Jack-Mackerel stock assessment simulation

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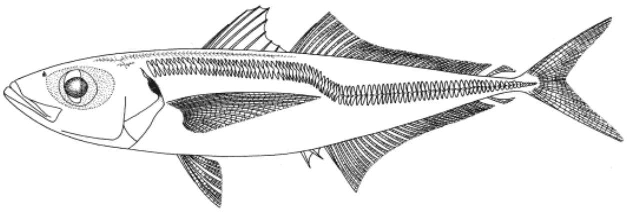
Report number C123/09



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Contents

Summary / Prospects

IMARES has been tasked to perform an ICA assessment on a simulated Jack Mackerel dataset. This in order to provide management advice within the SPRFMO framework.
The results of the assessments are only briefly discussed, as the Assessment Simulation Task Team mainly focused on agreeing on the underlying simulated dataset and assessment settings during the 8th SPRFMO meeting in Auckland, New Zealand. The summarized outcome of these discussions was that more realistic characteristics of the real fishery and surveys should be incorporated into the simulated dataset. This has been communicated to the designer of the dataset and will result in a revised dataset.
CVO (Centrum voor Visserij Onderzoek) has proposed to include the SPRFMO work in the near future into WOT tasks (Wettelijke Onderzoeks Taken). Early 2010 another meeting will be organized in which the Assessment Simulation Task Team will discuss the revised simulated datasets, discuss general assessment settings, perform assessments, compare and discuss these results. The results as listed in this report will be used within these discussions.

1 Introduction

The South Pacific Regional Fisheries Management Organisation has been tasked to provide advice on the management of the Jack Mackerel stock(s) near the coast of Chilli and Peru. However, the current status of the Jack Mackerel is unclear. As it remains unclear what kind of analytical stock assessment model provides best estimation of the stock status, or captures the biological characteristics of the stock(s), different approaches are undertaken, assessing a simulated dataset representing the Jack Mackerel stock, its fisheries and surveys.

IMARES, representing a European approach, will use an Integrated Catch at Age assessment method named ICA (Patterson 1998), as is commonly used to assess herring and mackerel stocks in European waters (ICES 2009). Comparing the assessment results with the underlying known truth (as the data is simulated from a known source), should indicate to what extend ICA, and other methods, are capable to capture the dynamics / stock status. The results will be discussed in this report and during the Jack Mackerel sub-group meeting in Auckland 1-4 November 2009.

2 Assignment

IMARES will report on and discuss the results of the ICA assessments on the simulated datasets provided by Dr James Ianelli, participant in the Jack Mackerel sub-group. Besides the agreed reporting on: SSB, F, TSB, recruitment, measures of fit of catches and surveys, fitted selectivity pattern and assessed numbers at age, general characteristics of the data provided and setup of the assessment control settings will be reported and discussed.

3 Materials and Methods

3.1 Simulated data description

The simulated data, which consists of 100 replicates, each of which are similar in setup but differ in absolute values contain information on:

Table 1:

Data description	Dimensions	Units	Variable
Years	start – end year	years	-
Age	recruits – oldest age	years	-
Number of fisheries	-	#	-
Fisheries Catch	start – end year fisheries	tons	√
Fisheries years active	start – end year fisheries	years	-
Fisheries age samples	start – end year fisheries	#	-
Fisheries age data	start – end year fisheries, recruits – oldest age	1/#	√
Fisheries weight at age	start – end year fisheries, recruits – oldest age	kg	-
Number of surveys	-	#	-

Survey years active	start – end year surveys	years	-
Survey month	-	#	-
Survey index	start – end year surveys	tons	√
Survey age sample years	-	years	-
Survey age samples	start – end year surveys	#	-
Survey age data	start - end year surveys	1/#	√
Survey weight at age	start – end year surveys, recruits – oldest age	kg	-
Population weight at age	recruits – oldest age	kg	-
Population mature at age	recruits – oldest age	1/#	-
Population spawning month	-	#	-
Ageing error	recruits – oldest age, recruits – oldest age	Var	-
Fisheries effort	start – end year fisheries	cpue	√
Fisheries catch number at age	start – end year fisheries, recruits – oldest age	#	√

3.2 Simulated data analyses

In order to understand the general characteristics of the simulated data set, analyses have been performed to visualize different aspects of the data. The catch numbers and weights and surveys have been analyzed over time for irregularities. Other catch analyses have been performed as described under paragraph §3.4.

3.3 Model setup

The simulated dataset will be analyzed using FLR (Kell et al. 2007). This software package, build into R (R Development Core Team 2008), is used to store all data provided in the simulated datasets into a predefined format that enables the user to perform the assessment, analyse and report on it in a standardized manner.

3.3.1 Fisheries

Within this project, it is assumed that all sub Jack Mackerel components belong to same spawning component i.e. stock. All three fisheries (Northern, Southern and Offshore) fish on the same stock, but in different geographical areas. Total landings are computed by summing landings from all three fisheries. Landing weights are computed as a weighted mean of the landing weights per fishery depending on the contribution of each fishery to an age group as measured in numbers at age. As no discard information is provided, catches and catch numbers equal landings and landing numbers respectively.

3.3.2 Surveys

All four survey time series cover different years of the total range of years the fishery has been active, and hence there is no overlap between them. All surveys are assumed to present estimated biomass per year. Proportion at age for the first two surveys (trawl survey and acoustic survey) is given. Based on these proportions, a number-at-age matrix can be composed to transform these surveys from biomass to number based. However, as no proportion-at-age is provided for the terminal year of the acoustic survey, this transformation is not possible while maintaining its current time series length.

Fisheries effort is provided by fleet. These time series, ranging similar years as the fisheries are operating, can be used as survey indices as well. At this stage however, it remains unclear how effort time series have been calculated for the fleets.

Survey tuning weights per year have been set to equal the inverse of the variance of each survey year, as provided in the simulated dataset. Variances have been standardized to the interval [0,1]. Index models have been assumed 'relative' which enables the assessment method to estimate catchability per year.

3.3.3 Population

The population size is estimated within the assessment method. However, few population characteristics have to be set externally. Population weight at age, maturity at age and time of spawning are obtained from the simulated data set. As no natural mortality estimates are provided, natural mortality is set at 0.01 (the assessment method cannot deal with no natural mortality) where the assessment method estimates F according to: F = F+M, and also at 0.15 year^{-1} similar to Atlantic mackerel natural mortality estimates (ICES 2009).

3.4 Assessment settings

As the assessment method ICA uses a separable period, it is necessary to specify the year ranges of this period. As the longest survey time series (fleet effort time series excluded) only dates 6 years back in time, the upper bound of the separable period is fixed to this length. The separable period is estimated by evaluating the trend in log-transformed catch at age over the past 10 years. The changes over time are fitted by a smoother function (Tuckey's smoothing) to visualize the trends in log-transformed catches. Changes with this trend could serve as an indication of the length of the separable period. Next to the period, also the separable age has to be set. This age, at which selection in the assessment model is fixed to be 1, is assumed to be represented by the age group most efficiently targeted by the fleet. Log-transformed catch per cohort could be analyzed to find this age group. The changes over age are fitted by a smoother function (Tuckey's smoothing) to visualize the trends. The age with the highest smoothed log-transformed catch value is assumed to be a good candidate for the separable age group setting. Default settings are used for other ICA specific assessment settings (see table 2).

Table 2:

Parameter	Description	Setting
sr	Fitting Stock Recruitment relationship	False
sr.age	separable age	See result section
lambda.age	Weighting matrices for catch-at-age	1
lambda.year	Relative weights by year	1
index.model	Catcahability model	'relative'
index.cor	Are the age-structured indices are correlated across ages	0
sep.nyr	Number of years for separable model	See result section
sep.sel	Selection on last true reference age	True

3.5 Assessment analyses tools

The fit of the assessment will be judges upon criteria put in practice over the past years in the Herring Assessment Working Group (ICES 2008; ICES 2009), and can be listed as:

- Diagnostics of the Acoustic survey catchability at age
- Weighted residual bubble plot
- Mean contribution of each index or catch to the objective function by age
- Retrospective selectivity pattern
- Retrospective summary plot including SSB, Recruits and mean F
- Retrospective cohort plot
- Model uncertainty plot
- Diagnostics of selection pattern fit
- Stock – Recruit plot

The following scenarios have been run:

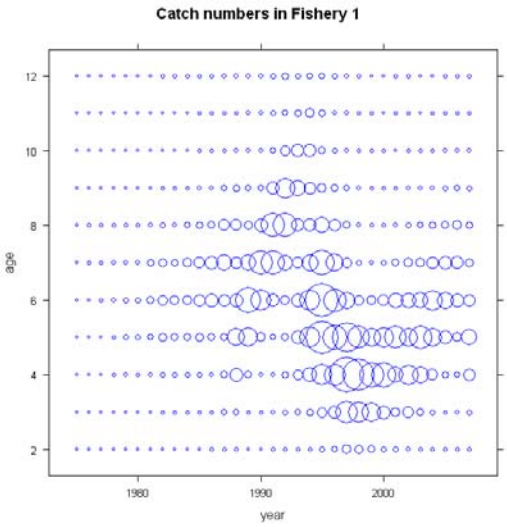
Table 3:

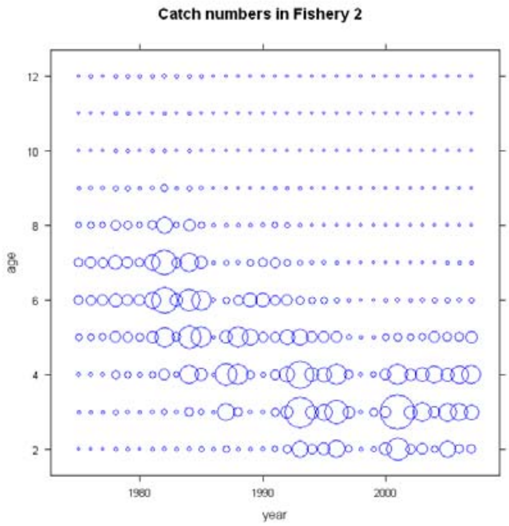
Survey	**Years**	**Control settings**	**Population settings**
Acoustic	2002 - 2007	sep.nyr = 6, sep.age=7	m=0.01
Acoustic + Trawl	2002 – 2007 + 1997 - 2001	sep.nyr = 6, sep.age=7	m=0.01
Fisheries effort	1975 - 2007	sep.nyr = 6, sep.age=7	m=0.01
Acoustic	2002 - 2007	sep.nyr = 6, sep.age=7	m=0.15
Acoustic + Trawl	2002 – 2007 + 1997 - 2001	sep.nyr = 6, sep.age=7	m=0.15
Fisheries effort	1975 - 2007	sep.nyr = 6, sep.age=7	m=0.15

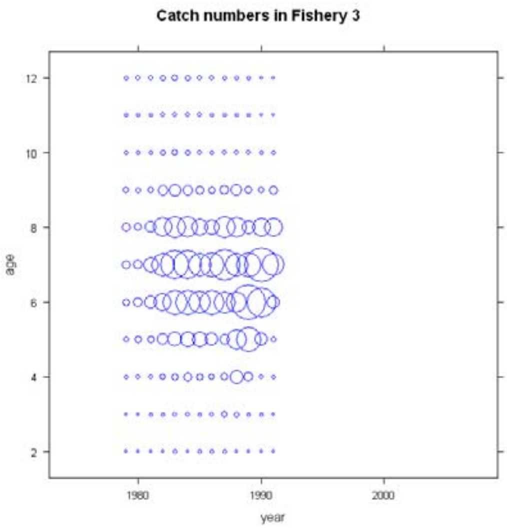
4 Results

4.1 Simulated data analyses

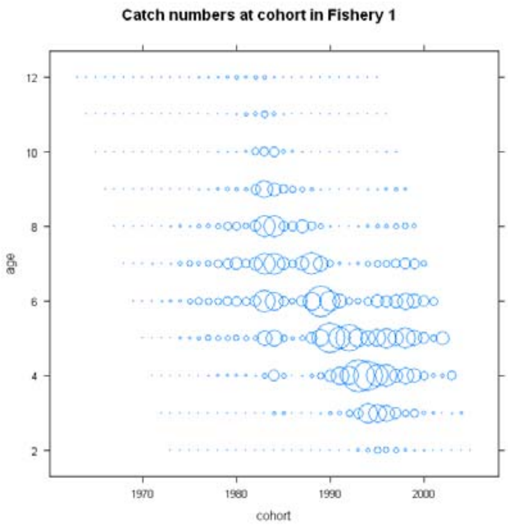
Graphically shown below are the scaled catches in number per fishery. Bigger bubbles indicate higher catches within a year at a certain age. Larger bubbles should appear at the ages most targeted by the fisheries.

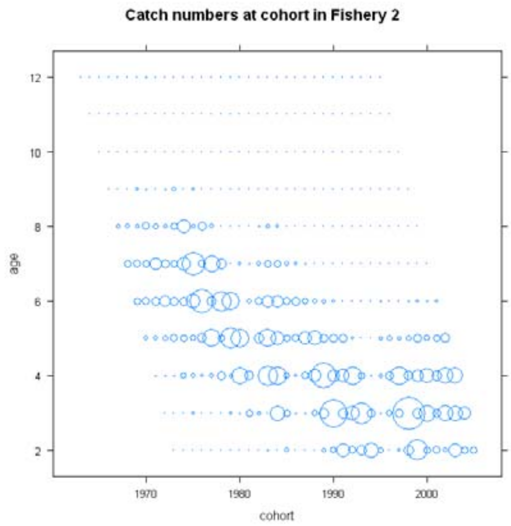


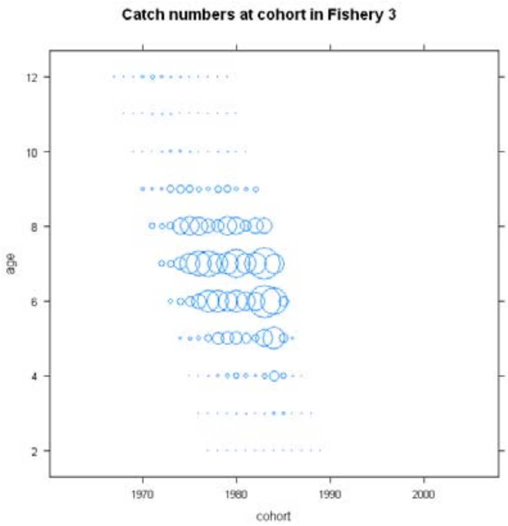




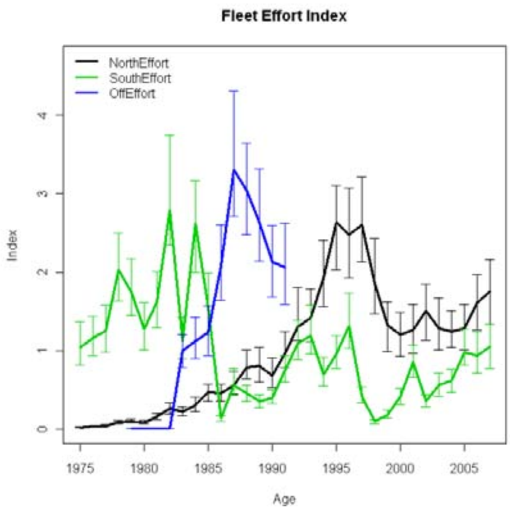
The figures below show the catch in numbers within a cohort. Cohorts are vertically lined up. Bigger bubbles indicate higher catches. Strong year classes could appear as bigger bubbles in the plots.

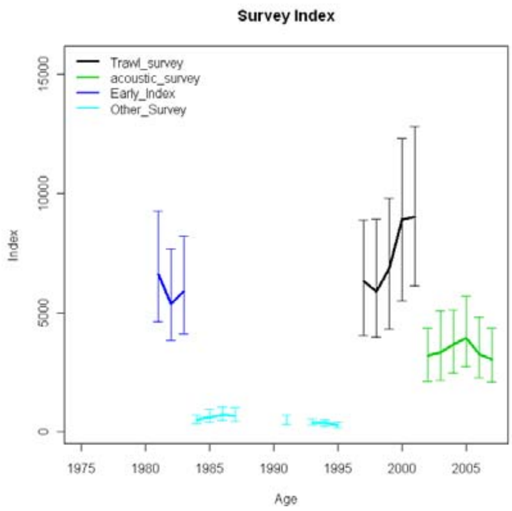

Catch numbers at cohort in Fishery 1
age
cohort
1970
1980
1990
2000
2
4
6
8
10
12


Catch numbers at cohort in Fishery 2
age
cohort
1970
1980
1990
2000
2
4
6
8
10
12

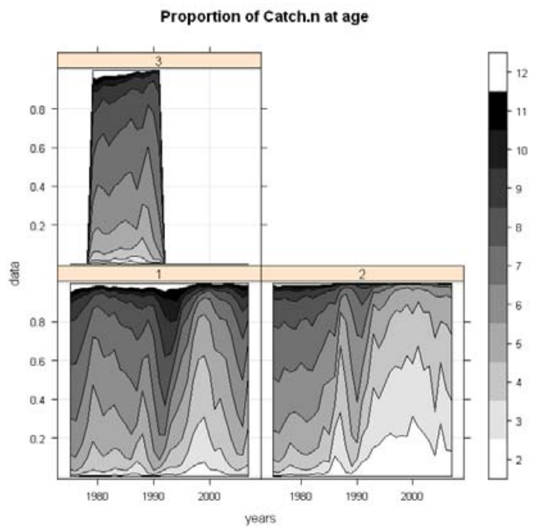

Catch numbers at cohort in Fishery 3
age
cohort
1970
1980
1990
2000
2
4
6
8
10
12

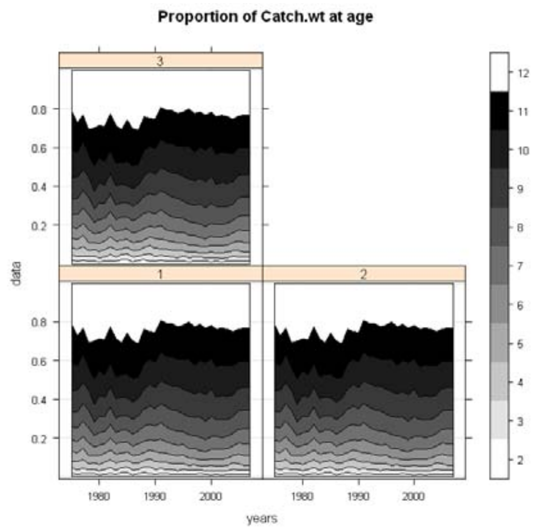
The trend of the fleet effort index is shown below (left). Vertical lines indicate 95% spread as computed based on the 100 simulated datasets. Each fleet effort time series has been given a different colour. The four different surveys, including a computed 95% spread, is given below too (right). As can be seen, no survey time series overlaps with another time series. As only 1 survey is available throughout the separable period, this is the most important survey as the assessment method uses the information in this survey to estimate stock numbers at age, and the terminal year fishing mortality.





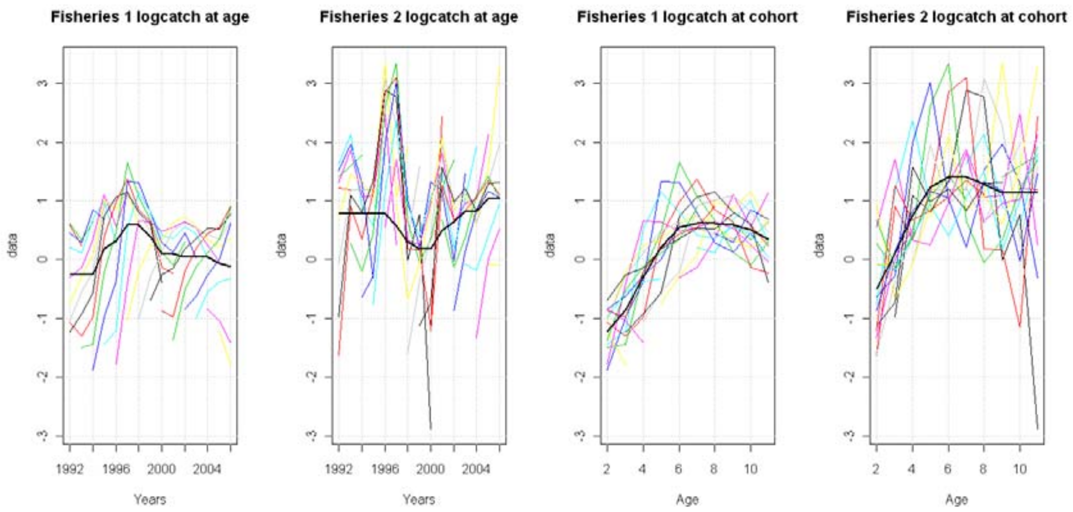
To investigate the development of catch number at age, their proportional contribution to the whole stock is plotted over the fishery, as well for catch weight at age. Catch numbers at age drop in all fisheries around 1990, while catch weight has been rather stable for a long period.





4.2 Assessment settings

To distinguish the most appropriate separable period length, as well as the separable age, two different types of plots have been made. First, to find the separable period, log-transformed catches have been plotted by age over the years. The fitted smoothed function that indicates the change over time is represented by the black solid line. A change in fishing trend can be observed for the past 6 years of data in both fisheries. Hence, the separable period has been set to 6 years. The log-transformed catches plotted by cohort indicate which age is targeted most by the fisheries as this results in the highest catches. Here, the black solid line represents the smoothed function over ages too. In both cases, age 7 appears to be the most targeted age group, hence, the separable age has been set at age 7.

