	3.6	10.0	17.2	36.8	57.1	82.9	102.5	138.5	169.2	203.0	248.1	278.8	315.1	350.2	371.3
1975	3.9	8.7	23.8	34.2	58.4	78.5	114.8	141.3	164.8	198.3	238.7	273.4	313.7	347.6	401.2
1976	3.9	10.3	18.9	34.1	51.9	81.1	119.4	152.2	171.8	201.8	231.8	266.1	303.9	347.6	402.2
1977	4.4	10.3	20.8	35.3	52.4	74.8	97.8	136.5	165.3	196.2	236.2	265.8	302.9	339.7	396.2
1978	5.0	10.7	21.7	35.5	54.4	73.6	107.0	145.3	183.0	203.8	235.4	267.1	302.1	339.0	406.7
1979	5.3	11.2	21.9	39.2	50.8	78.7	105.8	141.1	179.2	205.6	234.1	268.6	304.0	345.1	406.9
1980	5.0	12.2	21.4	35.7	53.3	84.6	114.4	140.6	186.7	225.2	249.2	276.3	309.7	348.3	405.3
1981	5.6	11.0	21.5	34.7	52.3	77.6	107.2	141.1	174.2	209.1	235.1	270.6	302.9	344.6	426.8
1982	4.0	10.8	21.3	34.3	59.6	82.0	115.2	150.1	181.6	216.4	246.7	284.5	333.1	367.5	450.1
1983	3.9	10.1	20.0	37.9	59.0	84.4	116.2	148.8	184.7	222.5	256.3	288.4	335.1	375.2	434.8
1984	4.7	11.2	23.6	39.4	60.0	85.9	116.4	148.2	182.9	216.3	258.2	294.6	335.8	379.3	462.7
1985	3.7	10.2	17.3	33.3	49.0	70.9	98.4	131.3	170.2	207.6	241.5	276.0	311.9	352.5	432.4
1986	4.2	9.9	20.2	41.2	57.0	84.8	116.2	148.5	178.6	216.3	252.1	287.6	326.9	355.8	431.9
1987	4.3	9.7	22.7	40.0	58.3	76.1	109.4	137.8	168.8	210.1	251.9	293.6	329.9	364.6	436.2
1988	3.9	11.4	21.1	38.0	56.8	80.8	107.9	140.3	178.1	213.4	249.7	292.0	324.4	361.0	452.7
1989	4.0	11.0	22.1	39.4	55.3	83.3	113.6	141.6	177.5	211.6	250.3	287.9	326.5	368.7	449.9
1990	4.5	11.4	19.0	38.8	55.2	77.8	111.4	146.5	179.2	215.3	250.8	290.0	326.8	357.0	436.1
1991	5.1	13.1	20.1	41.4	61.6	85.3	115.9	151.5	181.1	212.0	252.3	290.4	326.1	367.7	425.2
1992	5.7	12.6	19.1	39.1	60.0	82.3	112.5	141.2	179.1	213.6	248.1	287.3	323.2	360.0	430.6
1993	4.5	11.2	24.9	38.4	56.8	82.0	109.7	143.0	174.0	211.2	246.8	287.8	325.8	373.1	449.0
1994	4.8	11.7	23.5	34.9	52.2	74.5	111.4	137.7	176.4	209.6	245.8	280.7	318.7	364.1	430.8
1995	4.5	13.4	22.9	39.9	62.7	85.5	111.7	147.7	175.5	211.9	246.7	288.0	330.8	373.7	441.2
1996	3.8	11.1	23.7	38.2	55.1	85.0	113.6	145.9	184.5	217.8	254.2	297.8	333.9	375.0	436.0
1997	4.8	12.3	20.6	40.9	60.1	84.3	113.0	142.7	176.9	218.7	253.4	289.0	330.5	369.8	439.0
1998	4.4	11.3	21.7	34.5	62.8	83.5	119.9	148.6	176.2	215.8	251.5	290.7	323.3	361.4	431.9
1999	4.8	11.1	23.2	40.0	60.5	87.1	115.0	145.3	179.8	212.4	249.1	286.1	321.4	364.8	430.7
2000	4.8	11.9	19.7	36.8	56.3	83.9	112.4	147.7	183.7	220.5	257.4	300.4	339.1	378.9	448.0
2001	4.7	11.8	23.3	36.0	62.0	89.2	116.4	154.2	189.0	226.1	261.2	302.2	337.3	369.1	429.6
2002	5.9	10.7	20.1	38.2	55.2	83.6	116.2	145.6	181.4	220.1	259.1	297.4	332.5	372.6	447.8
2003	4.8	11.2	22.2	37.3	60.4	81.1	118.6	145.8	177.6	221.0	259.4	300.6	333.1	359.8	415.9
2004	5.6	11.2	22.1	38.5	53.5	76.5	111.6	143.0	177.4	212.1	247.0	288.9	329.9	356.3	417.1
2005	3.8	9.6	20.5	31.9	52.5	75.6	106.0	140.2	181.1	212.4	249.5	291.0	328.9	363.4	417.3
2006	4.6	11.7	17.7	37.4	54.6	72.9	107.2	136.0	173.6	211.6	253.8	280.1	322.3	360.9	419.8
2007	4.6	11.8	23.6	32.7	55.8	78.3	113.5	144.9	183.0	219.4	258.8	294.1	343.4	373.1	442.5

Table 5. Catch-at-age for Area 3 (Japan longline only).

YEAR	*AGE*									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10+*
1970	0	0	0	0	0	0	5	9	6	4
1971	0	0	1	0	1	6	19	25	40	51
1972	0	0	0	0	0	4	3	10	7	13
1973	0	0	0	0	0	0	0	0	0	63
1974	0	0	1	1	1	1	0	0	0	3
1975	0	0	0	2	1	1	1	1	4	40
1976	0	0	0	0	0	0	0	0	0	1
1977	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	1	1	2	0	0	2	15
1979	0	0	0	0	2	6	10	9	2	0
1980	0	0	4	2	7	16	24	28	38	77
1981	0	0	0	0	1	2	11	12	10	25
1982	0	0	0	0	0	0	34	10	5	97
1983	0	0	0	0	0	1	1	1	1	2
1984	0	0	0	1	3	8	14	30	20	11
1985	0	0	0	2	23	20	14	8	23	169
1986	0	1	2	5	20	17	22	25	47	108
1987	0	0	0	1	3	14	18	15	14	43
1988	0	0	0	1	3	12	26	25	21	58
1989	0	0	2	27	47	170	277	182	157	298
1990	0	2	15	41	186	439	619	900	696	648
1991	4	85	129	433	340	961	1206	2055	1962	2397
1992	0	10	230	846	1551	706	1859	2136	2291	6106
1993	0	10	95	926	2014	1969	1125	896	1300	3807
1994	4	1	12	55	266	577	1222	888	514	1341
1995	0	8	29	202	349	884	427	567	294	956
1996	0	0	49	268	340	886	1797	1854	1204	2047
1997	0	0	2	23	68	248	426	700	351	504
1998	0	0	7	8	25	126	172	297	311	393
1999	0	16	17	155	239	251	407	349	317	293
2000	0	3	34	294	737	1265	1381	2271	1368	1804
2001	0	0	0	79	211	3578	4052	2684	684	790
2002	0	0	1	2	1	2	30	393	403	262
2003	0	3	26	103	249	357	332	345	396	608
2004	0	10	90	132	312	184	535	757	218	555
2005	0	6	145	242	271	605	1041	1563	1920	1853
2006	0	55	0	287	326	386	737	1302	755	1769
2007	0	50	19	110	642	793	705	1335	1363	1812

Table East 6. East Atlantic BFT Abundance Indices. Standardized CPUE scaled to its mean and associated CVs for the Spanish baitboat fishery in the Bay of Biscay.

Series *age*	**Spain TRAP 6+**	**CV**	**Morocco TRAP**	**CV**	**MO+SP TRAP 6+**	**CV**	**JPN LL 4+**	**CV**	**JPN LL 4+**	**CV**
indexing	**Whole Season**		**Whole season**		**Whole Season**		**Mid-year**		**Mid-Year**	
area	**Number**		**Number**		**Number**		**Number**		**Number**	
method	**East Atlantic**		**East Atlantic**		**East Atlantic**		**Area 5 and Med**		**Med**	
time of year	**Neg. Binom. (log) no RE**		**Neg. Binom. (log) no RE**		**Neg. Binom. (log) no RE**		**Delta-logn Lognormal RE**		**Delta-logn Lognormal RE**	
source	**SCRS/2008/ 099**		**SCRS/2008/ 098**		**Working Group**		**SCRS/2008/ 103**		**Working Group**	
1975	-	-					1.26	0.14	1.42	0.42
1976	-	-					1.42	0.12	1.26	0.36
1977	-	-					2.35	0.14	2.03	0.71
1978	-	-					1.01	0.15	0.66	0.34
1979	-	-					1.79	0.13	1.24	0.64
1980	-	-					1.14	0.16	1.18	0.44
1981	1.15	30.43			1.10	62.79	1.11	0.17	1.23	0.50
1982	1.51	17.54			1.42	36.24	2.18	0.13	2.49	0.79
1983	1.60	17.54			1.51	36.24	1.40	0.13	1.29	0.40
1984	1.77	17.53			1.67	36.23	1.07	0.12	1.10	0.30
1985	1.20	17.55			1.13	36.24	1.15	0.15	1.29	0.38
1986	0.42	15.55	1.17	66.70	0.53	29.16	0.88	0.13	0.73	0.24
1987	0.56	15.52	0.89	66.73	0.58	29.15	1.43	0.13	0.98	0.33
1988	1.29	15.48	2.23	66.65	1.37	29.13	0.89	0.13	0.71	0.22
1989	0.69	15.51	0.73	48.47	0.72	27.09	0.69	0.16	0.60	0.25
1990	1.42	15.48	0.25	33.27	0.74	23.33	0.94	0.13	0.90	0.43
1991	0.75	15.51	1.24	33.14	1.00	23.32	0.81	0.13	0.95	0.37
1992	0.69	15.51	0.20	36.34	0.44	24.34	0.69	0.14	0.54	0.19
1993	0.65	15.51	0.26	33.26	0.43	23.35	0.69	0.14	0.70	0.25
1994	0.61	15.52	0.34	36.25	0.48	24.34	0.73	0.15	0.64	0.23
1995	0.44	15.54	0.19	36.36	0.31	24.36	0.90	0.15	0.93	0.31
1996	0.68	15.51	0.42	36.20	0.56	24.33	0.31	0.23	0.33	0.17
1997	1.82	15.47	0.78	36.15	1.30	24.30	0.33	0.22	0.37	0.18
1998	1.25	15.48	1.44	36.12	1.37	24.30	0.45	0.17	0.69	0.29
1999	2.21	15.47	0.93	36.14	1.54	24.30	0.40	0.23	0.66	0.33
2000	1.00	15.49	1.29	33.14	1.21	23.32	0.46	0.21	0.92	0.40
2001	0.80	15.50	3.11	33.12	2.11	23.31	0.60	0.17	0.88	0.35
2002	1.13	15.49	1.85	33.13	1.48	23.31	1.28	0.14	1.73	0.66
2003	0.50	17.60	1.09	33.14	0.83	24.38	1.06	0.13	1.11	0.39
2004	0.50	15.53	0.45	33.20	0.47	23.34	0.50	0.19	0.59	0.25
2005	0.59	15.52	1.25	33.14	0.94	23.32	0.55	0.15	0.70	0.25
2006	0.79	15.50	0.90	33.15	0.87	23.32	1.53	0.17	1.16	0.60
2007	0.97	15.49			0.91	31.99				

Table East 6. Continued. East Atlantic BFT abundance indices. Standardized CPUE scaled to its mean and associated CVs for Spanish and Moroccan traps as well as the Japanese longline fishery.

Series *age*	**SP BB 1**	**CV**	**SP BB 2**	**CV**	**SP BB 3**	**CV**	**SP BB 4**	**CV**	**SP BB 5+**	**CV**
indexing	**Number**		**Number**		**Number**		**Number**		**Number**	
area	**East Atlantic**		**East Atlantic**		**East Atlantic**		**East Atlantic**		**East Atlantic**	
method	**Delta lognormal**		**Delta lognormal**		**Delta lognormal**		**Delta lognormal**		**Delta lognormal**	
time of year	**Mid-year**		**Mid-year**		**Mid-year**		**Mid-year**		**Mid-year**	
source	**SCRS/2008/100**		**SCRS/2008/100**		**SCRS/2008/100**		**SCRS/2008/100**		**SCRS/2008/100**	
1975	0.35	30.17	1.23	30.15	0.88	30.50	1.10	33.57	0.07	38.48
1976	0.02	36.52	0.84	36.06	1.14	36.00	0.58	36.87	0.46	54.81
1977	0.03	34.49	1.24	30.78	1.82	30.77	1.23	30.78	0.19	43.28
1978	0.41	31.16	0.43	31.07	0.27	32.29	1.31	37.10	1.51	47.25
1979	0.00	125.25	0.20	37.92	1.30	38.09	5.09	37.85	3.22	37.81
1980	0.22	43.15	0.40	41.80	0.49	41.79	0.93	43.32	3.99	49.92
1981	0.90	36.74	0.55	36.70	0.10	36.71	0.08	51.91	0.09	76.07
1982	0.20	34.20	0.74	33.88	0.77	34.39	0.65	35.40	0.64	53.52
1983	1.67	31.54	0.68	31.53	0.26	34.20	0.11	44.45	0.03	102.42
1984	0.05	34.96	2.79	34.82	2.28	34.81	1.11	34.86	0.00	42.35
1985	0.17	33.13	2.20	31.14	2.00	30.92	0.09	42.26	0.05	70.88
1986	0.55	32.61	0.50	32.35	0.44	32.33	0.53	35.14	0.40	50.29
1987	0.29	31.46	2.41	31.25	0.20	36.73	0.37	42.09	0.57	49.16
1988	6.89	34.40	0.30	32.27	0.13	37.80	0.08	42.39	0.27	63.18
1989	3.45	30.01	2.80	29.48	0.15	31.76	0.05	50.39	0.07	63.01
1990	0.94	33.50	0.62	31.78	0.74	33.17	0.37	35.20	0.24	54.49
1991	0.98	32.68	0.98	31.77	0.43	32.48	0.39	45.09	0.10	49.62
1992	0.28	36.88	1.46	32.93	0.22	33.36	0.18	61.31	0.09	65.55
1993	0.14	36.53	2.48	33.93	3.36	33.83	3.58	36.08	0.85	45.44
1994	0.06	36.47	0.20	29.69	0.81	29.64	0.65	29.87	0.03	36.41
1995	1.52	29.45	1.12	28.86	1.14	29.17	0.10	33.35	0.03	68.62
1996	4.76	31.76	0.96	31.04	2.34	32.65	3.42	37.23	1.38	41.49
1997	2.13	32.11	0.73	30.38	3.56	29.79	0.96	30.06	0.53	38.89
1998	1.24	50.56	0.37	31.55	0.91	31.64	3.50	33.81	0.67	38.01
1999	0.16	70.30	0.02	46.98	0.24	38.14	1.79	40.55	9.68	41.85
2000	1.01	37.10	0.26	33.29	0.63	41.61	1.26	41.45	2.49	45.65
2001	0.09	38.80	1.93	37.79	1.16	40.44	0.61	46.17	0.50	57.48
2002	0.01	34.85	2.07	33.42	2.78	35.25	0.21	46.09	0.12	64.25
2003	0.03	81.05	0.48	49.42	0.23	53.58	0.57	45.88	0.87	59.88
2004	1.30	47.72	0.50	33.25	0.19	43.95	0.25	39.63	1.07	42.09
2005	2.03	31.57	0.77	30.57	1.16	34.77	0.22	38.87	0.63	47.59
2006	0.14	40.63	0.60	38.23	0.22	37.49	0.15	41.53	0.55	47.31
2007	-		0.13	38.11	0.66	36.65	1.49	36.75	1.57	39.24

Table 7. Description of available indices of abundance for the 2008 western bluefin tuna assessment. Note that the use of the models for the various VPA runs (continuity, base, extended boundary) is summarized in **Table 8**.

	CAN GLS	CAN SWNS	US RR<145
Age Min	13+	7	1
Age Max	13+	10	5
Catch Unit	Numbers	Numbers	Numbers
Effort Unit	Hour	Hour	Offset = log(Hours Fished)
Method	Delta-Lognormal	Delta-Lognormal	Delta-Poisson
Months Covered	Aug 1 - Oct 31	Aug 1 - Oct 31	June-Sept
Area Covered	Canada - Gulf of St. Lawrence	Canada - SW Nova Scotia	NE UNITED STATES

	CAN GLS		CAN SWNS		US RR<145	
YEAR	INDEX	CV	INDEX	CV	INDEX	CV
1970	-	-	-	-	-	-
1971	-	-	-	-	-	-
1972	-	-	-	-	-	-
1973	-	-	-	-	-	-
1974	-	-	-	-	-	-
1975	-	-	-	-	-	-
1976	-	-	-	-	-	-
1977	-	-	-	-	-	-
1978	-	-	-	-	-	-
1979	-	-	-	-	-	-
1980	-	-	-	-	0.799	0.430
1981	1.834	0.423	-	-	0.399	0.520
1982	1.741	0.437	-	-	2.102	0.330
1983	2.660	0.410	-	-	1.114	0.260
1984	1.501	0.424	-	-	0.000	0.000
1985	0.567	0.511	-	-	0.630	0.640
1986	0.727	0.544	-	-	0.778	0.430
1987	0.425	0.772	-	-	1.219	0.400
1988	0.803	0.589	2.100	0.500	0.988	0.380
1989	0.806	0.629	3.470	0.430	0.988	0.430
1990	0.458	0.583	2.170	0.430	0.904	0.340
1991	0.804	0.620	1.280	0.520	1.261	0.350
1992	0.872	0.543	1.300	0.390	0.820	0.420
1993	0.970	0.407	0.350	0.540	-	-
1994	0.332	0.487	1.220	0.390	-	-
1995	1.176	0.359	0.850	0.380	-	-
1996	0.402	0.378	0.360	0.490	-	-
1997	0.398	0.386	0.250	0.550	-	-
1998	0.753	0.371	0.370	0.480	-	-
1999	1.078	0.366	0.910	0.480	-	-
2000	0.914	0.370	0.170	0.610	-	-
2001	1.016	0.386	0.620	0.420	-	-
2002	0.911	0.423	0.410	0.600	-	-
2003	1.277	0.406	1.110	0.390	-	-
2004	2.271	0.416	0.490	0.490	-	-
2005	2.023	0.378	0.590	0.510	-	-
2006	2.034	0.378	1.020	0.380	-	-
2007	2.934	0.362	0.980	0.380	-	-

Table 7. Continued.

US RR66-114	US RR115-144	US RR145-177	US RR>195
2	4	6	8
3	5	7	10
Numbers	Numbers	Numbers	Numbers
Offset = log(Hours Fished)	Offset = log(Hours Fished)	Offset = log(Hours Fished)	Offset = log(Hours Fished)
Delta-Poisson	Delta-Poisson	Delta-Poisson	Delta-Poisson
June-Sept	June-Sept	June-Sept	June-Sept
NE UNITED STATES	NE UNITED STATES	NE UNITED STATES	NE UNITED STATES

US RR66-114		US RR115-144		US RR145-177		US RR>195	
INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	2.805	0.100
-	-	-	-	-	-	1.246	0.188
-	-	-	-	-	-	0.857	0.300
-	-	-	-	-	-	0.503	1.097
-	-	-	-	-	-	0.529	0.476
-	-	-	-	-	-	0.941	0.364
-	-	-	-	-	-	0.763	0.364
-	-	-	-	-	-	0.626	0.335
-	-	-	-	-	-	0.820	0.284
-	-	-	-	-	-	0.910	0.276
1.157	0.331	1.800	0.563	0.311	3.743	-	-
0.220	1.157	0.418	1.131	0.378	3.118	-	-
0.757	0.351	0.353	0.897	1.334	1.779	-	-
1.554	0.263	0.627	0.686	0.697	2.717	-	-
2.348	0.219	0.231	1.297	0.461	3.046	-	-
1.394	0.261	0.878	0.499	0.362	3.455	-	-
0.994	0.390	0.788	0.658	1.071	2.060	-	-
0.886	0.611	1.824	0.677	0.961	2.064	-	-
0.388	0.524	1.688	0.470	3.424	2.573	-	-
0.870	0.372	2.440	0.498	-	-	-	-
0.399	0.385	0.452	0.546	-	-	-	-
1.572	0.231	0.497	0.628	-	-	-	-
1.400	0.240	0.568	0.598	-	-	-	-
0.529	0.445	1.141	0.449	-	-	-	-
0.532	0.320	1.295	0.388	-	-	-	-

Table 7. Continued.

US RR>195 COMB	US RR>177	JLL AREA 2 (WEST)	JLL AREA 3 (31+32)
8	7	2	5
10	10	9	10
Numbers	Numbers	Numbers	Numbers
Offset = log(Hours Fished)	Offset = log(Hours Fished)		
Delta-Poisson	Delta-Poisson	Delta-lognormal	Delta-lognormal
June-Sept	June-Sept	Nov-Feb	Nov-Feb
NE UNITED STATES	NE UNITED STATES		

US RR>195 COMB		US RR>177		JLL AREA 2 (WEST)		JLL AREA 3 (31+32)	
INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	0.696	0.437	-	-
-	-	-	-	2.263	0.255	-	-
-	-	-	-	1.091	0.316	-	-
-	-	-	-	0.842	0.305	-	-
-	-	-	-	1.346	0.275	-	-
-	-	-	-	1.920	0.208	-	-
-	-	-	-	0.600	0.299	-	-
2.544	0.248	-	-	0.286	0.365	-	-
0.961	0.426	-	-	0.932	0.264	-	-
0.736	0.559	-	-	1.180	0.260	-	-
0.433	1.300	-	-	0.128	0.476	-	-
0.617	0.590	-	-	0.535	0.305	-	-
0.796	0.596	-	-	0.981	0.276	-	-
0.583	0.599	-	-	0.833	0.258	-	-
0.482	0.638	-	-	0.609	0.291	0.343	0.854
0.612	0.573	-	-	0.783	0.280	0.249	0.586
0.741	0.495	-	-	1.140	0.245	0.448	0.424
0.525	0.786	0.829	0.799	1.051	0.280	0.875	0.265
0.659	0.669	0.916	0.735	1.367	0.252	0.596	0.289
1.104	0.437	1.313	0.553	0.769	0.308	0.788	0.260
1.543	0.461	2.275	0.484	1.940	0.210	0.673	0.355
1.405	0.572	0.987	1.002	1.244	0.261	2.601	0.188
1.347	0.424	1.333	0.617	0.762	0.265	1.547	0.207
1.458	0.464	1.466	0.650	0.635	0.323	0.632	0.323
0.888	0.553	0.690	0.866	0.718	0.277	0.935	0.259
1.564	0.526	1.469	0.661	0.471	0.383	1.353	0.176
-	-	1.898	0.482	0.654	0.291	1.214	0.206
-	-	0.400	1.441	0.545	0.373	1.025	0.207
-	-	0.469	1.222	0.989	0.320	0.765	0.349
-	-	0.399	1.407	1.159	0.196	1.064	0.182
-	-	0.316	2.208	1.509	0.216	1.153	0.209
-	-	0.241	2.558	-	-	-	-

Table 7. Continued.

JLL AREA 17+18	JLL GOM	LARVAL ZERO INFLATED	US PLL GOM 1 - 6	US PLL GOM 1 - 6 Split
	10+	8	10+	10+
	10+	10	10+	10+
Numbers	Numbers	Index of Spawning Biomass	Numbers	Numbers
		CPUE = Larvae/100m^2	1000 Hooks	1000 Hooks
Delta-lognormal	Delta-lognormal	Delta-lognormal Zero inflated	Delta-lognormal	Delta-Lgn with Repeated Measures
Jan-Feb	Nov-Feb	Apr 20 - May 31	Jan 1 - May 31	Jan 1 - May 31
		Gulf of Mexico	Gulf of Mexico and US Florida East Coast	Gulf of Mexico and US Florida East Coast

JLL AREA 17+18		JLL GOM		LARVAL ZERO INFLATED		US PLL GOM 1 - 6		US PLL GOM 1 - 6 Split	
INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	0.968	0.266	-	-	-	-	-	-
-	-	0.534	0.205	-	-	-	-	-	-
2.123	0.593	0.666	0.207	-	-	-	-	-	-
1.989	0.382	0.913	0.216	2.504	0.476	-	-	-	-
1.307	0.411	0.876	0.225	4.869	0.234	-	-	-	-
1.115	0.371	1.287	0.283	-	-	-	-	-	-
1.446	0.337	1.158	0.265	-	-	-	-	-	-
1.743	0.309	0.553	0.239	0.735	0.433	-	-	-	-
1.000	0.392	-	-	1.356	0.292	-	-	-	-
0.547	0.438	-	-	1.202	0.354	-	-	-	-
1.201	0.338	-	-	0.367	0.556	-	-	-	-
0.705	0.412	-	-	-	-	-	-	-	-
0.714	0.491	-	-	0.404	0.434	-	-	-	-
0.636	0.411	-	-	0.346	0.476	2.840	0.280	2.510	0.340
1.032	0.360	-	-	1.084	0.317	1.500	0.320	1.210	0.400
1.202	0.343	-	-	0.765	0.368	2.480	0.290	2.040	0.350
1.524	0.345	-	-	0.332	0.337	1.660	0.320	1.290	0.400
1.228	0.386	-	-	0.388	0.590	2.200	0.310	1.880	0.370
2.039	0.333	-	-	0.527	0.360	0.910	0.340	0.770	0.430
0.989	0.372	-	-	0.498	0.670	0.560	0.410	0.490	0.520
2.338	0.337	-	-	0.487	0.352	0.430	0.450	0.380	0.590
1.308	0.368	-	-	0.348	0.558	0.330	0.500	0.290	0.660
1.583	0.394	-	-	0.966	0.516	0.260	0.530	0.240	0.700
0.466	0.517	-	-	0.408	0.412	0.550	0.400	0.510	0.510
1.112	0.374	-	-	0.117	0.553	0.400	0.480	0.380	0.610
0.458	0.701	-	-	0.512	0.531	0.780	0.350	1.090	0.270
0.662	0.393	-	-	0.344	0.545	0.800	0.370	1.040	0.270
0.916	0.859	-	-	0.387	0.383	0.580	0.410	0.840	0.290
0.750	0.526	-	-	0.304	0.660	0.590	0.420	0.870	0.290
0.103	2.541	-	-	0.737	0.410	0.740	0.370	1.150	0.250
0.651	0.686	-	-	0.541	0.681	1.090	0.330	1.220	0.240
1.376	0.326	-	-	0.230	0.327	0.720	0.380	1.000	0.250
1.609	0.390	-	-	0.605	0.358	0.540	0.450	0.710	0.300
-	-	-	-	0.355	0.405	1.060	0.360	1.090	0.240

Table 7. Continued.

	TAGGING	JLL Florida Historic	JLL Brazil Historic
Age Min	**1**	**2**	**2**
Age Max	**3**	**10**	**10**
Catch Unit	**Numbers**	**Numbers**	**Numbers**
Effort Unit	**-**	**-**	**-**
Method	**-**	**Delta lognormal**	**Delta lognormal**
Months Covered	**Mid-year**	**Nov-Feb**	**Nov-Feb**
Area Covered	**Gulf of Maine**	**Florida Eastern US**	**Brazil**

	TAGGING		JLL Florida Historic		JLL Brazil Historic	
YEAR	INDEX	CV	INDEX	CV	INDEX	CV
1960	-	-	-	-	0.580	0.314
1961	-	-	-	-	0.700	0.239
1962	-	-	-	-	2.406	0.140
1963	-	-	-	-	4.566	0.075
1964	-	-	6.084	0.094	2.119	0.083
1965	-	-	9.762	0.125	0.244	0.150
1966	-	-	7.375	0.141	0.111	0.356
1967	-	-	1.954	0.462	0.064	0.581
1968	-	-	2.481	0.584	0.108	0.511
1969	-	-	0.825	1.045	0.023	2.208
1970	1065132	0.200	0.050	4.670	0.014	2.082
1971	1001624	0.200	1.264	0.463	-	-
1972	431955	0.200	-	-	-	-
1973	183616	0.200	-	-	-	-
1974	341589	0.200	-	-	-	-
1975	554596	0.200	-	-	-	-
1976	253265	0.200	-	-	-	-
1977	257385	0.200	-	-	-	-
1978	121110	0.200	-	-	-	-
1979	98815	0.200	-	-	-	-
1980	192541	0.200	-	-	-	-
1981	337995	0.242	-	-	-	-
1982	-	-	-	-	-	-
1983	-	-	-	-	-	-
1984	-	-	-	-	-	-
1985	-	-	-	-	-	-
1986	-	-	-	-	-	-
1987	-	-	-	-	-	-
1988	-	-	-	-	-	-
1989	-	-	-	-	-	-
1990	-	-	-	-	-	-

Table 8. Model parameters used in western Atlantic VPA models.

Terminal F:

Continuity Case:

Age	Lower Bound	Best Est. (Numbers)	Upper Bound	Est. Method	SD
1	0	0.318 * F @ Age2	3	Fixed	NA
2	0.01	44560	5000000	Est. Frequentist	NA
3	0	1.0 * F @ Age2	3	Fixed	NA
4	0.01	21027	1000000	Est. Frequentist	NA
5	0	1.0 * F @ Age4	3	Fixed	NA
6	0.01	19833	1000000	Est. Frequentist	NA
7	0	1.0 * F @ Age6	3	Fixed	NA
8	0.01	10637	100000	Est. Frequentist	NA
9	0	1.0 * F @ Age8	3	Fixed	NA

All other runs:

Age	Lower Bound	Best Est. (Numbers)	Upper Bound	Est. Method	SD
1	0	9869	5000000	Est. Frequentist	NA
2	0	31233	5000000	Est. Frequentist	NA
3	0	70437	5000000	Est. Frequentist	NA
4	0	17391	5000000	Est. Frequentist	NA
5	0	14446	1000000	Est. Frequentist	NA
6	0	27115	1000000	Est. Frequentist	NA
7	0	22619	1000000	Est. Frequentist	NA
8	0	6716	100000	Est. Frequentist	NA
9	0	23940	100000	Est. Frequentist	NA

F-Ratio:

Continuity, Base and Sensitivity Cases 2, 3, 5, 7 and 9.:

YEAR	Best Estimate Ratio F_{10+}/F_9	Estimation Method	SD
1970-1973	1	Fixed	0
1974-1981	0.509	Estimated as Frequentist Parameter	NA
1982-2007	1.14	Estimated as random deviation from Prior	0.25

Case 4:

YEAR	Best Estimate Ratio F_{10+}/F_9	Estimation Method	SD
1960-1969	1	Fixed	NA
1970-1981	1	Estimated as random deviation from Prior	0.25
1982-2007	1.14	Estimated as random deviation from Prior	0.25

Case 6:

YEAR	Best Estimate Ratio F_{10+}/F_9	Estimation Method	SD
1970-1973	1	Fixed	NA
1974-1981	0.509	Estimated as Frequentist Parameter	NA
1982-1989	1.14	Estimated as random deviation from Prior	0.25
1990-2007	1.14	Estimated using a random walk from a parameter estimate obtained using a deviation from a prior	0.25

Case 9:

YEAR	Best Estimate Ratio F_{10+}/F_9	Estimation Method	SD
1970-1973	1	Fixed	NA
1974-1981	0.509	Estimated as Frequentist Parameter	NA
1982-2001	1.14	Estimated as random deviation from Prior	0.25
2002-2007	1.14	Estimated as Frequentist Parameter	NA

Table 9. Key to indices used for the WBFT continuity run, base-case, and sensitivity runs (Cases 2-9).

Index/Run	*Cont*	*Base*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
CAN GSL ADJ	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
CAN SWNS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
US RR<145	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes
US RR66-114	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes
US RR115-144	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes
US RR145-177										
US RR>195	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
US RR>195 COMB										
US RR>177	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
JLL AREA 2 (WEST)	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes
JLL AREA 3 (31+32)				Yes						
JLL AREAS 17+18			Yes							
LARVAL ZERO INFLATED	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
GOMPLL 1-6	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes
GOMPLL 1-6 Early						Yes				
GOMPLL 1-6 Late						Yes				
JLL GOM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TAGGING	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
JLL Florida Historic					Yes					
JLL Brazil Historic					Yes					

Table 10. Estimates of average total mortality for spawning BFT in the eastern Atlantic and Mediterranean from year-class curve analyses based on Japanese longline cpue data. Fishing mortality values are obtained assuming M=0.1 for those ages.

Age range 8-14						*Age range 9-14*				
Fishing years	*Cohorts*	*Z*	*F*	*p-values*		*Fishing years*	*Cohorts*	*Z*	*F*	*p-values*
1984-1989	1975	0.2632	0.1632	0.0311		1984-1989	1975	0.330	0.230	0.043
1985-1990	1976	0.2710	0.1710	0.0329		1985-1990	1976	0.291	0.191	0.089
1986-1991	1977	0.2822	0.1822	0.0635		1986-1991	1977	0.391	0.291	0.052
1987-1992	1978	0.1937	0.0937	0.0827		1987-1992	1978	0.328	0.228	0.007
1988-1993	1979	0.2764	0.1764	0.0016		1988-1993	1979	0.281	0.181	0.011
1989-1994	1980	0.2600	0.1600	0.0122		1989-1994	1980	0.307	0.207	0.025
1990-1995	1981	0.2598	0.1598	0.0110		1990-1995	1981	0.349	0.249	0.004
1991-1996	1982	0.3613	0.2613	0.0095		1991-1996	1982	0.409	0.309	0.026
1992-1997	1983	0.4010	0.3010	0.0093		1992-1997	1983	0.500	0.400	0.011
1993-1998	1984	0.3028	0.2028	0.0184		1993-1998	1984	0.354	0.254	0.039
1994-1999	1985	0.4034	0.3034	0.0208		1994-1999	1985	0.574	0.474	0.005
1995-2000	1986	0.3999	0.2999	0.0050		1995-2000	1986	0.427	0.327	0.021
1996-2001	1987	0.3371	0.2371	0.0083		1996-2001	1987	0.370	0.270	0.028
1997-2002	1988	0.3264	0.2264	0.0551		1997-2002	1988	0.458	0.358	0.038
1998-2003	1989	0.2939	0.1939	0.0502		1998-2003	1989	0.353	0.253	0.085
1999-2004	1990	0.2977	0.1977	0.0650		1999-2004	1990	0.385	0.285	0.079
2000-2005	1991	0.5291	0.4291	0.0284		2000-2005	1991	0.672	0.572	0.036
2001-2006	1992	0.3302	0.2302	0.0375		2001-2006	1992	0.454	0.354	0.026

Table 11. Eastern Atlantic and Mediterranean recent stock status indicators across the catch at age matricies used in the analysis.

	Adjusted CAA	*Unadjusted CAA*
$F/F_{0.1}$	7.05	6.78
$F/F_{30\%SPR}$	4.41	4.04
F/F_{MAX}	3.34	3.08
$F/F_{20\%SPR}$	2.66	2.36
$SSB/SSB_{0.1}$	0.11	0.12
$SSB/SSB_{30\%}$	0.15	0.17
SSB/SSB_{MAX}	0.18	0.20
$SSB/SSB_{20\%}$	0.22	0.25

Table 12. Summary statistics and diagnostic output for VPA runs. Only models with the same inputs are directly comparable (Cont, Base, Cases 6 and 8). AIC, AICc and BIC criteria cannot be computed accurately when the number of parameters exceeds the number of data point (Case 7).

	CONT	*BASE **	*CASE 2*	*CASE 3*	*CASE 4*	*CASE 5*	*CASE 6 **	*CASE 7*	*CASE 8 **	*CASE 9*
Total objective function	-6.9	7.5	10.5	-6.1	69.6	5.2	-36.0	390.98	6.1	9.3
(with constants)	292.1	306.5	283.1	305.3	376.4	305.1	263.0	-91.98	305.2	288.5
Number of parameters	19	24	21	25	26	25	42	320	25	23
Number of data points	214	214	172	231	233	214	214	214	214	187
AIC :	622.3	660.9	608.1	660.5	804.9	660.2	610.0	NA	660.3	623.1
AICc:	626.2	667.3	614.3	666.9	811.7	667.1	631.1	NA	667.2	629.9
BIC :	686.2	741.7	674.2	746.6	894.6	744.3	751.3	NA	744.4	697.4
Chi-square discrepancy	190.8	191.0	148.3	202.6	270.7	185.6	180.5	232.79	185.6	159.4
Loglikelihoods	5.6	5.8	2.4	11.1	-51.6	7.9	8.7	407.7	6.8	4.9
effort data	5.6	5.8	2.4	11.1	-51.6	7.9	8.7	-7.3	6.8	4.9
Log-posteriors	1.3	1.4	1.4	1.3	-4.3	1.4	40.6	-0.6	0.9	1.4
catchability	0.0	0.0	0.0	0.0	0.0	0.0	0.0	415.0	0.0	0.0
f-ratio	1.3	1.4	1.4	1.3	-4.3	1.4	40.6	-0.6	0.9	1.4
Constraints	0.0	-14.6	-14.3	-6.2	-13.7	-14.5	-13.3	-16.1	-13.9	-15.5
terminal F	0.0	-14.6	-14.3	-6.2	-13.7	-14.5	-13.3	-16.1	-13.9	-15.5
Comments		*					*	**	*	

* Only models with the same inputs and constraints are directly comparable (Base, Cases 6 and 8).
** For Case 7, the number of model parameters is higher than the number of data points because the catchability coefficients are estimated as a random walk (the variance was very low, so the effective number of parameters is less than the number of data points, nevertheless the AIC criteria would not apply).

Table 13. Sensitivity of the Base Case assessment for western bluefin tuna to the exclusion of various indices of abundance. The table shows the values of various estimates when one index is removed from the analysis.

Index Out	SSB_{1970}	SSB_{2007}	*S07/S70*	F_{max}	F_{2007}	$F_{2007}/Fmax$
None(base)	49642	8733	0.18	0.19	0.17	0.89
CanGSL	68774	7117	0.10	0.19	0.19	1.01
CanSWNS	50991	9459	0.19	0.19	0.16	0.85
JLLArea2	42860	8197	0.19	0.19	0.19	0.97
JLLGoM	86672	8600	0.10	0.20	0.18	0.91
Larval	28221	9864	0.35	0.19	0.16	0.83
Tagging	47963	8648	0.18	0.20	0.18	0.90
USLLGoM	54505	9865	0.18	0.19	0.15	0.82
USRR<145	48293	8700	0.18	0.20	0.18	0.90
USRR>177	41620	9412	0.23	0.22	0.19	0.86
USRR>195	47900	8579	0.18	0.20	0.18	0.91
USRR115-144	49685	8292	0.17	0.19	0.18	0.94
USRR66-114	46478	8517	0.18	0.20	0.18	0.91

Table 14. Estimated percent overlap rates for the five scenarios. The East and West overlap rates refer to the percentage of the eastern-origin population that moves west and the percentage of the western-origin population that moves east, respectively.

Model	*Stock*	*Age 1-3*	*Age 4-7*	*Age 8-10+*
Tag-full	East	0.31	3.54	1.73
Tag-reduced	East	0	2.90	2.10
Tag-reduced-Fratio	East	0	2.69	2.04
Proportion	East	3.4	5.5	0.04
Proportion-F-ratio	East	2.42	5.5	0.01
Tag-full	West	4.33	37.78	23.20
Tag-reduced	West	10.5	57.89	32.20
Tag-reduced-Fratio	West	10.55	56.20	30.10
Proportion	West	<0.01	<0.01	<0.01
Proportion-F-ratio	West	<0.01	<0.01	20.50

Table 15. Estimates of the total number of vessels fishing bluefin tuna in the Mediterranean Sea during 2007 (*i.e.* active capacity), probable catch (yield) estimated from catch per vessel per year (catch rates or CPU). Calculations are based on ICCAT vessels list and/or information from national scientists and are expressed in t/year.

Mediterranean 2007			*Active fleet*
Vessel category	*Nb Vessels*	*Catch rates*	*Estimated yields*
PS large (>= 40 m)	83	150 - 300	17550
PS medium (> 24 m & < 40 m)	205	75 - 150	22050
PS small (<= 24 m)	63	20 - 40	2040
LL large (>= 40 m)	43	50	2150
LL medium (> 24 m & < 40 m)	9	20	180
LL small (<= 24 m)	221	10	2210
Handline	127	3	381
Trawler	25	2	50
Trap	10	40	400
Other artisanal	220	4	880
Total Mediterranean	1006		47891
Mediterranean PS			41640
Mediterranean LL			4540
Mediterranean OTH			1711

Table 16. Estimates of the total number of vessels fishing bluefin tuna in the eastern Atlantic during 2007(*i.e.* active capacity), probable catch (yield) estimated from catch per vessel per year (catch rates or CPU). Calculations are based on ICCAT vessels list and/or information from national scientists and are expressed in t/year.

East Atlantic 2007			*Active fleet*
Vessel category	*Nb Vessels*	*Catch_rates*	*Estimated yields*
PS medium (> 24 m & < 40 m)	30	50	1500
PS small (<= 24 m)	4	25	100
LL large (>= 40 m)	55	50	2750
LL medium (> 24 m & < 40 m)	29	20	580
LL small (<= 24 m)	13	10	130
Baitboat > 24 m	39	40	1560
Baitboat <= 24 m	42	15	630
Handline	12	5	60
Trawler	98	15	1470
Trap	18	245	4410
Other artisanal	20	3	60
Total East-Atlantic	330		13250
East-Atlantic PS			1600
East-Atlantic LL			3460
East-Atlantic OTH			8190

Table 17. Estimates of bluefin tuna vessels that are currently fishing BFT or could target BFT in the Mediterranean Sea during 2007 (*i.e.* potential capacity), potential catch (yield) estimated from catch per vessel per year (catch rates or CPU). Calculations are based on ICCAT vessels list and/or information from national scientists and are expressed in t/year.

Mediterranean 2007	*Potential fleet*		*Potential catch*
Vessel category	*Nb Vessels*	*Catch rates*	*Estimated yields*
PS large (>= 40 m)	83	150 - 300	17550
PS medium (> 24 m & < 40 m)	205	75 - 150	22050
PS small (<= 24 m)	71	20 - 40	2360
LL large (>= 40 m)	56	50	2800
LL medium (> 24 m & < 40 m)	17	20	340
LL small (<= 24 m)	731	10	7310
Handline	312	3	936
Trawler	25	2	50
Trap	10	40	400
Other artisanal	562	4	2248
Total Mediterranean	2072		56044
Mediterranean PS			41960
Mediterranean LL			10450
Mediterranean OTH			3634

Table 18. Estimations of bluefin tuna vessels that are currently fishing BFT or could target BFT in the east Atlantic during 2007 (i.e. potential capacity), potential catch (yield) estimated from catch per vessel per year (catch rates or CPU). Calculations are based on ICCAT vessels list and/or information from national scientists and are expressed in t/year.

East Atlantic 2007	*Potential fleet*		*Potential catch*
Vessel category	*Nb Vessels*	*Catch_rates*	*estimated yields*
PS medium (> 24 m & < 40 m)	30	50	1500
PS small (<= 24 m)	4	25	100
LL large (>= 40 m)	55	50	2750
LL medium (> 24 m & < 40 m)	29	20	580
LL small (<= 24 m)	288	10	2880
Baitboat > 24 m	63	40	2520
Baitboat <= 24 m	42	15	630
Handline	12	5	60
Trawler	98	15	1470
Trap	18	245	4410
Other artisanal	20	3	60
Total East-Atlantic	629		16960
East-Atlantic PS			1600
East-Atlantic LL			6210
East-Atlantic OTH			9150

Table 19. Summary table of the different projection scenarios that have performed using FLR framework.

Scenario	*VPA*	*Steepness*	*Mean Recruitment*	*Selectivity*
1	Reported	0.5	medium	Rec. [06-05]
2	adjusted	0.5	medium	Rec. [06-05]
3	Reported	0.75	medium	Rec. [06-05]
4	adjusted	0.75	medium	Rec. [06-05]
5	Reported	0.99	medium	Rec. [06-05]
6	adjusted	0.99	medium	Rec. [06-05]
7	Reported	0.5	high	Rec. [06-05]
8	adjusted	0.5	high	Rec. [06-05]
9	Reported	0.75	high	Rec. [06-05]
10	adjusted	0.75	high	Rec. [06-05]
11	Reported	0.99	high	Rec. [06-05]
12	adjusted	0.99	high	Rec. [06-05]
13	Reported	0.5	medium	Rec. [06-05] 20%
14	adjusted	0.5	medium	Rec. [06-05] 20%
15	Reported	0.75	medium	Rec. [06-05] 20%
16	adjusted	0.75	medium	Rec. [06-05] 20%
17	Reported	0.99	medium	Rec. [06-05] 20%
18	adjusted	0.99	medium	Rec. [06-05]20%
19	Reported	0.5	high	Rec. [06-05] 20%
20	adjusted	0.5	high	Rec. [06-05]20%
21	Reported	0.75	high	Rec. [06-05] 20%
22	adjusted	0.75	high	Rec. [06-05] 20%
23	Reported	0.99	high	Rec. [06-05] 20%

24	adjusted	0.99	high	Rec. [06-05] 20%
25	Reported	0.5	medium	Rec. [06-05]& F0.1
26	adjusted	0.5	medium	Rec. [06-05]& F0.1
27	Reported	0.75	medium	Rec. [06-05] & F0.1
28	adjusted	0.75	medium	Rec. [06-05] & F0.1
29	Reported	0.99	medium	Rec. [06-05] & F0.1
30	adjusted	0.99	medium	Rec. [06-05] & F0.1
31	Reported	0.5	high	Rec. [06-05] & F0.1
32	adjusted	0.5	high	Rec. [06-05]& F0.1
33	Reported	0.75	high	Rec. [06-05] & F0.1
34	adjusted	0.75	high	Rec. [06-05] & F0.1
35	Reported	0.99	high	Rec. [06-05] & F0.1
36	adjusted	0.99	high	Rec. [06-05] & F0.1
37	Reported	0.5	medium	Rec. [06-05] & Fmax
38	adjusted	0.5	medium	Rec. [06-05] & Fmax
39	Reported	0.75	medium	Rec. [06-05] & Fmax
40	adjusted	0.75	medium	Rec. [06-05] & Fmax
41	Reported	0.99	medium	Rec. [06-05] & Fmax
42	adjusted	0.99	medium	Rec. [06-05] & Fmax
43	Reported	0.5	high	Rec. [06-05] & Fmax
44	adjusted	0.5	high	Rec. [06-05] & Fmax
45	Reported	0.75	high	Rec. [06-05] & Fmax
46	adjusted	0.75	high	Rec. [06-05] & Fmax
47	Reported	0.99	high	Rec. [06-05] & Fmax
48	adjusted	0.99	high	Rec. [06-05] & Fmax

Table 20. F-multiplers being applied to current F-selectivity vector according to Rec. [06-05] to either perfect implementation and a 20% implementation error.

	Full implementation	20% error implementation
Age 1	0	0.200
Age 2	0.315	0.468
Age 3	0.199	0.325
Age 4	0.320	0.436
Age 5	0.944	0.994
Age 6	0.973	0.997
Age 7	0.989	0.999
Age 8	0.899	0.997
Age 9	0.963	0.996
Age 10	0.912	0.998

Table 21. Table of benchmarks and reference points for the base VPA model under the low and high recruitment scenarios.

	BASE - 2 Line (low recruitment scenario)			BASE - B&H (high recruitment scenario)		
MEASURE	LOWER CI	MEDIAN	UPPER CI	LOWER CI	MEDIAN	UPPER CI
F at MSY	0.13	0.15	0.17	0.07	0.09	0.10
MSY	2680.3	2851.9	3031.9	4886.5	6201.1	9142.2
Y/R at MSY	39.6	41.3	43.2	36.5	38.7	40.9
S/R at MSY	215.3	220.2	223.9	354.2	377.7	408.6
SPR AT MSY	0.20	0.20	0.21	0.33	0.35	0.38
SSB AT MSY	14549	15148	15783	44626	59921	100045
F at max. Y/R	0.13	0.15	0.17	0.13	0.15	0.17
Y/R maximum	39.6	41.3	43.2	39.6	41.3	43.1
S/R at Fmax	215.3	220.2	223.9	215.5	220.3	224.2
SPR at Fmax	0.20	0.20	0.21	0.20	0.20	0.21
SSB at Fmax	14549	15148	15783	22914	27669	38546
F 0.1	0.08	0.08	0.09	0.08	0.08	0.09
Y/R at F0.1	37.0	38.4	39.9	37.0	38.4	39.9
S/R at F0.1	383.1	389.9	396.6	383.4	389.9	396.4
SPR at F0.1	0.36	0.36	0.37	0.36	0.36	0.37
SSB at F0.1	25699	26854	28062	49507	62527	93849
F 20% SPR	0.14	0.15	0.17	0.14	0.15	0.17
Y/R at F20	39.6	41.3	43.2	39.6	41.3	43.1
S/R at F20	216.6	217.3	218.0	216.6	217.3	218.0
SSB at F20	14328	14955	15677	22621	27276	37657
F 30% SPR	0.09	0.10	0.12	0.09	0.10	0.12
Y/R at F30	38.4	40.1	41.8	38.4	40.1	41.8
S/R at F30	324.5	325.6	326.9	324.4	325.6	326.8
SSB at F30	21462	22407	23498	39583	49426	72637
F 40% SPR	0.07	0.07	0.08	0.07	0.07	0.08
Y/R at F40	35.4	36.9	38.5	35.4	36.9	38.4
S/R at F40	432.3	434.2	435.8	432.2	434.0	435.9
SSB at F40	28612	29884	31252	56144	71433	109621
SSB 2007	6743	8506	10983	6743	8506	10983
SSB 2007 / SSB MSY	0.46	0.57	0.70	0.08	0.14	0.21
F Current	0.15	0.19	0.24	0.15	0.19	0.24
F Current / FMSY	1.04	1.27	1.53	1.74	2.18	2.64

Table 22. Table of benchmarks and reference points for the case 9 VPA model under the low and high recruitment scenarios.

	CASE 9 - 2 Line (low recruitment scenario)			CASE 9 - B&H (high recruitment scenario)		
MEASURE	LOWER CI	MEDIAN	UPPER CI	LOWER CI	MEDIAN	UPPER CI
F at MSY	0.13	0.15	0.17	0.07	0.09	0.10
MSY	2582.8	2755.2	2916.5	4739.4	5698.2	9209.7
Y/R at MSY	39.7	41.4	43.0	36.3	38.6	40.6
S/R at MSY	213.5	218.6	222.6	359.7	383.6	414.6
SPR AT MSY	0.20	0.20	0.21	0.33	0.36	0.39
SSB AT MSY	13929	14464	15107	44302	56029	97929
F at max. Y/R	0.13	0.15	0.17	0.13	0.15	0.17
Y/R maximum	39.7	41.4	43.0	39.7	41.4	43.0
S/R at Fmax	213.5	218.6	222.6	214.5	219.1	222.9
SPR at Fmax	0.20	0.20	0.21	0.20	0.20	0.21
SSB at Fmax	13929	14464	15107	20832	25046	38358
F 0.1	0.08	0.09	0.09	0.08	0.09	0.09
Y/R at F0.1	37.1	38.5	39.8	37.0	38.5	39.8
S/R at F0.1	381.6	388.7	395.5	382.3	388.7	395.6
SPR at F0.1	0.35	0.36	0.37	0.36	0.36	0.37
SSB at F0.1	24644	25809	26922	47675	57398	91576
F 20% SPR	0.13	0.15	0.17	0.14	0.15	0.17
Y/R at F20	39.7	41.4	43.0	39.7	41.4	43.0
S/R at F20	216.6	217.3	218.0	216.6	217.4	218.0
SSB at F20	13887	14409	15057	21002	24586	37605
F 30% SPR	0.09	0.10	0.11	0.09	0.10	0.11
Y/R at F30	38.5	40.2	41.7	38.5	40.2	41.7
S/R at F30	324.5	325.6	326.8	324.4	325.5	326.8
SSB at F30	20750	21620	22556	38043	45144	71777
F 40% SPR	0.07	0.07	0.08	0.07	0.07	0.08
Y/R at F40	35.5	37.0	38.3	35.4	37.0	38.3
S/R at F40	432.2	434.0	435.9	432.3	434.0	435.9
SSB at F40	27733	28769	30114	54831	65762	106657
SSB 2007	5233	6675	8511	5189	6672	8423
SSB 2007 / SSB MSY	0.38	0.46	0.57	0.06	0.12	0.17
F Current	0.18	0.22	0.28	0.18	0.22	0.28
F Current / FMSY	1.24	1.48	1.77	2.12	2.58	3.12

Table 23. Estimated chance of recovery under the high and low recruitment scenarios and two alternative assessment models (green=Yes, with year of recovery shown, red=No).

50% Probability				
Projected Catch Level (mt)	Base Case		Removing GSL (Case 9)	
	Low	High	Low	High
0	2012	No	2013	No
500	2012	No	2013	No
1000	2013	No	2014	No
1500	2014	No	2016	No
1600	2014	No	2017	No
1700	2015	No	2017	No
1800	2015	No	2018	No
1900	2015	No	2019	No
2000	2016	No	No	No
2100	2017	No	No	No
2200	2017	No	No	No
2300	2018	No	No	No
2400	2019	No	No	No
2500	No	No	No	No
2600	No	No	No	No
2700	No	No	No	No
3000	No	No	No	No
5000	No	No	No	No

75% Probability				
Projected Catch Level (mt)	Base Case		Removing GSL (Case 9)	
	Low	High	Low	High
0	2013	No	2013	No
500	2013	No	2014	No
1000	2014	No	2016	No
1500	2015	No	2019	No
1600	2016	No	No	No
1700	2016	No	No	No
1800	2017	No	No	No
1900	2018	No	No	No
2000	2019	No	No	No
2100	No	No	No	No
2200	No	No	No	No
2300	No	No	No	No
2400	No	No	No	No
2500	No	No	No	No
2600	No	No	No	No
2700	No	No	No	No
3000	No	No	No	No
5000	No	No	No	No

Table 24. Estimated chance of ending overfishing under the high and low recruitment scenarios and two alternative assessment models. Entries are year overfishing ends or "no" if overfishing has less than the given probability of success by 2019.

50% Probability				
Projected Catch Level (mt)	Base Case		Removing GSL (Case 9)	
	Low	High	Low	High
0	2009	2009	2009	2009
500	2009	2009	2009	2009
1000	2009	2009	2009	2011
1500	2009	2009	2009	2017
1600	2009	2010	2010	2018
1700	2009	2011	2011	No
1800	2009	2012	2012	No
1900	2009	2013	2013	No
2000	2010	2014	2015	No
2100	2011	2015	2016	No
2200	2012	2016	2019	No
2300	2014	2017	No	No
2400	2015	2018	No	No
2500	2017	No	No	No
2600	No	No	No	No
2700	No	No	No	No
3000	No	No	No	No
5000	No	No	No	No
75% Probability				
Projected Catch Level (mt)	Base Case		Removing GSL (Case 9)	
	Low	High	Low	High
0	2009	2009	2009	2009
500	2009	2009	2009	2009
1000	2009	2010	2009	2013
1500	2009	2015	2011	No
1600	2009	2016	2012	No
1700	2009	2018	2014	No
1800	2011	2019	2015	No
1900	2012	No	2018	No
2000	2013	No	No	No
2100	2014	No	No	No
2200	2016	No	No	No
2300	2019	No	No	No
2400	No	No	No	No
2500	No	No	No	No
2600	No	No	No	No
2700	No	No	No	No
3000	No	No	No	No
5000	No	No	No	No

Table 25. Table of percent increase in weight for the harvests that showed positive growth. Increase in weight was determined from the difference between the assumed weights at capture based on measured lengths at harvest and the ICCAT length-weight conversion for Mediterranean BFT from the reported weights of the sample or reported total catch, when provided.

UniqueID, based on the combination of flag, Year, Reported total catch, reported weight of sample and reported number of fish	*1. Reported weight of sample (kg)*	*2. Reported total catch (kg)*	*3. Weight from sum of reported lengths using L-W regression (Kg)*	*% increase (1-3)/3 or (2-3)/3*	*Number of fish*	*Note*
Turkey 2005 NA 129434 1384	129,434	NA	115,392	12.2%	1384	A
Turkey 2005 NA 34780 350	34,780	NA	24,229	43.5%	350	A
Turkey 2005 NA 4439 48	4,439	NA	3,071	44.5%	48	A
Turkey 2005 NA 46064 587	46,064	NA	41,420	11.2%	587	A
Turkey 2005 NA 77088 1028	77,088	NA	69,524	10.9%	1028	A
Turkey 2006 NA 33513 629	33,513	NA	30,612	9.5%	629	A
Turkey 2006 NA 90038 1282	90,038	NA	81,662	10.3%	1282	A
EC.España 2005 1122 NA NA	NA	1,122	1,077	4.2%	5	B
EC.España 2005 1169 NA NA	NA	1,169	802	45.8%	6	B
EC.España 2005 534 NA NA	NA	534	439	21.6%	3	B
EC.España 2005 572 NA NA	NA	572	371	54.3%	3	B
EC.España 2006 1482 NA NA	NA	1,482	1,145	29.4%	17	B
EC.España 2006 1656 NA NA	NA	1,656	1,406	17.8%	32	B
EC.España 2006 1691 NA NA	NA	1,691	1,155	46.5%	21	B
EC.España 2006 2135 NA NA	NA	2,135	1,739	22.7%	22	B
EC.España 2006 2283 NA NA	NA	2,283	1,568	45.6%	16	B
EC.España 2006 2963 NA NA	NA	2,963	2,538	16.8%	46	B
EC.España 2006 3268 NA NA	NA	3,268	2,860	14.3%	13	B
EC.España 2006 3715 NA NA	NA	3,715	3,244	14.5%	20	B
EC.España 2006 4123 NA NA	NA	4,123	3,484	18.3%	35	B
EC.España 2006 4551 NA NA	NA	4,551	3,932	15.7%	18	B
EC.España 2006 4566 NA NA	NA	4,566	3,732	22.3%	35	B
EC.España 2006 5284 NA NA	NA	5,284	3,597	46.9%	20	B
EC.España 2006 5664 NA NA	NA	5,664	4,871	16.3%	20	B
EC.España 2006 679 NA NA	NA	679	603	12.6%	10	B
EC.España 2006 781 NA NA	NA	781	664	17.6%	12	B
EC.España 2006 7826 NA NA	NA	7,826	6,362	23.0%	36	B
Mean of percentages				24.0%		
Median of percentages				17.8%		
Overall percentage		471,420	411,500	14.56%		
Mean Turkey				20.3%		
Median Turkey				11.2%		
Mean Spain				25.3%		
Median Spain				19.9%		

Note A. This recent data from Turkey has both length and weight by size classes, as well as weight of the harvest.
Note B. The results appear legitimate but the harvests are very low, between 3 and 46 fish. It is disturbing that there are some decreases in weight for EC.España in Note C, Table 2, and one is for the largest Spanish trap harvest (26,068 kg).

Table 26. Table unique combinations of flag, year, reported total catch, reported weight of sample and reported number of fish that showed negative or strange growth.

UniqueID, based on the combination of flag, Year, Reported total catch, reported weight of sample and reported number of fish	*1. Reported weight of sample (kg)*	*2. Reported total catch (kg)*	*3. Weight from sum of reported lengths using L-W regression (Kg)*	*% increase (1-3)/3 or (2-3)/3*	*Number of fish*	*Note*
EC.Cyprus 2006 77399 NA NA	NA	77399	82381	-6.05%	403	C
EC.España 2005 1043 NA NA	NA	1043	1067	-2.27%	5	C
EC.España 2006 26068 NA NA	NA	26068	26516	-1.69%	150	C
EC.Greece 2005 13850 NA NA	NA	13850	14295	-3.11%	100	C
EC.Greece 2005 14795 NA NA	NA	14795	15520	-4.67%	143	C
EC.Greece 2005 15119 NA NA	NA	15119	16518	-8.47%	105	C
EC.Malta 2005 18733 NA NA	NA	18733	20010	-6.38%	59	C
EC.Malta 2005 22294 NA NA	NA	22294	23919	-6.80%	97	C
EC.Malta 2005 23140 NA NA	NA	23140	25211	-8.22%	91	C
EC.Malta 2005 25620 NA NA	NA	25620	26398	-2.95%	200	C
EC.Malta 2005 29362 NA NA	NA	29362	31261	-6.07%	96	C
EC.Malta 2005 30737 NA NA	NA	30737	31706	-3.06%	200	C
EC.Malta 2005 33070 NA NA	NA	33070	33650	-1.72%	200	C
EC.Malta 2005 39823 NA NA	NA	39823	44054	-9.61%	151	C
EC.Malta 2005 41117 NA NA	NA	41117	42441	-3.12%	130	C
EC.Malta 2005 41674 NA NA	NA	41674	44127	-5.56%	146	C
EC.Malta 2005 42757 NA NA	NA	42757	46386	-7.82%	203	C
EC.Malta 2005 43537 NA NA	NA	43537	44228	-1.56%	200	C
EC.Malta 2005 43820 NA NA	NA	43820	44814	-2.22%	200	C
EC.Malta 2005 56088 NA NA	NA	56088	59466	-5.68%	169	C
EC.Malta 2005 56325 NA NA	NA	56325	59501	-5.34%	193	C
EC.Malta 2005 8195 NA NA	NA	8195	9123	-10.17%	52	C
EC.Cyprus 2006 63313 NA NA	NA	63313	73371	-13.71%	280	D
EC.Greece 2005 12926 NA NA	NA	12926	15981	-19.11%	107	D
EC.Greece 2005 4785 NA NA	NA	4785	6134	-21.99%	63	D
EC.Italy 2004 35843 NA NA	NA	35843	46066	-22.19%	189	D
EC.Malta 2005 195 NA NA	NA	195	287	-32.02%	3	D
EC.Malta 2005 20068 NA NA	NA	20068	22705	-11.61%	105	D
EC.Malta 2005 27653 NA NA	NA	27653	31711	-12.80%	101	D
EC.Malta 2005 305 NA NA	NA	305	368	-17.23%	2	D
Turkey 2004 423383 NA NA	NA	423383	641157	-33.97%	7880	D
EC.Malta 2005 14194 NA NA	NA	14194	4313	229.09%	200	E
EC.Malta 2005 24791 NA NA	NA	24791	10789	129.79%	200	E
EC.Malta 2005 25474 NA NA	NA	25474	11908	113.92%	200	E
EC.Malta 2005 29820 NA NA	NA	29820	14405	107.01%	200	E
EC.Malta 2005 30525 NA NA	NA	30525	14630	108.64%	200	E
EC.Malta 2005 53104 NA NA	NA	53104	41374	28.35%	200	E
EC.Malta 2005 53655 NA NA	NA	53655	42419	26.49%	200	E

Note C. The reported total catch is lower than if we applied the L-W regression but is within 10%. This could be due to growth in length during tenure in the farms but without further information we cannot explain these differences.
Note D. The reported total catch is much lower than if we applied the L-W regression. We have no explanation for this.
Note E. Increase greater than 100%, for many samples from Malta. This requires further exploration.

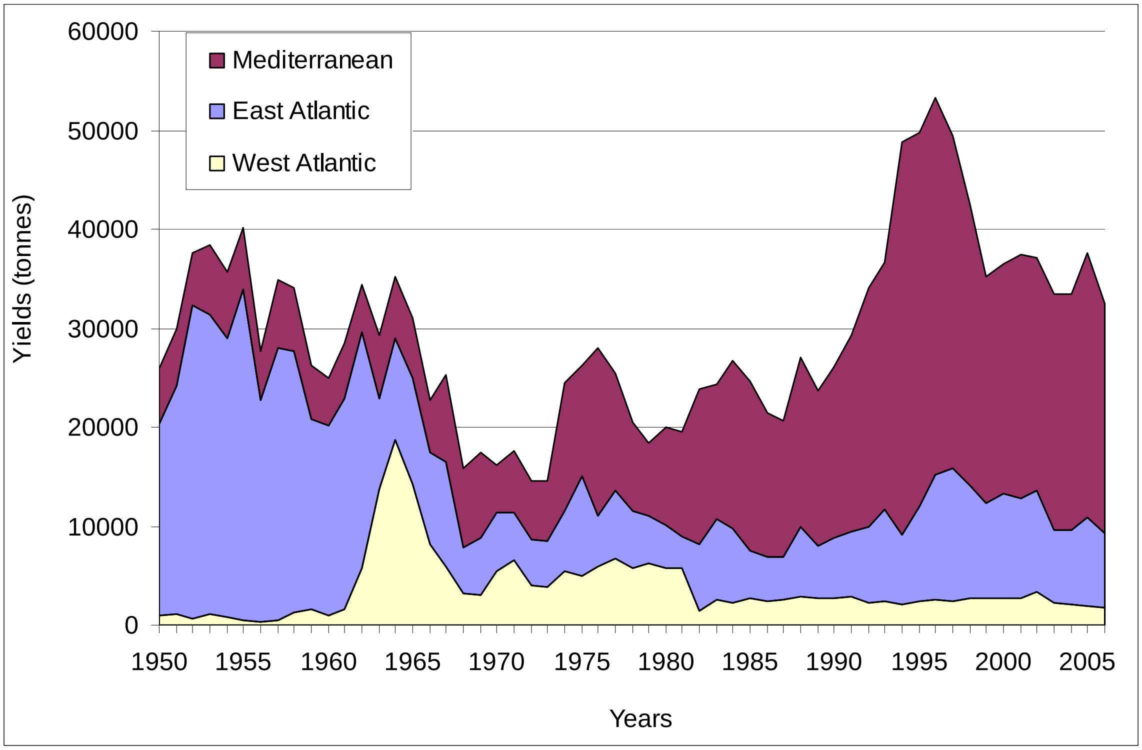


Figure 1. Bluefin reported catches by year and area.

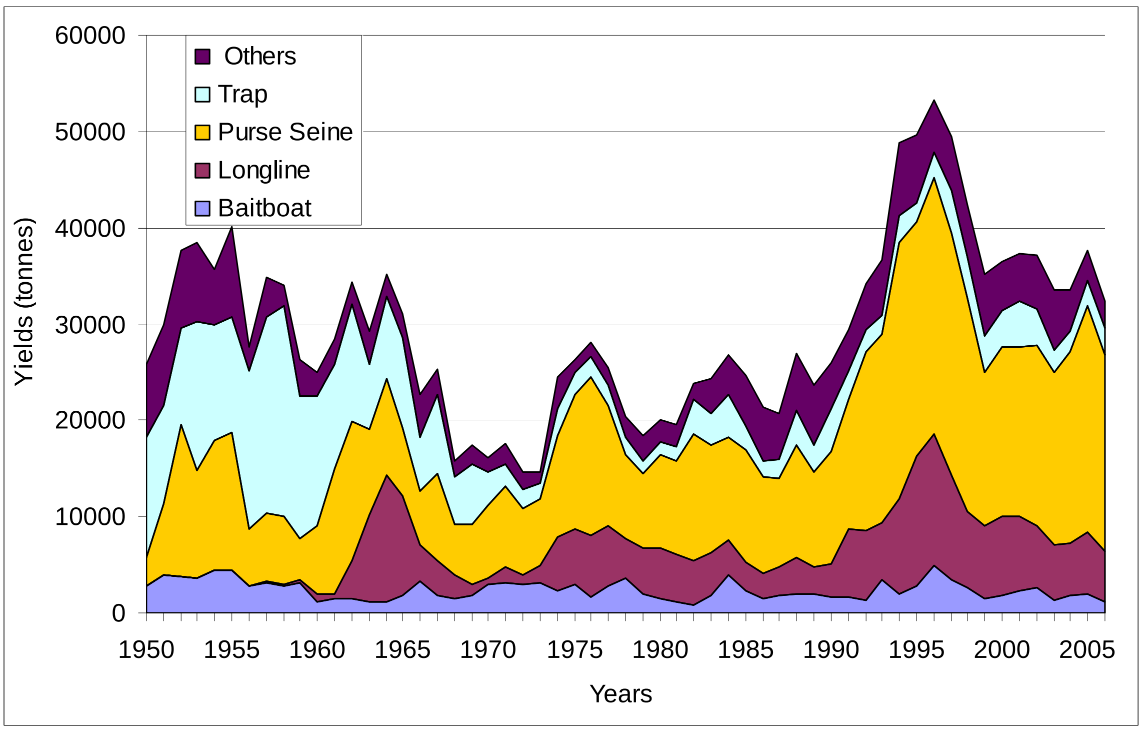
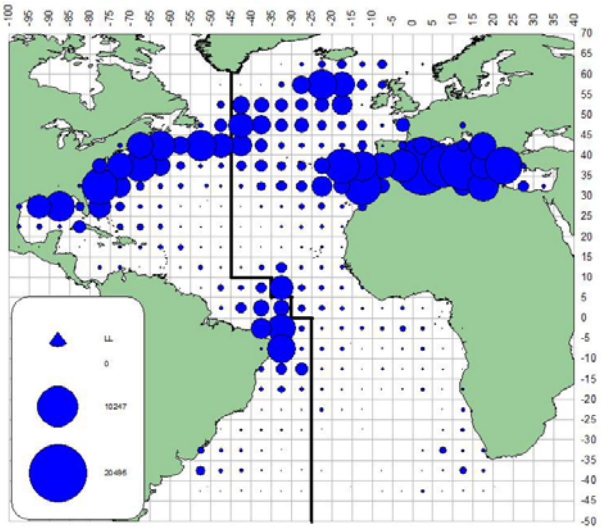
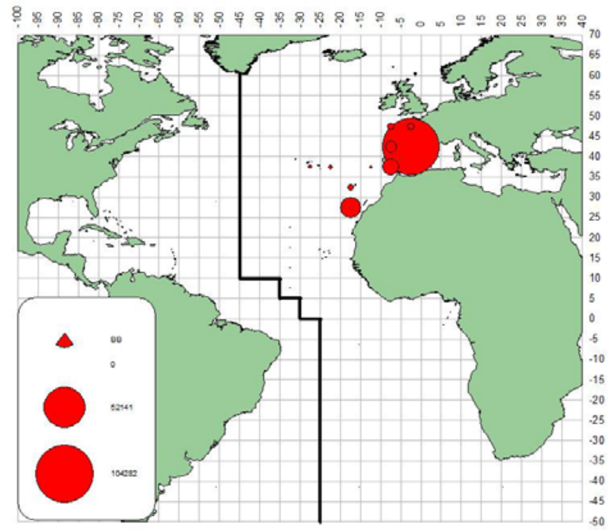


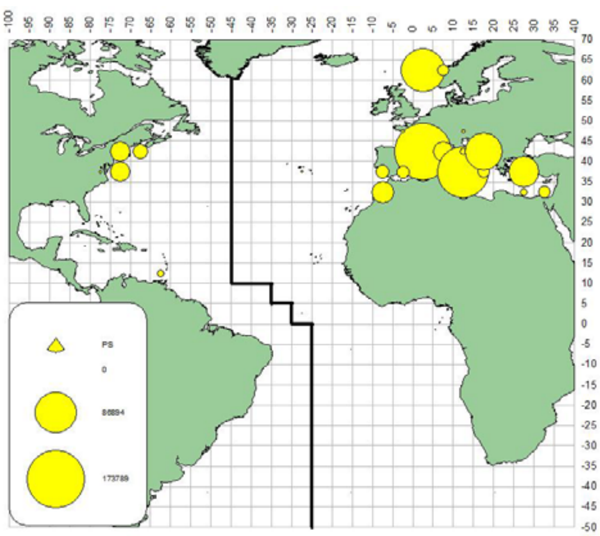
Figure 2. Bluefin reported annual catches by gear.



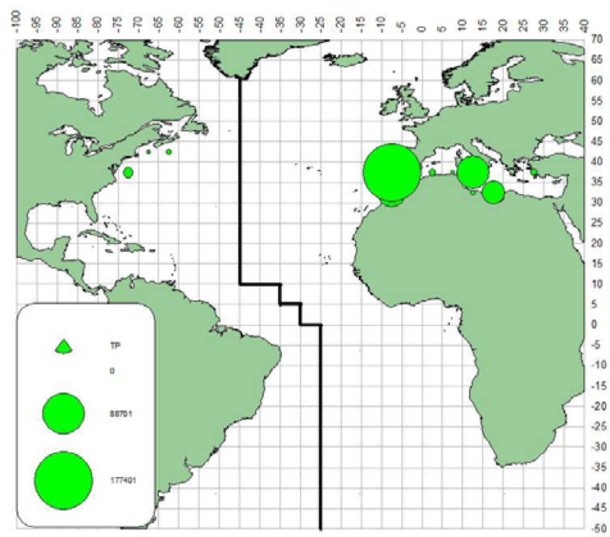
a. BFT (LL)



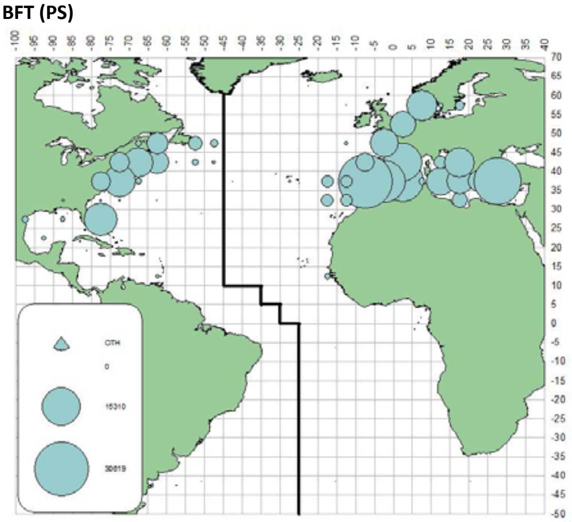
b. BFT (BB)



c. BFT (PS)

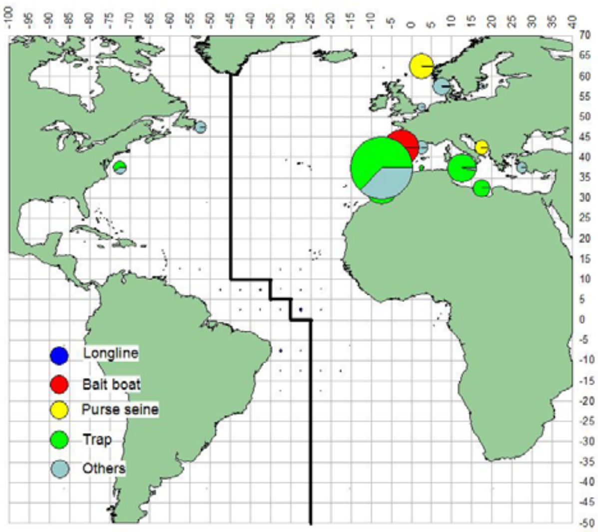


d. BFT (TRAP)

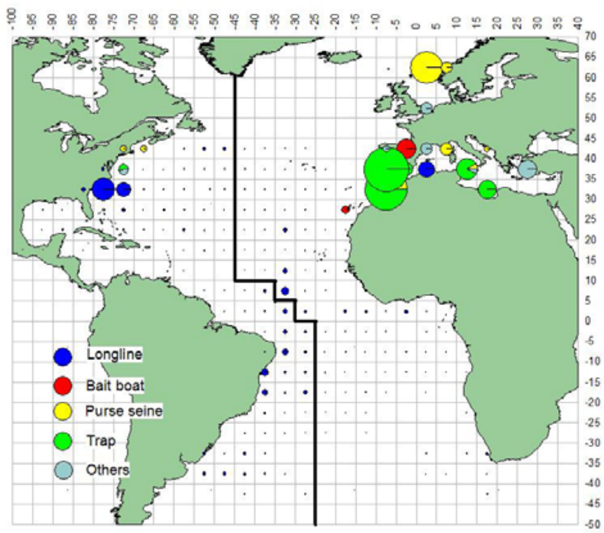


e. BFT (OT)

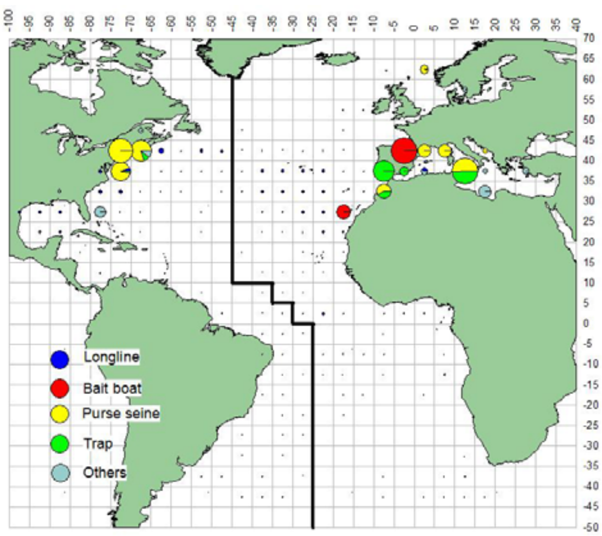
Figure 3. Geographical distribution of bluefin catches (BFT, *Thunnus thynnus*) 1950-2006.