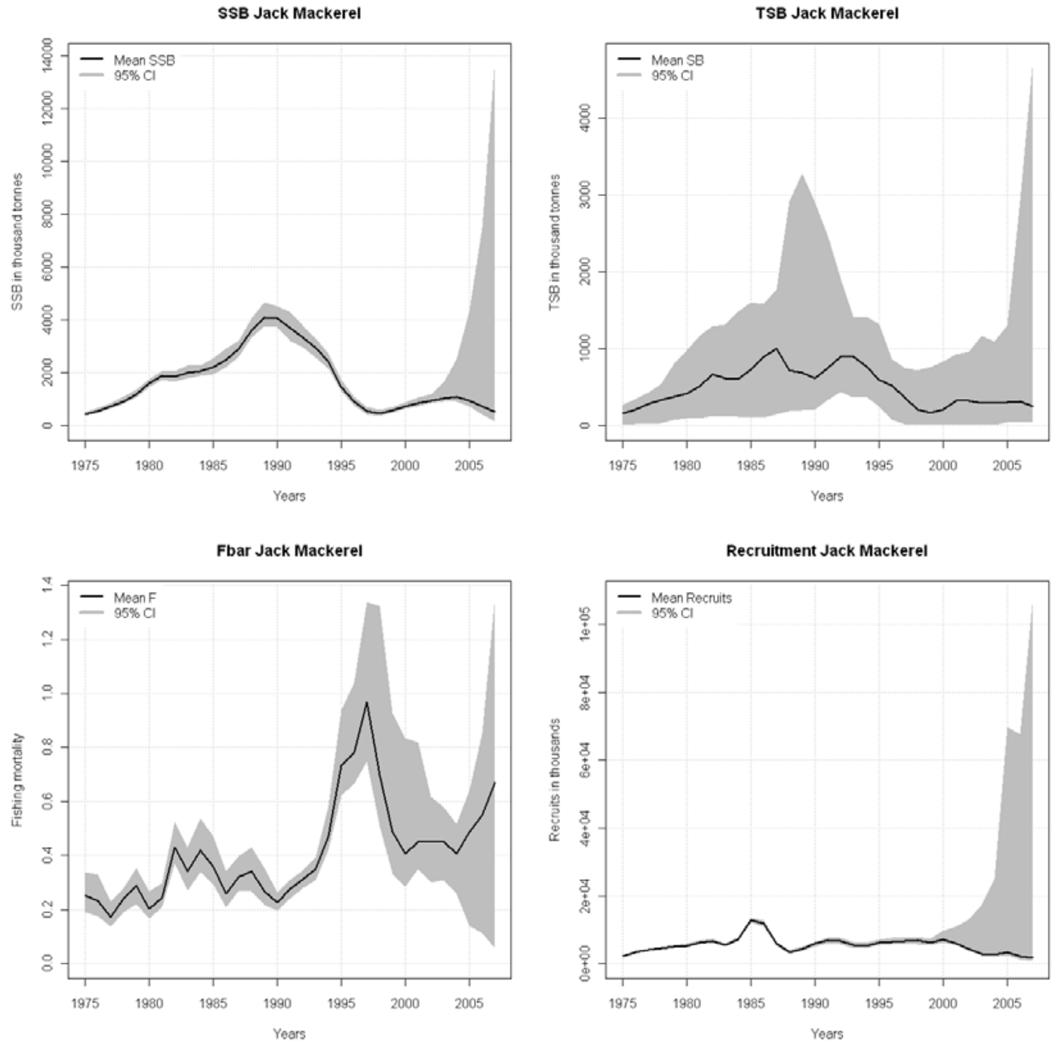


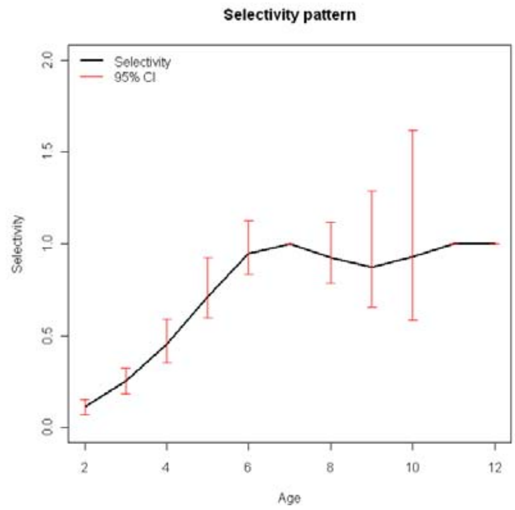
4.3 Assessment results

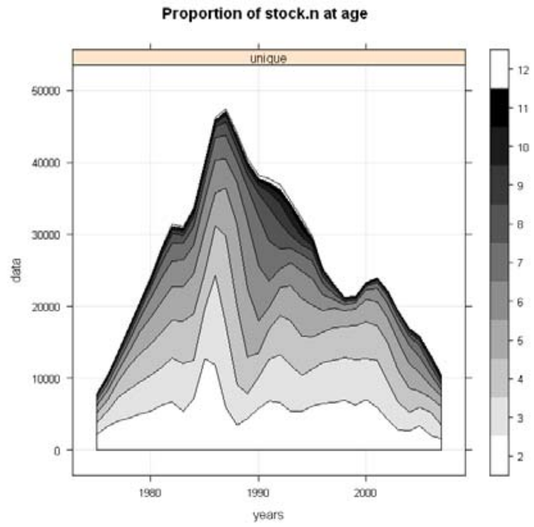
In total 6 different scenarios have been run to investigate the performance of the ICA assessment method in its ability to estimate the stock size of the simulated Jack Mackerel stock. A range of diagnostic plots, used to evaluate the fit of the model, can be found in appendix A. To limit the number of figures, per run, only 3 sets of figures have been produced. One of each for the 5% spread, 50% spread and 95% spread in outcomes.

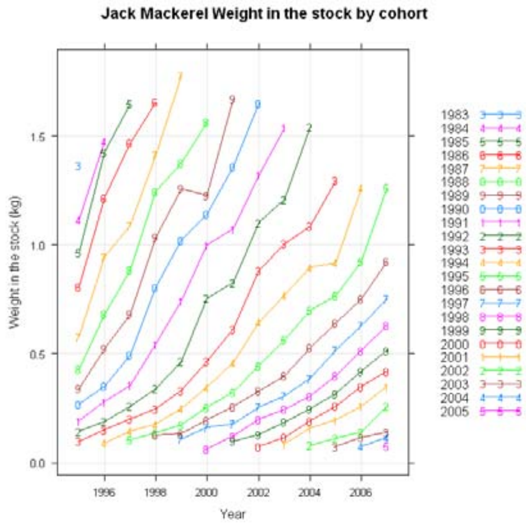
4.4 Standard graphs

4.4.1 Scenario 1:



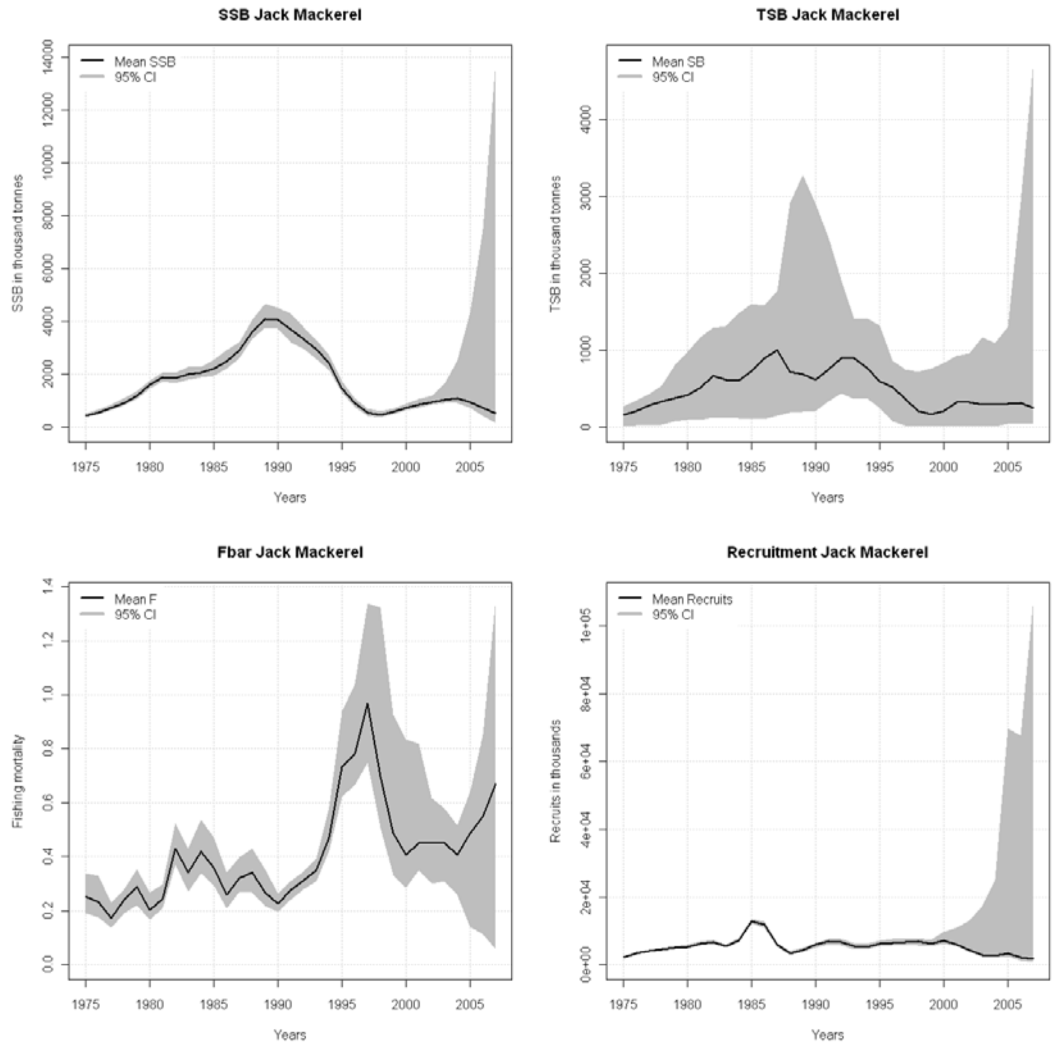


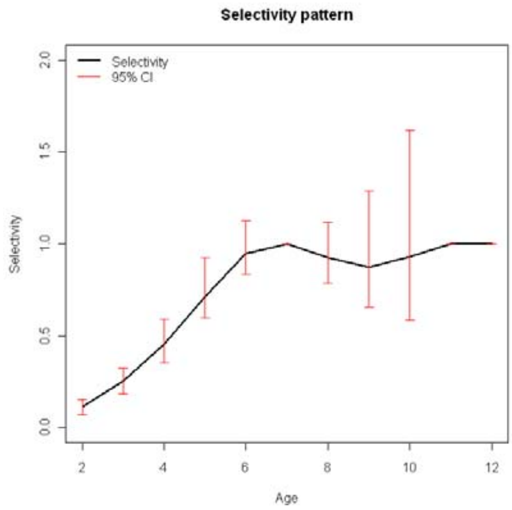


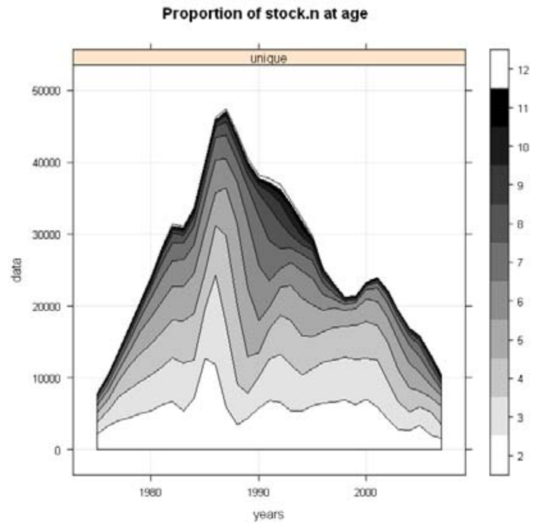


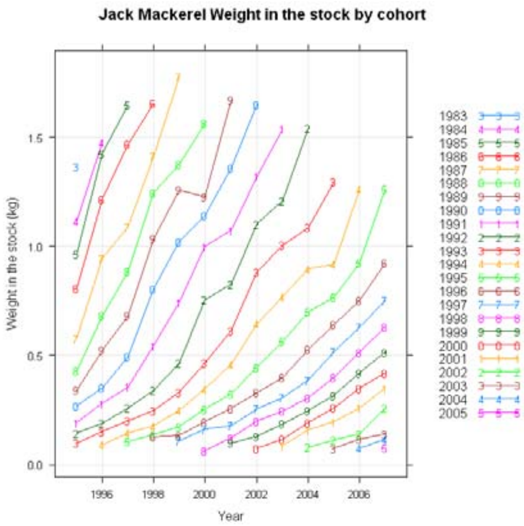
The stock status indicators (TSB, SSB, Fbar and stock numbers at age) indicate that the stock size is declining over the past four years while fishing mortality is increasing. Recruitment failure is indicated by the recruitment plot and is reflected as well in the stock numbers at age where lower abundances for young ages can be observed. Uncertainty however on these trends is large, especially in the most recent years. Uncertainty on total biomass (TSB) is large too in the period in which fishery 3 was operational.

4.4.2 Scenario 2



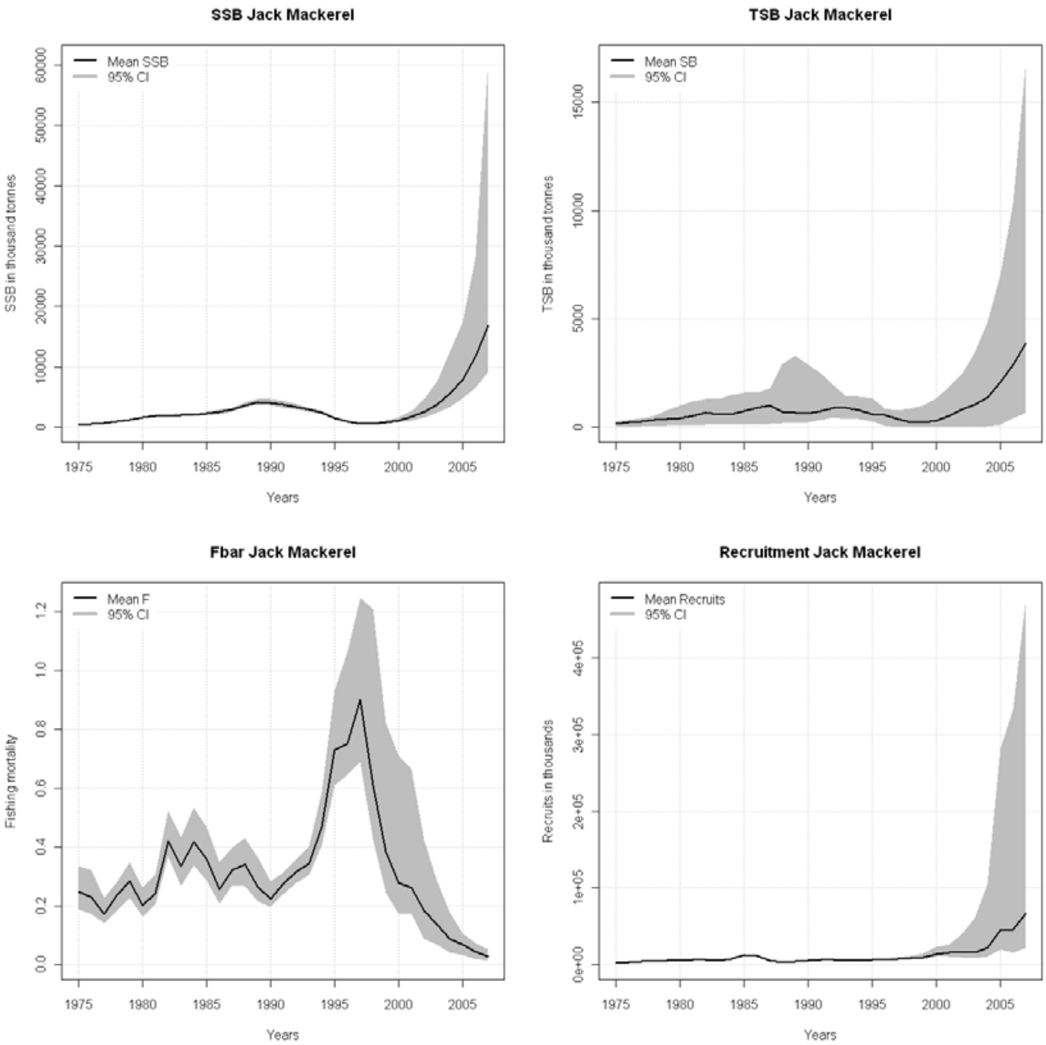


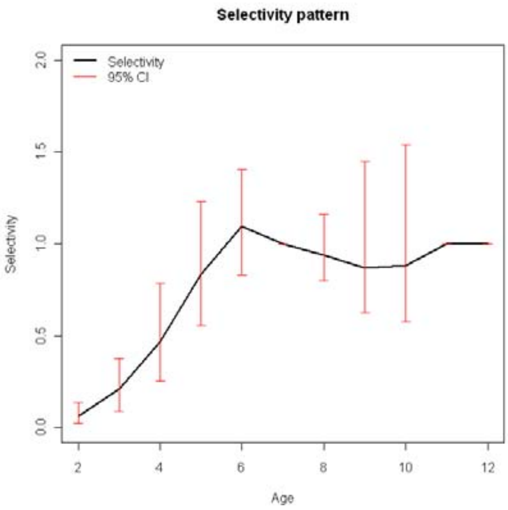


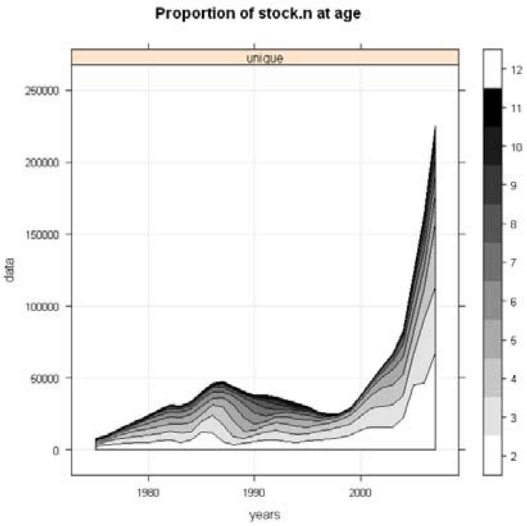


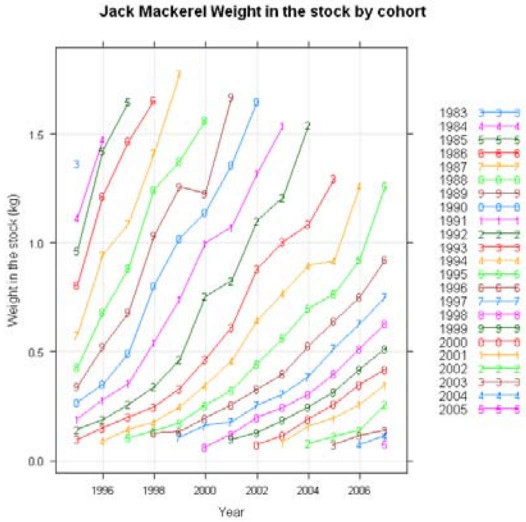
The stock status indicators (TSB, SSB, Fbar and stock numbers at age) indicate that the stock size is declining over the past four years while fishing mortality is increasing. Recruitment failure is indicated by the recruitment plot and is reflected as well in the stock numbers at age where lower abundances for young ages can be observed. Uncertainty however on these trends is large, especially in the most recent years. Uncertainty on total biomass (TSB) is large too in the period in which fishery 3 was operational. In relation to scenario 1, no significant differences can be observed between scenario 1 and scenario 2. Concluding that the effect of the trawl survey has only limited influence on the fitting of the assessment model.

4.4.3 <u>Scenario 3</u>



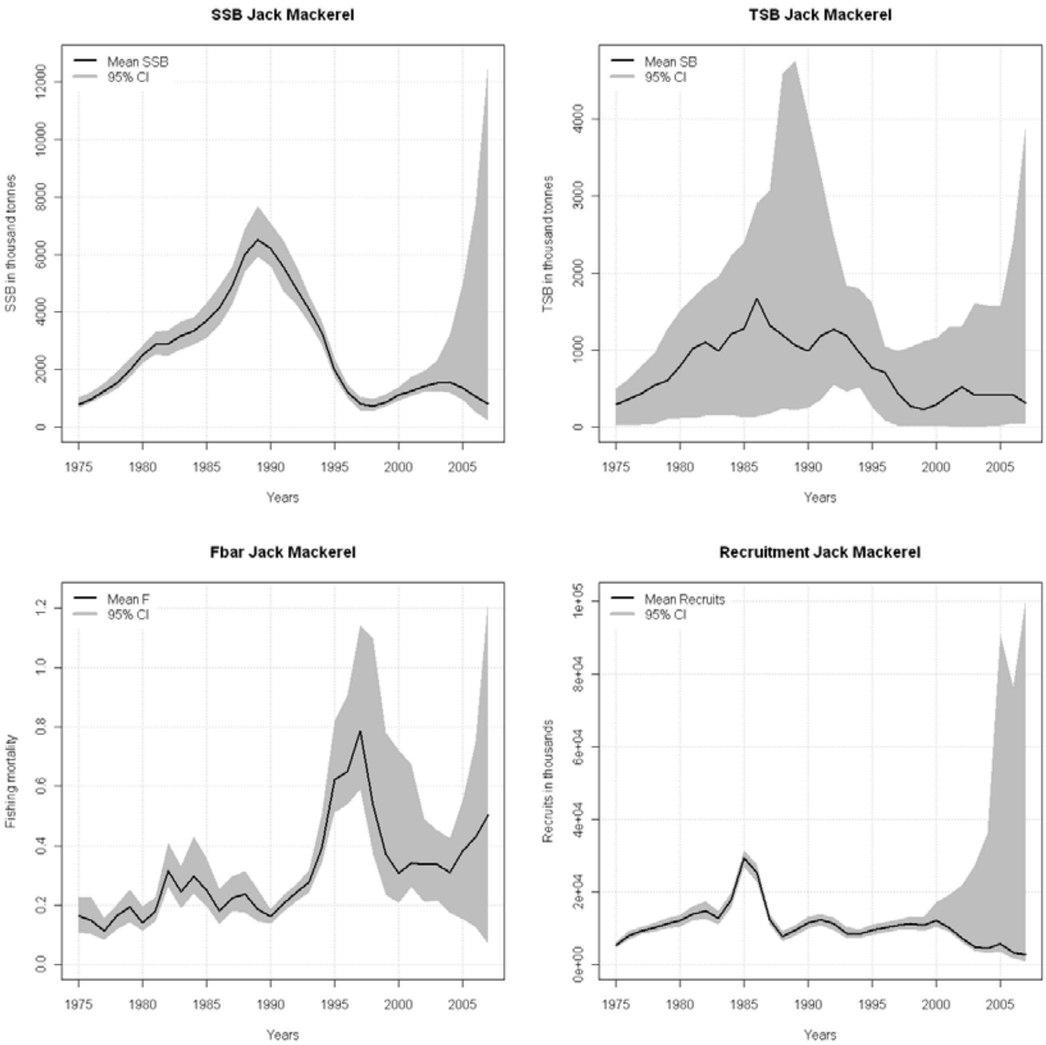


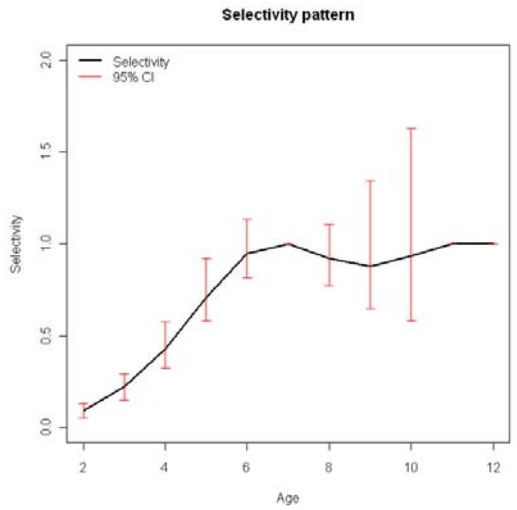


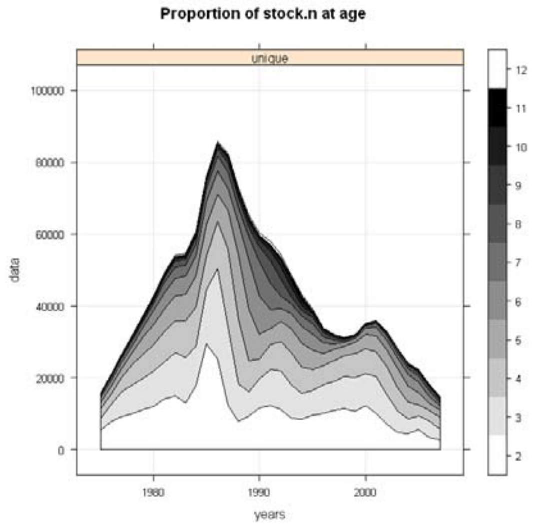


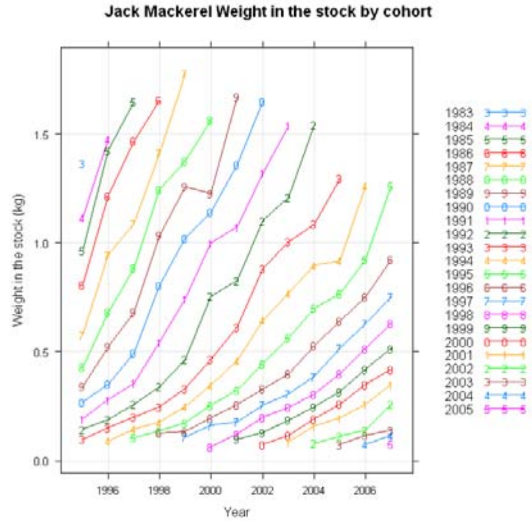
The stock status indicators (TSB, SSB, Fbar and stock numbers at age) indicate that the stock size is increasing rapidly over the past decade and fishing mortality is declining. These results show the opposite view on stock status as the results in which non-fishery dependent surveys were used to tune the assessment model. As effort has hardly ever been a reliable estimation of species abundance in pelagic fisheries, as well as it is uncertain how effort time series were computed, these results should be treated with care.

4.4.4 Scenario 4



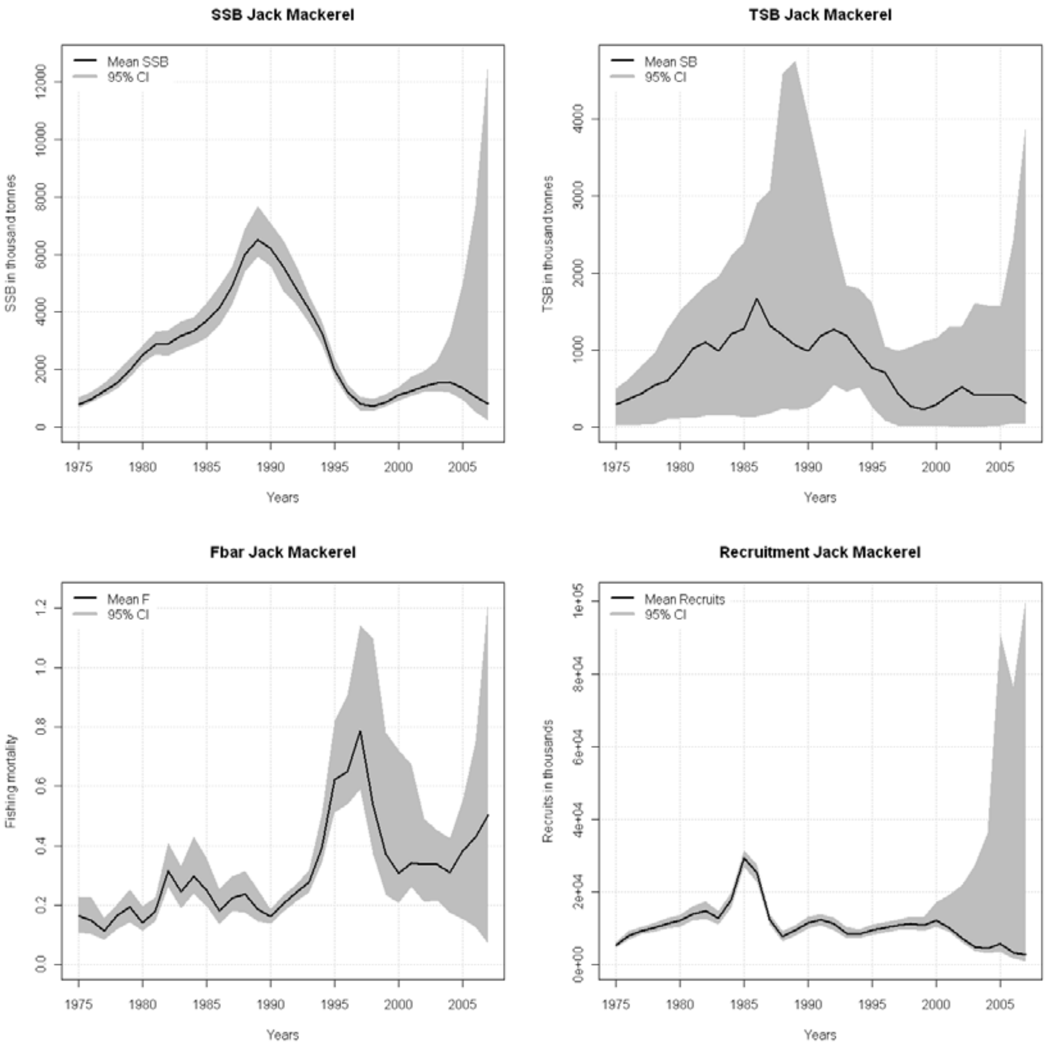


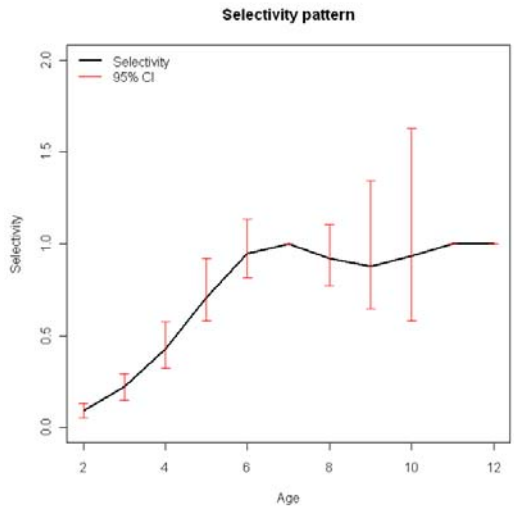


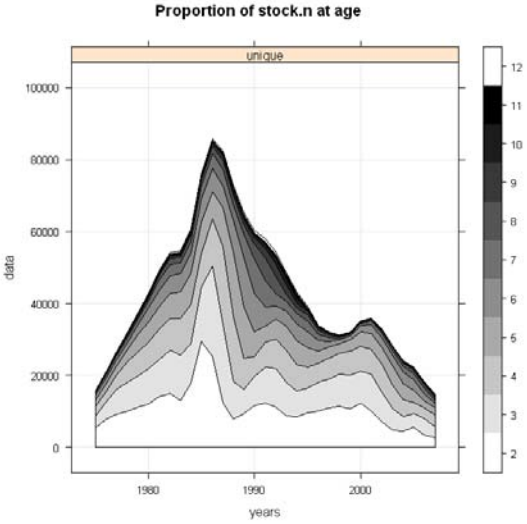


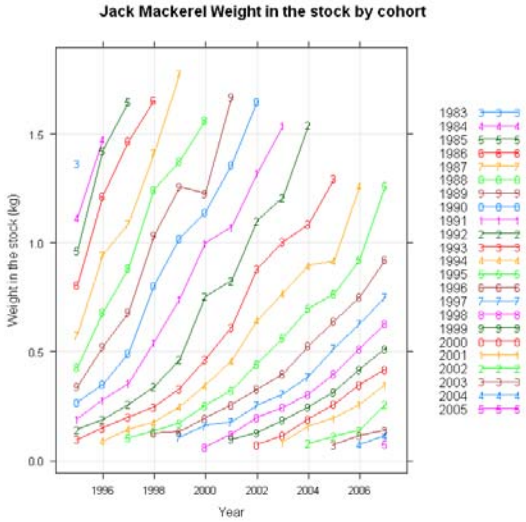
The stock status indicators (TSB, SSB, Fbar and stock numbers at age) indicate that the stock size is declining over the past four years while fishing mortality is increasing. Recruitment failure is indicated by the recruitment plot and is reflected as well in the stock numbers at age where lower abundances for young ages can be observed. Uncertainty however on these trends is large, especially in the most recent years. Uncertainty on total biomass (TSB) is large too in the period in which fishery 3 was operational.

4.4.5 Scenario 5



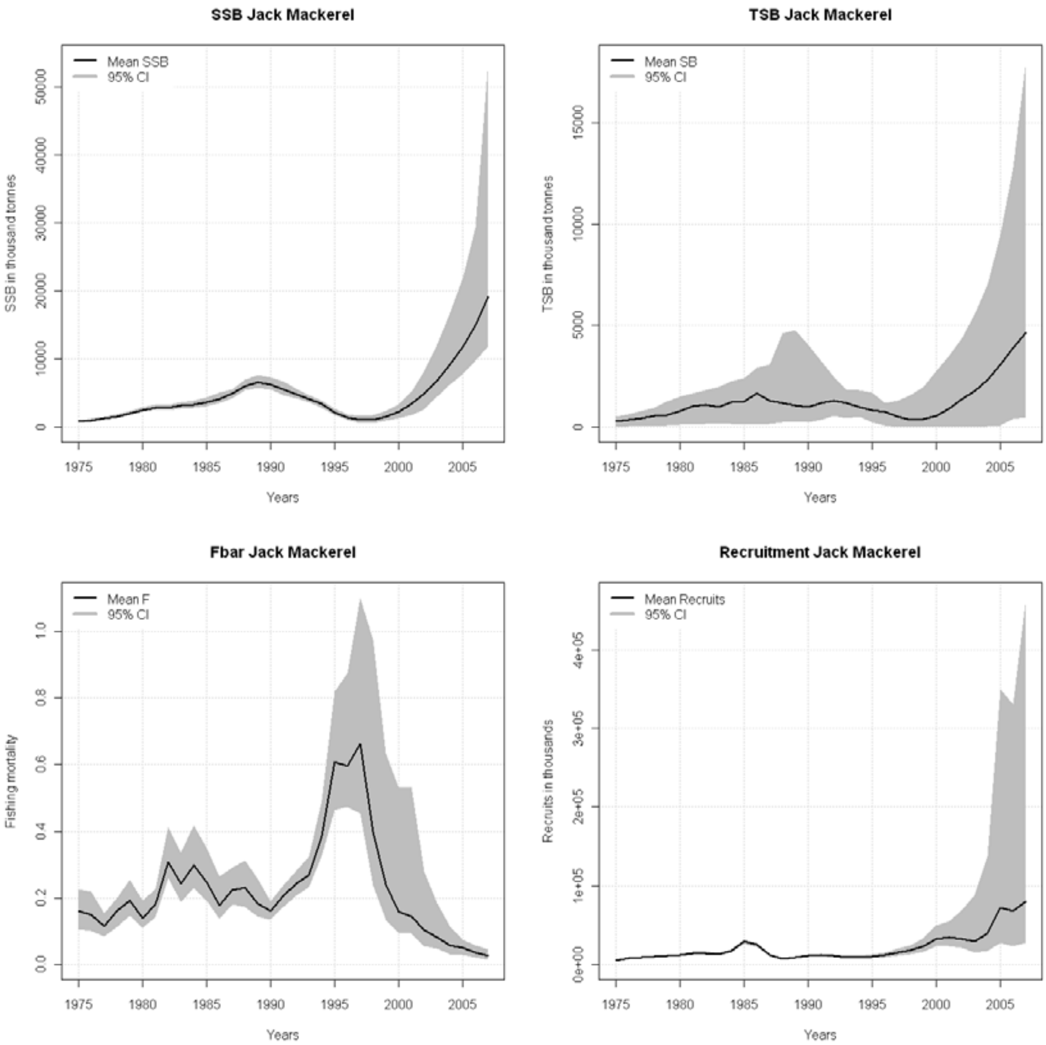


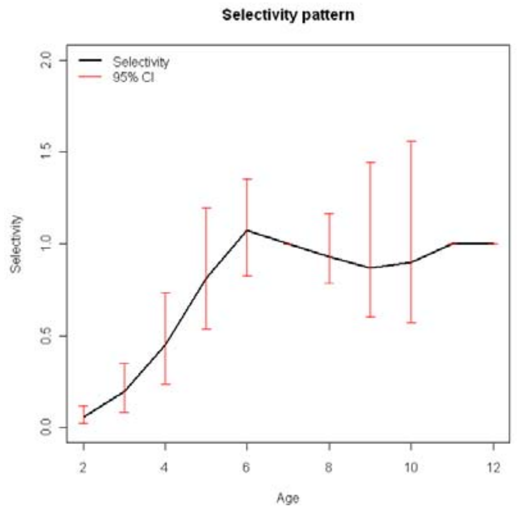


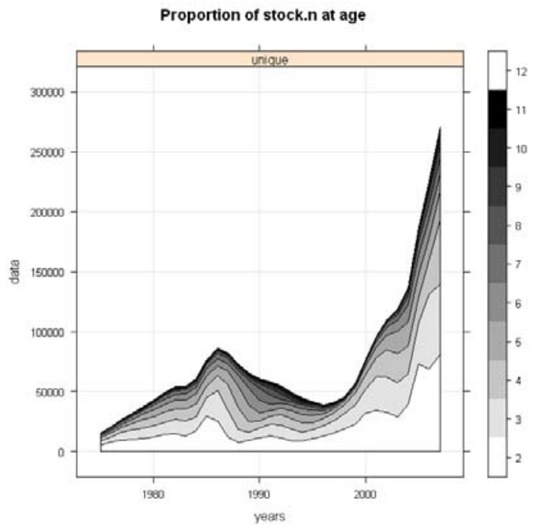


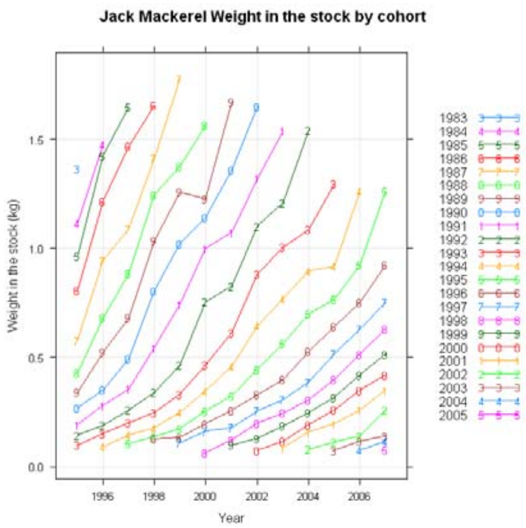
The stock status indicators (TSB, SSB, Fbar and stock numbers at age) indicate that the stock size is declining over the past four years while fishing mortality is increasing. Recruitment failure is indicated by the recruitment plot and is reflected as well in the stock numbers at age where lower abundances for young ages can be observed. Uncertainty however on these trends is large, especially in the most recent years. Uncertainty on total biomass (TSB) is large too in the period in which fishery 3 was operational. In relation to scenario 4, no significant differences can be observed between scenario 4 and scenario 5. Concluding that the effect of the trawl survey has only limited influence on the fitting of the assessment model.

4.4.6 Scenario 6









The stock status indicators (TSB, SSB, Fbar and stock numbers at age) indicate that the stock size is increasing rapidly over the past decade and fishing mortality is declining. These results show the opposite view on stock status as the results in which non-fishery dependent surveys were used to tune the assessment model. As effort has hardly ever been a reliable estimation of species abundance in pelagic fisheries, as well as it is uncertain how effort time series were computed, these results should be treated with care.

Overall, uncertainty in all stock indicators is large towards the more recent years. This might be due to a relative large error structure in the simulated datasets, as well as the lack in long-term tuning indices. Revision of the simulated dataset should give insight what source of data has a considerable contribution to the uncertainty in the results.

5 Conclusions

5.1 Assessment conclusions

At the meeting in Auckland, the assessment outcomes as listed above were not presented and discussed as it was decided by the assessment simulation task team to first focus on getting the simulated dataset right. At this stage, no further concluding remarks can be made based on the results shown above as many elements in the simulated dataset are in need of clarification. If participation by IMARES in the SPRFMO meetings will be continued, results will be further discussed in a later stage. Remarks on the work done during the Auckland meeting are given below.

5.2 Auckland meeting

The assessment simulation task team (ASTT), represented by the Peruvian, Chilean and European members, discussed the design of the simulated data as supplied by dr. J. Ianelli on the 22nd of October. Unfortunately, due to miscommunication, the Peruvian members did not receive the dataset in time and will respond to the design of the simulated dataset after the meeting.

The most important questions raised by the members concerning the dataset, as will be posted to dr. J. Ianelli, are described below. All participating members should agree on these points in order to finalize the design of the dataset. To assure that similar assessment settings will be used, a section is added to discuss the parameter settings that are needed to be set outside the assessment and do not rely on the simulated dataset. The general characteristics of the simulated data are given in a table below.

Questions regarding the simulated dataset “JM_Sim_Dataset1_v2.zip”:

General remark: Although in contrary to the recent communication between the ASTT and dr. J. Ianelli, the group views it as important that the features within the simulated data are as representative as possible for the Jack Mackerel stock. Hence, it would be very welcome if values for e.g. landings and survey series are in close agreement with the real data. However, the addition of extra data, like a survey times series, that can function to test the flexibility of the assessment methods used, is still very welcome.

- The landings of the offshore fishery range from the years 1975 until 2007. However, this time series starts with a series of years where the landings equal 2. The ASTT questions whether these values represent tiny known landings, zero landings or artificially chosen small landings. In case of the latter situation, what is the reasoning not to supply ‘not available’ values for these years?.

- As is commented within the simulated datasets, catch biomass uncertainty is listed as standard errors. Some members questioned whether this should be interpreted as the coefficient of variation or as standard errors, and in case of the latter situation, why it is chosen to list standard errors in stead of the coefficient of variation?

- The age ranges from years 2 to 12. Is year 12 a plus group? If so, could it be made apparent by adding a “+” to the age ranges?

- Concerning the representativeness of the acoustic survey, would it be possible to extend this time series up to the length of the current acoustic survey active within the Chilean waters?.

- In recent years, an egg / biomass survey has been executed on the Jack Mackerel stock. Would it be possible to include this survey?

- If available, could targeted age ranges per survey time series be supplied?.

- The acoustic survey currently ranges from 2002 until 2007, its time series representing biomass. In combination with the proportion at age within this survey it is possible to distinguish the main ages targeted, in a quantitative manner, for this survey. However, the proportions at age are only listed for the years 2002 until 2006, where there is no information supplied for its final year: 2007. The group questions whether this series was designed to have a missing year on age composition data, or if it should have been supplied?

- It remains unclear to the ASTT why maturity at age within the population levels of to a maximum value of 0.5, instead of the common assumed value 1?

- The supplied effort series is a very welcome addition of the simulated dataset. However, would it be possible to supply coefficients of variation for these time series as well?

- It remains unclear to the ASTT what the exact units are of e.g. the listed landings (tonnes, or kg's), survey indices etc. Would it be possible to make these available?

- Currently, no natural mortality estimates are given in the dataset. Are these standard generated within the model you are using to generate these data or would you advice to estimate these outside the model, or, if possible, inside the assessment method?

6 Work in progress

To be fully able to compare the performance of the different methods used within the ASTT, it is recommended that assessment settings correspond between methods too. It should be stated however that different methods have the need for different control settings that cannot be compared in a straight manner. These settings should be supplied by expert knowledge and be described in detail in the reporting of the assessment results.

Settings that can be compared are listed below.

- Natural mortality. If it is decided to estimate natural mortality outside the assessment model, what values can be decided on to be used as the natural mortality rates at age.
- Stock to recruitment relationship (SSR). If it is decided that the SSR plays a role in the assessment, what functional relationship is assumed and what is concerned to be the most representative parameters for this relationship. As well, to what extend should the SRR be weighted within the assessment method.
- Target age. What is the age group that is most efficiently targeted by the fleets.
- Fisheries period. What is the most appropriate period in time assumed in which no major shifts in trend in the fisheries has occurred (i.e. the separable period).
- Survey importance: What are the main targeted age groups within each survey
- Survey importance: To what extend do the different surveys contribute to the assessment (weighting).

7 Quality Assurance

IMARES utilises an ISO 9001:2000 certified quality management system (certificate number: 08602-2004-AQ-ROT-RvA). This certificate is valid until 15 December 2009. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

References

ICES (2008). Report of the Herring Assessment Working Group South of 62 N (HAWG). I. C. 2008/ACOM:02**:** 613.

ICES (2009). Report of the Herring Assessment Working Group for the Area South of 62 N (HAWG). ICES C.M. 2009/ACOM:03**:** 653.

Kell, L. T., I. Mosqueira, P. Grosjean, J.-M. Fromentin, G. D., R. Hillary, E. Jardim, S. Mardle, M. A. Pastoors, J. J. Poos, F. Scott and R. D. Scott (2007). "FLR: an open-source framework for the evaluation and development of management strategies." ICES Journal of Marine Science **64**: 640-646.

Patterson, K. R. (1998). Integrated Catch at Age Analyses Version 1.4. Report No. 28, S.F. Research.

R Development Core Team (2008). R: A language and environment for statistical computing. Vienna, Austria, R Foundation for Statistical Computing.

Justification

Rapport C 123/09
Project Number: PFA part: 4301100007
CVO part: 4301217007

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Dr. M. Dickey-Collas

Signature: Mark Collas

Date: 26 th. November

Approved: Dr.ir. T.P. Bult
Head of department Fisheries

Signature:

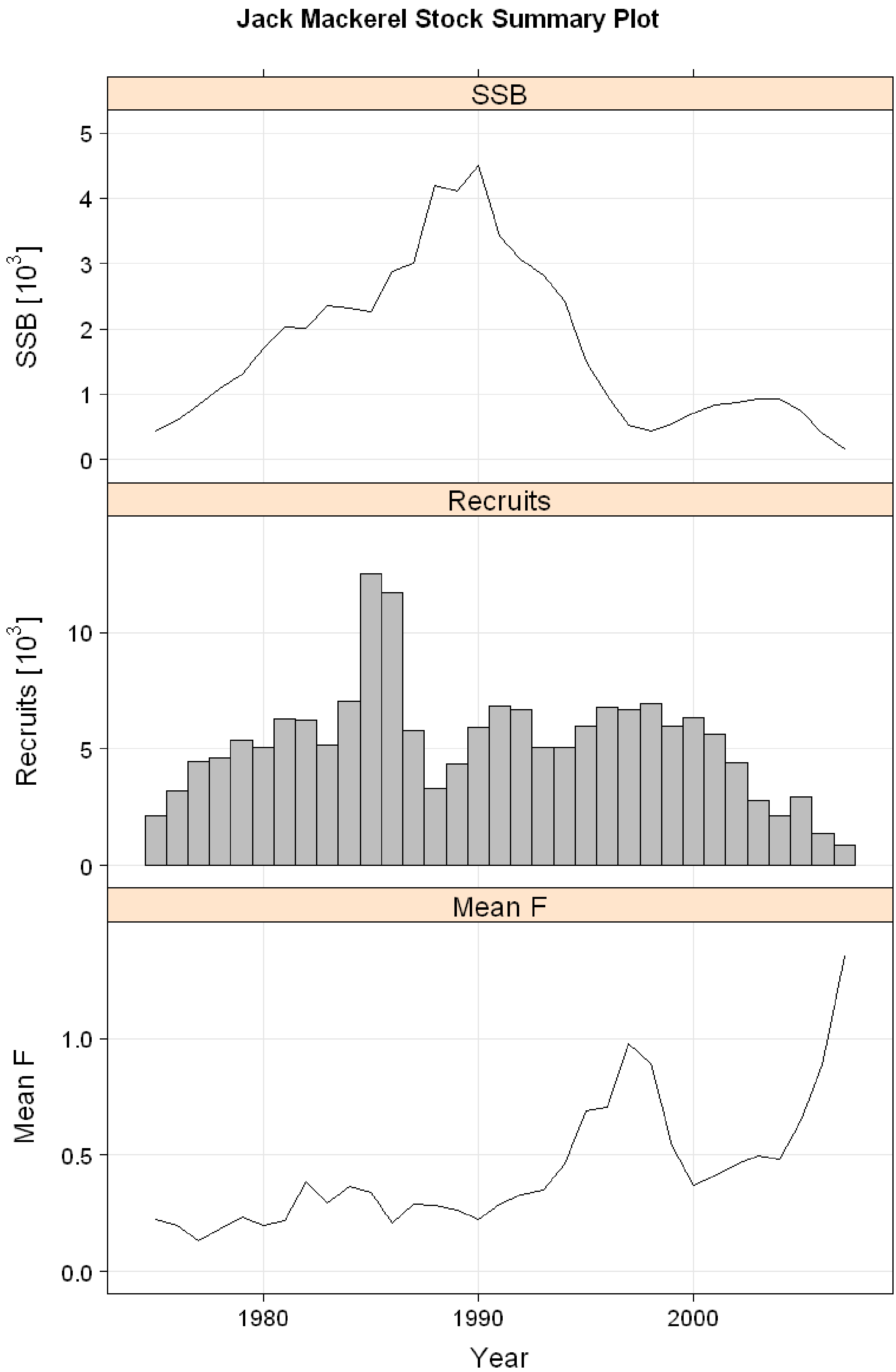
Date: 26 th. November

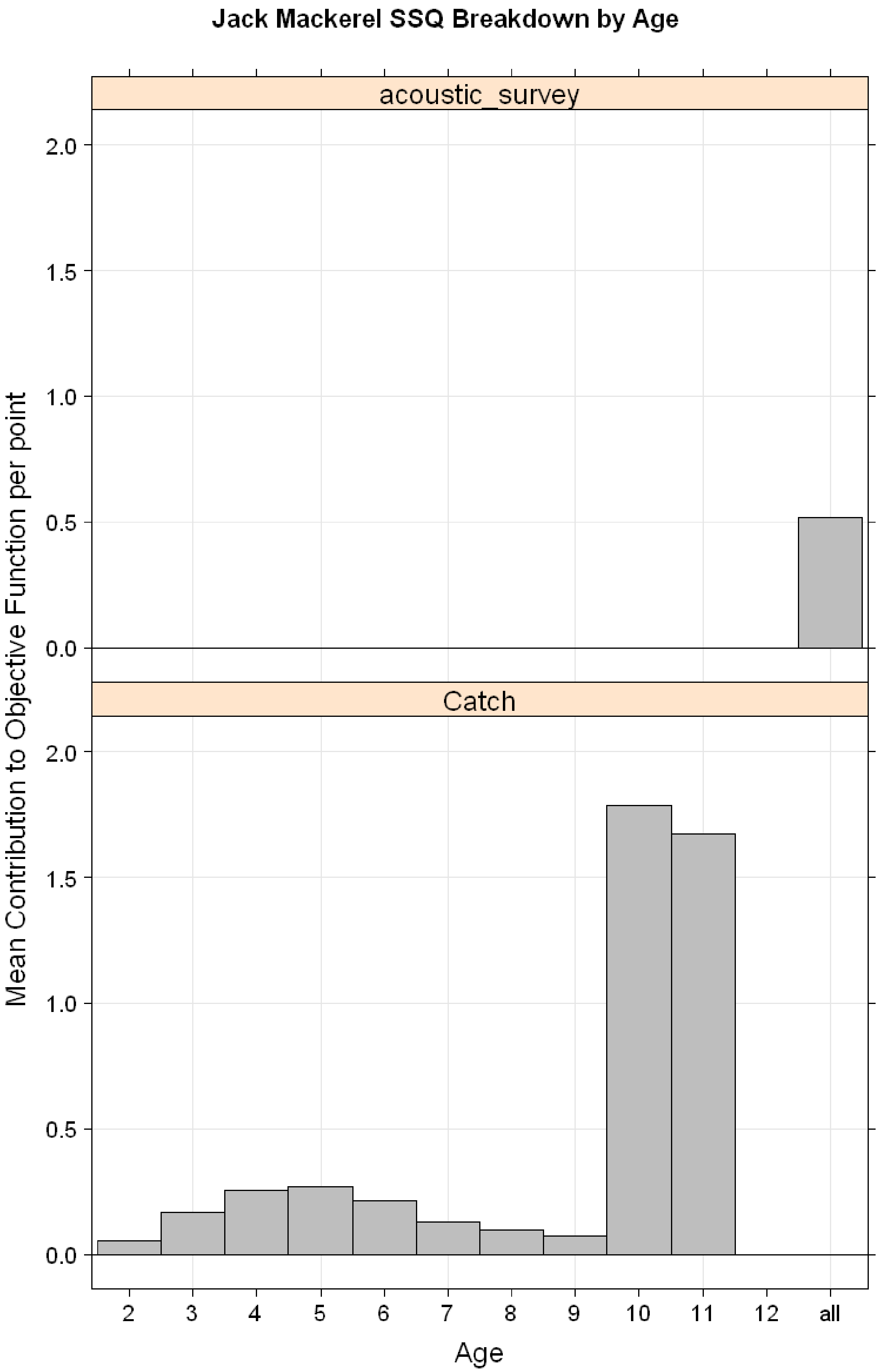
Number of copies:	8
Number of pages	208
Number of tables:	3
Number of appendix attachments:	1