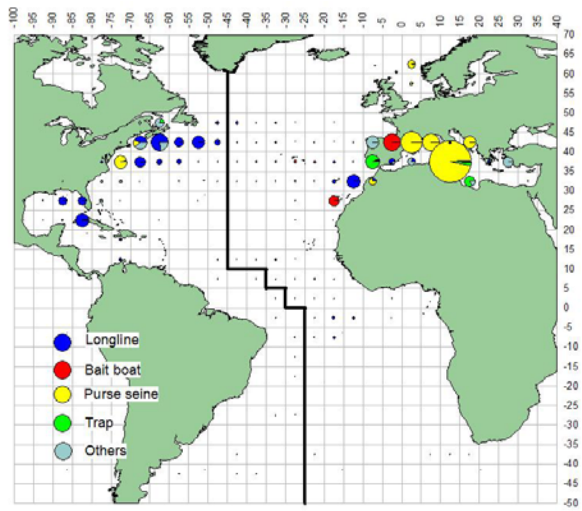
a. BFT(1950-59)



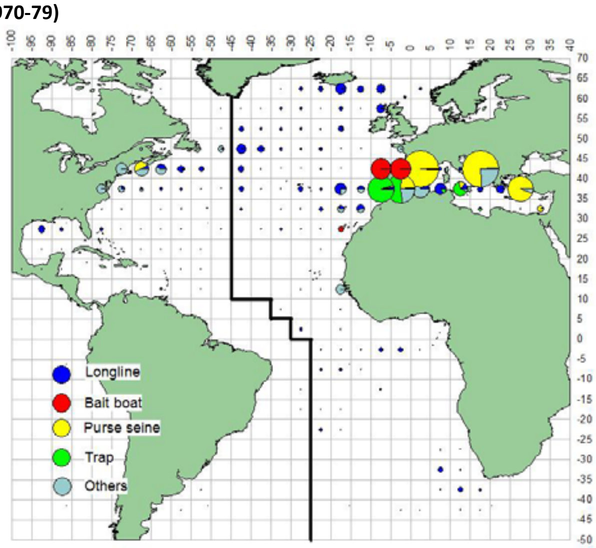
b. BFT(1960-69)



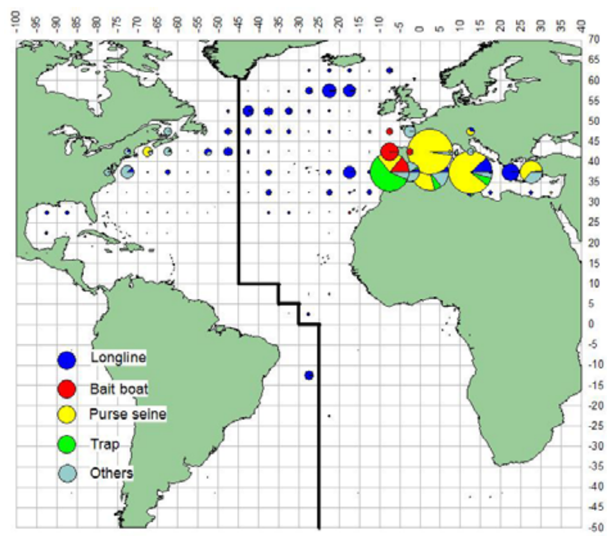
c. BFT(1970-79)



d. BFT(1980-89)



e. BFT (1990-99)



f. BFT (2000-2006)

Figures 4. Geographical distribution of BFT catch by major gears and decade.

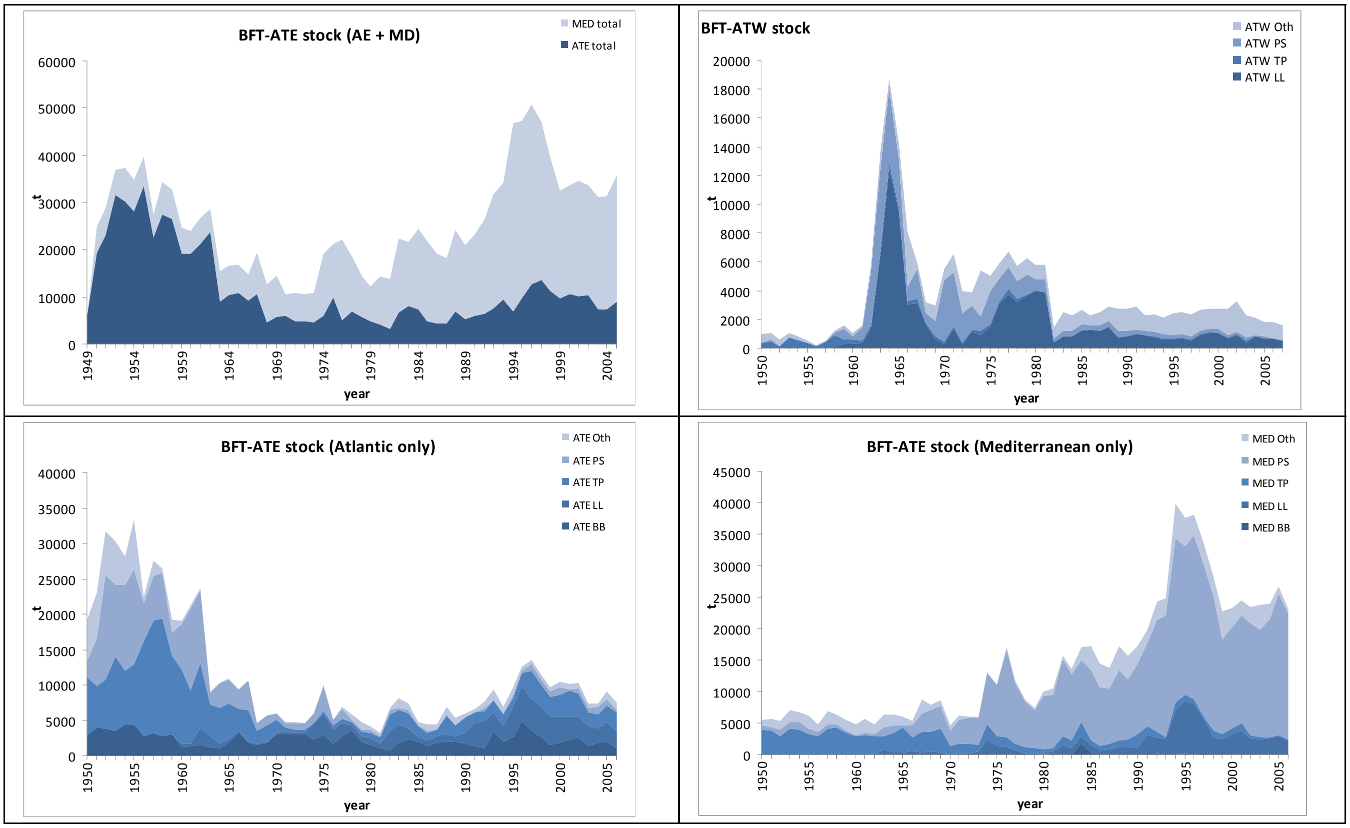


Figure 5. Bluefin reported annual catches by area and gear.

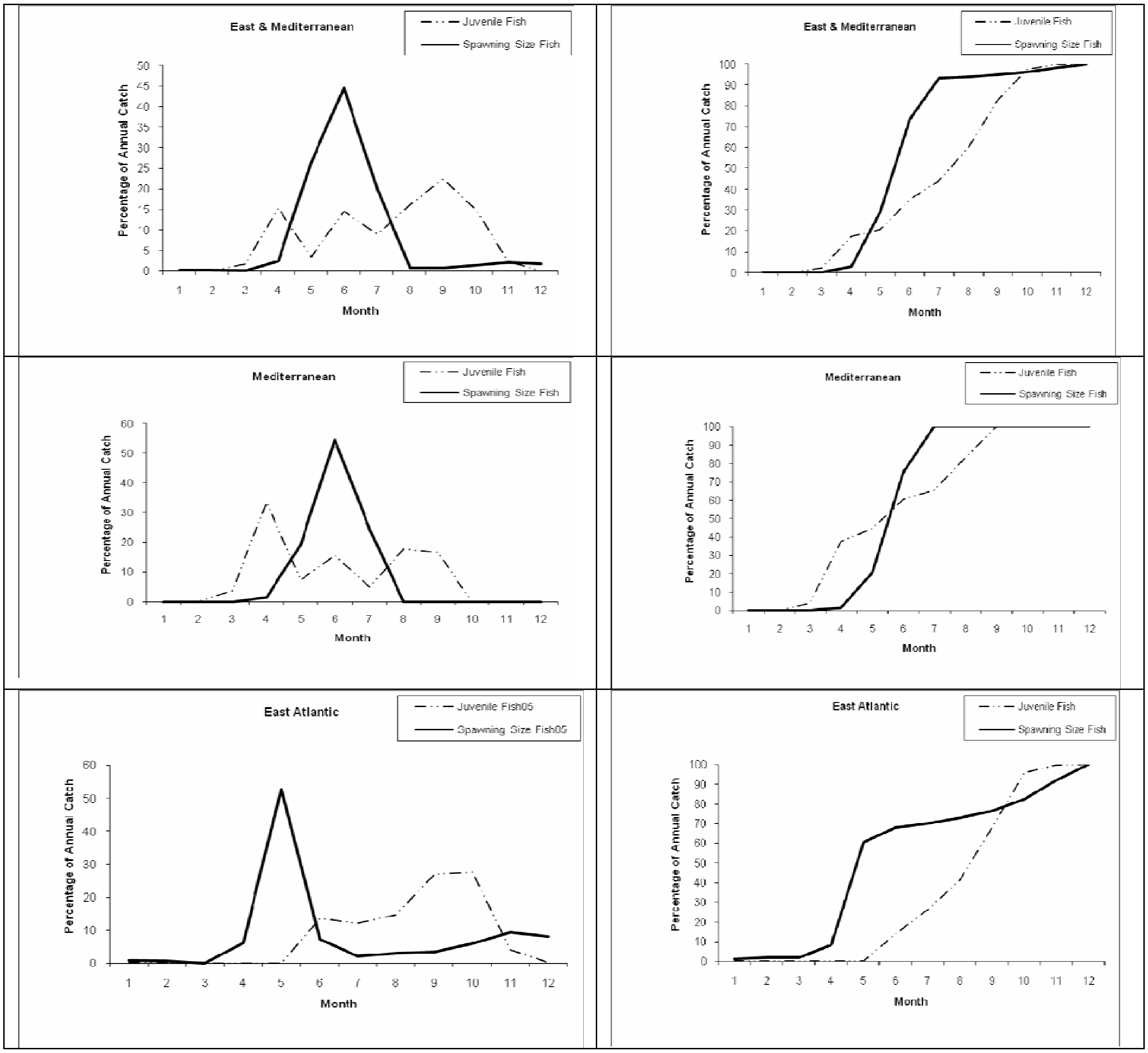


Figure 6. Estimated temporal pattern in monthly catches of spawning size (> 130 cm FL) and juvenile (< 130 cm FL) bluefin tuna in the east Atlantic and Mediterranean fisheries

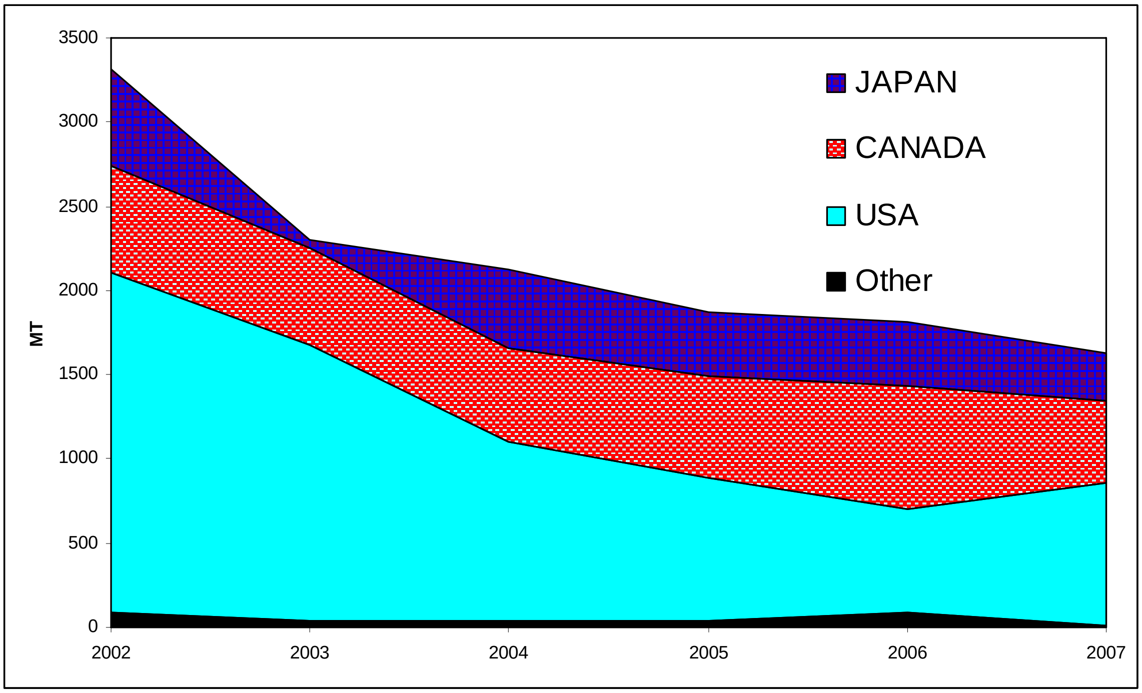


Figure 7. Recent trends in bluefin tuna catch (landings + discards) by flag.

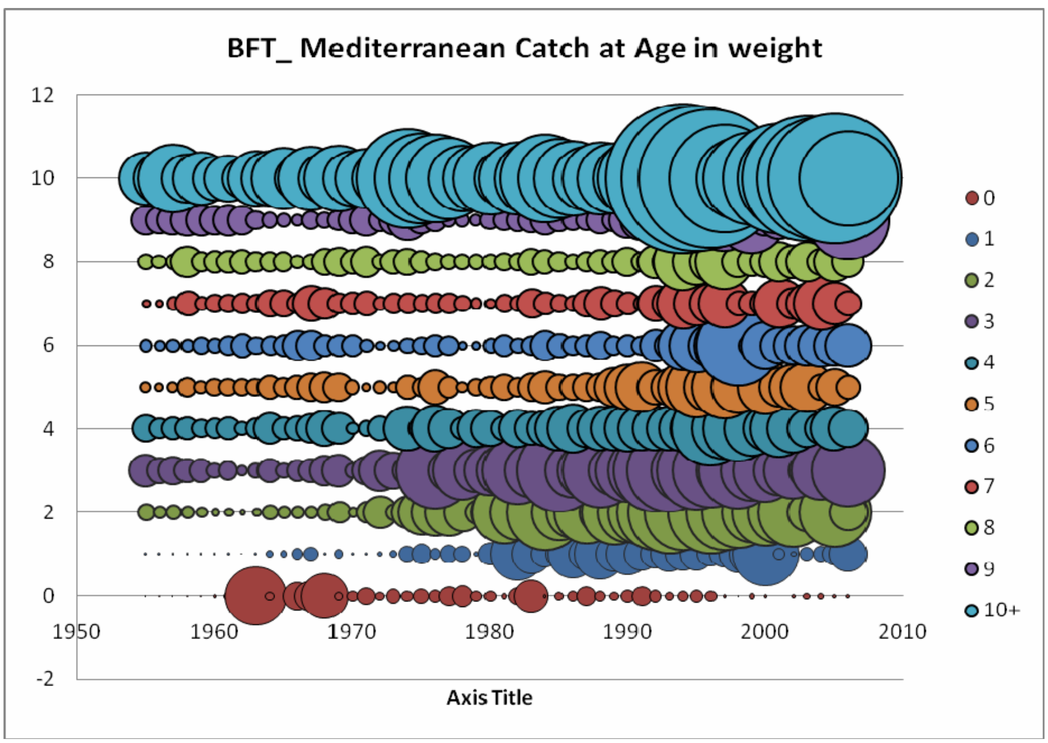


Figure 8. Catch at age, in weight, of the Mediterranean bluefin for period 1955-2006.

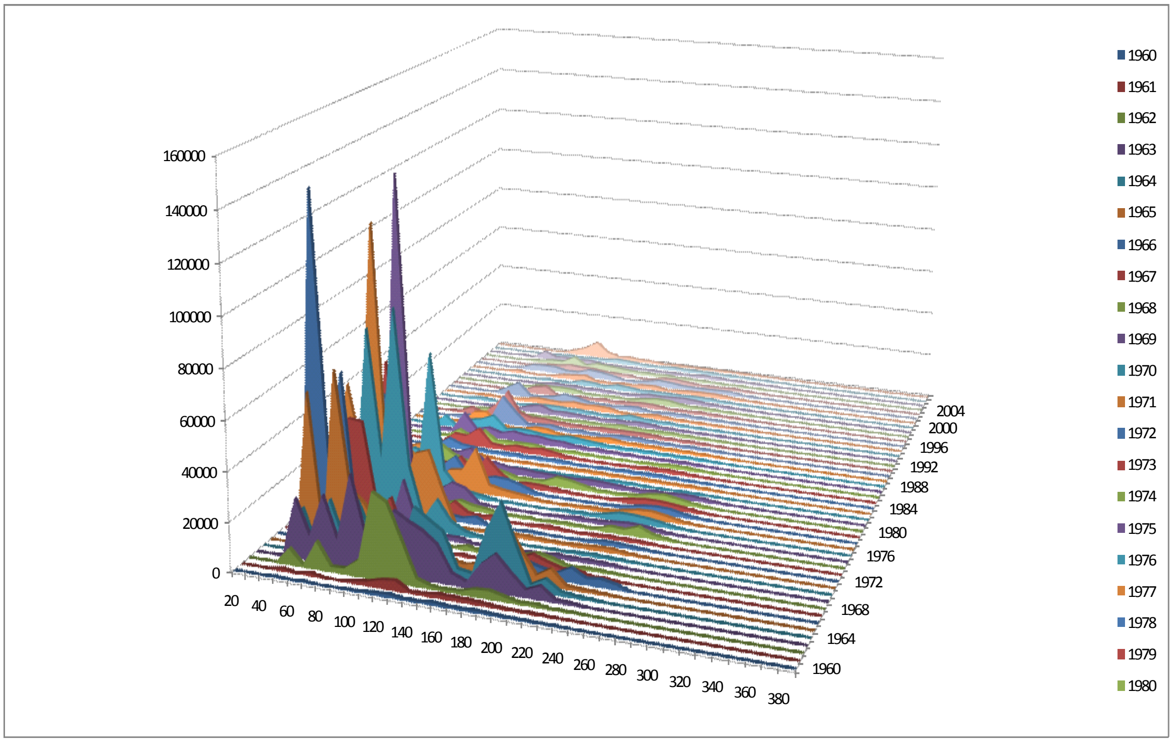
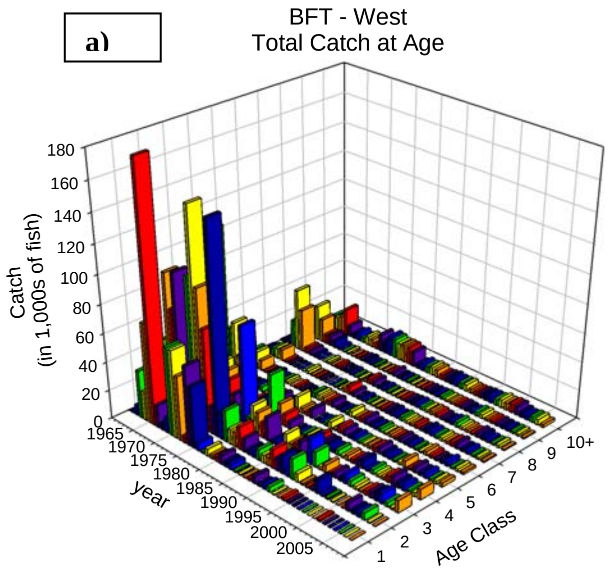


Figure 9. Frequency distribution of catch at size, by year, for western Atlantic bluefin tuna.



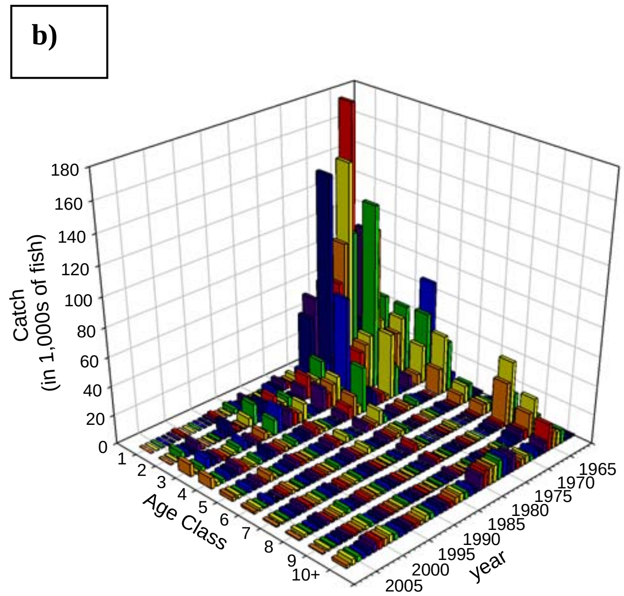


Figure 10. Frequency distribution of total catches at age 1960-2007, by year, for western Atlantic (areas 1 + 2) bluefin tuna (colors are consistent across age classes within a year). Graphs (a) and (b) represent the same graph seen from different angles to reveal bars which may be hidden behind larger bars.

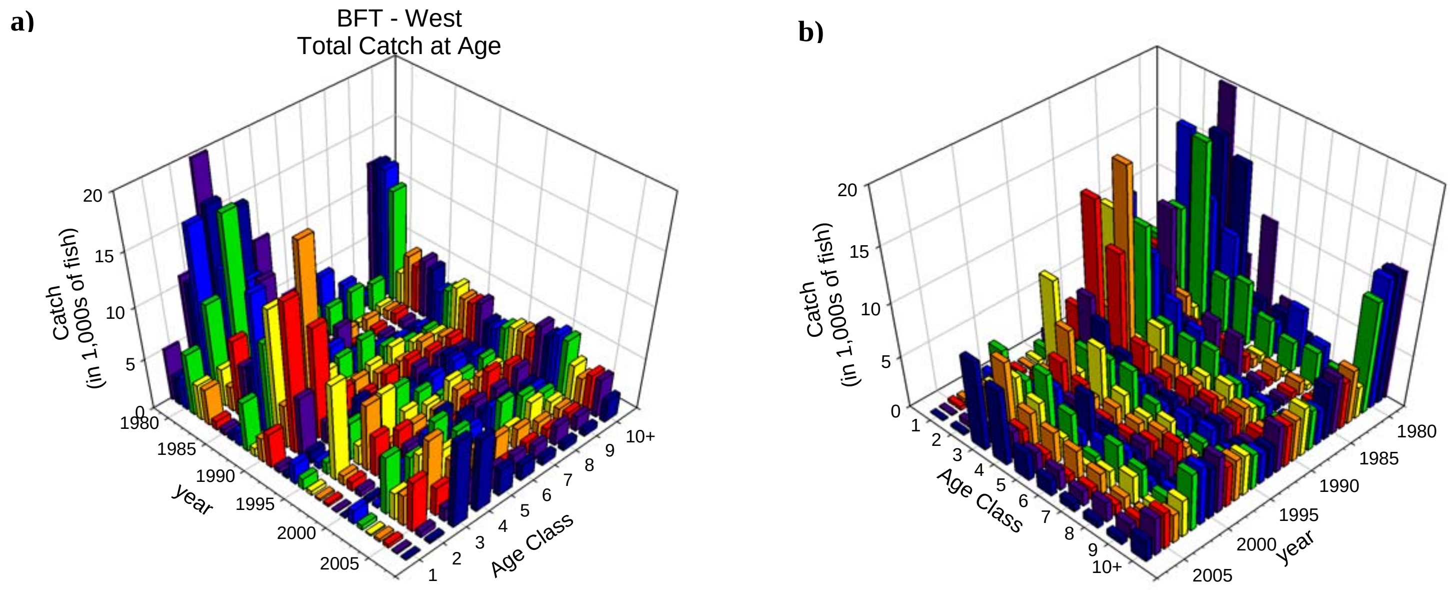


Figure 11. Frequency distribution of total catches at age during the most recent 30 years (1978-2007), by year, for western Atlantic (areas 1 + 2) bluefin tuna (colors are consistent across age classes within a year). Graphs (a) and (b) represent the same graph seen from different angles to reveal bars which may be hidden behind larger bars.

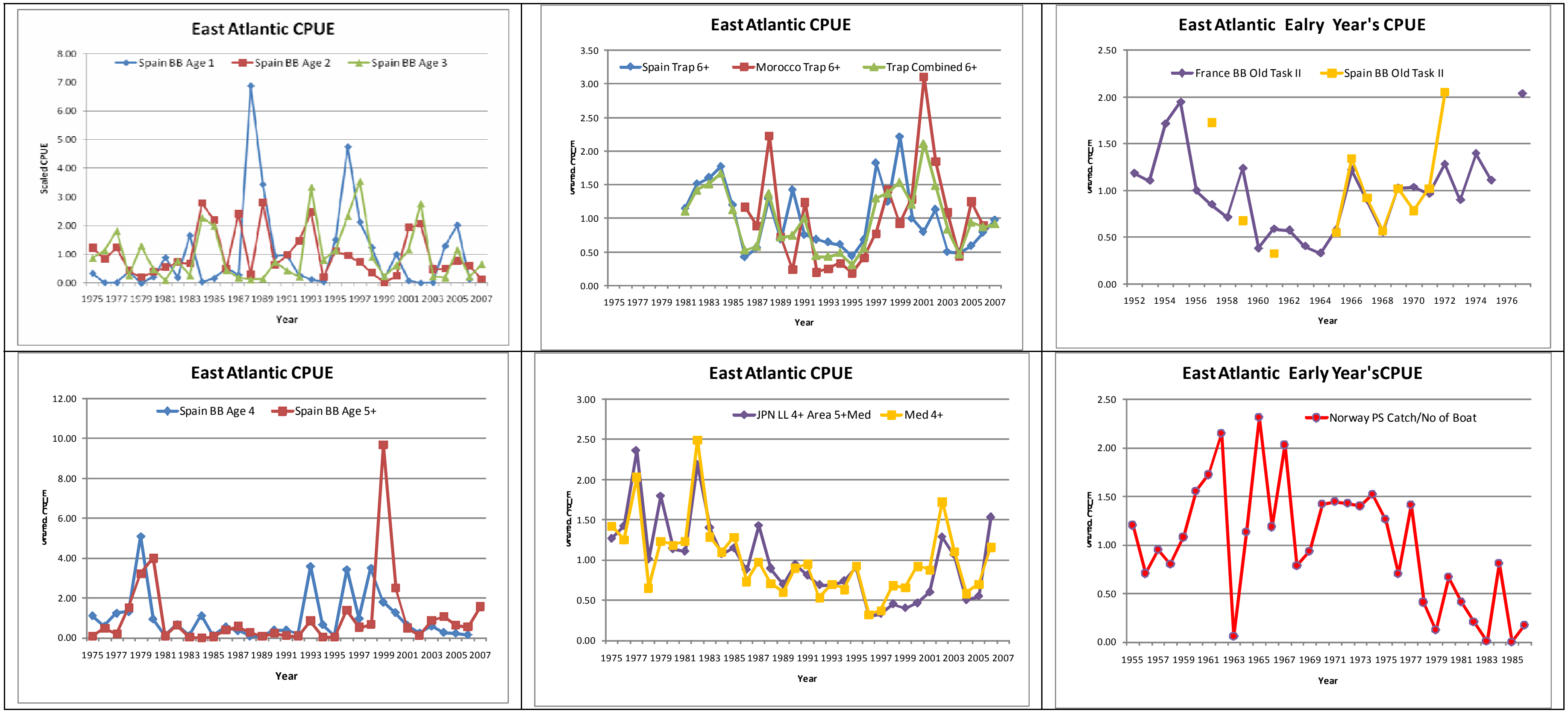


Figure East 12. East Atlantic BFT Abundance Indices considered by the Working Group. Standardized CPUE scaled to its mean

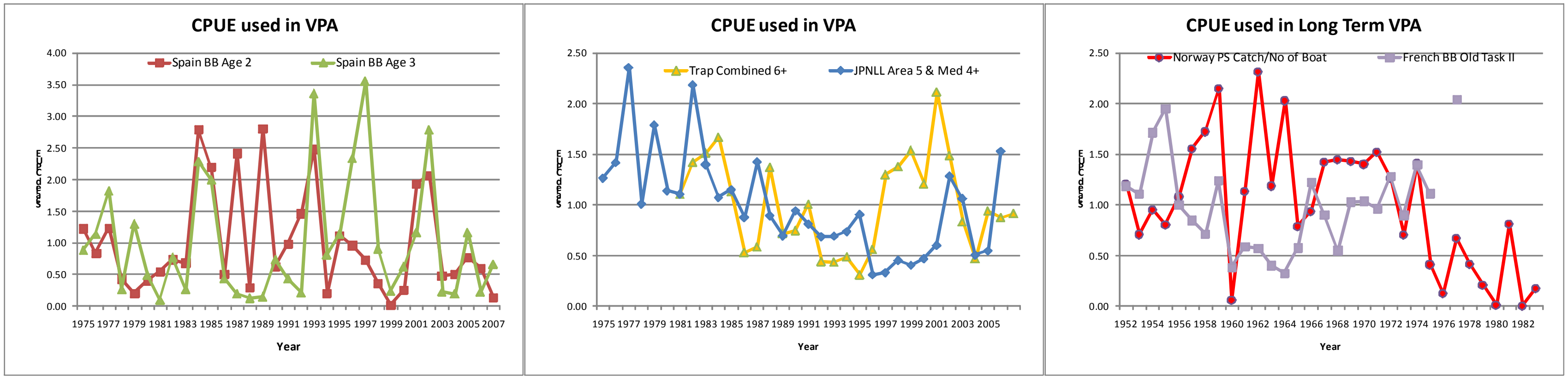


Figure East 13. East Atlantic BFT Abundance Indices used in VPA analysis. CPUE was scaled to its mean.

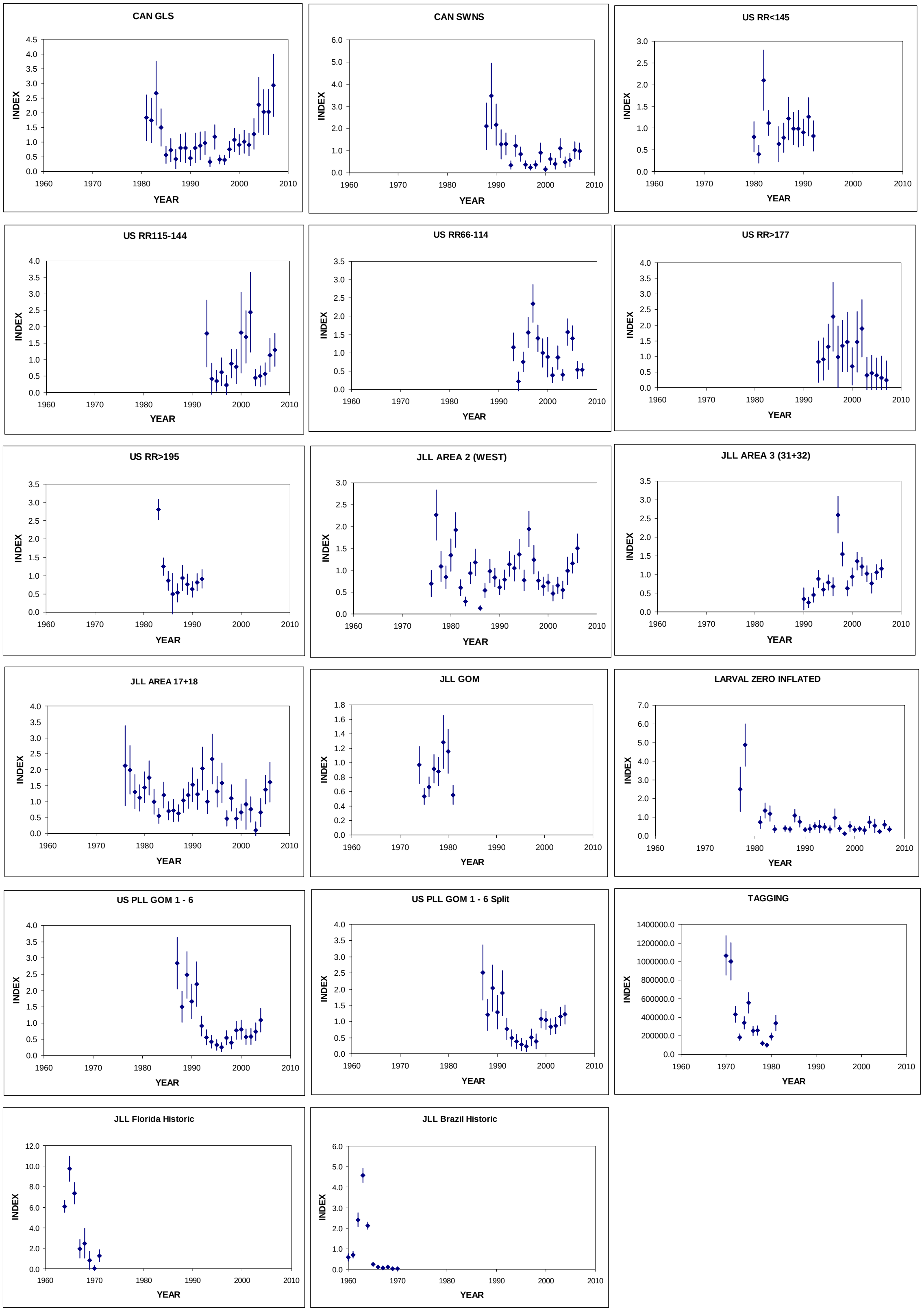


Figure 14. Comparison of standardized CPUE series for adult bluefin in the western Atlantic.

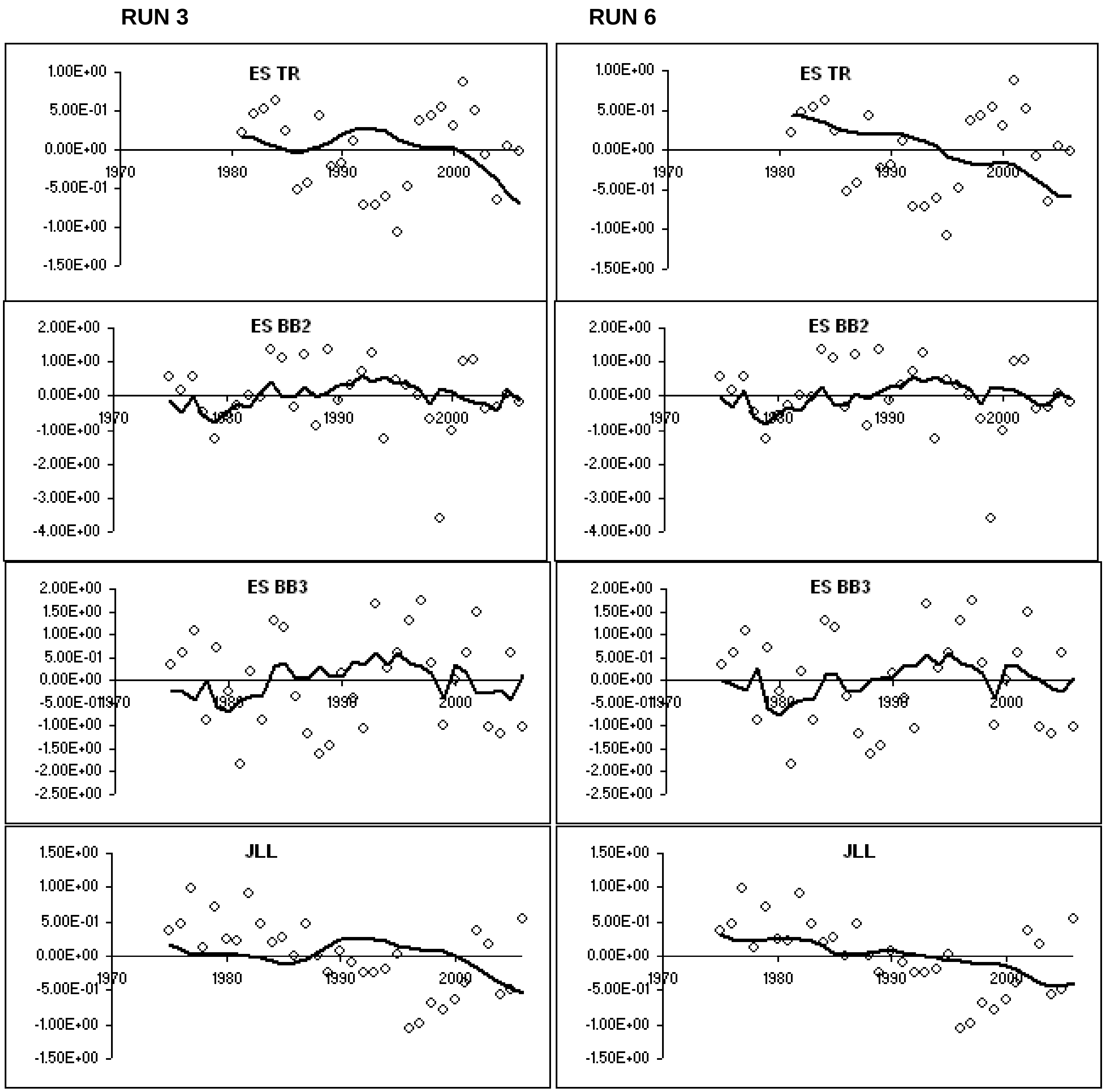


Figure 15. VPA fits to the available eastern bluefin CPUE indices in RUN 3 and RUN 6.

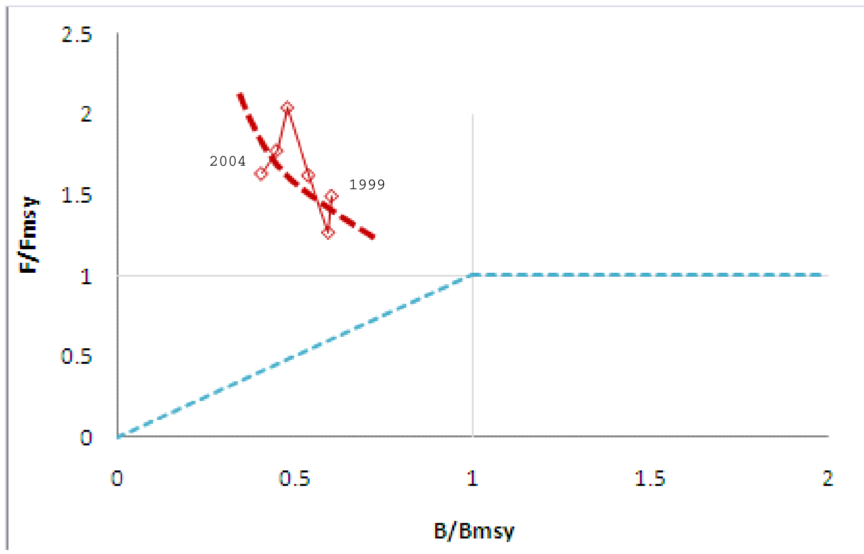


Figure 16. Recent trajectory of F and B relative to MSY proxy references showing a trend towards increasing F and declining B as estimated in 2006.

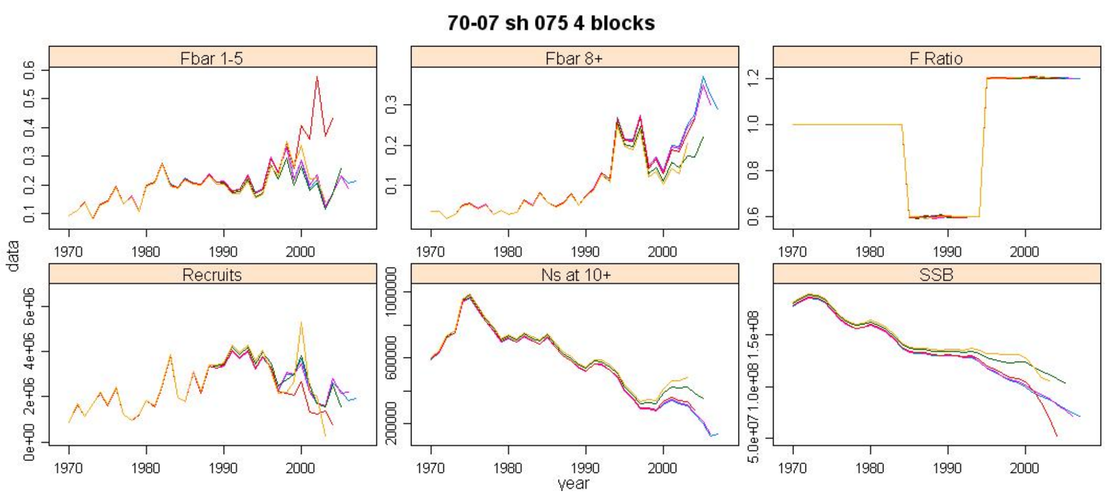


Figure 17. VPA results for Run 6.

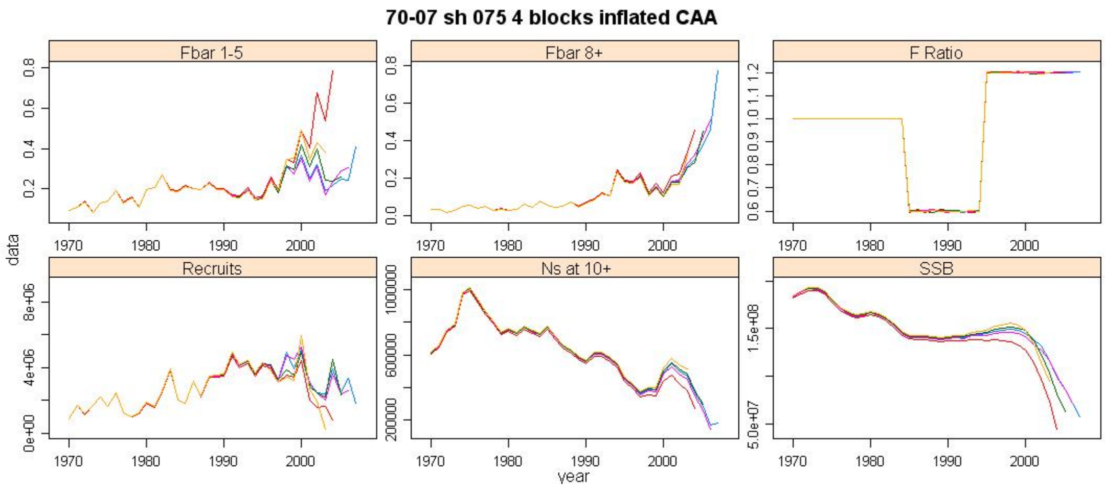


Figure 18. VPA results for Run 7.

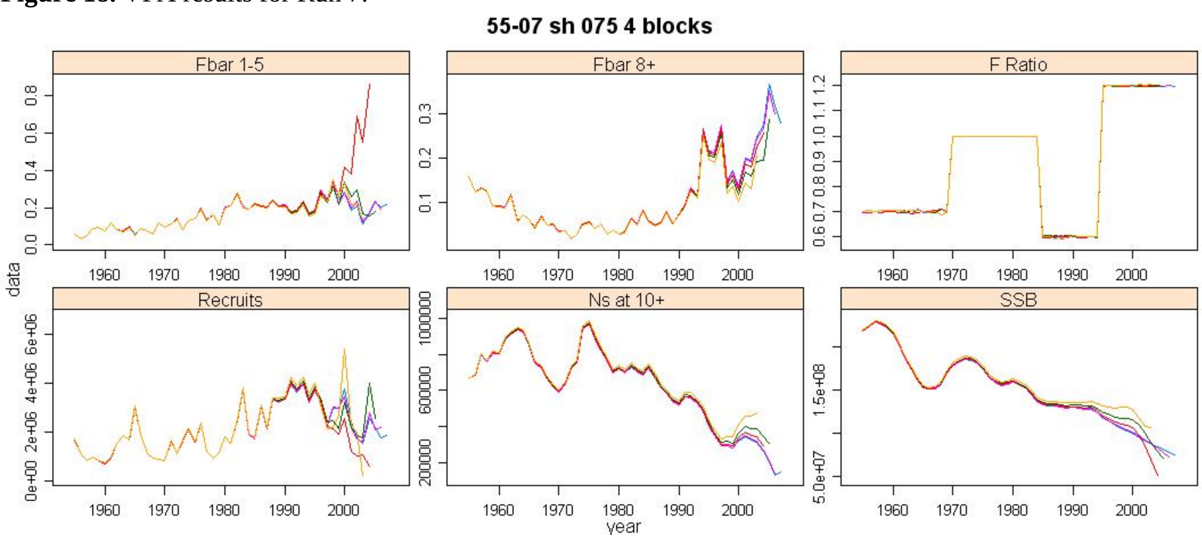


Figure 19. VPA results for Run 13.

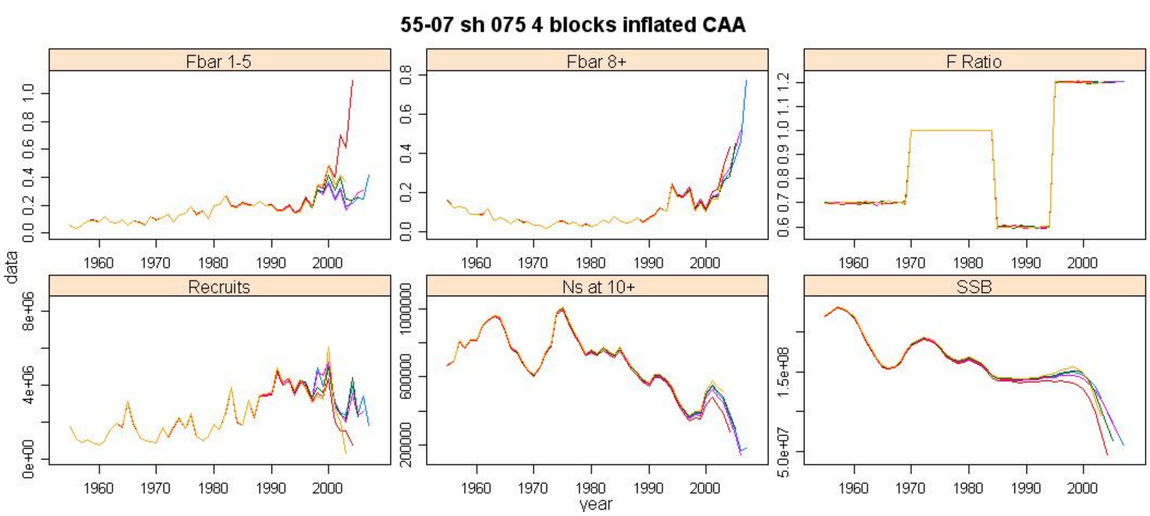


Figure 20. VPA results for Run 14.

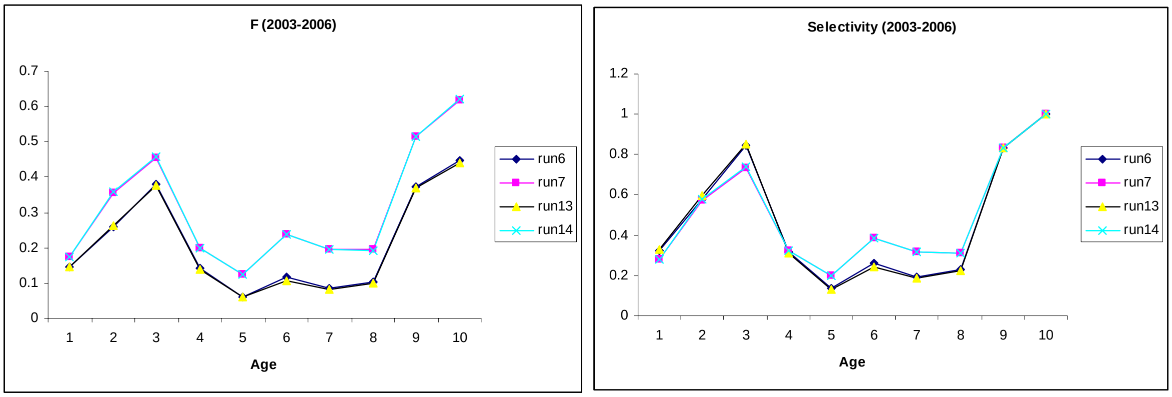


Figure 21. Geometric mean of F for the period 2003-2006 and corresponding selectivity vectors.

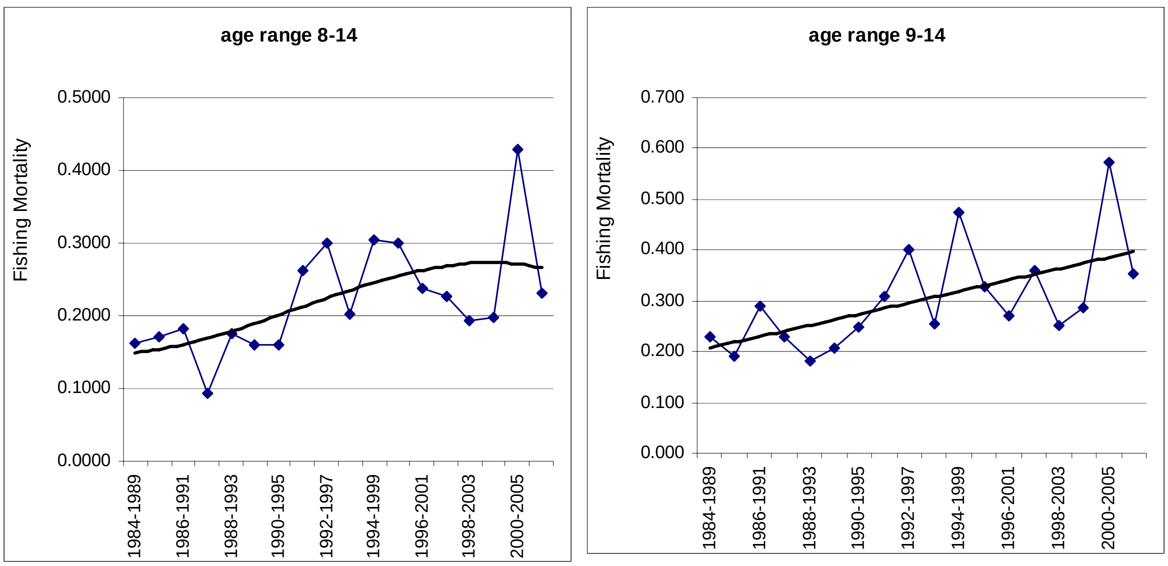


Figure 22. Estimates of fishing mortality (assuming M=0.1) for spawning BFT in the Eastern Atlantic and Mediterranean from year-class curve analyses based on Japanese longline cpue data. Estimates are average F values applied on different cohorts over 5 year periods (in the X axis).

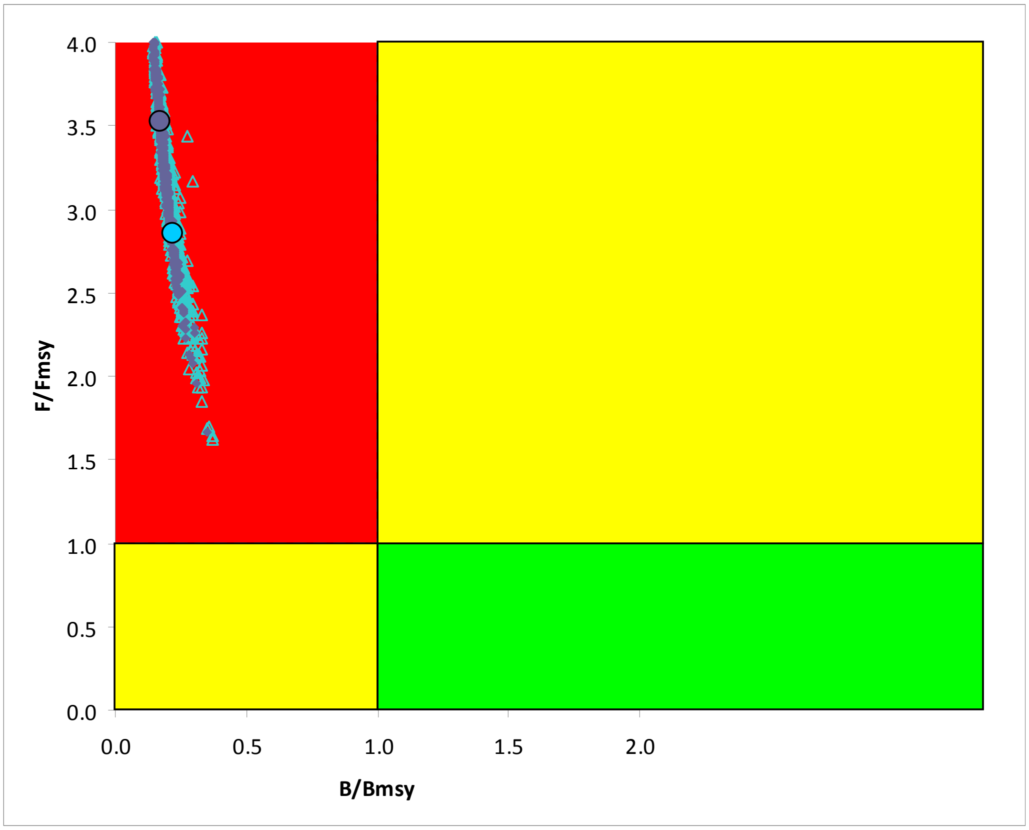


Figure 23. Phase plot of eastern Atlantic and Mediterranean recent stock status evaluations based upon two assumptions about recent catch at age.

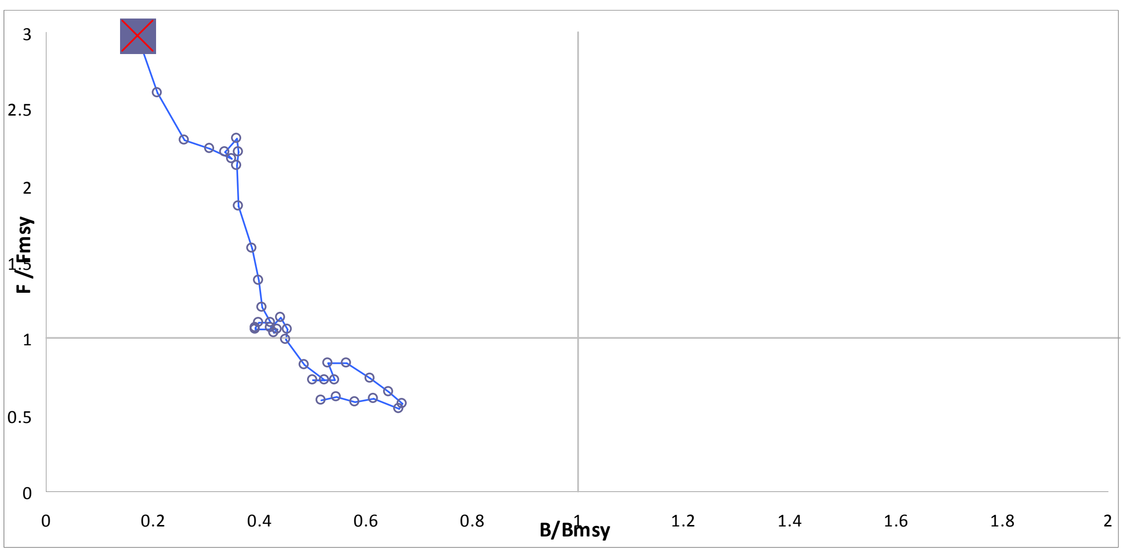
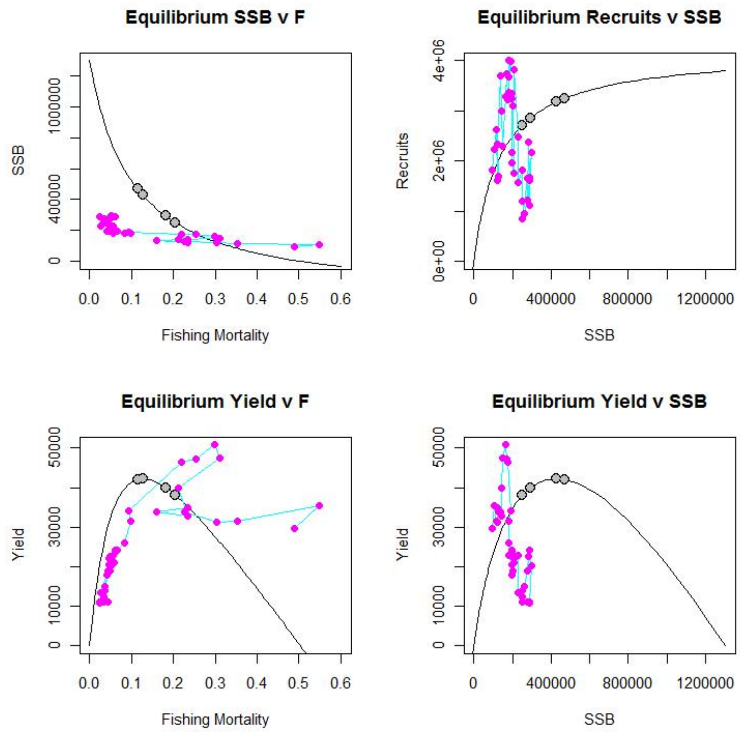
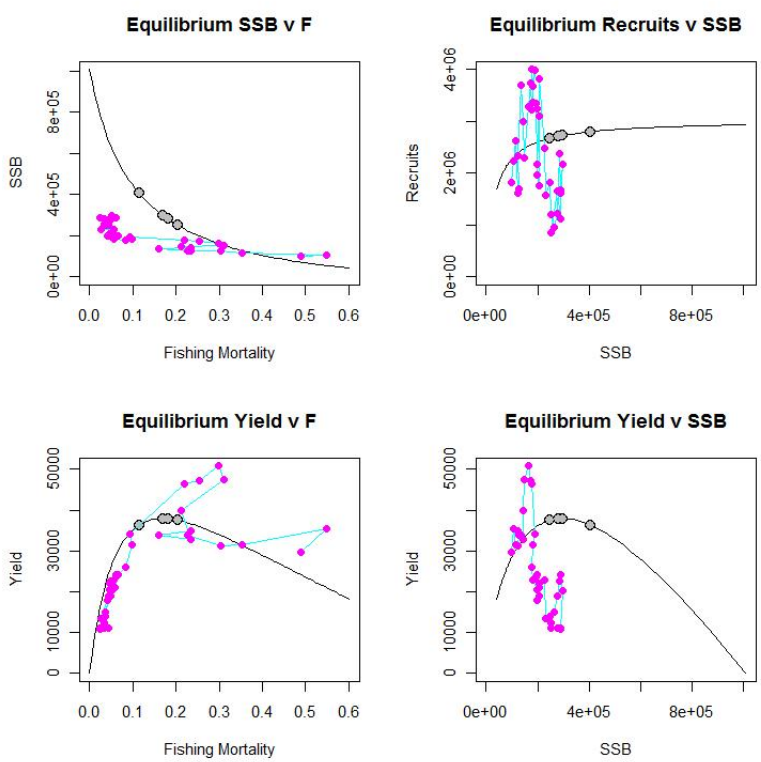


Figure 24. Snail track for East Atlantic and Mediterranean bluefin tuna. The X indicates 2006 status.

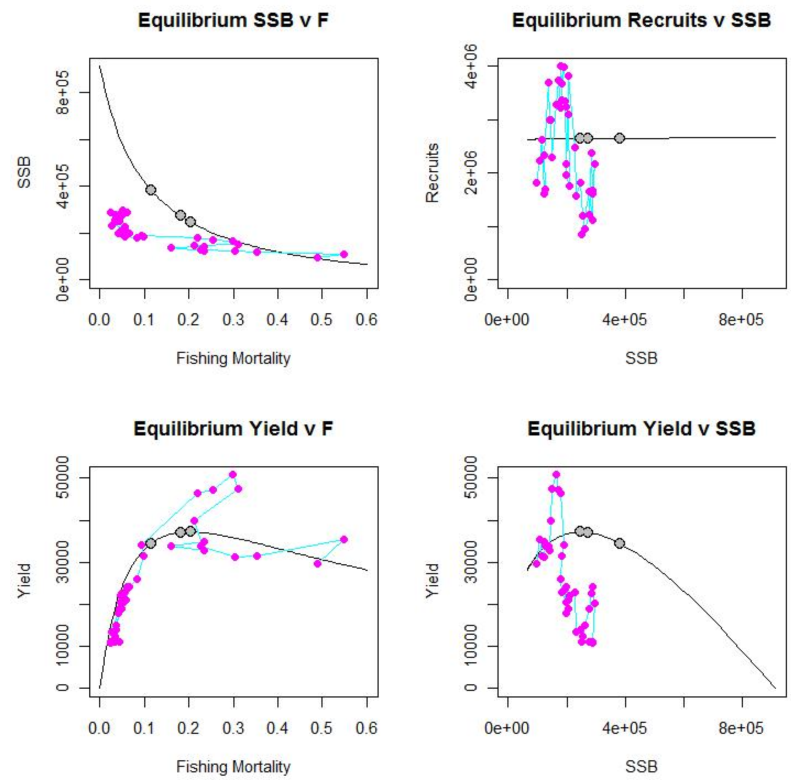
a) Reported catch, low recruitment (70s level), steepness = 0.5



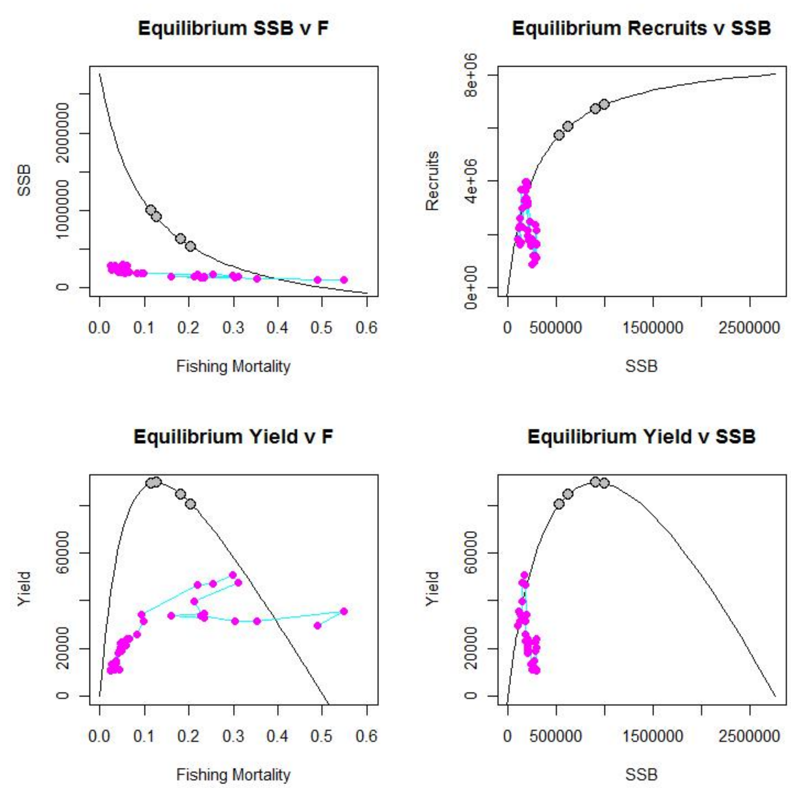
b) Reported catch, low recruitment (70s level), steepness = 0.75



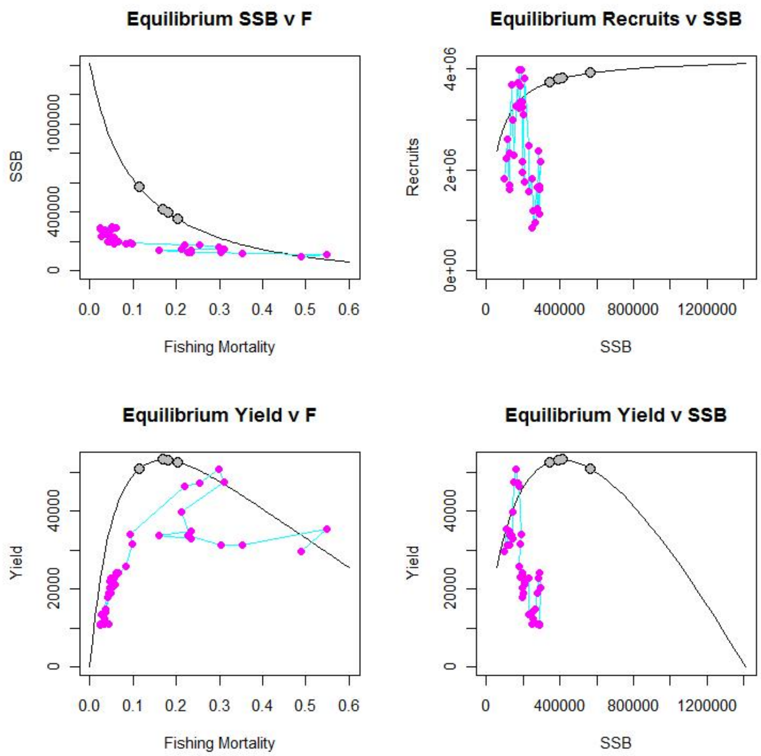
c) Reported catch, low recruitment (70s level), steepness = 0.99



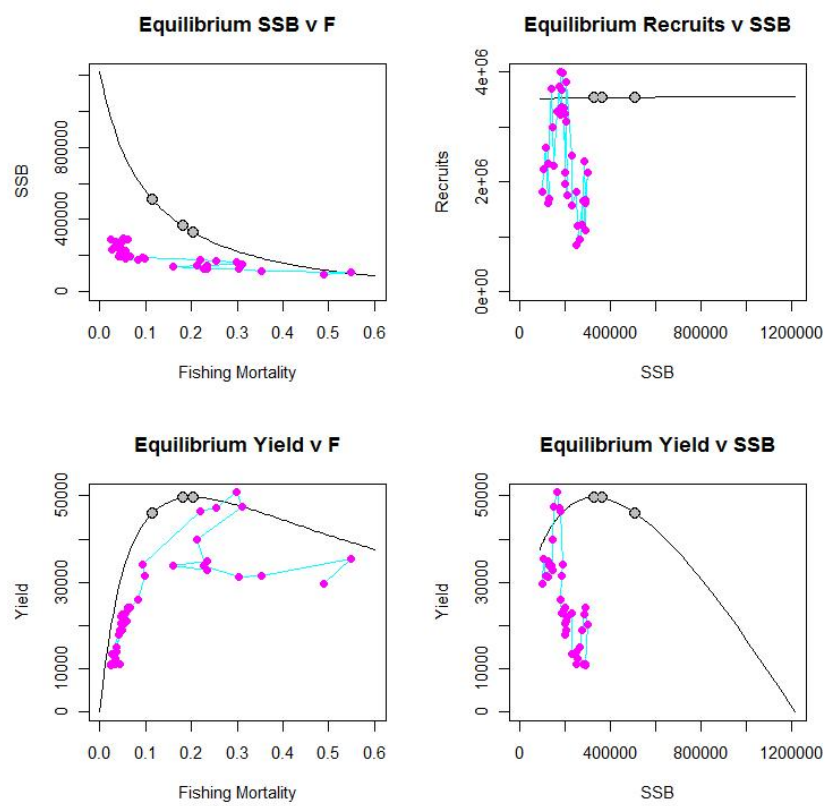
d) Reported catch, high recruitment (90s level), steepness = 0.5



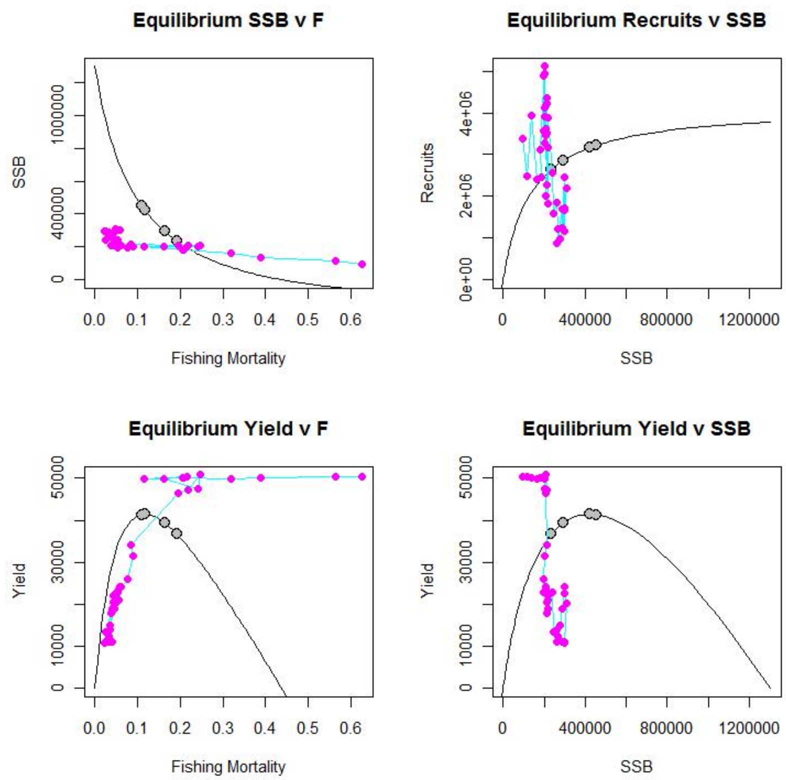
e) Reported catch, high recruitment (90s level), steepness = 0.75



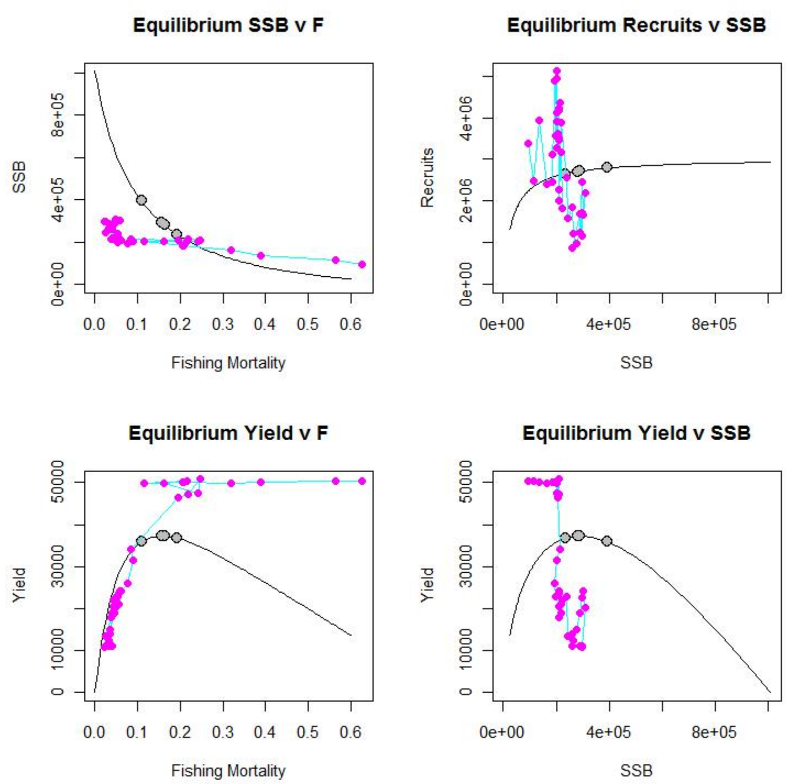
f) Reported catch, high recruitment (90s level), steepness = 0.99



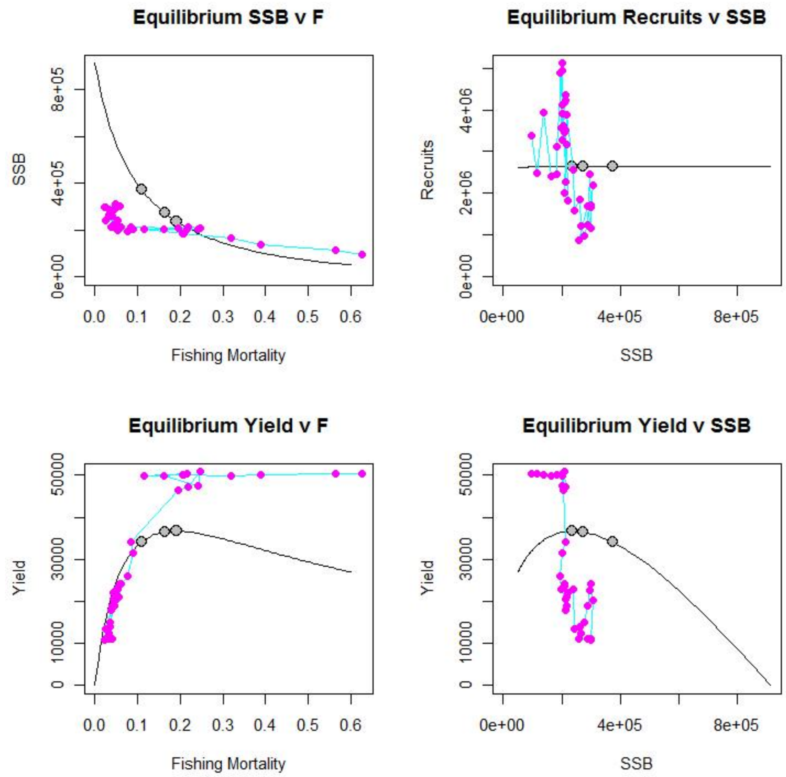
g) Adjusted catch, low recruitment (70s level), steepness = 0.5



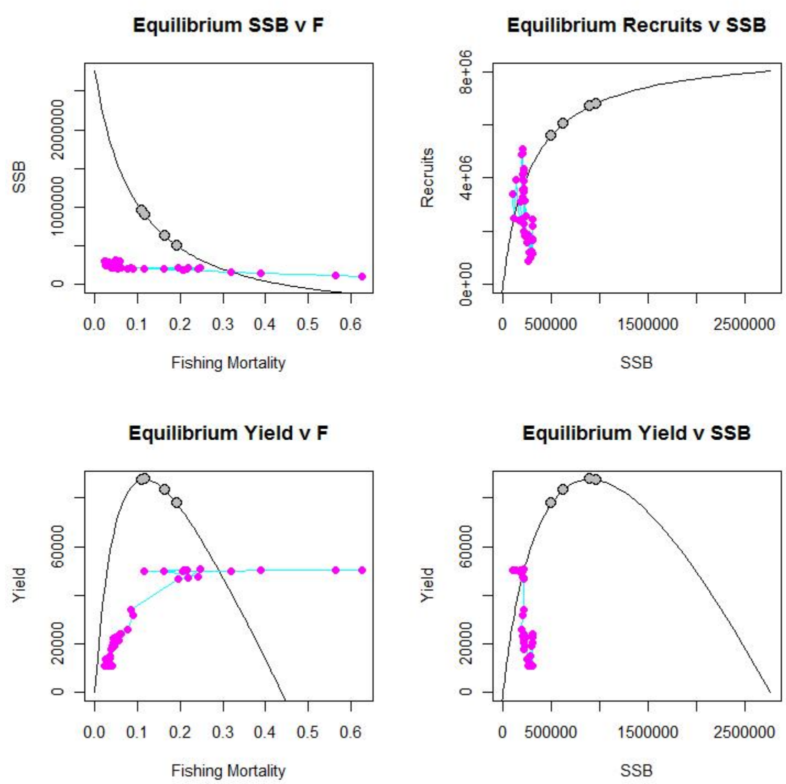
h) Adjusted catch, low recruitment (70s level), steepness = 0.75



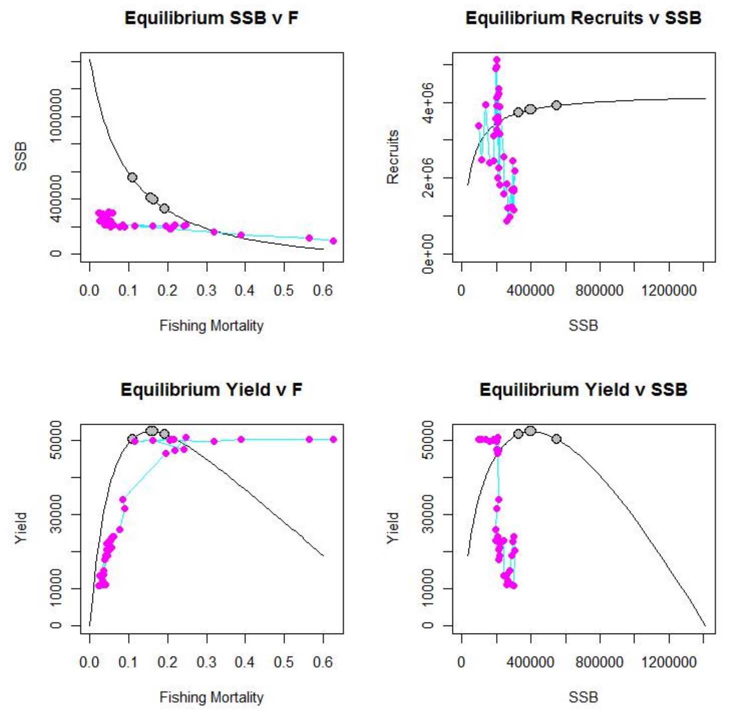
i) Adjusted catch, low recruitment (70s level), steepness = 0.99



j) Adjusted catch, high recruitment (90s level), steepness = 0.5



k) Adjusted catch, high recruitment (90s level), steepness = 0.75



l) Adjusted catch, high recruitment (90s level), steepness = 0.99

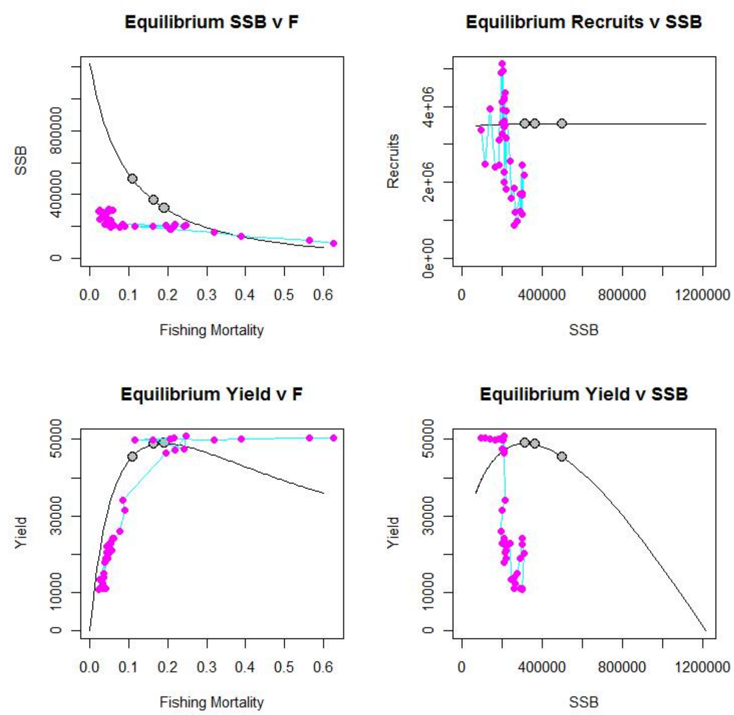


Figure 25. Results of projections made assuming high (mean 90s) and low (mean 70s) recruitment levels, different steepness values for the Beverton and Holt stock recruitment relationship (0.5, 0.75 or 0.99) and reported catch and adjusted catch.