8 Appendix A

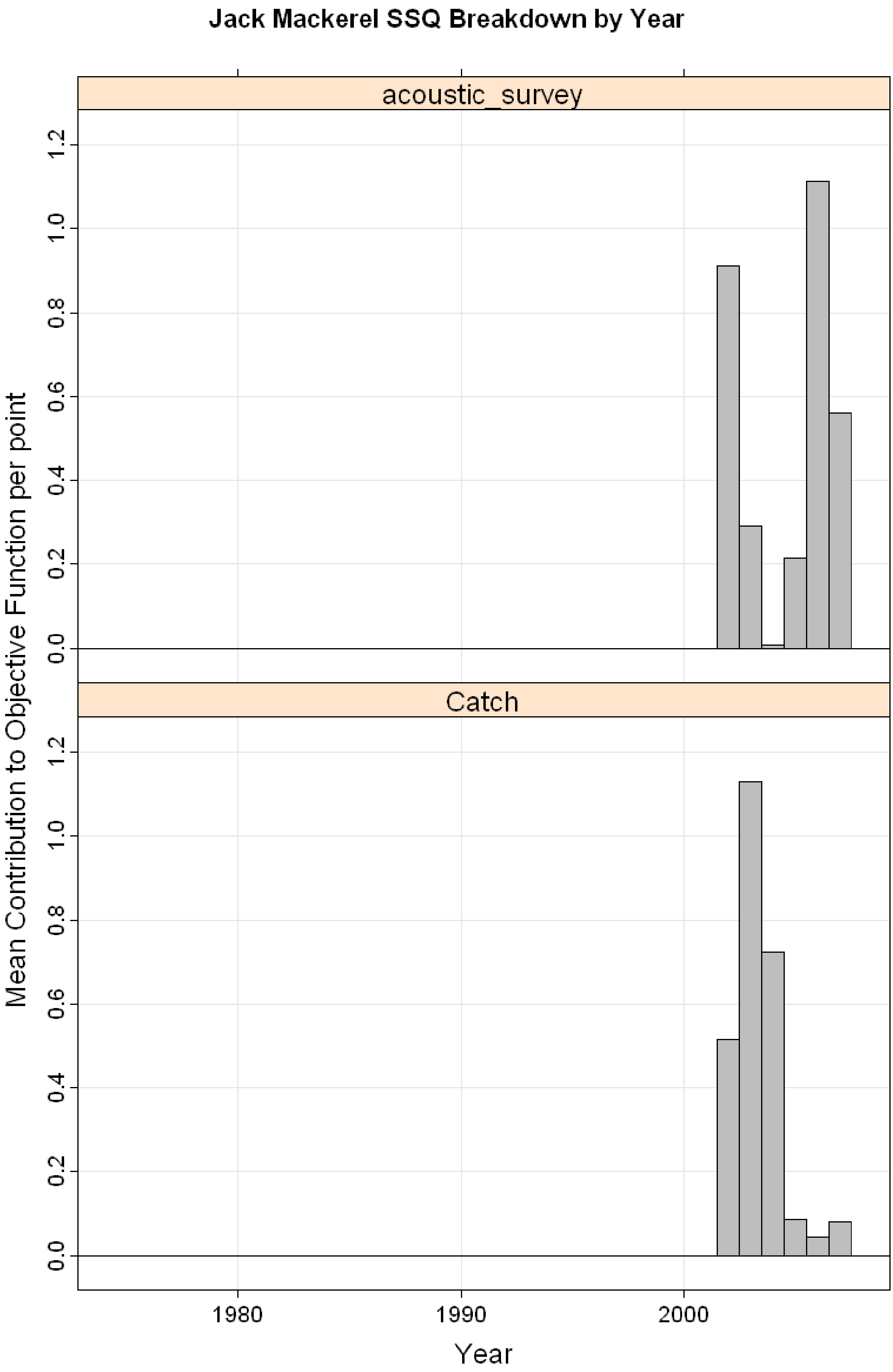
8.1 Scenario 1

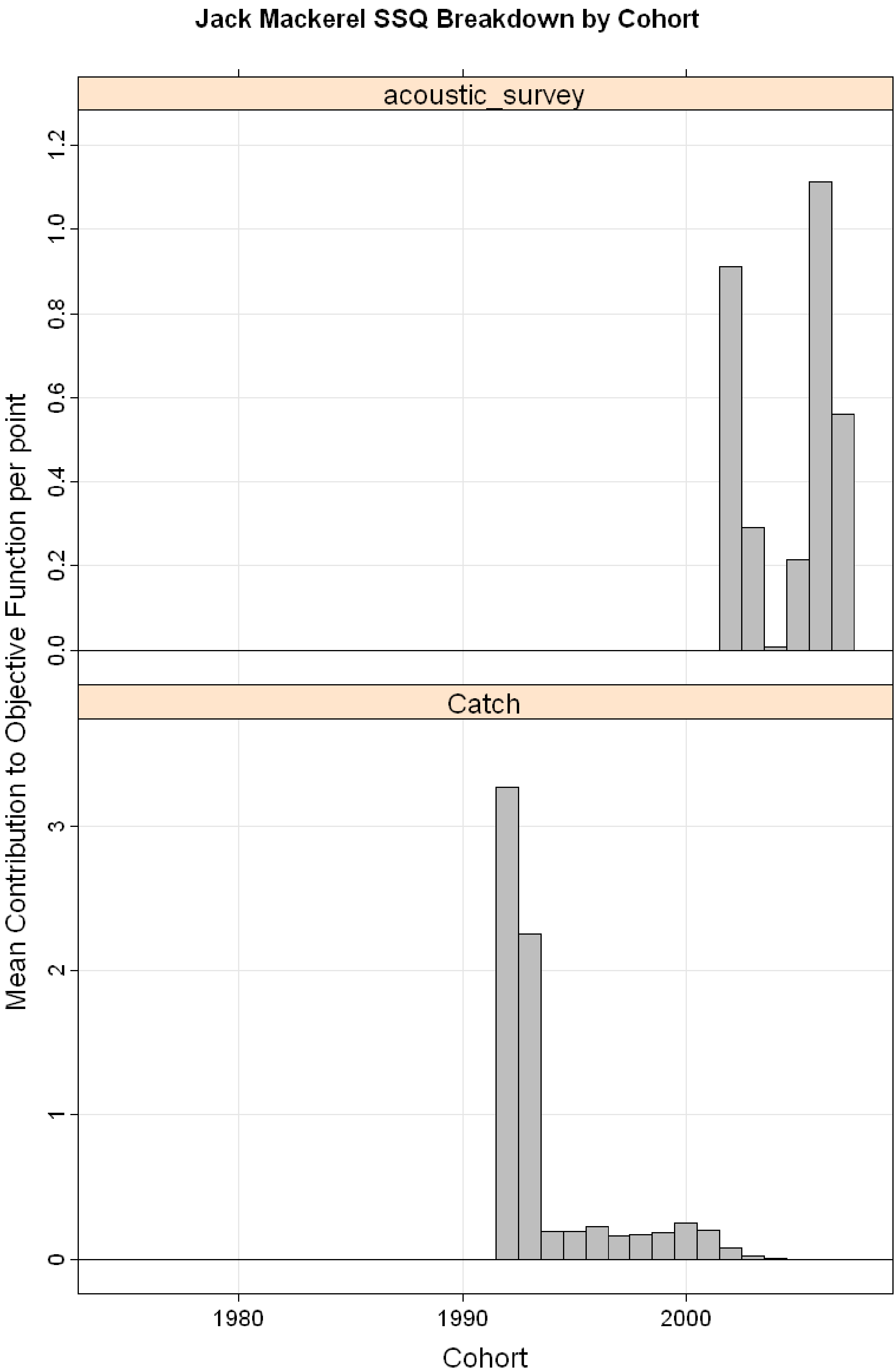
8.1.1 5%

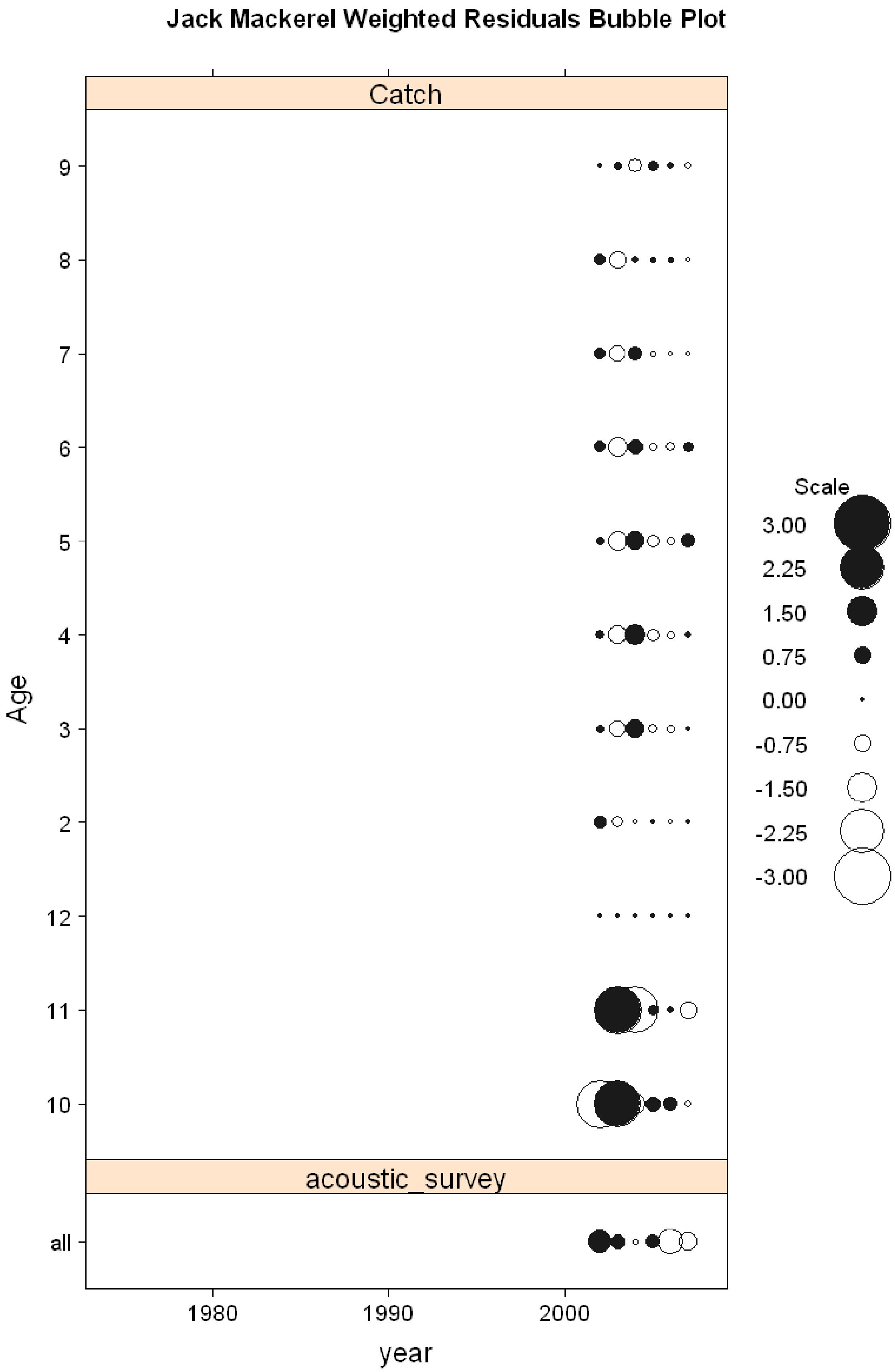

Jack Mackerel Stock Summary Plot
SSB
Recruits
Mean F
SSB [10^3]
Recruits [10^3]
Mean F
0
1
2
3
4
5
10
0.0
0.5
1.0
1980
1990
2000
Year

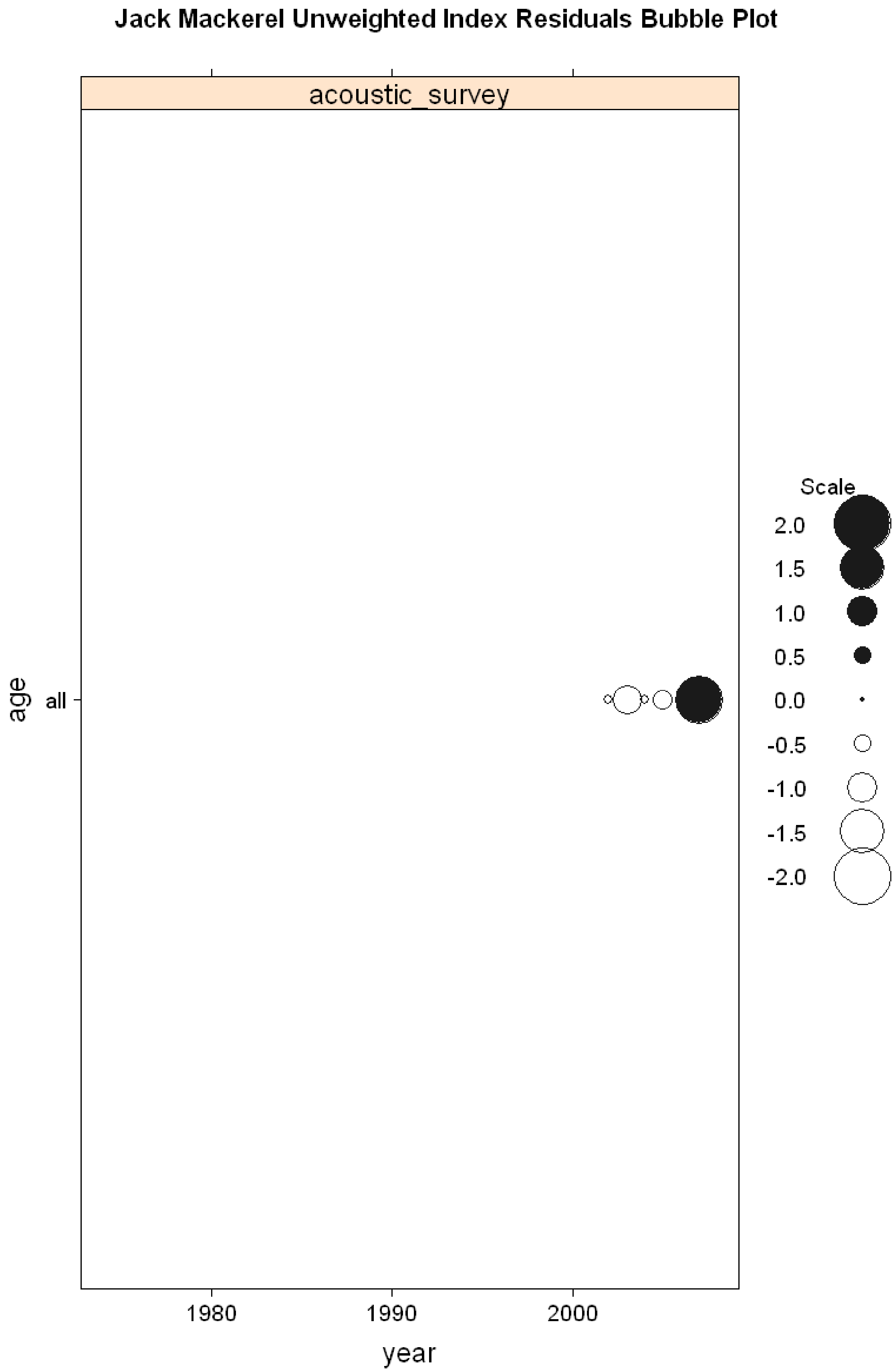


Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Mean Contribution to Objective Function per point
Age
2.0
1.5
1.0
0.5
0.0
2
3
4
5
6
7
8
9
10
11
12
all

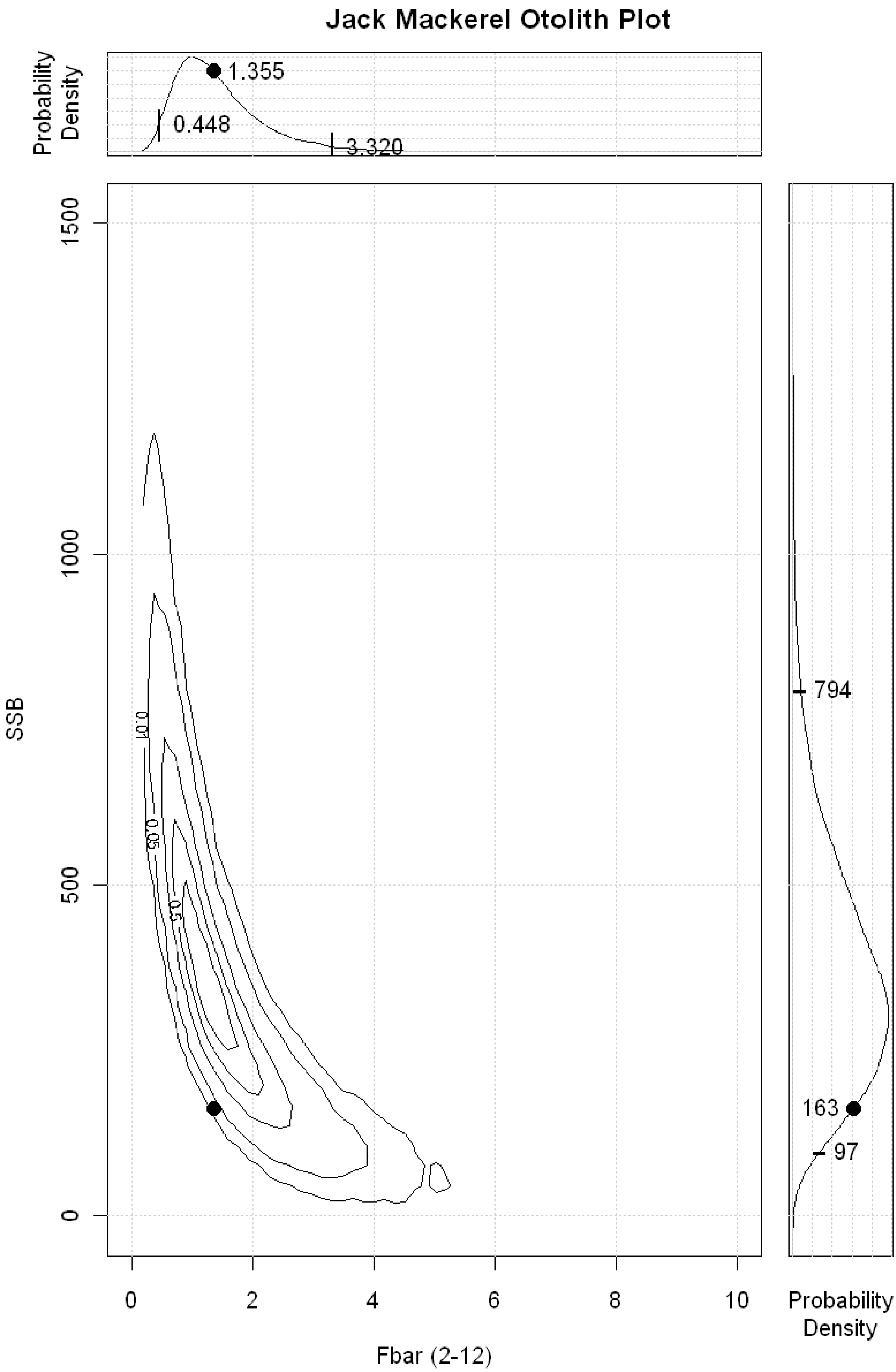

Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Mean Contribution to Objective Function per point
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1980
1990
2000
Year


Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Mean Contribution to Objective Function per point
Cohort
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
1
2
3
1980
1990
2000

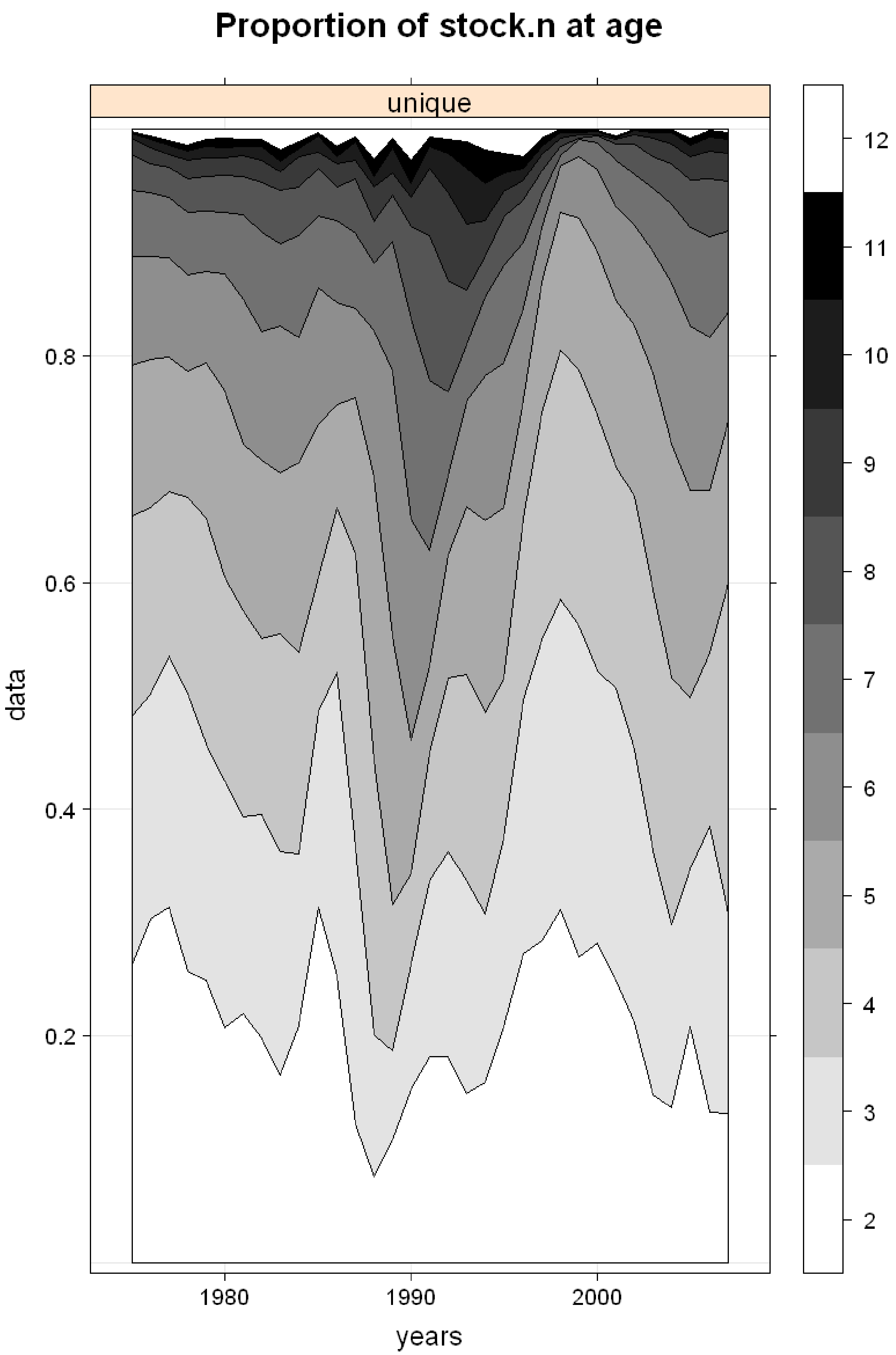

Jack Mackerel Weighted Residuals Bubble Plot
Catch
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00

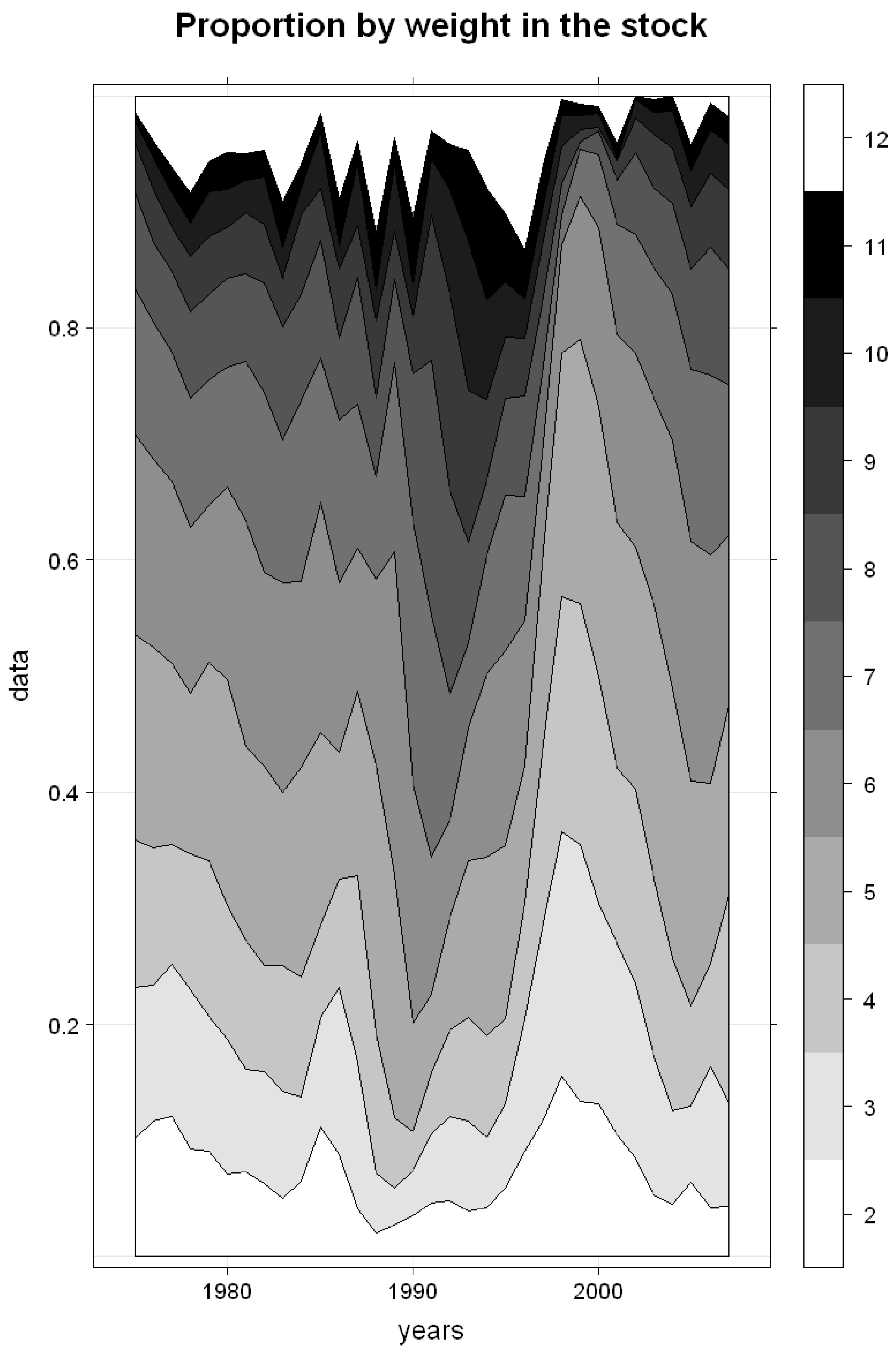


Jack Mackerel Unweighted Index Residuals Bubble Plot
acoustic_survey
age
all
1980
1990
2000
year
Scale
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0



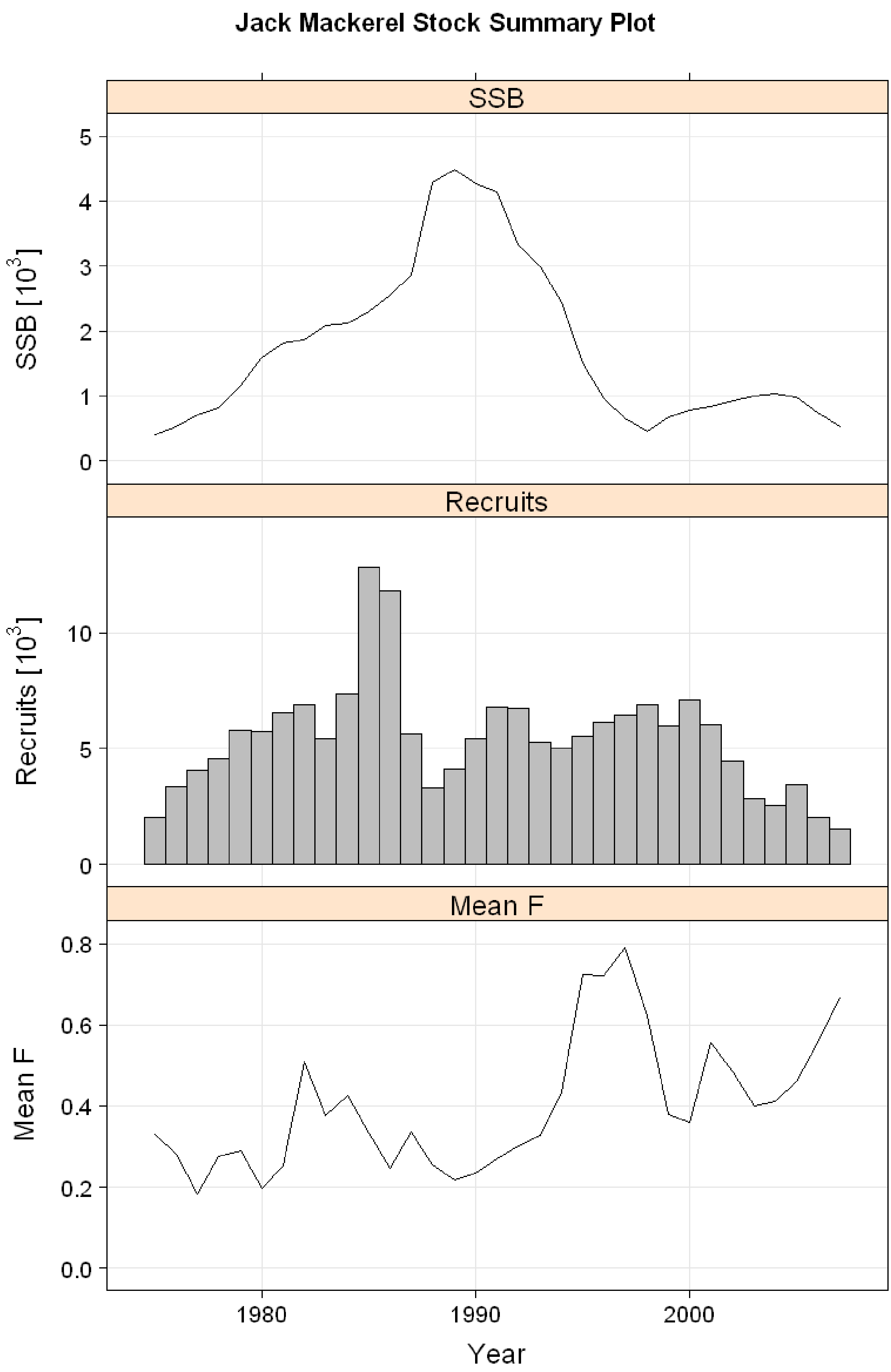
Jack Mackerel Otolith Plot
Probability Density
1.355
0.448
3.320
SSB
1500
1000
500
0
0.01
0.05
0.5
0
2
4
6
8
10
Fbar (2-12)
794
163
97
Probability Density

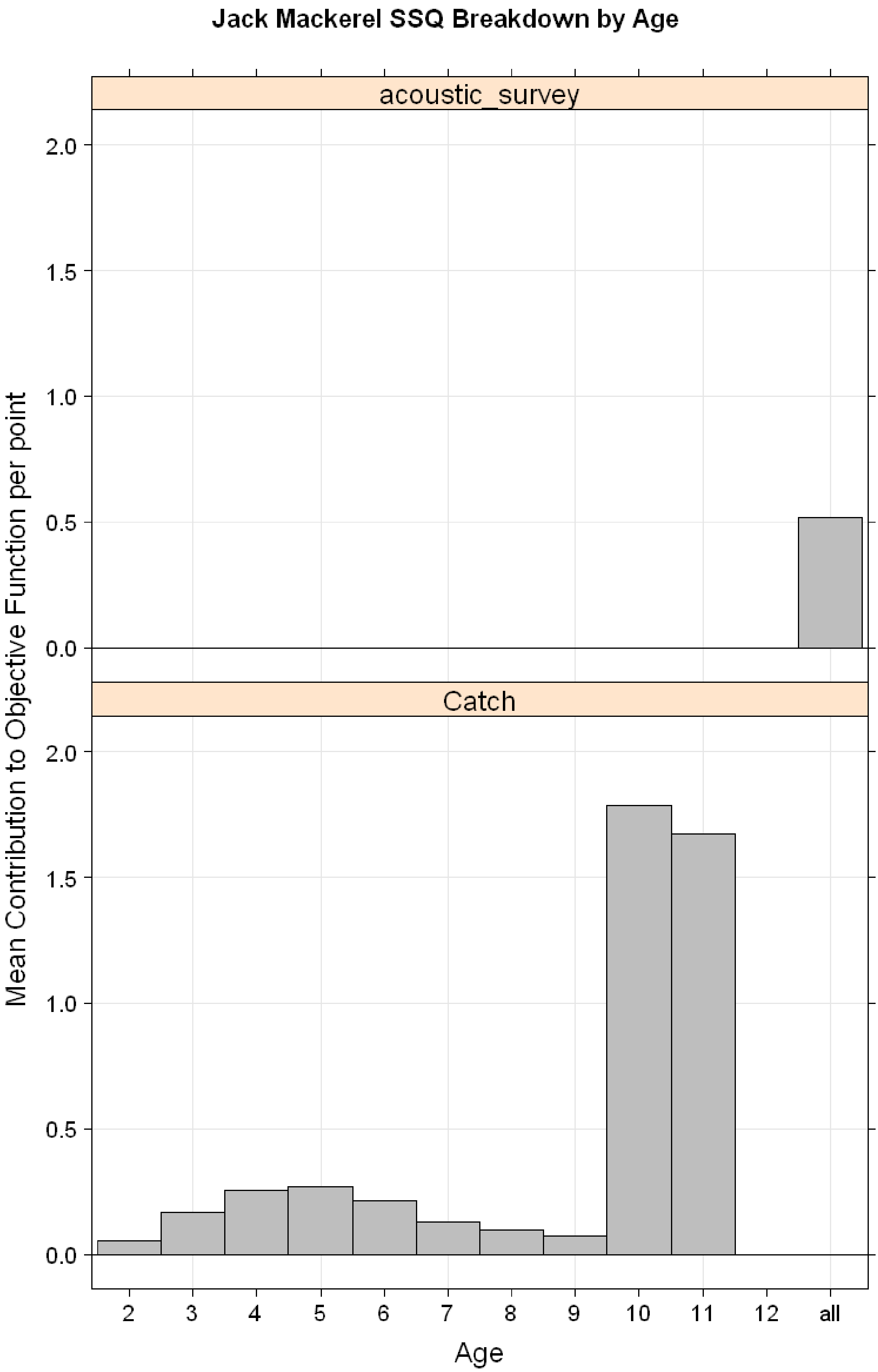

Proportion of stock.n at age
unique
data
0.8
0.6
0.4
0.2
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2



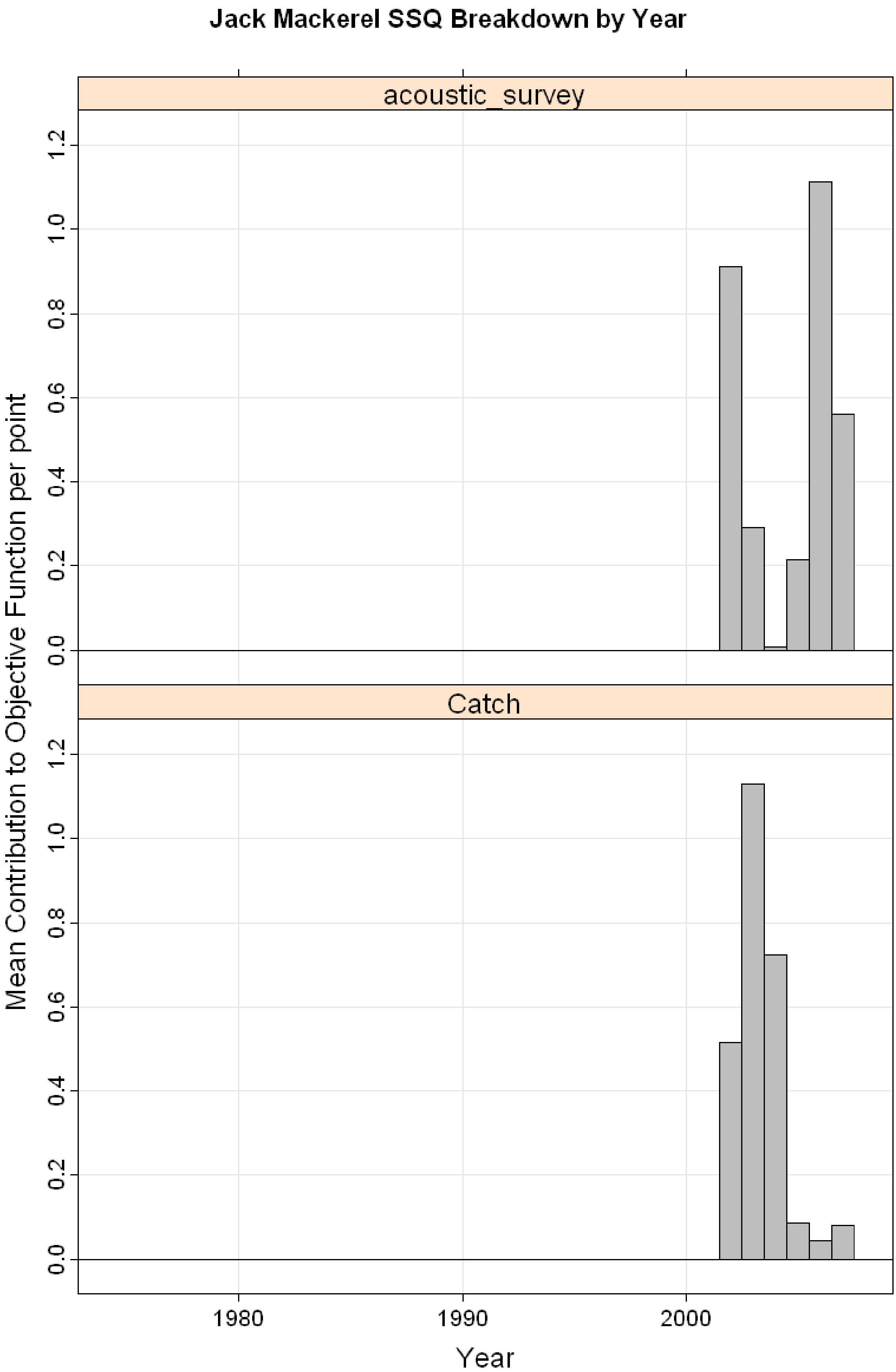
Proportion by weight in the stock
data
years
0.2
0.4
0.6
0.8
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

8.1.2 <u>50%</u>

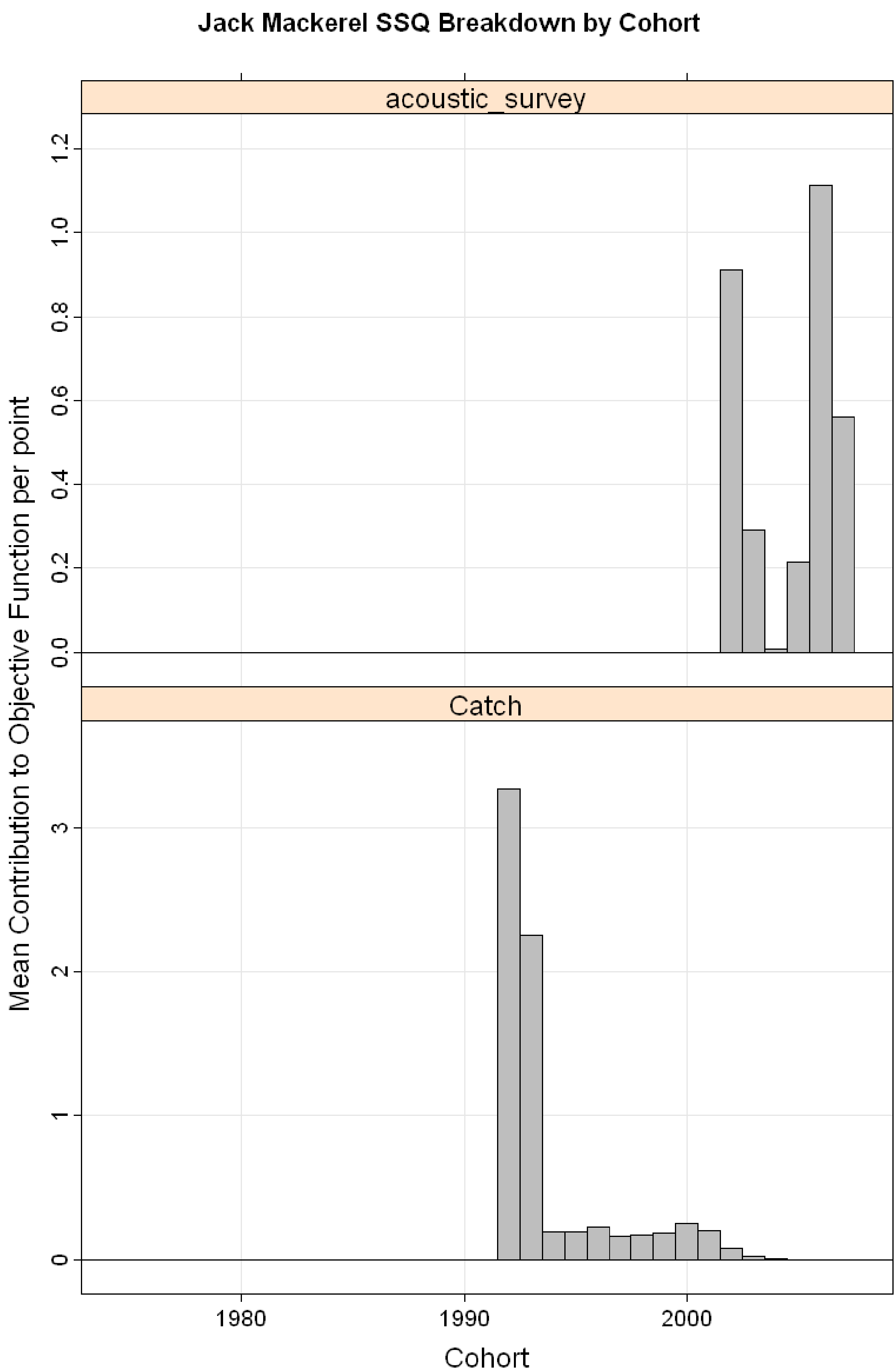

Jack Mackerel Stock Summary Plot
SSB
SSB [10^3]
5
4
3
2
1
0
Recruits
Recruits [10^3]
10
5
0
Mean F
Mean F
0.8
0.6
0.4
0.2
0.0
1980
1990
2000
Year

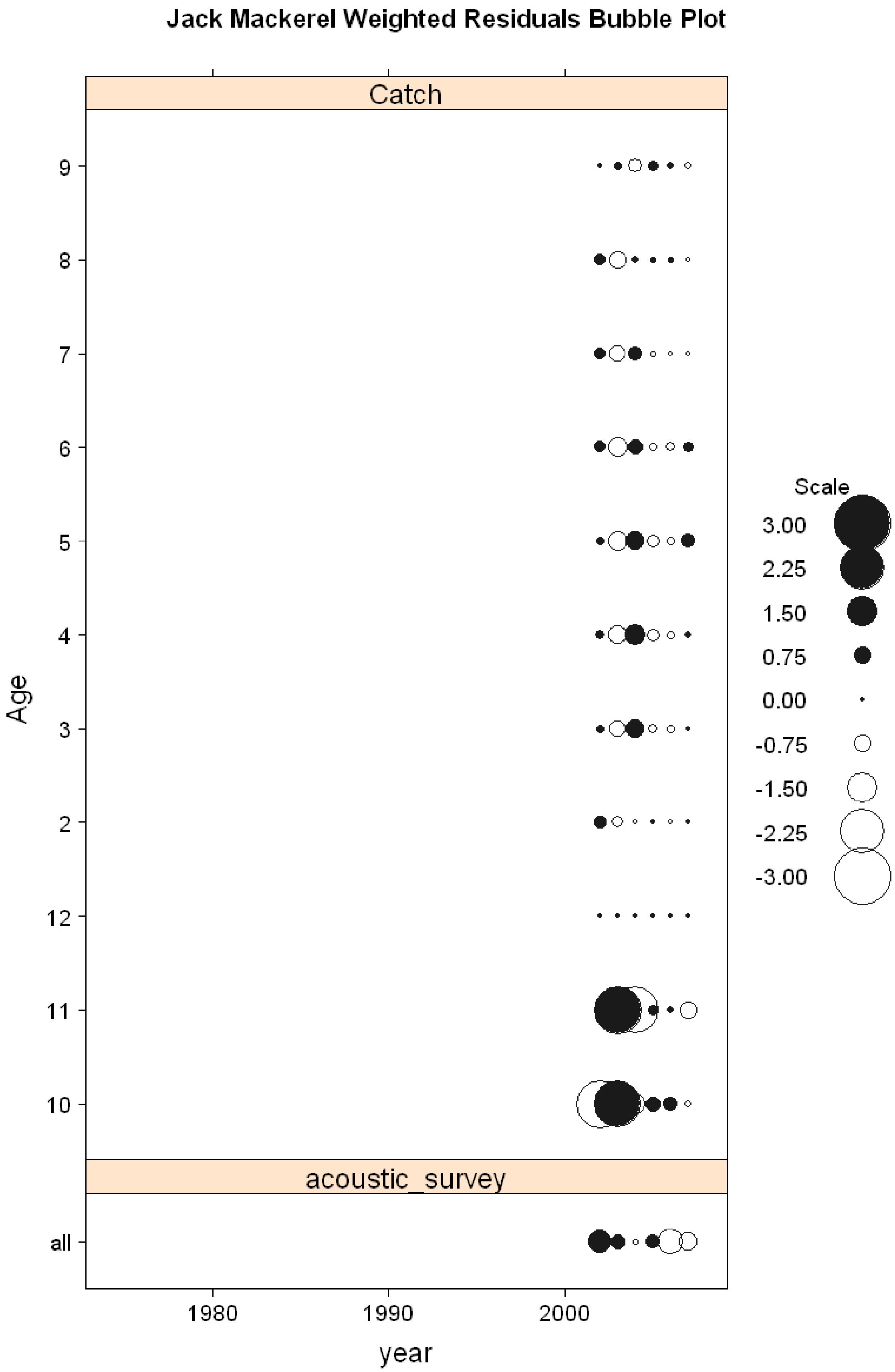


Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Mean Contribution to Objective Function per point
2.0
1.5
1.0
0.5
0.0
2
3
4
5
6
7
8
9
10
11
12
all
Age