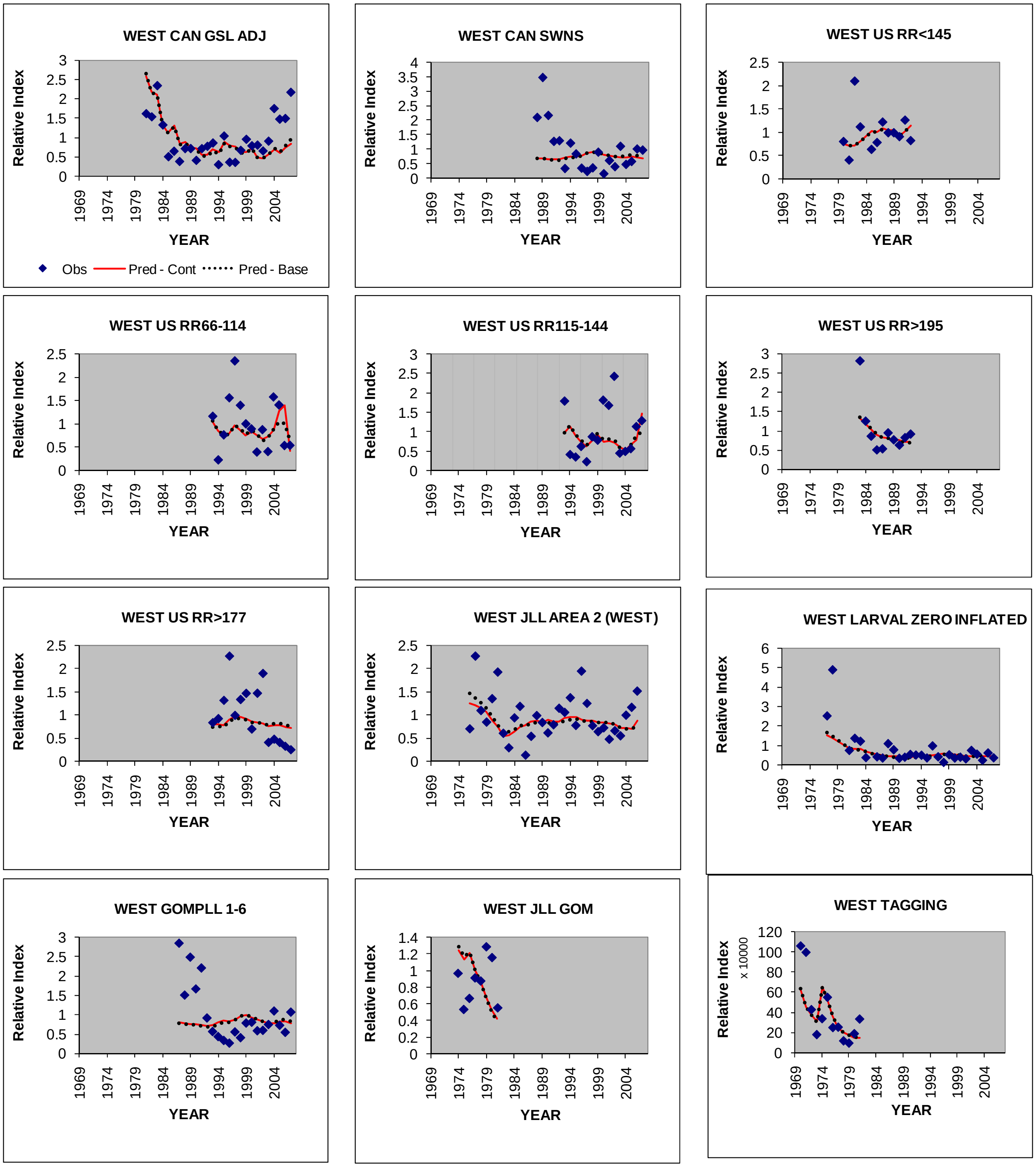


Figure 26. Fits to the CPUE indices for western Atlantic BFT continuity VPA (solid line) and base VPA(dashed line).

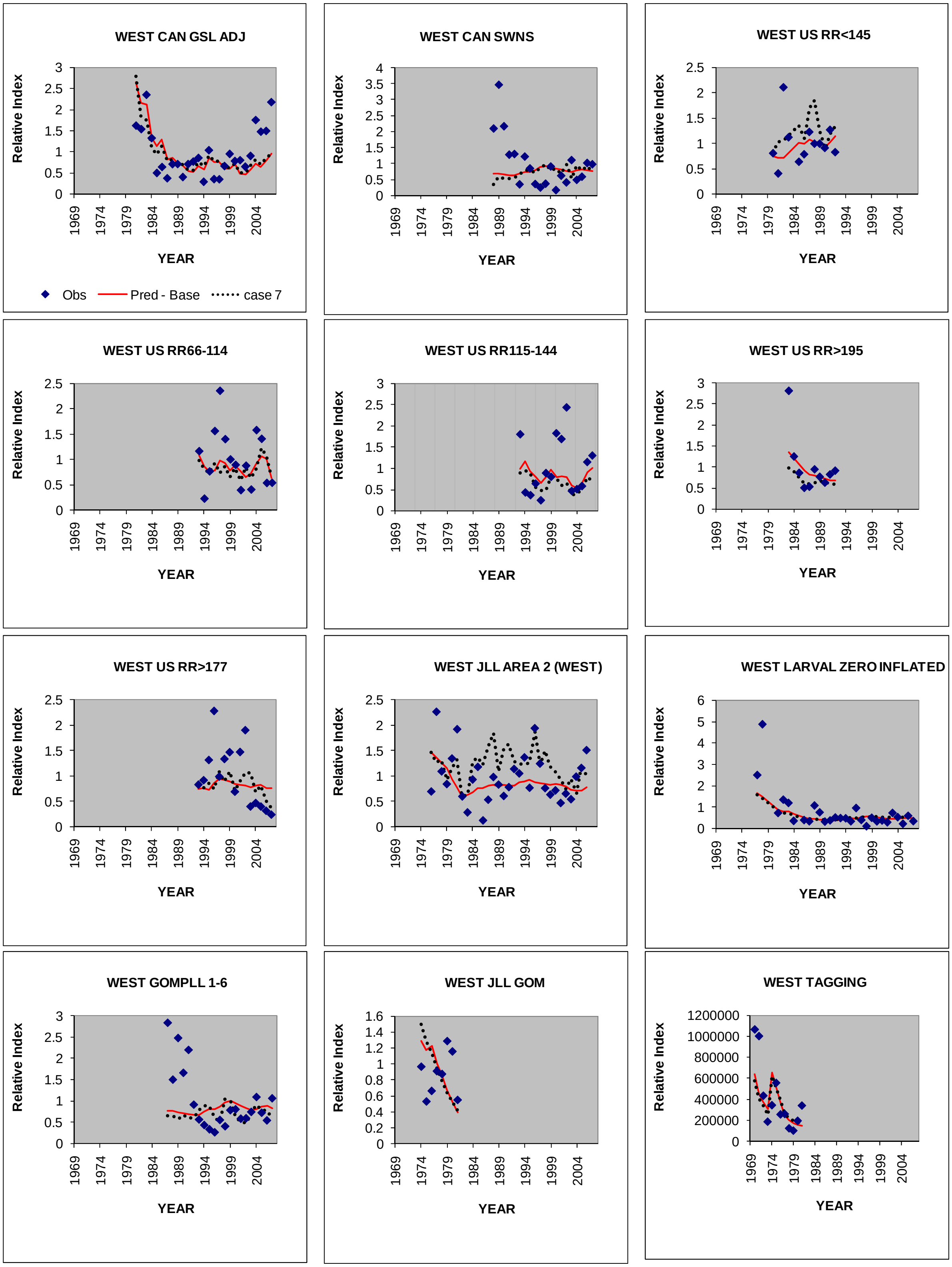


Figure 27. Fits to the CPUE indices for western Atlantic base VPA (solid line) and Case 7 (dashed line).

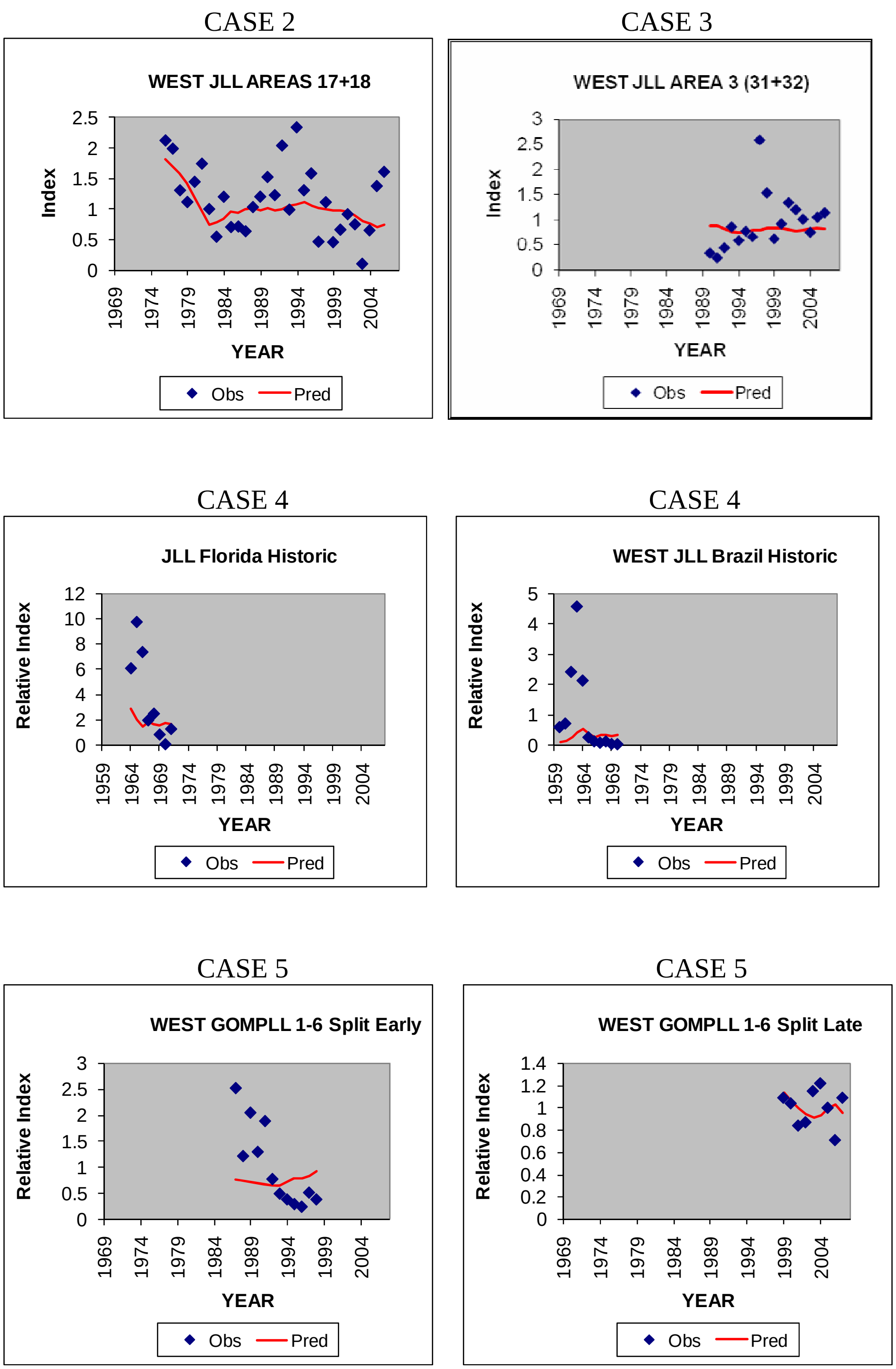


Figure 28. Fits to assorted CPUE indices for western Atlantic BFT used in sensitivity cases only.

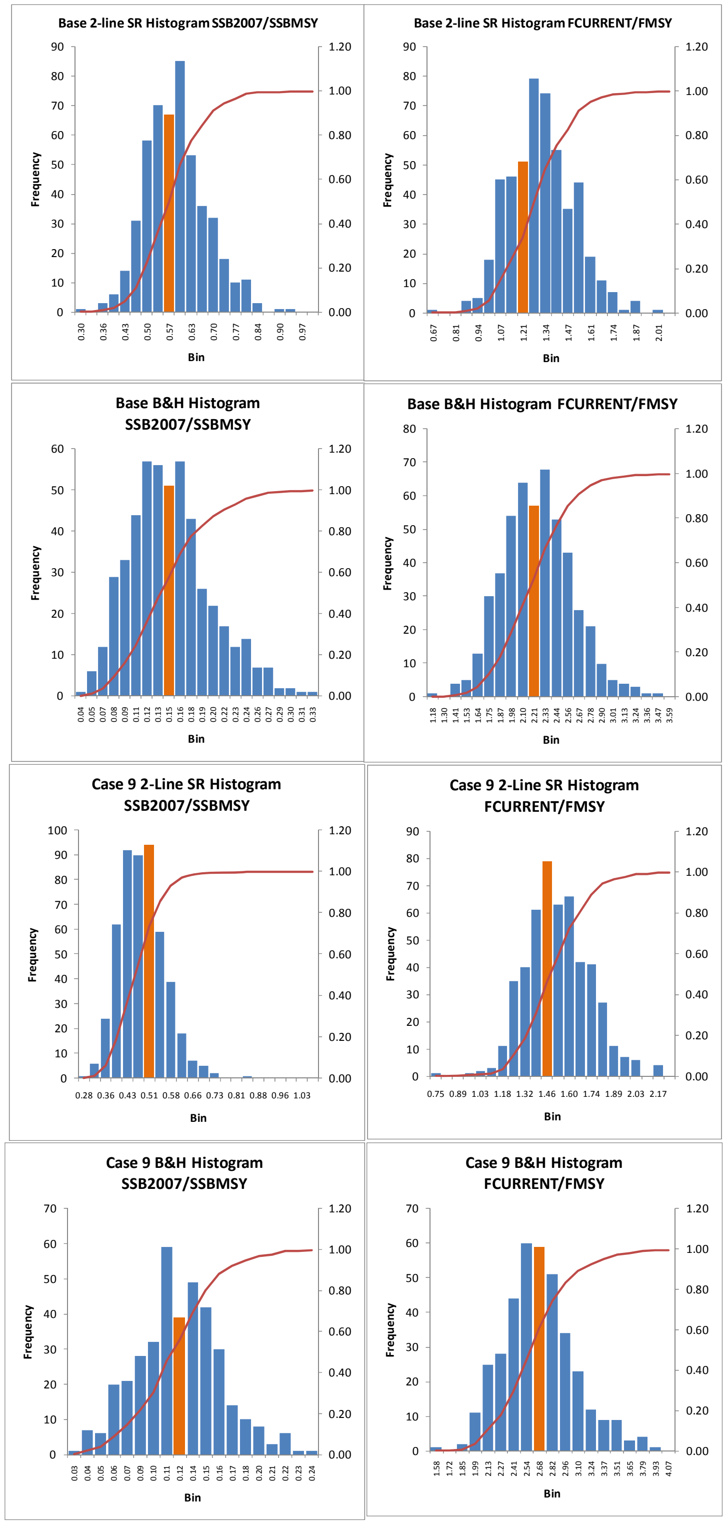
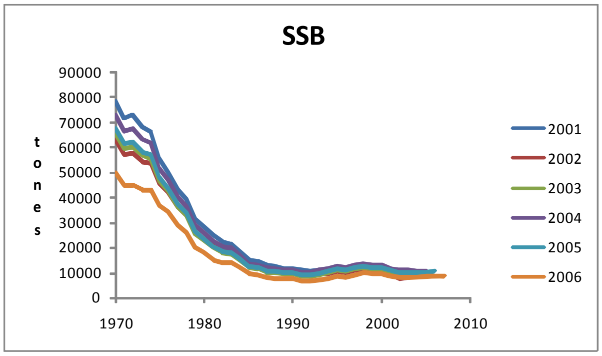


Figure 29. Histograms of bootstrap estimates of 2007 stock status. The red bar represents the values corresponding to the base-case deterministic estimate. The cumulative frequency is indicated with a solid red line.



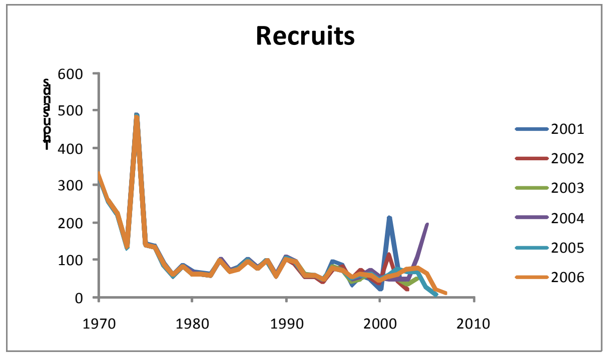


Figure 30. Retrospective trends of spawning biomass and recruits (age 1) from the West BFT base case. Each line represent the latest year included in the model fit.

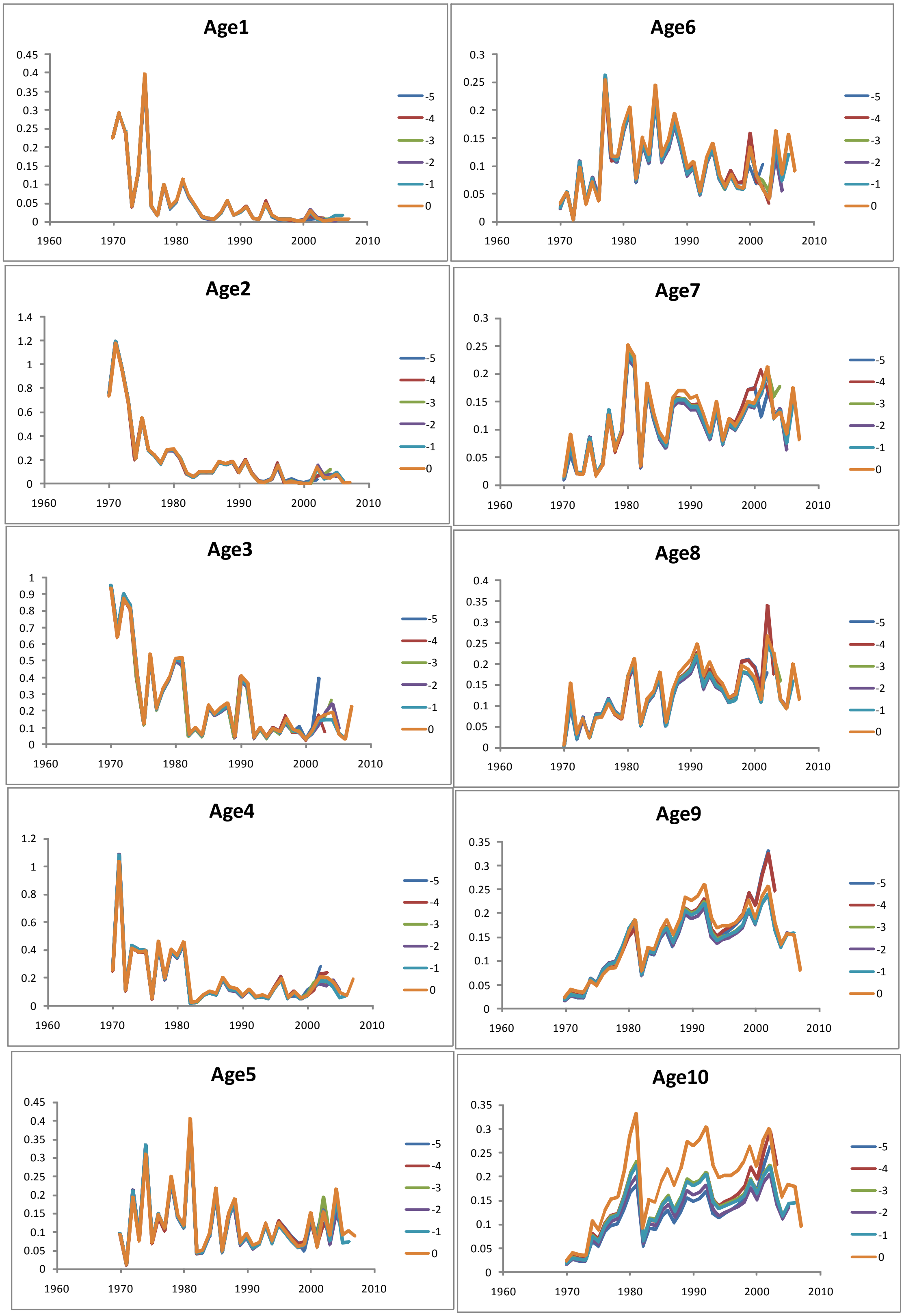


Figure 31. Retrospective patterns of fishing mortality by age (FAA) from the West BFT base case model. The legend indicates the number of years removed from the 2008 base run.

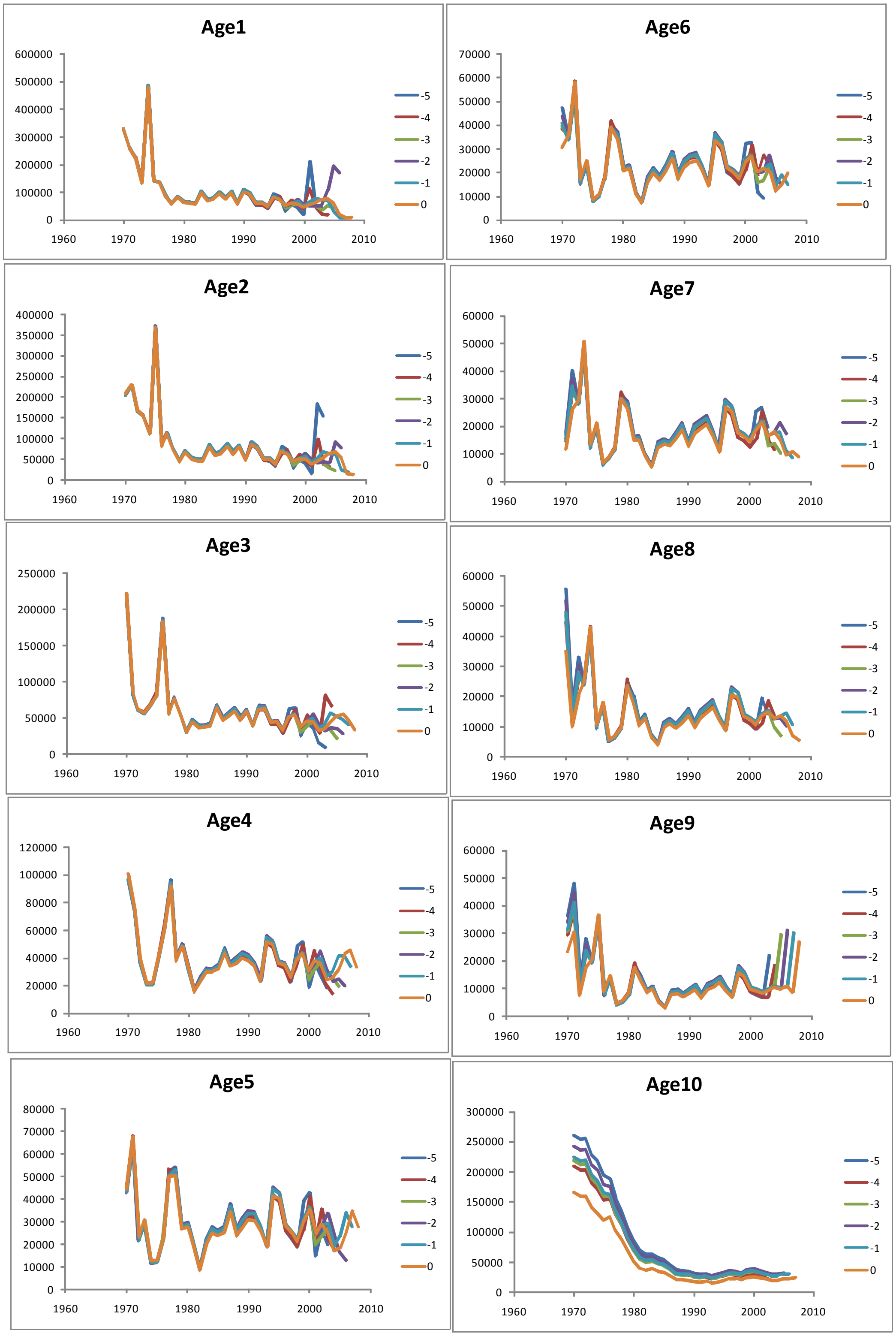


Figure 32. Retrospective patterns of numbers at age (NAA) from the West BFT base case model. The legend indicates the number of years removed from the 2008 base run.

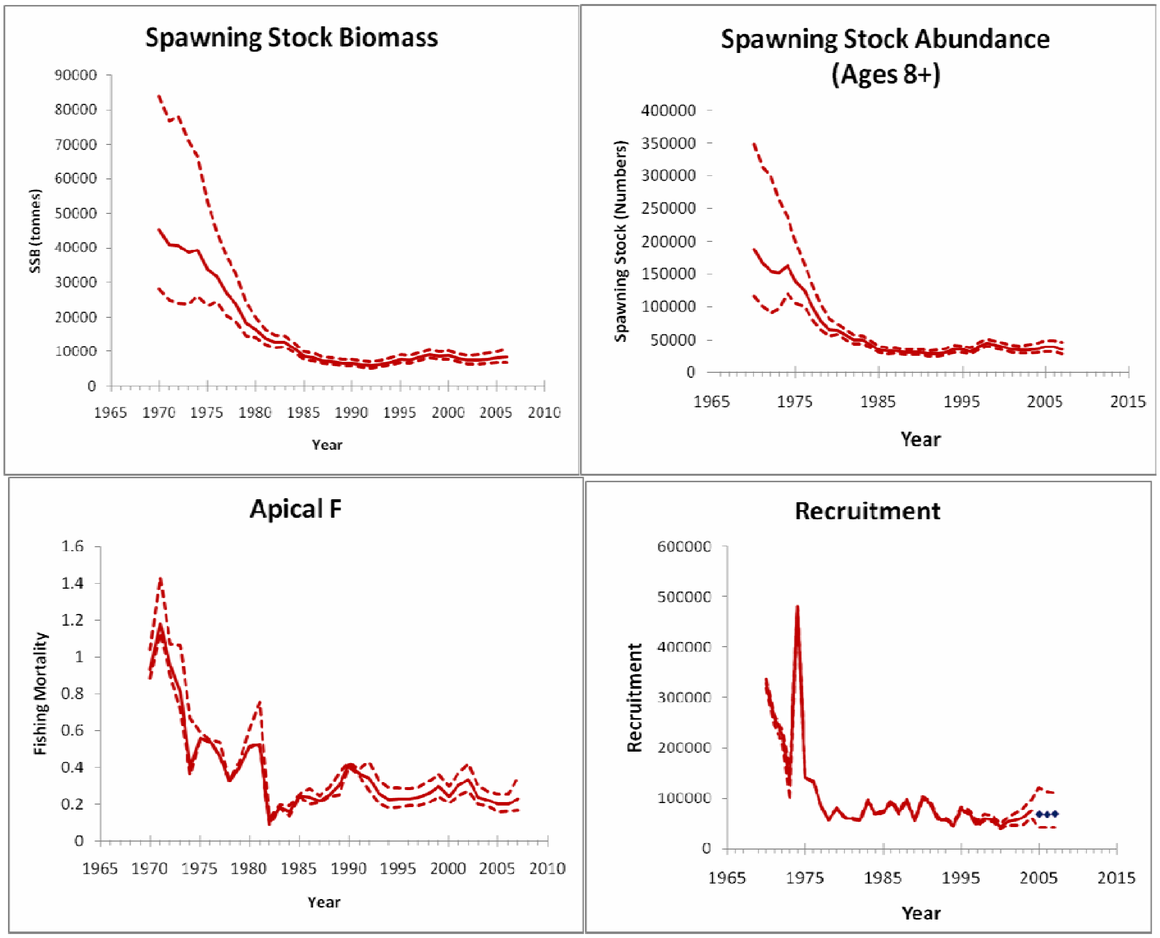


Figure 33. Annual median estimates of total biomass, yield, spawning stock biomass, abundance of spawners (Age 8+), apical fishing mortality and recruitment relationship. The 2005-2007 recruitment estimates were replaced by values from the two-line S-R relationship (blue diamonds). Dashed lines indicate the 80% confidence interval.

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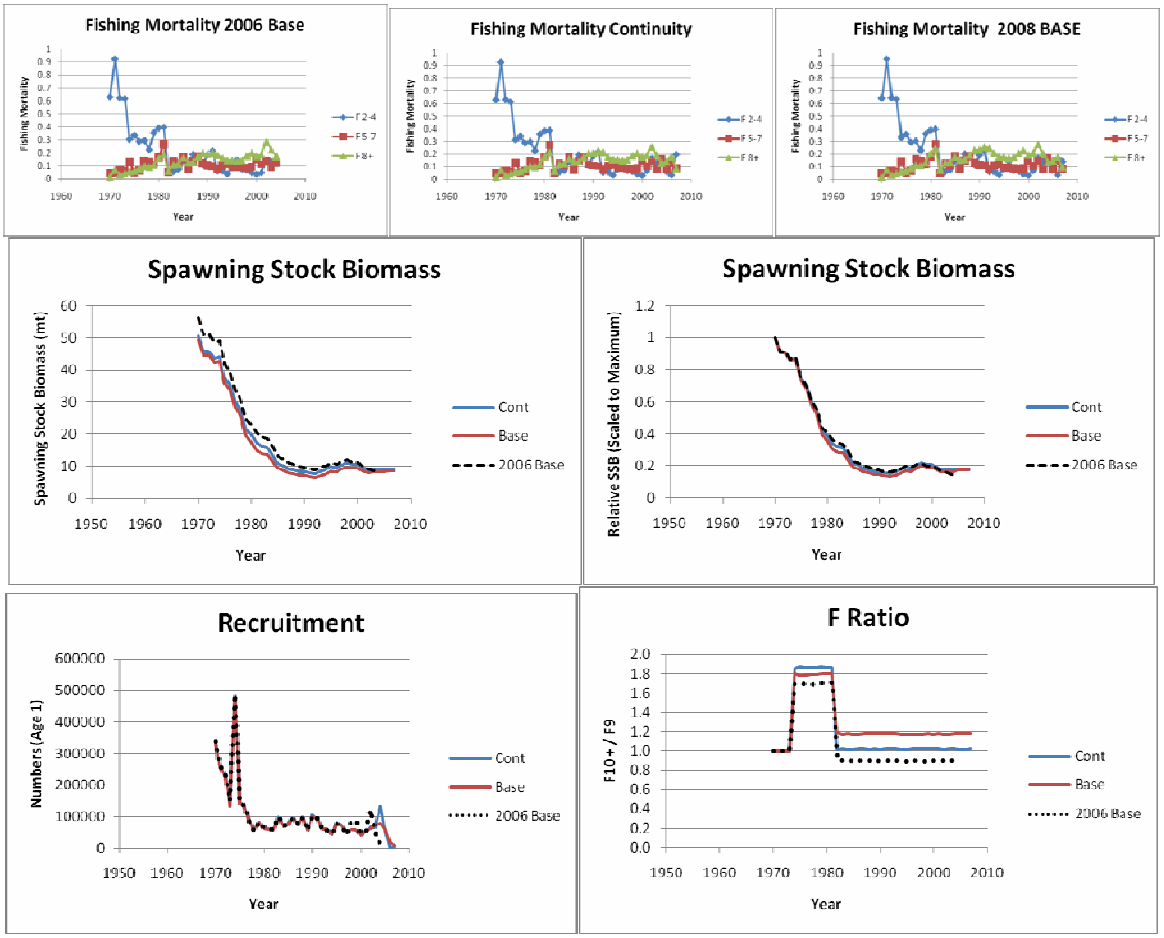


Figure 34. Annual estimates of average fishing mortality by age group, spawning stock biomass (SSB), recruitment and F-Ratio for the 2006 base and 2008 base and continuity VPA runs.

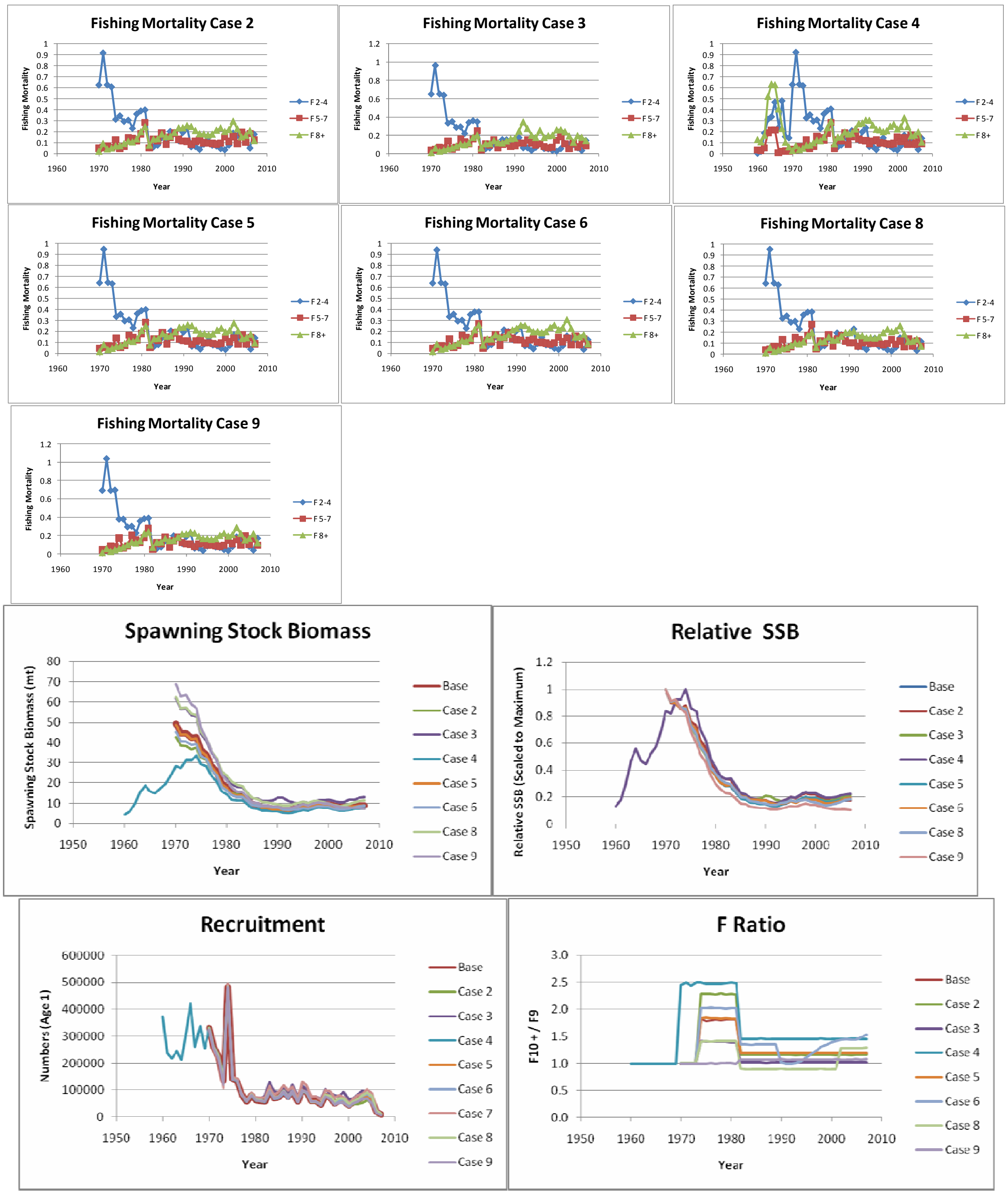


Figure 35. Annual estimates of spawning stock biomass (SSB), recruitment and F-Ratio for the VPA base and sensitivity runs.

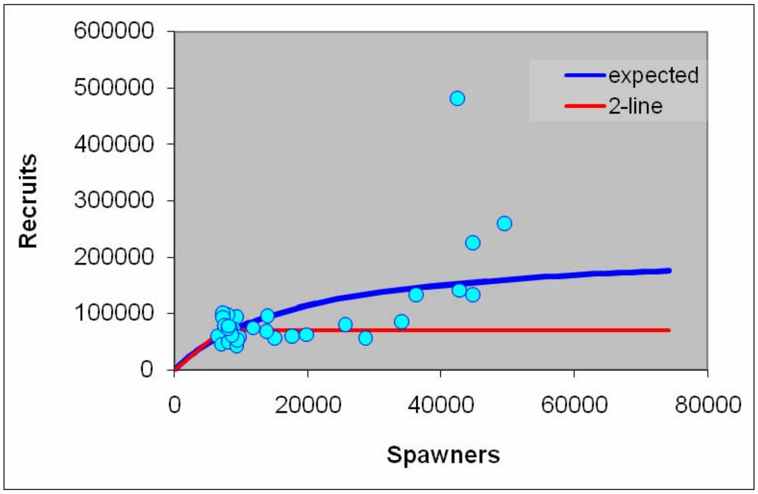


Figure 36. The spawner-recruit relationships fit to the 2008 VPA base model. The two-line and Beverton and Holt formulations were used to calculate management reference points and project the population dynamics through 2019.

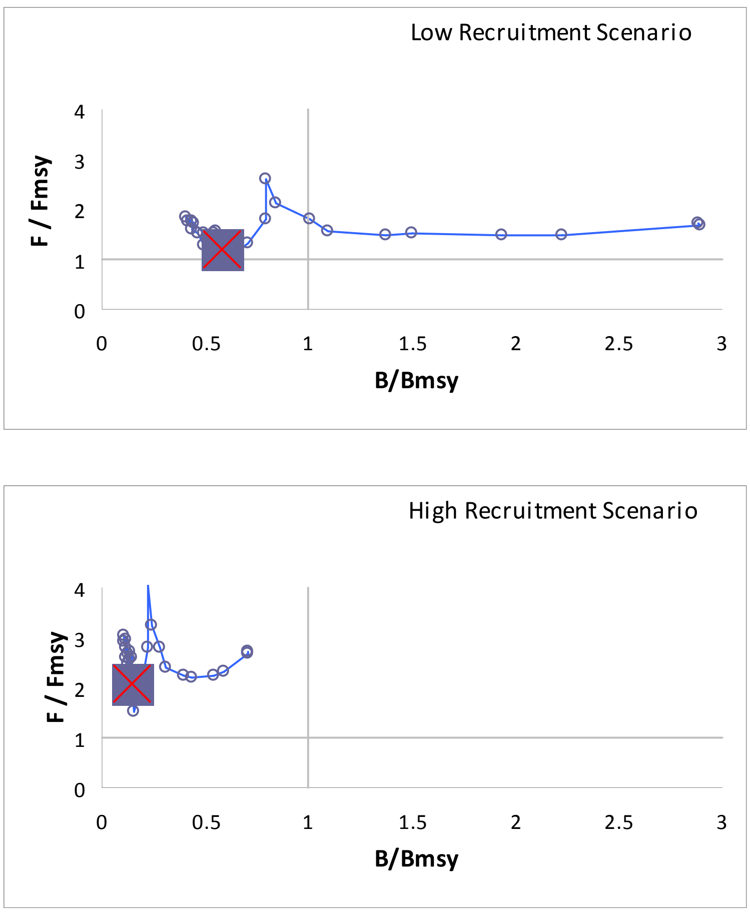


Figure 37. Trajectory of stock status estimated by the VPA base case. Two types of S-R relationships were examined, a two-line model (low recruitment) and the Beverton and Holt (high recruitment) option. F current is defined as the geometric mean fishing mortality during 2004-2006. The X is the current median status result. The calculation of MSY benchmarks was made annually so as to allow for interannual changes in selectivity.

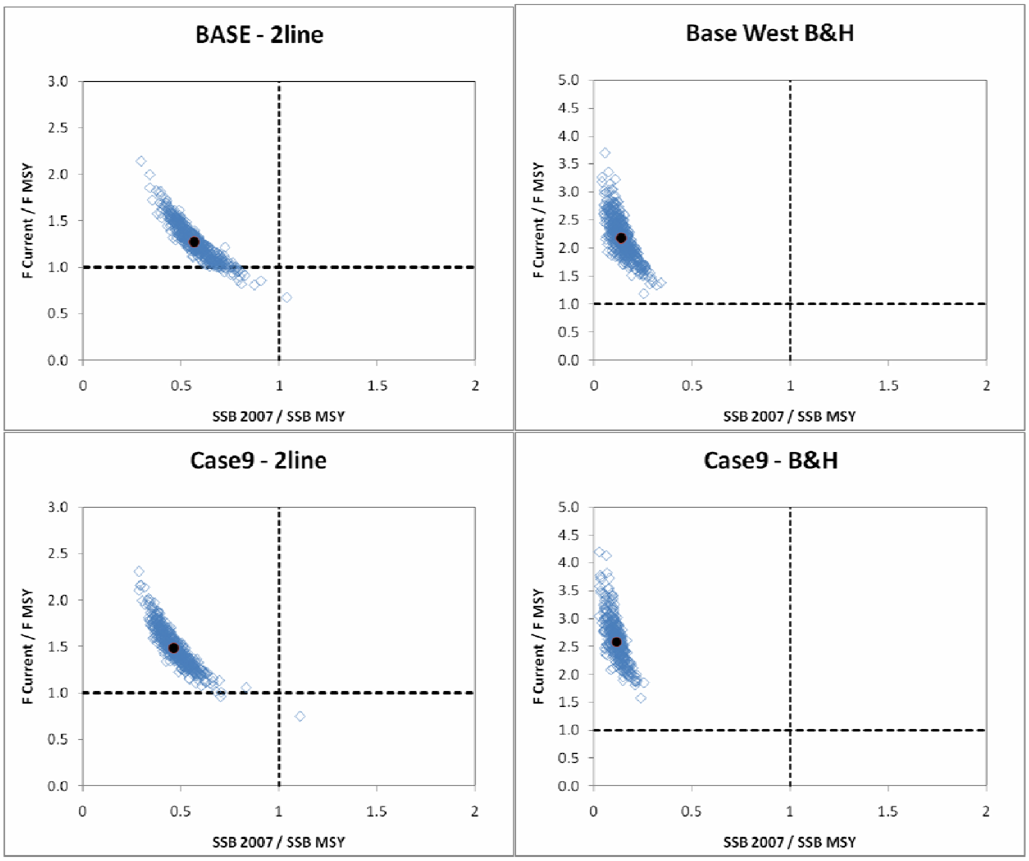


Figure 38. Stock status in 2007 estimated by the VPA base and Case 9 models (Case 9: remove Can GSL index). Two types of S-R relationships were examined, a two-line model (low recruitment) and the Beverton and Holt (high recruitment) option. F current is defined as the geometric mean fishing mortality during 2004-2006. The filled circle is the median result. The open circles are estimates of stock status from 500 bootstrap runs.

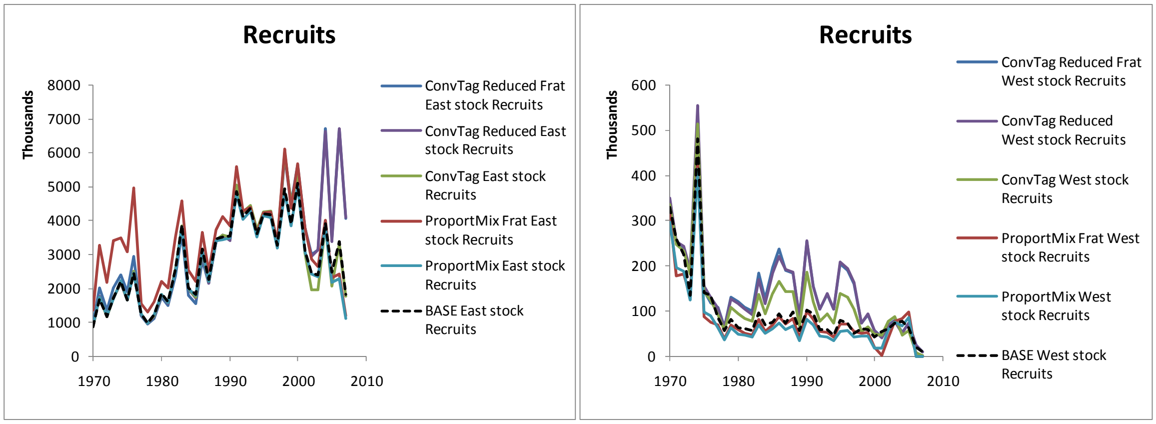


Figure 39. Recruitment (age 1) estimates for the eastern (left) and western (right) populations of bluefin tuna for the five scenarios compared to the corresponding base cases without mixing (dashed line).

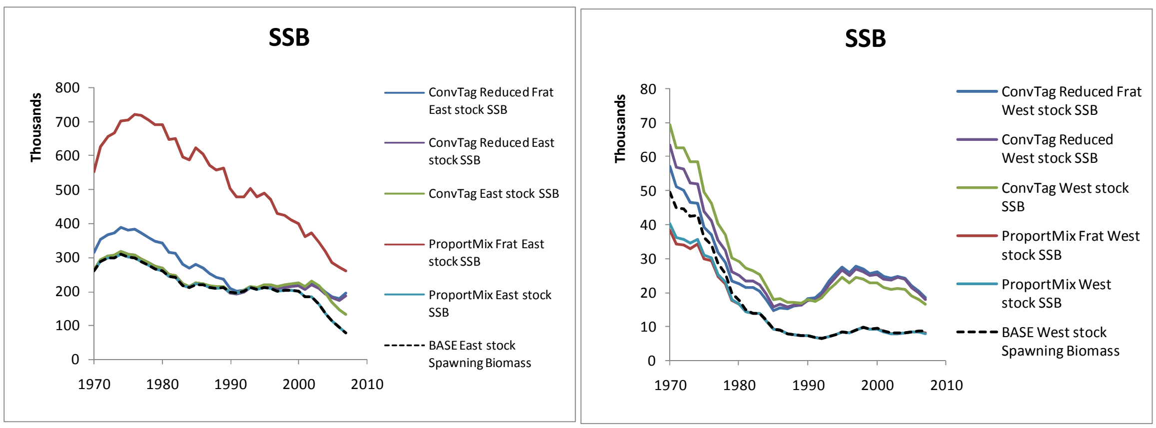


Figure 40. Spawning biomass estimates (tons) for the eastern (left) and western (right) populations of bluefin tuna for the five scenarios compared to the corresponding base cases without mixing (dashed line).

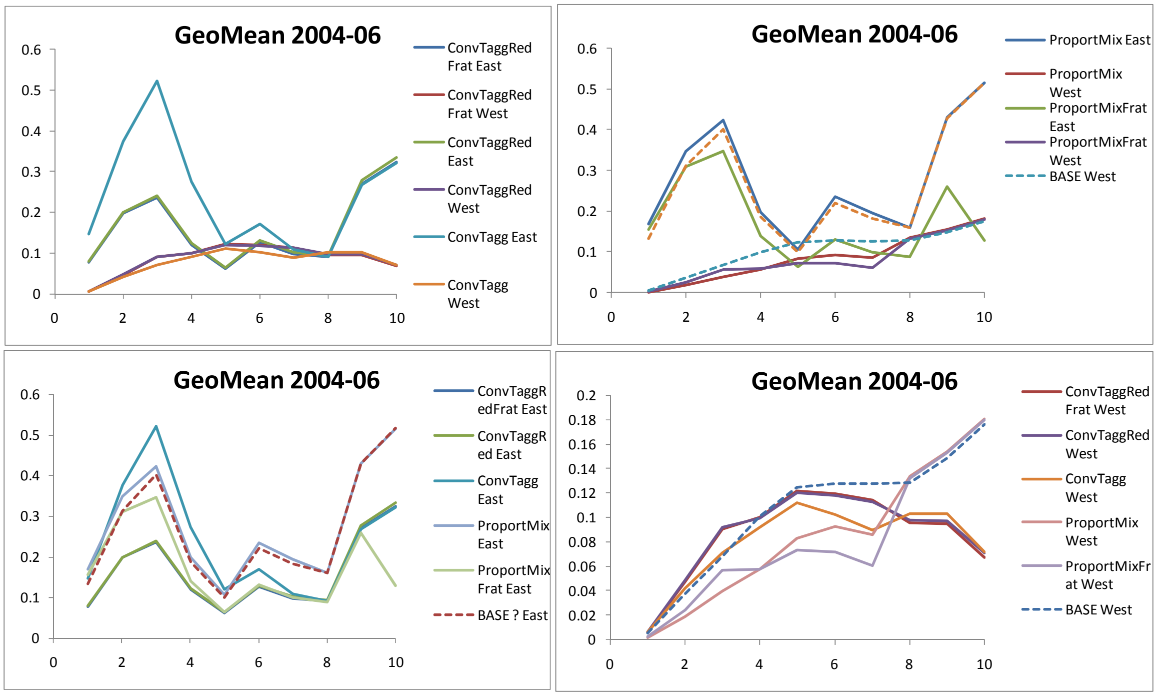
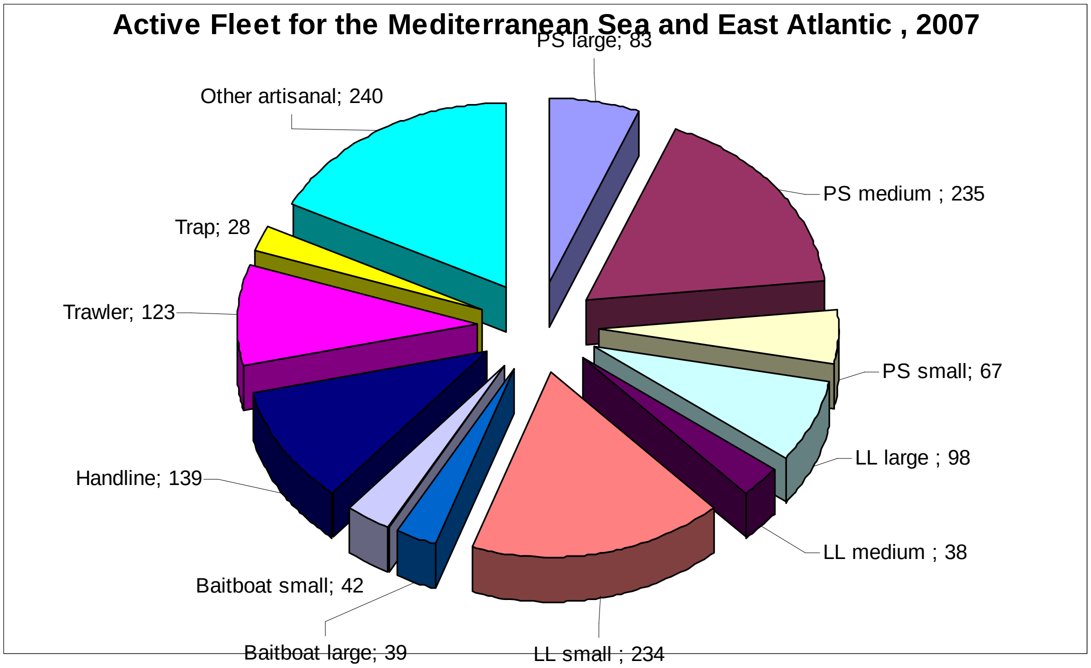


Figure 41. Recent fishing mortality rate estimates (geometric mean from 2004-2006) for the eastern (left) and western (right) populations of bluefin tuna for the five scenarios compared to the corresponding base cases without mixing (dashed line).



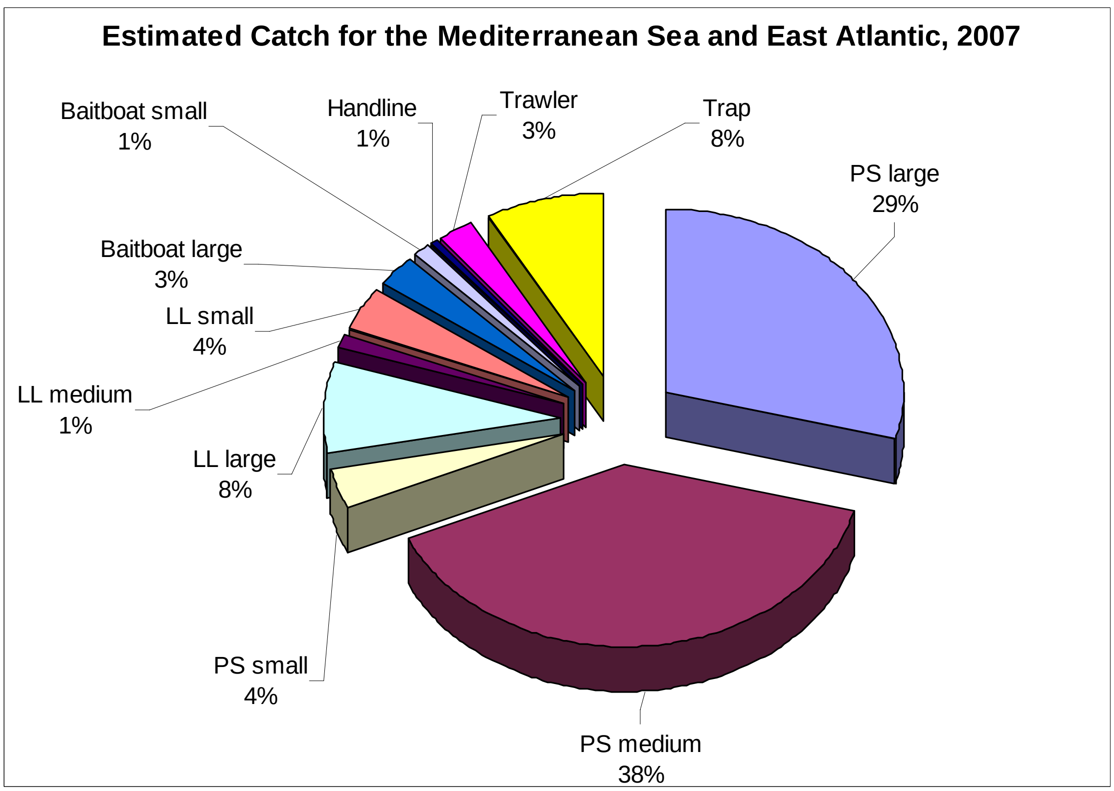


Figure 42. Estimated 2007 active fleet fishing for bluefin (upper) and the corresponding percentage contribution to an estimated overall catch of about 60,000 t in 2007 (lower) by fleet types for the Mediterranean Sea and East Atlantic.

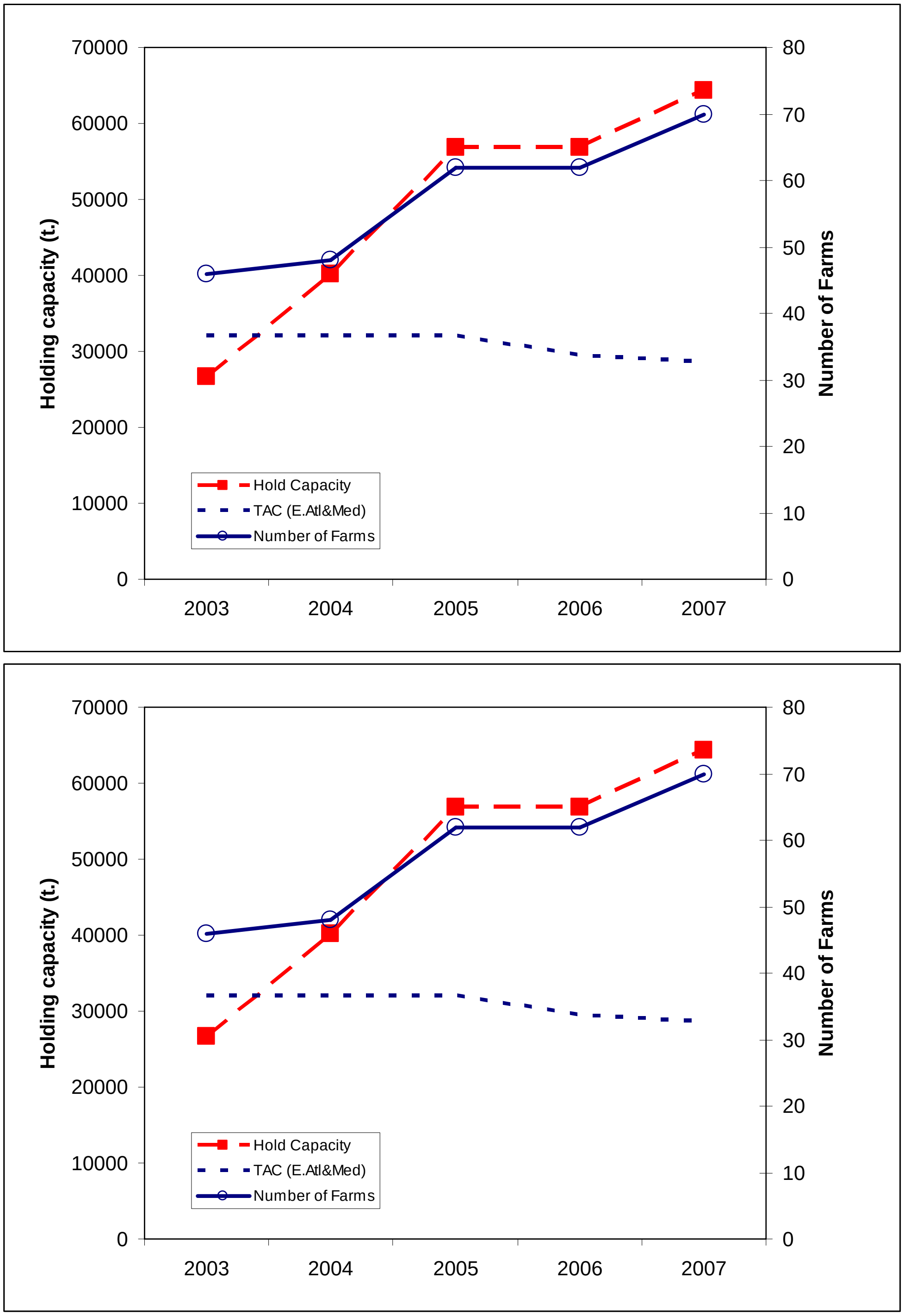
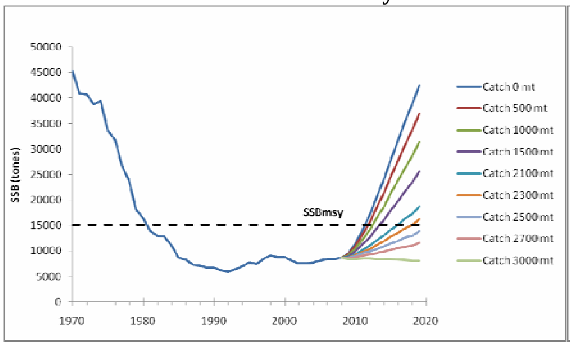
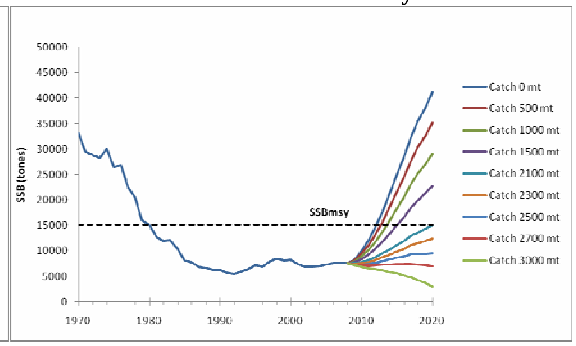


Figure 43. Estimated Mediterranean bluefin farm capacity and number of farms as reported by CPCs to the Secretariat. Agreed TACs for the time period are also indicated.

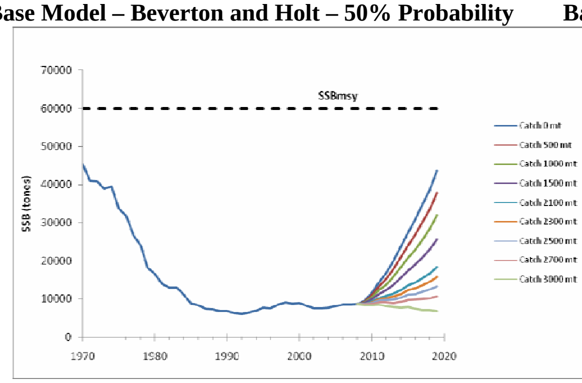
Base Model – Two-line – 50% Probability



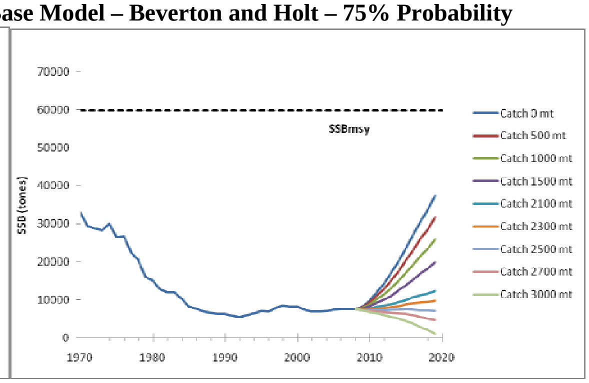
Base Model – Two-line – 75% Probability



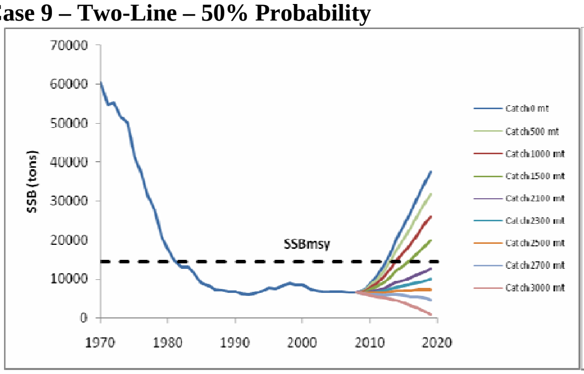
Base Model – Beverton and Holt – 50% Probability



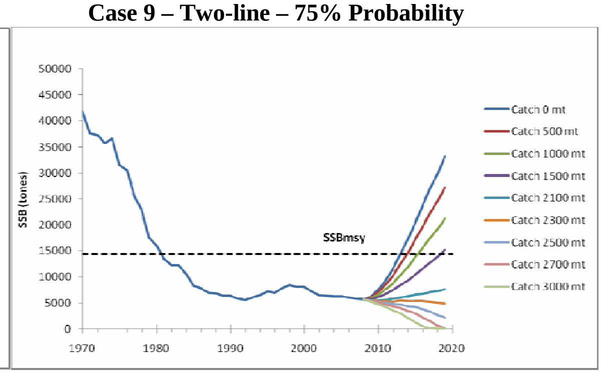
Base Model – Beverton and Holt – 75% Probability



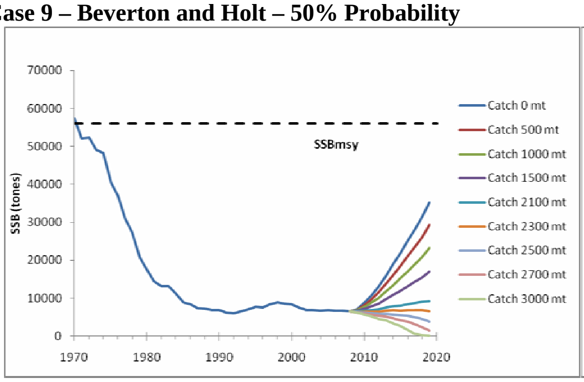
Case 9 – Two-Line – 50% Probability



Case 9 – Two-line – 75% Probability



Case 9 – Beverton and Holt – 50% Probability



Case 9 – Beverton and Holt – 75% Probability

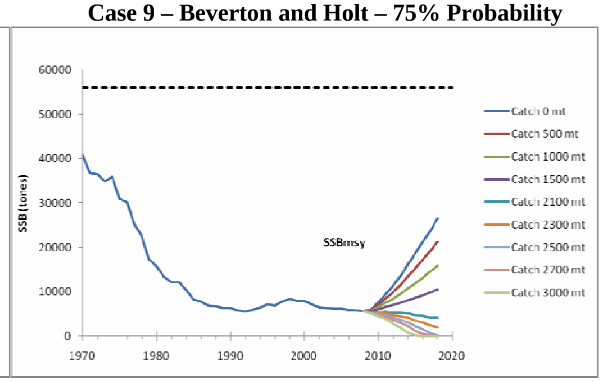


Figure 44. Projections of spawning stock biomass (SSB) from the Base and Case 9 (no GSL index) VPAs under various levels of constant catch. The labels "50% probability" and "75% probability" refer to the probability that the SSB will be greater than or equal to the values indicated by each line. Note that the lines corresponding to each catch level are arranged sequentially in the same order as the legends.

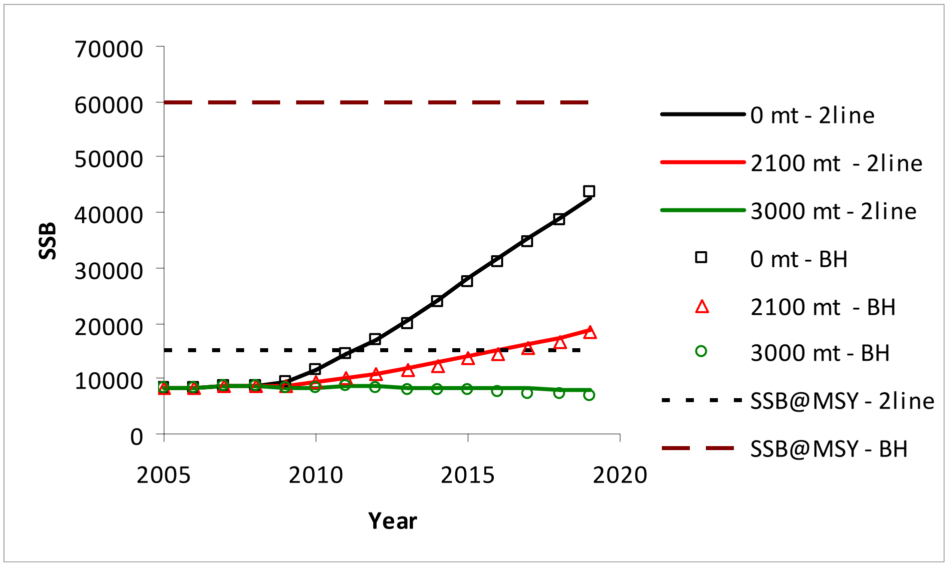


Figure 45. Median projections of spawning stock biomass (SSB) for the Base Case assessment under various levels of constant catch (left) and under various levels of constant fishing mortality rate (right). NOTE: Lines are arranged sequentially in the same order as the legends.

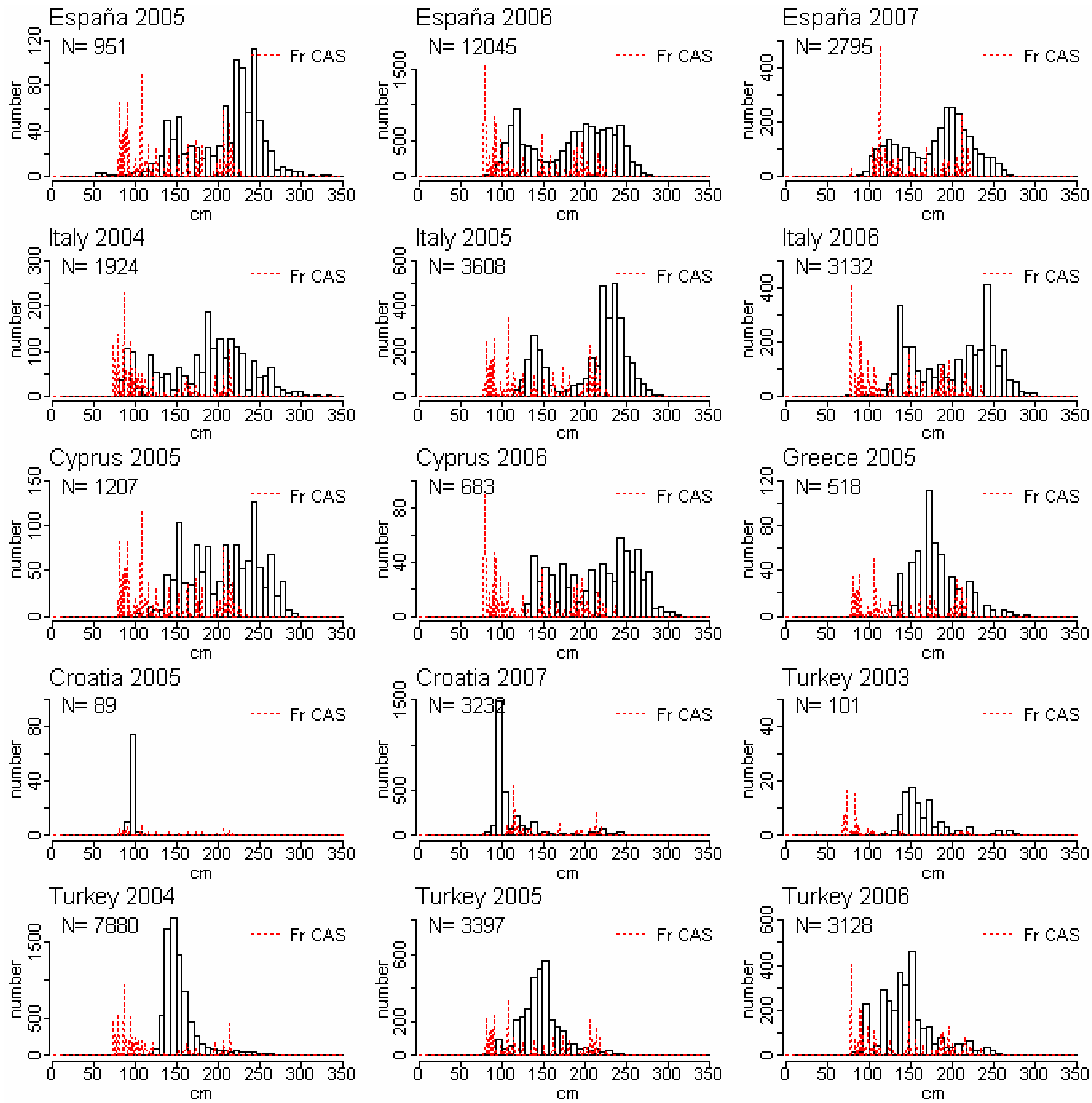


Figure 46. Histogram of fork lengths or weights of fish at time of harvest from Mediterranean BFT farms. French purse seine catch at size for the year of harvest plotted in red. (note that catch is usually taken in May-June, while the farm harvest is in December so there could be some growth in length over this time period).