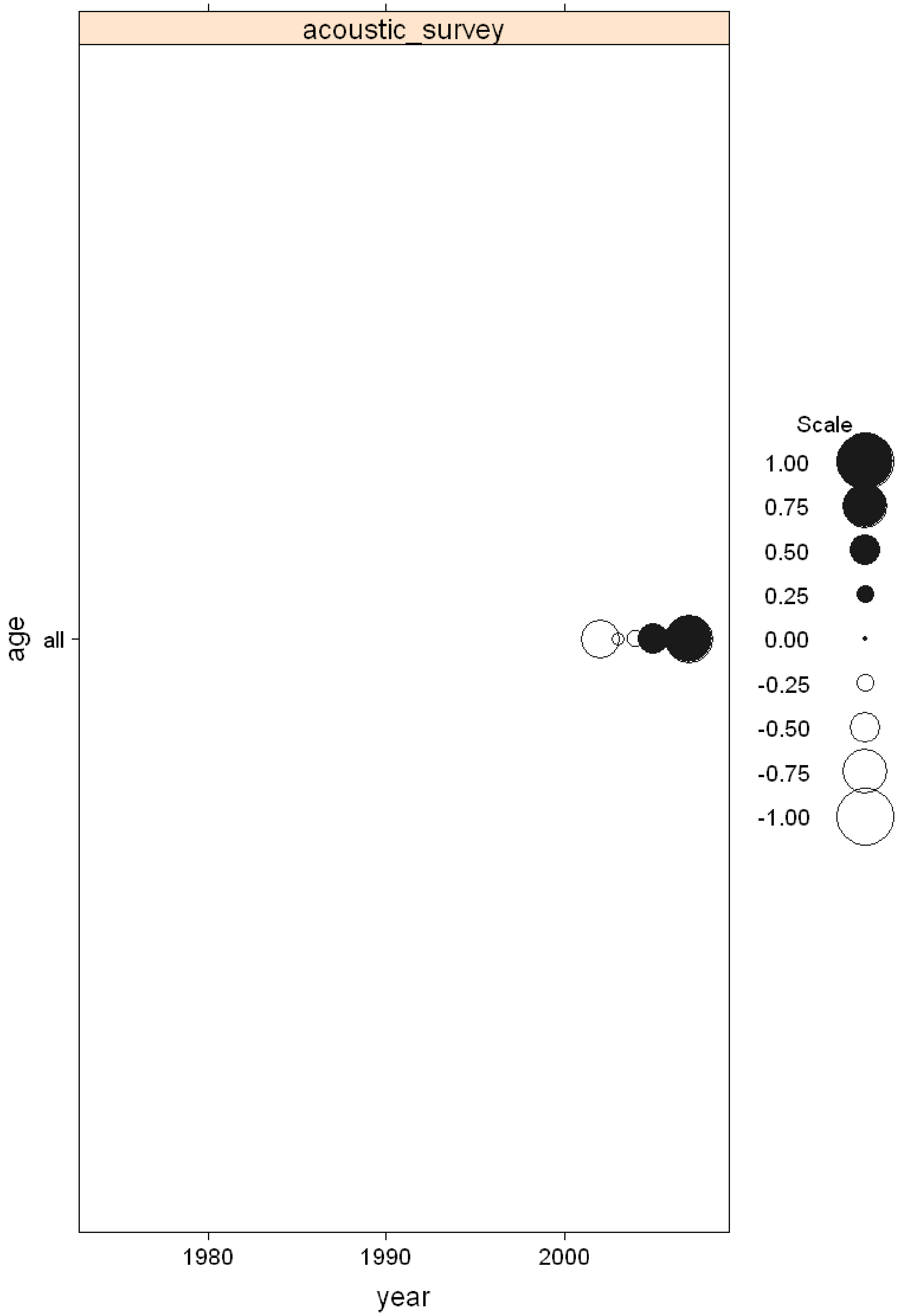
Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Mean Contribution to Objective Function per point
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1980
1990
2000
Year

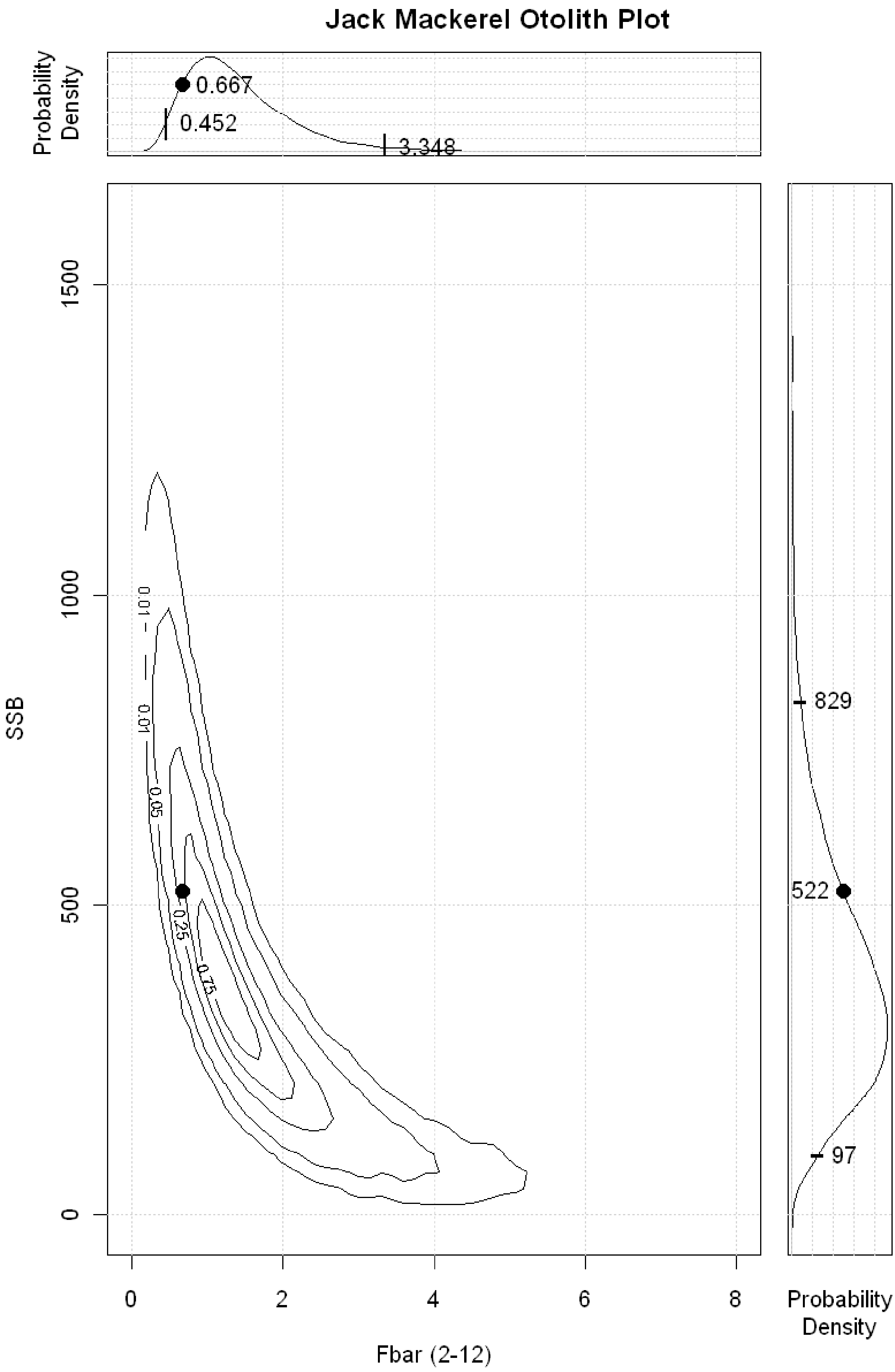

Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Mean Contribution to Objective Function per point
Cohort
1980
1990
2000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
1
2
3

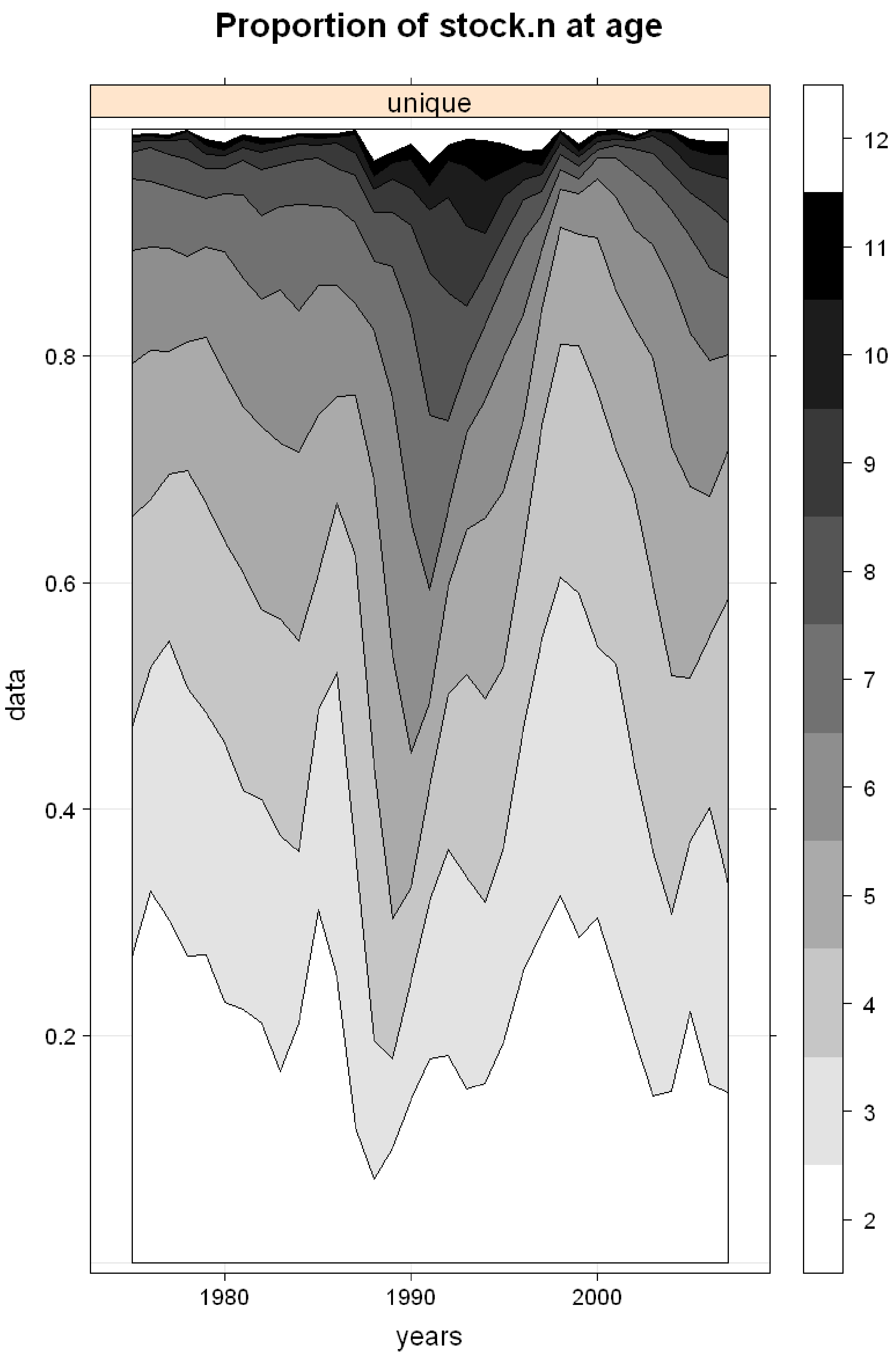


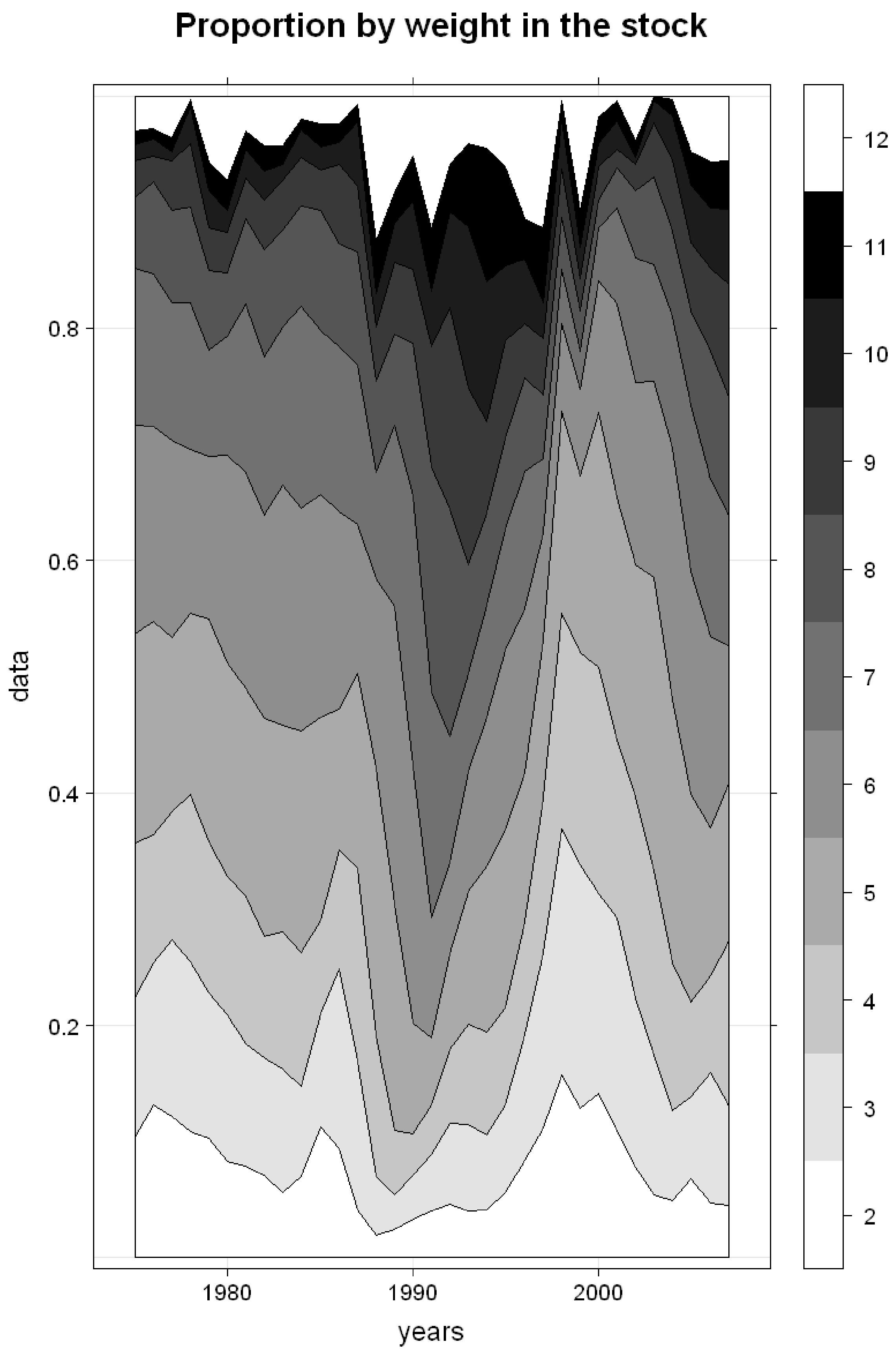
Jack Mackerel Weighted Residuals Bubble Plot
Catch
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00

Jack Mackerel Unweighted Index Residuals Bubble Plot

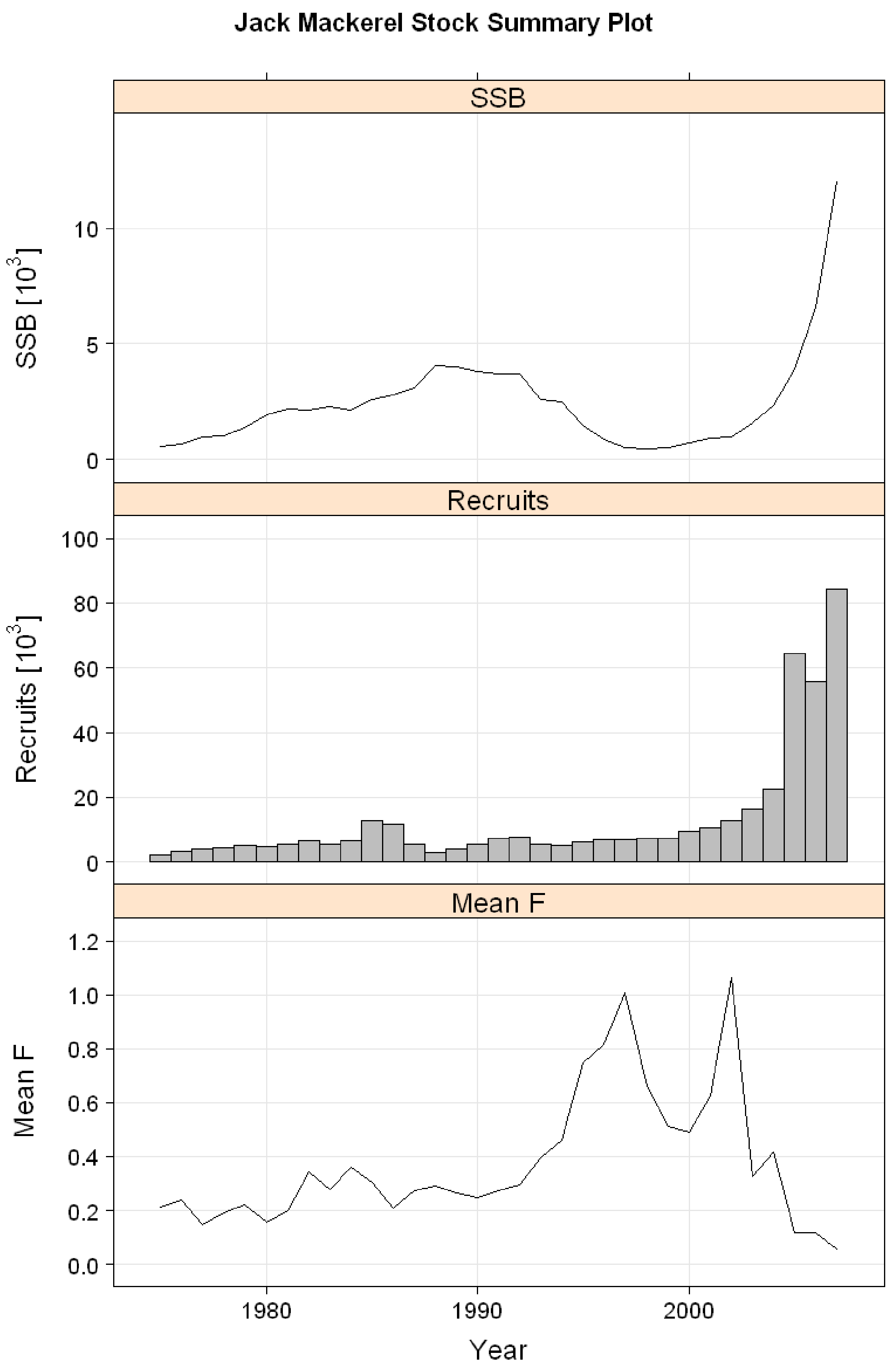


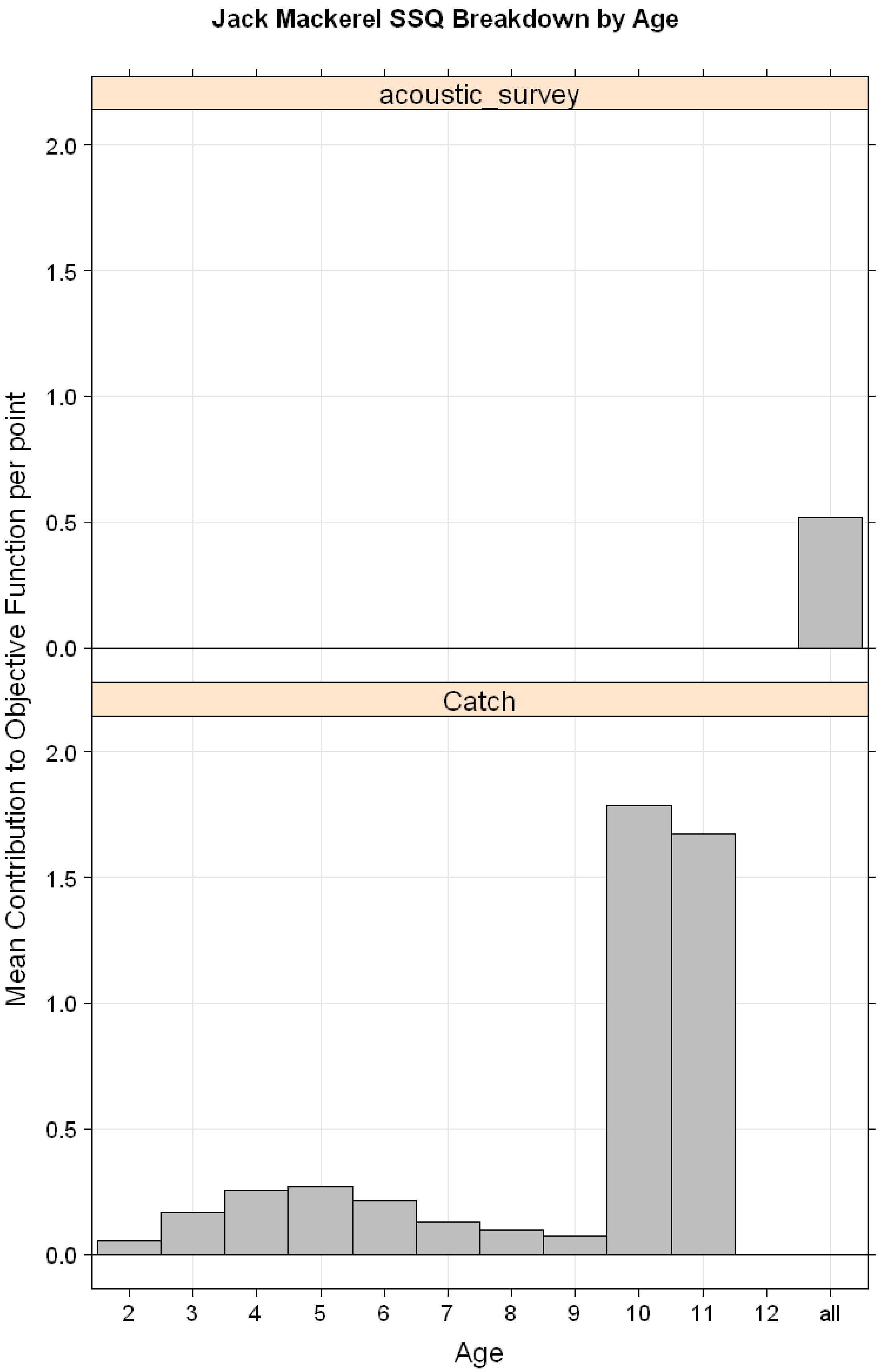

Jack Mackerel Otolith Plot
Probability Density
0.667
0.452
3.348
SSB
1500
1000
500
0
0.01
0.05
0.25
0.75
829
522
97
0
2
4
6
8
Fbar (2-12)
Probability Density