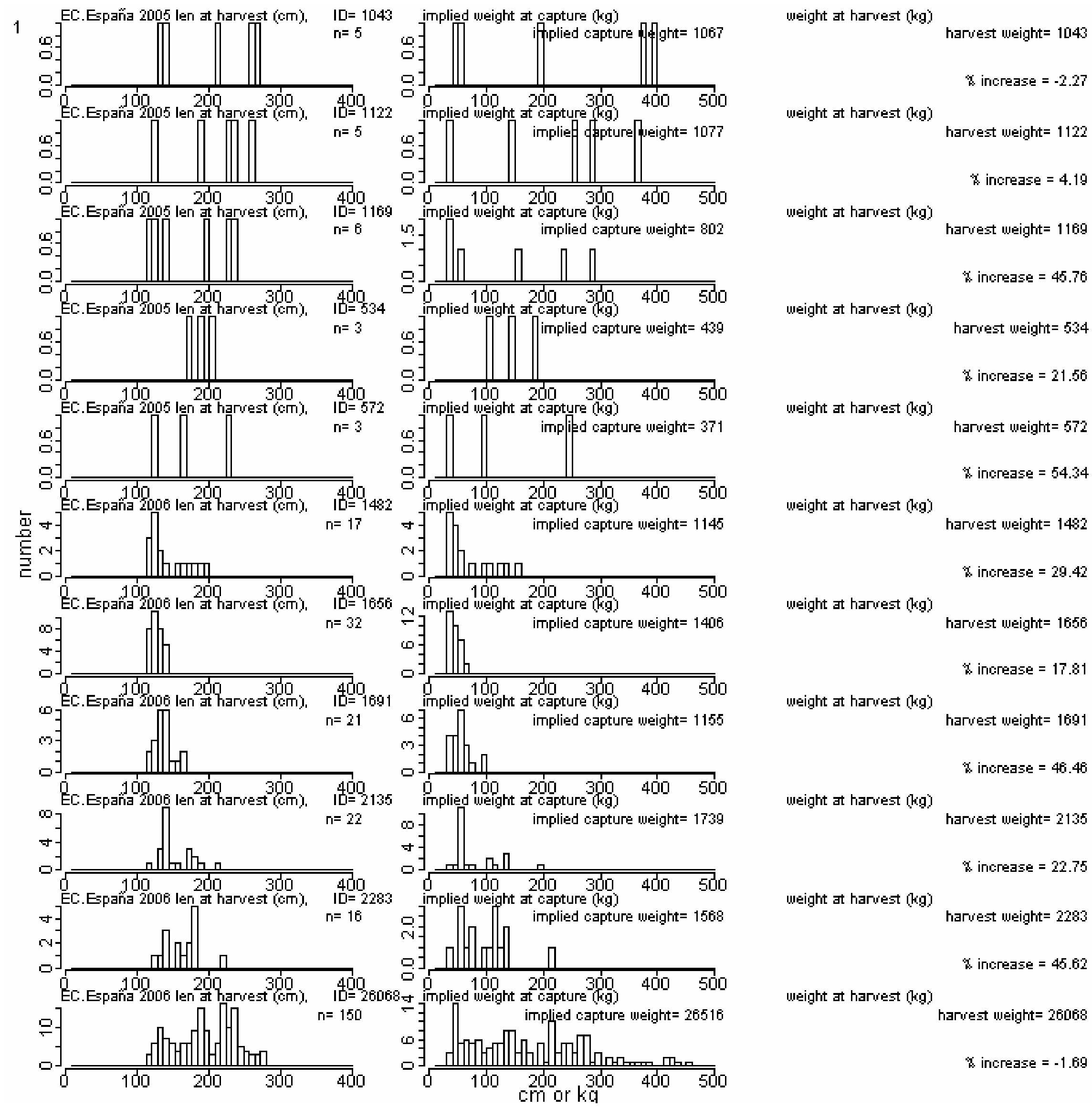


Figure 47. Histograms of length at harvest, implied weight at capture assuming that captured BFT follow the ICCAT length-weight conversion (Arena, unpub.) and the actual weights at harvest for the farms from Spain for which weight at harvest was provided.

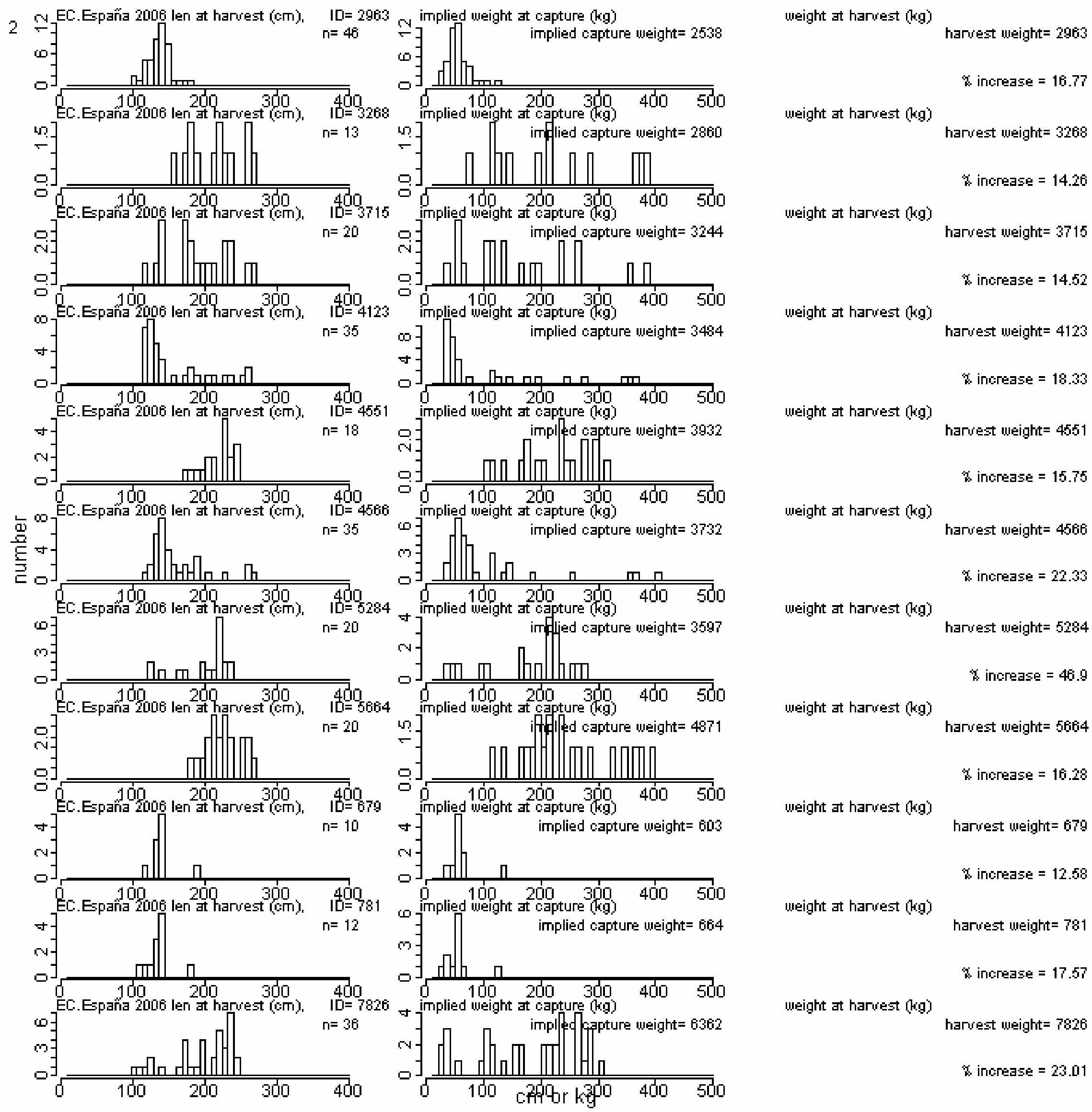


Figure 47 Continued.

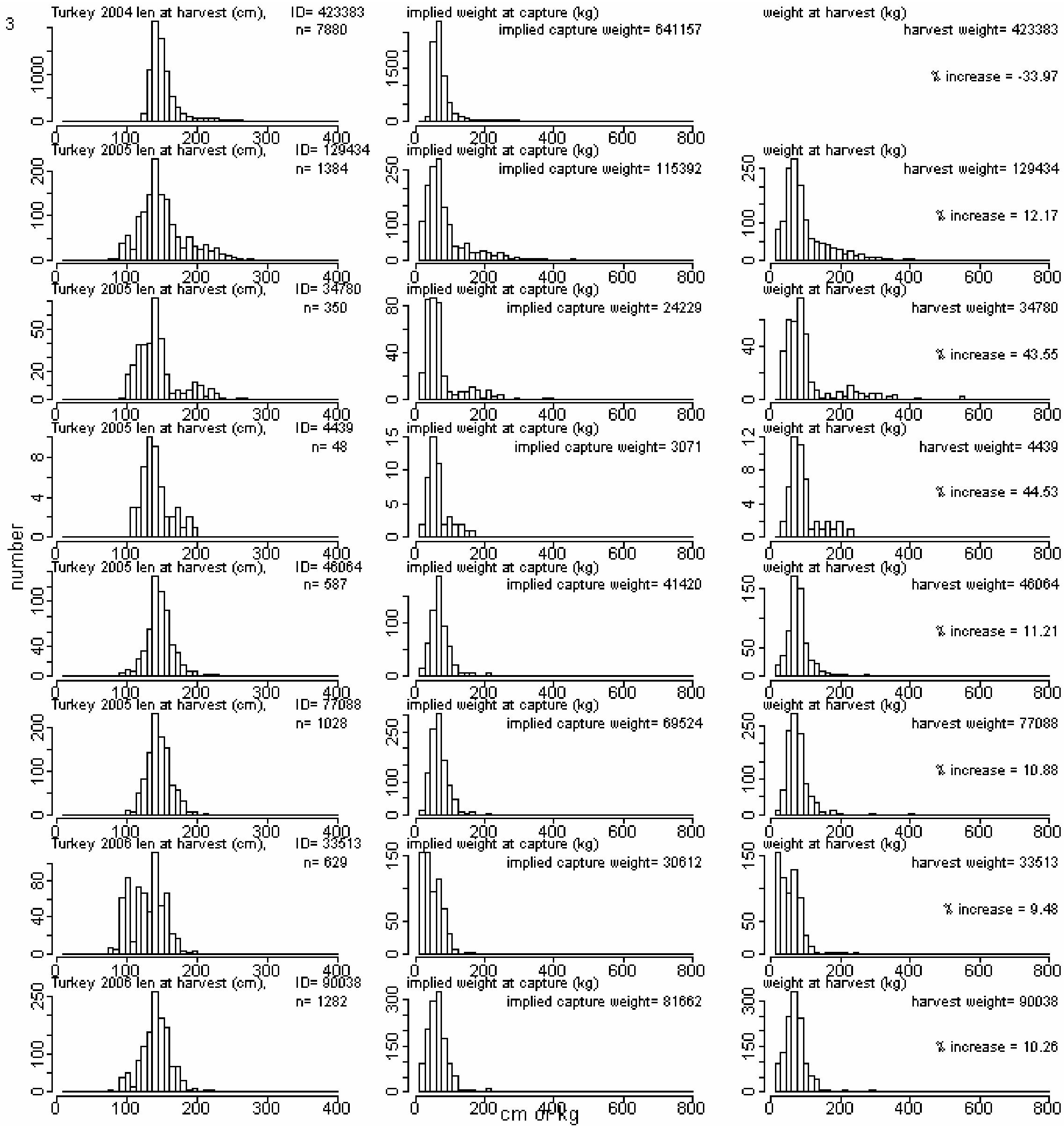


Figure 48. Histograms of length at harvest, implied weight at capture assuming that captured BFT follow the ICCAT length-weight conversion (Arena, unpub.) and the actual weights at harvest for the farms from Turkey for which weight at harvest was provided.

Appendix 1

Agenda

1. Opening, adoption of the Agenda and meeting arrangements.
2. Review of the Rebuilding Plans for Atlantic and Mediterranean bluefin tuna and previous SCRS advice
3. Consideration of the findings and recommendations of the World Symposium for the Study into the Stock Fluctuation of Northern Bluefin Tunas (*Thunnus thynnus* and *Thunnus orientalis*), including the historic periods
4. New biological information, including results from tagging, microconstituent analysis, growth and reproductive studies, and other studies pertinent to the assessment
5. Catch data, including size frequencies and fisheries trends
    5.1 Fishery trends – East
    5.2 Fishery trends – West
    5.3 Catch data – East
    5.4 Catch data – West
    5.5 Mixing variants
6. Relative abundance indices and other fishery indicators
    6.1 Relative abundance indices – East
    6.2 Relative abundance indices – West
7. Methods and other data relevant to the assessment
    7.1 Methods – East
    7.2 Methods – West
    7.3 Methods – Mixing variants
    7.4 Methods – Regulatory analyses
    7.5 Methods for integration of management advice across multiple hypotheses
    7.6 Other methods
8. Stock status results
    8.1 Stock status – East
    8.2 Stock status – West
    8.3 Stock status – variants considering mixing
9. Evaluation of fishing capacity relative to the ICCAT Convention objectives
    9.1 East
    9.2 West
10. Projections
    10.1 Projections – East
    10.2 Projections – West
11. Recommendations
    11.1 Research and statistics – East
    11.2 Research and statistics – West
    11.3 Management – East, including advice on the odds of achieving the current Rebuilding Plan objectives without further adjustment
    11.4 Management – West, including advice on the odds of achieving the current Rebuilding Plan objectives without further adjustment
12. Other matters
13. Adoption of the report and closure

Appendix 2

BLUEFIN TUNA WORKPLAN: YEAR 2008

1. Overview

The next bluefin tuna stock assessment (East and West) has been scheduled by the Commission for 2008. The Bluefin Tuna Species Group reiterates the fact that its general advice is unlikely to change significantly within two years time because of bluefin tuna long life span and the necessary delay to detect first effects of most recent regulations. The group thinks that a four-year period would be more appropriate between each comprehensive bluefin tuna stock assessment session. This will allow the Group more time for inter-sessional work, especially to investigate important or novel issues regarding data and models. If the requirement of a stock assessment in 2008 remains, this should be scheduled in late June/early July. Nine days are considered sufficient for the quantitative assessment work and report writing only if much of the data-preparatory work is carried out in advance of the meeting. In particular, it is essential that catch (being disaggregated by gear/main area[1]/month), catch-at-age and tagging data through 2006 be as final as a few months prior to the meeting to allow preparatory works and analyses.

2. Data submission

National scientists should submit any missing eastern Atlantic and Mediterranean statistics forthwith. Data for the eastern and western stock through 2006 should be submitted to the Secretariat by the end of March 2008, while data of 2007 should be submitted, at the latest, one week prior to the meeting, so that the Secretariat can incorporate the statistics into the database. *Action National Scientists*

Estimates of unreported landings for the eastern unit should be investigated prior to the meeting and completed during the assessment meeting. *Action National Scientists and Secretariat*

All National Scientists should provide catch, catch-at-size, tagging and CPUE data up to and including 2007 where available (East and West). The group recognizes that this may not be possible for all fleets. Assessment software should be adapted to accommodate the possibility of incomplete data for 2007 and earlier. *Action National Scientists and Secretariat*

The SCRS has also recommended that efforts be made to extend the assessment time series into the past. National Scientists are asked to ensure that any available historical data (especially catch-at-size pre-1970) have been made available to the Secretariat. *Action National Scientists*

The SCRS also recommended that efforts be made to share novel biological information prior to the meeting, e.g. through a list server maintained by the secretariat. *Action National Scientists and Secretariat*

3. Catch summaries

The Secretariat should prepare summaries of the available catch data as well as catch-at-size data by the start of the meeting. Late submissions will not be included. *Action Secretariat*

4. Assessment

The stock assessment work should update the 2006 stock assessments. In the case of the West stock, mainline advice should be based on results from validated and documented software retained in the ICCAT catalog. These catalog entries need to be completed by April 2008. *Action National Scientists*

In the case of the East stock, it is still recommended that the Bluefin Tuna Species Group should investigate various assessment methods that may be robust to or that can take into account the large uncertainties in the total

[1]Main areas correspond to the 6 areas defined in Figure 3 of the ICCAT Bluefin Tuna Mixing Workshop (Anon. 2002).

catch and catch-at-size data. It is also expected that the Group will investigate more deeply the effects on stock status of the management measures that were adopted in November 2006 in Dubrovnik. *Action National Scientists*

Appendix 3

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Appendix 4

LIST OF DOCUMENTS

SCRS/2008/013	Proceedings of the joint CANADA-ICCAT 2008 Workshop on the Precautionary Approach for Western Bluefin Tuna *(Halifax, Nova Scotia, Canada, March 17 to 20, 2008).* Gavaris S (Chairman), Hazin F, Neilson JN, Pallares P, Porch C, Restrepo VR, Scott G, Shelton P, Wang Y (editors).
SCRS/2008/083	Indices of stock status from the Canadian bluefin tuna fishery. Neilson, J., Smith, Ortiz and Lester.
SCRS/2008/084	Growth of Atlantic bluefin tuna: direct age estimates. Secor, D. H., R.L. Wingate, J.D. Neilson, J.R. Rooker, and S.E. Campana.
SCRS/2008/085	Standardized catch rates of bluefin tuna *(Thunnus thynnus)* from the U.S. pelagic longline vessels in the Gulf of Mexico 1987-2007. Diaz, G., and S. Cass-Calay.
SCRS/2008/086	Annual indices of bluefin tuna *(Thunnus thynnus)* spawning biomass in the Gulf of Mexico developed using delta-lognormal and multivariate models. Ingram, G.W. Jr., W. J. Richards, C. E. Porch, V. Restrepo, J. T. Lamkin, B. Muhling, J. LycDiaz, G.A., V. Restrepo, and B. McHalezkowski-Shultz, G. P. Scott and S. C. Turner.
SCRS/2008/087	Characterization of the U.S. commercial and recreational tuna fleets during 2007. Diaz, G.A., V. Restrepo and B. McHale.
SCRS/2008/088	Standardized catch rates of bluefin tuna, *Thunnus thynnus*, from the rod and reel/handline fishery off the northeast United States during 1980-2007. Brown, C.
SCRS/2008/089	Three different strategies for modeling the terminal-year fishing mortality rates in virtual population analyses of western bluefin tuna: Retrospective patterns and consequences for projections. Walter, J. and C. Porch.
SCRS/2008/091	Sensitivity of virtual population analyses of western Atlantic bluefin tuna to the use of an alternative growth curve for estimation of catch at age. Porch, C., V. Restrepo, J. Nielson and D. Secor.
SCRS/2008/092	Preliminary results from electronic Tagging of bluefin tuna *(Thunnus thynnus)* in the Gulf of St. Lawrence, Canada. Block, B.A., G. L. Lawson, A. M. Boustany, M. J.W. Stokesbury, M. Castleton, A. Spares, and J. D. Neilson.
SCRS/2008/093	A year-class curve analysis to estimate mortality of Atlantic bluefin tuna caught by the Norwegian fishery from 1956 to 1979. Fromentin, J.M. and V. Restrepo.
SCRS/2008/094	Evaluation of the performance and robustness of VPA-based stock assessment and MSY-based management strategy to process error: An Atlantic bluefin tuna case study. Fromentin, J.M. and L. Kell.
SCRS/2008/096	Preliminary estimation of the size composition of bluefin tuna (*thunnus thynnus*) caught by Moroccan Atlantic traps from biological scraps in 2006. Idrissi, M. and N. Abid.
SCRS/2008/097	A multi stock tag integrated age structured assessment of Atlantic bluefin tuna. Taylor, N., M. McAllister, B. Block and G. Lawson.
SCRS/2008/098	Updated standardized indices for bluefin tuna from the Moroccan trap fishery (1998-2006). Abid, N., M. Idrissi and J.M. Ortiz de Urbina.
SCRS/2008/099	Updated standardized indices for bluefin tuna from the Spanish trap fishery (1981-2007). Ortiz de Urbina, J.M., J.M. de la Sern and D. Macías.

SCRS/2008/100 Updated standardized CPUE of Atlantic bluefin tuna caught by the Spanish baitboat fishery in the Bay of Biscay (eastern Atlantic). Time series from 1975 to 2007. Rodriguez-Marin, E., M. Ortiz, C. Rodríguez-Cabello and S. Barreiro.

SCRS/2008/101 The key importance of the underlying stock-recruitment assumption when evaluating the potential of management regulations of Atlantic bluefin tuna. Fromentin, J.M.

SCRS/2008/102 Revised catch-at-size estimates of Atlantic bluefin tuna (eastern and western stocks: 1960-06). Palma, C & P.Kebe.

SCRS/2008/103 Standardized bluefin CPUE from the Japanese longline fishery in the Atlantic up to 2007. Ohshima, K., Y. Takeuchi and N. Miyabe.

SCRS/2008/104 Repartition demographique du thon rouge engraisse dans les fermes Tunisiennes pendant les campagnes 2005 à 2007. Hattour, A.

Appendix 5

Investigations of Growth Modeling Undertaken by the Group

As illustrated by SCRS/2008/084, estimates of age derived from bluefin tuna otoliths can provide useful information concerning age and growth. However, as the authors of SCRS/2008/084 (referred to as Secor *et al.* here) noted, there was a need to include a broader range of ages in their investigation. For example, the Secor *et al.* equation does not predict length at age well for the youngest ages (ages 1-3), whereas the Restrepo *et al.* model currently in use by the SCRS appears to provide better predictions **(Figure Appendix 5.1)**.

As noted previously, the Secor et al. curve was estimated using age-length data derived from otolith reading while the curve used by the SCRS was derived from length frequency data and tagging. Given the differences observed between the two growth curves, the Group decided to explore the results of combining different data sets and using different error assumptions to estimate growth curves. Because the complete data set used to estimate the current SCRS growth curve was not available, the Group utilized the data used by Restrepo et al. (Col. Vol. Sci. Pap. ICCAT (60)3:1014-1026) to estimate their growth curve. Although the L_∞ estimated by Restrepo *et al.* was lower than the value estimated by Turner and Restrepo (1994) (353.2 cm vs. 382.0 cm), the Group agreed that for comparison purposes the Restrepo et al. curve was a good approximation **(Table Appendix 5.1)**.

The data sets available were:

1. Length frequency data (ages 1-3) from modal analysis (Restrepo *et al.*).
2. Tagging data (Restrepo *et al.*).
3. Age-length data derived from otolith readings (Secor *et al.*).
4. Age-length data derived from using deposition of bomb radiocarbon to derive age (Neilson and Campana, Can. J. Fish. Aquat. Sci. (65) in press).

The curve derived using the Restrepo et al. data used the following likelihood functions (Kirkwood and Somers, 1984):

$$\Phi_1 = -\frac{n_1}{2}\ln(2\pi\sigma_1^2) - \frac{1}{2\sigma_1^2}\sum_{i=1}^{n_1}\left[\delta t_i + \frac{1}{K}\ln\left(1 - \frac{\delta l_i}{L_\infty - R_i}\right)\right]^2$$

$$\Phi_2 = -\frac{n_2}{2}\ln(2\pi\sigma_2^2) - \frac{1}{2\sigma_2^2}\sum_{i=1}^{n_2}\left[t_i - t_0 + \frac{1}{K}\ln\left(1 - \frac{l_i}{L_\infty}\right)\right]^2$$

where the subscripts 1 and 2 indicate the tagging data and age-length data derived from modal analysis, respectively. Note than in the Restrepo *et al.* formulations an observed length could not be greater than L_∞ and length was the predicted variable.

The following combinations of data/error assumptions were used to estimate growth curves (numbers 1, 2, 3, and 4 correspond to the data sets described above).

1) 1 + 2 + 3 using length as predicted var.

2) 1 + 2 + 3 using age as predicted var.

3) 3 + 4 using length as predicted var.

4) 1 + 3 + 4 using length as predicted var.

5) 1 + 2 + 3 + 4 using length as predicted var.

6) 1 + 2 + 3 + 4 using age as predicted var.

The difference between the last formulation (number 6) and the other 5 is that the likelihood functions included a model error term (σm, i) and a common σL∞ as follows (equations taken from Restrepo *et al.*):

$$\Phi_1 = -\sum_i \frac{\ln(2\pi(\sigma^2{}_{L_\infty}(1-e^{-K\delta t_t})^2 + \sigma^2{}_{m,1}))}{2} + \frac{(\delta l_1 - (L_\infty - R_i)(1-e^{-K\delta_{t_i}}))^2}{2(\sigma^2{}_{L\infty}(1-e^{-K\delta t_t})^2 + \sigma^2{}_{m,1})}$$

$$\Phi_2 = -\sum_i \frac{\ln(2\pi(\sigma^2{}_{L_\infty}(1-e^{-K(t_i-t_o)})^2 + \sigma^2{}_{m,2}))}{2} + \frac{(l_1 - L_\infty(1-e^{-K(t_i-t_o)}))^2}{2(\sigma^2{}_{L_\infty}(1-e^{-K(t_i-t_o)})^2 + \sigma^2{}_{m,2})}$$

Where $\sigma^2{}_{L_\infty}$ = variance of L_∞,

$\sigma^2{}_{L_m}$ = variance for model error

Table 4.1.1 summarizes the estimated growth parameters of the SCRS (Turner and Restrepo 1994), the Restrepo *et al.,* and Secor *et al.* growth curves and the 6 additional cases. The estimated six curves lay between the Restrepo et al., Secor *et al.* curves **(Figure Appendix 5.2)**. For simplification purposes, Figure APPENDIX 5.3 only shows the Restrepo et al. and Secor et al. growths curves together with the curve estimated using all data and assuming an error model for each data set and a common error for L_∞ (case 6).

Table X.1. Estimated growth parameters for the Secor *et al.* and Restrepo *et al.* growth curves and 6 combinations of data and error assumptions.

Parameters	**SCRS**	**Secor *et al.* fit**	**Restrepo *et al.* fit**	**1. Combine R+S- Fit pred to obs length**	**2. Combine R+S - Fit pred to obs age**	**3. Combine S+Neilson and Campana**	**4. Combine R modal age 1-3+S+N**	**5. Combine all data, fit to length at age**	**6. All data with error on each model and one Linf**
L(inf)	382	256.65	353.17	336.15	353.2	271.46	276.26	300.67	306.68
K	0.079	0.195	0.089	0.156	1.210	0.151	0.136	0.100	0.11
t0	-0.707	0.83	-0.71	0.22	2.21	0.00	-0.33	-0.85	-0.886

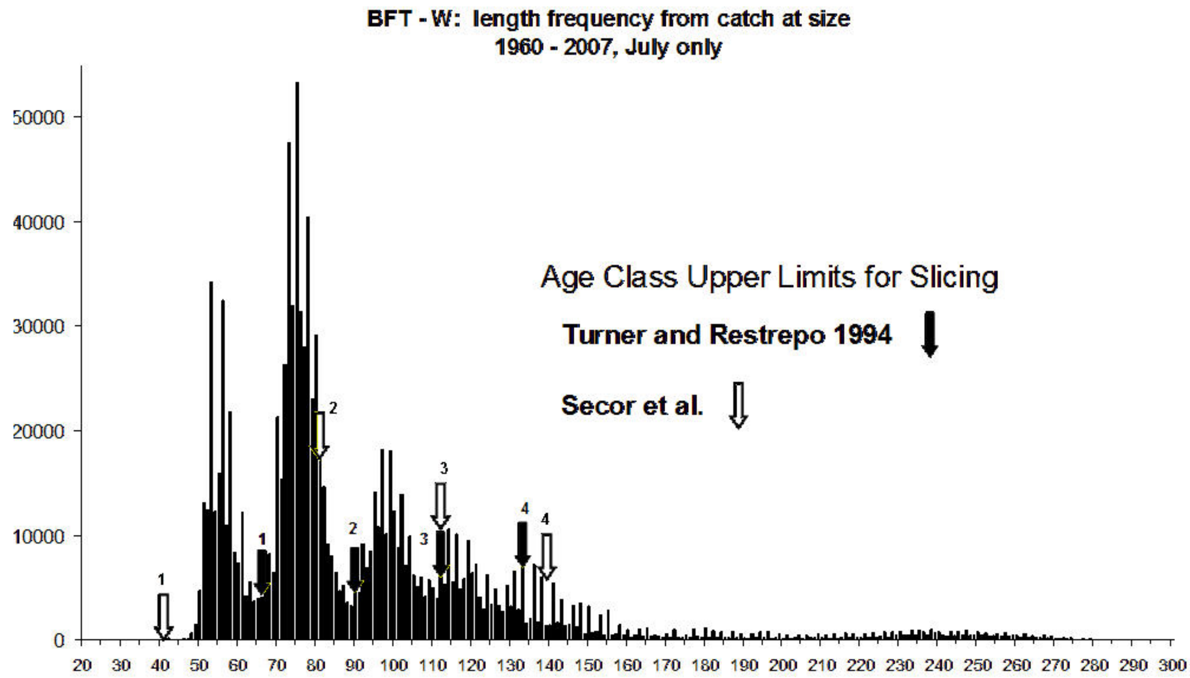

Figure Appendix 5.1 Upper limits for slicing of age groups using the Turner and Restrepo (1994) equation, compared with the Secor *et al.* growth equation for western origin – western capture bluefin tuna (SCRS/ 2008/084)

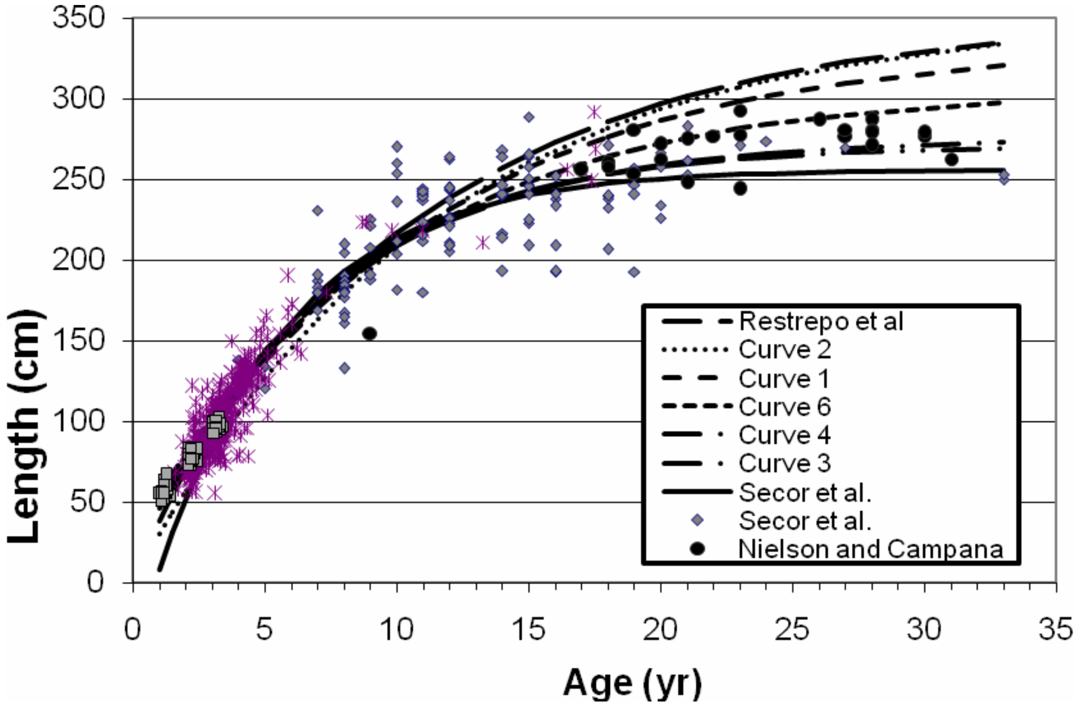

Figure Appendix 5.2 Age-length observations, modal analysis data, and estimated growth curves. The order of the curves in the legend follow the order of the curves in the graphs (i.e., the Restrepo *et al.* curve is the top curve in the graph and the Secor *et al.* is the bottom curve). Curve 1 was estimated using the tagging data (crosses), modal analysis data (gray squares) and the age-length data from Secor *et al.* (gray diamonds) and length as the predicted variable. Curve 2 used the same data and used age as the predicted variable. Curve 3 used only age-length data from Secor *et al.* (gray diamonds) and Neilson and Campana (black circles). Curve 4 used the modal data, and the age-length data from Secor et al. and Campana and Neilson and length as predicted variable. Curve 6 used all data and assumed individual model error for each data set and a common variance for L_∞.

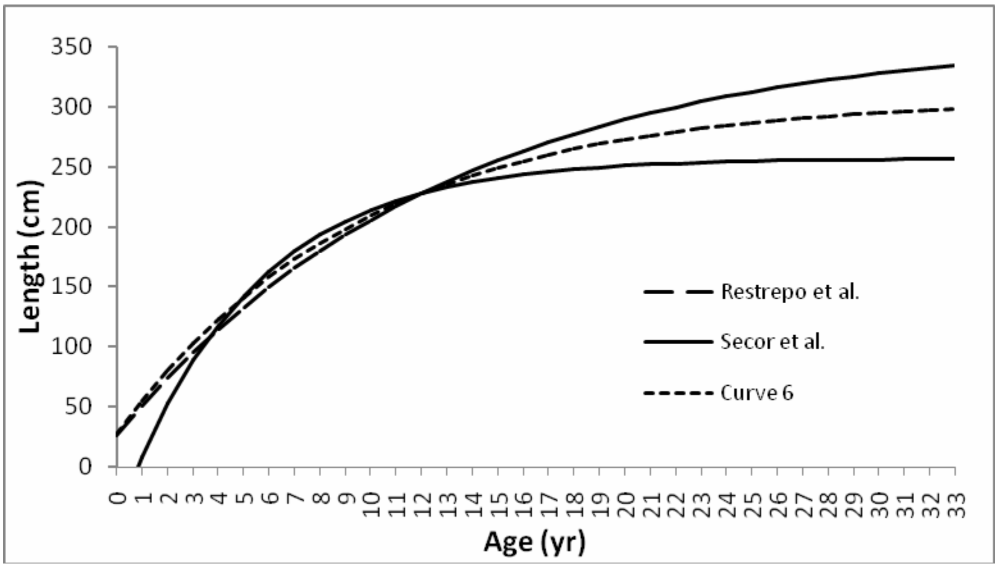

Figure Appendix 5.3 Estimated growth curves. Curve 6 used all data and assumed individual model error for each data set and a common variance for L_∞.

Appendix 6

Letter sent by scientists participating at the meeting to the Commission Chairperson

INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS — COMMISSION INTERNATIONALE POUR LA CONSERVATION DES THONIDES DE L'ATLANTIQUE

ICCAT CICTA CICAA

COMISIÓN INTERNACIONAL PARA LA CONSERVACIÓN DEL ATÚN ATLÁNTICO

Madrid – June 27, 2008

TO: Commission Chair
THROUGH: SCRS Chair
FROM: Scientists participating at the 2008 Bluefin Tuna Stock Assessment Session

SUBJECT: Concern about the paucity of reported data for 2007 for the eastern Atlantic and Mediterranean

We, the scientists participating at the bluefin assessment session are expected to conduct analyses, requested by the Commission, that the SCRS will use as the basis for advice to the Commission. Such work includes the evaluation of current stock status, as well as other tasks requested by the Commission. The 2006 Recovery Plan for Bluefin Tuna in the Eastern Atlantic and Mediterranean calls for the SCRS to "monitor and review the progress of the Plan and submit an assessment to the Commission for the first time in 2008, and each two years thereafter."

Now, upon completion of the fourth day (of 10 days) of the assessment meeting, we only have Task I (total catch) and Task II (catch/effort and size samples) from three of CPCs that have quotas in the eastern Atlantic and Mediterranean, which amount to less than 15% of the Total Allowable Catch. Note that the deadline of submission for the 2007 data was June 9, 2008 (i.e., two weeks prior to the meeting).

It takes considerable time to prepare, assimilate and validate data into the databases and then to analyze these data. Consequently, we will not be able to evaluate the status of the eastern stock as of 2007, nor will we be able to carry out the review of the progress of the plan which has been requested from us, even if we received these data today.

The SCRS planned, and the Commission endorsed this plan, to conduct these analyses three months before the Species Groups and Plenary sessions so that there would be sufficient time to review the results and prepare the advice requested by the Commission. We realize that the 2007 Task I and Task II data may become available between now and the SCRS plenary, and that therefore there will be pressure for us to meet once more during the Species Groups. This is unfortunate because most of us will also be expected to work on other ICCAT species at the same time and there will not be enough time at the September meeting to conduct a complete reassessment of the eastern stock.

It is also disappointing that such a large group of scientists and international experts meets during two weeks at considerable expense to their organizations and is unable to complete the work required because of a (chronic) lack of data being transmitted in time. This situation is even more incomprehensible given the high international concern about bluefin tuna stock status.

cc: Executive Secretary

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Appendix 7

Tuna Farming Sampling Coverage

Length distributions from ICCAT Secretariat SizeCaging_v3 were converted to RW (based on previous work by J. Walter. **Table 1**). For those samples originally submitted in weight, a 14.5 per cent discount was applied in order to account for the increase in weight during the fattening process.

Since there is not official information regarding the amount of fish in each farm, sampling coverage can not be estimated by flag. Assuming that TASK I figures for all purse seiners in the Mediterranean (Table 2) is a proxy for the caged fish in the Mediterranean farms, sampling coverage percentage is estimated as the ratio between total sampled weight in the farms by year and reported Task I catch for purse seines in the Mediterranean for the corresponding year.

Table 1. Farming samples (kg RW) by country and year (in brackets, sample size in number of fish).

	Croatia	*EC.Cyprus*	*EC.España*	*EC.Greece*	*EC.Italy*	*EC.Malta*	*Turkey*	*Total*
2003							10896.43 *(101)*	10.90
2004					305779.50 *(1924)*		1284419.00 *(15760)*	1590.20
2005	1638.03 *(89)*	244354.90 *(1207)*	193203.80 *(951)*	68446.94 *(518)*	747183.30 *(3608)*	1617281.00 *(7996)*	466352.86 *(6794)*	3338.46
2006		155751.80 *(683)*	1815113.60 *(12045)*		623070.40 *(3132)*		336003.08 *(5039)*	2929.94
2007	153309.43 *(3232)*		407758.40 *(2795)*			689364.10 *(4155)*	866634.52 *(6968)*	2117.07

Table 2. Reported catches (t RW) for purse seine (PS) in the Mediterranean by year.

	Task I Med. PS (t)
2003	17167
2004	18785
2005	22475
2006	20020
2007	Total catch not available

Table 3. Estimated sampling coverage (%) in tuna farms. Mediterranean Sea.

	Sampling rate (%)
2003	0.06
2004	8.47
2005	14.85
2006	14.64
2007	Not estimated

Remarks:

- Since there is not an official Task I figure for 2007, sampling coverage could not be estimated.
- Due to misreporting, figures in Table 3 could be overestimated.

Appendix 8

Analysis of Bluefin Conventional Tagging Data 2008

In preparation for the bluefin 2008 stock assessment an update of the conventional tagging data was provided by the Secretariat. After reviewing the data by national scientists, it was found several inconsistencies between the tagging files provided and a similar tagging files used in the 1998 assessment, particularly for the main tagging fleets (USA, EC-Spain and Canada) **(Table 1.tagging.section)**. These differences appeared in both tag releases and recaptures by year, and fleet. Further revision indicated that the tagging files changed between 2004 and 2005, particularly for the historical time series. The tagging files at the Secretariat were correct for 2004 forward with exception of the U.S. tagging records. Therefore it was proposed to use the 2004 Secretariat files (included tag release-recaptures up to 2003), and update this file with tag releases-recaptures from the United States provided by national scientist, and current tagging files for other contracting parties from the Secretariat 2008. EC-Spain scientist also provided tag releases and recaptures for 2004.

The resulting BFT tag release-recapture file was compared to the 1998 inputs, and revised by scientist from the main tagging fleets. There were some tag filtering during the assembling process; tags with no release or recapture date, tags put on ranched-farm fish, and tags without recapture date were excluded. **Table 2.tagging.section** summarizes the tag releases by fleet and quadrant by year of the compiled database. **Table 3.tagging.section** shows the overall number of releases and recaptures by year matrix. For the mix VPA analysis the conventional tagging information was restricted to releases recaptures with complete latitude longitude information, size (or estimated size from weight if size was not recorded), and date of release and recapture. The mix VPA used Tags releases from 1970 through 2007 and their respective recaptures.

Tag release-recapture cohorts (by year and BFT area of release) were aged using the slicing program with the corresponding growth function, Table 3.tagging.section summarizes the tag releases-recaptures inputs after fish were aged. About 80% of the tag release records were input in the MIX VPA run, as indicators of movement transfer rates by age and cohort between the east and west BFT areas.

Table Appendix 8.1 Comparison of tag release-recaptures matrix by year for the 2008 ICCAT tag database and the 1998 tagging database. Top, all fleets, and for main tagging fleet/countries USA, EC-Spain and Canada.

difference: ICCAT 2007 data -(ICCAT 1998 (Spain, Canada, others) + CGFTP for US)

																																difference relative to 1998		
rYear	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	total recaptures	not recaptured	total releases	total recaptures	not recaptured	total releases
1970	(60)	(86)	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(145)	137	(8)	-71%	25%	-1%
1971	-	(50)	(19)	(5)	(2)	(1)	(1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(78)	(264)	(342)	-52%	-40%	-42%
1972	-	-	(5)	15	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	(18)	(6)	21%	-6%	-2%
1973	-	-	-	(5)	2	3	-	(1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(1)	(62)	(63)	-1%	-12%	-11%
1974	-	-	-	-	2	33	19	1	1	-	(1)	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	58	(3)	55	27%	0%	3%
1975	-	-	-	-	-	(4)	5	-	1	(1)	(1)	(1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(1)	(6)	(7)	-2%	-1%	-1%
1976	-	-	-	-	-	-	1	-	5	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	9	229	238	3%	11%	10%
1977	-	-	-	-	-	-	-	(17)	23	5	2	-	-	2	-	-	1	-	1	-	-	-	-	-	-	-	-	-	17	217	234	5%	12%	11%
1978	-	-	-	-	-	-	-	-	(2)	9	1	2	2	3	-	1	2	-	1	-	2	-	1	1	-	-	-	-	23	334	357	11%	20%	19%
1979	-	-	-	-	-	-	-	-	-	(4)	(10)	2	-	-	-	(1)	-	-	-	-	-	-	-	-	-	-	-	-	(13)	223	210	-19%	19%	17%
1980	-	-	-	-	-	-	-	-	-	-	(30)	(2)	(2)	(1)	1	(1)	-	-	-	-	-	-	-	-	-	-	-	1	(34)	226	192	-11%	7%	6%
1981	-	-	-	-	-	-	-	-	-	-	-	(4)	(6)	-	(1)	-	-	-	-	-	-	-	-	-	-	-	-	-	(11)	231	220	-8%	11%	10%
1982	-	-	-	-	-	-	-	-	-	-	-	-	(1)	(7)	(2)	1	(2)	-	-	-	-	1	-	-	-	-	-	-	(10)	48	38	-33%	8%	6%
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	(1)	1	-	(1)	-	-	-	-	-	-	-	-	-	-	1	-	64	64	0%	8%	8%
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(2)	-	(2)	-	-	-	-	-	-	1	-	-	-	-	(3)	329	326	-11%	53%	50%
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(3)	(2)	-	-	-	-	-	-	-	-	-	-	-	(5)	58	53	-23%	11%	10%
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(9)	-	(2)	-	1	-	-	-	-	-	-	(10)	76	66	-16%	9%	7%
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10	0%	16%	16%
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4)	(4)	-	-	-	-	-	-	-	-	(8)	66	58	-13%	6%	5%
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	1	-	5	34	39	63%	15%	17%
1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4)	(1)	-	(1)	1	1	-	2	(2)	(8)	(10)	-2%	0%	0%
1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(2)	-	-	-	-	-	-	(2)	3	1	-2%	0%	0%
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1	4	66	70	10%	4%	5%
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	371	372	4%	60%	57%
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51	1	1	-	53	1,099	1,152	72%	109%	107%
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	4	30	42	165	207	76%	10%	12%

Table Appendix 8.2 Compiled bluefin tuna conventional tag releases by county/fleet ID and geographical quadrant.

No.Tags / Year release	CountryID: Canada	Cuba	France	Greece	Italy	Japan	Malta	Portugal	Spain	USA	Mexico	Unk	Ireland	Unk	Grand Total	Count of strTags: rYear	NE	SE	SW	NW	Unk	Grand Total
1940										24					24	1940				17	7	24
1954										193					193	1954				193		193
1955										230					230	1955				230		230
1956										99					99	1956				99		99
1957										37					37	1957				37		37
1958										38					38	1958				38		38
1959										147					147	1959				147		147
1960										236					236	1960				236		236
1961										185					185	1961				185		185
1962										127					127	1962				127		127
1963	18									222					240	1963				240		240
1964	20									552					572	1964		2		570		572
1965	300									1806					2106	1965				2100	6	2106
1966	74									4131					4205	1966				4205		4205
1967	204									712					916	1967				916		916
1968	26									519					545	1968				545		545
1969	44									566					610	1969	19			590	1	610
1970	20									733					753	1970				753		753
1971	368									446					814	1971				814		814
1972	82									287					369	1972				369		369
1973	172									397					569	1973				569		569
1974	49									1746					1795	1974				1795		1795
1975	170									352					522	1975				522		522
1976	30								1	2428					2459	1976				2459		2459
1977	11								133	2138					2282	1977				2281	1	2282
1978	6	1							174	1697					1878	1978				1869	9	1878
1979									100	1127					1227	1979				1227		1227
1980	16								301	3088					3405	1980				3405		3405
1981	9		1						294	1845					2149	1981				2149		2149
1982	1								403	210					614	1982				614		614
1983			1						709	150				1	861	1983	4			857		861

1984									858	89					947	1984				947		947
1985									412	131					543	1985				543		543
1986									849	51					900	1986	1			899		900
1987										64					64	1987				64		64
1988									1163	98					1261	1988				1261		1261
1989									133	113					246	1989				246		246
1990	74		1						1521	427					2023	1990	8			2015		2023
1991	95				16				2358	1111					3580	1991	112			3467	1	3580
1992	55				1				473	1018					1547	1992	90			1457		1547
1993					4				310	649					963	1993	5			958		963
1994	8				573				1139	375					2095	1994	650			1443	2	2095
1995			1		6				178	1704					1889	1995	8			1862	19	1889
1996	3				1				14	3382					3400	1996	2			3386	12	3400
1997					2				391	3450					3843	1997	16			3826	1	3843
1998					1					1914					1915	1998	5			1902	8	1915
1999						60				684		1			745	1999	60		1	682	2	745
2000					1					699					700	2000				699	1	700
2001						16				298					314	2001	19			295		314
2002									1	8					9	2002				9		9
2003									6	5					11	2003				11		11
2004	1		3	41			1		475	1597	1		3	4	2126	2004	1724		30	372		2126
2005	1		10	8	1				2141	264				11	2436	2005	263		30	2127	16	2436
2006			21	9				8	105	122					265	2006	138	2	15	107	3	265
2007										285					285	2007	271		14			285
2008										9					9	2008	9					9
Grand Total	1857	1	38	58	606	76	1	8	14642	45015	1	1	3	16	62323	Grand Total	3404	4	90	58736	89	62323

Table Appendix 8.3 Summary of tag releases-recaptures by BFT area and age input into the MIX VPA runs 1970-2007.

Sum of total rec		*Area recovered*				*Sum of number tag released*		
Aarea rel	*Age rel*	*1*	*2*		*Grand Total*	*Area rel.*	*Age at release*	*Total*
1	1	242	8		250	1	1	13889
	2	34	3		37		2	2423
	3	5	0		5		3	489
	4	1	0		1		4	175
	5	0	0		0		5	41
	6	0	0		0		6	32
	7	0	0		0		7	28
	8	0	0		0		8	16
	9	0	0		0		9	20
	10	0	0		0		10	190
1 Total		282	11		293	**1 Total**		17303
2	1	24	633		657	2	1	5609
	2	19	768		787		2	7875
	3	16	121		137		3	2614
	4	6	24		30		4	714
	5	6	21		27		5	685
	6	5	29		34		6	1146
	7	5	66		71		7	1485
	8	5	46		51		8	993
	9	4	30		34		9	706
	10	7	121		128		10	2433
2 Total		97	1859		1956	**2 Total**		24260
				0	0			0
Total				0	0	**Total**		0
Grand Total		379	1870	0	2249	**Grand Total**		41563

Appendix 9

BFT Report File for VPA Runs

BFT _Eastern stock_Report file for the VPA runs 13 and 14.

RUN 13

****

VPA-2BOX

SUMMARY STATISTICS AND DIAGNOSTIC OUTPUT

****

BFT East 55-06 test
9:27, 2 July 2008

===

Total objective function = 34.79
(with constants) = 189.17
Number of parameters (P) = 15
Number of data points (D)= 168
AIC : 2*objective+2P = 408.35
AICc: 2*objective+2P(...)= 411.50
BIC : 2*objective+Plog(D)= 455.20
Chi-square discrepancy = 83.28

Loglikelihoods (deviance)= -38.69 (168.09)
effort data = -38.69 (168.09)

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

Constraints = 3.90
terminal F = 3.90
stock-rec./sex ratio = 0.00

Out of bounds penalty = 0.00

===

TABLE 1. FISHING MORTALITY RATE FOR EAST OF 45

	1	2	3	4	5	6	7	8	9	10
1955	0.008	0.052	0.104	0.047	0.066	0.084	0.143	0.100	0.225	0.157
1956	0.006	0.039	0.054	0.030	0.035	0.062	0.077	0.138	0.139	0.097
1957	0.009	0.075	0.099	0.044	0.043	0.091	0.178	0.131	0.157	0.110
1958	0.027	0.095	0.144	0.060	0.106	0.113	0.095	0.161	0.129	0.090
1959	0.012	0.089	0.228	0.092	0.044	0.040	0.041	0.047	0.137	0.096
1960	0.008	0.051	0.081	0.100	0.147	0.090	0.047	0.080	0.116	0.081
1961	0.010	0.095	0.146	0.105	0.241	0.196	0.048	0.048	0.129	0.091
1962	0.006	0.058	0.134	0.090	0.121	0.258	0.096	0.124	0.136	0.095
1963	0.004	0.036	0.103	0.109	0.115	0.095	0.108	0.067	0.065	0.045
1964	0.010	0.054	0.101	0.140	0.182	0.109	0.088	0.098	0.072	0.051
1965	0.006	0.055	0.069	0.063	0.080	0.113	0.101	0.046	0.085	0.059
1966	0.026	0.071	0.212	0.083	0.052	0.098	0.083	0.052	0.047	0.033
1967	0.076	0.073	0.093	0.106	0.041	0.050	0.137	0.062	0.086	0.060

1968	0.029	0.084	0.078	0.048	0.056	0.020	0.045	0.068	0.048	0.034
1969	0.061	0.262	0.197	0.065	0.022	0.026	0.015	0.039	0.067	0.047
1970	0.060	0.179	0.124	0.080	0.027	0.016	0.031	0.022	0.043	0.043
1971	0.003	0.227	0.180	0.082	0.069	0.016	0.013	0.042	0.033	0.033
1972	0.006	0.184	0.345	0.094	0.073	0.057	0.019	0.008	0.024	0.024
1973	0.006	0.154	0.144	0.084	0.033	0.039	0.063	0.037	0.025	0.025
1974	0.027	0.174	0.193	0.148	0.122	0.060	0.042	0.054	0.050	0.050
1975	0.068	0.364	0.148	0.095	0.045	0.106	0.054	0.047	0.061	0.061
1976	0.009	0.273	0.477	0.125	0.100	0.032	0.069	0.031	0.049	0.049
1977	0.072	0.242	0.180	0.159	0.024	0.035	0.026	0.064	0.048	0.048
1978	0.138	0.359	0.183	0.086	0.042	0.012	0.025	0.013	0.037	0.037
1979	0.017	0.107	0.288	0.095	0.038	0.024	0.017	0.051	0.034	0.034
1980	0.112	0.246	0.422	0.193	0.031	0.036	0.031	0.017	0.036	0.036
1981	0.077	0.444	0.342	0.106	0.091	0.022	0.032	0.048	0.027	0.027
1982	0.248	0.400	0.489	0.178	0.070	0.042	0.023	0.079	0.056	0.056
1983	0.248	0.206	0.333	0.137	0.083	0.062	0.121	0.035	0.059	0.059
1984	0.111	0.461	0.127	0.136	0.133	0.099	0.090	0.121	0.065	0.065
1985	0.094	0.417	0.411	0.120	0.073	0.070	0.038	0.057	0.077	0.046
1986	0.280	0.322	0.252	0.155	0.032	0.045	0.041	0.033	0.073	0.044
1987	0.146	0.402	0.301	0.122	0.048	0.030	0.086	0.063	0.067	0.040
1988	0.347	0.218	0.398	0.169	0.060	0.043	0.051	0.078	0.101	0.061
1989	0.194	0.379	0.175	0.156	0.145	0.033	0.052	0.036	0.077	0.046
1990	0.178	0.254	0.328	0.135	0.170	0.057	0.055	0.076	0.095	0.057
1991	0.080	0.302	0.234	0.142	0.144	0.047	0.050	0.061	0.140	0.084
1992	0.082	0.303	0.374	0.095	0.074	0.064	0.108	0.135	0.165	0.099
1993	0.093	0.515	0.368	0.142	0.065	0.069	0.076	0.100	0.157	0.094
1994	0.127	0.291	0.220	0.093	0.130	0.100	0.196	0.217	0.367	0.220
1995	0.161	0.233	0.292	0.127	0.125	0.185	0.104	0.179	0.211	0.254
1996	0.187	0.483	0.388	0.285	0.143	0.072	0.120	0.094	0.248	0.298
1997	0.184	0.382	0.254	0.234	0.179	0.174	0.108	0.254	0.260	0.312
1998	0.156	0.600	0.440	0.313	0.152	0.331	0.053	0.058	0.175	0.210
1999	0.130	0.215	0.363	0.258	0.135	0.064	0.066	0.085	0.195	0.234
2000	0.349	0.314	0.247	0.234	0.259	0.186	0.074	0.115	0.133	0.160
2001	0.008	0.388	0.177	0.179	0.178	0.149	0.246	0.170	0.195	0.234
2002	0.043	0.465	0.309	0.128	0.092	0.170	0.106	0.172	0.188	0.226
2003	0.025	0.237	0.115	0.079	0.121	0.093	0.274	0.196	0.251	0.302
2004	0.080	0.326	0.304	0.076	0.041	0.086	0.150	0.183	0.291	0.350
2005	0.197	0.382	0.305	0.193	0.078	0.077	0.089	0.102	0.453	0.543
2006	0.174	0.178	0.447	0.178	0.056	0.116	0.057	0.072	0.401	0.481
2007	0.164	0.219	0.490	0.136	0.068	0.178	0.061	0.074	0.349	0.418

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TABLE 2. ABUNDANCE AT THE BEGINNING OF THE YEAR [BY AREA] FOR EAST OF 45

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	1	2	3	4	5	6	7	8	9	10
1955	1712816.	1575283.	1221373.	1021769.	615394.	515277.	274724.	399963.	243764.	663721.
1956	1081682.	1040496.	1176936.	866283.	766890.	453241.	388007.	199920.	311360.	684967.
1957	837090.	658442.	786947.	876934.	661421.	582439.	348929.	301526.	149877.	801526.
1958	1006726.	508104.	480610.	560646.	660210.	498260.	435330.	245037.	227701.	762749.
1959	858493.	600365.	363437.	327253.	415365.	467194.	364391.	332271.	179584.	807197.

1960	738764.	519889.	432075.	227528.	234838.	312791.	367502.	293749.	272991.	802072.
1961	968713.	448894.	388788.	313344.	161994.	159418.	234100.	294352.	233392.	883511.
1962	1546138.	587412.	321244.	264233.	221925.	100141.	107314.	187296.	241504.	911167.
1963	1877340.	941820.	435834.	221092.	190013.	154673.	63314.	81847.	142408.	935811.
1964	1688720.	1145419.	714430.	309251.	155899.	133266.	115127.	47731.	65886.	927019.
1965	3035718.	1024113.	853815.	507832.	211387.	102236.	97794.	88473.	37261.	851454.
1966	1914027.	1849345.	762322.	626604.	375254.	153450.	74769.	74222.	72732.	756392.
1967	1132353.	1142056.	1355560.	485017.	453687.	280294.	113905.	57755.	60660.	723550.
1968	952632.	643022.	835287.	971263.	343035.	342668.	218346.	83408.	46723.	665786.
1969	914503.	566817.	465014.	607768.	727872.	255241.	274938.	175282.	67052.	621708.
1970	850272.	526927.	343084.	300375.	447976.	559922.	203675.	227337.	145135.	591923.
1971	1649638.	490758.	346676.	238388.	218123.	342914.	451206.	165731.	191349.	635956.
1972	1123825.	1007933.	307538.	227865.	172818.	160177.	276359.	373807.	136771.	719908.
1973	1666713.	684167.	659932.	171344.	163229.	126374.	123900.	227521.	319109.	753869.
1974	2161394.	1015062.	461269.	449714.	123977.	124190.	99549.	97677.	188677.	939990.
1975	1610861.	1289309.	671264.	299277.	305046.	86334.	95786.	80166.	79671.	967512.
1976	2375431.	922109.	704983.	455269.	214182.	229500.	63564.	76171.	65839.	889607.
1977	1221908.	1441672.	551959.	344178.	316189.	152426.	182061.	49822.	63549.	822121.
1978	958743.	696481.	890606.	362722.	230985.	242825.	120560.	148887.	40209.	762804.
1979	1190761.	511396.	382565.	583677.	261699.	174151.	196494.	98712.	126456.	699281.
1980	1820093.	717128.	361354.	225734.	417485.	198210.	139237.	162177.	80712.	719490.
1981	1560673.	996805.	441208.	186426.	146376.	318295.	156558.	113298.	137286.	696406.
1982	2481481.	885488.	502892.	246581.	131934.	105180.	255011.	127313.	92990.	731318.
1983	3806864.	1186378.	466949.	242698.	162282.	96781.	82543.	209252.	101250.	703203.
1984	1950635.	1820686.	759694.	263226.	166534.	117494.	74457.	61368.	173933.	684293.
1985	1762617.	1069405.	903641.	526518.	180697.	114657.	87156.	57134.	46804.	724040.
1986	3097453.	983142.	554126.	471044.	367458.	132079.	87567.	70431.	46464.	663591.
1987	2165222.	1434089.	560654.	338935.	317254.	279923.	103402.	70588.	58670.	612982.
1988	3348612.	1146355.	754534.	326388.	235973.	237946.	222325.	79640.	57063.	581395.
1989	3250205.	1449812.	724855.	398760.	216889.	174793.	186617.	177279.	63385.	540717.

1990	3361449.	1639636.	781021.	478614.	268283.	147570.	138478.	148672.	147138.	519017.
1991	3996324.	1723106.	1000403.	442544.	328984.	178087.	114136.	109987.	118556.	561587.
1992	3669586.	2260370.	1001931.	623065.	301936.	224189.	139083.	91165.	89054.	558167.
1993	3988467.	2070950.	1313795.	542136.	445609.	220646.	172121.	104784.	68580.	523990.
1994	3221540.	2226862.	973695.	715432.	369896.	328468.	168554.	133868.	81567.	483384.
1995	3735603.	1738584.	1309851.	614467.	512691.	255555.	243451.	116324.	92755.	400743.
1996	3276449.	1947413.	1083337.	769475.	425503.	355927.	173815.	184173.	83751.	347655.
1997	2292542.	1665456.	944819.	577912.	455189.	290018.	271202.	129403.	144349.	291137.
1998	3007903.	1168659.	893773.	576562.	359854.	299473.	199439.	204396.	86386.	291085.
1999	3003343.	1576546.	504504.	452606.	331666.	243053.	176140.	158764.	165937.	277413.
2000	3769605.	1616061.	999917.	276168.	275066.	228060.	186752.	138440.	125544.	319194.
2001	2425260.	1629615.	928324.	614515.	171928.	166972.	155084.	145545.	106160.	343202.
2002	1790886.	1473399.	869268.	611723.	403996.	113238.	117803.	101777.	105723.	322717.
2003	1573795.	1050867.	728332.	502004.	423441.	289938.	78220.	88920.	73787.	310301.
2004	2603448.	940126.	651904.	510626.	364731.	295223.	216238.	49915.	62916.	258341.
2005	2219122.	1472367.	533893.	378406.	372437.	275486.	221695.	156254.	35793.	206287.
2006	1796012.	1116760.	790262.	309505.	245404.	271083.	208771.	170280.	121435.	128515.
2007	1896656.	924149.	735216.	397520.	203827.	182476.	197581.	165478.	136350.	143646.
2008		985735.	583820.	354405.	273028.	149774.	125061.	156085.	132217.	170459.

TABLE 3. CATCH OF EAST OF 45

	1	2	3	4	5	6	7	8	9	10
1955	11390.	70400.	107008.	41704.	34906.	37542.	33620.	35532.	46230.	92065.
1956	5455.	35668.	55302.	22639.	23547.	24550.	26464.	23989.	38002.	60427.
1957	6091.	42266.	66121.	33498.	24920.	46045.	52455.	34392.	20523.	79533.
1958	21162.	41049.	57587.	29029.	59060.	48301.	36300.	33860.	25940.	62720.
1959	7804.	45504.	66262.	25576.	15776.	16623.	13275.	14031.	21575.	70071.
1960	4765.	22821.	30043.	19236.	28693.	24382.	15475.	20995.	28190.	59676.

1961	7810.	36085.	47151.	27817.	30990.	25774.	10084.	12790.	26672.	72883.
1962	6948.	29693.	35820.	20199.	22545.	20762.	9015.	20314.	28861.	78671.
1963	6053.	29894.	38039.	20408.	18355.	12761.	5931.	4925.	8392.	39445.
1964	13483.	53408.	61333.	36132.	23139.	12549.	8941.	4128.	4324.	43564.
1965	13434.	48963.	50961.	27408.	14527.	9909.	8615.	3689.	2841.	46567.
1966	39436.	112263.	130125.	44396.	16847.	13006.	5482.	3480.	3133.	23246.
1967	65608.	71404.	107636.	43596.	16077.	12342.	13370.	3226.	4680.	40047.
1968	21694.	46196.	55796.	40894.	16520.	6218.	8761.	5117.	2075.	21100.
1969	43107.	116782.	74227.	34077.	14296.	5870.	3784.	6187.	4111.	27275.
1970	38988.	76925.	35680.	20559.	10718.	7994.	5735.	4664.	5693.	23503.
1971	3451.	89131.	50860.	16647.	12908.	4866.	5421.	6342.	5904.	19863.
1972	5573.	150797.	80312.	18135.	10831.	8023.	4886.	2837.	3049.	16246.
1973	7760.	87196.	78670.	12234.	4762.	4339.	6926.	7721.	7439.	17790.
1974	44979.	144277.	72124.	55216.	12678.	6529.	3719.	4751.	8656.	43652.
1975	83784.	352023.	82482.	24048.	11829.	7896.	4634.	3412.	4453.	54737.
1976	17530.	197044.	240034.	47517.	18182.	6467.	3870.	2172.	2940.	40211.
1977	67420.	276479.	81061.	45073.	6668.	4692.	4314.	2886.	2775.	36339.
1978	98571.	188168.	132601.	26750.	8539.	2562.	2725.	1825.	1375.	26405.
1979	15969.	46352.	85483.	47165.	8652.	3706.	3029.	4589.	3957.	22150.
1980	153269.	139588.	111493.	35389.	11433.	6339.	3921.	2484.	2707.	24427.
1981	91415.	320655.	114344.	16664.	11282.	6186.	4494.	4886.	3452.	17726.
1982	435146.	261565.	174480.	35938.	7924.	3956.	5269.	8996.	4771.	37980.
1983	666701.	196951.	118425.	27630.	11504.	5298.	8674.	6661.	5419.	38096.
1984	162820.	602875.	80534.	29877.	18519.	10023.	5876.	6501.	10301.	41021.
1985	125240.	327181.	273233.	52924.	11390.	6990.	2989.	2928.	3280.	31283.
1986	604933.	241954.	110132.	60406.	10325.	5246.	3194.	2105.	3059.	26910.
1987	233816.	425593.	130343.	34716.	13139.	7595.	7836.	3987.	3555.	22852.
1988	787349.	200802.	221886.	45198.	12255.	9080.	10230.	5575.	5152.	32507.
1989	457215.	409309.	103864.	51463.	26117.	5129.	8733.	5880.	4406.	23170.
1990	436999.	328717.	195473.	53837.	37369.	7406.	6846.	10160.	12584.	27460.

1991	243243.	401951.	186083.	52343.	39217.	7448.	5083.	6060.	14583.	43095.
1992	229347.	527898.	280117.	50401.	19090.	12665.	13102.	10684.	12771.	50172.
1993	280529.	748302.	362086.	64111.	24966.	13407.	11619.	9313.	9357.	44739.
1994	304848.	502294.	171943.	56716.	40132.	28248.	27584.	24304.	23658.	91141.
1995	443085.	322791.	296580.	65551.	53670.	39327.	22102.	17701.	16646.	85602.
1996	444406.	669905.	312384.	170611.	50658.	22395.	18071.	15306.	17363.	85496.
1997	306585.	474121.	189317.	107583.	66457.	42198.	25467.	27049.	31140.	74424.
1998	345669.	474407.	285557.	138603.	45368.	76858.	9468.	10784.	13078.	52629.
1999	290411.	272684.	137391.	91981.	37212.	13568.	10307.	11994.	27671.	55147.
2000	889624.	389997.	195408.	51453.	56123.	35130.	12280.	14042.	14717.	44867.
2001	15983.	469972.	134430.	90059.	24959.	20978.	31158.	21135.	17743.	68377.
2002	59817.	491266.	206723.	65445.	31541.	16088.	10913.	14935.	17076.	62176.
2003	31032.	198423.	70574.	34139.	42903.	23442.	17278.	14728.	15451.	77057.
2004	158681.	233924.	152821.	33093.	12918.	22186.	27674.	7752.	14992.	72739.
2005	315743.	419027.	125614.	59295.	24776.	18596.	17314.	14102.	12307.	82644.
2006	228907.	162488.	255565.	44959.	11954.	27022.	10693.	11027.	37860.	46891.
2007	228907.	162488.	255565.	44959.	11954.	27022.	10693.	11027.	37860.	46891.

TABLE 4. SPAWNING STOCK FECUNDITY AND RECRUITMENT OF EAST OF 45

year	spawning biomass	recruits from VPA
1955	278890.	1712816.
1956	290065.	1081682.
1957	301128.	837090.
1958	305136.	1006726.
1959	290660.	858493.
1960	271944.	738764.
1961	266051.	968713.
1962	253527.	1546138.
1963	225337.	1877340.
1964	228995.	1688720.
1965	240704.	3035718.
1966	226754.	1914027.
1967	235291.	1132353.
1968	243630.	952632.
1969	262779.	914503.
1970	250412.	850272.
1971	278237.	1649638.

1972	287473.	1123825.
1973	288073.	1666713.
1974	297194.	2161394.
1975	288002.	1610861.
1976	285281.	2375431.
1977	275360.	1221908.
1978	263599.	958743.
1979	252886.	1190761.
1980	247884.	1820093.
1981	230570.	1560673.
1982	228289.	2481481.
1983	205248.	3806864.
1984	198062.	1950635.
1985	207407.	1762617.
1986	204504.	3097453.
1987	197572.	2165222.
1988	195088.	3348612.
1989	196746.	3250205.
1990	182163.	3361449.
1991	178785.	3996324.
1992	181860.	3669586.
1993	189909.	3988467.
1994	178053.	3221540.
1995	171927.	3735603.
1996	162863.	3276449.
1997	149042.	2292542.
1998	144084.	3007903.
1999	142302.	3003343.
2000	137926.	3769605.
2001	124530.	2425260.
2002	127796.	1790886.
2003	124894.	1573795.
2004	117992.	2603448.
2005	110082.	2219122.
2006	101002.	1796012.
2007	100046.	1896656.

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TABLE 5. FITS TO INDEX DATA FOR EAST OF 45

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5.1 ESP MAR Trap

Lognormal dist.
average numbers
Ages 6 - 10
log-likelihood = -0.15
deviance = 14.34
Chi-sq. discrepancy= 8.03

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1981	0.211	0.429	-0.218	0.763	0.457E-02	3248.936	4040.421	0.201
1982	0.464	0.416	0.047	0.763	0.457E-02	4181.572	3987.632	0.059
1983	0.528	0.383	0.145	0.763	0.457E-02	4457.914	3856.273	0.023
1984	0.626	0.346	0.280	0.763	0.457E-02	4919.679	3719.024	0.000
1985	0.234	0.287	-0.053	0.763	0.457E-02	3323.686	3506.103	0.108

1986	-0.527	0.224	-0.751	0.763	0.457E-02	1552.599	3291.742	0.530
1987	-0.429	0.205	-0.634	0.763	0.457E-02	1712.964	3229.876	0.461
1988	0.428	0.190	0.238	0.763	0.457E-02	4036.118	3180.860	0.003
1989	-0.219	0.184	-0.403	0.763	0.457E-02	2112.991	3161.338	0.317
1990	-0.182	0.195	-0.376	0.763	0.457E-02	2193.198	3194.995	0.300
1991	0.117	0.185	-0.068	0.763	0.457E-02	2956.781	3165.696	0.115
1992	-0.710	0.147	-0.857	0.763	0.457E-02	1293.345	3046.638	0.589
1993	-0.725	0.101	-0.827	0.763	0.457E-02	1273.456	2910.561	0.573
1994	-0.609	0.038	-0.648	0.763	0.457E-02	1430.110	2732.928	0.469
1995	-1.067	-0.073	-0.994	0.763	0.457E-02	905.197	2444.966	0.661
1996	-0.473	-0.128	-0.345	0.763	0.457E-02	1639.230	2313.743	0.280
1997	0.375	-0.176	0.551	0.763	0.457E-02	3827.381	2206.679	0.111
1998	0.433	-0.185	0.618	0.763	0.457E-02	4053.510	2185.158	0.188
1999	0.544	-0.164	0.708	0.763	0.457E-02	4531.091	2231.747	0.338
2000	0.303	-0.144	0.447	0.763	0.457E-02	3559.320	2276.336	0.036
2001	0.863	-0.189	1.052	0.763	0.457E-02	6234.335	2178.103	1.639
2002	0.510	-0.293	0.803	0.763	0.457E-02	4380.586	1961.929	0.565
2003	-0.072	-0.377	0.305	0.763	0.457E-02	2448.107	1804.944	0.000
2004	-0.649	-0.476	-0.173	0.763	0.457E-02	1374.174	1633.382	0.174
2005	0.048	-0.566	0.614	0.763	0.457E-02	2759.992	1493.550	0.183
2006	-0.022	-0.561	0.539	0.763	0.457E-02	2572.432	1500.911	0.100

Selectivities by age

Year	6	7	8	9	10
1981	0.157	0.264	0.463	0.790	1.000
1982	0.157	0.264	0.463	0.790	1.000
1983	0.157	0.264	0.463	0.790	1.000
1984	0.157	0.264	0.463	0.790	1.000
1985	0.157	0.264	0.463	0.790	1.000
1986	0.157	0.264	0.463	0.790	1.000
1987	0.157	0.264	0.463	0.790	1.000
1988	0.157	0.264	0.463	0.790	1.000
1989	0.157	0.264	0.463	0.790	1.000
1990	0.157	0.264	0.463	0.790	1.000
1991	0.157	0.264	0.463	0.790	1.000
1992	0.157	0.264	0.463	0.790	1.000
1993	0.157	0.264	0.463	0.790	1.000
1994	0.157	0.264	0.463	0.790	1.000
1995	0.157	0.264	0.463	0.790	1.000
1996	0.157	0.264	0.463	0.790	1.000
1997	0.157	0.264	0.463	0.790	1.000
1998	0.157	0.264	0.463	0.790	1.000
1999	0.157	0.264	0.463	0.790	1.000
2000	0.157	0.264	0.463	0.790	1.000
2001	0.157	0.264	0.463	0.790	1.000
2002	0.157	0.264	0.463	0.790	1.000
2003	0.157	0.264	0.463	0.790	1.000
2004	0.157	0.264	0.463	0.790	1.000
2005	0.157	0.264	0.463	0.790	1.000
2006	0.157	0.264	0.463	0.790	1.000

5.2 ESP BB 1

Not used

5.3 ESP BB 2

Lognormal dist.
average numbers
Ages 2 - 2
log-likelihood = -17.44
deviance = 52.17
Chi-sq. discrepancy= 20.92

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
----	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------
1975	0.542	-0.019	0.561	0.763	0.126E-03	213.720	122.007	0.121
1976	0.163	-0.313	0.476	0.763	0.126E-03	146.320	90.917	0.052
1977	0.548	0.148	0.400	0.763	0.126E-03	215.130	144.215	0.017
1978	-0.504	-0.633	0.129	0.763	0.126E-03	75.110	66.043	0.029
1979	-1.277	-0.826	-0.452	0.763	0.126E-03	34.670	54.459	0.348
1980	-0.583	-0.552	-0.031	0.763	0.126E-03	69.410	71.602	0.096
1981	-0.270	-0.312	0.043	0.763	0.126E-03	94.950	90.996	0.061
1982	0.030	-0.411	0.441	0.763	0.126E-03	128.090	82.443	0.033
1983	-0.045	-0.030	-0.015	0.763	0.126E-03	118.830	120.660	0.088
1984	1.362	0.283	1.079	0.763	0.126E-03	485.620	165.007	1.818
1985	1.123	-0.230	1.353	0.763	0.126E-03	382.160	98.790	4.519
1986	-0.353	-0.271	-0.082	0.763	0.126E-03	87.360	94.818	0.123
1987	1.218	0.070	1.148	0.763	0.126E-03	420.300	133.385	2.319
1988	-0.876	-0.070	-0.805	0.763	0.126E-03	51.800	115.911	0.561
1989	1.368	0.092	1.276	0.763	0.126E-03	488.140	136.280	3.553
1990	-0.134	0.271	-0.405	0.763	0.126E-03	108.780	163.084	0.318
1991	0.319	0.299	0.020	0.763	0.126E-03	171.110	167.658	0.071
1992	0.717	0.570	0.147	0.763	0.126E-03	254.590	219.893	0.023
1993	1.246	0.388	0.858	0.763	0.126E-03	432.270	183.272	0.735
1994	-1.272	0.561	-1.833	0.763	0.126E-03	34.840	217.814	0.980
1995	0.449	0.340	0.109	0.763	0.126E-03	194.750	174.608	0.035
1996	0.298	0.340	-0.042	0.763	0.126E-03	167.510	174.732	0.102
1997	0.024	0.229	-0.204	0.763	0.126E-03	127.410	156.283	0.193
1998	-0.671	-0.221	-0.450	0.763	0.126E-03	63.560	99.658	0.346
1999	-3.608	0.250	-3.858	0.763	0.126E-03	3.370	159.633	1.225
2000	-1.030	0.229	-1.259	0.763	0.126E-03	44.400	156.375	0.785
2001	0.996	0.204	0.792	0.763	0.126E-03	336.760	152.506	0.534
2002	1.063	0.070	0.993	0.763	0.126E-03	359.870	133.295	1.308
2003	-0.402	-0.166	-0.236	0.763	0.126E-03	83.220	105.324	0.212
2004	-0.350	-0.318	-0.032	0.763	0.126E-03	87.650	90.498	0.097
2005	0.078	0.105	-0.027	0.763	0.126E-03	134.470	138.172	0.094
2006	-0.170	-0.078	-0.093	0.763	0.126E-03	104.880	115.050	0.129

Selectivities by age

Year	2
----	-----
1975	1.000
1976	1.000
1977	1.000
1978	1.000
1979	1.000
1980	1.000
1981	1.000
1982	1.000
1983	1.000
1984	1.000
1985	1.000
1986	1.000
1987	1.000

1988	1.000
1989	1.000
1990	1.000
1991	1.000
1992	1.000
1993	1.000
1994	1.000
1995	1.000
1996	1.000
1997	1.000
1998	1.000
1999	1.000
2000	1.000
2001	1.000
2002	1.000
2003	1.000
2004	1.000
2005	1.000
2006	1.000

5.4 ESP BB 3

Lognormal dist.
average numbers
Ages 3 - 3
log-likelihood = -16.41
deviance = 50.10
Chi-sq. discrepancy= 35.28

Year	Observed	Residuals Predicted	Standard (Obs-pred)	Q Deviation	Untransfrmd Catchabil.	Untransfrmd Observed	Chi-square Predicted	Discrepancy
1975	0.332	-0.010	0.342	0.763	0.622E-04	48.740	34.617	0.003
1976	0.590	-0.110	0.700	0.763	0.622E-04	63.040	31.314	0.322
1977	1.057	-0.220	1.278	0.763	0.622E-04	100.630	28.049	3.571
1978	-0.868	0.257	-1.125	0.763	0.622E-04	14.670	45.201	0.725
1979	0.721	-0.636	1.358	0.763	0.622E-04	71.910	18.500	4.586
1980	-0.251	-0.754	0.503	0.763	0.622E-04	27.200	16.448	0.070
1981	-1.855	-0.518	-1.336	0.763	0.622E-04	5.470	20.816	0.816
1982	0.199	-0.453	0.652	0.763	0.622E-04	42.670	22.224	0.239
1983	-0.873	-0.458	-0.415	0.763	0.622E-04	14.600	22.116	0.325
1984	1.285	0.124	1.161	0.763	0.622E-04	126.380	39.577	2.429
1985	1.150	0.167	0.983	0.763	0.622E-04	110.430	41.321	1.256
1986	-0.363	-0.249	-0.113	0.763	0.622E-04	24.320	27.240	0.140
1987	-1.175	-0.260	-0.914	0.763	0.622E-04	10.800	26.946	0.620
1988	-1.612	-0.007	-1.606	0.763	0.622E-04	6.970	34.715	0.913
1989	-1.443	0.055	-1.497	0.763	0.622E-04	8.260	36.916	0.877
1990	0.152	0.059	0.093	0.763	0.622E-04	40.680	37.078	0.041
1991	-0.381	0.350	-0.731	0.763	0.622E-04	23.880	49.590	0.518
1992	-1.066	0.287	-1.353	0.763	0.622E-04	12.040	46.587	0.823
1993	1.672	0.561	1.110	0.763	0.622E-04	185.980	61.263	2.034
1994	0.251	0.329	-0.078	0.763	0.622E-04	44.930	48.560	0.120
1995	0.590	0.592	-0.003	0.763	0.622E-04	63.030	63.213	0.082
1996	1.308	0.359	0.949	0.763	0.622E-04	129.240	50.052	1.092
1997	1.728	0.283	1.445	0.763	0.622E-04	196.790	46.397	5.949
1998	0.360	0.143	0.217	0.763	0.622E-04	50.100	40.347	0.007
1999	-0.973	-0.394	-0.579	0.763	0.622E-04	13.210	23.581	0.427
2000	-0.009	0.343	-0.352	0.763	0.622E-04	34.650	49.263	0.285

2001	0.611	0.301	0.310	0.763	0.622E-04	64.420	47.234	0.000
2002	1.483	0.175	1.308	0.763	0.622E-04	153.960	41.626	3.933
2003	-1.010	0.087	-1.098	0.763	0.622E-04	12.730	38.149	0.712
2004	-1.183	-0.111	-1.072	0.763	0.622E-04	10.710	31.290	0.700
2005	0.610	-0.311	0.921	0.763	0.622E-04	64.340	25.610	0.973
2006	-1.039	0.017	-1.056	0.763	0.622E-04	12.370	35.568	0.693

Selectivities by age

Year	3
1975	1.000
1976	1.000
1977	1.000
1978	1.000
1979	1.000
1980	1.000
1981	1.000
1982	1.000
1983	1.000
1984	1.000
1985	1.000
1986	1.000
1987	1.000
1988	1.000
1989	1.000
1990	1.000
1991	1.000
1992	1.000
1993	1.000
1994	1.000
1995	1.000
1996	1.000
1997	1.000
1998	1.000
1999	1.000
2000	1.000
2001	1.000
2002	1.000
2003	1.000
2004	1.000
2005	1.000
2006	1.000

5.5 ESP BB 4

Not used

5.6 ESP BB 5

Not used

5.7 JLL EastMed

Lognormal dist.
average numbers
Ages 4 - 10

log-likelihood = 3.20
deviance = 10.88
Chi-sq. discrepancy= 6.94

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1975	0.357	0.315	0.042	0.763	0.215E-05	1.956	1.876	0.062
1976	0.472	0.255	0.216	0.763	0.215E-05	2.194	1.767	0.007
1977	0.979	0.218	0.762	0.763	0.215E-05	3.647	1.702	0.456
1978	0.131	0.217	-0.086	0.763	0.215E-05	1.561	1.701	0.125
1979	0.705	0.250	0.455	0.763	0.215E-05	2.771	1.758	0.040
1980	0.253	0.246	0.007	0.763	0.215E-05	1.763	1.751	0.077
1981	0.223	0.263	-0.040	0.763	0.215E-05	1.712	1.781	0.100
1982	0.904	0.241	0.663	0.763	0.215E-05	3.382	1.742	0.257
1983	0.458	0.211	0.247	0.763	0.215E-05	2.165	1.691	0.002
1984	0.192	0.143	0.049	0.763	0.215E-05	1.660	1.581	0.059
1985	0.261	0.042	0.219	0.763	0.215E-05	1.778	1.429	0.006
1986	-0.010	0.017	-0.027	0.763	0.215E-05	1.356	1.393	0.094
1987	0.477	0.022	0.456	0.763	0.215E-05	2.207	1.400	0.040
1988	0.008	0.038	-0.030	0.763	0.215E-05	1.380	1.422	0.095
1989	-0.242	0.074	-0.316	0.763	0.215E-05	1.075	1.475	0.262
1990	0.064	0.099	-0.034	0.763	0.215E-05	1.460	1.511	0.098
1991	-0.088	0.055	-0.143	0.763	0.215E-05	1.254	1.447	0.157
1992	-0.252	0.017	-0.269	0.763	0.215E-05	1.064	1.393	0.233
1993	-0.248	0.002	-0.250	0.763	0.215E-05	1.069	1.372	0.221
1994	-0.186	-0.018	-0.168	0.763	0.215E-05	1.137	1.345	0.172
1995	0.022	-0.066	0.088	0.763	0.215E-05	1.400	1.281	0.043
1996	-1.054	-0.077	-0.978	0.763	0.215E-05	0.477	1.268	0.653
1997	-0.984	-0.094	-0.890	0.763	0.215E-05	0.512	1.246	0.607
1998	-0.677	-0.114	-0.563	0.763	0.215E-05	0.696	1.222	0.417
1999	-0.789	-0.104	-0.684	0.763	0.215E-05	0.622	1.234	0.491
2000	-0.643	-0.147	-0.496	0.763	0.215E-05	0.720	1.182	0.375
2001	-0.393	-0.208	-0.185	0.763	0.215E-05	0.924	1.112	0.181
2002	0.372	-0.299	0.671	0.763	0.215E-05	1.986	1.016	0.269
2003	0.182	-0.384	0.567	0.763	0.215E-05	1.643	0.932	0.127
2004	-0.562	-0.427	-0.135	0.763	0.215E-05	0.781	0.894	0.152
2005	-0.481	-0.419	-0.063	0.763	0.215E-05	0.846	0.901	0.112
2006	0.547	-0.368	0.915	0.763	0.215E-05	2.366	0.948	0.946

Selectivities by age

Year	4	5	6	7	8	9	10
1975	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1976	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1977	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1978	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1979	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1980	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1981	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1982	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1983	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1984	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1985	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1986	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1987	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1988	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1989	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1990	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1991	0.038	0.079	0.217	0.441	0.762	1.000	0.741

1992	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1993	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1994	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1995	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1996	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1997	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1998	0.038	0.079	0.217	0.441	0.762	1.000	0.741
1999	0.038	0.079	0.217	0.441	0.762	1.000	0.741
2000	0.038	0.079	0.217	0.441	0.762	1.000	0.741
2001	0.038	0.079	0.217	0.441	0.762	1.000	0.741
2002	0.038	0.079	0.217	0.441	0.762	1.000	0.741
2003	0.038	0.079	0.217	0.441	0.762	1.000	0.741
2004	0.038	0.079	0.217	0.441	0.762	1.000	0.741
2005	0.038	0.079	0.217	0.441	0.762	1.000	0.741
2006	0.038	0.079	0.217	0.441	0.762	1.000	0.741

5.8 MAR Trap

Not used

5.9 ESP Trap

Not used

5.10 FR BB

Lognormal dist.
average biomass
Ages 2 - 5
log-likelihood = 0.63
deviance = 9.55
Chi-sq. discrepancy= 5.52

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1955	0.879	0.758	0.121	0.763	0.138E-04	808.267	716.428	0.031
1956	0.212	0.653	-0.441	0.763	0.138E-04	415.143	645.318	0.341
1957	0.048	0.392	-0.344	0.763	0.138E-04	352.273	496.750	0.279
1958	-0.125	0.016	-0.141	0.763	0.138E-04	296.136	341.130	0.156
1959	0.426	-0.295	0.721	0.763	0.138E-04	514.177	249.993	0.364
1960	-0.754	-0.401	-0.353	0.763	0.138E-04	158.000	224.810	0.285
1961	-0.315	-0.465	0.150	0.763	0.138E-04	245.135	210.957	0.022
1962	-0.343	-0.473	0.130	0.763	0.138E-04	238.272	209.306	0.028
1963	-0.698	-0.247	-0.451	0.763	0.138E-04	167.077	262.291	0.347
1964	-0.907	0.049	-0.956	0.763	0.138E-04	135.593	352.633	0.642
1965	-0.340	0.233	-0.574	0.763	0.138E-04	238.846	423.938	0.424
1966	0.413	0.445	-0.032	0.763	0.138E-04	507.500	524.063	0.097
1967	0.108	0.577	-0.470	0.763	0.138E-04	373.913	598.087	0.359
1968	-0.381	0.399	-0.780	0.763	0.138E-04	229.412	500.466	0.546
1969	0.241	0.042	0.199	0.763	0.138E-04	427.200	350.081	0.010
1970	0.249	-0.338	0.587	0.763	0.138E-04	430.588	239.468	0.149
1971	0.175	-0.586	0.761	0.763	0.138E-04	400.000	186.811	0.455
1972	0.461	-0.404	0.865	0.763	0.138E-04	532.374	224.048	0.760
1973	0.104	-0.265	0.369	0.763	0.138E-04	372.414	257.570	0.008
1974	0.547	-0.092	0.638	0.763	0.138E-04	580.000	306.322	0.218

Selectivities by age

Year	2	3	4	5
1955	0.809	1.000	0.446	0.173
1956	0.809	1.000	0.446	0.173
1957	0.809	1.000	0.446	0.173
1958	0.809	1.000	0.446	0.173
1959	0.809	1.000	0.446	0.173
1960	0.809	1.000	0.446	0.173
1961	0.809	1.000	0.446	0.173
1962	0.809	1.000	0.446	0.173
1963	0.809	1.000	0.446	0.173
1964	0.809	1.000	0.446	0.173
1965	0.809	1.000	0.446	0.173
1966	0.809	1.000	0.446	0.173
1967	0.809	1.000	0.446	0.173
1968	0.809	1.000	0.446	0.173
1969	0.809	1.000	0.446	0.173
1970	0.809	1.000	0.446	0.173
1971	0.809	1.000	0.446	0.173
1972	0.809	1.000	0.446	0.173
1973	0.809	1.000	0.446	0.173
1974	0.809	1.000	0.446	0.173

5.11 NOR PS

Lognormal dist.
average biomass
Ages 10 - 10
log-likelihood = -8.51
deviance = 31.05
Chi-sq. discrepancy= 6.59

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1955	0.235	-0.418	0.653	0.763	0.169E-06	36.199	18.845	0.240
1956	-0.298	-0.323	0.025	0.763	0.169E-06	21.254	20.731	0.069
1957	-0.001	-0.155	0.154	0.763	0.169E-06	28.607	24.512	0.021
1958	-0.171	-0.130	-0.041	0.763	0.169E-06	24.126	25.130	0.101
1959	0.124	-0.131	0.255	0.763	0.169E-06	32.408	25.118	0.002
1960	0.492	-0.149	0.641	0.763	0.169E-06	46.831	24.661	0.222
1961	0.594	-0.018	0.611	0.763	0.169E-06	51.836	28.128	0.180
1962	0.815	0.044	0.771	0.763	0.169E-06	64.669	29.909	0.479
1963	-2.841	0.015	-2.856	0.763	0.169E-06	1.671	29.061	1.158
1964	0.171	0.098	0.073	0.763	0.169E-06	33.978	31.572	0.048
1965	0.889	0.142	0.747	0.763	0.169E-06	69.604	32.992	0.420
1966	0.221	-0.011	0.232	0.763	0.169E-06	35.705	28.302	0.004
1967	0.758	-0.022	0.779	0.763	0.169E-06	61.057	28.015	0.499
1968	-0.196	-0.086	-0.110	0.763	0.169E-06	23.532	26.255	0.138
1969	-0.020	-0.113	0.093	0.763	0.169E-06	28.056	25.576	0.041
1970	0.401	-0.292	0.693	0.763	0.169E-06	42.755	21.373	0.309
1971	0.419	-0.068	0.487	0.763	0.169E-06	43.519	26.751	0.059
1972	0.408	0.072	0.336	0.763	0.169E-06	43.047	30.764	0.003
1973	0.387	0.123	0.264	0.763	0.169E-06	42.148	32.377	0.001
1974	0.468	0.310	0.158	0.763	0.169E-06	45.719	39.028	0.020
1975	0.283	0.332	-0.049	0.763	0.169E-06	38.000	39.906	0.105

1976	-0.302	0.308	-0.610	0.763	0.169E-06	21.160	38.954	0.446
1977	0.394	0.241	0.152	0.763	0.169E-06	42.444	36.444	0.021
1978	-0.846	0.160	-1.007	0.763	0.169E-06	12.278	33.603	0.668
1979	-2.033	0.046	-2.079	0.763	0.169E-06	3.750	29.981	1.039
1980	-0.351	0.022	-0.374	0.763	0.169E-06	20.143	29.268	0.298

Selectivities by age

Year	10
1955	1.000
1956	1.000
1957	1.000
1958	1.000
1959	1.000
1960	1.000
1961	1.000
1962	1.000
1963	1.000
1964	1.000
1965	1.000
1966	1.000
1967	1.000
1968	1.000
1969	1.000
1970	1.000
1971	1.000
1972	1.000
1973	1.000
1974	1.000
1975	1.000
1976	1.000
1977	1.000
1978	1.000
1979	1.000
1980	1.000

==

TOTAL NUMBER OF FUNCTION EVALUATIONS = 2984

RUN 14

****

VPA-2BOX

SUMMARY STATISTICS AND DIAGNOSTIC OUTPUT

****

BFT East 55-06 test

9:27, 2 July 2008

==

Total objective function = 41.85

(with constants) = 196.23

Number of parameters (P) = 15

Number of data points (D)= 168

AIC : 2*objective+2P = 422.46

AICc: 2*objective+2P(...)= 425.62

BIC : 2*objective+Plog(D)= 469.32

Chi-square discrepancy = 83.08

Loglikelihoods (deviance)= -44.59 (167.92)
effort data = -44.59 (167.92)

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

Constraints = 2.74
terminal F = 2.74
stock-rec./sex ratio = 0.00

Out of bounds penalty = 0.00
==

TABLE 1. FISHING MORTALITY RATE FOR EAST OF 45

	1	2	3	4	5	6	7	8	9	10
1955	0.008	0.051	0.102	0.046	0.065	0.083	0.141	0.099	0.222	0.156
1956	0.006	0.039	0.053	0.029	0.035	0.061	0.076	0.136	0.137	0.096
1957	0.009	0.074	0.098	0.043	0.043	0.090	0.176	0.129	0.155	0.109
1958	0.027	0.094	0.143	0.059	0.104	0.111	0.094	0.158	0.127	0.089
1959	0.011	0.088	0.226	0.091	0.043	0.039	0.040	0.046	0.134	0.094
1960	0.008	0.050	0.080	0.099	0.145	0.088	0.046	0.079	0.114	0.080
1961	0.010	0.093	0.144	0.103	0.238	0.192	0.047	0.047	0.127	0.089
1962	0.006	0.058	0.131	0.088	0.119	0.254	0.094	0.121	0.133	0.093
1963	0.004	0.036	0.101	0.107	0.112	0.093	0.105	0.065	0.063	0.044
1964	0.010	0.052	0.099	0.138	0.178	0.107	0.086	0.095	0.071	0.049
1965	0.005	0.054	0.068	0.061	0.079	0.110	0.098	0.045	0.082	0.058
1966	0.026	0.069	0.207	0.080	0.050	0.096	0.081	0.050	0.046	0.032
1967	0.074	0.071	0.091	0.103	0.039	0.048	0.133	0.060	0.083	0.058
1968	0.029	0.082	0.076	0.047	0.054	0.020	0.043	0.066	0.047	0.033
1969	0.060	0.256	0.192	0.063	0.022	0.025	0.015	0.038	0.065	0.046
1970	0.059	0.174	0.121	0.078	0.026	0.015	0.030	0.022	0.041	0.041
1971	0.003	0.223	0.174	0.079	0.067	0.015	0.013	0.041	0.032	0.032
1972	0.006	0.178	0.337	0.090	0.071	0.055	0.019	0.008	0.023	0.023
1973	0.006	0.150	0.139	0.081	0.032	0.037	0.061	0.036	0.024	0.024
1974	0.026	0.168	0.187	0.143	0.118	0.057	0.040	0.052	0.048	0.048
1975	0.066	0.357	0.143	0.091	0.043	0.102	0.052	0.045	0.059	0.059
1976	0.009	0.265	0.463	0.119	0.096	0.030	0.066	0.030	0.047	0.047
1977	0.071	0.233	0.173	0.152	0.023	0.033	0.025	0.062	0.046	0.046
1978	0.135	0.351	0.175	0.083	0.041	0.011	0.024	0.013	0.035	0.035
1979	0.017	0.104	0.279	0.091	0.036	0.023	0.016	0.049	0.032	0.032
1980	0.110	0.239	0.407	0.186	0.030	0.034	0.030	0.016	0.035	0.035
1981	0.075	0.435	0.330	0.101	0.087	0.021	0.030	0.045	0.026	0.026
1982	0.239	0.389	0.472	0.170	0.066	0.040	0.022	0.075	0.053	0.053
1983	0.243	0.196	0.320	0.130	0.079	0.059	0.116	0.033	0.055	0.055
1984	0.108	0.447	0.120	0.129	0.126	0.093	0.085	0.114	0.061	0.061
1985	0.091	0.401	0.393	0.113	0.069	0.066	0.036	0.053	0.073	0.044
1986	0.274	0.310	0.238	0.146	0.030	0.042	0.038	0.031	0.068	0.041
1987	0.139	0.390	0.287	0.114	0.045	0.028	0.081	0.059	0.062	0.037
1988	0.334	0.206	0.379	0.159	0.056	0.040	0.048	0.073	0.094	0.056
1989	0.179	0.358	0.164	0.147	0.135	0.031	0.049	0.034	0.071	0.043
1990	0.168	0.229	0.303	0.125	0.158	0.053	0.051	0.071	0.088	0.053
1991	0.065	0.280	0.205	0.129	0.131	0.044	0.046	0.056	0.129	0.077
1992	0.073	0.237	0.337	0.082	0.066	0.058	0.099	0.123	0.151	0.090

1993	0.084	0.438	0.266	0.125	0.055	0.062	0.069	0.091	0.141	0.085
1994	0.113	0.259	0.176	0.063	0.112	0.083	0.172	0.192	0.326	0.196
1995	0.142	0.202	0.251	0.098	0.081	0.156	0.086	0.152	0.182	0.218
1996	0.144	0.405	0.322	0.235	0.107	0.045	0.098	0.076	0.205	0.246
1997	0.126	0.273	0.199	0.182	0.141	0.125	0.065	0.200	0.202	0.243
1998	0.122	0.527	0.403	0.328	0.168	0.364	0.043	0.038	0.136	0.163
1999	0.190	0.244	0.462	0.314	0.148	0.066	0.068	0.068	0.179	0.215
2000	0.510	0.509	0.278	0.263	0.281	0.223	0.075	0.107	0.097	0.116
2001	0.010	0.574	0.281	0.195	0.197	0.140	0.294	0.161	0.172	0.207
2002	0.038	0.636	0.571	0.256	0.099	0.195	0.094	0.171	0.172	0.206
2003	0.025	0.270	0.166	0.201	0.297	0.103	0.337	0.207	0.265	0.318
2004	0.072	0.337	0.443	0.119	0.101	0.240	0.166	0.187	0.324	0.389
2005	0.217	0.366	0.277	0.270	0.117	0.199	0.247	0.094	0.470	0.564
2006	0.153	0.253	0.534	0.203	0.086	0.225	0.149	0.233	0.522	0.627
2007	0.392	0.522	0.667	0.244	0.233	0.297	0.237	0.339	0.896	1.076

TABLE 2. ABUNDANCE AT THE BEGINNING OF THE YEAR [BY AREA] FOR EAST OF 45

	1	2	3	4	5	6	7	8	9	10
1955	1736848.	1597729.	1236915.	1034900.	621522.	520828.	277390.	404162.	246129.	670382.
1956	1093366.	1055216.	1194593.	878504.	777215.	458060.	392551.	202155.	314972.	693078.
1957	844063.	665599.	798525.	890820.	671035.	590558.	352874.	305339.	151800.	812052.
1958	1021211.	512375.	486237.	569751.	671129.	505824.	441977.	248347.	230983.	773955.
1959	870920.	609239.	366796.	331681.	422528.	475783.	370582.	337850.	182432.	820261.
1960	748982.	527506.	439053.	230166.	238320.	318427.	374530.	298946.	277793.	816424.
1961	983755.	455153.	394779.	318830.	164068.	162156.	238714.	300252.	237865.	900770.
1962	1580676.	596626.	326168.	268944.	226239.	101771.	109554.	191169.	246583.	930718.
1963	1925067.	962985.	443081.	224963.	193717.	158066.	64647.	83728.	145741.	957922.
1964	1724113.	1174655.	731079.	314951.	158944.	136179.	117904.	48849.	67504.	950029.
1965	3120179.	1045792.	876811.	520927.	215867.	104629.	100178.	90804.	38224.	873731.
1966	1965051.	1901099.	779375.	644692.	385554.	156975.	76728.	76223.	74739.	777406.
1967	1154908.	1173314.	1396261.	498420.	467916.	288396.	116790.	59400.	62382.	744350.
1968	972429.	656842.	859869.	1003274.	353577.	353861.	224979.	85830.	48138.	686096.
1969	934494.	578946.	475883.	627102.	753051.	263532.	284101.	180849.	69135.	641221.
1970	863567.	539173.	352611.	308919.	463182.	579728.	210460.	235030.	149926.	611463.
1971	1692900.	498903.	356301.	245880.	224843.	354873.	467423.	171427.	197969.	657958.

1972	1152386.	1034445.	313940.	235432.	178710.	165462.	286151.	387422.	141673.	745713.
1973	1717086.	701662.	680773.	176368.	169180.	131009.	128228.	235742.	330829.	781555.
1974	2196570.	1045918.	475026.	466101.	127929.	128871.	103343.	101311.	195752.	975237.
1975	1651172.	1310859.	695518.	310092.	317932.	89441.	99619.	83351.	82798.	1005483.
1976	2448968.	946796.	721893.	474340.	222688.	239636.	66108.	79388.	68580.	926641.
1977	1242764.	1486730.	571352.	357421.	331188.	159116.	190359.	51957.	66318.	857935.
1978	980476.	709253.	926013.	377967.	241398.	254625.	126037.	155853.	42047.	797670.
1979	1219496.	524696.	392586.	611513.	273691.	182341.	206156.	103310.	132452.	732435.
1980	1849152.	734729.	371813.	233605.	439376.	207643.	145942.	170288.	84669.	754767.
1981	1595021.	1014599.	455040.	194625.	152564.	335514.	164281.	118926.	144265.	731811.
1982	2564629.	906531.	516837.	257438.	138383.	110046.	269111.	133796.	97835.	769412.
1983	3877844.	1237200.	483452.	253617.	170817.	101854.	86526.	221086.	106829.	741946.
1984	2008307.	1864079.	799639.	276181.	175118.	124207.	78610.	64711.	184119.	724360.
1985	1811972.	1104721.	937632.	557931.	190884.	121409.	92652.	60620.	49681.	769230.
1986	3159758.	1013370.	581817.	497697.	392164.	140090.	93094.	75044.	49464.	707050.
1987	2262575.	1472144.	584384.	360691.	338211.	299358.	109960.	75228.	62640.	655006.
1988	3462646.	1205943.	784374.	345025.	253083.	254431.	238236.	85145.	61056.	622895.
1989	3512123.	1519342.	771692.	422163.	231542.	188251.	200114.	190634.	68123.	581748.
1990	3552554.	1799869.	835571.	515436.	286685.	159091.	149496.	160002.	158633.	560330.
1991	4873058.	1840042.	1126305.	485369.	357941.	192555.	123569.	119235.	128306.	609067.
1992	4126302.	2797355.	1093764.	722009.	335612.	246958.	150927.	99082.	97014.	609714.
1993	4369670.	2350672.	1735601.	614197.	523431.	247133.	190762.	114725.	75393.	577681.
1994	3605480.	2460324.	1192758.	1046587.	426560.	389679.	190237.	149515.	90122.	537965.
1995	4218166.	1973653.	1493221.	786658.	773153.	300113.	293560.	134518.	106216.	457645.
1996	4178050.	2242765.	1268077.	913512.	560922.	560775.	210278.	226231.	99405.	410988.
1997	3267734.	2217212.	1176247.	722873.	568343.	396511.	438908.	160007.	180545.	362214.
1998	4945338.	1765532.	1326891.	758422.	473790.	388440.	286597.	345162.	112711.	387282.
1999	3918775.	2681311.	819946.	697457.	429780.	315172.	221087.	230564.	286099.	384660.
2000	5120961.	1985414.	1653348.	406539.	400636.	291682.	241586.	173404.	185403.	491936.
2001	3123352.	1883395.	938464.	984623.	245856.	237957.	191049.	188142.	134038.	544769.

2002	2460795.	1893665.	834444.	557318.	637596.	158754.	169299.	119582.	137822.	500523.
2003	2402065.	1451898.	788509.	370775.	339247.	454271.	106977.	129374.	86757.	470952.
2004	3927801.	1435916.	871589.	525288.	238497.	198342.	335390.	64128.	90528.	368621.
2005	2475036.	2239034.	806188.	440059.	366987.	169607.	127775.	238420.	45769.	283724.
2006	3378944.	1220327.	1221176.	480662.	264303.	256787.	113788.	83826.	186818.	171299.
2007	1829416.	1776547.	745636.	563165.	308740.	190846.	167955.	82303.	57179.	180627.
2008		757512.	828936.	301031.	346938.	192389.	116071.	111230.	50464.	76331.

TABLE 3. CATCH OF EAST OF 45

	1	2	3	4	5	6	7	8	9	10
1955	11390.	70400.	107008.	41704.	34906.	37542.	33620.	35532.	46230.	92065.
1956	5455.	35668.	55302.	22639.	23547.	24550.	26464.	23989.	38002.	60427.
1957	6091.	42266.	66121.	33498.	24920.	46045.	52455.	34392.	20523.	79533.
1958	21162.	41049.	57587.	29029.	59060.	48301.	36300.	33860.	25940.	62720.
1959	7804.	45504.	66262.	25576.	15776.	16623.	13275.	14031.	21575.	70071.
1960	4765.	22821.	30043.	19236.	28693.	24382.	15475.	20995.	28190.	59676.
1961	7810.	36085.	47151.	27817.	30990.	25774.	10084.	12790.	26672.	72883.
1962	6948.	29693.	35820.	20199.	22545.	20762.	9015.	20314.	28861.	78671.
1963	6053.	29894.	38039.	20408.	18355.	12761.	5931.	4925.	8392.	39445.
1964	13483.	53408.	61333.	36132.	23139.	12549.	8941.	4128.	4324.	43564.
1965	13434.	48963.	50961.	27408.	14527.	9909.	8615.	3689.	2841.	46567.
1966	39436.	112263.	130125.	44396.	16847.	13006.	5482.	3480.	3133.	23246.
1967	65608.	71404.	107636.	43596.	16077.	12342.	13370.	3226.	4680.	40047.
1968	21694.	46196.	55796.	40894.	16520.	6218.	8761.	5117.	2075.	21100.
1969	43107.	116782.	74227.	34077.	14296.	5870.	3784.	6187.	4111.	27275.
1970	38988.	76925.	35680.	20559.	10718.	7994.	5735.	4664.	5693.	23503.
1971	3451.	89131.	50860.	16647.	12908.	4866.	5421.	6342.	5904.	19863.
1972	5573.	150797.	80312.	18135.	10831.	8023.	4886.	2837.	3049.	16246.

1973	7760.	87196.	78670.	12234.	4762.	4339.	6926.	7721.	7439.	17790.
1974	44979.	144277.	72124.	55216.	12678.	6529.	3719.	4751.	8656.	43652.
1975	83784.	352023.	82482.	24048.	11829.	7896.	4634.	3412.	4453.	54737.
1976	17530.	197044.	240034.	47517.	18182.	6467.	3870.	2172.	2940.	40211.
1977	67420.	276479.	81061.	45073.	6668.	4692.	4314.	2886.	2775.	36339.
1978	98571.	188168.	132601.	26750.	8539.	2562.	2725.	1825.	1375.	26405.
1979	15969.	46352.	85483.	47165.	8652.	3706.	3029.	4589.	3957.	22150.
1980	153269.	139588.	111493.	35389.	11433.	6339.	3921.	2484.	2707.	24427.
1981	91415.	320655.	114344.	16664.	11282.	6186.	4494.	4886.	3452.	17726.
1982	435146.	261565.	174480.	35938.	7924.	3956.	5269.	8996.	4771.	37980.
1983	666701.	196951.	118425.	27630.	11504.	5298.	8674.	6661.	5419.	38096.
1984	162820.	602875.	80534.	29877.	18519.	10023.	5876.	6501.	10301.	41021.
1985	125240.	327181.	273233.	52924.	11390.	6990.	2989.	2928.	3280.	31283.
1986	604933.	241954.	110132.	60406.	10325.	5246.	3194.	2105.	3059.	26910.
1987	233816.	425593.	130343.	34716.	13139.	7595.	7836.	3987.	3555.	22852.
1988	787349.	200802.	221886.	45198.	12255.	9080.	10230.	5575.	5152.	32507.
1989	457215.	409309.	103864.	51463.	26117.	5129.	8733.	5880.	4406.	23170.
1990	436999.	328717.	195473.	53837.	37369.	7406.	6846.	10160.	12584.	27460.
1991	243243.	401951.	186083.	52343.	39217.	7448.	5083.	6060.	14583.	43095.
1992	229347.	527898.	280117.	50401.	19090.	12665.	13102.	10684.	12771.	50172.
1993	280529.	748302.	362086.	64111.	24966.	13407.	11619.	9313.	9357.	44739.
1994	304848.	502294.	171943.	56716.	40132.	28248.	27584.	24304.	23658.	91141.
1995	443085.	322791.	296580.	65551.	53670.	39327.	22102.	17701.	16646.	85602.
1996	444406.	669905.	312384.	170611.	50658.	22395.	18071.	15306.	17363.	85496.
1997	306585.	474121.	189317.	107583.	66457.	42198.	25467.	27049.	31140.	74424.
1998	451731.	649694.	394557.	189770.	65233.	107965.	10958.	11856.	13452.	55410.
1999	540099.	517710.	271985.	168325.	52591.	18235.	13333.	14086.	44138.	70849.
2000	1651573.	711627.	359074.	84005.	87737.	53068.	16037.	16434.	16114.	51446.
2001	25533.	739701.	205608.	155369.	39309.	28320.	44773.	26069.	19960.	96913.
2002	71927.	802414.	326482.	112638.	53543.	25543.	13947.	17481.	20485.	88878.

2003	46055.	307381.	107698.	60328.	77901.	40516.	28196.	22527.	19063.	122562.
2004	216436.	367903.	279989.	52360.	20386.	38471.	47244.	10194.	23660.	113503.
2005	385283.	614905.	174453.	93018.	36131.	27849.	25703.	19866.	16213.	116936.
2006	381072.	243431.	453977.	78709.	19316.	46985.	14476.	16199.	71825.	76296.
2007	476208.	649262.	326962.	109102.	57313.	44700.	32636.	22075.	32112.	114263.

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TABLE 4. SPAWNING STOCK FECUNDITY AND RECRUITMENT OF EAST OF 45

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year	spawning biomass	recruits from VPA
1955	281954.	1736848.
1956	293686.	1093366.
1957	305347.	844063.
1958	309932.	1021211.
1959	295669.	870920.
1960	276992.	748982.
1961	271430.	983755.
1962	259169.	1580676.
1963	230712.	1925067.
1964	234749.	1724113.
1965	247121.	3120179.
1966	233128.	1965051.
1967	242289.	1154908.
1968	251277.	972429.
1969	271379.	934494.
1970	258938.	863567.
1971	288022.	1692900.
1972	297867.	1152386.
1973	298750.	1717086.
1974	308609.	2196570.
1975	299682.	1651172.
1976	297488.	2448968.
1977	287708.	1242764.
1978	275893.	980476.
1979	265092.	1219496.
1980	260270.	1849152.
1981	242430.	1595021.
1982	240487.	2564629.
1983	216818.	3877844.
1984	209947.	2008307.
1985	220586.	1811972.
1986	218118.	3159758.
1987	211313.	2262575.
1988	209345.	3462646.
1989	211845.	3512123.
1990	196955.	3552554.
1991	194648.	4873058.
1992	200396.	4126302.
1993	212334.	4369670.
1994	206727.	3605480.
1995	211502.	4218166.

1996	209234.	4178050.
1997	201479.	3267734.
1998	202337.	4945338.
1999	202877.	3918775.
2000	200567.	5120961.
2001	183252.	3123352.
2002	184442.	2460795.
2003	163087.	2402065.
2004	136590.	3927801.
2005	113838.	2475036.
2006	94978.	3378944.
2007	78724.	1829416.

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TABLE 5. FITS TO INDEX DATA FOR EAST OF 45

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5.1 ESP MAR Trap

Lognormal dist.
average numbers
Ages 6 - 10
log-likelihood = 0.91
deviance = 10.36
Chi-sq. discrepancy= 5.24

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1981	0.211	0.298	-0.086	0.791	0.368E-02	3248.936	3541.909	0.125
1982	0.464	0.287	0.177	0.791	0.368E-02	4181.572	3503.041	0.019
1983	0.528	0.254	0.274	0.791	0.368E-02	4457.914	3389.974	0.002
1984	0.626	0.213	0.413	0.791	0.368E-02	4919.679	3253.580	0.013
1985	0.234	0.150	0.084	0.791	0.368E-02	3323.686	3057.316	0.048
1986	-0.527	0.093	-0.620	0.791	0.368E-02	1552.599	2887.361	0.423
1987	-0.429	0.083	-0.512	0.791	0.368E-02	1712.964	2859.060	0.363
1988	0.428	0.081	0.348	0.791	0.368E-02	4036.118	2851.305	0.001
1989	-0.219	0.085	-0.304	0.791	0.368E-02	2112.991	2864.800	0.244
1990	-0.182	0.098	-0.279	0.791	0.368E-02	2193.198	2900.316	0.230
1991	0.117	0.087	0.030	0.791	0.368E-02	2956.781	2869.870	0.070
1992	-0.710	0.057	-0.766	0.791	0.368E-02	1293.345	2783.499	0.501
1993	-0.725	0.026	-0.751	0.791	0.368E-02	1273.456	2698.741	0.493
1994	-0.609	-0.007	-0.602	0.791	0.368E-02	1430.110	2611.502	0.413
1995	-1.067	-0.076	-0.991	0.791	0.368E-02	905.197	2437.907	0.610
1996	-0.473	-0.051	-0.422	0.791	0.368E-02	1639.230	2499.511	0.311
1997	0.375	-0.022	0.397	0.791	0.368E-02	3827.381	2572.335	0.009
1998	0.433	0.027	0.405	0.791	0.368E-02	4053.510	2702.987	0.011
1999	0.544	0.070	0.474	0.791	0.368E-02	4531.091	2820.305	0.035
2000	0.303	0.087	0.216	0.791	0.368E-02	3559.320	2868.026	0.010
2001	0.863	0.037	0.826	0.791	0.368E-02	6234.335	2730.150	0.516
2002	0.510	-0.079	0.590	0.791	0.368E-02	4380.586	2429.226	0.117
2003	-0.072	-0.171	0.099	0.791	0.368E-02	2448.107	2217.854	0.043
2004	-0.649	-0.348	-0.301	0.791	0.368E-02	1374.174	1856.262	0.242
2005	0.048	-0.552	0.600	0.791	0.368E-02	2759.992	1515.004	0.127
2006	-0.022	-0.726	0.704	0.791	0.368E-02	2572.432	1272.267	0.263

Selectivities by age

Year	6	7	8	9	10

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1981	0.179	0.326	0.550	0.849	1.000
1982	0.179	0.326	0.550	0.849	1.000
1983	0.179	0.326	0.550	0.849	1.000
1984	0.179	0.326	0.550	0.849	1.000
1985	0.179	0.326	0.550	0.849	1.000
1986	0.179	0.326	0.550	0.849	1.000
1987	0.179	0.326	0.550	0.849	1.000
1988	0.179	0.326	0.550	0.849	1.000
1989	0.179	0.326	0.550	0.849	1.000
1990	0.179	0.326	0.550	0.849	1.000
1991	0.179	0.326	0.550	0.849	1.000
1992	0.179	0.326	0.550	0.849	1.000
1993	0.179	0.326	0.550	0.849	1.000
1994	0.179	0.326	0.550	0.849	1.000
1995	0.179	0.326	0.550	0.849	1.000
1996	0.179	0.326	0.550	0.849	1.000
1997	0.179	0.326	0.550	0.849	1.000
1998	0.179	0.326	0.550	0.849	1.000
1999	0.179	0.326	0.550	0.849	1.000
2000	0.179	0.326	0.550	0.849	1.000
2001	0.179	0.326	0.550	0.849	1.000
2002	0.179	0.326	0.550	0.849	1.000
2003	0.179	0.326	0.550	0.849	1.000
2004	0.179	0.326	0.550	0.849	1.000
2005	0.179	0.326	0.550	0.849	1.000
2006	0.179	0.326	0.550	0.849	1.000

5.2 ESP BB 1

Not used

5.3 ESP BB 2

Lognormal dist.
average numbers
Ages 2 - 2
log-likelihood = -20.80
deviance = 56.60
Chi-sq. discrepancy= 22.58

Year	Observed	Residuals Predicted	Standard (Obs-pred)	Q Deviation	Untransfrmd Catchabil.	Untransfrmd Observed	Chi-square Predicted	Discrepancy
----	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------
1975	0.542	-0.136	0.678	0.791	0.110E-03	213.720	108.513	0.223
1976	0.163	-0.420	0.583	0.791	0.110E-03	146.320	81.702	0.110
1977	0.548	0.046	0.502	0.791	0.110E-03	215.130	130.173	0.050
1978	-0.504	-0.748	0.244	0.791	0.110E-03	75.110	58.847	0.005
1979	-1.277	-0.936	-0.342	0.791	0.110E-03	34.670	48.788	0.265
1980	-0.583	-0.662	0.079	0.791	0.110E-03	69.410	64.163	0.050
1981	-0.270	-0.427	0.158	0.791	0.110E-03	94.950	81.110	0.024
1982	0.030	-0.519	0.549	0.791	0.110E-03	128.090	73.968	0.082
1983	-0.045	-0.121	0.075	0.791	0.110E-03	118.830	110.194	0.051
1984	1.362	0.175	1.187	0.791	0.110E-03	485.620	148.186	2.242
1985	1.123	-0.327	1.450	0.791	0.110E-03	382.160	89.636	5.157
1986	-0.353	-0.373	0.020	0.791	0.110E-03	87.360	85.655	0.074
1987	1.218	-0.035	1.253	0.791	0.110E-03	420.300	120.070	2.798

1988	-0.876	-0.151	-0.725	0.791	0.110E-03	51.800	106.914	0.479
1989	1.368	0.011	1.357	0.791	0.110E-03	488.140	125.695	3.893
1990	-0.134	0.239	-0.373	0.791	0.110E-03	108.780	157.930	0.283
1991	0.319	0.238	0.082	0.791	0.110E-03	171.110	157.692	0.049
1992	0.717	0.676	0.040	0.791	0.110E-03	254.590	244.490	0.065
1993	1.246	0.411	0.835	0.791	0.110E-03	432.270	187.593	0.540
1994	-1.272	0.538	-1.810	0.791	0.110E-03	34.840	212.867	0.891
1995	0.449	0.344	0.105	0.791	0.110E-03	194.750	175.304	0.040
1996	0.298	0.379	-0.081	0.791	0.110E-03	167.510	181.635	0.122
1997	0.024	0.427	-0.403	0.791	0.110E-03	127.410	190.602	0.300
1998	-0.671	0.086	-0.757	0.791	0.110E-03	63.560	135.510	0.496
1999	-3.608	0.631	-4.239	0.791	0.110E-03	3.370	233.682	1.126
2000	-1.030	0.211	-1.241	0.791	0.110E-03	44.400	153.566	0.715
2001	0.996	0.130	0.866	0.791	0.110E-03	336.760	141.626	0.628
2002	1.063	0.109	0.954	0.791	0.110E-03	359.870	138.645	0.928
2003	-0.402	0.005	-0.407	0.791	0.110E-03	83.220	124.990	0.303
2004	-0.350	-0.036	-0.313	0.791	0.110E-03	87.650	119.907	0.249
2005	0.078	0.395	-0.317	0.791	0.110E-03	134.470	184.543	0.251
2006	-0.170	-0.160	-0.010	0.791	0.110E-03	104.880	105.909	0.087

Selectivities by age

Year	2
----	-----
1975	1.000
1976	1.000
1977	1.000
1978	1.000
1979	1.000
1980	1.000
1981	1.000
1982	1.000
1983	1.000
1984	1.000
1985	1.000
1986	1.000
1987	1.000
1988	1.000
1989	1.000
1990	1.000
1991	1.000
1992	1.000
1993	1.000
1994	1.000
1995	1.000
1996	1.000
1997	1.000
1998	1.000
1999	1.000
2000	1.000
2001	1.000
2002	1.000
2003	1.000
2004	1.000
2005	1.000
2006	1.000

5.4 ESP BB 3

Lognormal dist.
average numbers
Ages 3 - 3
log-likelihood = -16.95
deviance = 48.90
Chi-sq. discrepancy= 36.47

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1975	0.332	-0.107	0.440	0.791	0.543E-04	48.740	31.401	0.021
1976	0.590	-0.216	0.805	0.791	0.543E-04	63.040	28.173	0.466
1977	1.057	-0.318	1.375	0.791	0.543E-04	100.630	25.431	4.123
1978	-0.868	0.164	-1.032	0.791	0.543E-04	14.670	41.183	0.629
1979	0.721	-0.742	1.464	0.791	0.543E-04	71.910	16.641	5.365
1980	-0.251	-0.854	0.604	0.791	0.543E-04	27.200	14.874	0.131
1981	-1.855	-0.618	-1.237	0.791	0.543E-04	5.470	18.850	0.714
1982	0.199	-0.554	0.753	0.791	0.543E-04	42.670	20.091	0.352
1983	-0.873	-0.553	-0.320	0.791	0.543E-04	14.600	20.116	0.253
1984	1.285	0.043	1.242	0.791	0.543E-04	126.380	36.490	2.701
1985	1.150	0.077	1.074	0.791	0.543E-04	110.430	37.743	1.493
1986	-0.363	-0.330	-0.033	0.791	0.543E-04	24.320	25.130	0.098
1987	-1.175	-0.348	-0.827	0.791	0.543E-04	10.800	24.682	0.532
1988	-1.612	-0.096	-1.517	0.791	0.543E-04	6.970	31.771	0.810
1989	-1.443	-0.013	-1.430	0.791	0.543E-04	8.260	34.503	0.782
1990	0.152	0.002	0.149	0.791	0.543E-04	40.680	35.031	0.026
1991	-0.381	0.346	-0.727	0.791	0.543E-04	23.880	49.405	0.481
1992	-1.066	0.256	-1.322	0.791	0.543E-04	12.040	45.157	0.745
1993	1.672	0.750	0.921	0.791	0.543E-04	185.980	74.017	0.806
1994	0.251	0.417	-0.165	0.791	0.543E-04	44.930	53.015	0.166
1995	0.590	0.606	-0.017	0.791	0.543E-04	63.030	64.103	0.091
1996	1.308	0.411	0.897	0.791	0.543E-04	129.240	52.711	0.723
1997	1.728	0.392	1.336	0.791	0.543E-04	196.790	51.735	3.650
1998	0.360	0.420	-0.060	0.791	0.543E-04	50.100	53.179	0.111
1999	-0.973	-0.088	-0.885	0.791	0.543E-04	13.210	32.019	0.561
2000	-0.009	0.696	-0.705	0.791	0.543E-04	34.650	70.108	0.469
2001	0.611	0.128	0.483	0.791	0.543E-04	64.420	39.743	0.040
2002	1.483	-0.118	1.601	0.791	0.543E-04	153.960	31.060	7.922
2003	-1.010	0.007	-1.017	0.791	0.543E-04	12.730	35.211	0.622
2004	-1.183	-0.019	-1.164	0.791	0.543E-04	10.710	34.311	0.685
2005	0.610	-0.022	0.632	0.791	0.543E-04	64.340	34.203	0.162
2006	-1.039	0.279	-1.318	0.791	0.543E-04	12.370	46.195	0.743

Selectivities by age

Year	3
1975	1.000
1976	1.000
1977	1.000
1978	1.000
1979	1.000
1980	1.000
1981	1.000
1982	1.000
1983	1.000
1984	1.000
1985	1.000
1986	1.000
1987	1.000
1988	1.000

1989	1.000
1990	1.000
1991	1.000
1992	1.000
1993	1.000
1994	1.000
1995	1.000
1996	1.000
1997	1.000
1998	1.000
1999	1.000
2000	1.000
2001	1.000
2002	1.000
2003	1.000
2004	1.000
2005	1.000
2006	1.000

5.5 ESP BB 4

Not used

5.6 ESP BB 5

Not used

5.7 JLL EastMed

Lognormal dist.
average numbers
Ages 4 - 10
log-likelihood = 0.48
deviance = 14.04
Chi-sq. discrepancy= 7.95

Year	Observed	Residuals Predicted	Standard (Obs-pred)	Q Deviation	Untransfrmd Catchabil.	Untransfrmd Observed	Chi-square Predicted	Discrepancy
1975	0.357	0.200	0.156	0.791	0.185E-05	1.956	1.673	0.024
1976	0.472	0.144	0.327	0.791	0.185E-05	2.194	1.582	0.000
1977	0.979	0.112	0.867	0.791	0.185E-05	3.647	1.532	0.631
1978	0.131	0.117	0.014	0.791	0.185E-05	1.561	1.540	0.077
1979	0.705	0.153	0.551	0.791	0.185E-05	2.771	1.596	0.083
1980	0.253	0.151	0.102	0.791	0.185E-05	1.763	1.593	0.042
1981	0.223	0.168	0.055	0.791	0.185E-05	1.712	1.620	0.059
1982	0.904	0.149	0.756	0.791	0.185E-05	3.382	1.589	0.357
1983	0.458	0.120	0.338	0.791	0.185E-05	2.165	1.544	0.001
1984	0.192	0.050	0.143	0.791	0.185E-05	1.660	1.439	0.028
1985	0.261	-0.048	0.309	0.791	0.185E-05	1.778	1.305	0.000
1986	-0.010	-0.066	0.057	0.791	0.185E-05	1.356	1.281	0.059
1987	0.477	-0.056	0.533	0.791	0.185E-05	2.207	1.295	0.070
1988	0.008	-0.032	0.040	0.791	0.185E-05	1.380	1.326	0.066
1989	-0.242	0.011	-0.253	0.791	0.185E-05	1.075	1.384	0.215
1990	0.064	0.037	0.027	0.791	0.185E-05	1.460	1.421	0.071
1991	-0.088	-0.003	-0.085	0.791	0.185E-05	1.254	1.366	0.124

1992	-0.252	-0.029	-0.223	0.791	0.185E-05	1.064	1.331	0.198
1993	-0.248	-0.028	-0.220	0.791	0.185E-05	1.069	1.332	0.196
1994	-0.186	-0.009	-0.177	0.791	0.185E-05	1.137	1.357	0.172
1995	0.022	-0.010	0.032	0.791	0.185E-05	1.400	1.356	0.069
1996	-1.054	0.040	-1.094	0.791	0.185E-05	0.477	1.425	0.656
1997	-0.984	0.092	-1.075	0.791	0.185E-05	0.512	1.501	0.648
1998	-0.677	0.132	-0.809	0.791	0.185E-05	0.696	1.563	0.523
1999	-0.789	0.151	-0.940	0.791	0.185E-05	0.622	1.593	0.586
2000	-0.643	0.084	-0.727	0.791	0.185E-05	0.720	1.489	0.480
2001	-0.393	0.018	-0.412	0.791	0.185E-05	0.924	1.395	0.305
2002	0.372	-0.087	0.459	0.791	0.185E-05	1.986	1.256	0.028
2003	0.182	-0.207	0.389	0.791	0.185E-05	1.643	1.114	0.007
2004	-0.562	-0.326	-0.236	0.791	0.185E-05	0.781	0.988	0.205
2005	-0.481	-0.441	-0.040	0.791	0.185E-05	0.846	0.881	0.102
2006	0.547	-0.588	1.135	0.791	0.185E-05	2.366	0.761	1.867

Selectivities by age

Year	4	5	6	7	8	9	10
1975	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1976	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1977	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1978	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1979	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1980	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1981	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1982	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1983	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1984	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1985	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1986	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1987	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1988	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1989	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1990	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1991	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1992	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1993	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1994	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1995	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1996	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1997	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1998	0.042	0.086	0.228	0.470	0.797	1.000	0.722
1999	0.042	0.086	0.228	0.470	0.797	1.000	0.722
2000	0.042	0.086	0.228	0.470	0.797	1.000	0.722
2001	0.042	0.086	0.228	0.470	0.797	1.000	0.722
2002	0.042	0.086	0.228	0.470	0.797	1.000	0.722
2003	0.042	0.086	0.228	0.470	0.797	1.000	0.722
2004	0.042	0.086	0.228	0.470	0.797	1.000	0.722
2005	0.042	0.086	0.228	0.470	0.797	1.000	0.722
2006	0.042	0.086	0.228	0.470	0.797	1.000	0.722

5.8 MAR Trap

Not used

5.9 ESP Trap

Not used

5.10 FR BB

Lognormal dist.
average biomass
Ages 2 - 5
log-likelihood = 0.26
deviance = 8.85
Chi-sq. discrepancy= 4.91

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1955	0.879	0.748	0.130	0.791	0.135E-04	808.267	709.583	0.032
1956	0.212	0.645	-0.433	0.791	0.135E-04	415.143	640.029	0.318
1957	0.048	0.384	-0.336	0.791	0.135E-04	352.273	492.792	0.262
1958	-0.125	0.007	-0.133	0.791	0.135E-04	296.136	338.124	0.149
1959	0.426	-0.304	0.730	0.791	0.135E-04	514.177	247.680	0.309
1960	-0.754	-0.409	-0.345	0.791	0.135E-04	158.000	223.128	0.267
1961	-0.315	-0.471	0.157	0.791	0.135E-04	245.135	209.607	0.024
1962	-0.343	-0.478	0.135	0.791	0.135E-04	238.272	208.110	0.030
1963	-0.698	-0.250	-0.448	0.791	0.135E-04	167.077	261.455	0.326
1964	-0.907	0.050	-0.957	0.791	0.135E-04	135.593	353.030	0.595
1965	-0.340	0.236	-0.577	0.791	0.135E-04	238.846	425.138	0.399
1966	0.413	0.450	-0.037	0.791	0.135E-04	507.500	526.398	0.100
1967	0.108	0.585	-0.477	0.791	0.135E-04	373.913	602.502	0.343
1968	-0.381	0.407	-0.788	0.791	0.135E-04	229.412	504.229	0.512
1969	0.241	0.048	0.193	0.791	0.135E-04	427.200	352.320	0.015
1970	0.249	-0.332	0.581	0.791	0.135E-04	430.588	240.960	0.108
1971	0.175	-0.581	0.756	0.791	0.135E-04	400.000	187.749	0.358
1972	0.461	-0.399	0.860	0.791	0.135E-04	532.374	225.368	0.609
1973	0.104	-0.256	0.360	0.791	0.135E-04	372.414	259.871	0.003
1974	0.547	-0.080	0.627	0.791	0.135E-04	580.000	309.781	0.157

Selectivities by age

Year	2	3	4	5
1955	0.808	1.000	0.446	0.173
1956	0.808	1.000	0.446	0.173
1957	0.808	1.000	0.446	0.173
1958	0.808	1.000	0.446	0.173
1959	0.808	1.000	0.446	0.173
1960	0.808	1.000	0.446	0.173
1961	0.808	1.000	0.446	0.173
1962	0.808	1.000	0.446	0.173
1963	0.808	1.000	0.446	0.173
1964	0.808	1.000	0.446	0.173
1965	0.808	1.000	0.446	0.173
1966	0.808	1.000	0.446	0.173
1967	0.808	1.000	0.446	0.173
1968	0.808	1.000	0.446	0.173
1969	0.808	1.000	0.446	0.173
1970	0.808	1.000	0.446	0.173
1971	0.808	1.000	0.446	0.173
1972	0.808	1.000	0.446	0.173
1973	0.808	1.000	0.446	0.173
1974	0.808	1.000	0.446	0.173

5.11 NOR PS

Lognormal dist.
average biomass
Ages 10 - 10
log-likelihood = -8.49
deviance = 29.17
Chi-sq. discrepancy= 5.93

Year	Observed	Residuals Predicted	Standard (Obs-pred)	Q Deviation	Untransfrmd Catchabil.	Untransfrmd Observed	Chi-square Predicted	Discrepancy
1955	0.235	-0.437	0.672	0.791	0.164E-06	36.199	18.494	0.214
1956	-0.298	-0.340	0.042	0.791	0.164E-06	21.254	20.378	0.065
1957	-0.001	-0.171	0.170	0.791	0.164E-06	28.607	24.128	0.020
1958	-0.171	-0.145	-0.026	0.791	0.164E-06	24.126	24.773	0.095
1959	0.124	-0.143	0.268	0.791	0.164E-06	32.408	24.800	0.002
1960	0.492	-0.160	0.652	0.791	0.164E-06	46.831	24.388	0.188
1961	0.594	-0.027	0.621	0.791	0.164E-06	51.836	27.867	0.149
1962	0.815	0.037	0.778	0.791	0.164E-06	64.669	29.691	0.404
1963	-2.841	0.009	-2.851	0.791	0.164E-06	1.671	28.897	1.055
1964	0.171	0.094	0.078	0.791	0.164E-06	33.978	31.432	0.050
1965	0.889	0.139	0.750	0.791	0.164E-06	69.604	32.894	0.345
1966	0.221	-0.013	0.234	0.791	0.164E-06	35.705	28.254	0.007
1967	0.758	-0.022	0.779	0.791	0.164E-06	61.057	28.004	0.406
1968	-0.196	-0.085	-0.110	0.791	0.164E-06	23.532	26.281	0.137
1969	-0.020	-0.111	0.090	0.791	0.164E-06	28.056	25.629	0.046
1970	0.401	-0.289	0.690	0.791	0.164E-06	42.755	21.450	0.241
1971	0.419	-0.063	0.482	0.791	0.164E-06	43.519	26.885	0.039
1972	0.408	0.078	0.330	0.791	0.164E-06	43.047	30.951	0.000
1973	0.387	0.130	0.257	0.791	0.164E-06	42.148	32.602	0.003
1974	0.468	0.318	0.150	0.791	0.164E-06	45.719	39.348	0.026
1975	0.283	0.342	-0.059	0.791	0.164E-06	38.000	40.311	0.111
1976	-0.302	0.320	-0.622	0.791	0.164E-06	21.160	39.432	0.424
1977	0.394	0.256	0.138	0.791	0.164E-06	42.444	36.960	0.029
1978	-0.846	0.176	-1.023	0.791	0.164E-06	12.278	34.143	0.625
1979	-2.033	0.064	-2.096	0.791	0.164E-06	3.750	30.511	0.952
1980	-0.351	0.041	-0.393	0.791	0.164E-06	20.143	29.834	0.295

Selectivities by age

Year	10
1955	1.000
1956	1.000
1957	1.000
1958	1.000
1959	1.000
1960	1.000
1961	1.000
1962	1.000
1963	1.000
1964	1.000
1965	1.000
1966	1.000
1967	1.000
1968	1.000
1969	1.000

1970	1.000
1971	1.000
1972	1.000
1973	1.000
1974	1.000
1975	1.000
1976	1.000
1977	1.000
1978	1.000
1979	1.000
1980	1.000

==

TOTAL NUMBER OF FUNCTION EVALUATIONS = 2202

BFT _Western stock_Report file for the VPA base model.

BFT _Western stock_Report file for the VPA base model and Case 9 sensitivity run.

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

BFT West 1970-2007 BASE RUN
 9:04,  1      July 2008

=======================================================================
Total objective function =         7.46
      (with constants)   =       306.46
Number of parameters (P) =           24
Number of data points (D)=          214
AIC : 2*objective+2P     =       660.92
AICc: 2*objective+2P(...)=       667.27
BIC : 2*objective+Plog(D)=       741.70
Chi-square discrepancy   =       190.95

Loglikelihoods (deviance)=         5.75 (       214.17)
   effort data           =         5.75 (       214.17)

Log-posteriors           =         1.38
   catchability          =         0.00
   f-ratio               =         1.38
   natural mortality     =         0.00
   mixing coeff.         =         0.00

Constraints              =       -14.58
   terminal F            =       -14.58
   stock-rec./sex ratio  =         0.00

Out of bounds penalty    =         0.00
=======================================================================
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TABLE 1. FISHING MORTALITY RATE

	1	2	3	4	5	6	7	8	9	10
1970	0.224	0.741	0.933	0.254	0.091	0.032	0.016	0.005	0.024	0.024
1971	0.292	1.183	0.637	1.032	0.011	0.051	0.093	0.154	0.041	0.041
1972	0.242	0.957	0.875	0.106	0.194	0.002	0.021	0.031	0.038	0.038
1973	0.041	0.685	0.813	0.409	0.076	0.097	0.020	0.069	0.036	0.036
1974	0.133	0.212	0.404	0.387	0.307	0.030	0.077	0.023	0.059	0.107
1975	0.396	0.556	0.120	0.394	0.070	0.071	0.016	0.070	0.050	0.089
1976	0.043	0.288	0.542	0.053	0.145	0.036	0.034	0.072	0.072	0.129
1977	0.016	0.241	0.213	0.462	0.110	0.254	0.125	0.104	0.085	0.153
1978	0.100	0.171	0.326	0.196	0.250	0.118	0.062	0.079	0.088	0.158
1979	0.037	0.288	0.390	0.405	0.147	0.116	0.098	0.070	0.118	0.213
1980	0.056	0.297	0.514	0.356	0.117	0.171	0.252	0.170	0.159	0.287
1981	0.113	0.221	0.518	0.456	0.405	0.205	0.232	0.213	0.186	0.336
1982	0.068	0.089	0.051	0.024	0.045	0.075	0.034	0.056	0.079	0.094
1983	0.041	0.058	0.098	0.033	0.051	0.151	0.183	0.115	0.130	0.153
1984	0.014	0.105	0.053	0.078	0.093	0.120	0.129	0.132	0.125	0.148
1985	0.008	0.106	0.235	0.101	0.218	0.245	0.094	0.179	0.162	0.191
1986	0.006	0.104	0.181	0.089	0.050	0.118	0.076	0.059	0.185	0.218
1987	0.023	0.192	0.215	0.202	0.146	0.143	0.156	0.135	0.156	0.184
1988	0.056	0.174	0.247	0.133	0.189	0.194	0.170	0.176	0.185	0.219
1989	0.016	0.189	0.045	0.121	0.072	0.147	0.170	0.191	0.233	0.275
1990	0.026	0.099	0.407	0.071	0.094	0.095	0.156	0.208	0.227	0.268
1991	0.039	0.200	0.364	0.118	0.062	0.107	0.161	0.249	0.237	0.280
1992	0.008	0.086	0.039	0.067	0.070	0.053	0.130	0.171	0.261	0.308
1993	0.006	0.024	0.095	0.076	0.126	0.111	0.095	0.204	0.194	0.229
1994	0.048	0.014	0.040	0.059	0.074	0.139	0.151	0.169	0.170	0.200
1995	0.015	0.035	0.094	0.129	0.124	0.085	0.080	0.152	0.175	0.206
1996	0.006	0.162	0.069	0.193	0.102	0.061	0.120	0.119	0.175	0.206
1997	0.005	0.017	0.151	0.056	0.079	0.084	0.106	0.127	0.182	0.214
1998	0.005	0.023	0.084	0.095	0.060	0.062	0.125	0.196	0.197	0.232
1999	0.001	0.012	0.068	0.052	0.064	0.060	0.151	0.188	0.227	0.268
2000	0.002	0.006	0.026	0.068	0.152	0.134	0.147	0.166	0.190	0.224
2001	0.028	0.009	0.073	0.134	0.058	0.084	0.172	0.115	0.233	0.275
2002	0.008	0.147	0.154	0.208	0.153	0.057	0.213	0.267	0.258	0.304
2003	0.002	0.057	0.173	0.198	0.089	0.040	0.120	0.225	0.182	0.214
2004	0.004	0.054	0.191	0.163	0.216	0.162	0.131	0.116	0.135	0.160
2005	0.006	0.084	0.060	0.087	0.089	0.083	0.091	0.092	0.158	0.187
2006	0.007	0.012	0.028	0.072	0.101	0.156	0.175	0.199	0.155	0.183
2007	0.007	0.016	0.221	0.188	0.086	0.090	0.082	0.114	0.082	0.097

TABLE 2. ABUNDANCE AT THE BEGINNING OF THE YEAR

	1	2	3	4	5	6	7	8	9	10
1970	329661.	208096.	221232.	100395.	44442.	30387.	11810.	34915.	23096.	164601.
1971	259140.	229067.	86186.	75657.	67679.	35259.	25582.	10106.	30203.	159271.
1972	225523.	168174.	61027.	39614.	23429.	58220.	29120.	20274.	7529.	158111.

1973	133767.	153951.	56125.	22115.	30968.
16784.	50504.	24787.	17091.	138654.	
1974	481004.	111663.	67477.	21640.	12769.
24943.	13242.	43020.	20114.	130668.	
1975	141253.	366230.	78525.	39164.	12777.
8164.	21051.	10662.	36549.	118537.	
1976	133775.	82607.	182508.	60524.	22957.
10360.	6610.	18009.	8645.	124489.	
1977	85851.	111363.	53842.	92267.	49906.
17259.	8686.	5555.	14569.	102110.	
1978	57245.	73452.	76058.	37809.	50557.
38865.	11634.	6661.	4352.	87787.	
1979	80320.	45018.	53803.	47746.	27019.
34215.	30037.	9505.	5352.	68625.	
1980	62645.	67271.	29339.	31669.	27678.
20284.	26495.	23683.	7707.	52349.	
1981	60453.	51519.	43459.	15258.	19294.
21396.	14862.	17896.	17379.	39858.	
1982	57260.	46930.	35915.	22505.	8408.
11192.	15147.	10243.	12575.	37300.	
1983	96297.	46495.	37329.	29682.	19100.
6990.	9029.	12723.	8422.	39626.	
1984	68711.	80364.	38151.	29434.	24974.
15785.	5223.	6535.	9863.	35996.	
1985	74826.	58926.	62885.	31449.	23663.
19787.	12171.	3990.	4977.	34551.	
1986	94481.	64521.	46089.	43235.	24723.
16549.	13469.	9628.	2900.	28490.	
1987	73141.	81614.	50567.	33440.	34395.
20455.	12790.	10849.	7889.	22007.	
1988	97382.	62157.	58563.	35446.	23745.
25830.	15413.	9515.	8240.	21793.	
1989	56490.	80074.	45407.	39761.	26980.
17083.	18489.	11299.	6935.	21176.	
1990	101361.	48332.	57599.	37751.	30619.
21836.	12820.	13557.	8112.	18752.	
1991	93532.	85884.	38067.	33316.	30566.
24230.	17258.	9539.	9568.	18087.	
1992	59639.	78181.	61148.	22989.	25735.
24982.	18931.	12769.	6466.	18444.	
1993	59689.	51415.	62369.	51138.	18698.
20854.	20595.	14458.	9353.	16108.	
1994	45855.	51569.	43642.	49301.	41205.
14336.	16222.	16282.	10246.	17834.	
1995	79211.	37989.	44188.	36440.	40422.
33273.	10842.	12130.	11958.	20203.	
1996	72394.	67850.	31903.	34986.	27844.
31053.	26572.	8699.	9059.	23016.	
1997	50360.	62551.	50177.	25886.	25067.
21867.	25395.	20494.	6715.	22888.	
1998	60097.	43577.	53453.	37492.	21275.
20143.	17485.	19857.	15699.	20928.	
1999	58648.	52004.	37027.	42735.	29629.
17414.	16458.	13414.	14193.	25630.	
2000	42839.	50918.	44661.	30073.	35254.
24160.	14252.	12301.	9665.	26874.	
2001	53856.	37151.	44007.	37826.	24418.
26339.	18376.	10692.	9058.	25625.	

2002	61476.	45518.	31997.	35567.	28769.	20022.	21051.	13454.	8282.	23155.
2003	73714.	53002.	34171.	23858.	25103.	21465.	16443.	14794.	8954.	20410.
2004	78127.	63930.	43519.	24979.	17011.	19962.	17923.	12685.	10265.	20808.
2005	62284.	67635.	52661.	31249.	18442.	11919.	14756.	13663.	9820.	23212.
2006	19472.	53804.	54059.	43116.	24903.	14665.	9533.	11709.	10830.	24033.
2007	9486.	16816.	46217.	45711.	34894.	19576.	10906.	6959.	8345.	25468.
2008		8186.	14384.	32197.	32921.	27829.	15547.	8731.	5398.	26781.

TABLE 3. CATCH OF BFT

	1	2	3	4	5	6	7	8	9	10
1970	61909.	102549.	126581.	21101.	3629.	897.	173.	162.	513.	3656.
1971	61511.	150254.	38184.	45991.	663.	1646.	2112.	1351.	1134.	5980.
1972	45326.	97755.	33545.	3730.	3856.	118.	568.	574.	261.	5481.
1973	4971.	71796.	29419.	6964.	2126.	1450.	951.	1541.	559.	4535.
1974	55834.	19960.	21028.	6508.	3164.	681.	913.	914.	1083.	12401.
1975	43341.	146792.	8323.	11959.	803.	523.	313.	671.	1650.	9468.
1976	5301.	19357.	71719.	2911.	2901.	344.	206.	1168.	558.	14098.
1977	1270.	22341.	9683.	32004.	4860.	3629.	957.	513.	1109.	13568.
1978	5103.	10813.	19800.	6294.	10482.	4031.	654.	472.	341.	11996.
1979	2745.	10552.	16287.	14915.	3447.	3493.	2611.	598.	557.	12315.
1980	3160.	16182.	11066.	8879.	2865.	2981.	5531.	3453.	1061.	12240.
1981	6046.	9549.	16496.	5241.	6019.	3717.	2882.	3210.	2763.	10658.
1982	3528.	3729.	1655.	499.	343.	753.	478.	518.	896.	3114.
1983	3600.	2438.	3243.	891.	880.	918.	1414.	1287.	957.	5253.
1984	868.	7501.	1845.	2069.	2068.	1668.	592.	757.	1087.	4630.
1985	568.	5523.	12308.	2813.	4329.	4019.	1024.	612.	696.	5622.
1986	563.	5938.	7129.	3429.	1115.	1716.	924.	517.	458.	5226.

1987	1534.	13328.	9162.	5731.	4378.	2548.	1725.	1281.	1063.	3452.
1988	4925.	9282.	12004.	4123.	3829.	4267.	2259.	1438.	1304.	4005.
1989	835.	12925.	1851.	4243.	1740.	2184.	2707.	1840.	1351.	4772.
1990	2400.	4245.	18073.	2420.	2567.	1854.	1727.	2386.	1543.	4128.
1991	3364.	14542.	10893.	3470.	1709.	2293.	2403.	1967.	1892.	4136.
1992	464.	6015.	2171.	1383.	1632.	1207.	2150.	1880.	1392.	4583.
1993	346.	1134.	5287.	3494.	2063.	2050.	1743.	2500.	1543.	3084.
1994	2015.	691.	1611.	2619.	2738.	1743.	2121.	2363.	1497.	3030.
1995	1088.	1206.	3685.	4123.	4394.	2530.	781.	1598.	1794.	3523.
1996	414.	9473.	1986.	5754.	2514.	1720.	2802.	911.	1360.	4016.
1997	219.	994.	6591.	1320.	1772.	1639.	2386.	2276.	1043.	4130.
1998	260.	920.	4013.	3186.	1162.	1131.	1921.	3303.	2625.	4060.
1999	73.	589.	2274.	2038.	1717.	953.	2158.	2147.	2699.	5641.
2000	98.	278.	1074.	1854.	4634.	2825.	1826.	1760.	1563.	5045.
2001	1398.	323.	2891.	4424.	1295.	1984.	2712.	1089.	1763.	5770.
2002	476.	5807.	4257.	6259.	3813.	1035.	3774.	2953.	1763.	5691.
2003	165.	2748.	5085.	4013.	2001.	792.	1731.	2794.	1392.	3686.
2004	306.	3133.	7084.	3520.	3088.	2794.	2063.	1298.	1215.	2872.
2005	369.	5093.	2863.	2432.	1470.	891.	1202.	1126.	1343.	3695.
2006	120.	599.	1380.	2781.	2228.	1982.	1429.	1974.	1453.	3754.
2007	65.	253.	8590.	7335.	2693.	1582.	806.	700.	614.	2195.

TABLE 4. SPAWNING STOCK FECUNDITY AND RECRUITMENT

year	spawning biomass	recruits from VPA
1970	49482.	329661.
1971	44743.	259140.
1972	44686.	225523.
1973	42422.	133767.
1974	42659.	481004.
1975	36221.	141253.
1976	34066.	133775.
1977	28643.	85851.

1978	25643.	57245.
1979	19749.	80320.
1980	17657.	62645.
1981	15012.	60453.
1982	13943.	57260.
1983	13829.	96297.
1984	11817.	68711.
1985	9350.	74826.
1986	8941.	94481.
1987	7936.	73141.
1988	7704.	97382.
1989	7297.	56490.
1990	7276.	101361.
1991	6723.	93532.
1992	6511.	59639.
1993	7029.	59689.
1994	7576.	45855.
1995	8393.	79211.
1996	8109.	72394.
1997	9093.	50360.
1998	9738.	60097.
1999	9351.	58648.
2000	9411.	42839.
2001	8629.	53856.
2002	8031.	61476.
2003	8084.	73714.
2004	8202.	78127.
2005	8542.	62284.
2006	8681.	19472.
2007	8693.	9486.