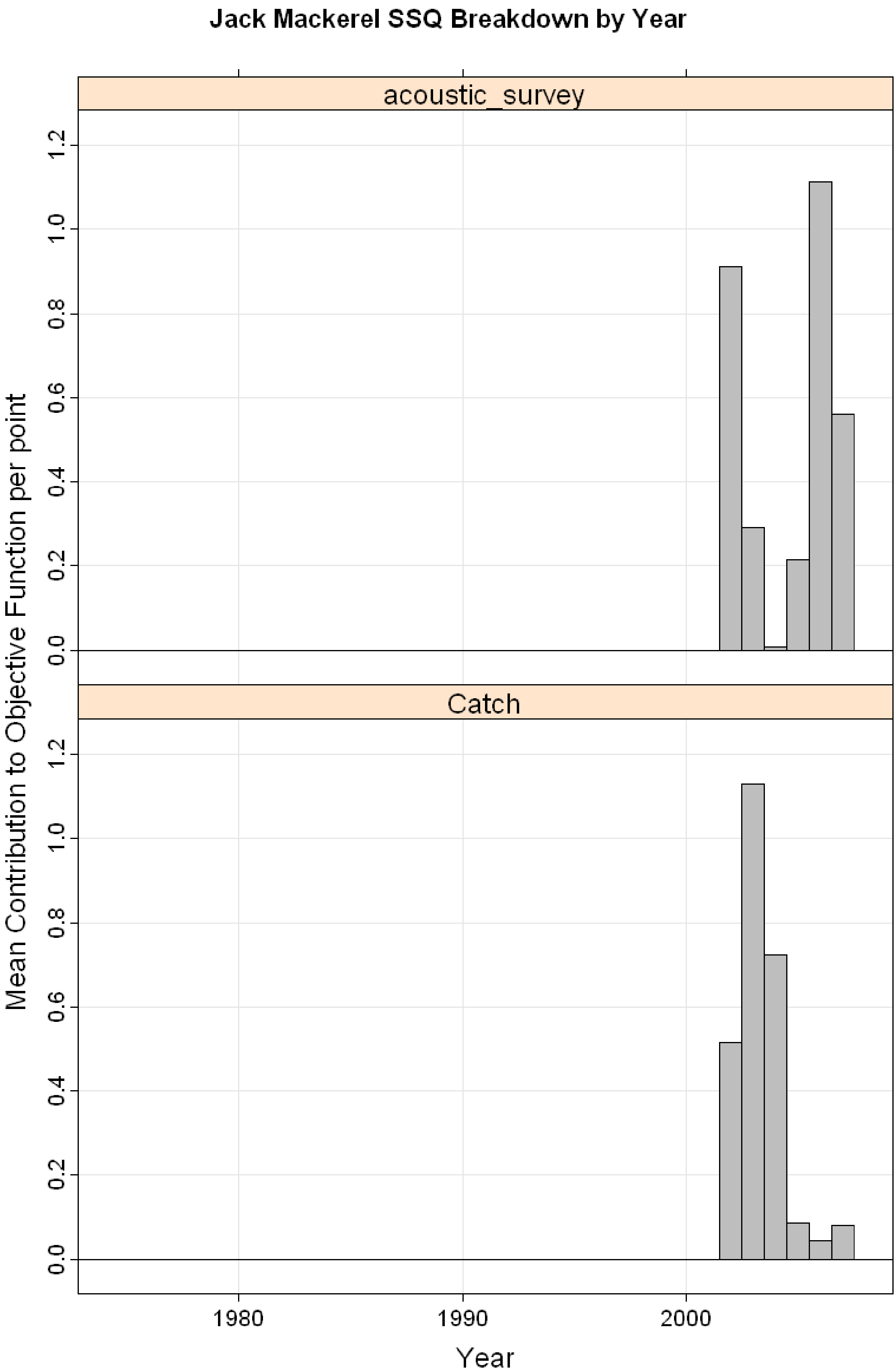

Proportion of stock.n at age
unique
data
0.2
0.4
0.6
0.8
1980
1990
2000
years
2
3
4
5
6
7
8
9
10
11
12

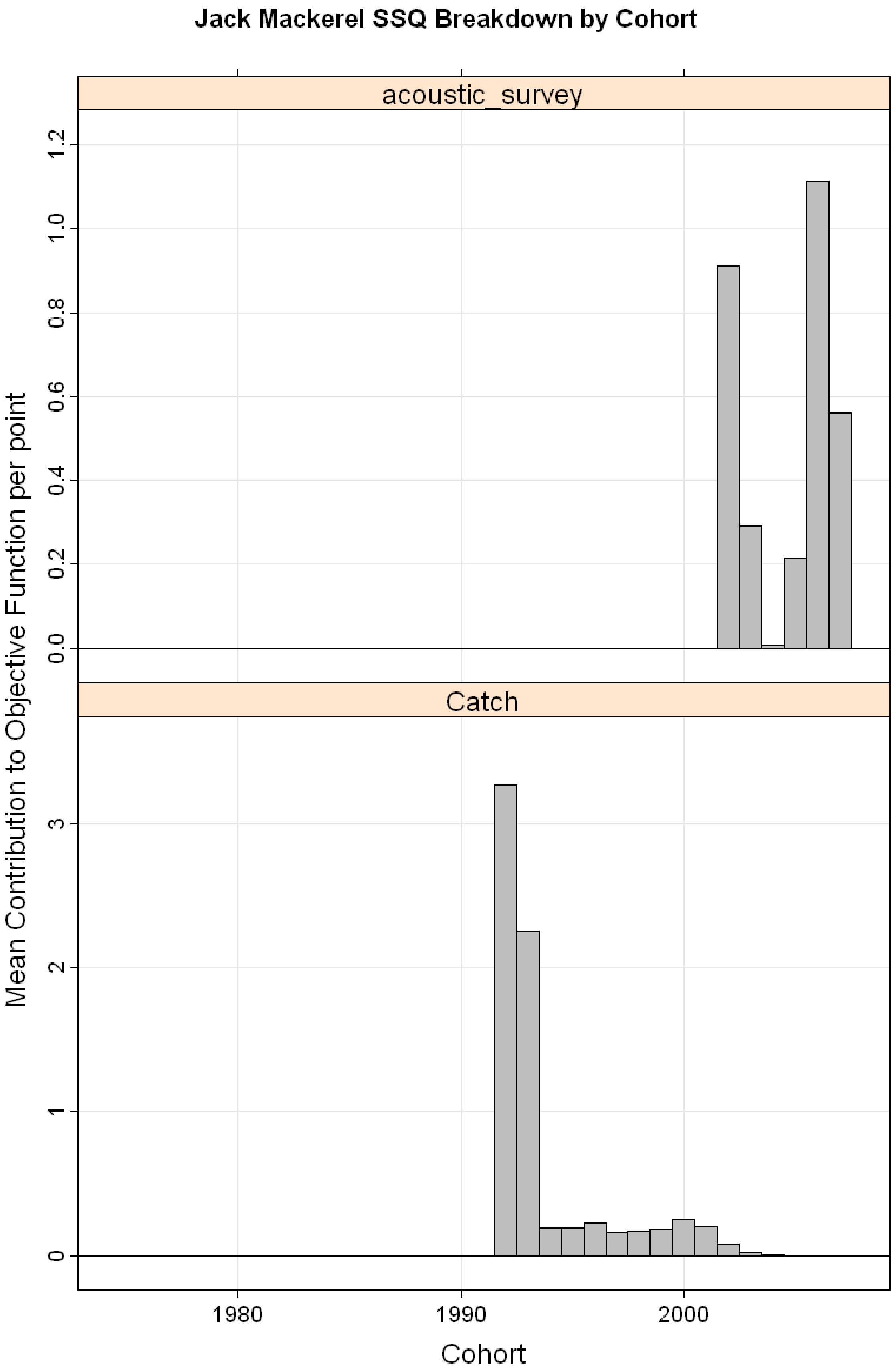

Proportion by weight in the stock
data
0.2
0.4
0.6
0.8
1980
1990
2000
years
2
3
4
5
6
7
8
9
10
11
12

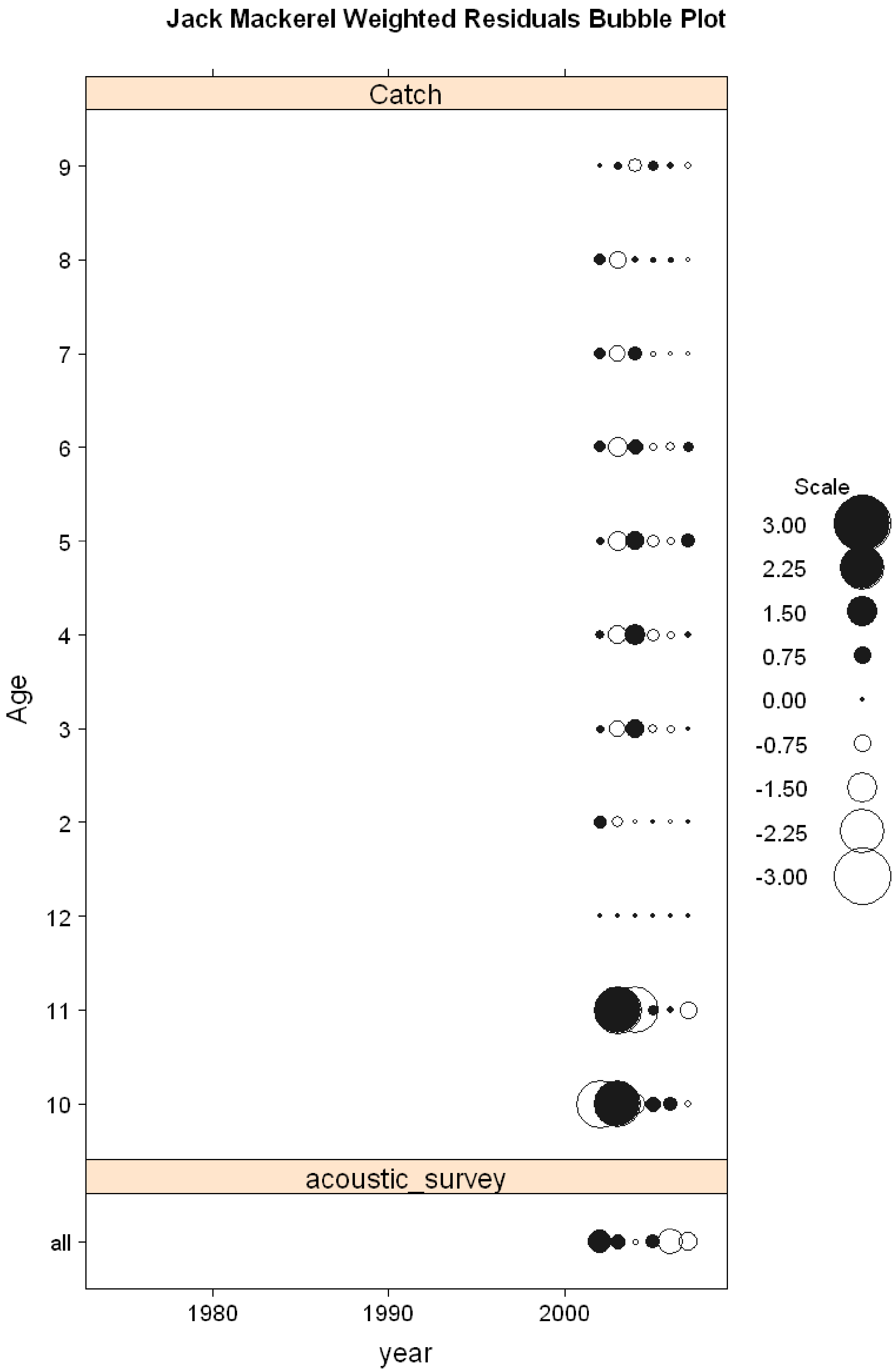
8.1.3 95%


Jack Mackerel Stock Summary Plot
SSB
SSB [10^3]
0
5
10
Recruits
Recruits [10^3]
0
20
40
60
80
100
Mean F
Mean F
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1980
1990
2000
Year

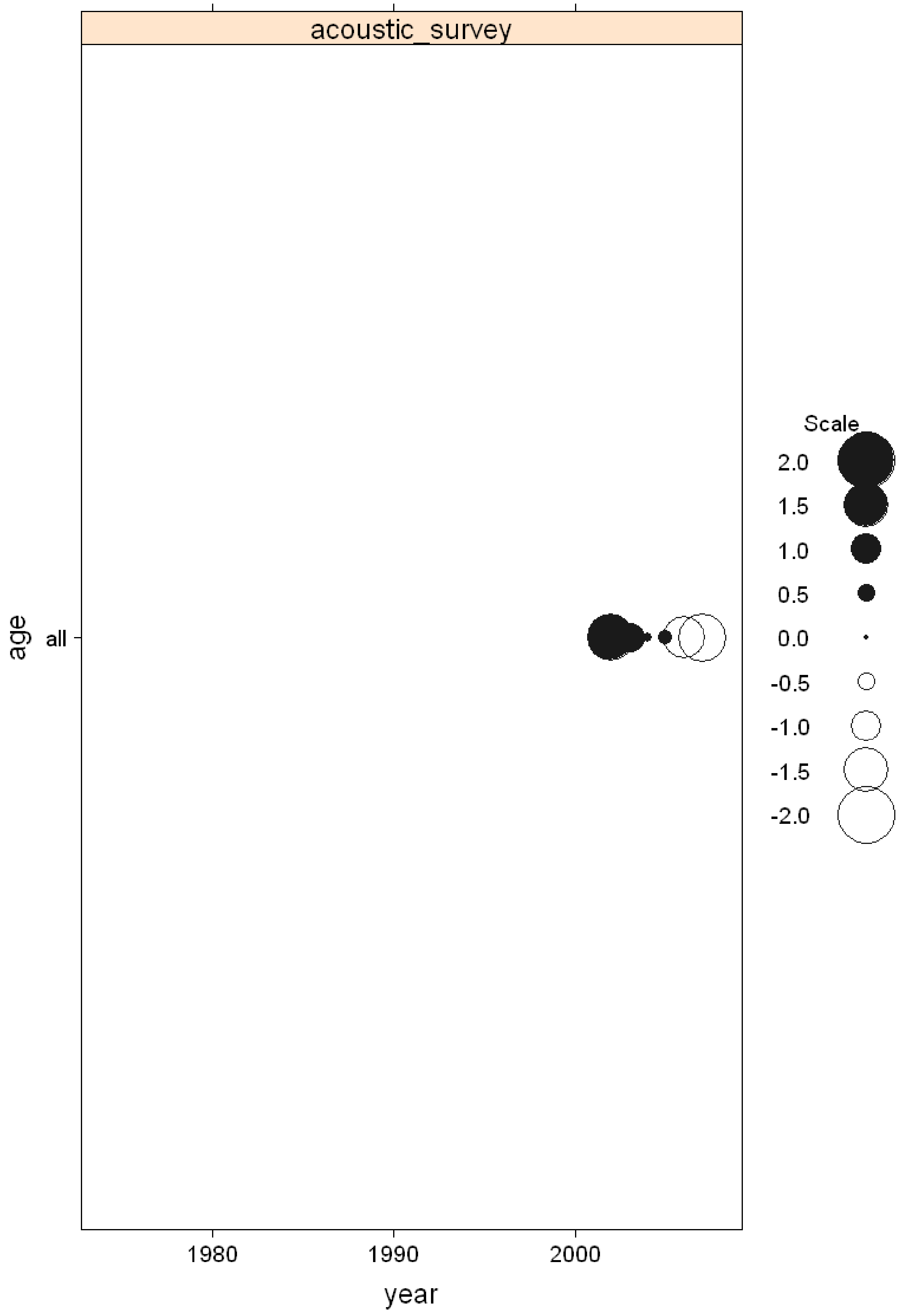

Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Mean Contribution to Objective Function per point
Age
0.0
0.5
1.0
1.5
2.0
2
3
4
5
6
7
8
9
10
11
12
all

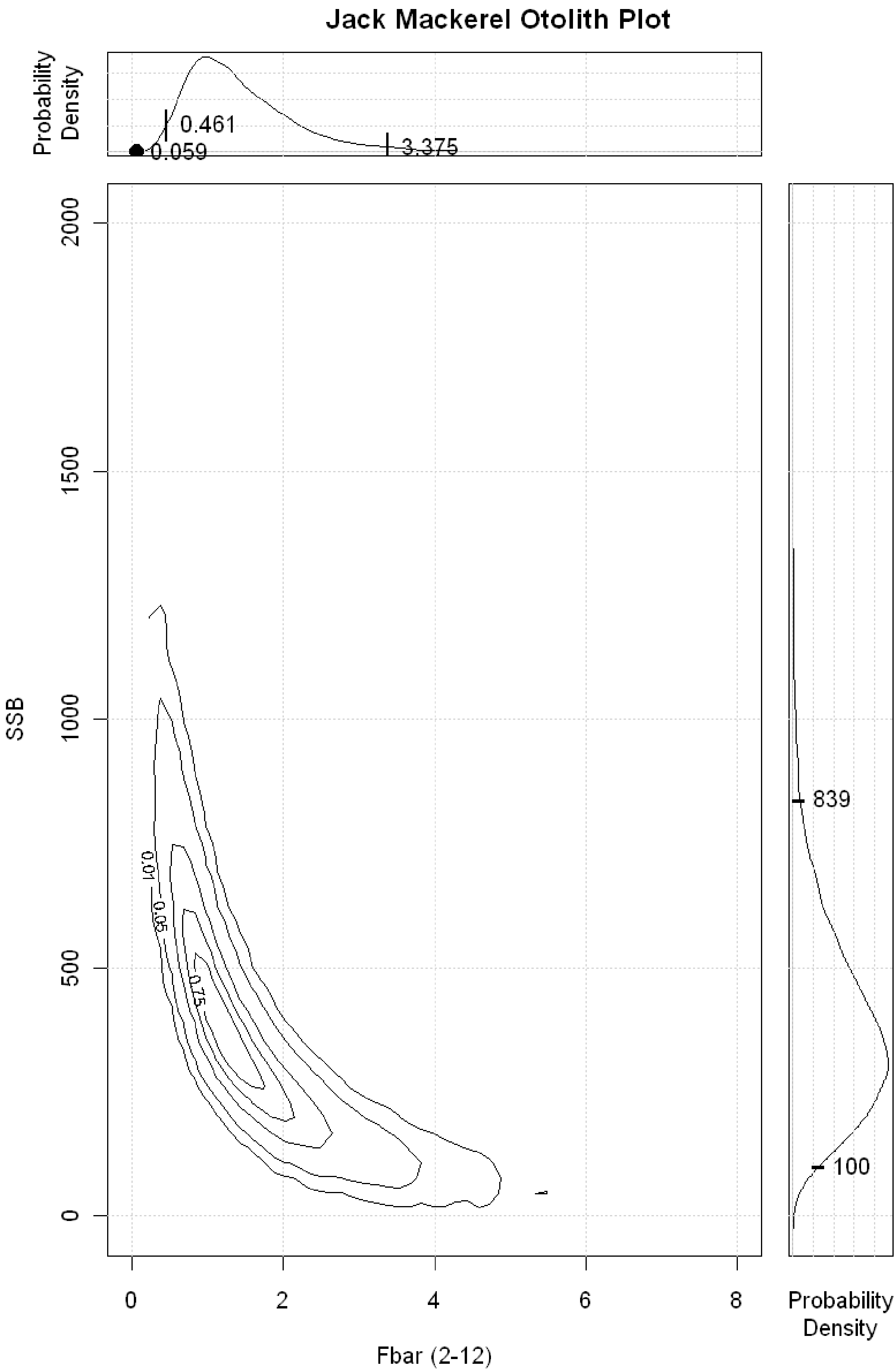

Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Mean Contribution to Objective Function per point
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1980
1990
2000
Year


Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Mean Contribution to Objective Function per point
Cohort
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
1
2
3
1980
1990
2000

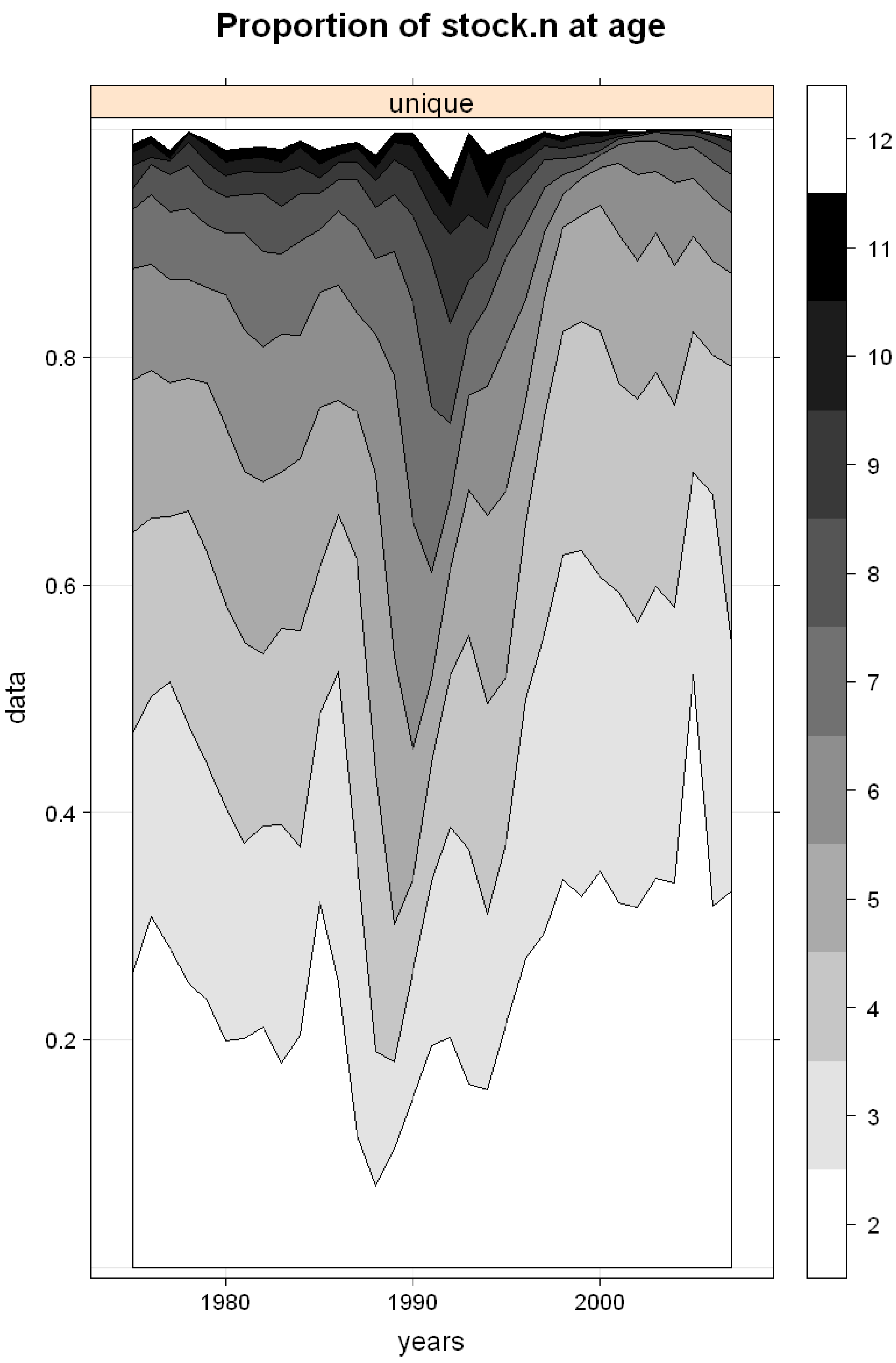

Jack Mackerel Weighted Residuals Bubble Plot
Catch
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00