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TABLE 5. FITS TO INDEX DATA

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5.1 CAN GSL ADJ

Lognormal dist.
average numbers
Ages 10 - 10
log-likelihood = 3.13
deviance = 22.21
Chi-sq. discrepancy= 15.65

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1981	0.479	0.975	-0.496	0.590	0.132E-03	1.614	2.651	0.573
1982	0.427	0.766	-0.339	0.590	0.132E-03	1.532	2.151	0.387
1983	0.850	0.750	0.101	0.590	0.132E-03	2.341	2.117	0.012

1984	0.278	0.289	-0.010	0.590	0.132E-03	1.321	1.334	0.068
1985	-0.695	0.126	-0.822	0.590	0.132E-03	0.499	1.135	0.954
1986	-0.447	0.260	-0.707	0.590	0.132E-03	0.640	1.297	0.823
1987	-0.983	-0.206	-0.778	0.590	0.132E-03	0.374	0.814	0.905
1988	-0.347	-0.143	-0.204	0.590	0.132E-03	0.707	0.867	0.238
1989	-0.344	-0.308	-0.035	0.590	0.132E-03	0.709	0.735	0.086
1990	-0.909	-0.365	-0.544	0.590	0.132E-03	0.403	0.694	0.630
1991	-0.346	-0.619	0.273	0.590	0.132E-03	0.708	0.539	0.026
1992	-0.265	-0.645	0.380	0.590	0.132E-03	0.767	0.525	0.125
1993	-0.158	-0.411	0.253	0.590	0.132E-03	0.854	0.663	0.016
1994	-1.230	-0.528	-0.703	0.590	0.132E-03	0.292	0.590	0.818
1995	0.034	-0.153	0.187	0.590	0.132E-03	1.035	0.858	0.000
1996	-1.039	-0.269	-0.770	0.590	0.132E-03	0.354	0.764	0.895
1997	-1.049	-0.279	-0.770	0.590	0.132E-03	0.350	0.756	0.896
1998	-0.412	-0.494	0.082	0.590	0.132E-03	0.663	0.610	0.018
1999	-0.053	-0.485	0.433	0.590	0.132E-03	0.949	0.615	0.209
2000	-0.247	-0.328	0.081	0.590	0.132E-03	0.781	0.721	0.019
2001	-0.225	-0.709	0.484	0.590	0.132E-03	0.799	0.492	0.316
2002	-0.434	-0.759	0.326	0.590	0.132E-03	0.648	0.468	0.064
2003	-0.104	-0.531	0.427	0.590	0.132E-03	0.901	0.588	0.198
2004	0.557	-0.329	0.886	0.590	0.132E-03	1.746	0.719	2.588
2005	0.386	-0.447	0.833	0.590	0.132E-03	1.471	0.639	2.086
2006	0.398	-0.214	0.612	0.590	0.132E-03	1.489	0.807	0.725
2007	0.774	-0.046	0.820	0.590	0.132E-03	2.168	0.955	1.976

Selectivities by age

Year	10
1981	0.631
1982	0.488
1983	0.465
1984	0.322
1985	0.291
1986	0.409
1987	0.327

1988	0.358
1989	0.320
1990	0.341
1991	0.275
1992	0.267
1993	0.372
1994	0.295
1995	0.380
1996	0.297
1997	0.296
1998	0.264
1999	0.221
2000	0.242
2001	0.177
2002	0.189
2003	0.259
2004	0.302
2005	0.244
2006	0.297
2007	0.318

5.2 CAN SWNS

Lognormal dist.
average numbers
Ages 7 - 10
log-likelihood = -8.86
deviance = 38.81
Chi-sq. discrepancy= 48.11

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1988	0.742	-0.356	1.098	0.590	0.222E-04	2.100	0.700	5.537
1989	1.244	-0.367	1.611	0.590	0.222E-04	3.470	0.693	24.697
1990	0.775	-0.413	1.188	0.590	0.222E-04	2.170	0.661	7.404
1991	0.247	-0.442	0.689	0.590	0.222E-04	1.280	0.643	1.086
1992	0.262	-0.428	0.690	0.590	0.222E-04	1.300	0.652	1.093
1993	-1.050	-0.372	-0.678	0.590	0.222E-04	0.350	0.689	0.789
1994	0.199	-0.305	0.503	0.590	0.222E-04	1.220	0.737	0.365
1995	-0.163	-0.309	0.147	0.590	0.222E-04	0.850	0.734	0.002
1996	-1.022	-0.236	-0.786	0.590	0.222E-04	0.360	0.790	0.914
1997	-1.386	-0.127	-1.260	0.590	0.222E-04	0.250	0.881	1.392

1998	-0.994	-0.099	-0.895	0.590	0.222E-04	0.370	0.906	1.035
1999	-0.094	-0.121	0.026	0.590	0.222E-04	0.910	0.886	0.045
2000	-1.772	-0.175	-1.597	0.590	0.222E-04	0.170	0.839	1.652
2001	-0.478	-0.224	-0.254	0.590	0.222E-04	0.620	0.799	0.291
2002	-0.892	-0.263	-0.629	0.590	0.222E-04	0.410	0.769	0.731
2003	0.104	-0.292	0.397	0.590	0.222E-04	1.110	0.747	0.149
2004	-0.713	-0.252	-0.461	0.590	0.222E-04	0.490	0.777	0.530
2005	-0.528	-0.213	-0.314	0.590	0.222E-04	0.590	0.808	0.358
2006	0.020	-0.248	0.268	0.590	0.222E-04	1.020	0.780	0.023
2007	-0.020	-0.276	0.256	0.590	0.222E-04	0.980	0.759	0.018

Selectivities by age

Year	7	8	9	10
1988	0.262	0.577	0.716	1.000
1989	0.262	0.577	0.716	1.000
1990	0.262	0.577	0.716	1.000
1991	0.262	0.577	0.716	1.000
1992	0.262	0.577	0.716	1.000
1993	0.262	0.577	0.716	1.000
1994	0.262	0.577	0.716	1.000
1995	0.262	0.577	0.716	1.000
1996	0.262	0.577	0.716	1.000
1997	0.262	0.577	0.716	1.000
1998	0.262	0.577	0.716	1.000
1999	0.262	0.577	0.716	1.000
2000	0.262	0.577	0.716	1.000
2001	0.262	0.577	0.716	1.000
2002	0.262	0.577	0.716	1.000
2003	0.262	0.577	0.716	1.000
2004	0.262	0.577	0.716	1.000
2005	0.262	0.577	0.716	1.000
2006	0.262	0.577	0.716	1.000
2007	0.262	0.577	0.716	1.000

5.3 US RR<145

Lognormal dist.
average numbers
Ages 1 - 5
log-likelihood = 3.38
deviance = 5.89
Chi-sq. discrepancy= 7.26

Residuals Standard Q
Untransfrmd Untransfrmd Chi-square

Year	Observed	Predicted	(Obs-pred)	Deviation	Catchabil.	Observed	Predicted	Discrepancy
1980	-0.224	-0.278	0.054	0.590	0.809E-05	0.799	0.757	0.031
1981	-0.919	-0.334	-0.585	0.590	0.809E-05	0.399	0.716	0.679
1982	0.743	-0.325	1.068	0.590	0.809E-05	2.102	0.723	5.002
1983	0.108	-0.208	0.316	0.590	0.809E-05	1.114	0.812	0.056
1985	-0.462	0.015	-0.477	0.590	0.809E-05	0.630	1.015	0.549
1986	-0.251	0.003	-0.254	0.590	0.809E-05	0.778	1.003	0.291
1987	0.198	0.068	0.130	0.590	0.809E-05	1.219	1.071	0.005
1988	-0.012	0.031	-0.043	0.590	0.809E-05	0.988	1.032	0.092
1989	-0.012	0.033	-0.046	0.590	0.809E-05	0.988	1.034	0.093
1990	-0.101	-0.065	-0.036	0.590	0.809E-05	0.904	0.937	0.086
1991	0.232	0.027	0.205	0.590	0.809E-05	1.261	1.027	0.002
1992	-0.198	0.134	-0.332	0.590	0.809E-05	0.820	1.143	0.379

Selectivities by age

Year	1	2	3	4	5
1980	0.221	0.949	1.000	0.231	0.082
1981	0.221	0.949	1.000	0.231	0.082
1982	0.221	0.949	1.000	0.231	0.082
1983	0.221	0.949	1.000	0.231	0.082
1985	0.221	0.949	1.000	0.231	0.082
1986	0.221	0.949	1.000	0.231	0.082
1987	0.221	0.949	1.000	0.231	0.082
1988	0.221	0.949	1.000	0.231	0.082
1989	0.221	0.949	1.000	0.231	0.082
1990	0.221	0.949	1.000	0.231	0.082
1991	0.221	0.949	1.000	0.231	0.082
1992	0.221	0.949	1.000	0.231	0.082

5.4 US RR66-114

```
Lognormal dist.
average numbers
Ages  2 -  3
log-likelihood     =        0.58
deviance           =       14.66
Chi-sq. discrepancy=        8.46
```

```
                                    Residuals    Standard         Q
Untransfrmd  Untransfrmd  Chi-square
```

Year	Observed	Predicted	(Obs-pred)	Deviation	Catchabil.	Observed	Predicted	Discrepancy
1993	0.146	0.070	0.076	0.590	0.136E-04	1.157	1.073	0.021
1994	-1.514	-0.149	-1.365	0.590	0.136E-04	0.220	0.862	1.481
1995	-0.278	-0.263	-0.015	0.590	0.136E-04	0.757	0.769	0.071
1996	0.441	-0.247	0.688	0.590	0.136E-04	1.554	0.781	1.081
1997	0.854	-0.023	0.876	0.590	0.136E-04	2.348	0.978	2.485
1998	0.332	-0.083	0.416	0.590	0.136E-04	1.394	0.920	0.179
1999	-0.006	-0.254	0.248	0.590	0.136E-04	0.994	0.776	0.014
2000	-0.121	-0.133	0.012	0.590	0.136E-04	0.886	0.876	0.054
2001	-0.947	-0.262	-0.685	0.590	0.136E-04	0.388	0.769	0.797
2002	-0.139	-0.445	0.306	0.590	0.136E-04	0.870	0.641	0.048
2003	-0.919	-0.330	-0.589	0.590	0.136E-04	0.399	0.719	0.684
2004	0.452	-0.116	0.568	0.590	0.136E-04	1.572	0.891	0.559
2005	0.336	0.052	0.285	0.590	0.136E-04	1.400	1.053	0.033
2006	-0.637	0.010	-0.647	0.590	0.136E-04	0.529	1.010	0.752
2007	-0.631	-0.459	-0.172	0.590	0.136E-04	0.532	0.632	0.206

Selectivities by age

Year	2	3
1993	0.487	1.000
1994	0.487	1.000
1995	0.487	1.000
1996	0.487	1.000
1997	0.487	1.000
1998	0.487	1.000
1999	0.487	1.000
2000	0.487	1.000
2001	0.487	1.000
2002	0.487	1.000
2003	0.487	1.000
2004	0.487	1.000
2005	0.487	1.000
2006	0.487	1.000
2007	0.487	1.000

5.5 US RR115-144

Lognormal dist.

average numbers
Ages 4 - 5
log-likelihood = -1.02
deviance = 17.86
Chi-sq. discrepancy= 14.98

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1993	0.588	-0.014	0.602	0.590	0.179E-04	1.800	0.986	0.684
1994	-0.872	0.154	-1.026	0.590	0.179E-04	0.418	1.167	1.172
1995	-1.041	-0.081	-0.961	0.590	0.179E-04	0.353	0.922	1.105
1996	-0.467	-0.253	-0.214	0.590	0.179E-04	0.627	0.777	0.248
1997	-1.465	-0.442	-1.024	0.590	0.179E-04	0.231	0.643	1.170
1998	-0.130	-0.238	0.107	0.590	0.179E-04	0.878	0.789	0.010
1999	-0.238	-0.040	-0.198	0.590	0.179E-04	0.788	0.961	0.232
2000	0.601	-0.239	0.840	0.590	0.179E-04	1.824	0.788	2.146
2001	0.524	-0.209	0.733	0.590	0.179E-04	1.688	0.811	1.344
2002	0.892	-0.244	1.136	0.590	0.179E-04	2.440	0.784	6.263
2003	-0.794	-0.538	-0.256	0.590	0.179E-04	0.452	0.584	0.293
2004	-0.699	-0.640	-0.059	0.590	0.179E-04	0.497	0.527	0.104
2005	-0.566	-0.411	-0.155	0.590	0.179E-04	0.568	0.663	0.189
2006	0.132	-0.090	0.221	0.590	0.179E-04	1.141	0.914	0.006
2007	0.259	0.006	0.253	0.590	0.179E-04	1.295	1.006	0.016

Selectivities by age

Year	4	5
1993	1.000	0.549
1994	1.000	0.549
1995	1.000	0.549
1996	1.000	0.549
1997	1.000	0.549
1998	1.000	0.549
1999	1.000	0.549
2000	1.000	0.549
2001	1.000	0.549
2002	1.000	0.549
2003	1.000	0.549
2004	1.000	0.549
2005	1.000	0.549

2006	1.000	0.549
2007	1.000	0.549

5.6 US RR145-177

Not used

5.7 US RR>195

Lognormal dist.
average numbers
Ages 8 - 10
log-likelihood = 3.41
deviance = 3.72
Chi-sq. discrepancy= 3.07

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1983	1.031	0.305	0.726	0.590	0.330E-04	2.805	1.357	1.301
1984	0.220	0.196	0.024	0.590	0.330E-04	1.246	1.217	0.047
1985	-0.154	0.066	-0.221	0.590	0.330E-04	0.857	1.069	0.255
1986	-0.687	-0.087	-0.600	0.590	0.330E-04	0.503	0.917	0.697
1987	-0.637	-0.201	-0.435	0.590	0.330E-04	0.529	0.818	0.500
1988	-0.061	-0.235	0.174	0.590	0.330E-04	0.941	0.791	0.000
1989	-0.270	-0.281	0.010	0.590	0.330E-04	0.763	0.755	0.055
1990	-0.468	-0.322	-0.147	0.590	0.330E-04	0.626	0.725	0.181
1991	-0.198	-0.379	0.180	0.590	0.330E-04	0.820	0.685	0.000
1992	-0.094	-0.384	0.289	0.590	0.330E-04	0.910	0.681	0.036

Selectivities by age

Year	8	9	10
1983	0.314	0.437	1.000
1984	0.314	0.437	1.000
1985	0.314	0.437	1.000
1986	0.314	0.437	1.000
1987	0.314	0.437	1.000
1988	0.314	0.437	1.000
1989	0.314	0.437	1.000
1990	0.314	0.437	1.000
1991	0.314	0.437	1.000
1992	0.314	0.437	1.000

5.8 US RR>195 COMB

Not used

5.9 US RR>177

Lognormal dist.
average numbers
Ages 7 - 10
log-likelihood = -0.90
deviance = 17.63
Chi-sq. discrepancy= 12.14

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1993	-0.188	-0.300	0.112	0.590	0.209E-04	0.829	0.741	0.009
1994	-0.088	-0.275	0.187	0.590	0.209E-04	0.916	0.760	0.000
1995	0.272	-0.312	0.584	0.590	0.209E-04	1.313	0.732	0.617
1996	0.822	-0.142	0.964	0.590	0.209E-04	2.275	0.868	3.472
1997	-0.013	-0.057	0.044	0.590	0.209E-04	0.987	0.944	0.036
1998	0.287	-0.084	0.371	0.590	0.209E-04	1.333	0.920	0.114
1999	0.383	-0.106	0.488	0.590	0.209E-04	1.466	0.899	0.327
2000	-0.371	-0.165	-0.206	0.590	0.209E-04	0.690	0.848	0.240
2001	0.385	-0.185	0.570	0.590	0.209E-04	1.469	0.831	0.564
2002	0.641	-0.206	0.847	0.590	0.209E-04	1.898	0.814	2.208
2003	-0.916	-0.258	-0.658	0.590	0.209E-04	0.400	0.773	0.766
2004	-0.757	-0.214	-0.543	0.590	0.209E-04	0.469	0.808	0.629
2005	-0.919	-0.196	-0.723	0.590	0.209E-04	0.399	0.822	0.842
2006	-1.152	-0.264	-0.888	0.590	0.209E-04	0.316	0.768	1.027
2007	-1.423	-0.274	-1.149	0.590	0.209E-04	0.241	0.760	1.292

Selectivities by age

Year	7	8	9	10
1993	0.538	0.551	0.672	1.000
1994	0.538	0.551	0.672	1.000

1995	0.538	0.551	0.672	1.000
1996	0.538	0.551	0.672	1.000
1997	0.538	0.551	0.672	1.000
1998	0.538	0.551	0.672	1.000
1999	0.538	0.551	0.672	1.000
2000	0.538	0.551	0.672	1.000
2001	0.538	0.551	0.672	1.000
2002	0.538	0.551	0.672	1.000
2003	0.538	0.551	0.672	1.000
2004	0.538	0.551	0.672	1.000
2005	0.538	0.551	0.672	1.000
2006	0.538	0.551	0.672	1.000
2007	0.538	0.551	0.672	1.000

5.10 JLL AREA 2 (WEST)

Lognormal dist.
month 0 numbers
Ages 2 - 10
log-likelihood = 3.72
deviance = 25.24
Chi-sq. discrepancy= 14.29

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1976	-0.363	0.377	-0.740	0.590	0.632E-05	0.696	1.458	0.861
1977	0.817	0.305	0.512	0.590	0.632E-05	2.263	1.357	0.386
1978	0.088	0.238	-0.150	0.590	0.632E-05	1.091	1.268	0.184
1979	-0.172	0.137	-0.309	0.590	0.632E-05	0.842	1.147	0.353
1980	0.297	-0.058	0.356	0.590	0.632E-05	1.346	0.943	0.095
1981	0.652	-0.256	0.909	0.590	0.632E-05	1.920	0.774	2.821
1982	-0.510	-0.507	-0.004	0.590	0.632E-05	0.600	0.602	0.064
1983	-1.253	-0.455	-0.798	0.590	0.632E-05	0.286	0.635	0.928
1984	-0.070	-0.387	0.317	0.590	0.632E-05	0.932	0.679	0.057
1985	0.165	-0.262	0.427	0.590	0.632E-05	1.180	0.770	0.199
1986	-2.052	-0.266	-1.787	0.590	0.632E-05	0.128	0.767	1.772
1987	-0.626	-0.198	-0.428	0.590	0.632E-05	0.535	0.820	0.491
1988	-0.020	-0.188	0.168	0.590	0.632E-05	0.981	0.829	0.000
1989	-0.183	-0.224	0.041	0.590	0.632E-05	0.833	0.799	0.037

1990	-0.496	-0.179	-0.317	0.590	0.632E-05		
0.609	0.836	0.361					
1991	-0.245	-0.216	-0.029	0.590	0.632E-05		
0.783	0.805	0.081					
1992	0.131	-0.205	0.335	0.590	0.632E-05		
1.140	0.815	0.073					
1993	0.050	-0.131	0.181	0.590	0.632E-05		
1.051	0.877	0.000					
1994	0.313	-0.114	0.426	0.590	0.632E-05		
1.367	0.892	0.198					
1995	-0.262	-0.086	-0.176	0.590	0.632E-05		
0.769	0.917	0.209					
1996	0.663	-0.127	0.789	0.590	0.632E-05		
1.940	0.881	1.732					
1997	0.218	-0.157	0.375	0.590	0.632E-05		
1.244	0.855	0.119					
1998	-0.271	-0.164	-0.107	0.590	0.632E-05		
0.762	0.849	0.144					
1999	-0.454	-0.184	-0.271	0.590	0.632E-05		
0.635	0.832	0.309					
2000	-0.331	-0.168	-0.163	0.590	0.632E-05		
0.718	0.845	0.196					
2001	-0.753	-0.180	-0.573	0.590	0.632E-05		
0.471	0.836	0.665					
2002	-0.425	-0.224	-0.201	0.590	0.632E-05		
0.654	0.799	0.235					
2003	-0.607	-0.324	-0.283	0.590	0.632E-05		
0.545	0.724	0.324					
2004	-0.011	-0.346	0.335	0.590	0.632E-05		
0.989	0.708	0.073					
2005	0.147	-0.347	0.494	0.590	0.632E-05		
1.159	0.707	0.342					
2006	0.411	-0.258	0.669	0.590	0.632E-05		
1.509	0.773	0.985					

Selectivities by age

Year	2	3	4	5	6	7	8	9	10
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1976	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1977	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1978	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1979	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1980	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1981	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1982	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1983	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1984	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1985	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1986	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1987	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1988	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1989	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1990	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1991	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1992	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1993	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1994	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1995	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1996	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484

1997	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1998	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
1999	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
2000	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
2001	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
2002	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
2003	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
2004	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
2005	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484
2006	0.053	0.411	0.631	0.851	1.000	0.900	0.702	0.537	0.484

5.11 JLL AREA 3 (31+32)

Not used

5.12 JLL AREAS 17+18

Not used

5.13 LARVAL ZERO INFLATED

Lognormal dist.
average biomass
Ages 8 - 10
log-likelihood = 2.53
deviance = 24.46
Chi-sq. discrepancy= 19.77

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1977	0.918	0.508	0.410	0.590	0.578E-07	2.504	1.663	0.169
1978	1.583	0.398	1.185	0.590	0.578E-07	4.869	1.489	7.332
1981	-0.309	-0.133	-0.175	0.590	0.578E-07	0.735	0.875	0.209
1982	0.305	-0.213	0.518	0.590	0.578E-07	1.356	0.808	0.403
1983	0.184	-0.220	0.404	0.590	0.578E-07	1.202	0.803	0.160
1984	-1.001	-0.377	-0.624	0.590	0.578E-07	0.367	0.686	0.726
1986	-0.907	-0.655	-0.252	0.590	0.578E-07	0.404	0.520	0.289
1987	-1.062	-0.775	-0.287	0.590	0.578E-07	0.346	0.461	0.328
1988	0.080	-0.803	0.884	0.590	0.578E-07	1.084	0.448	2.561
1989	-0.268	-0.856	0.588	0.590	0.578E-07	0.765	0.425	0.630

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    1990       -1.103      -0.859      -0.244       0.590    0.578E-07
0.332      0.424      0.280
    1991       -0.946      -0.938      -0.009       0.590    0.578E-07
0.388      0.392      0.067
    1992       -0.640      -0.969       0.329       0.590    0.578E-07
0.527      0.379      0.068
    1993       -0.696      -0.895       0.198       0.590    0.578E-07
0.498      0.409      0.001
    1994       -0.719      -0.821       0.102       0.590    0.578E-07
0.487      0.440      0.012
    1995       -1.056      -0.718      -0.338       0.590    0.578E-07
0.348      0.488      0.386
    1996       -0.035      -0.752       0.717       0.590    0.578E-07
0.966      0.471      1.249
    1997       -0.897      -0.638      -0.259       0.590    0.578E-07
0.408      0.528      0.296
    1998       -2.142      -0.569      -1.573       0.590    0.578E-07
0.117      0.566      1.636
    1999       -0.669      -0.608      -0.060       0.590    0.578E-07
0.512      0.544      0.105
    2000       -1.068      -0.603      -0.465       0.590    0.578E-07
0.344      0.547      0.535
    2001       -0.949      -0.689      -0.260       0.590    0.578E-07
0.387      0.502      0.298
    2002       -1.190      -0.759      -0.430       0.590    0.578E-07
0.304      0.468      0.494
    2003       -0.305      -0.755       0.450       0.590    0.578E-07
0.737      0.470      0.242
    2004       -0.614      -0.742       0.128       0.590    0.578E-07
0.541      0.476      0.005
    2005       -1.468      -0.701      -0.767       0.590    0.578E-07
0.230      0.496      0.892
    2006       -0.502      -0.685       0.183       0.590    0.578E-07
0.605      0.504      0.000
    2007       -1.036      -0.685      -0.351       0.590    0.578E-07
0.355      0.504      0.400

    Selectivities by age
    Year      8      9     10
    ----    -----  -----  -----
    1977    1.000  1.000  1.000
    1978    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
    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
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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
2007	1.000	1.000	1.000

5.14 GOMPLL 1-6

Lognormal dist.
month 0 numbers
Ages 8 - 10
log-likelihood   =   -3.16
deviance   =   28.47
Chi-sq. discrepancy=   35.04

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1987	1.044	-0.255	1.299	0.590	0.248E-04	2.840	0.775	10.387
1988	0.405	-0.270	0.675	0.590	0.248E-04	1.500	0.763	1.016
1989	0.908	-0.299	1.207	0.590	0.248E-04	2.480	0.742	7.851
1990	0.507	-0.327	0.834	0.590	0.248E-04	1.660	0.721	2.091
1991	0.788	-0.365	1.154	0.590	0.248E-04	2.200	0.694	6.639
1992	-0.094	-0.387	0.293	0.590	0.248E-04	0.910	0.679	0.038
1993	-0.580	-0.379	-0.201	0.590	0.248E-04	0.560	0.684	0.235
1994	-0.844	-0.277	-0.567	0.590	0.248E-04	0.430	0.758	0.658
1995	-1.109	-0.211	-0.897	0.590	0.248E-04	0.330	0.810	1.037
1996	-1.347	-0.223	-1.124	0.590	0.248E-04	0.260	0.800	1.269
1997	-0.598	-0.149	-0.449	0.590	0.248E-04	0.550	0.861	0.516
1998	-0.916	-0.042	-0.874	0.590	0.248E-04	0.400	0.958	1.012
1999	-0.248	-0.007	-0.242	0.590	0.248E-04	0.780	0.993	0.278
2000	-0.223	-0.064	-0.159	0.590	0.248E-04	0.800	0.938	0.193
2001	-0.545	-0.125	-0.420	0.590	0.248E-04	0.580	0.883	0.481
2002	-0.528	-0.183	-0.344	0.590	0.248E-04	0.590	0.833	0.393

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    2003      -0.301      -0.239      -0.062       0.590    0.248E-04
0.740     0.787     0.106
    2004       0.086      -0.222       0.308       0.590    0.248E-04
1.090     0.801     0.049
    2005      -0.329      -0.149      -0.180       0.590    0.248E-04
0.720     0.862     0.213
    2006      -0.616      -0.126      -0.491       0.590    0.248E-04
0.540     0.882     0.566
    2007       0.058      -0.182       0.240       0.590    0.248E-04
1.060     0.834     0.011

    Selectivities by age
    Year      8      9     10
    ----    -----  -----  -----
    1987    0.354  0.678  1.000
    1988    0.354  0.678  1.000
    1989    0.354  0.678  1.000
    1990    0.354  0.678  1.000
    1991    0.354  0.678  1.000
    1992    0.354  0.678  1.000
    1993    0.354  0.678  1.000
    1994    0.354  0.678  1.000
    1995    0.354  0.678  1.000
    1996    0.354  0.678  1.000
    1997    0.354  0.678  1.000
    1998    0.354  0.678  1.000
    1999    0.354  0.678  1.000
    2000    0.354  0.678  1.000
    2001    0.354  0.678  1.000
    2002    0.354  0.678  1.000
    2003    0.354  0.678  1.000
    2004    0.354  0.678  1.000
    2005    0.354  0.678  1.000
    2006    0.354  0.678  1.000
    2007    0.354  0.678  1.000


    --------------------
    5.15 GOMPLL 1-6 Split Early
    --------------------
    Not used

    --------------------
    5.16 GOMPLL 1-6 Split Late
    --------------------
    Not used

    --------------------
    5.17 JLL GOM
    --------------------
    Lognormal dist.
    month  0 numbers
    Ages 10 - 10
    log-likelihood     =         0.97
    deviance           =         6.49
    Chi-sq. discrepancy=         4.93

                                       Residuals    Standard         Q
Untransfrmd  Untransfrmd  Chi-square
```

```
    Year    Observed    Predicted    (Obs-pred)   Deviation    Catchabil.
Observed    Predicted   Discrepancy
    ----  -----------  -----------  -----------  -----------  -----------  -------
----  -----------  -----------
    1974       -0.033        0.257       -0.289        0.590    0.989E-05
0.968        1.293        0.330
    1975       -0.627        0.159       -0.787        0.590    0.989E-05
0.534        1.173        0.915
    1976       -0.406        0.208       -0.615        0.590    0.989E-05
0.666        1.231        0.714
    1977       -0.091        0.010       -0.101        0.590    0.989E-05
0.913        1.010        0.139
    1978       -0.132       -0.141        0.009        0.590    0.989E-05
0.876        0.868        0.056
    1979        0.252       -0.387        0.640        0.590    0.989E-05
1.287        0.679        0.843
    1980        0.147       -0.658        0.805        0.590    0.989E-05
1.158        0.518        1.853
    1981       -0.592       -0.931        0.338        0.590    0.989E-05
0.553        0.394        0.076

    Selectivities by age
    Year     10
    ----    -----
    1974    1.000
    1975    1.000
    1976    1.000
    1977    1.000
    1978    1.000
    1979    1.000
    1980    1.000
    1981    1.000


    --------------------
    5.18 TAGGING
    --------------------
    Lognormal dist.
    average numbers
    Ages  1 -  3
    log-likelihood     =         1.95
    deviance           =         8.74
    Chi-sq. discrepancy=         7.22

                                    Residuals    Standard         Q
Untransfrmd  Untransfrmd  Chi-square
    Year    Observed    Predicted    (Obs-pred)   Deviation    Catchabil.
Observed    Predicted   Discrepancy
    ----  -----------  -----------  -----------  -----------  -----------  -------
----  -----------  -----------
    1970       13.879       13.359        0.520        0.590    0.115E+01
1065132.000   633429.942        0.409
    1971       13.817       13.033        0.784        0.590    0.115E+01
1001624.000   457379.162        1.693
    1972       12.976       12.841        0.135        0.590    0.115E+01
431955.000   377443.365        0.004
    1973       12.121       12.622       -0.502        0.590    0.115E+01
183616.000   303199.322        0.579
```

```
    1974       12.741       13.389       -0.648        0.590    0.115E+01
341589.000   652872.386       0.754
    1975       13.226       13.140        0.086        0.590    0.115E+01
554596.000   509062.771       0.017
    1976       12.442       12.822       -0.380        0.590    0.115E+01
253265.000   370333.577       0.434
    1977       12.458       12.430        0.028        0.590    0.115E+01
257385.000   250287.805       0.044
    1978       11.704       12.212       -0.508        0.590    0.115E+01
121110.000   201224.523       0.586
    1979       11.501       12.072       -0.571        0.590    0.115E+01
98815.000   174948.782       0.663
    1980       12.168       11.938        0.230        0.590    0.115E+01
192541.000   153022.419       0.008
    1981       12.731       11.904        0.826        0.590    0.115E+01
337995.000   147910.254       2.030

    Selectivities by age
    Year      1      2      3
    ----    -----  -----  -----
    1970    1.000  1.000  1.000
    1971    1.000  1.000  1.000
    1972    1.000  1.000  1.000
    1973    1.000  1.000  1.000
    1974    1.000  1.000  1.000
    1975    1.000  1.000  1.000
    1976    1.000  1.000  1.000
    1977    1.000  1.000  1.000
    1978    1.000  1.000  1.000
    1979    1.000  1.000  1.000
    1980    1.000  1.000  1.000
    1981    1.000  1.000  1.000

=======================================================================
TOTAL NUMBER OF FUNCTION EVALUATIONS =         3285
```

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

BFT West 1970-2007 CASE 9
18:48, 30      June 2008

=======================================================================
Total objective function =         9.25
      (with constants)   =       288.54
Number of parameters (P) =           23
Number of data points (D)=          187
AIC : 2*objective+2P     =       623.09
AICc: 2*objective+2P(...)=       629.86
BIC : 2*objective+Plog(D)=       697.40
Chi-square discrepancy   =       159.35

Loglikelihoods (deviance)=         4.94 (      187.49)
   effort data           =         4.94 (      187.49)

Log-posteriors           =         1.35
   catchability          =         0.00
   f-ratio               =         1.35
   natural mortality     =         0.00
   mixing coeff.         =         0.00

Constraints              =       -15.54
   terminal F            =       -15.54
   stock-rec./sex ratio  =         0.00

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

TABLE 1. FISHING MORTALITY RATE

	1	2	3	4	5	6	7	8	9	10
1970	0.227	0.800	0.972	0.307	0.107	0.023	0.012	0.004	0.017	0.017
1971	0.298	1.217	0.746	1.157	0.013	0.061	0.066	0.112	0.029	0.029
1972	0.249	0.996	0.946	0.134	0.239	0.003	0.025	0.022	0.027	0.027
1973	0.045	0.720	0.896	0.476	0.099	0.124	0.025	0.083	0.025	0.025
1974	0.132	0.240	0.440	0.463	0.384	0.039	0.101	0.029	0.073	0.073
1975	0.395	0.554	0.139	0.449	0.088	0.093	0.021	0.094	0.063	0.063
1976	0.043	0.286	0.539	0.062	0.173	0.046	0.045	0.097	0.099	0.100
1977	0.016	0.240	0.212	0.457	0.131	0.316	0.164	0.143	0.118	0.118
1978	0.100	0.171	0.324	0.194	0.247	0.143	0.080	0.107	0.125	0.126
1979	0.037	0.287	0.389	0.402	0.145	0.114	0.122	0.092	0.166	0.167
1980	0.055	0.293	0.510	0.354	0.116	0.169	0.247	0.220	0.219	0.221
1981	0.112	0.217	0.508	0.451	0.402	0.203	0.229	0.207	0.257	0.258
1982	0.067	0.088	0.050	0.023	0.044	0.074	0.034	0.055	0.077	0.082
1983	0.040	0.057	0.096	0.032	0.049	0.149	0.181	0.113	0.127	0.135
1984	0.013	0.104	0.052	0.077	0.091	0.117	0.127	0.131	0.123	0.131
1985	0.008	0.104	0.231	0.098	0.213	0.239	0.091	0.176	0.160	0.170
1986	0.006	0.101	0.178	0.087	0.048	0.115	0.074	0.057	0.181	0.193
1987	0.022	0.189	0.210	0.199	0.143	0.139	0.152	0.131	0.150	0.160

1988	0.055	0.171	0.242	0.129	0.185	0.189	0.165	0.171	0.179	0.191
1989	0.016	0.188	0.044	0.118	0.069	0.143	0.165	0.184	0.225	0.240
1990	0.026	0.098	0.404	0.070	0.092	0.092	0.151	0.201	0.217	0.232
1991	0.040	0.199	0.363	0.117	0.060	0.104	0.155	0.240	0.226	0.241
1992	0.009	0.087	0.039	0.066	0.070	0.052	0.125	0.163	0.249	0.265
1993	0.006	0.024	0.096	0.076	0.125	0.110	0.093	0.196	0.183	0.195
1994	0.050	0.015	0.041	0.059	0.073	0.138	0.149	0.164	0.162	0.173
1995	0.015	0.036	0.096	0.132	0.125	0.084	0.080	0.150	0.169	0.180
1996	0.006	0.167	0.072	0.199	0.104	0.062	0.119	0.118	0.172	0.183
1997	0.005	0.018	0.157	0.059	0.081	0.086	0.107	0.126	0.180	0.192
1998	0.005	0.025	0.089	0.100	0.063	0.064	0.128	0.198	0.195	0.208
1999	0.001	0.014	0.075	0.056	0.067	0.063	0.157	0.194	0.231	0.246
2000	0.003	0.007	0.029	0.076	0.162	0.141	0.155	0.174	0.197	0.210
2001	0.030	0.010	0.082	0.152	0.066	0.091	0.183	0.123	0.246	0.263
2002	0.009	0.157	0.165	0.238	0.177	0.064	0.232	0.289	0.278	0.296
2003	0.003	0.061	0.187	0.217	0.104	0.047	0.137	0.252	0.201	0.214
2004	0.005	0.059	0.206	0.179	0.241	0.194	0.157	0.135	0.155	0.165
2005	0.008	0.095	0.066	0.095	0.099	0.095	0.112	0.113	0.189	0.202
2006	0.008	0.015	0.032	0.079	0.110	0.176	0.203	0.254	0.195	0.208
2007	0.009	0.020	0.276	0.218	0.096	0.100	0.094	0.136	0.109	0.117

TABLE 2. ABUNDANCE AT THE BEGINNING OF THE YEAR

	1	2	3	4	5	6	7	8	9	10
1970	325739.	197667.	215745.	85332.	38240.	41483.	15902.	48612.	31985.	227946.
1971	254600.	225660.	77182.	70938.	54596.	29867.	35228.	13663.	42110.	222063.
1972	219474.	164231.	58116.	31829.	19384.	46846.	24433.	28660.	10621.	223045.
1973	120469.	148696.	52736.	19609.	24202.	13269.	40616.	20712.	24381.	197796.
1974	482216.	100102.	62936.	18719.	10595.	19062.	10186.	34424.	16572.	188431.
1975	141751.	367284.	68481.	35223.	10243.	6276.	15937.	8006.	29076.	165670.
1976	134317.	83039.	183420.	51793.	19538.	8157.	4970.	13564.	6336.	158966.
1977	86060.	111833.	54217.	93057.	42316.	14289.	6771.	4128.	10705.	130069.
1978	57444.	73633.	76467.	38135.	51241.	32267.	9054.	4997.	3112.	108730.
1979	81210.	45191.	53960.	48100.	27303.	34810.	24302.	7262.	3905.	85755.
1980	63492.	68044.	29489.	31806.	27985.	20530.	27012.	18698.	5757.	65980.
1981	61170.	52256.	44130.	15388.	19412.	21664.	15076.	18345.	13047.	50006.
1982	58282.	47553.	36555.	23087.	8521.	11295.	15379.	10429.	12965.	42349.
1983	97583.	47384.	37870.	30239.	19606.	7088.	9118.	12925.	8584.	44353.

1984	69589.	81482.	38924.	29905.	25458.	16225.	5308.	6613.	10039.	40244.
1985	76375.	59689.	63858.	32121.	24072.	20208.	12554.	4064.	5045.	38396.
1986	95894.	65868.	46752.	44079.	25307.	16904.	13834.	9961.	2964.	31890.
1987	74326.	82842.	51738.	34016.	35130.	20962.	13099.	11167.	8178.	25016.
1988	97863.	63187.	59630.	36464.	24246.	26468.	15854.	9784.	8516.	24660.
1989	56691.	80492.	46302.	40688.	27865.	17518.	19044.	11682.	7169.	23907.
1990	101758.	48507.	57962.	38530.	31425.	22604.	13199.	14039.	8445.	21327.
1991	92928.	86229.	38220.	33631.	31244.	24931.	17926.	9868.	9987.	20613.
1992	58634.	77655.	61448.	23121.	26009.	25571.	19540.	13350.	6752.	21002.
1993	58389.	50542.	61912.	51398.	18813.	21092.	21106.	14987.	9857.	18578.
1994	44286.	50439.	42883.	48904.	41431.	14436.	16429.	16727.	10706.	20419.
1995	76858.	36625.	43206.	35781.	40077.	33470.	10929.	12310.	12344.	22848.
1996	68700.	65804.	30717.	34132.	27271.	30753.	26743.	8774.	9216.	25652.
1997	45800.	59339.	48399.	24855.	24325.	21369.	25134.	20642.	6780.	25314.
1998	53760.	39612.	50661.	35947.	20379.	19498.	17052.	19631.	15828.	23092.
1999	52516.	46494.	33581.	40308.	28286.	16635.	15898.	13037.	13996.	27623.
2000	40007.	45587.	39872.	27077.	33144.	22992.	13575.	11814.	9338.	28434.
2001	50782.	34689.	39372.	33662.	21814.	24505.	17361.	10103.	8634.	26696.
2002	57813.	42845.	29856.	31538.	25150.	17759.	19457.	12572.	7770.	23718.
2003	67778.	49816.	31848.	21997.	21603.	18320.	14475.	13409.	8187.	20454.
2004	69450.	58770.	40750.	22960.	15394.	16918.	15189.	10974.	9062.	20181.
2005	51440.	60092.	48175.	28842.	16688.	10514.	12111.	11286.	8333.	21622.
2006	15829.	44376.	47502.	39216.	22811.	13140.	8312.	9411.	8764.	21359.
2007	7877.	13650.	38021.	40011.	31504.	17758.	9581.	5898.	6348.	21348.
2008		6787.	11631.	25077.	27968.	24883.	13966.	7579.	4476.	21464.

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TABLE 3. CATCH OF BFT 2002 base case WEST OF 45

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	1	2	3	4	5	6	7	8	9	10

1970	61909.	102549.	126581.	21101.	3629.	897.	173.	162.	513.	3656.
1971	61511.	150254.	38184.	45991.	663.	1646.	2112.	1351.	1134.	5980.
1972	45326.	97755.	33545.	3730.	3856.	118.	568.	574.	261.	5481.
1973	4971.	71796.	29419.	6964.	2126.	1450.	951.	1541.	559.	4535.
1974	55834.	19960.	21028.	6508.	3164.	681.	913.	914.	1083.	12401.
1975	43341.	146792.	8323.	11959.	803.	523.	313.	671.	1650.	9468.
1976	5301.	19357.	71719.	2911.	2901.	344.	206.	1168.	558.	14098.
1977	1270.	22341.	9683.	32004.	4860.	3629.	957.	513.	1109.	13568.
1978	5103.	10813.	19800.	6294.	10482.	4031.	654.	472.	341.	11996.
1979	2745.	10552.	16287.	14915.	3447.	3493.	2611.	598.	557.	12315.
1980	3160.	16182.	11066.	8879.	2865.	2981.	5531.	3453.	1061.	12240.
1981	6046.	9549.	16496.	5241.	6019.	3717.	2882.	3210.	2763.	10658.
1982	3528.	3729.	1655.	499.	343.	753.	478.	518.	896.	3114.
1983	3600.	2438.	3243.	891.	880.	918.	1414.	1287.	957.	5253.
1984	868.	7501.	1845.	2069.	2068.	1668.	592.	757.	1087.	4630.
1985	568.	5523.	12308.	2813.	4329.	4019.	1024.	612.	696.	5622.
1986	563.	5938.	7129.	3429.	1115.	1716.	924.	517.	458.	5226.
1987	1534.	13328.	9162.	5731.	4378.	2548.	1725.	1281.	1063.	3452.
1988	4925.	9282.	12004.	4123.	3829.	4267.	2259.	1438.	1304.	4005.
1989	835.	12925.	1851.	4243.	1740.	2184.	2707.	1840.	1351.	4772.
1990	2400.	4245.	18073.	2420.	2567.	1854.	1727.	2386.	1543.	4128.
1991	3364.	14542.	10893.	3470.	1709.	2293.	2403.	1967.	1892.	4136.
1992	464.	6015.	2171.	1383.	1632.	1207.	2150.	1880.	1392.	4583.
1993	346.	1134.	5287.	3494.	2063.	2050.	1743.	2500.	1543.	3084.
1994	2015.	691.	1611.	2619.	2738.	1743.	2121.	2363.	1497.	3030.
1995	1088.	1206.	3685.	4123.	4394.	2530.	781.	1598.	1794.	3523.
1996	414.	9473.	1986.	5754.	2514.	1720.	2802.	911.	1360.	4016.
1997	219.	994.	6591.	1320.	1772.	1639.	2386.	2276.	1043.	4130.

1998	260.	920.	4013.	3186.	1162.	1131.	1921.	3303.	2625.	4060.
1999	73.	589.	2274.	2038.	1717.	953.	2158.	2147.	2699.	5641.
2000	98.	278.	1074.	1854.	4634.	2825.	1826.	1760.	1563.	5045.
2001	1398.	323.	2891.	4424.	1295.	1984.	2712.	1089.	1763.	5770.
2002	476.	5807.	4257.	6259.	3813.	1035.	3774.	2953.	1763.	5691.
2003	165.	2748.	5085.	4013.	2001.	792.	1731.	2794.	1392.	3686.
2004	306.	3133.	7084.	3520.	3088.	2794.	2063.	1298.	1215.	2872.
2005	369.	5093.	2863.	2432.	1470.	891.	1202.	1126.	1343.	3695.
2006	120.	599.	1380.	2781.	2228.	1982.	1429.	1974.	1453.	3754.
2007	65.	253.	8590.	7335.	2693.	1582.	806.	700.	614.	2195.

TABLE 4. SPAWNING STOCK FECUNDITY AND RECRUITMENT

year	spawning biomass	recruits from VPA
1970	68774.	325739.
1971	62726.	254600.
1972	63395.	219474.
1973	58918.	120469.
1974	56902.	482216.
1975	46948.	141751.
1976	42019.	134317.
1977	35514.	86060.
1978	31433.	57444.
1979	24146.	81210.
1980	20768.	63492.
1981	17506.	61170.
1982	15526.	58282.
1983	15280.	97583.
1984	13054.	69589.
1985	10375.	76375.
1986	9962.	95894.
1987	8847.	74326.
1988	8570.	97863.
1989	8121.	56691.
1990	8094.	101758.
1991	7505.	92928.
1992	7293.	58634.
1993	7858.	58389.
1994	8370.	44286.
1995	9218.	76858.
1996	8856.	68700.
1997	9778.	45800.
1998	10301.	53760.
1999	9766.	52516.

2000	9702.	40007.
2001	8748.	50782.
2002	7973.	57813.
2003	7779.	67778.
2004	7609.	69450.
2005	7579.	51440.
2006	7350.	15829.
2007	7117.	7877.

TABLE 5. FITS TO INDEX DATA

5.1 CAN GSL ADJ

Not used

5.2 CAN SWNS

Lognormal dist.
average numbers
Ages 7 - 10
log-likelihood = -8.39
deviance = 37.88
Chi-sq. discrepancy= 40.38

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1988	0.742	-0.283	1.025	0.590	0.209E-04	2.100	0.754	4.325
1989	1.244	-0.291	1.536	0.590	0.209E-04	3.470	0.747	20.234
1990	0.775	-0.333	1.108	0.590	0.209E-04	2.170	0.717	5.722
1991	0.247	-0.358	0.605	0.590	0.209E-04	1.280	0.699	0.696
1992	0.262	-0.341	0.604	0.590	0.209E-04	1.300	0.711	0.692
1993	-1.050	-0.284	-0.765	0.590	0.209E-04	0.350	0.752	0.891
1994	0.199	-0.227	0.426	0.590	0.209E-04	1.220	0.797	0.197
1995	-0.163	-0.243	0.080	0.590	0.209E-04	0.850	0.785	0.019
1996	-1.022	-0.181	-0.841	0.590	0.209E-04	0.360	0.835	0.976
1997	-1.386	-0.080	-1.306	0.590	0.209E-04	0.250	0.923	1.433
1998	-0.994	-0.061	-0.933	0.590	0.209E-04	0.370	0.941	1.077
1999	-0.094	-0.103	0.009	0.590	0.209E-04	0.910	0.902	0.056

2000	-1.772	-0.177	-1.595	0.590	0.209E-04	0.170	0.838	1.653
2001	-0.478	-0.242	-0.237	0.590	0.209E-04	0.620	0.785	0.272
2002	-0.892	-0.300	-0.592	0.590	0.209E-04	0.410	0.741	0.688
2003	0.104	-0.359	0.463	0.590	0.209E-04	1.110	0.699	0.270
2004	-0.713	-0.357	-0.357	0.590	0.209E-04	0.490	0.700	0.407
2005	-0.528	-0.361	-0.167	0.590	0.209E-04	0.590	0.697	0.200
2006	0.020	-0.438	0.458	0.590	0.209E-04	1.020	0.645	0.259
2007	-0.020	-0.501	0.481	0.590	0.209E-04	0.980	0.606	0.309

Selectivities by age

Year	7	8	9	10
1988	0.293	0.639	0.782	1.000
1989	0.293	0.639	0.782	1.000
1990	0.293	0.639	0.782	1.000
1991	0.293	0.639	0.782	1.000
1992	0.293	0.639	0.782	1.000
1993	0.293	0.639	0.782	1.000
1994	0.293	0.639	0.782	1.000
1995	0.293	0.639	0.782	1.000
1996	0.293	0.639	0.782	1.000
1997	0.293	0.639	0.782	1.000
1998	0.293	0.639	0.782	1.000
1999	0.293	0.639	0.782	1.000
2000	0.293	0.639	0.782	1.000
2001	0.293	0.639	0.782	1.000
2002	0.293	0.639	0.782	1.000
2003	0.293	0.639	0.782	1.000
2004	0.293	0.639	0.782	1.000
2005	0.293	0.639	0.782	1.000
2006	0.293	0.639	0.782	1.000
2007	0.293	0.639	0.782	1.000

5.3 US RR<145

Lognormal dist.
average numbers
Ages 1 - 5
log-likelihood = 3.40
deviance = 5.87
Chi-sq. discrepancy= 7.20

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

1980	-0.224	-0.280	0.055	0.590	0.798E-05	0.799	0.756	0.030
1981	-0.919	-0.330	-0.589	0.590	0.798E-05	0.399	0.719	0.684
1982	0.743	-0.321	1.064	0.590	0.798E-05	2.102	0.726	4.942
1983	0.108	-0.204	0.312	0.590	0.798E-05	1.114	0.816	0.052
1985	-0.462	0.018	-0.480	0.590	0.798E-05	0.630	1.019	0.554
1986	-0.251	0.008	-0.259	0.590	0.798E-05	0.778	1.008	0.297
1987	0.198	0.075	0.123	0.590	0.798E-05	1.219	1.078	0.006
1988	-0.012	0.036	-0.048	0.590	0.798E-05	0.988	1.037	0.095
1989	-0.012	0.032	-0.044	0.590	0.798E-05	0.988	1.033	0.092
1990	-0.101	-0.071	-0.030	0.590	0.798E-05	0.904	0.932	0.082
1991	0.232	0.017	0.214	0.590	0.798E-05	1.261	1.018	0.004
1992	-0.198	0.119	-0.317	0.590	0.798E-05	0.820	1.126	0.362

Selectivities by age

Year	1	2	3	4	5
1980	0.222	0.951	1.000	0.230	0.080
1981	0.222	0.951	1.000	0.230	0.080
1982	0.222	0.951	1.000	0.230	0.080
1983	0.222	0.951	1.000	0.230	0.080
1985	0.222	0.951	1.000	0.230	0.080
1986	0.222	0.951	1.000	0.230	0.080
1987	0.222	0.951	1.000	0.230	0.080
1988	0.222	0.951	1.000	0.230	0.080
1989	0.222	0.951	1.000	0.230	0.080
1990	0.222	0.951	1.000	0.230	0.080
1991	0.222	0.951	1.000	0.230	0.080
1992	0.222	0.951	1.000	0.230	0.080

5.4 US RR66-114

Lognormal dist.
average numbers
Ages 2 - 3
log-likelihood = 0.68
deviance = 14.47
Chi-sq. discrepancy= 7.80

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

```
    1993        0.146        0.142        0.004        0.590    0.149E-04
1.157        1.152        0.059
    1994       -1.514       -0.087       -1.427        0.590    0.149E-04
0.220        0.917        1.531
    1995       -0.278       -0.209       -0.070        0.590    0.149E-04
0.757        0.812        0.112
    1996        0.441       -0.203        0.644        0.590    0.149E-04
1.554        0.816        0.865
    1997        0.854        0.014        0.840        0.590    0.149E-04
2.348        1.014        2.148
    1998        0.332       -0.069        0.401        0.590    0.149E-04
1.394        0.934        0.156
    1999       -0.006       -0.279        0.273        0.590    0.149E-04
0.994        0.757        0.026
    2000       -0.121       -0.165        0.044        0.590    0.149E-04
0.886        0.848        0.036
    2001       -0.947       -0.281       -0.665        0.590    0.149E-04
0.388        0.755        0.775
    2002       -0.139       -0.435        0.296        0.590    0.149E-04
0.870        0.647        0.040
    2003       -0.919       -0.320       -0.599        0.590    0.149E-04
0.399        0.726        0.696
    2004        0.452       -0.114        0.566        0.590    0.149E-04
1.572        0.893        0.553
    2005        0.336        0.029        0.307        0.590    0.149E-04
1.400        1.029        0.049
    2006       -0.637       -0.060       -0.577        0.590    0.149E-04
0.529        0.942        0.670
    2007       -0.631       -0.594       -0.037        0.590    0.149E-04
0.532        0.552        0.087

    Selectivities by age
    Year      2      3
    ----    -----  -----
    1993    0.481  1.000
    1994    0.481  1.000
    1995    0.481  1.000
    1996    0.481  1.000
    1997    0.481  1.000
    1998    0.481  1.000
    1999    0.481  1.000
    2000    0.481  1.000
    2001    0.481  1.000
    2002    0.481  1.000
    2003    0.481  1.000
    2004    0.481  1.000
    2005    0.481  1.000
    2006    0.481  1.000
    2007    0.481  1.000


    --------------------
    5.5 US RR115-144
    --------------------
    Lognormal dist.
    average numbers
    Ages  4 -  5
    log-likelihood     =         -1.81
    deviance           =         19.45
```

Chi-sq. discrepancy= 16.97

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1993	0.588	0.063	0.525	0.590	0.193E-04	1.800	1.065	0.425
1994	-0.872	0.221	-1.093	0.590	0.193E-04	0.418	1.247	1.240
1995	-1.041	-0.026	-1.016	0.590	0.193E-04	0.353	0.975	1.163
1996	-0.467	-0.207	-0.259	0.590	0.193E-04	0.627	0.813	0.297
1997	-1.465	-0.409	-1.056	0.590	0.193E-04	0.231	0.664	1.203
1998	-0.130	-0.211	0.081	0.590	0.193E-04	0.878	0.810	0.019
1999	-0.238	-0.026	-0.212	0.590	0.193E-04	0.788	0.974	0.247
2000	0.601	-0.261	0.862	0.590	0.193E-04	1.824	0.771	2.349
2001	0.524	-0.261	0.785	0.590	0.193E-04	1.688	0.770	1.701
2002	0.892	-0.311	1.203	0.590	0.193E-04	2.440	0.733	7.759
2003	-0.794	-0.583	-0.211	0.590	0.193E-04	0.452	0.558	0.246
2004	-0.699	-0.666	-0.033	0.590	0.193E-04	0.497	0.514	0.084
2005	-0.566	-0.428	-0.137	0.590	0.193E-04	0.568	0.652	0.172
2006	0.132	-0.115	0.247	0.590	0.193E-04	1.141	0.891	0.014
2007	0.259	-0.058	0.317	0.590	0.193E-04	1.295	0.944	0.056

Selectivities by age

Year	4	5
1993	1.000	0.548
1994	1.000	0.548
1995	1.000	0.548
1996	1.000	0.548
1997	1.000	0.548
1998	1.000	0.548
1999	1.000	0.548
2000	1.000	0.548
2001	1.000	0.548
2002	1.000	0.548
2003	1.000	0.548
2004	1.000	0.548
2005	1.000	0.548
2006	1.000	0.548
2007	1.000	0.548

5.6 US RR145-177

Not used

5.7 US RR>195

Lognormal dist.
average numbers
Ages 8 - 10
log-likelihood = 3.43
deviance = 3.70
Chi-sq. discrepancy= 3.13

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1983	1.031	0.292	0.739	0.590	0.288E-04	2.805	1.339	1.388
1984	0.220	0.182	0.038	0.590	0.288E-04	1.246	1.200	0.039
1985	-0.154	0.048	-0.202	0.590	0.288E-04	0.857	1.049	0.236
1986	-0.687	-0.096	-0.591	0.590	0.288E-04	0.503	0.909	0.687
1987	-0.637	-0.196	-0.441	0.590	0.288E-04	0.529	0.822	0.507
1988	-0.061	-0.232	0.171	0.590	0.288E-04	0.941	0.793	0.000
1989	-0.270	-0.276	0.006	0.590	0.288E-04	0.763	0.759	0.058
1990	-0.468	-0.310	-0.158	0.590	0.288E-04	0.626	0.733	0.192
1991	-0.198	-0.364	0.165	0.590	0.288E-04	0.820	0.695	0.000
1992	-0.094	-0.368	0.273	0.590	0.288E-04	0.910	0.692	0.026

Selectivities by age

Year	8	9	10
1983	0.346	0.493	1.000
1984	0.346	0.493	1.000
1985	0.346	0.493	1.000
1986	0.346	0.493	1.000
1987	0.346	0.493	1.000
1988	0.346	0.493	1.000
1989	0.346	0.493	1.000
1990	0.346	0.493	1.000
1991	0.346	0.493	1.000
1992	0.346	0.493	1.000

5.8 US RR>195 COMB

Not used

5.9 US RR>177

Lognormal dist.
average numbers
Ages 7 - 10
log-likelihood = 0.97
deviance = 13.89
Chi-sq. discrepancy= 10.36

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1993	-0.188	-0.187	0.000	0.590	0.201E-04	0.829	0.829	0.062
1994	-0.088	-0.171	0.084	0.590	0.201E-04	0.916	0.842	0.018
1995	0.272	-0.219	0.491	0.590	0.201E-04	1.313	0.803	0.335
1996	0.822	-0.061	0.883	0.590	0.201E-04	2.275	0.940	2.563
1997	-0.013	0.014	-0.027	0.590	0.201E-04	0.987	1.014	0.080
1998	0.287	-0.019	0.307	0.590	0.201E-04	1.333	0.981	0.048
1999	0.383	-0.062	0.445	0.590	0.201E-04	1.466	0.940	0.232
2000	-0.371	-0.141	-0.230	0.590	0.201E-04	0.690	0.869	0.266
2001	0.385	-0.176	0.560	0.590	0.201E-04	1.469	0.839	0.535
2002	0.641	-0.217	0.858	0.590	0.201E-04	1.898	0.805	2.314
2003	-0.916	-0.300	-0.616	0.590	0.201E-04	0.400	0.741	0.717
2004	-0.757	-0.294	-0.463	0.590	0.201E-04	0.469	0.745	0.533
2005	-0.919	-0.318	-0.601	0.590	0.201E-04	0.399	0.728	0.698
2006	-1.152	-0.422	-0.730	0.590	0.201E-04	0.316	0.656	0.850
2007	-1.423	-0.462	-0.961	0.590	0.201E-04	0.241	0.630	1.106

Selectivities by age

Year	7	8	9	10
1993	0.604	0.617	0.748	1.000
1994	0.604	0.617	0.748	1.000
1995	0.604	0.617	0.748	1.000
1996	0.604	0.617	0.748	1.000
1997	0.604	0.617	0.748	1.000
1998	0.604	0.617	0.748	1.000

1999	0.604	0.617	0.748	1.000
2000	0.604	0.617	0.748	1.000
2001	0.604	0.617	0.748	1.000
2002	0.604	0.617	0.748	1.000
2003	0.604	0.617	0.748	1.000
2004	0.604	0.617	0.748	1.000
2005	0.604	0.617	0.748	1.000
2006	0.604	0.617	0.748	1.000
2007	0.604	0.617	0.748	1.000

5.10 JLL AREA 2 (WEST)

Lognormal dist.
month 0 numbers
Ages 2 - 10
log-likelihood = 3.45
deviance = 25.82
Chi-sq. discrepancy= 14.74

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1976	-0.363	0.336	-0.699	0.590	0.660E-05	0.696	1.400	0.815
1977	0.817	0.274	0.542	0.590	0.660E-05	2.263	1.316	0.476
1978	0.088	0.216	-0.129	0.590	0.660E-05	1.091	1.242	0.164
1979	-0.172	0.135	-0.308	0.590	0.660E-05	0.842	1.145	0.351
1980	0.297	-0.039	0.337	0.590	0.660E-05	1.346	0.961	0.075
1981	0.652	-0.220	0.873	0.590	0.660E-05	1.920	0.802	2.456
1982	-0.510	-0.467	-0.043	0.590	0.660E-05	0.600	0.627	0.092
1983	-1.253	-0.422	-0.830	0.590	0.660E-05	0.286	0.655	0.965
1984	-0.070	-0.353	0.283	0.590	0.660E-05	0.932	0.703	0.032
1985	0.165	-0.230	0.395	0.590	0.660E-05	1.180	0.795	0.147
1986	-2.052	-0.226	-1.826	0.590	0.660E-05	0.128	0.798	1.796
1987	-0.626	-0.149	-0.477	0.590	0.660E-05	0.535	0.861	0.550
1988	-0.020	-0.138	0.118	0.590	0.660E-05	0.981	0.871	0.007
1989	-0.183	-0.173	-0.010	0.590	0.660E-05	0.833	0.842	0.068
1990	-0.496	-0.127	-0.368	0.590	0.660E-05	0.609	0.881	0.421
1991	-0.245	-0.164	-0.081	0.590	0.660E-05	0.783	0.849	0.122

1992	0.131	-0.158	0.289	0.590	0.660E-05	1.140	0.854	0.035
1993	0.050	-0.090	0.140	0.590	0.660E-05	1.051	0.914	0.003
1994	0.313	-0.079	0.391	0.590	0.660E-05	1.367	0.924	0.141
1995	-0.262	-0.058	-0.204	0.590	0.660E-05	0.769	0.944	0.239
1996	0.663	-0.108	0.770	0.590	0.660E-05	1.940	0.898	1.596
1997	0.218	-0.146	0.365	0.590	0.660E-05	1.244	0.864	0.106
1998	-0.271	-0.163	-0.109	0.590	0.660E-05	0.762	0.850	0.146
1999	-0.454	-0.204	-0.251	0.590	0.660E-05	0.635	0.816	0.287
2000	-0.331	-0.209	-0.122	0.590	0.660E-05	0.718	0.811	0.158
2001	-0.753	-0.239	-0.514	0.590	0.660E-05	0.471	0.787	0.594
2002	-0.425	-0.295	-0.130	0.590	0.660E-05	0.654	0.744	0.165
2003	-0.607	-0.408	-0.199	0.590	0.660E-05	0.545	0.665	0.233
2004	-0.011	-0.436	0.426	0.590	0.660E-05	0.989	0.646	0.197
2005	0.147	-0.448	0.596	0.590	0.660E-05	1.159	0.639	0.661
2006	0.411	-0.365	0.777	0.590	0.660E-05	1.509	0.694	1.642

Selectivities by age

Year	2	3	4	5	6	7	8	9	10
----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1976	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1977	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1978	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1979	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1980	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1981	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1982	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1983	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1984	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1985	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1986	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1987	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1988	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1989	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1990	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1991	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1992	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1993	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1994	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1995	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1996	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1997	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1998	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
1999	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
2000	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384

2001	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
2002	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
2003	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
2004	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
2005	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384
2006	0.051	0.394	0.611	0.841	1.000	0.907	0.736	0.588	0.384

5.11 JLL AREA 3 (31+32)

Not used

5.12 JLL AREAS 17+18

Not used

5.13 LARVAL ZERO INFLATED

Lognormal dist.
average biomass
Ages 8 - 10
log-likelihood = 3.55
deviance = 22.45
Chi-sq. discrepancy= 16.07

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1977	0.918	0.664	0.254	0.590	0.546E-07	2.504	1.943	0.016
1978	1.583	0.542	1.040	0.590	0.546E-07	4.869	1.720	4.564
1981	-0.309	-0.039	-0.269	0.590	0.546E-07	0.735	0.961	0.308
1982	0.305	-0.164	0.469	0.590	0.546E-07	1.356	0.849	0.282
1983	0.184	-0.179	0.363	0.590	0.546E-07	1.202	0.836	0.104
1984	-1.001	-0.336	-0.665	0.590	0.546E-07	0.367	0.714	0.775
1986	-0.907	-0.605	-0.301	0.590	0.546E-07	0.404	0.546	0.344
1987	-1.062	-0.725	-0.337	0.590	0.546E-07	0.346	0.485	0.385
1988	0.080	-0.756	0.836	0.590	0.546E-07	1.084	0.470	2.117
1989	-0.268	-0.808	0.540	0.590	0.546E-07	0.765	0.446	0.470
1990	-1.103	-0.812	-0.291	0.590	0.546E-07	0.332	0.444	0.333
1991	-0.946	-0.887	-0.060	0.590	0.546E-07	0.388	0.412	0.104

```
    1992       -0.640       -0.915        0.275        0.590    0.546E-07
0.527      0.400      0.027
    1993       -0.696       -0.842        0.146        0.590    0.546E-07
0.498      0.431      0.002
    1994       -0.719       -0.780        0.061        0.590    0.546E-07
0.487      0.459      0.028
    1995       -1.056       -0.683       -0.373        0.590    0.546E-07
0.348      0.505      0.427
    1996       -0.035       -0.723        0.688        0.590    0.546E-07
0.966      0.485      1.084
    1997       -0.897       -0.624       -0.273        0.590    0.546E-07
0.408      0.536      0.312
    1998       -2.142       -0.571       -1.571        0.590    0.546E-07
0.117      0.565      1.636
    1999       -0.669       -0.624       -0.045        0.590    0.546E-07
0.512      0.536      0.093
    2000       -1.068       -0.631       -0.437        0.590    0.546E-07
0.344      0.532      0.502
    2001       -0.949       -0.733       -0.216        0.590    0.546E-07
0.387      0.480      0.250
    2002       -1.190       -0.824       -0.365        0.590    0.546E-07
0.304      0.438      0.417
    2003       -0.305       -0.852        0.546        0.590    0.546E-07
0.737      0.427      0.489
    2004       -0.614       -0.875        0.261        0.590    0.546E-07
0.541      0.417      0.020
    2005       -1.468       -0.879       -0.589        0.590    0.546E-07
0.230      0.415      0.685
    2006       -0.502       -0.908        0.406        0.590    0.546E-07
0.605      0.403      0.164
    2007       -1.036       -0.943       -0.093        0.590    0.546E-07
0.355      0.389      0.132

    Selectivities by age
    Year      8      9     10
    ----    -----  -----  -----
    1977    1.000  1.000  1.000
    1978    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
    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
2007	1.000	1.000	1.000

5.14 GOMPLL 1-6

Lognormal dist.
month 0 numbers
Ages 8 - 10
log-likelihood = -2.85
deviance = 27.87
Chi-sq. discrepancy= 29.93

Year	Observed	Predicted	Residuals (Obs-pred)	Standard Deviation	Q Catchabil.	Untransfrmd Observed	Untransfrmd Predicted	Chi-square Discrepancy
1987	1.044	-0.190	1.234	0.590	0.231E-04	2.840	0.827	8.535
1988	0.405	-0.208	0.614	0.590	0.231E-04	1.500	0.812	0.733
1989	0.908	-0.238	1.146	0.590	0.231E-04	2.480	0.789	6.482
1990	0.507	-0.257	0.764	0.590	0.231E-04	1.660	0.774	1.550
1991	0.788	-0.294	1.083	0.590	0.231E-04	2.200	0.745	5.267
1992	-0.094	-0.315	0.221	0.590	0.231E-04	0.910	0.730	0.006
1993	-0.580	-0.296	-0.284	0.590	0.231E-04	0.560	0.744	0.324
1994	-0.844	-0.201	-0.643	0.590	0.231E-04	0.430	0.818	0.748
1995	-1.109	-0.149	-0.959	0.590	0.231E-04	0.330	0.861	1.104
1996	-1.347	-0.177	-1.170	0.590	0.231E-04	0.260	0.838	1.313
1997	-0.598	-0.107	-0.490	0.590	0.231E-04	0.550	0.898	0.566
1998	-0.916	-0.003	-0.913	0.590	0.231E-04	0.400	0.997	1.056
1999	-0.248	0.008	-0.256	0.590	0.231E-04	0.780	1.008	0.294
2000	-0.223	-0.070	-0.153	0.590	0.231E-04	0.800	0.933	0.187
2001	-0.545	-0.146	-0.399	0.590	0.231E-04	0.580	0.864	0.457
2002	-0.528	-0.219	-0.308	0.590	0.231E-04	0.590	0.803	0.352
2003	-0.301	-0.297	-0.004	0.590	0.231E-04	0.740	0.743	0.064
2004	0.086	-0.316	0.402	0.590	0.231E-04	1.090	0.729	0.157

```
    2005       -0.329       -0.284       -0.044        0.590    0.231E-04
0.720        0.753        0.092
    2006       -0.616       -0.306       -0.310        0.590    0.231E-04
0.540        0.737        0.354
    2007        0.058       -0.414        0.473        0.590    0.231E-04
1.060        0.661        0.291

    Selectivities by age
    Year      8      9     10
    ----    -----  -----  -----
    1987    0.405  0.764  1.000
    1988    0.405  0.764  1.000
    1989    0.405  0.764  1.000
    1990    0.405  0.764  1.000
    1991    0.405  0.764  1.000
    1992    0.405  0.764  1.000
    1993    0.405  0.764  1.000
    1994    0.405  0.764  1.000
    1995    0.405  0.764  1.000
    1996    0.405  0.764  1.000
    1997    0.405  0.764  1.000
    1998    0.405  0.764  1.000
    1999    0.405  0.764  1.000
    2000    0.405  0.764  1.000
    2001    0.405  0.764  1.000
    2002    0.405  0.764  1.000
    2003    0.405  0.764  1.000
    2004    0.405  0.764  1.000
    2005    0.405  0.764  1.000
    2006    0.405  0.764  1.000
    2007    0.405  0.764  1.000


    --------------------
    5.15 GOMPLL 1-6 Split Early
    --------------------
    Not used

    --------------------
    5.16 GOMPLL 1-6 Split Late
    --------------------
    Not used

    --------------------
    5.17 JLL GOM
    --------------------
    Lognormal dist.
    month  0 numbers
    Ages 10 - 10
    log-likelihood     =         0.55
    deviance           =         7.35
    Chi-sq. discrepancy=         5.54

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

```
    1974       -0.033        0.362       -0.395         0.590    0.763E-05
0.968        1.437        0.452
    1975       -0.627        0.234       -0.861         0.590    0.763E-05
0.534        1.263        0.999
    1976       -0.406        0.192       -0.599         0.590    0.763E-05
0.666        1.212        0.696
    1977       -0.091       -0.008       -0.083         0.590    0.763E-05
0.913        0.992        0.123
    1978       -0.132       -0.187        0.055         0.590    0.763E-05
0.876        0.829        0.030
    1979        0.252       -0.425        0.677         0.590    0.763E-05
1.287        0.654        1.027
    1980        0.147       -0.687        0.834         0.590    0.763E-05
1.158        0.503        2.096
    1981       -0.592       -0.964        0.372         0.590    0.763E-05
0.553        0.381        0.115

    Selectivities by age
    Year     10
    ----    -----
    1974    1.000
    1975    1.000
    1976    1.000
    1977    1.000
    1978    1.000
    1979    1.000
    1980    1.000
    1981    1.000


    --------------------
    5.18 TAGGING
    --------------------
    Lognormal dist.
    average numbers
    Ages  1 -  3
    log-likelihood     =         1.96
    deviance           =         8.75
    Chi-sq. discrepancy=         7.23

                                           Residuals    Standard         Q
Untransfrmd  Untransfrmd  Chi-square
    Year     Observed     Predicted    (Obs-pred)    Deviation    Catchabil.
Observed     Predicted    Discrepancy
    ----  -----------  -----------  -----------  -----------  -----------  -------
----  -----------  -----------
    1970       13.879       13.339        0.539         0.590    0.117E+01
1065132.000   621080.929        0.467
    1971       13.817       13.007        0.810         0.590    0.117E+01
1001624.000   445475.107        1.900
    1972       12.976       12.818        0.158         0.590    0.117E+01
431955.000   368922.862        0.001
    1973       12.121       12.556       -0.435         0.590    0.117E+01
183616.000   283733.477        0.500
    1974       12.741       13.380       -0.639         0.590    0.117E+01
341589.000   647089.000        0.744
    1975       13.226       13.138        0.088         0.590    0.117E+01
554596.000   508065.953        0.016
```

```
    1976       12.442       12.844       -0.402        0.590    0.117E+01
253265.000   378421.558       0.460
    1977       12.458       12.451        0.007        0.590    0.117E+01
257385.000   255500.090       0.057
    1978       11.704       12.232       -0.528        0.590    0.117E+01
121110.000   205351.802       0.611
    1979       11.501       12.096       -0.595        0.590    0.117E+01
98815.000   179120.687       0.691
    1980       12.168       11.967        0.201        0.590    0.117E+01
192541.000   157446.131       0.002
    1981       12.731       11.936        0.795        0.590    0.117E+01
337995.000   152646.729       1.779

    Selectivities by age
    Year      1      2      3
    ----    -----  -----  -----
    1970    1.000  1.000  1.000
    1971    1.000  1.000  1.000
    1972    1.000  1.000  1.000
    1973    1.000  1.000  1.000
    1974    1.000  1.000  1.000
    1975    1.000  1.000  1.000
    1976    1.000  1.000  1.000
    1977    1.000  1.000  1.000
    1978    1.000  1.000  1.000
    1979    1.000  1.000  1.000
    1980    1.000  1.000  1.000
    1981    1.000  1.000  1.000

=======================================================================


TOTAL NUMBER OF FUNCTION EVALUATIONS =         2846
```

Tests for Positive Lag 1 Autocorrelation in Stock-Recruit Deviates

The VPA reconstructed spawner-recruit datasets were tested for positive lag 1 autocorrelation using a test statistic obtained from Anderson (1941) and Salas et al (1980). We test the null hypothesis that the lag auto-correlation coefficient is less than or equal to zero. The lag 1 autocorrelation coefficient was computed for each stock-recruit dataset using the Excel correlation function. The one–tailed test statistic (Anderson-Salsa test statistic) for this null hypothesis using an alpha of 0.05 is given by:

$$r(95\%) = \frac{-1 + 1.645\sqrt{N'-k-1}}{N'-k}$$

Here *N'* is the effective sample size accounting for the degree of auto-correlation on the effective number of statistically independent samples (see below) and *k* is the lag tested for ($k = 1$)

$$N' = N\frac{(1-|r_k|)}{(1+|r_k|)}$$

where *N* is the sample size and r_k is the maximum likelihood estimate of the correlation coefficient at lag *k*.

When all recruitment estimates up to 2004 are included in the analysis, i.e., excluding estimates for the last 3 years, test results for positive lag 1 autocorrelation were found to be significant at the 0.05 alpha level for all but one (VPA run 6) of the high recruitment scenarios **(Table Appendix 10.1)**. Test results were not significant for any of the low recruitment scenarios. Significant autocorrelation estimates for the high recruitment scenario ranged from about 0.4 to 0.7 **(Table Appendix 10.1)**.

Table Appendix 10.1 Results are shown for each VPA run and the two recruitment scenarios. The high recruitment scenario refers to a Beverton-Holt model fitted to the full time series and the low recruitment scenario refers to a hockey stick model fitted to the series starting in 1976. The remaining columns refer to, respectively, the estimated values for r_1, number of spawner-recruit data points (sample size *N*), effective sample size (*N'*), the Anderson-Salsa (A-S) test statistic, and the conclusion of whether it was significant at the alpha=0.05 level. All recruitment estimates to 2004 are included.

VPA Run	Recruitment	r_1	N	N'	A-S statistic	Significant?
Continuity	High	0.48	33	11.7	0.39	Yes
	Low	0.14	26	19.4	0.32	No
Case 1	High	0.52	36	11.5	0.39	Yes
	Low	0.14	26	19.5	0.32	No
Case 2	High	0.42	33	13.5	0.37	Yes
	Low	0.31	26	13.7	0.36	No
Case 3	High		36			
	Low		29			
Case 4	High	0.69	46	7.8	0.44	Yes
	Low	0.18	29	18.0	0.33	No
Case 5	High	0.38	33	14.7	0.35	Yes
	Low	0.12	26	20.3	0.31	No
Case 6	High	0.30	33	17.9	0.33	No
	Low	-0.02	26	24.9	0.29	No

Case 7	High	0.25	33	19.6	0.32	Yes
	Low	0.16	26	18.7	0.33	No
Case 8	High	0.37	33	15.1	0.35	Yes
	Low	0.09	26	21.7	0.30	No
Case 9	High	0.35	33	16.0	0.34	Yes
	Low	0.29	26	14.4	0.36	No

References

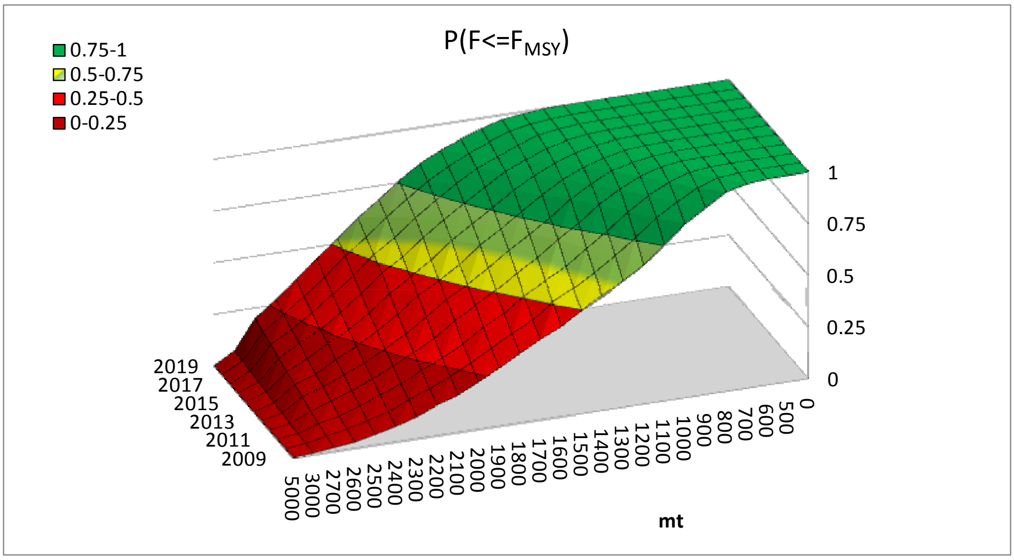
ANDERSON, R.L., 1941, Distribution of the serial correlation coefficients: Annals of Math. Statistics, v. 8, no. 1, p. 1-13.

SALAS, J.D., Delleur, J.W., Yevjevich, V.M., and Lane, W.L., 1980, Applied modeling of hydrologic time series: Littleton, Colorado, Water Resources Publications, 484 pp.

Appendix 11

Combined projections of western Atlantic bluefin tuna under the high and low recruitment scenarios

The implications of the projections of western Atlantic bluefin tuna stock status under the high and low recruitment scenarios were discussed further by the bluefin working group that met September 23-25, 2009. The Group agreed that it had no strong evidence to favor one recruitment hypothesis over the other and that management should consider this when deciding upon an appropriate TAC. Moreover, the Group felt that it would be useful to present the results in surface plots that would allow managers to consider TAC and probability levels other than the values given in Tables. Accordingly, **Figure Appendix 11.1** below summarizea the chance that various constant catch policies will allow rebuilding or end overfishing when the high and low recruitment scenarios are considered to be equally plausible. For comparison, similar plots are also provided for the cases where the high and low recruitment scenarios are considered separately (**Figure Appendix 11.2**).



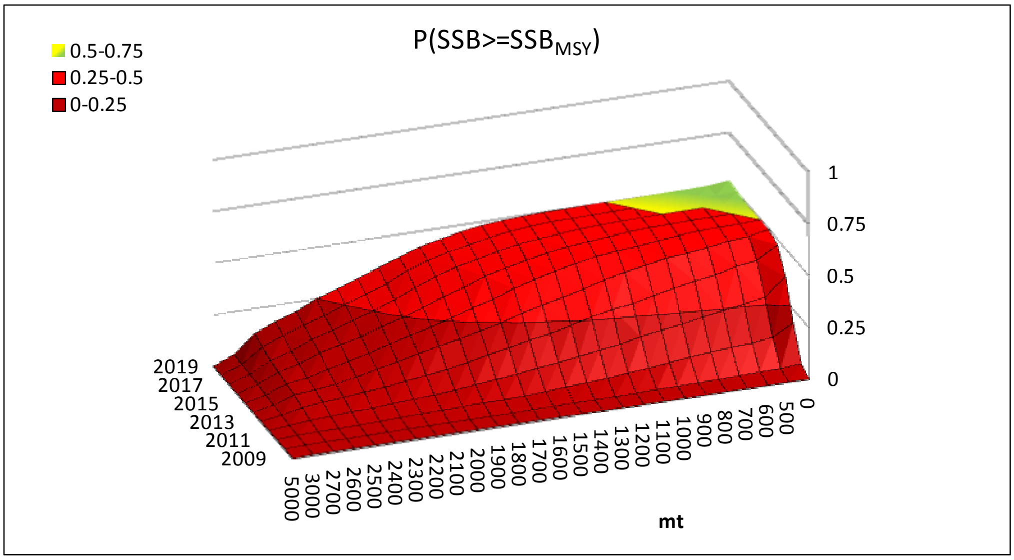


Figure Appendix 11.1 Estimated probability of rebuilding to spawning biomass levels above B_{MSY} (top) and probability of ending overfishing (bottom) by year under various constant catch levels and assuming the high and low recruitment scenarios are equally likely.

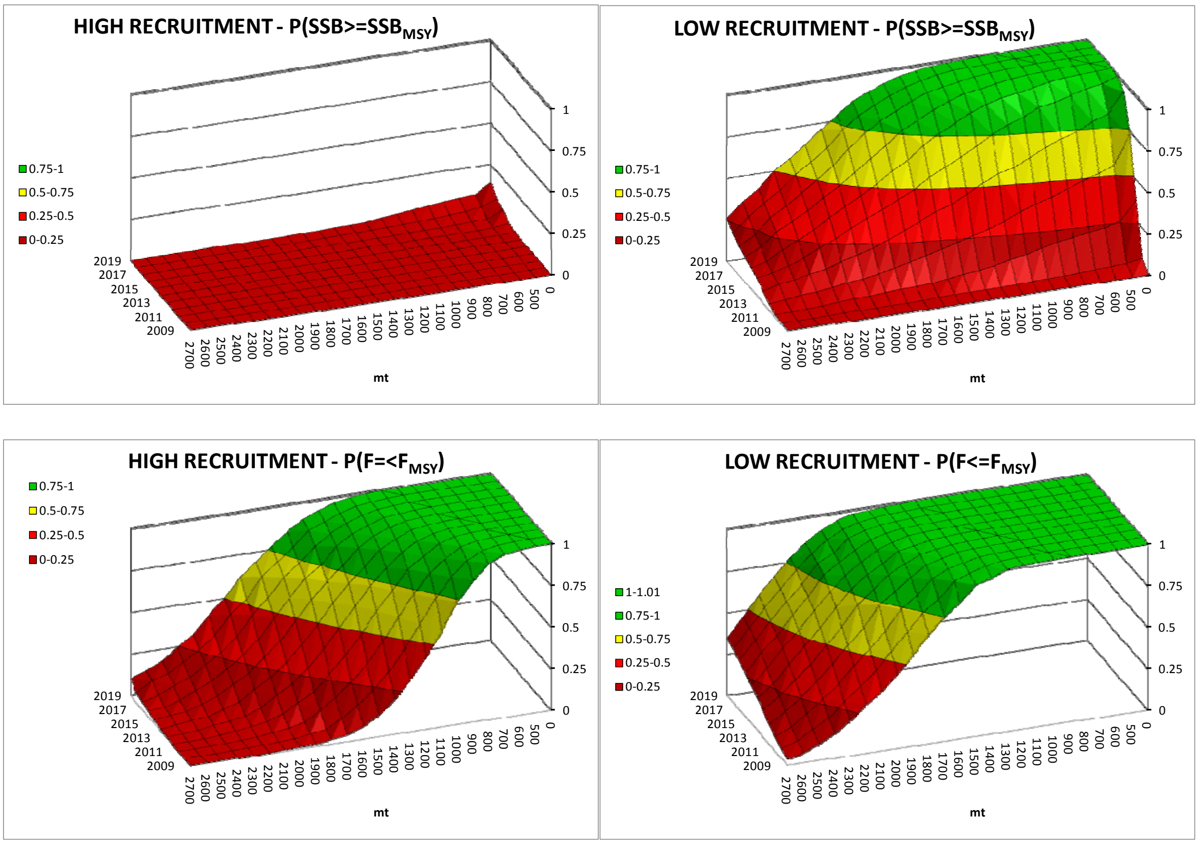


Figure Appendix 11.2 Estimated probability of rebuilding to spawning biomass levels above B_{MSY} (top) and probability of ending overfishing (bottom) by year under various constant catch levels and assuming either the high or low recruitment scenarios.

Appendix 12

Non-equilibrium projections for the East Atlantic and Mediterranean bluefin stock

Following the 2008 stock assessment meeting, the Working Group conducted non-equilibrium projections during the Species Group in September 2008, using two different models (FLR and PRO2BOX) for comparisons purposes. In addition to the 24 scenarios that were agreed on (see **Table 19**), the Group also considered additional scenarios including a medium recruitment level (i.e. equal to the mean of the estimated recruitment over the 1970-2006 period) and an implementation error of 20% of Rec[06.05] that would affect the selectivity pattern and future TAC. In total, 72 scenarios have been investigated to address the possible impact on stock status of future management given by Rec. [06-05] under several hypotheses of stock productivity and implementation error.

All of the 72 scenarios were implemented under the model Pro2Box, but only 24 of them were run under FLR because of a lack of time. Although there are some differences in results between the two tested models, particularly in the underlying stock recruitment relationship, when comparing the 24 common scenarios, both models are in general agreement, especially when regarding the overall trends in probability among the different scenarios (**Figure Appendix 12.1**). This validation exercise gives to the Group good confidence in the technical aspects of the projections. However both models possess some differences that lie different implementation of the stock recruitment relationship. The fact that FLR is more optimistic when looking at the probability of F to be lower than F_{MSY} under 20% implementation error is likely to come from different initial assumptions about the state of stock in 2006-2007 in the two sets of projections and from differences in the underlying stock-recruitment relationships.

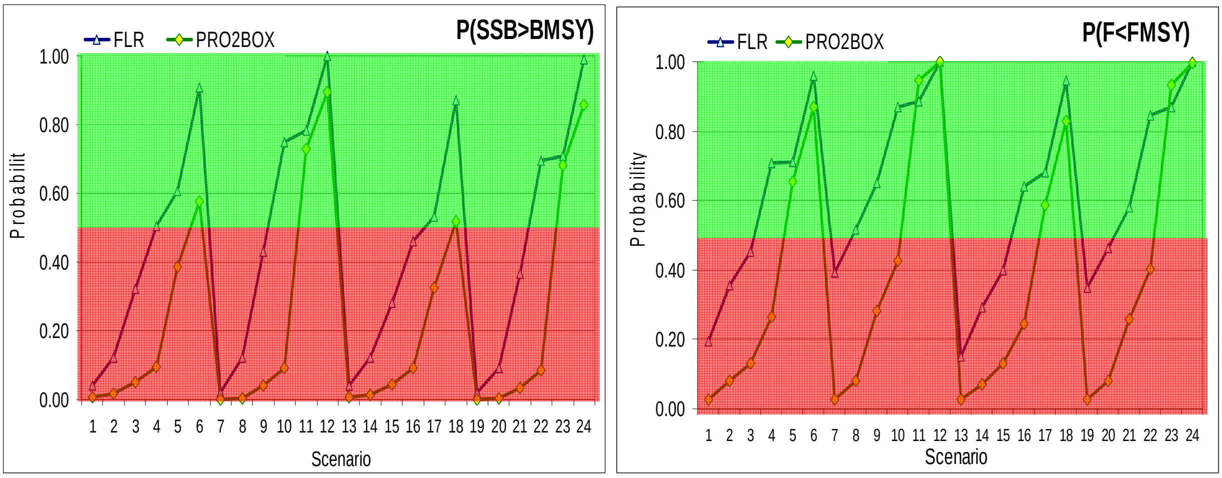


Figure Appendix 12.1 Comparison of the outputs of FLR and Pro2Box for the evaluation of Rec[06.05]. The outputs of the projections are summarised, for each of the 24 comparable scenarios, as the probability of F_{2023} to be lower than F_{MSY} and SSB_{2023} to be greater than B_{MSY} (see also and **Table Appendix 12.1 Table Appendix 12.2**).

The projection results are summarised in **Table Appendix 12.1 Table Appendix 12.2**. Whatever the model used, the results clearly indicate that only scenarios with medium to high recruitment levels together with a high steepness (0.75 to 0.99, i.e scenarios that assume that the stock will be highly productive over the next 15 years and that this productivity will not be affected by the current low level of the SSB) allow the rebuilding of the stock with probability greater than 50% by 2023. The remaining scenarios of a low or medium productivity of the stock which are considered to be as plausible as the high productivity scenarios would not allow the rebuilding of the stock by 2023. Furthermore, Rec[06.05] would be insufficient to avoid a collapse of the population in a substantial number of scenarios considered (**Figure Appendix 12.2**, below).

PRO2BOX							
Scenario	*Catch*	*Steepness*	*Recruitment level*	*Implementation*	*HCR*	*P(SSB>BMSY)*	*P(F<FMSY)*
1	reported	0.5	Medium	Perfect	TAC	0.006	0.026
2	adjusted	0.5	Medium	Perfect	TAC	0.018	0.08
3	reported	0.75	Medium	Perfect	TAC	0.05	0.132
4	adjusted	0.75	Medium	Perfect	TAC	0.096	0.266
5	reported	0.99	Medium	Perfect	TAC	0.388	0.656
6	adjusted	0.99	Medium	Perfect	TAC	0.576	0.87
7	reported	0.5	High (1990s)	Perfect	TAC	0	0.026
8	adjusted	0.5	High (1990s)	Perfect	TAC	0.002	0.082
9	reported	0.75	High (1990s)	Perfect	TAC	0.04	0.282
10	adjusted	0.75	High (1990s)	Perfect	TAC	0.09	0.426
11	reported	0.99	High (1990s)	Perfect	TAC	0.728	0.946
12	adjusted	0.99	High (1990s)	Perfect	TAC	0.896	1
13	reported	0.5	Medium	20% error	TAC	0.006	0.026
14	adjusted	0.5	Medium	20% error	TAC	0.014	0.07
15	reported	0.75	Medium	20% error	TAC	0.044	0.13
16	adjusted	0.75	Medium	20% error	TAC	0.09	0.246
17	reported	0.99	Medium	20% error	TAC	0.326	0.588
18	adjusted	0.99	Medium	20% error	TAC	0.518	0.83
19	reported	0.5	High (1990s)	20% error	TAC	0	0.026
20	adjusted	0.5	High (1990s)	20% error	TAC	0.002	0.082
21	reported	0.75	High (1990s)	20% error	TAC	0.034	0.258
22	adjusted	0.75	High (1990s)	20% error	TAC	0.084	0.404
23	reported	0.99	High (1990s)	20% error	TAC	0.682	0.934
24	adjusted	0.99	High (1990s)	20% error	TAC	0.856	0.996
25	reported	0.5	Low (1970's)	Perfect	TAC	0.032	0.022
26	adjusted	0.5	Low (1970's)	Perfect	TAC	0.084	0.058
27	reported	0.75	Low (1970's)	Perfect	TAC	0.076	0.066
28	adjusted	0.75	Low (1970's)	Perfect	TAC	0.168	0.156
29	reported	0.99	Low (1970's)	Perfect	TAC	0.206	0.214
30	adjusted	0.99	Low (1970's)	Perfect	TAC	0.352	0.368
31	reported	0.5	Low (1970's)	20% error	TAC	0.044	0.024
32	adjusted	0.5	Low (1970's)	20% error	TAC	0.08	0.046
33	reported	0.75	Low (1970's)	20% error	TAC	0.07	0.05
34	adjusted	0.75	Low (1970's)	20% error	TAC	0.15	0.138
35	reported	0.99	Low (1970's)	20% error	TAC	0.176	0.162
36	adjusted	0.99	Low (1970's)	20% error	TAC	0.318	0.318
37	reported	0.5	Medium	Perfect	TAC + 20%	0.002	0.004
38	adjusted	0.5	Medium	Perfect	TAC + 20%	0.008	0.02
39	reported	0.75	Medium	Perfect	TAC + 20%	0.016	0.034
40	adjusted	0.75	Medium	Perfect	TAC + 20%	0.04	0.106
41	reported	0.99	Medium	Perfect	TAC + 20%	0.132	0.27
42	adjusted	0.99	Medium	Perfect	TAC + 20%	0.316	0.552
43	reported	0.5	High (1990s)	Perfect	TAC + 20%	0	0.004
44	adjusted	0.5	High (1990s)	Perfect	TAC + 20%	0.002	0.024
45	reported	0.75	High (1990s)	Perfect	TAC + 20%	0.018	0.084
46	adjusted	0.75	High (1990s)	Perfect	TAC + 20%	0.04	0.204
47	reported	0.99	High (1990s)	Perfect	TAC + 20%	0.482	0.742
48	adjusted	0.99	High (1990s)	Perfect	TAC + 20%	0.742	0.942
49	reported	0.5	Medium	20% error	TAC + 20%	0.002	0.002
50	adjusted	0.5	Medium	20% error	TAC + 20%	0.008	0.02
51	reported	0.75	Medium	20% error	TAC + 20%	0.01	0.03
52	adjusted	0.75	Medium	20% error	TAC + 20%	0.034	0.096
53	reported	0.99	Medium	20% error	TAC + 20%	0.094	0.2
54	adjusted	0.99	Medium	20% error	TAC + 20%	0.25	0.496
55	reported	0.5	High (1990s)	20% error	TAC + 20%	0	0.004
56	adjusted	0.5	High (1990s)	20% error	TAC + 20%	0.002	0.022
57	reported	0.75	High (1990s)	20% error	TAC + 20%	0.01	0.07
58	adjusted	0.75	High (1990s)	20% error	TAC + 20%	0.032	0.174
59	reported	0.99	High (1990s)	20% error	TAC + 20%	0.428	0.702
60	adjusted	0.99	High (1990s)	20% error	TAC + 20%	0.68	0.93
61	reported	0.5	Low (1970's)	Perfect	TAC + 20%	0.012	0.002
62	adjusted	0.5	Low (1970's)	Perfect	TAC + 20%	0.04	0.02
63	reported	0.75	Low (1970's)	Perfect	TAC + 20%	0.026	0.016
64	adjusted	0.75	Low (1970's)	Perfect	TAC + 20%	0.086	0.044
65	reported	0.99	Low (1970's)	Perfect	TAC + 20%	0.054	0.034
66	adjusted	0.99	Low (1970's)	Perfect	TAC + 20%	0.158	0.132
67	reported	0.5	Low (1970's)	20% error	TAC + 20%	0.016	0.006
68	adjusted	0.5	Low (1970's)	20% error	TAC + 20%	0.034	0.016
69	reported	0.75	Low (1970's)	20% error	TAC + 20%	0.024	0.014
70	adjusted	0.75	Low (1970's)	20% error	TAC + 20%	0.08	0.036
71	reported	0.99	Low (1970's)	20% error	TAC + 20%	0.044	0.03
72	adjusted	0.99	Low (1970's)	20% error	TAC + 20%	0.138	0.112

Table Appendix 12.1 Results of the projections run under Pro2Box for the 72 scenarios (the 24 first scenarios being common with FLR, see Table 10.1.4). Results are summarised as the probability of F_{2023} to be lower than F_{MSY} and SSB_{2023} to be greater than SSB_{MSY}. Catch levels are either those officially reported, either those adjusted by the SCRS over the last decade. Steepness and recruitment levels correspond to the slope and the asymptotes in the Beverton & Holt models used. Implementation corresponds to the selectivity pattern under Rec[06.05] with or without 20% implementation error. HCR is the harvest control rule, i.e. TAC of 25,500 t from 2010 to 2023 under perfect implementation (see Rec[06.05]) while TAC+20% is 30,600 t.

FLR

Scenario	Catch	Steepness	Recruitment level	Implementation	HCR	P(SSB>B $_{MSY}$)	P(F<F $_{MSY}$)
1	reported	0.5	Medium	Perfect	TAC	0.04	0.19
2	adjusted	0.5	Medium	Perfect	TAC	0.12	0.36
3	reported	0.75	Medium	Perfect	TAC	0.32	0.45
4	adjusted	0.75	Medium	Perfect	TAC	0.51	0.71
5	reported	0.99	Medium	Perfect	TAC	0.61	0.71
6	adjusted	0.99	Medium	Perfect	TAC	0.91	0.96
7	reported	0.5	High (1990s)	Perfect	TAC	0.02	0.39
8	adjusted	0.5	High (1990s)	Perfect	TAC	0.12	0.52
9	reported	0.75	High (1990s)	Perfect	TAC	0.43	0.65
10	adjusted	0.75	High (1990s)	Perfect	FLR C	0.75	0.87
11	reported	0.99	High (1990s)	Perfect	TAC	0.78	0.89
12	adjusted	0.99	High (1990s)	Perfect	TAC	1.00	1.00
13	reported	0.5	Medium	20% error	TAC	0.04	0.15
14	adjusted	0.5	Medium	20% error	TAC	0.12	0.29
15	reported	0.75	Medium	20% error	TAC	0.28	0.40
16	adjusted	0.75	Medium	20% error	TAC	0.46	0.64
17	reported	0.99	Medium	20% error	TAC	0.53	0.68
18	adjusted	0.99	Medium	20% error	TAC	0.87	0.95
19	reported	0.5	High (1990s)	20% error	TAC	0.02	0.35
20	adjusted	0.5	High (1990s)	20% error	TAC	0.09	0.46
21	reported	0.75	High (1990s)	20% error	TAC	0.37	0.58
22	adjusted	0.75	High (1990s)	20% error	TAC	0.69	0.85
23	reported	0.99	High (1990s)	20% error	TAC	0.71	0.87
24	adjusted	0.99	High (1990s)	20% error	TAC	0.99	1.00

Table Appendix 12.2 Results of the projections run under FLR for 24 scenarios. Results are summarised as the probability of F_{2023} to be lower than F_{MSY} and SSB_{2023} to be greater than SSB_{MSY} and scenario about catch, steepness, recruitment level, implementation and HCR are the same as those in Table 10.1.3

The results of the projections are, however, highly dependent on the state of the stock in 2007 (i.e. the VPA outputs) and future recruitment levels which are unknown. Considering the WG has little confidence in the absolute magnitude of the VPA outputs because of the very poor quality of the catch statistics (see Section 5) and that the possibility of recruitment overfishing in the near future cannot be dismissed because of high *F* exerted on spawners for the last decade, the WG decided to contrast the above projections related to Rec[06.05] with additional management strategies, i.e.:

- $F_{0.1}$ and F_{MAX} strategies (implying short-term yields at about 14,000 t)
- Closure of the Mediterranean Sea in May-June-July together with a size limit (i.e. the recommendation by SCRS in 2006)
- Moratorium over the East Atlantic and Mediterranean Sea during 1, 3 and 5 years followed by an $F_{0.1}$ strategy
-

The results that are summarized in **Figure Appendix 12.2** (below) clearly indicate that all these alternative management strategies modeled (or any combination of them) would have a higher probability of rebuilding the stock by 2023 and a lower probability of stock collapse in the future than Rec[06.05], regardless of the assumed productivity of the stock. The moratorium scenarios and $F_{0.1}$ strategy lead to very close results while the closure of the Mediterranean Sea is quite similar as the F_{MAX} strategy (note that these last two scenarios are slightly less conservative than the first ones). As previously noted, the WG considers it unlikely that the rebuilding objectives of Rec[06-05] can be met without adjustments to the Plan, especially considering the uncertainties due to the lack/quality of data and the uncertainty about future productivity of the stock. The general advice is thus to follow an $F_{0.1}$ (or another adequate F_{MSY} proxy, such as F_{MAX}) strategy to rebuild the stock, because such strategies appear more robust to a wide range of uncertainty about current status and future productivity. The WG further believes that a time area closure could greatly facilitate the implementation and the monitoring of such a rebuilding strategy.

Fig. 10.2.a. Runs 1,37, reported, steepness =0.5, recruit=medium, implem.= perf.

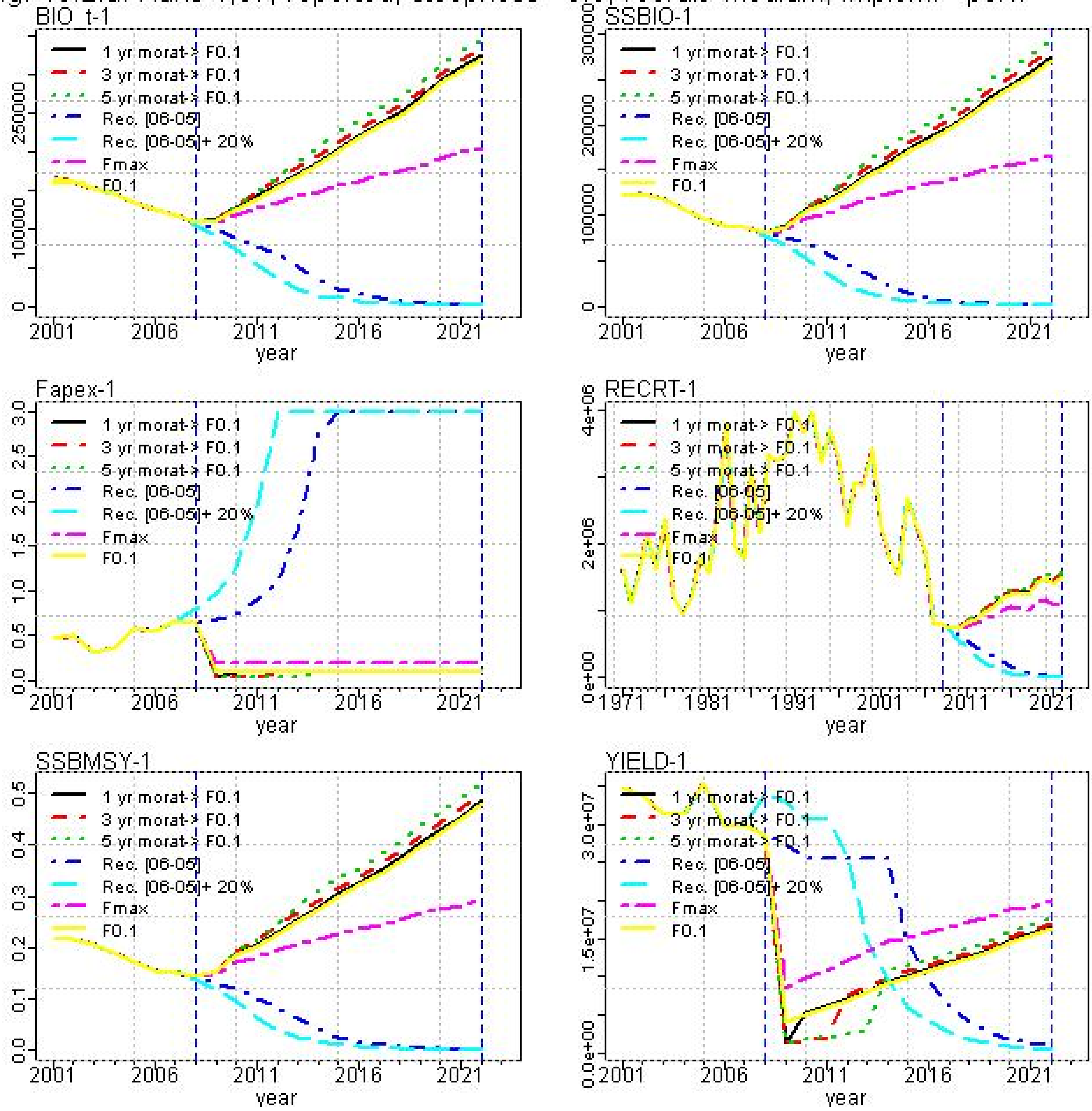


Fig. 10.2.b. Runs 2,38, adjusted, steepness =0.5, recruit=medium, implem.= perf.

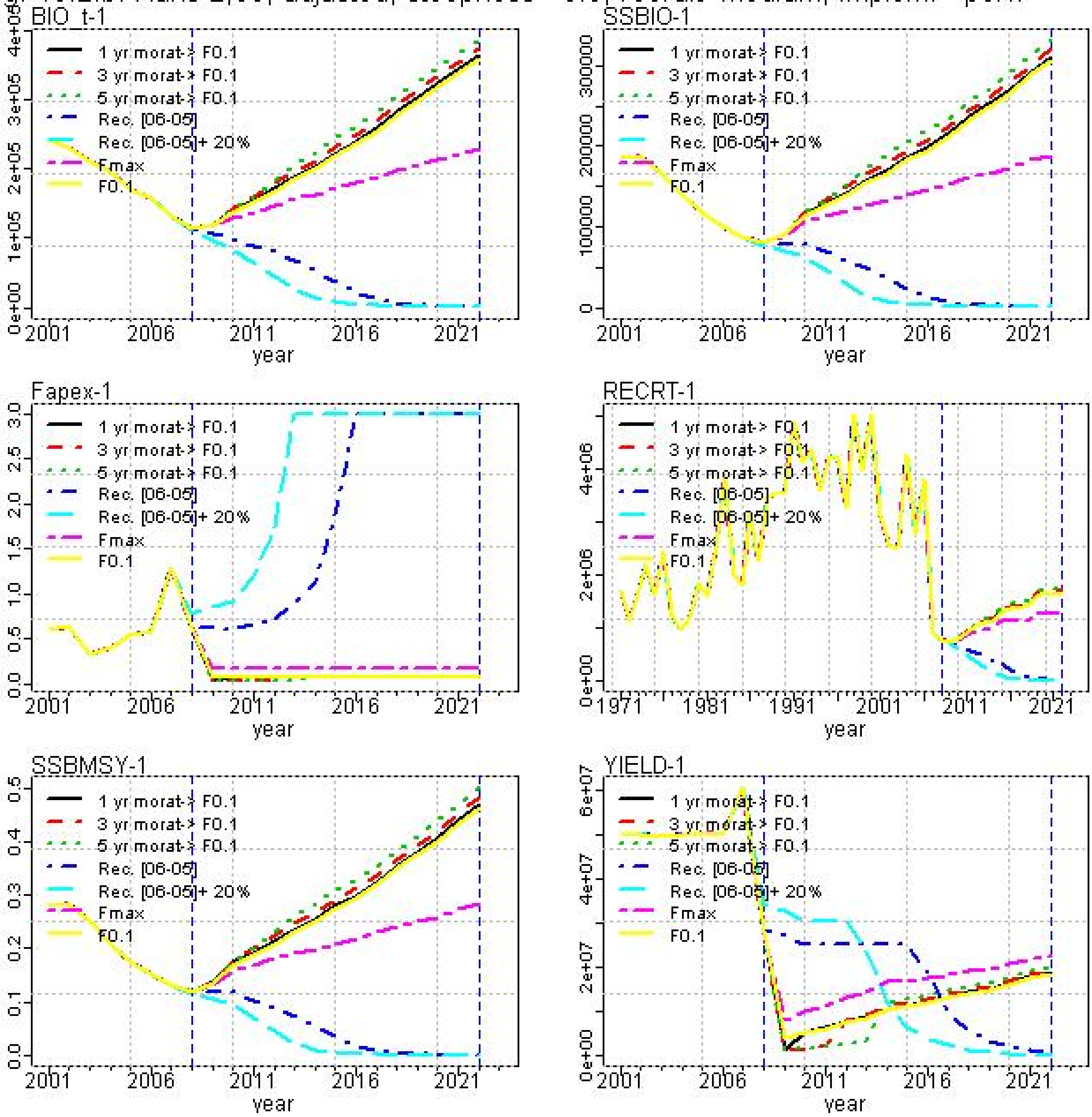


Fig. 10.2.c. Runs 3,39, reported, steepness =0.75, recruit=medium, implem.= perf.

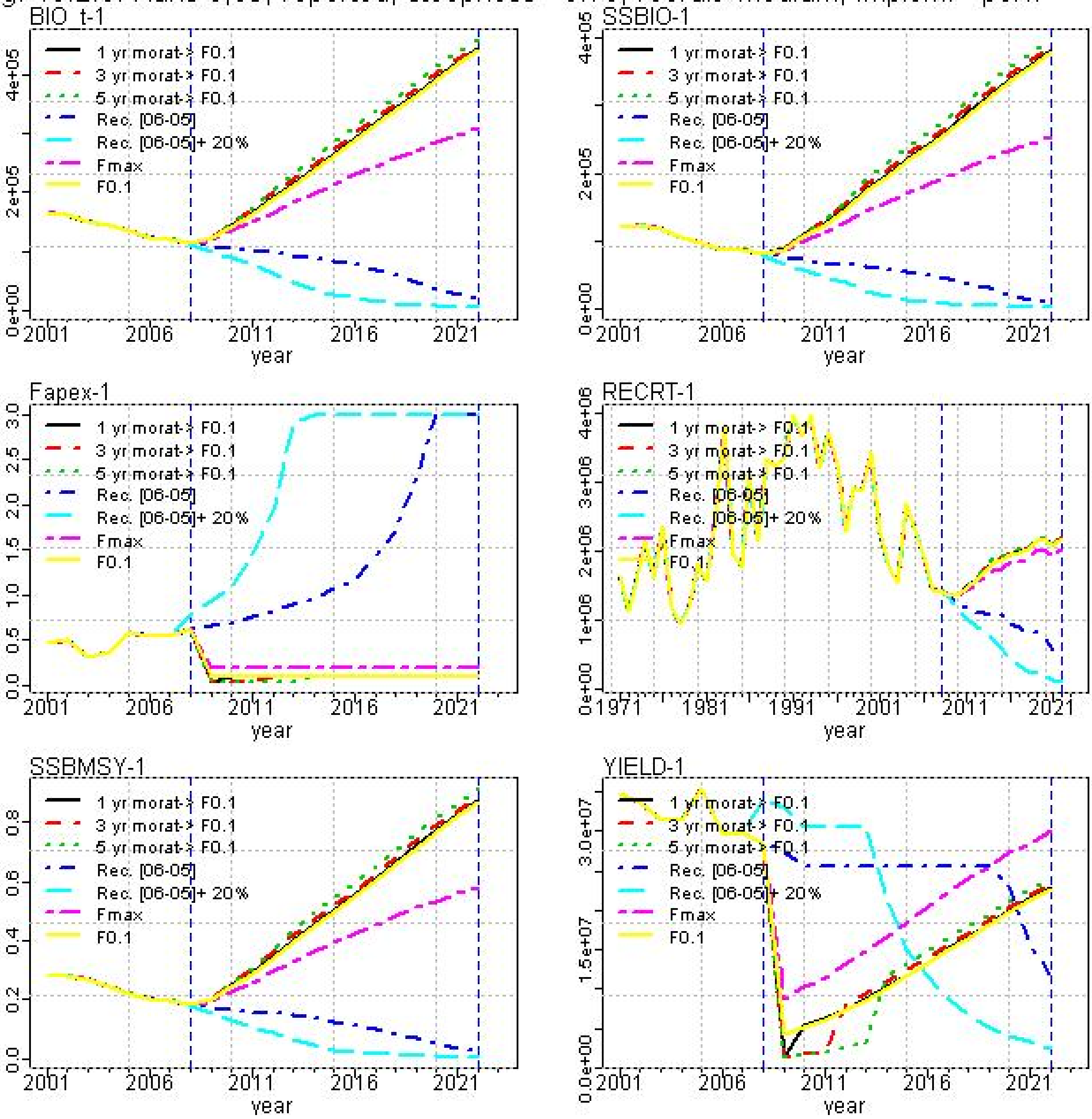


Fig. 10.2.d. Runs 4,40, adjusted, steepness =0.75, recruit=medium, implem.= perf.

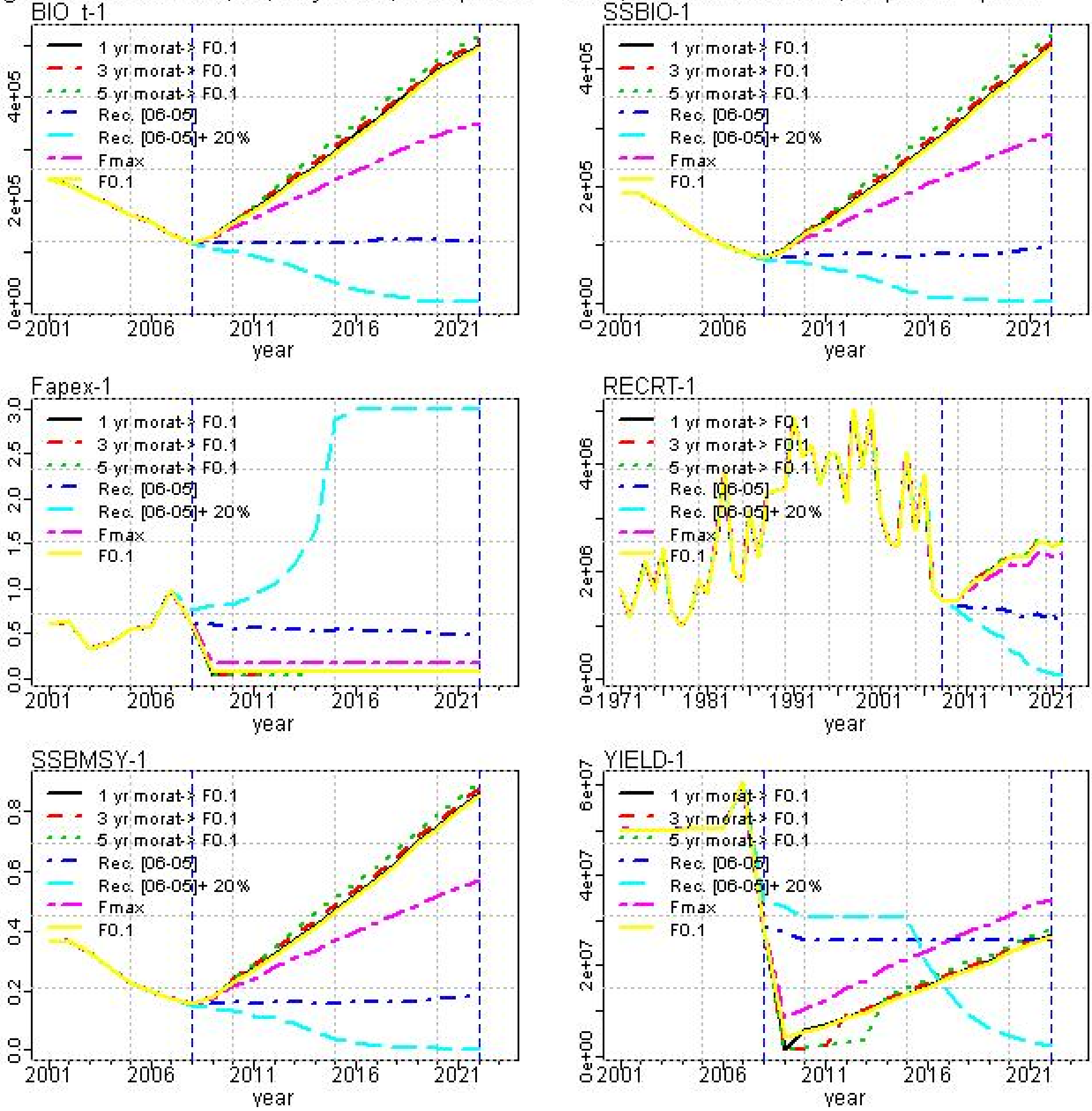


Fig. 10.2.e. Runs 5,41, reported, steepness =0.99, recruit=medium, implem.= perf.

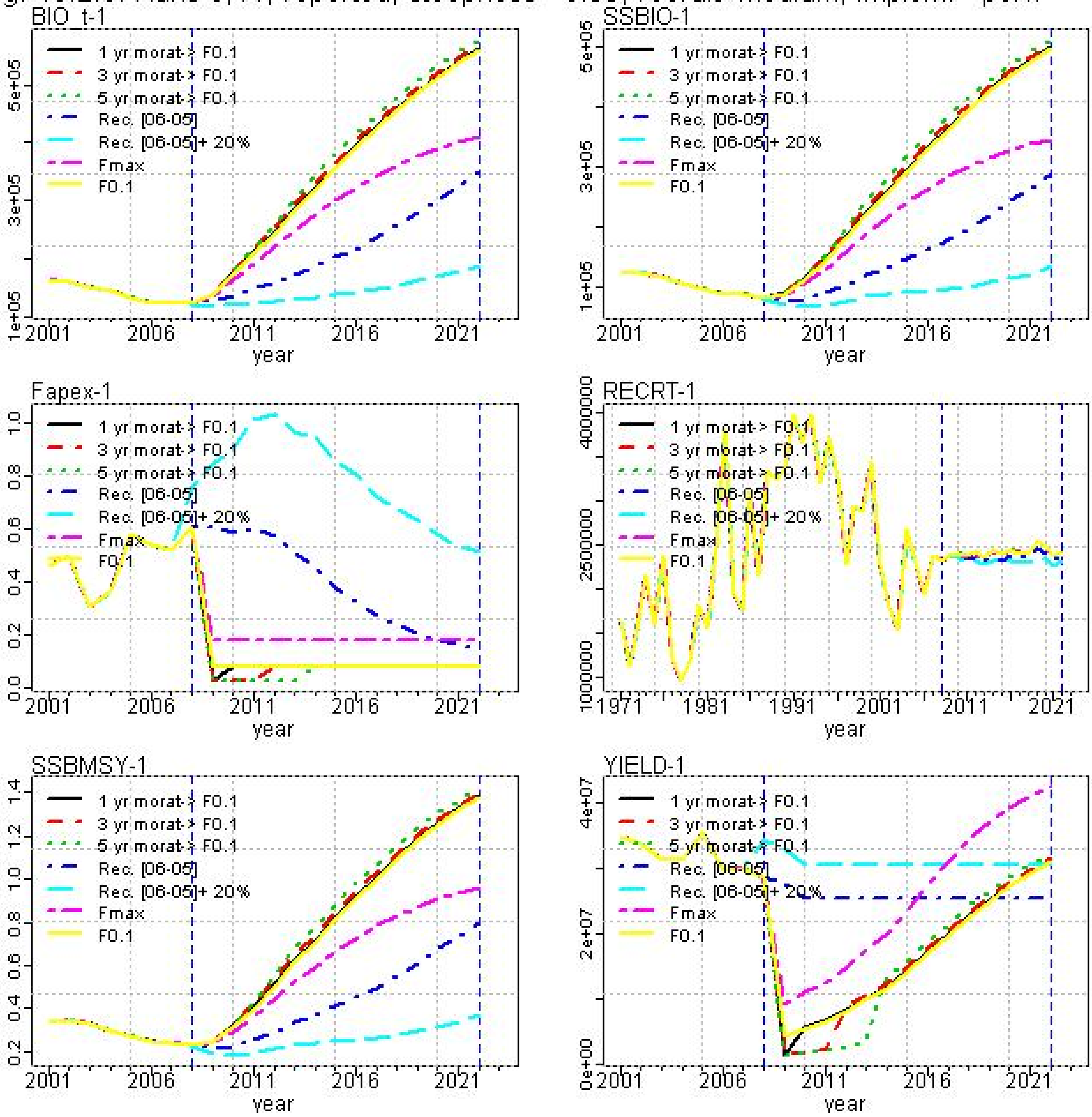


Fig. 10.2.f. Runs 6,42, adjusted, steepness =0.99, recruit=medium, implem.= perf.

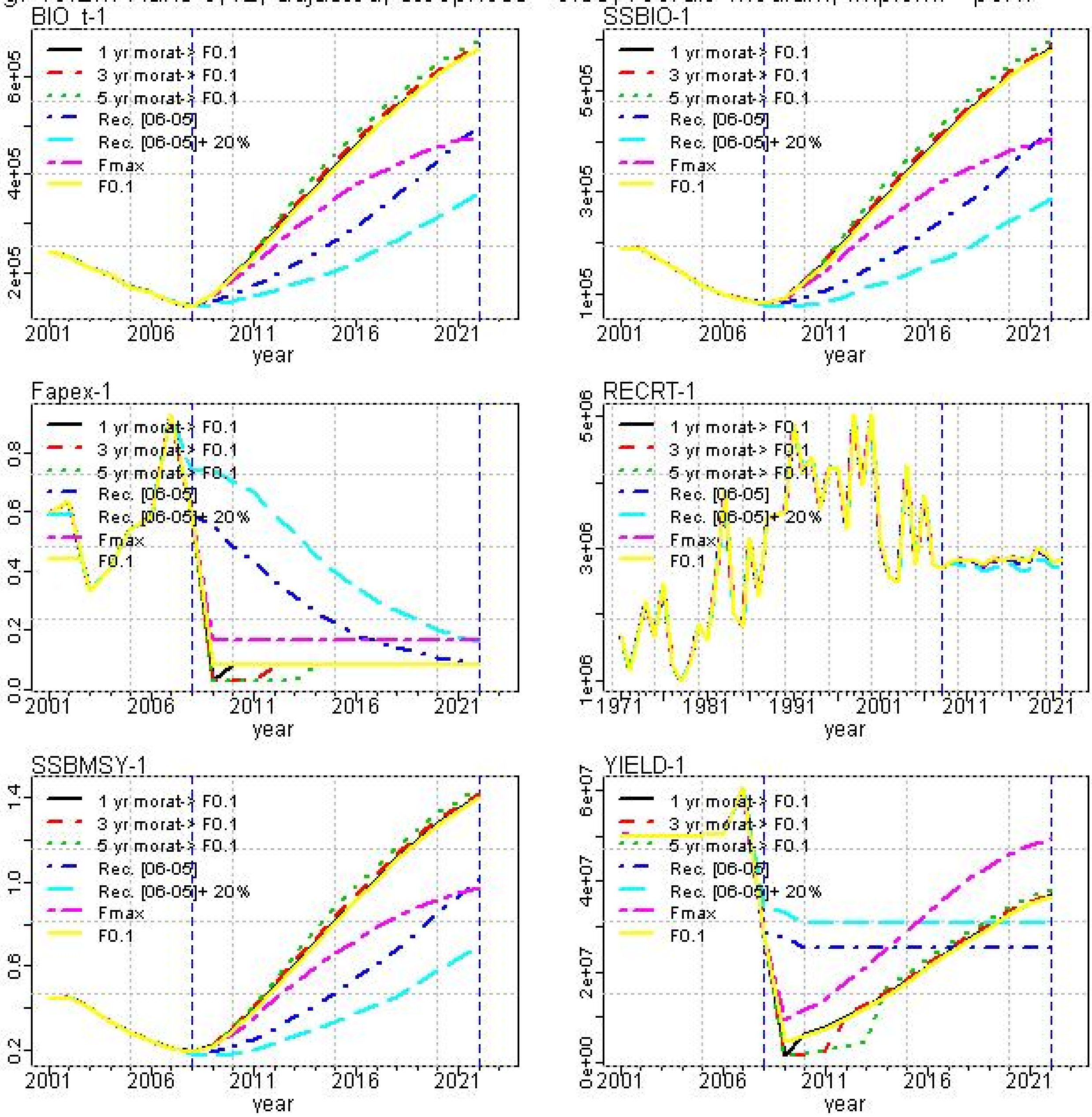


Fig. 10.2.g. Runs 7,43, reported, steepness =0.5, recruit=hi, implem.= perf.

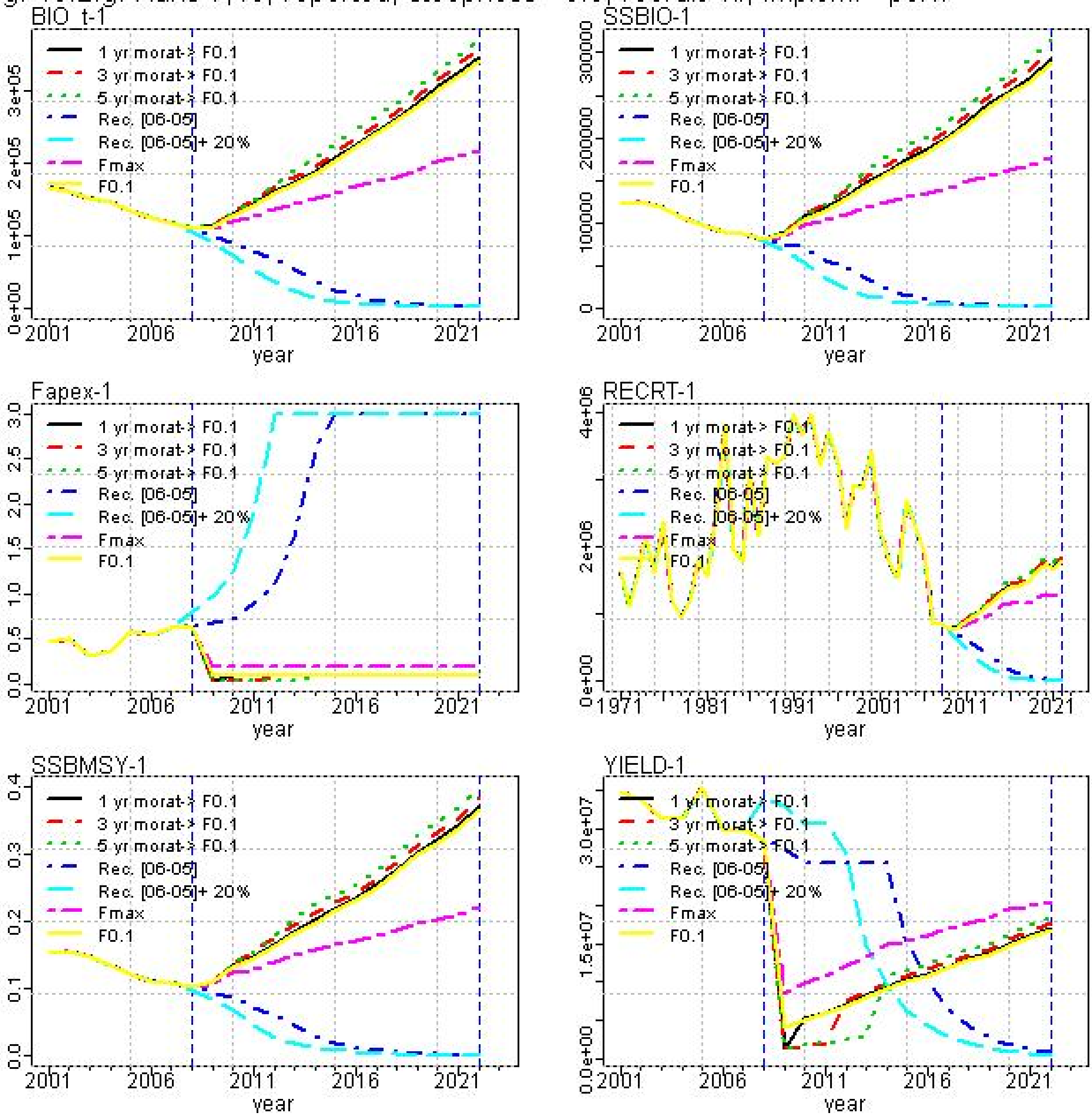


Fig. 10.2.h. Runs 8,44, adjusted, steepness =0.5, recruit=hi, implem.= perf.

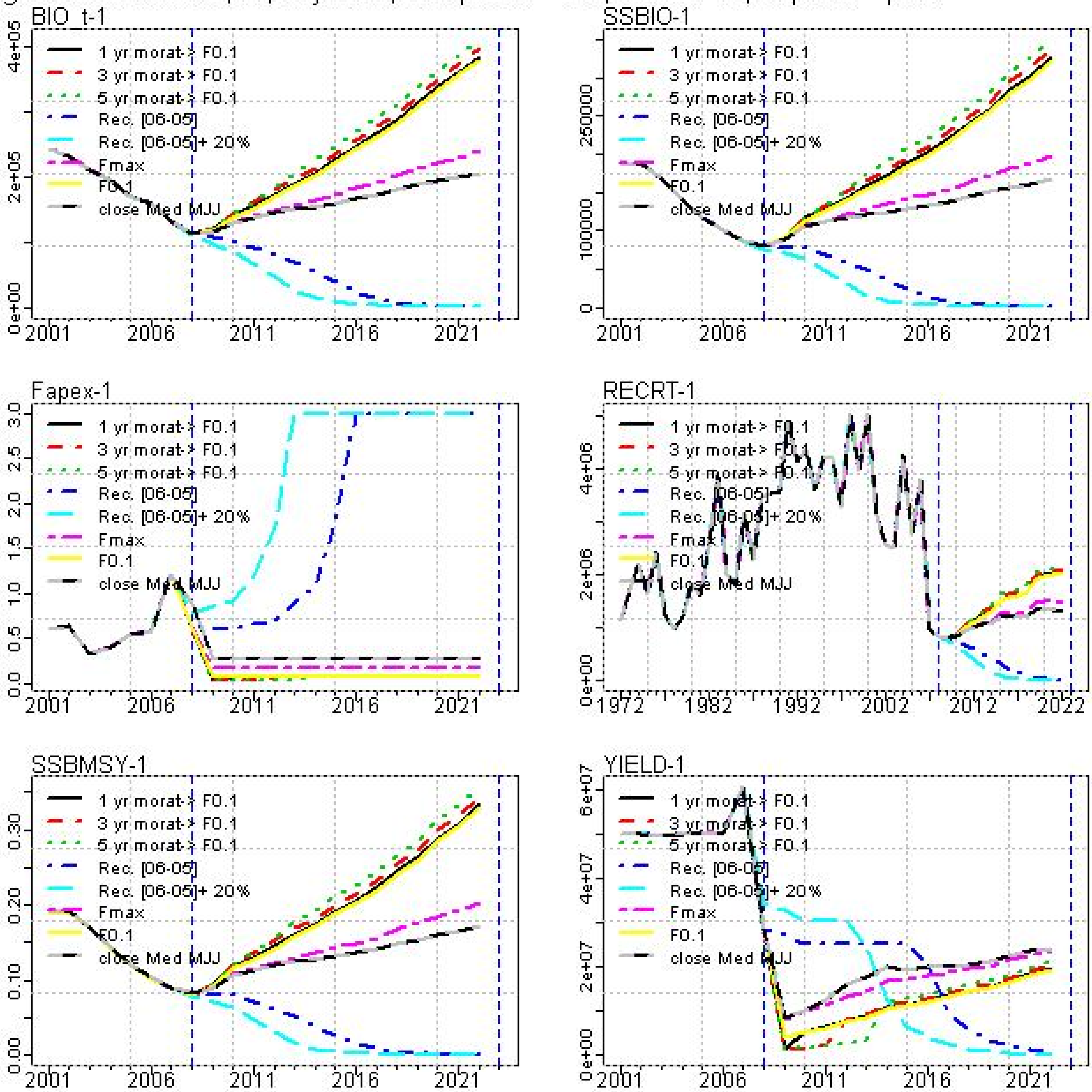


Fig. 10.2.i. Runs 9,45, reported, steepness =0.75, recruit=hi, implem.= perf.

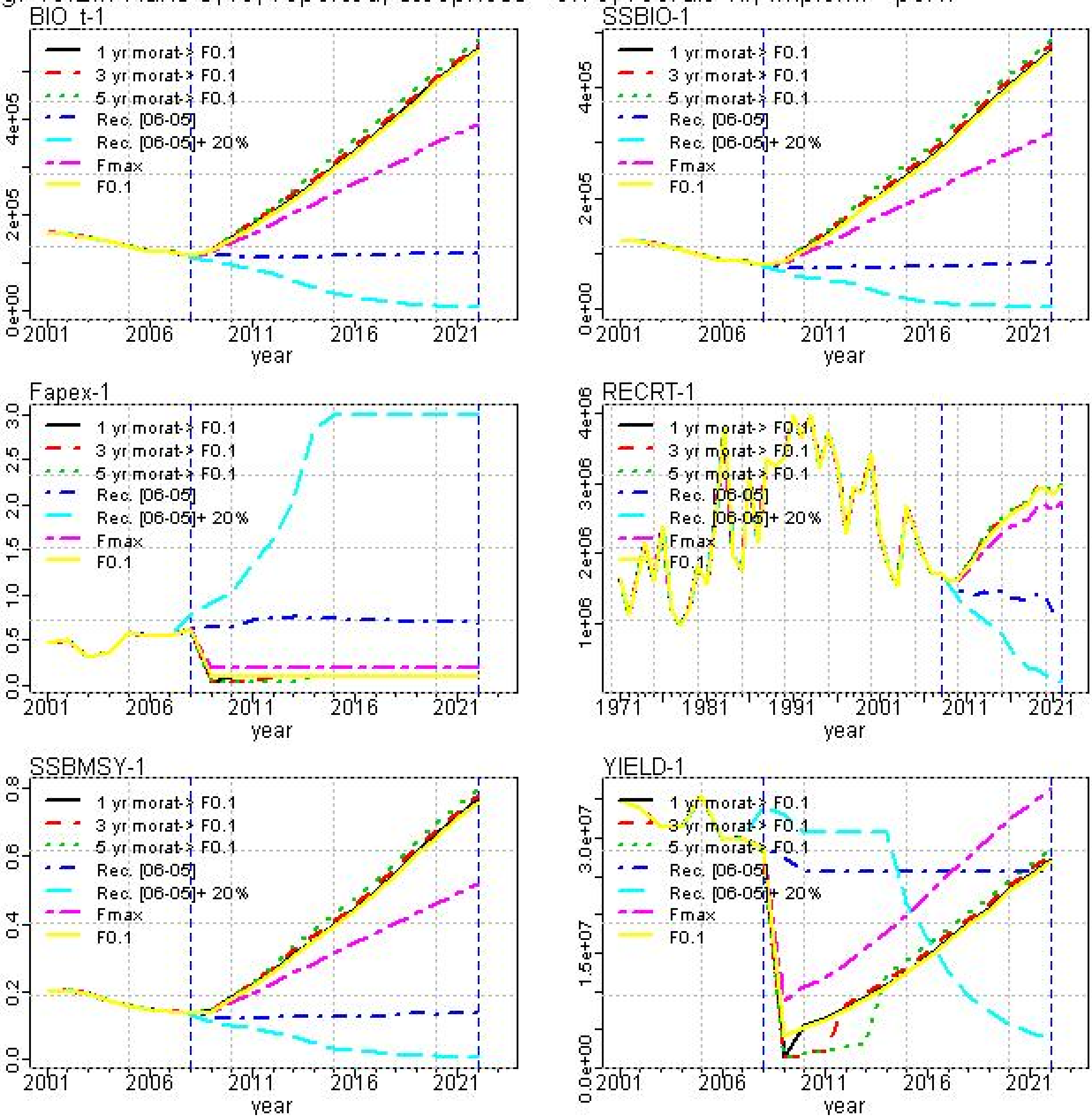


Fig. 10.2.j. Runs 10,46, adjusted, steepness =0,75, recruit=hi, implem.= perf.

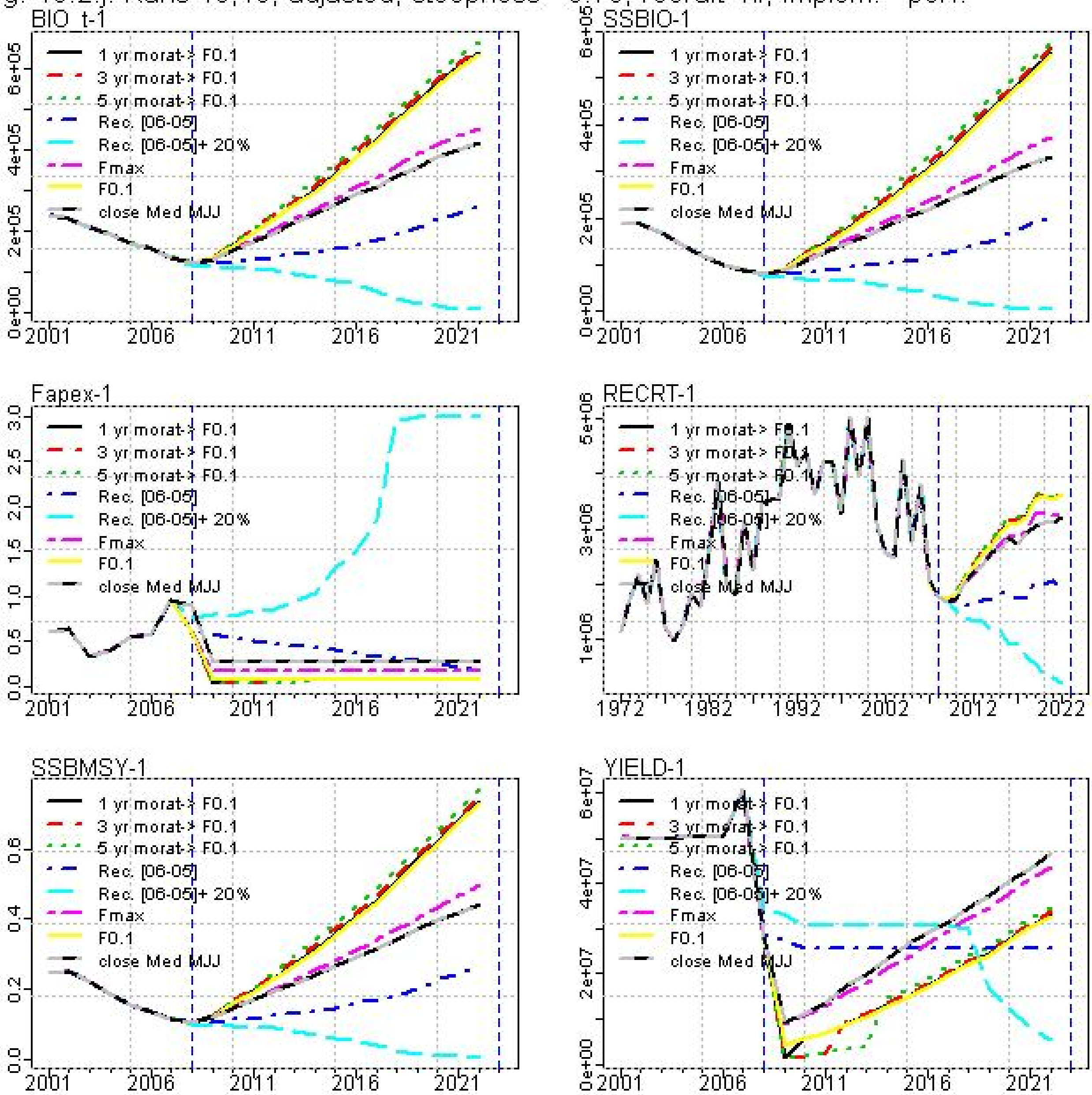


Fig. 10.2.k. Runs 11,47, reported, steepness =0.99, recruit=hi, implem.= perf.

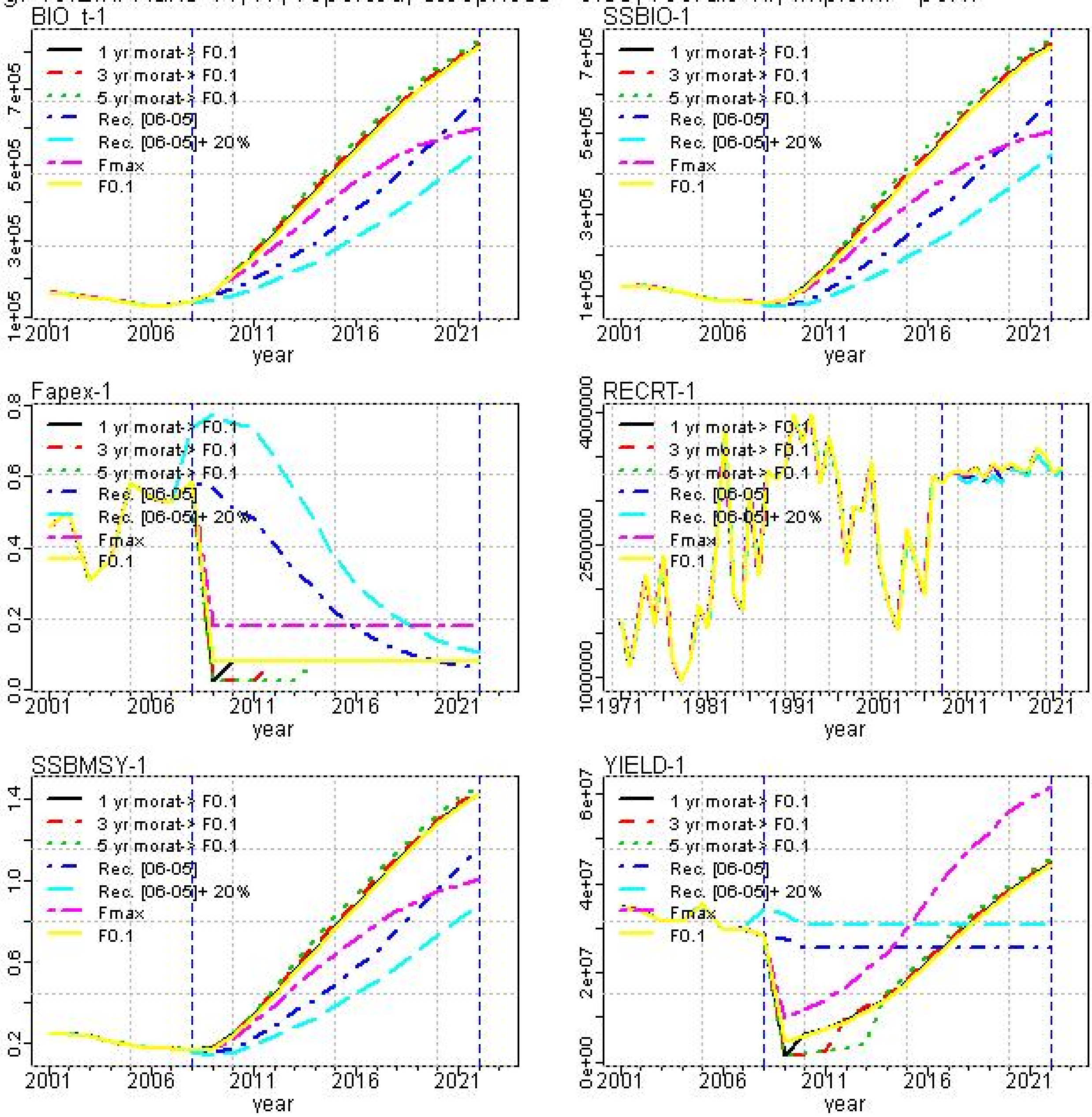


Fig. 10.2.l. Runs 12,48, adjusted, steepness =0.99, recruit=hi, implem.= perf.

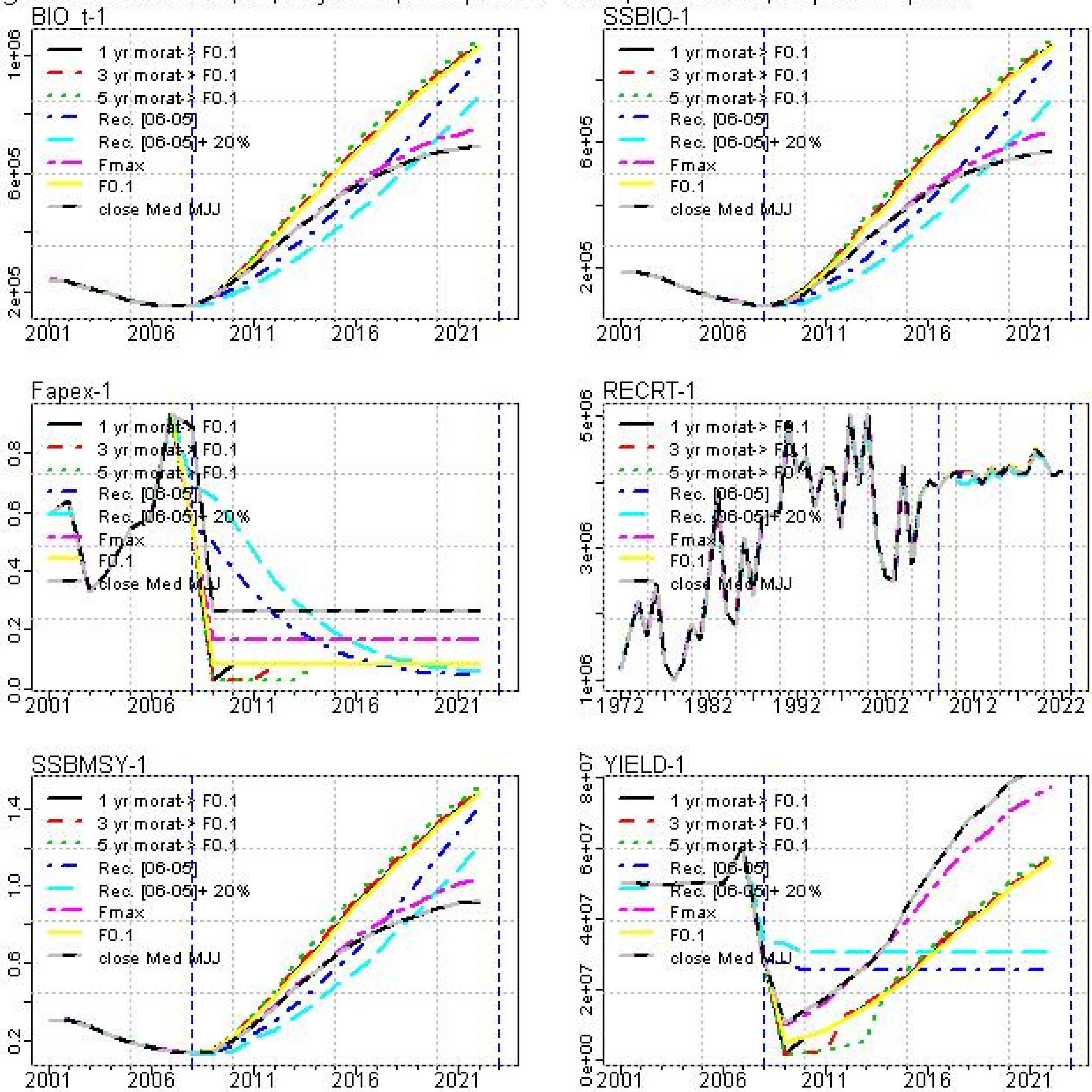


Fig. 10.2.m. Runs 13,49, reported, steepness =0.5, recruit=medium, implem.= 20% err.

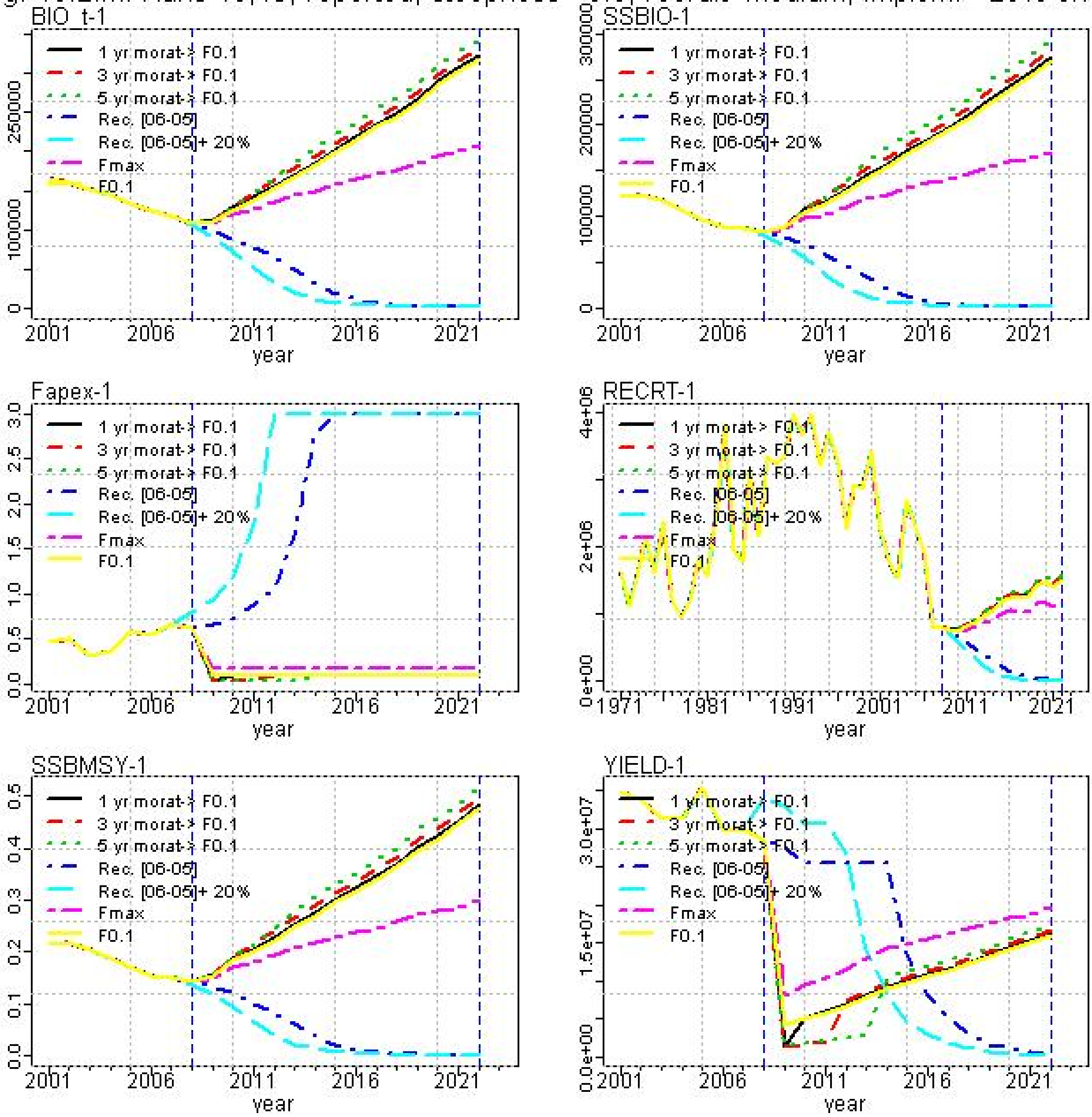


Fig. 10.2.n. Runs 14,50, adjusted, steepness =0.5, recruit=medium, implem.= 20% err.

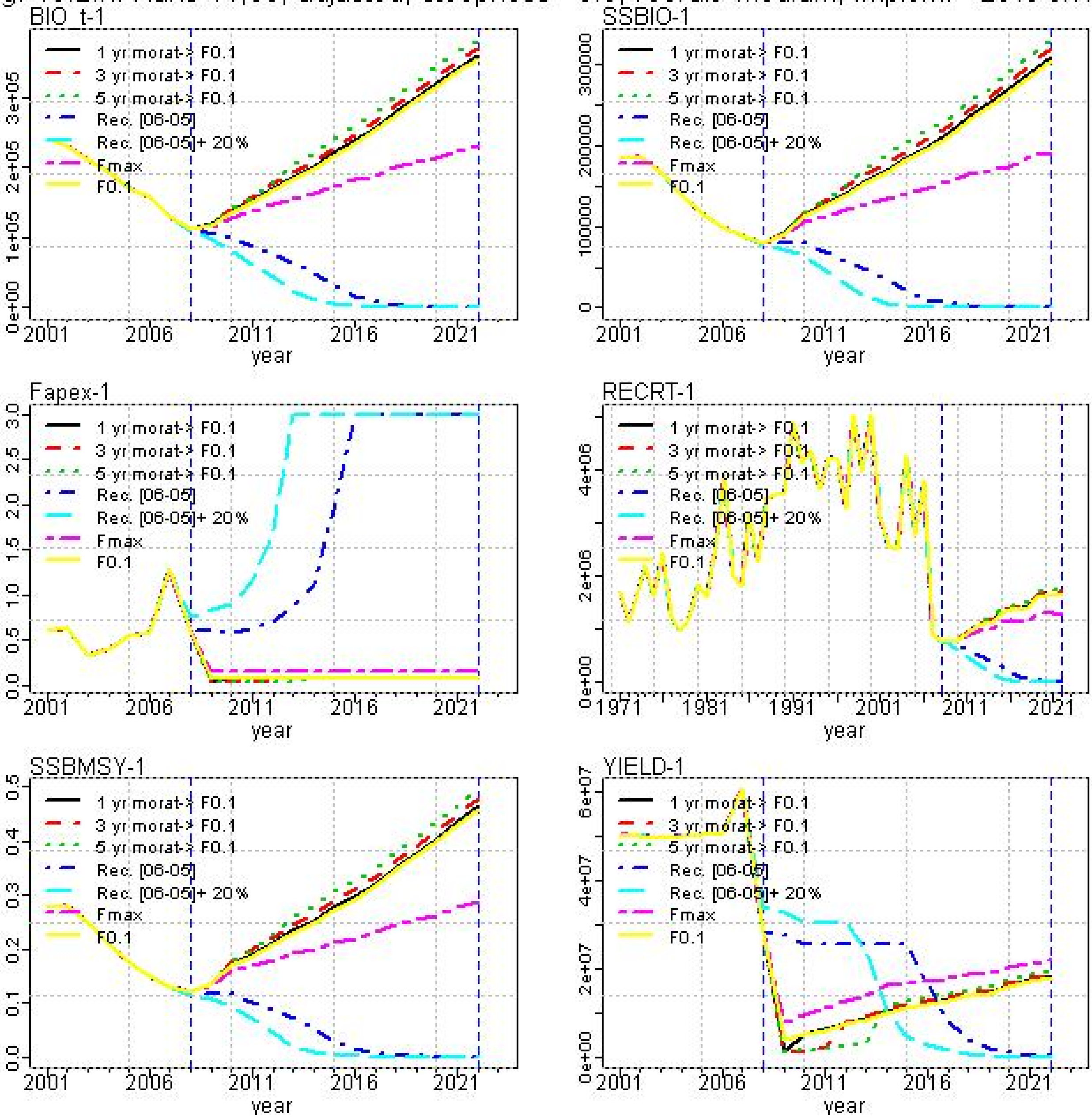


Fig. 10.2.o. Runs 15,51, reported, steepness =0.75, recruit=medium, implem.= 20% err.

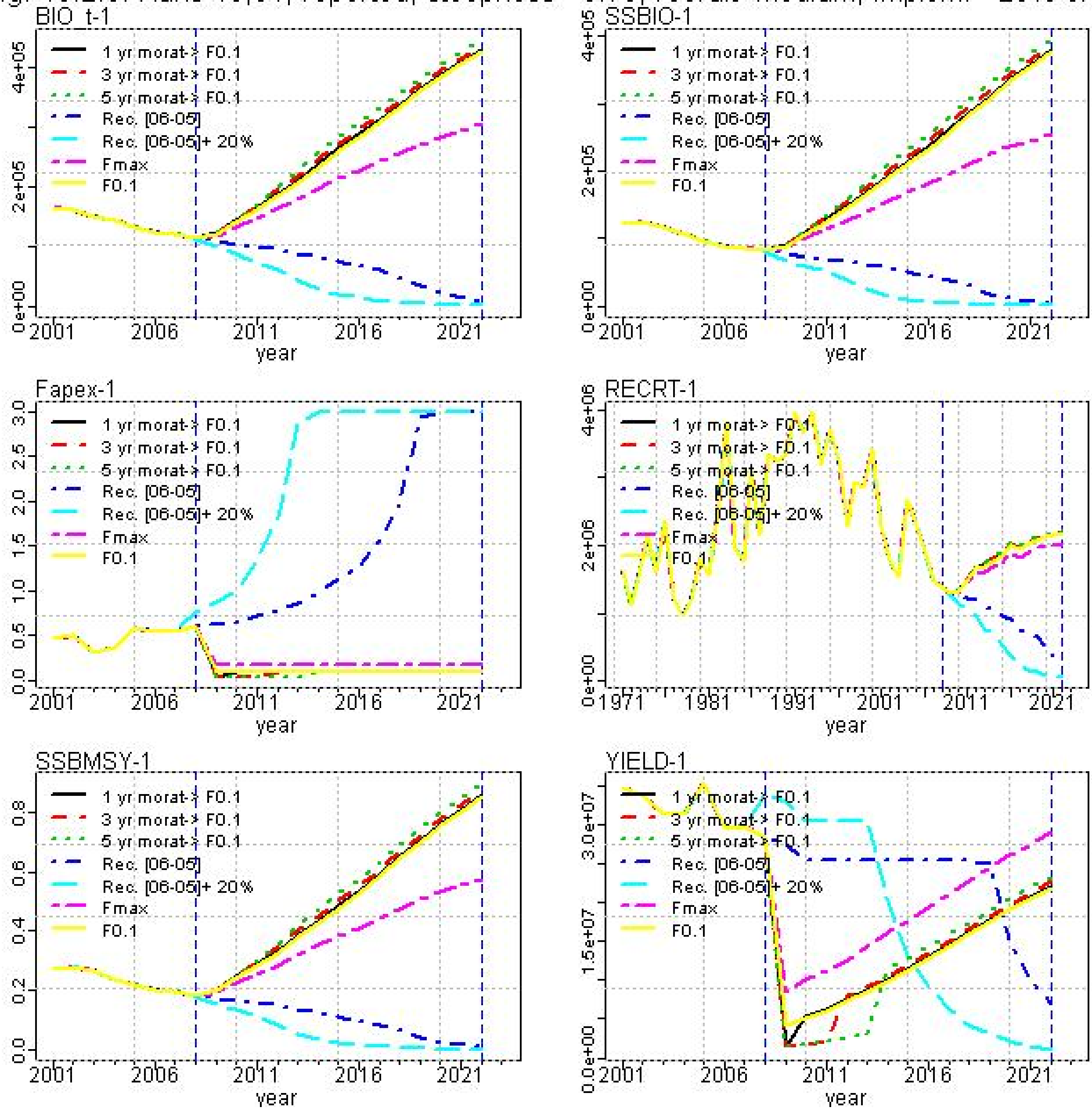


Fig. 10.2.p. Runs 16,52, adjusted, steepness =0.75, recruit=medium, implem.= 20% err.

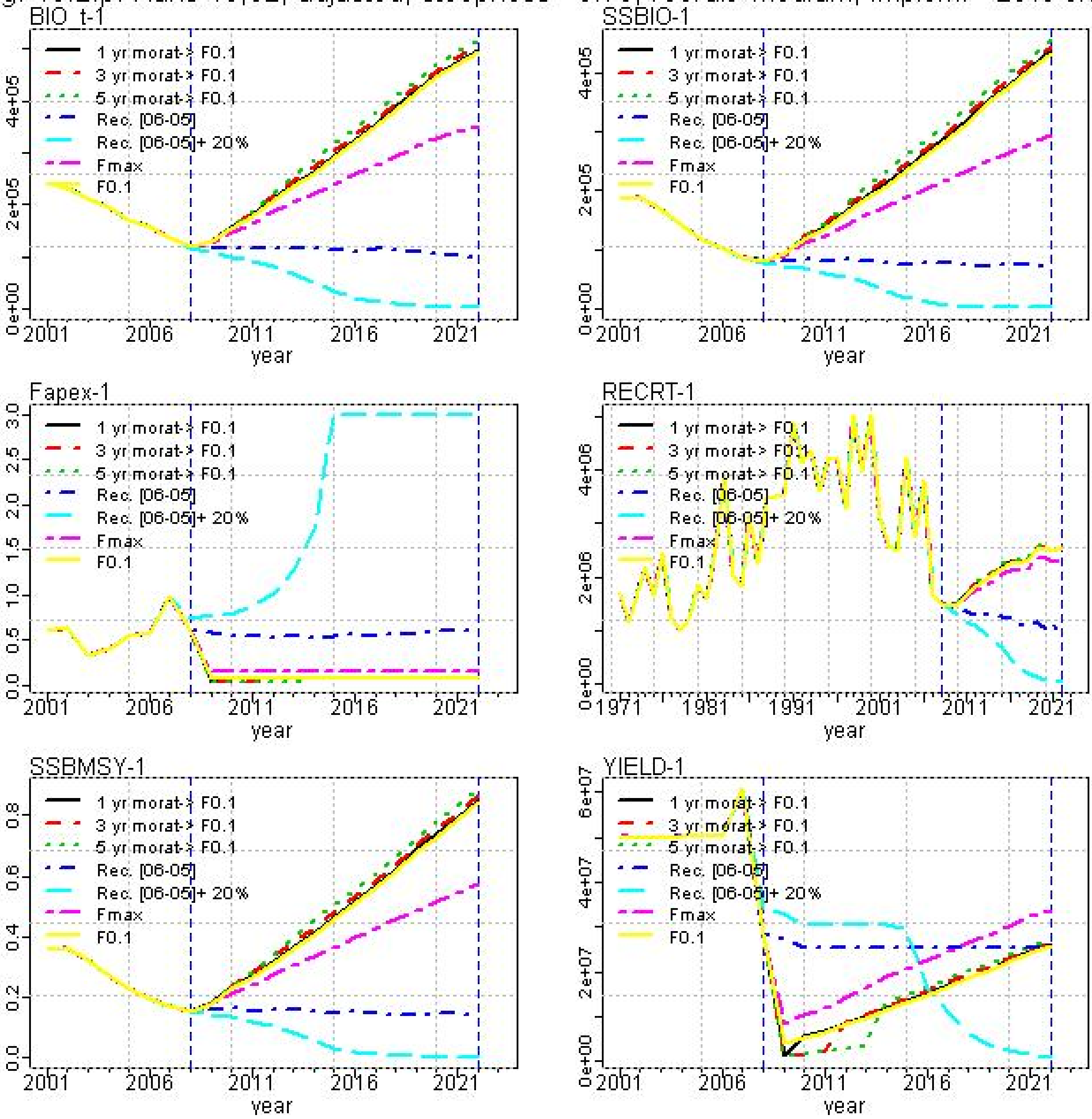


Fig. 10.2.q. Runs 17,53, reported, steepness =0.99, recruit=medium, implem.= 20% err.

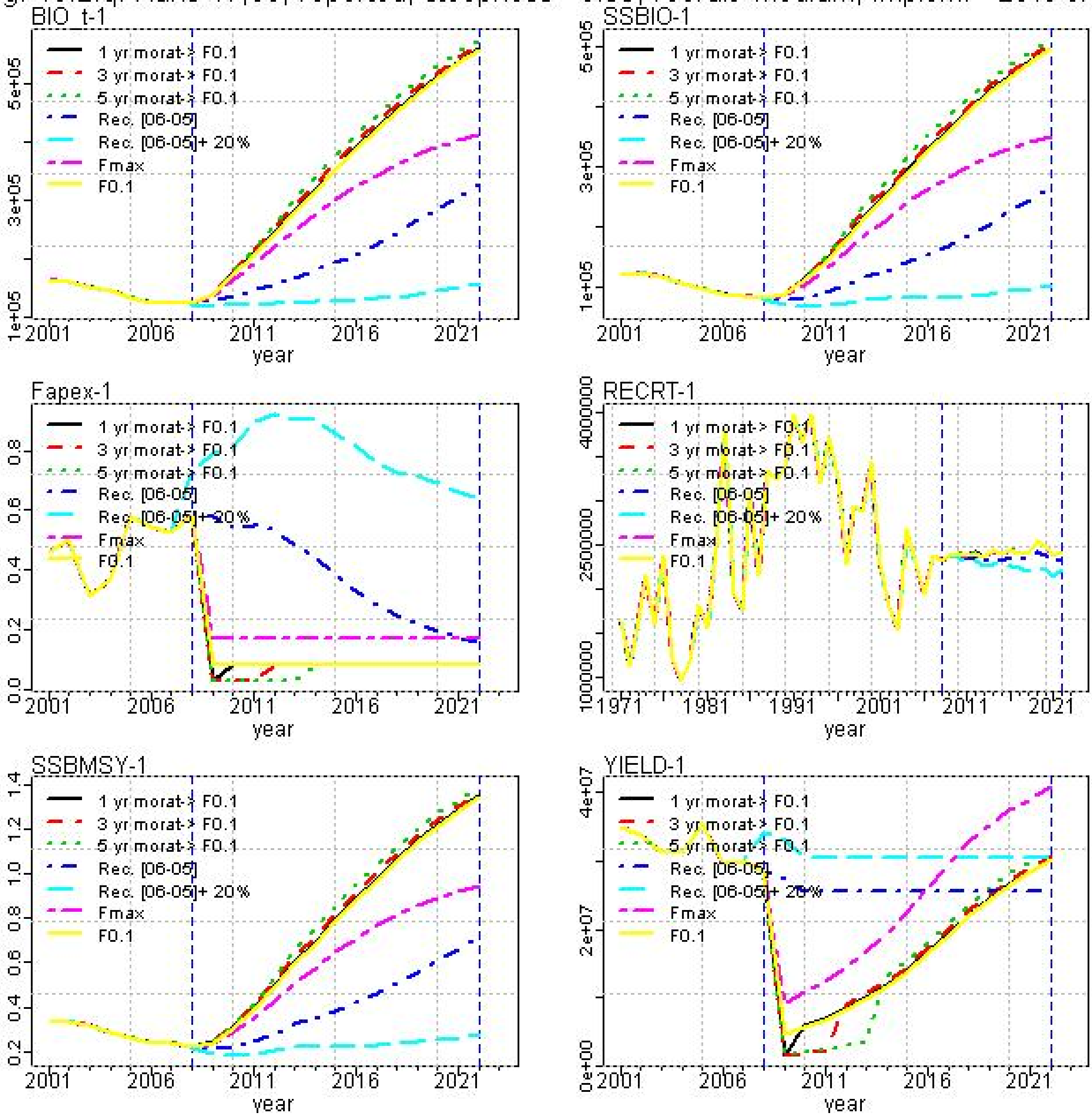


Fig. 10.2.r. Runs 18,54, adjusted, steepness =0.99, recruit=medium, implem.= 20% err.

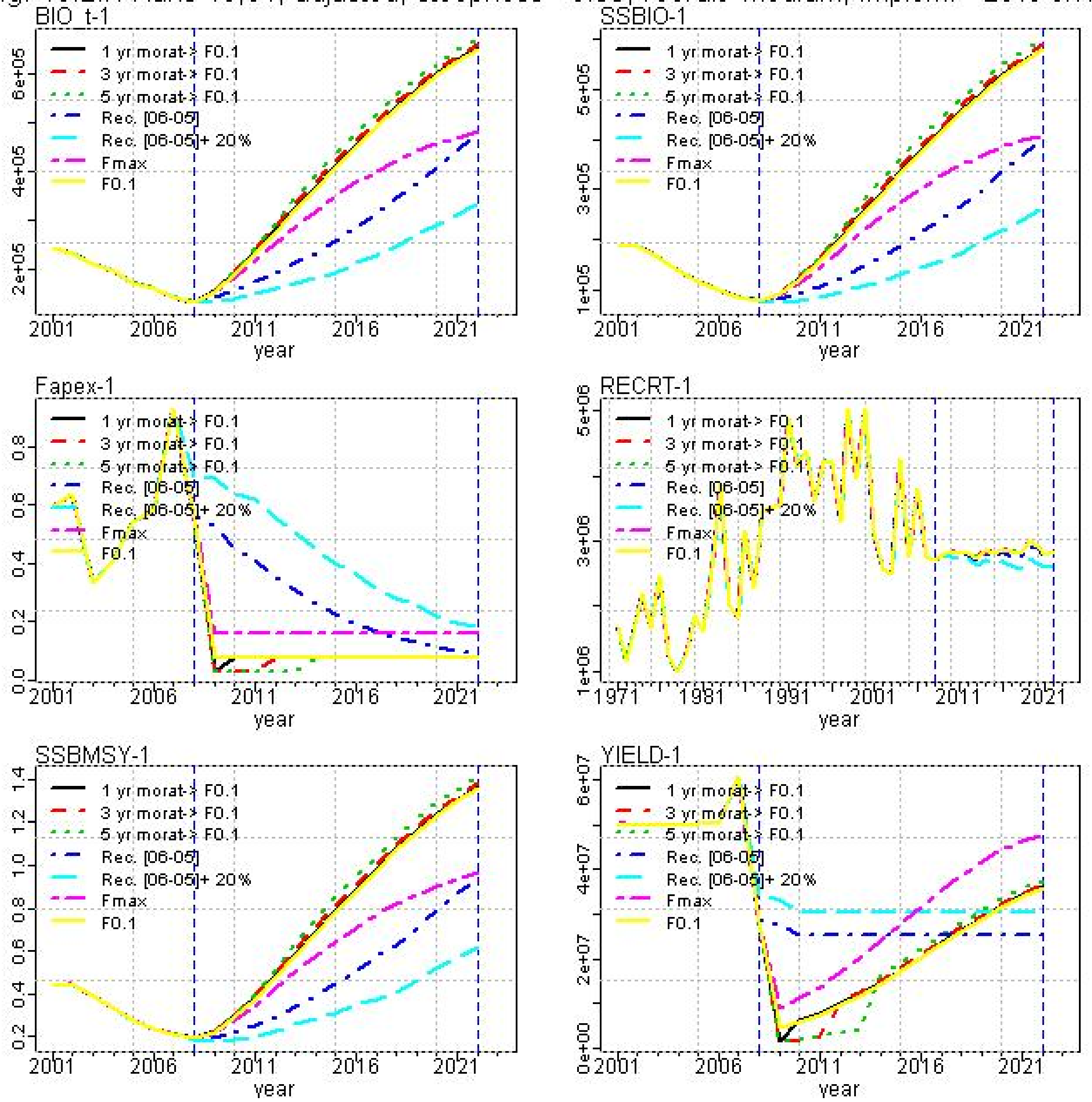


Fig. 10.2.s. Runs 19,55, reported, steepness =0.5, recruit=hi, implem.= 20% err.

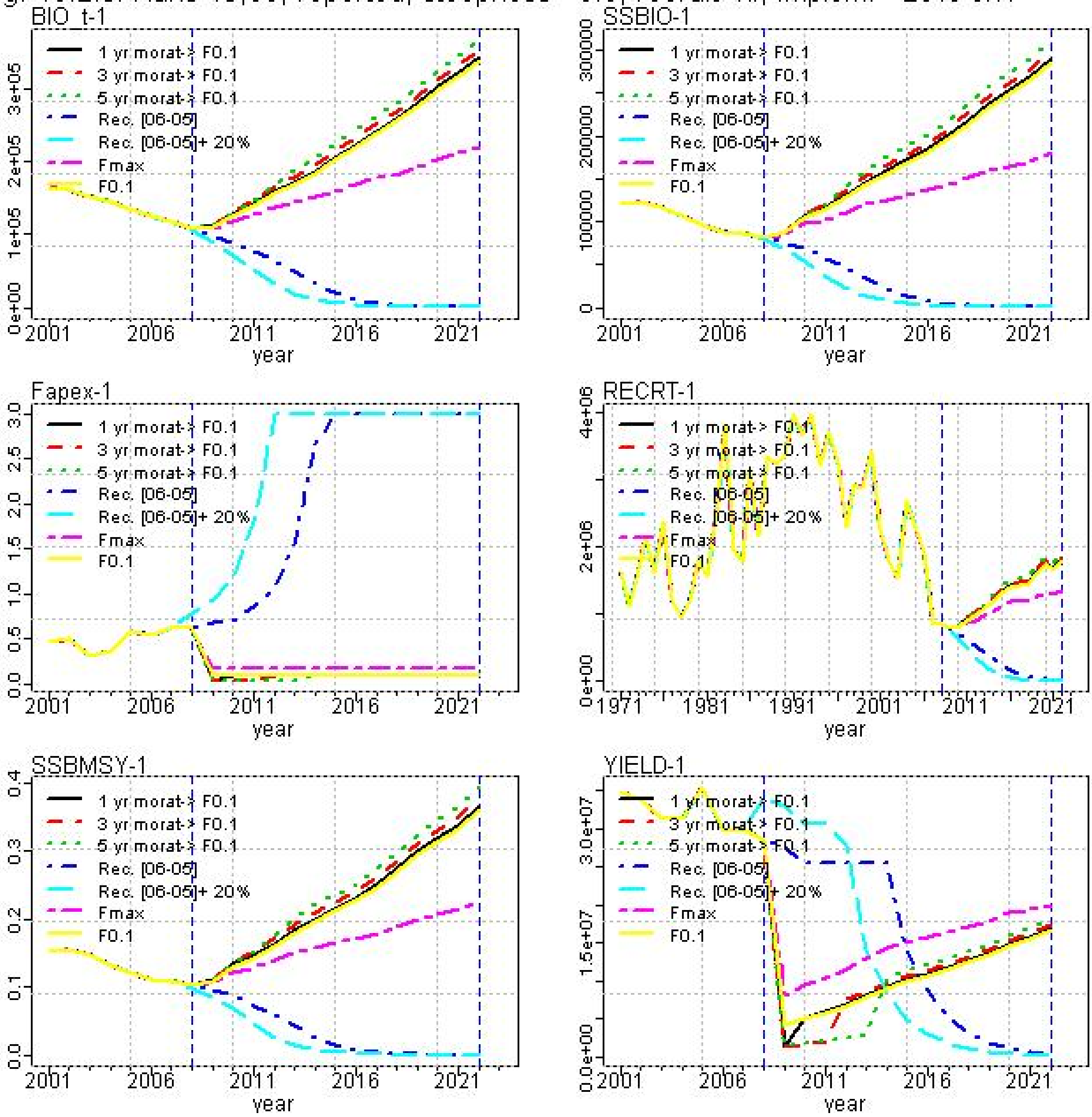


Fig. 10.2.t. Runs 20,56, adjusted, steepness =0.5, recruit=hi, implem.= 20% err.

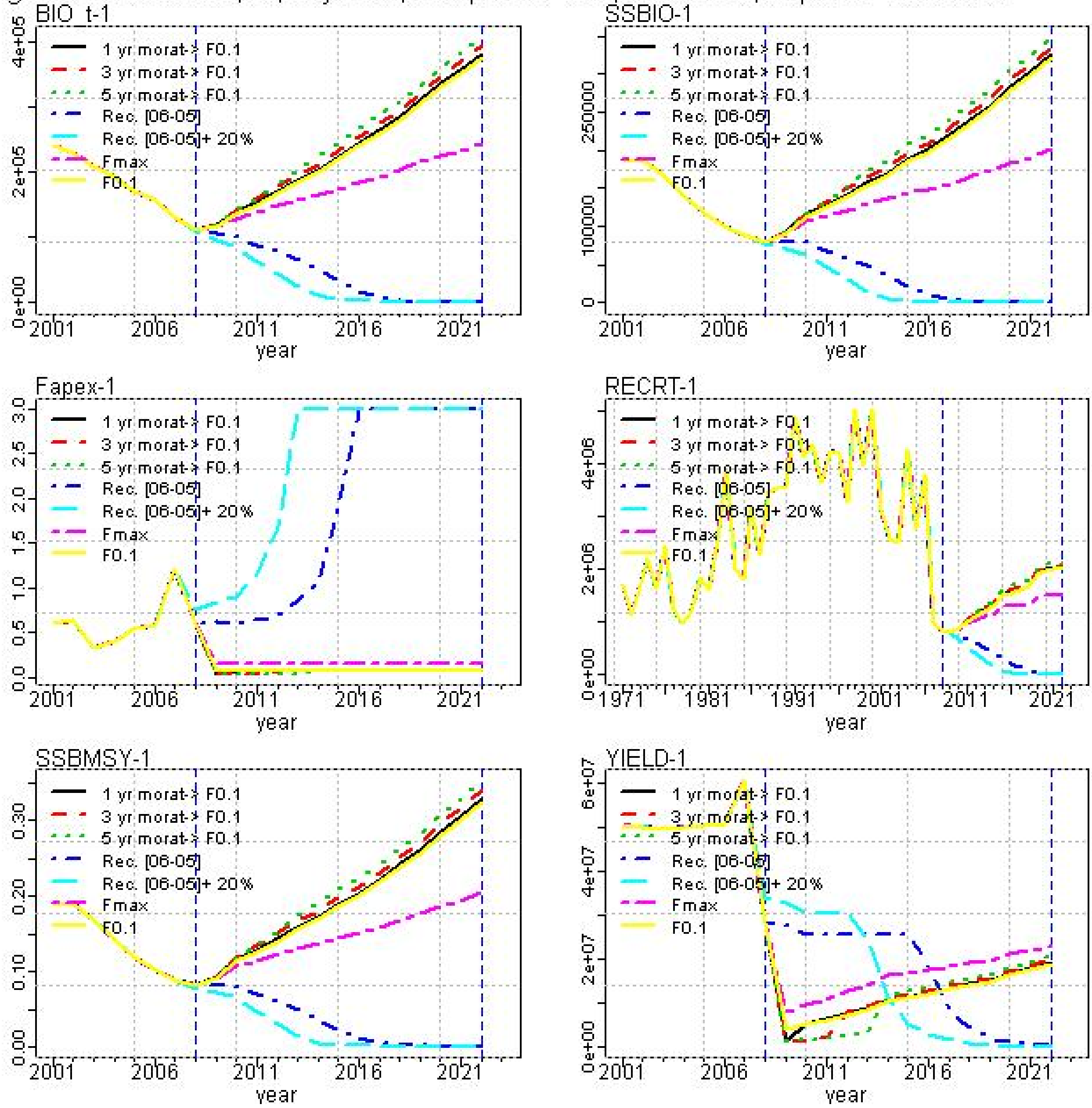


Fig. 10.2.u. Runs 21,57, reported, steepness =0.75, recruit=hi, implem.= 20% err.

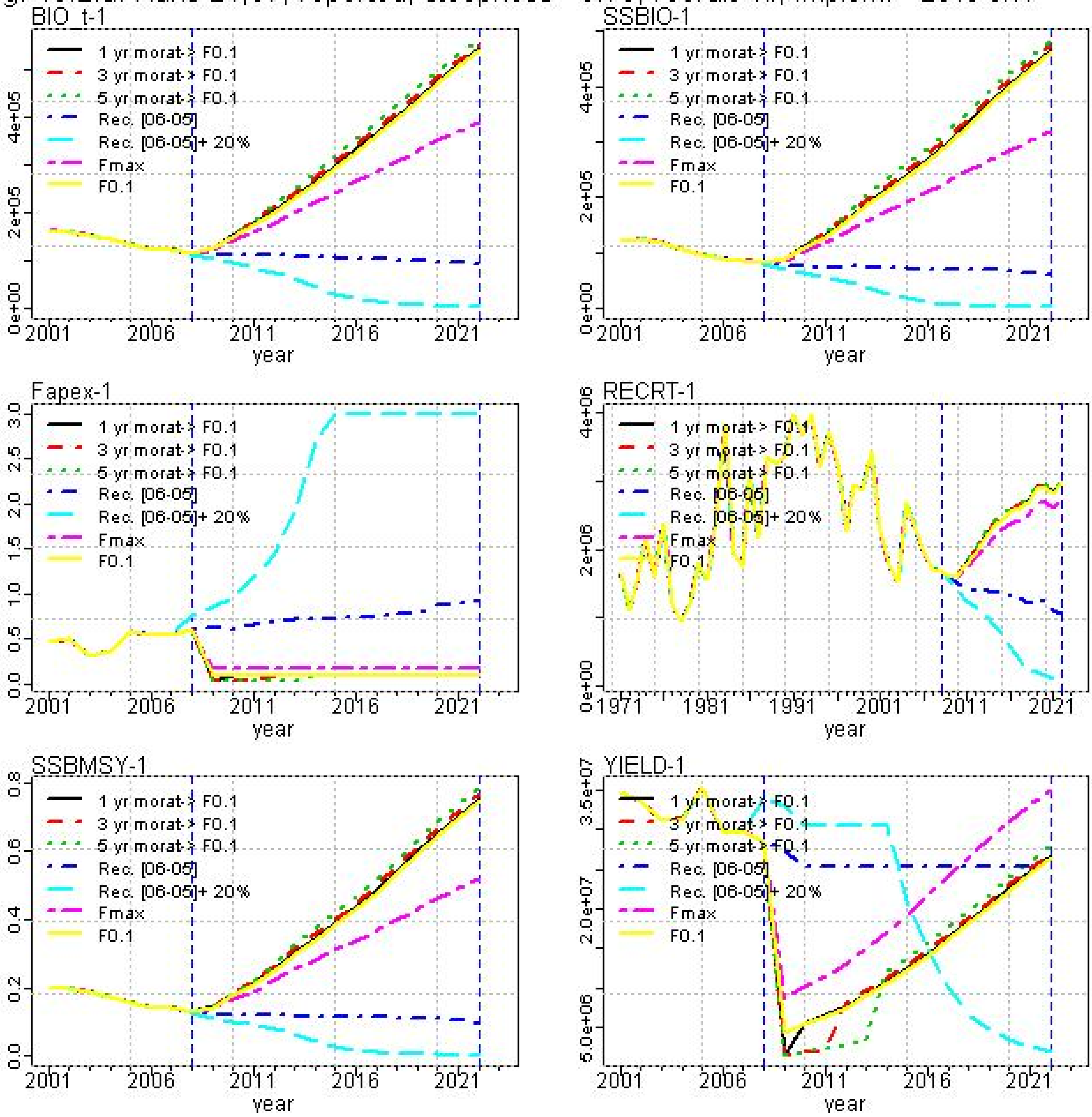


Fig. 10.2.v. Runs 22,58, adjusted, steepness =0.75, recruit=hi, implem.= 20% err.

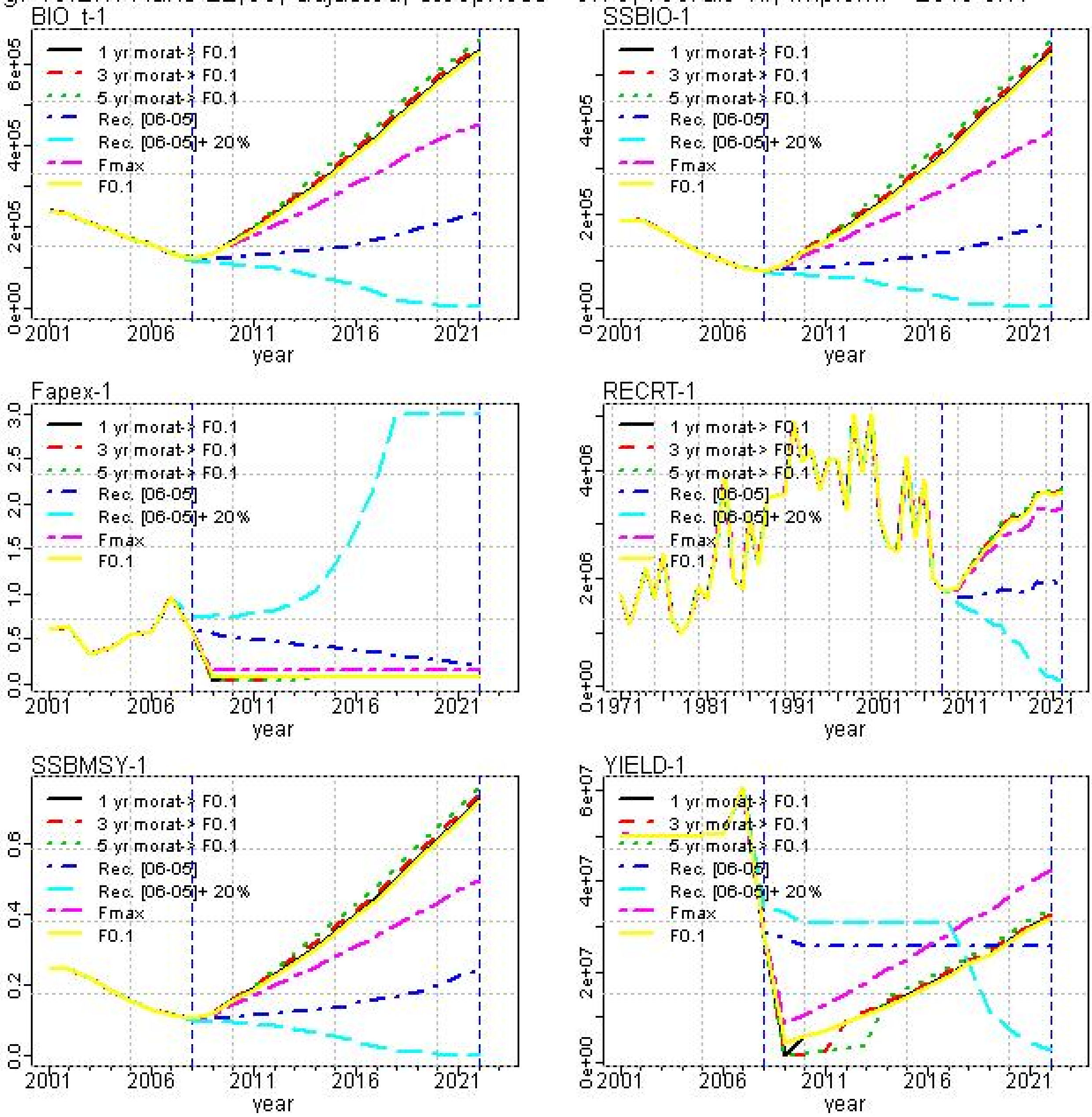


Fig. 10.2.w. Runs 23,59, reported, steepness =0.99, recruit=hi, implem.= 20% err.

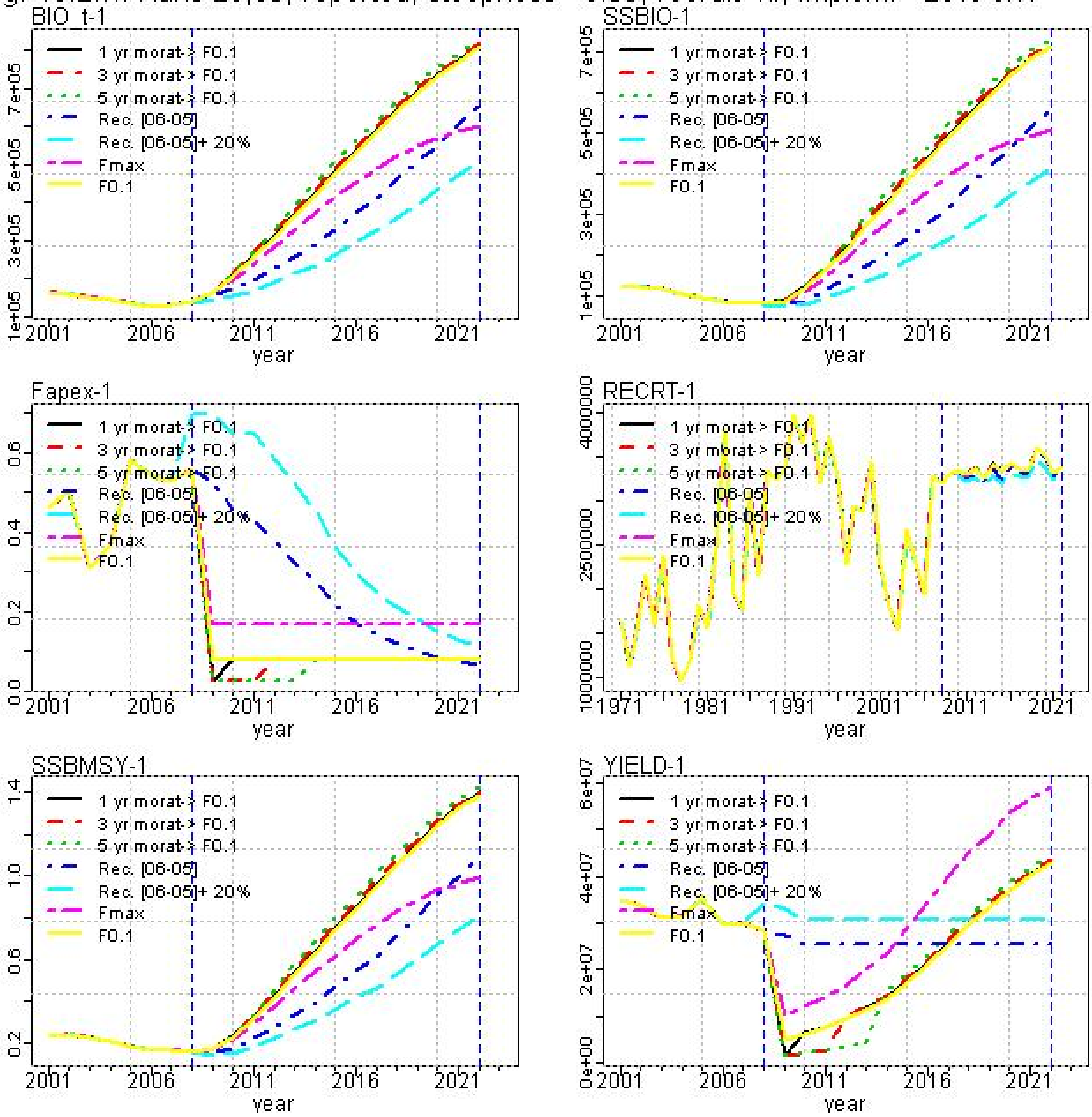


Fig. 10.2.x. Runs 24,60, adjusted, steepness =0.99, recruit=hi, implem.= 20% err.

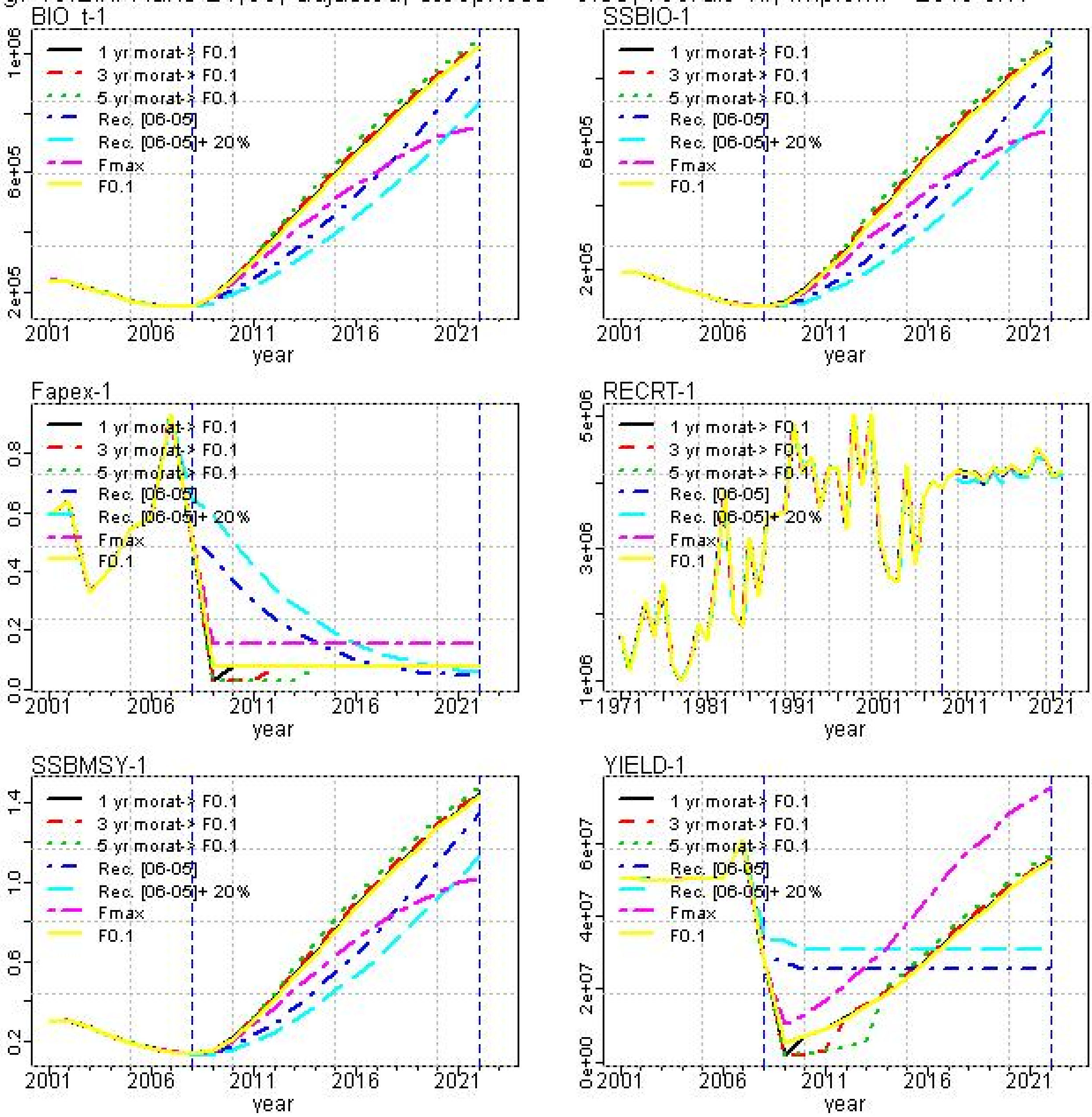


Fig. 10.2.y. Runs 25,61, reported, steepness =0.5, recruit=low, implem.= perf.

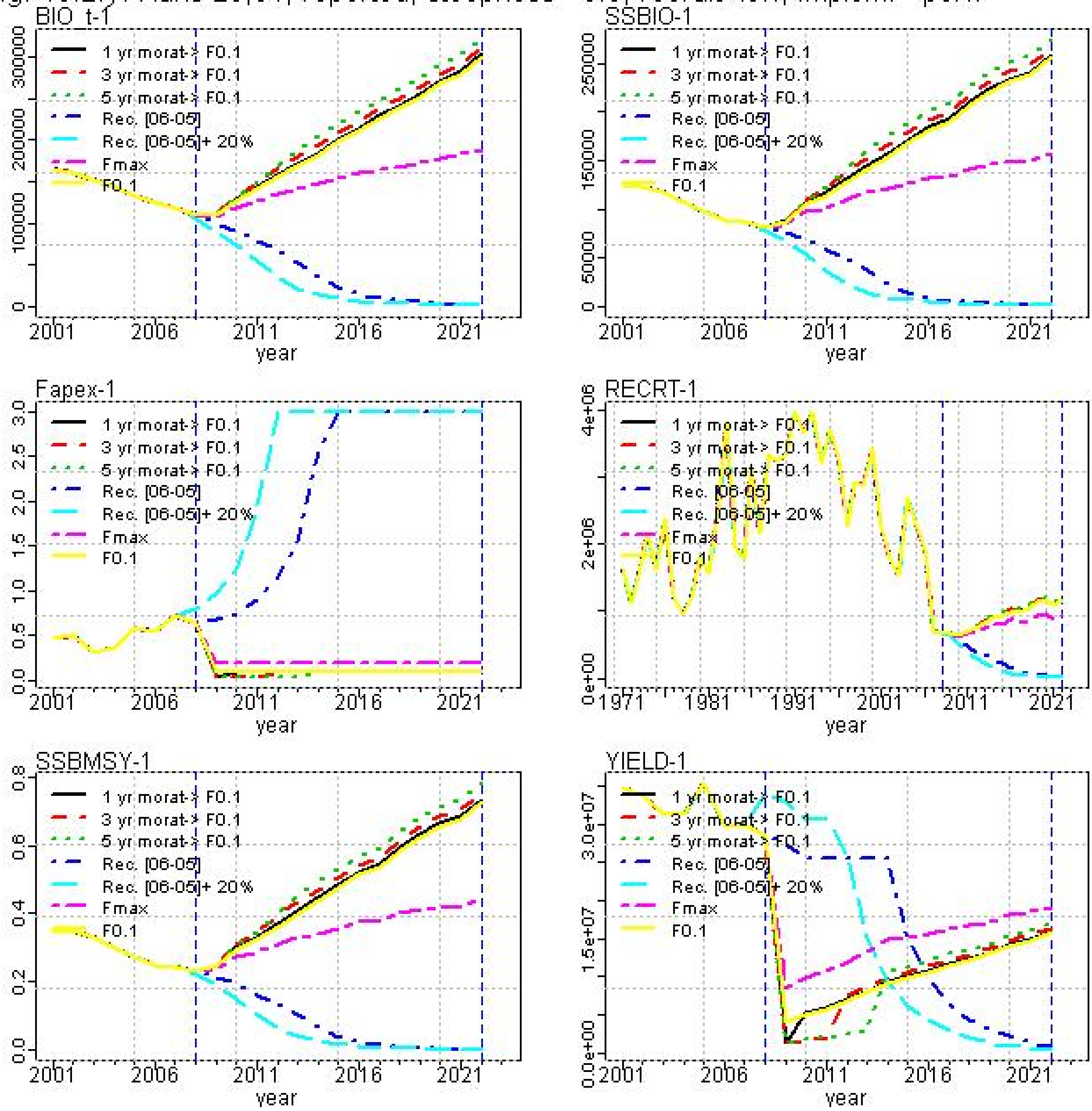


Fig. 10.2.z. Runs 26,62, adjusted, steepness =0.5, recruit=low, implem.= perf.

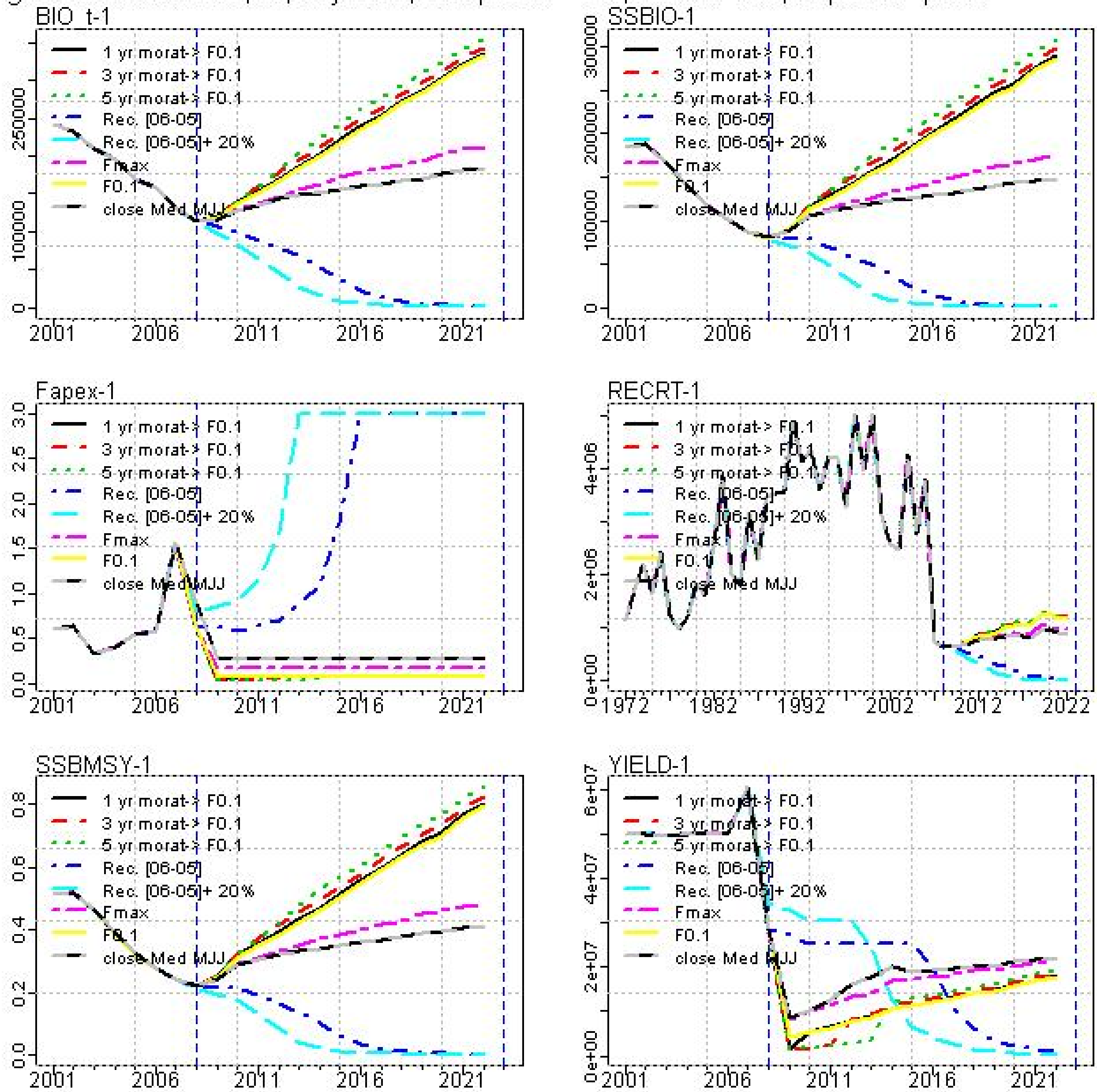


Fig. 10.2.aa. Runs 27,63, reported, steepness =0.75, recruit=low, implem.= perf.

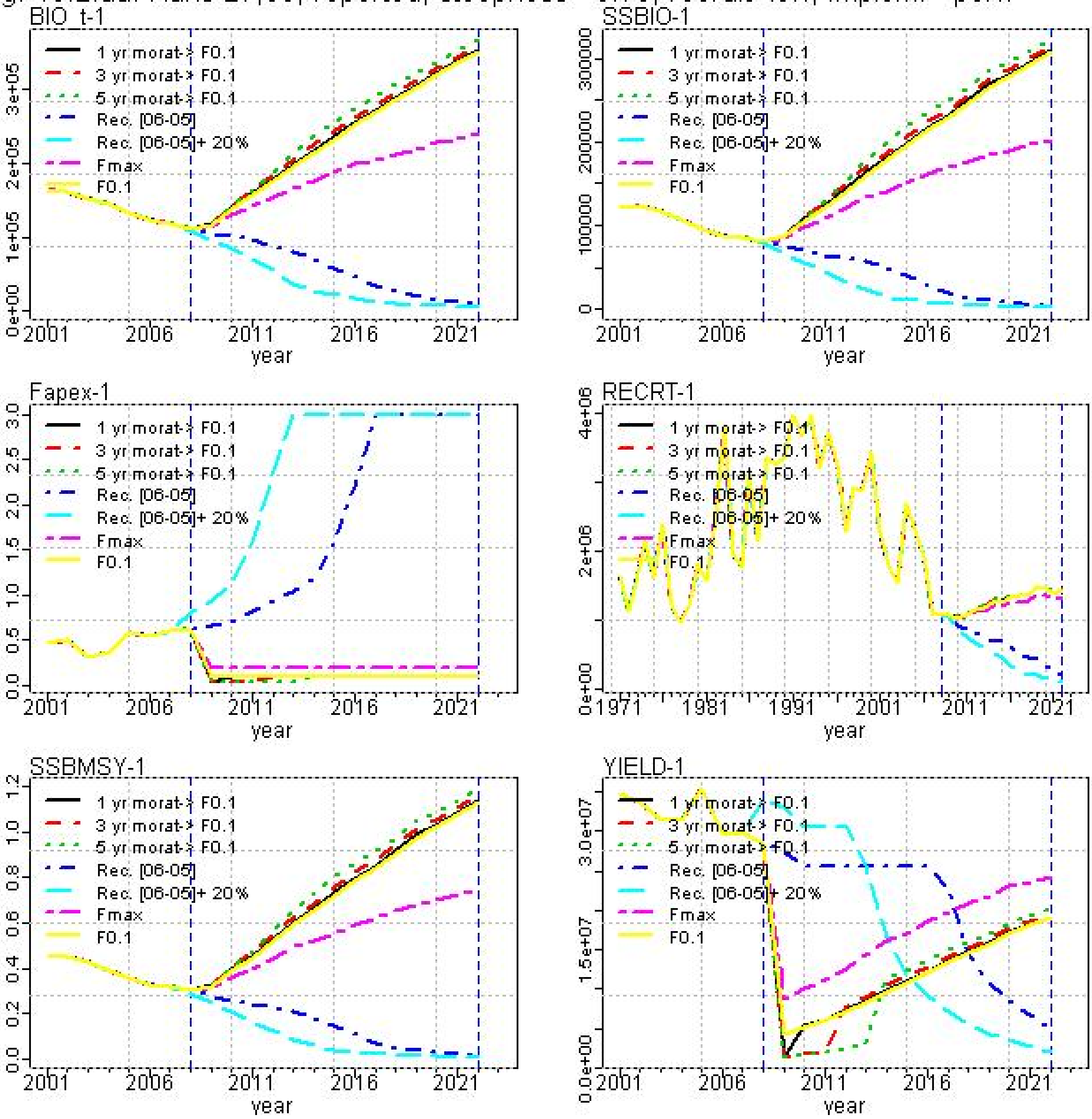


Fig. 10.2.bb. Runs 28,64, adjusted, steepness =0.75, recruit=low, implem.= perf.

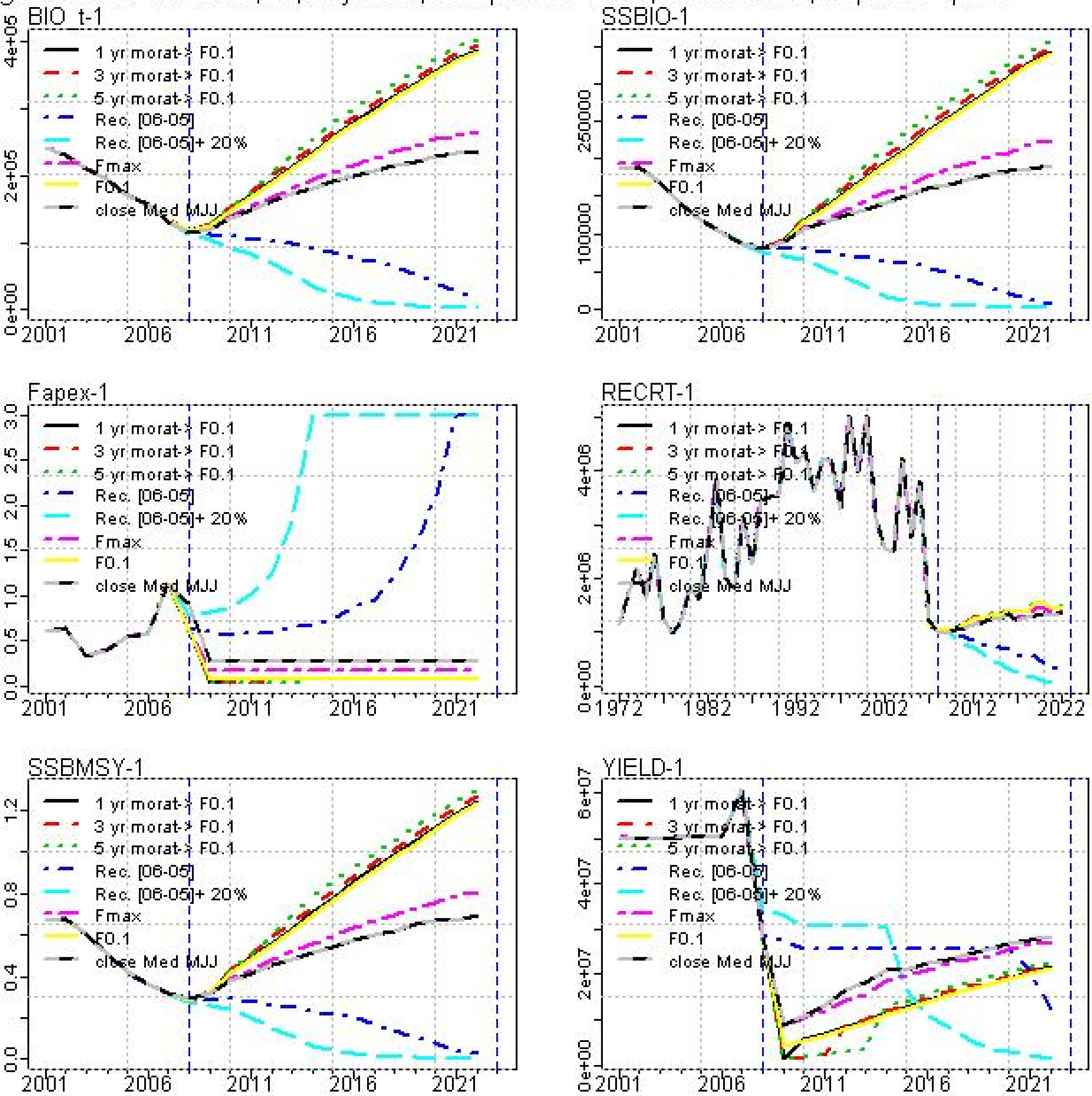


Fig. 10.2.cc. Runs 29,65, reported, steepness =0.99, recruit=low, implem.= perf.

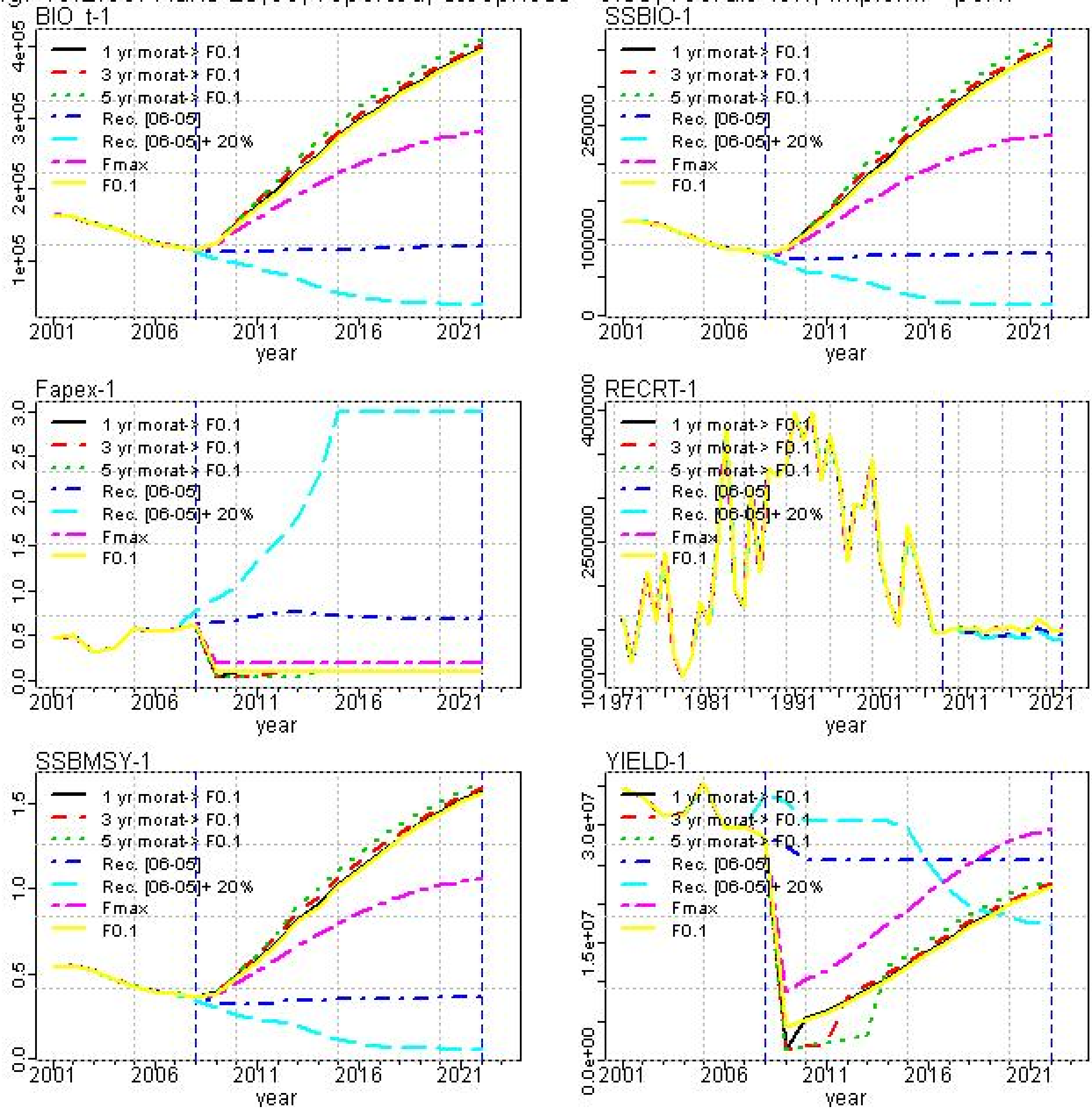


Fig. 10.2.dd. Runs 30,66, adjusted, steepness =0.99, recruit=low, implem.= perf.

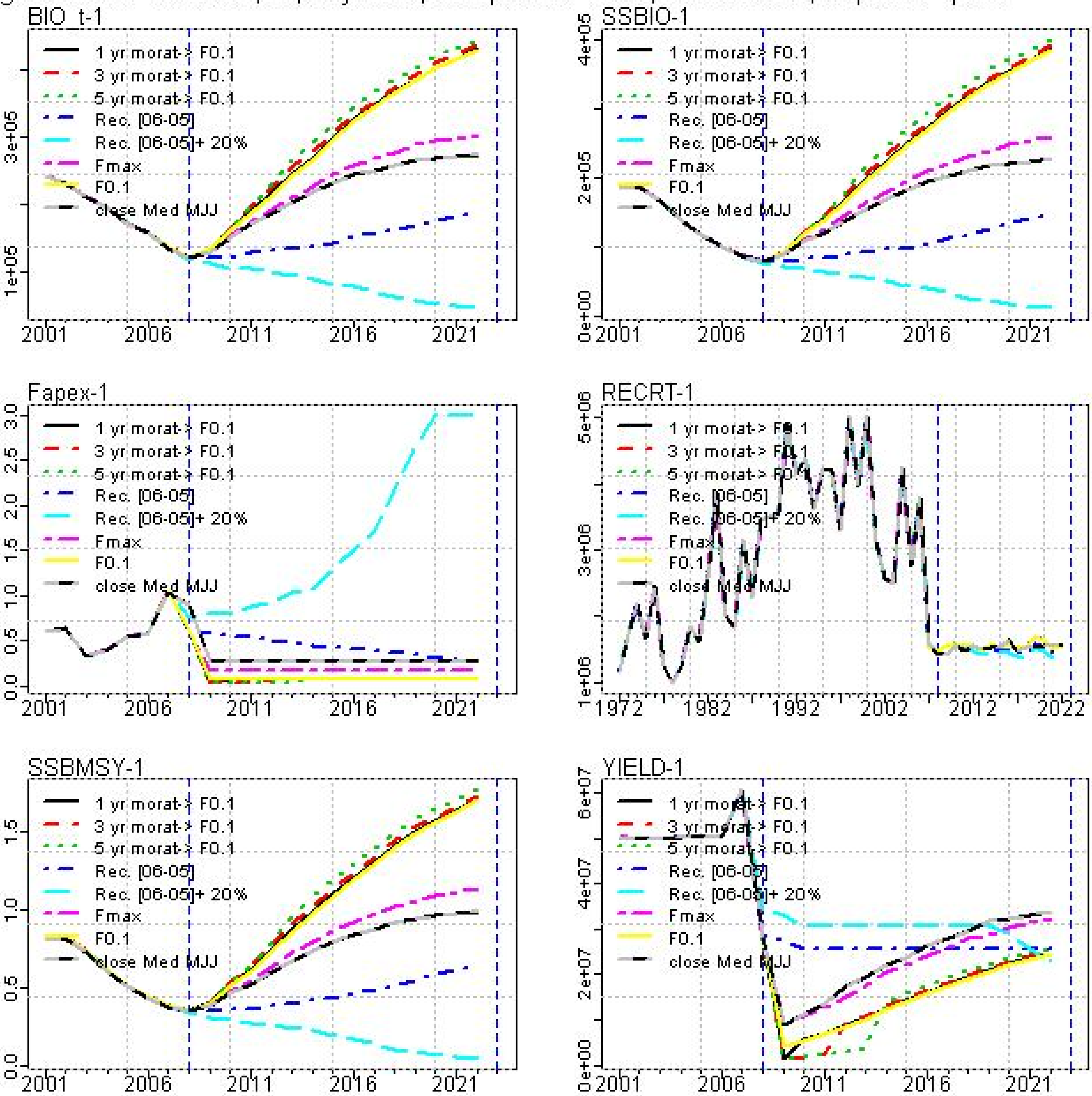


Fig. 10.2.ee. Runs 31,67, reported, steepness =0.5, recruit=low, implem.= 20% err.

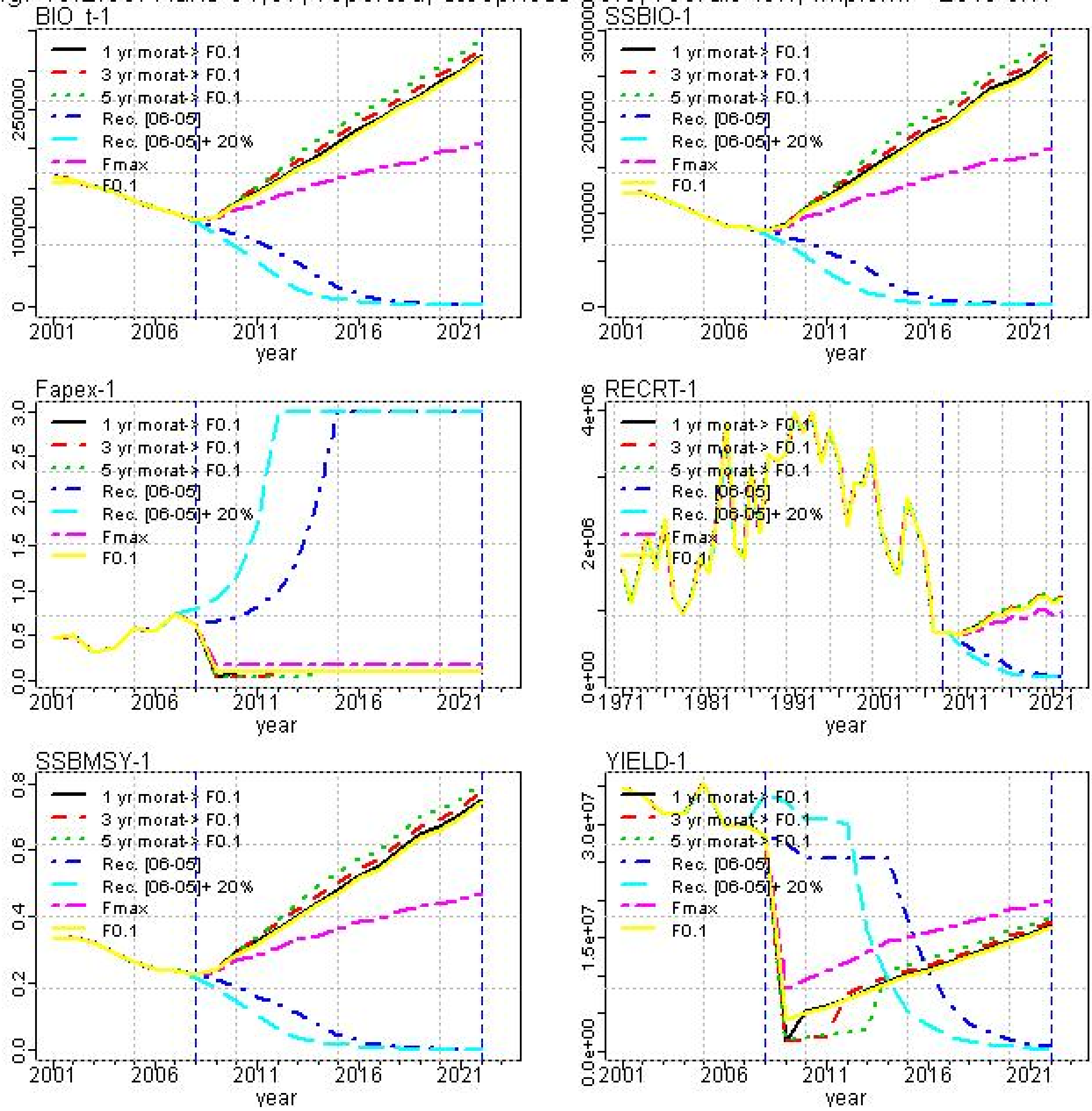


Fig. 10.2.ff. Runs 32,68, adjusted, steepness =0.5, recruit=low, implem.= 20% err.

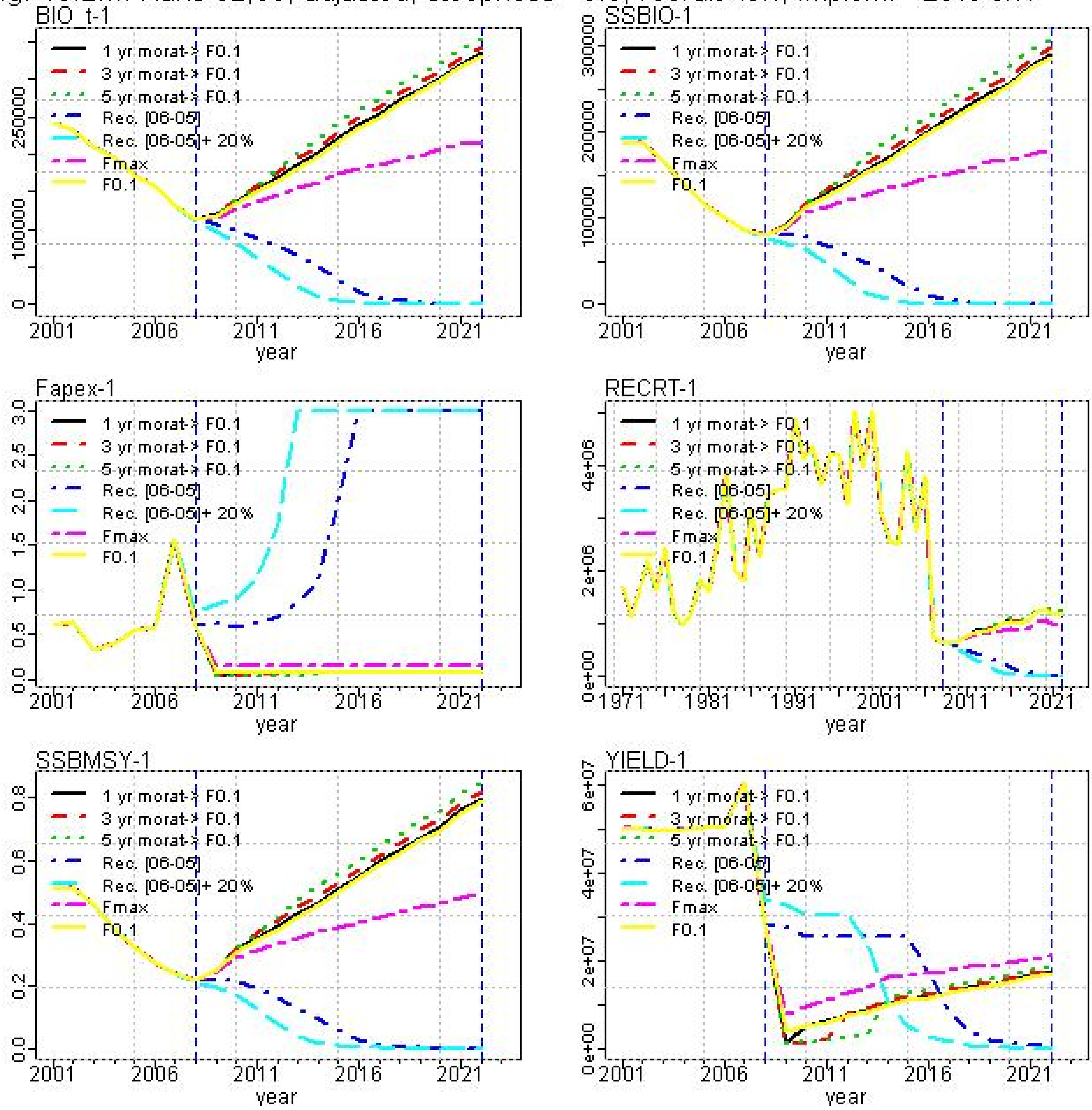


Fig. 10.2.gg. Runs 33,69, reported, steepness =0.75, recruit=low, implem.= 20% err.

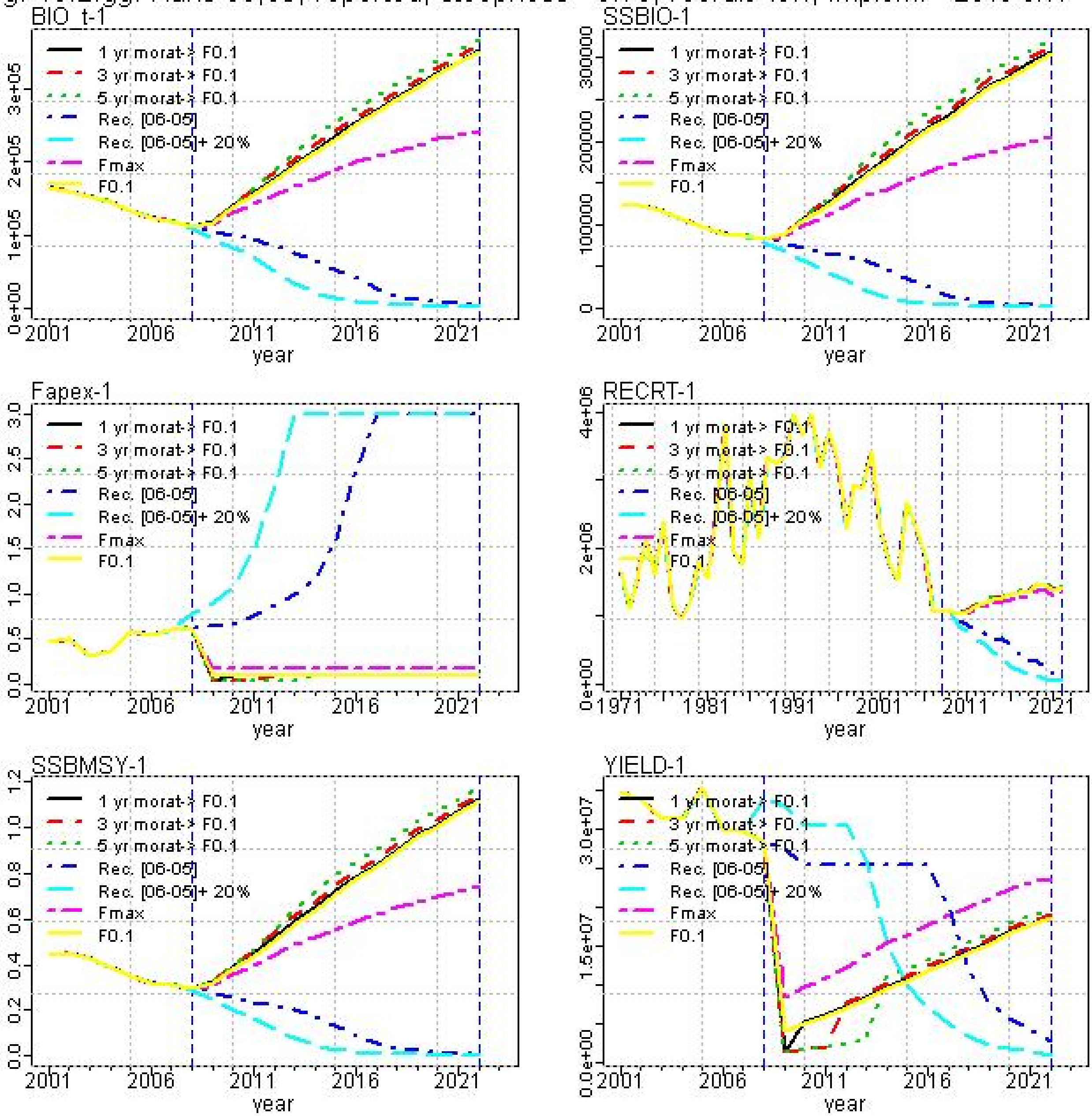


Fig. 10.2.hh. Runs 34,70, adjusted, steepness =0.75, recruit=low, implem.= 20% err.

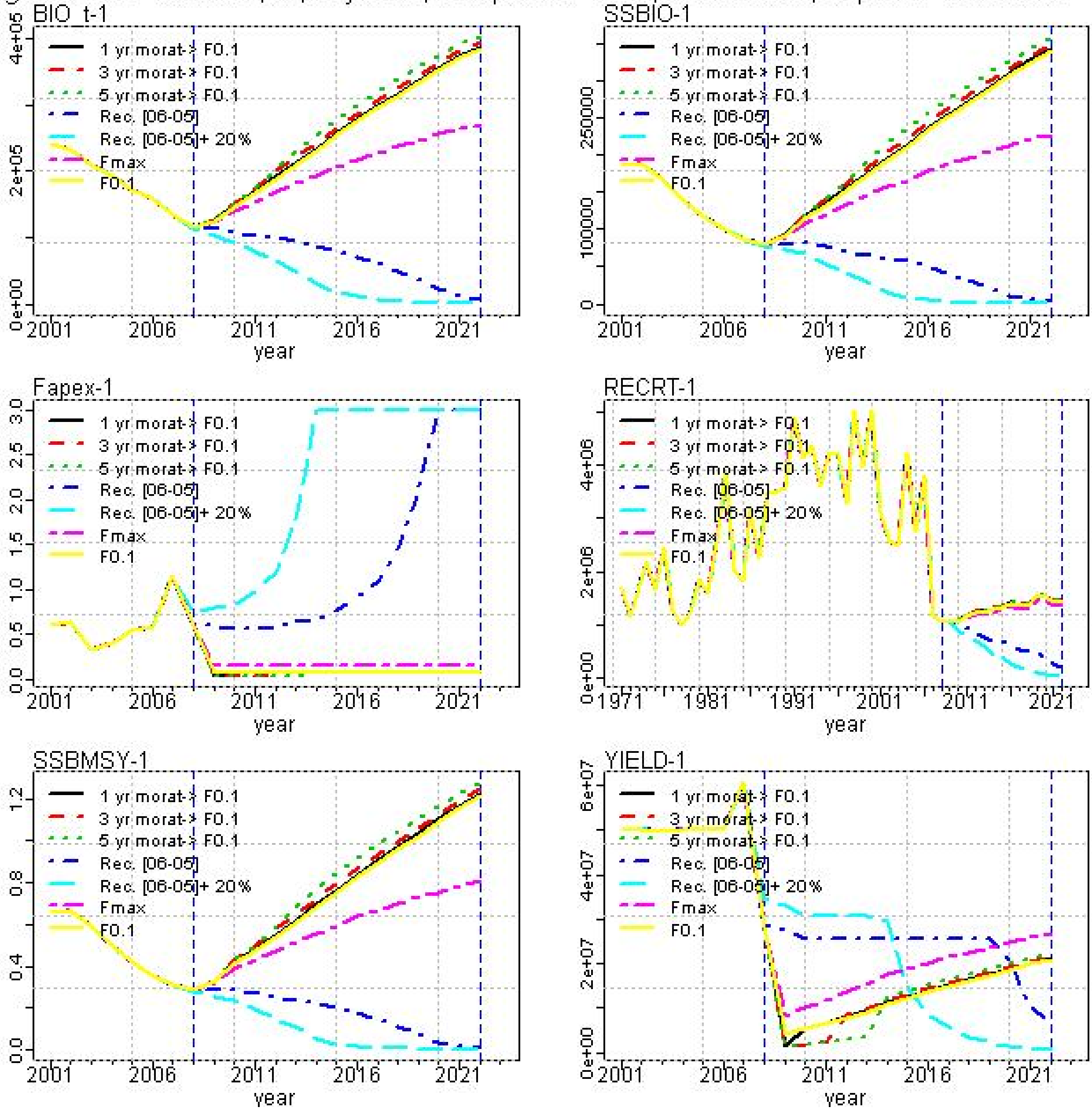


Fig. 10.2.ii. Runs 35,71, reported, steepness =0.99, recruit=low, implem.= 20% err.

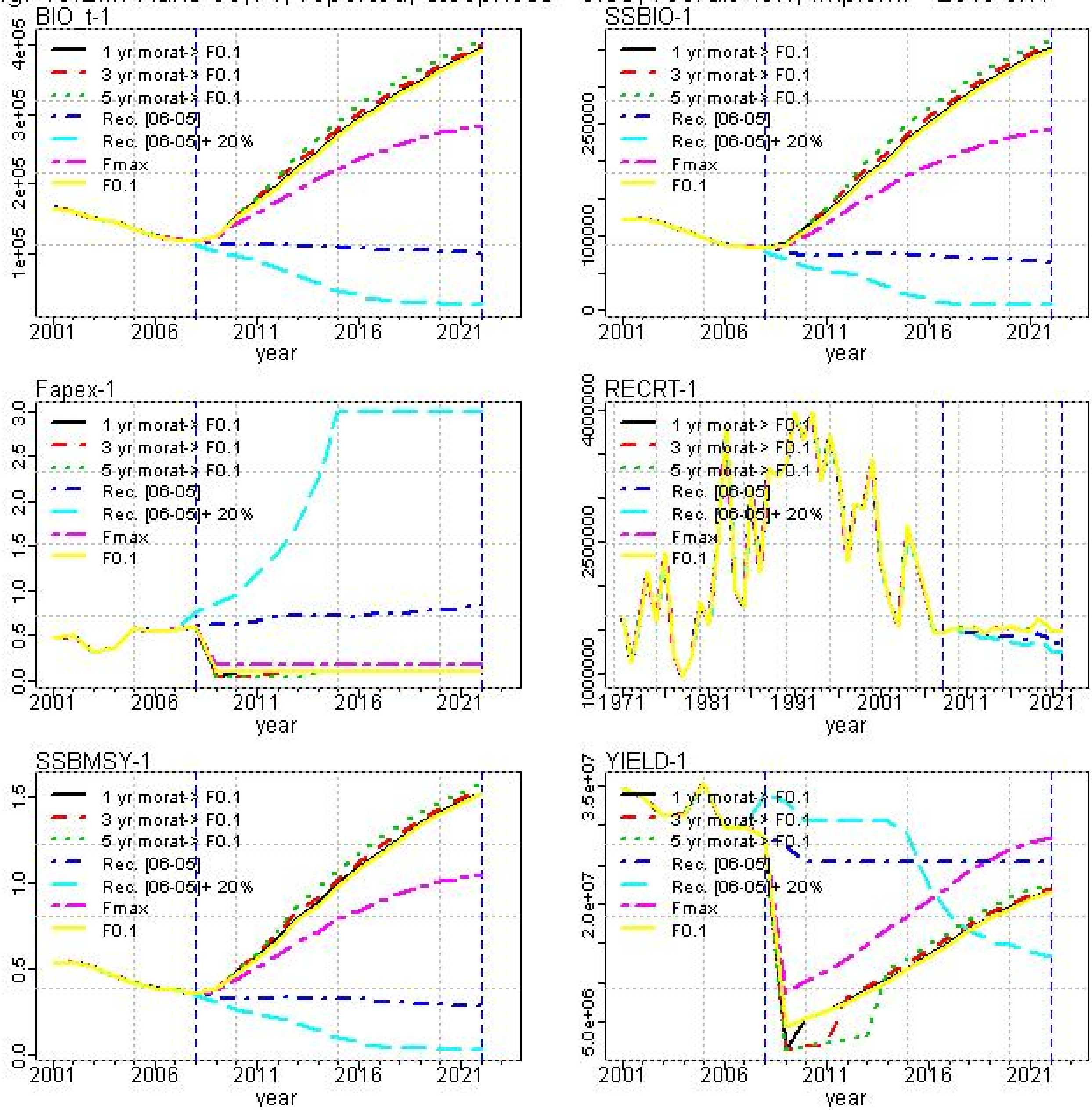


Fig. 10.2.jj. Runs 36,72, adjusted, steepness =0.99, recruit=low, implem.= 20% err.