Jack Mackerel Unweighted Index Residuals Bubble Plot

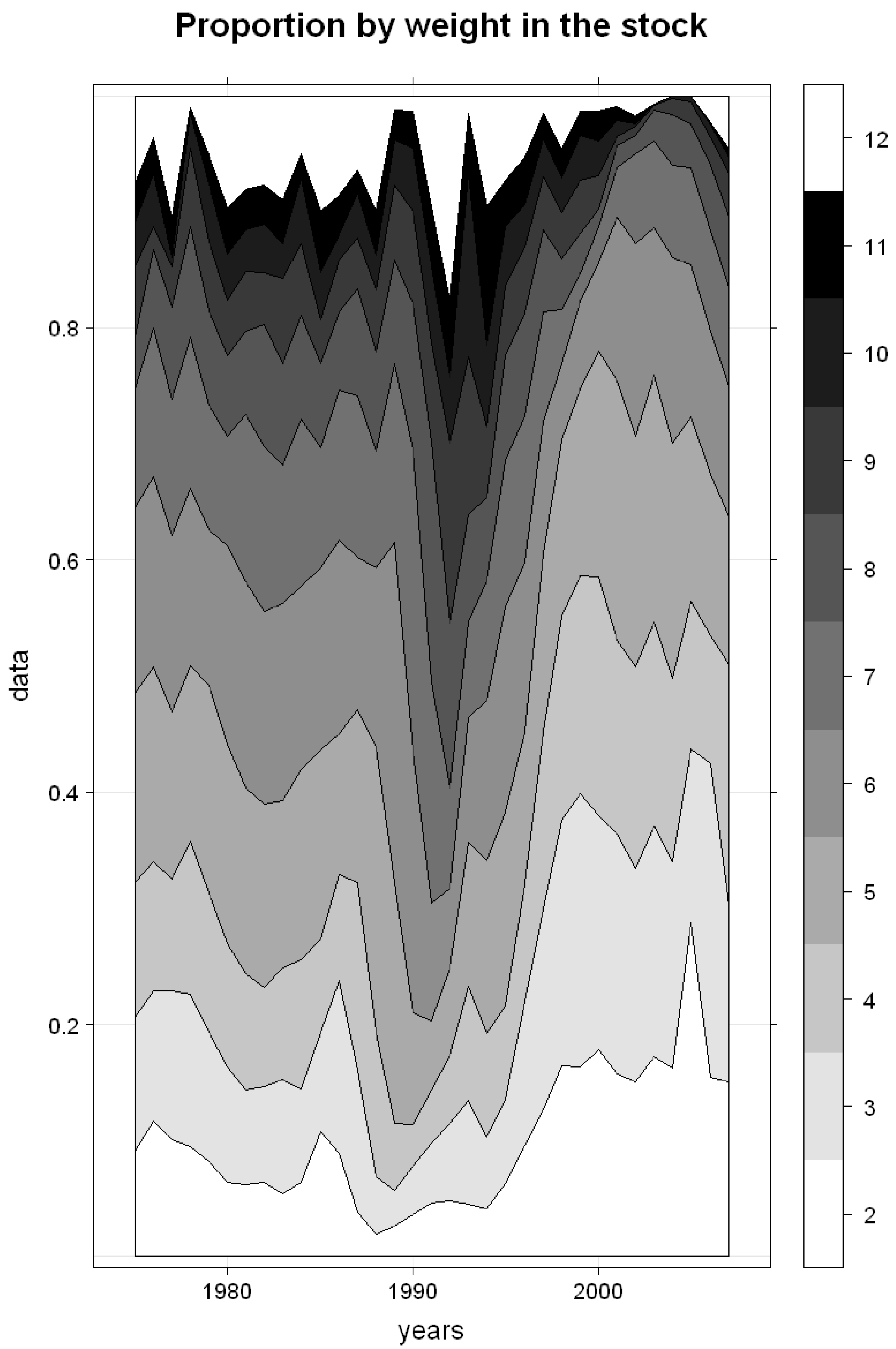




Jack Mackerel Otolith Plot
Probability Density
0.461
0.059
3.375
SSB
2000
1500
1000
500
0
0.01
0.05
0.75
839
100
0
2
4
6
8
Fbar (2-12)
Probability Density

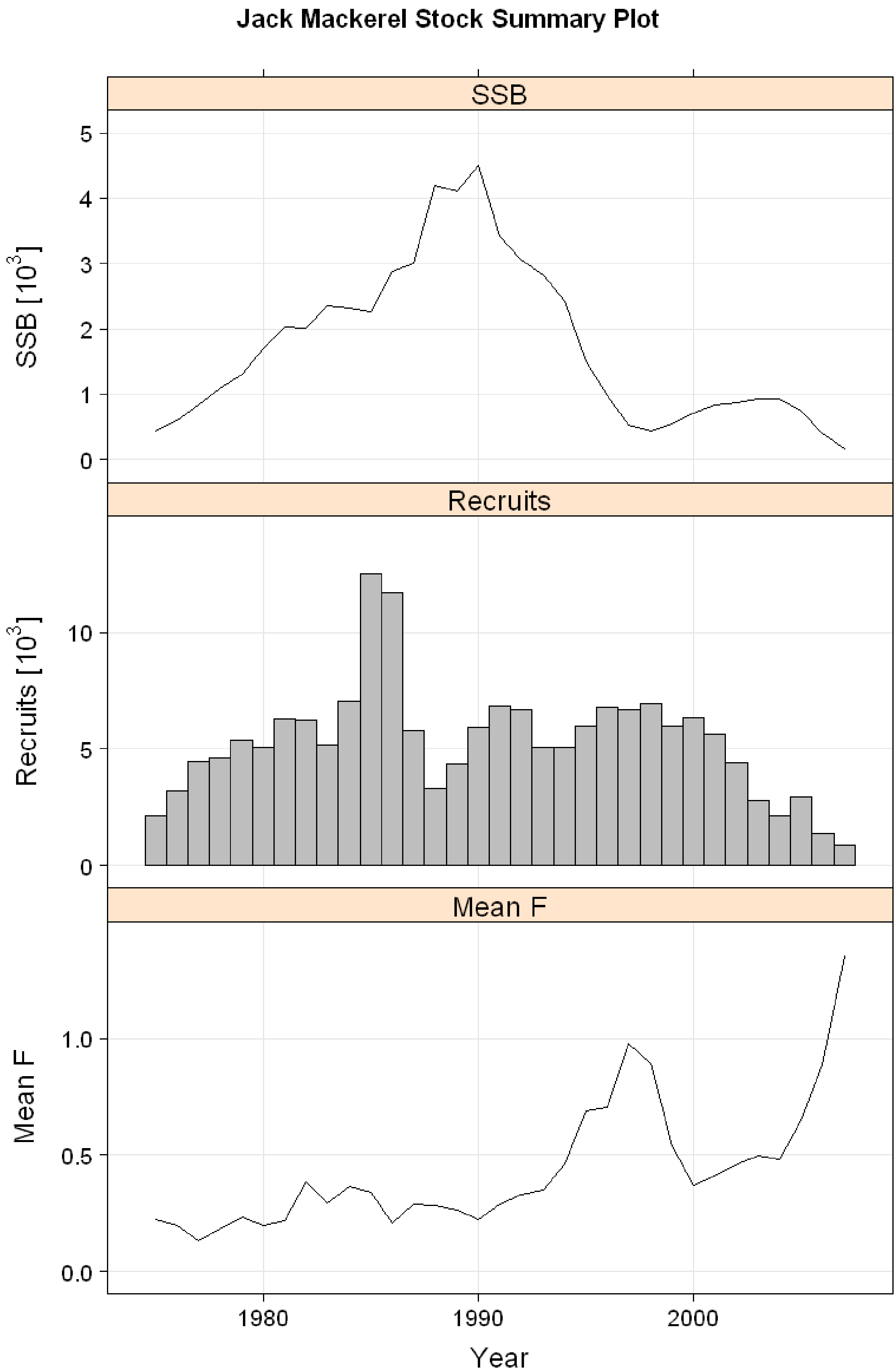


Proportion of stock.n at age
unique
data
years
0.2
0.4
0.6
0.8
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

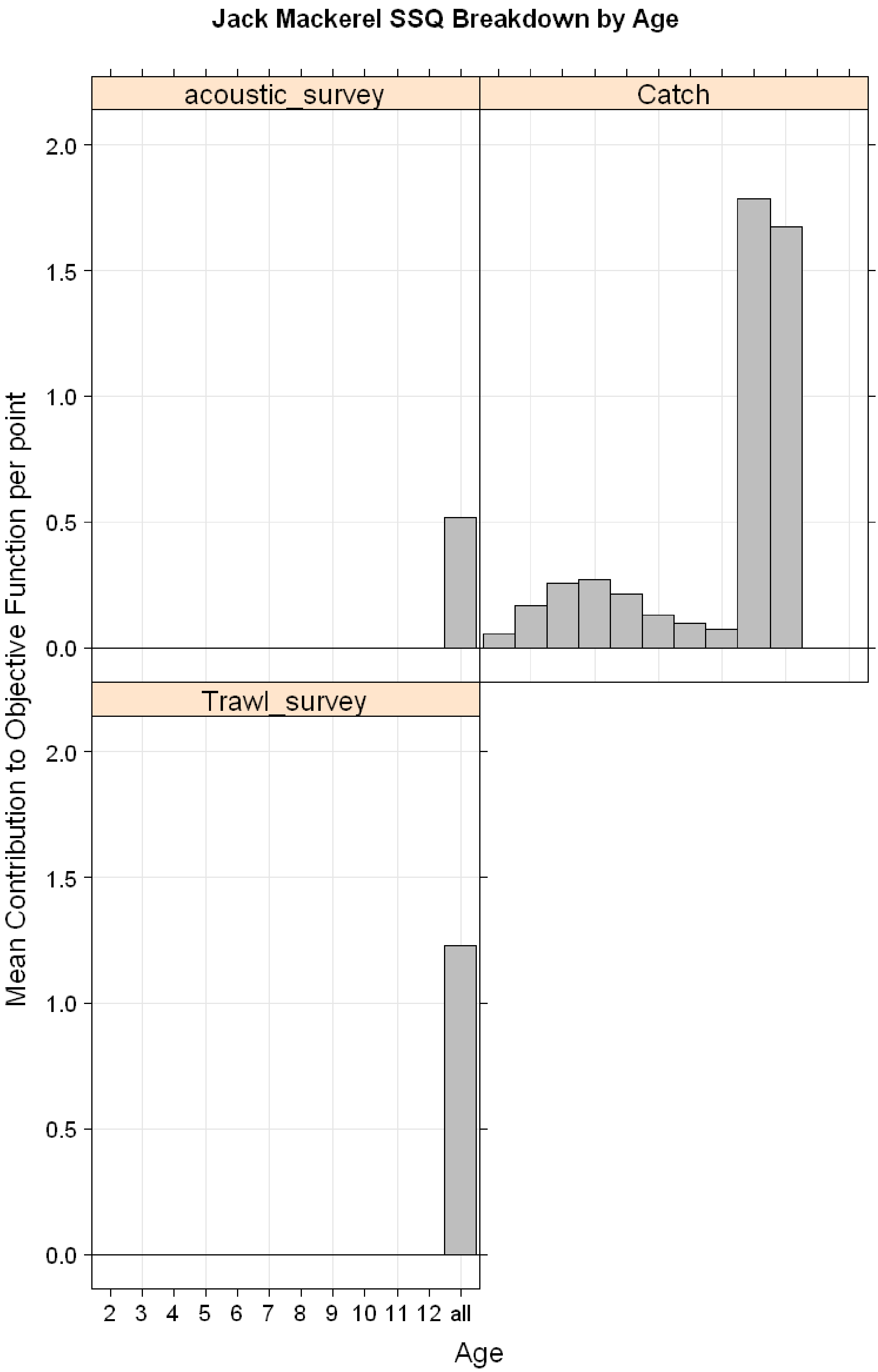

Proportion by weight in the stock
data
0.2
0.4
0.6
0.8
1980
1990
2000
years
2
3
4
5
6
7
8
9
10
11
12

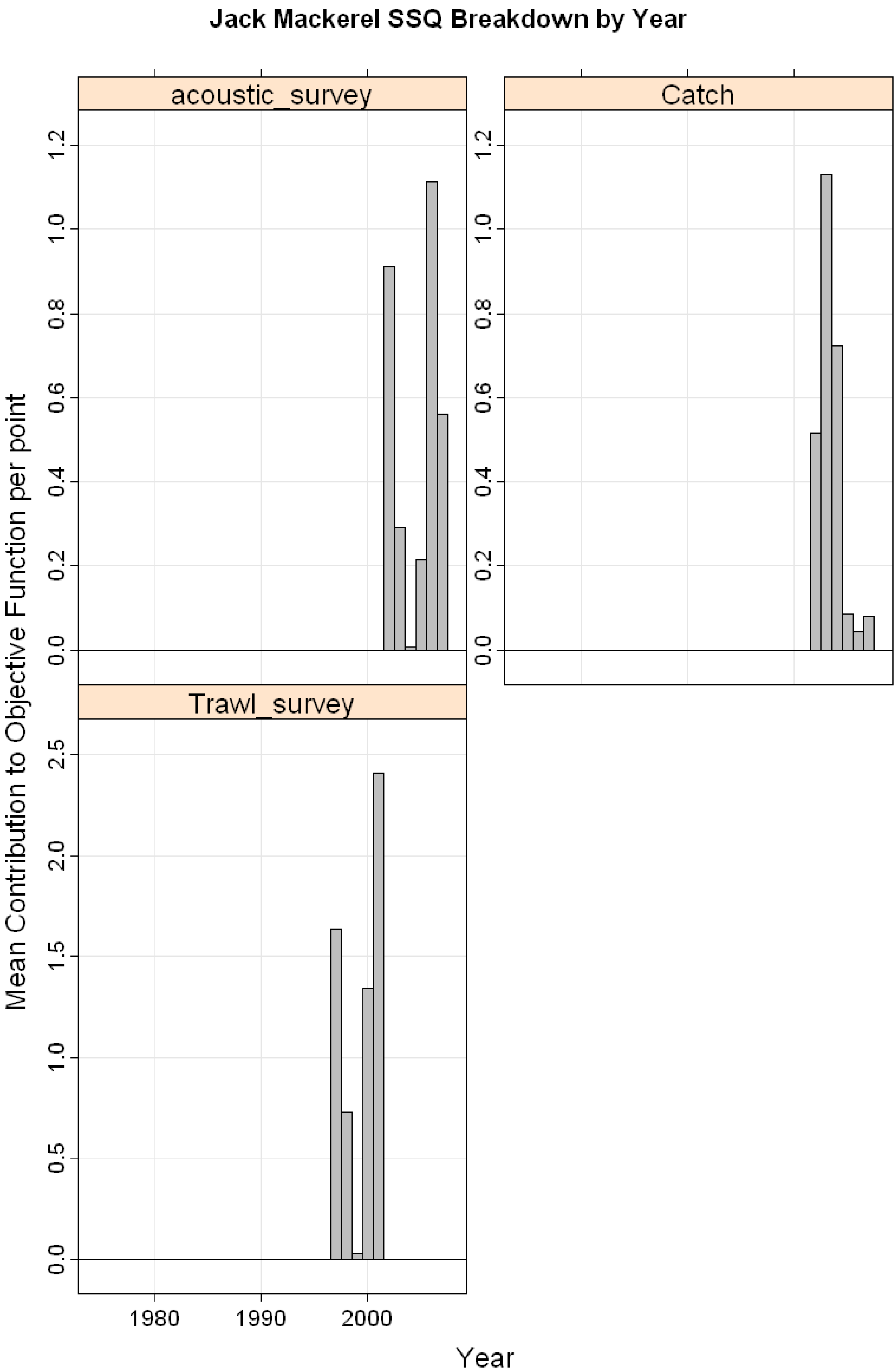
8.2 Scenario 2

8.2.1 5%

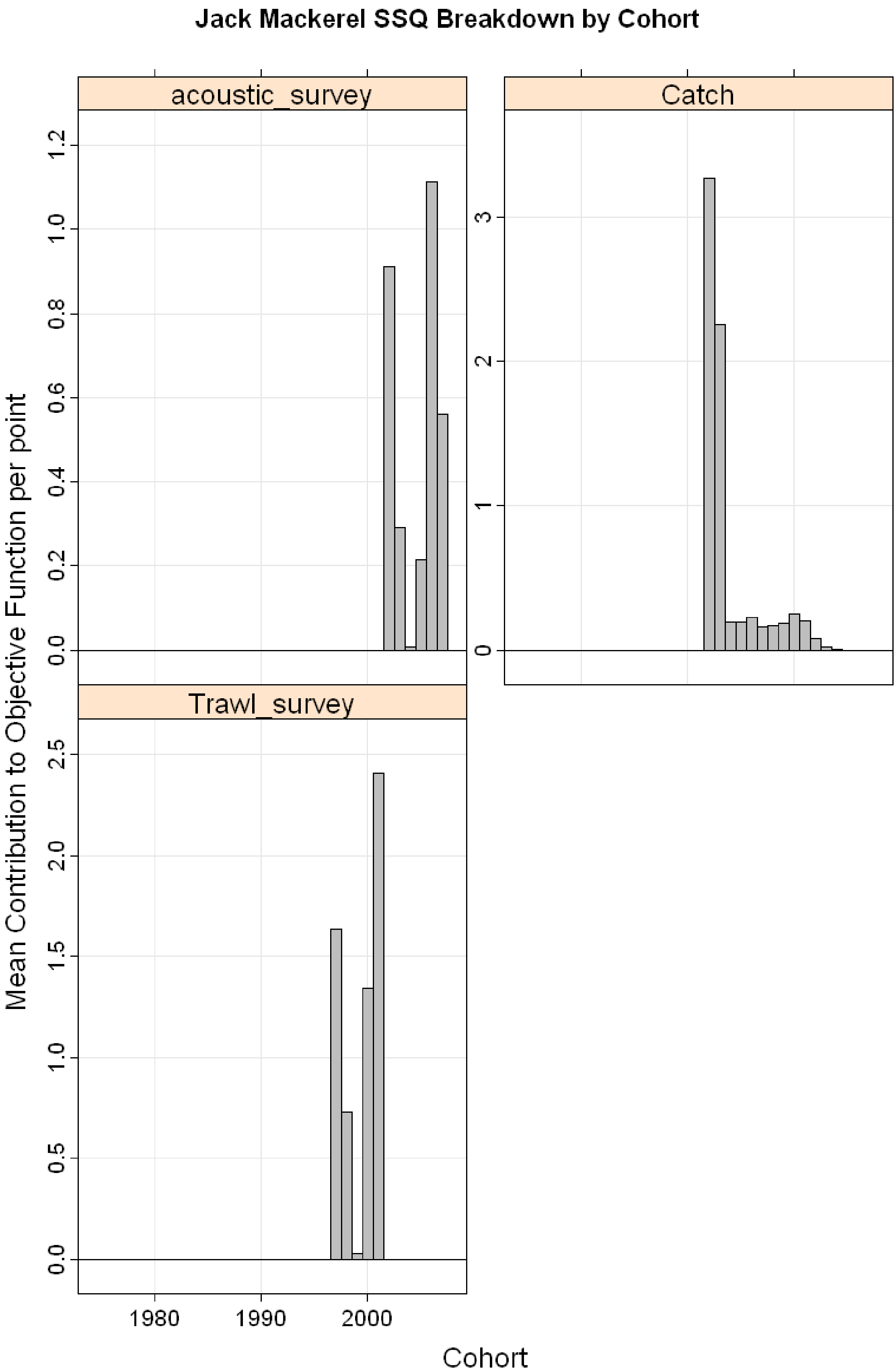


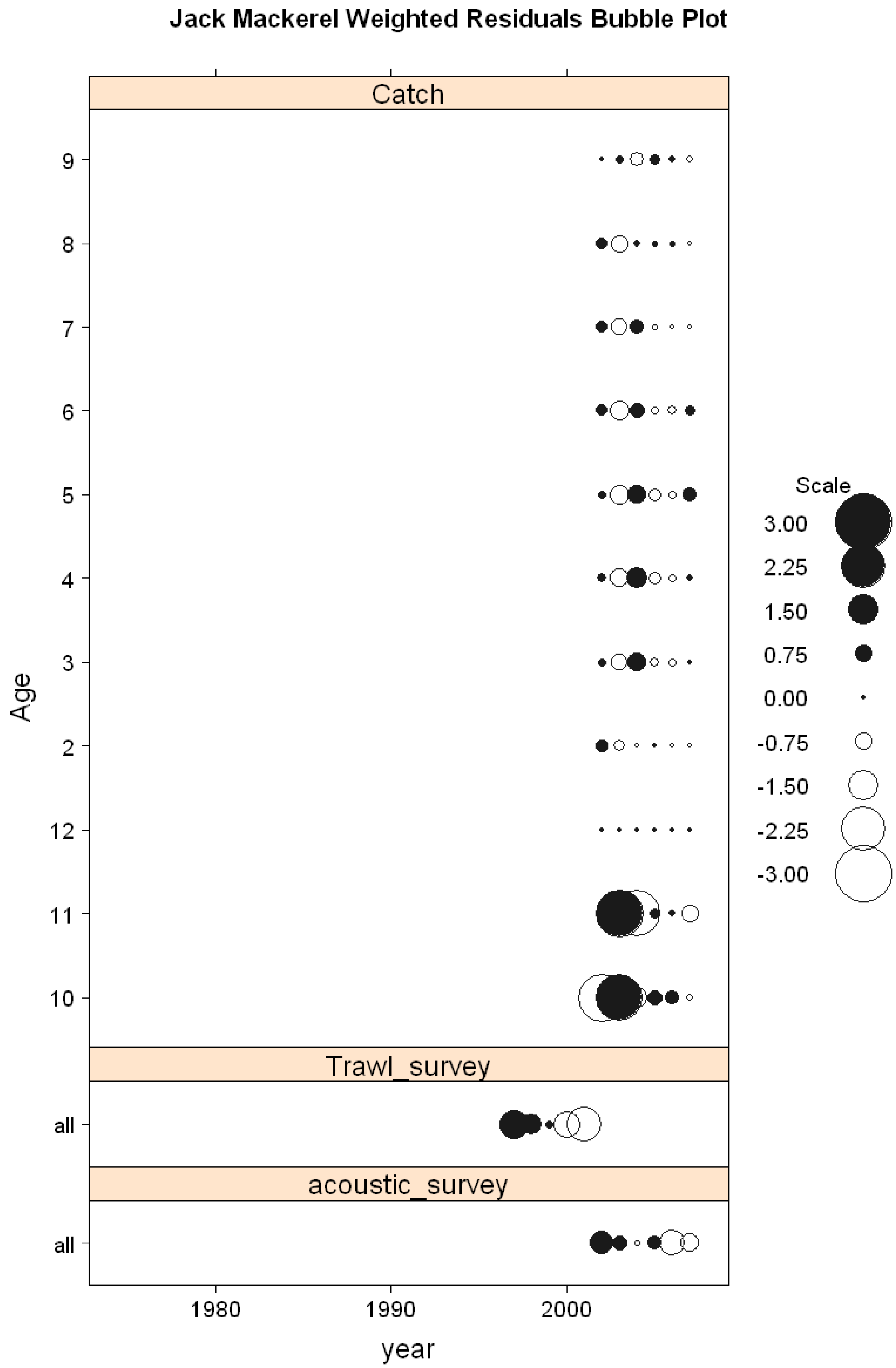
Jack Mackerel Stock Summary Plot
SSB
SSB [10^3]
0
1
2
3
4
5
Recruits
Recruits [10^3]
0
5
10
Mean F
Mean F
0.0
0.5
1.0
1980
1990
2000
Year

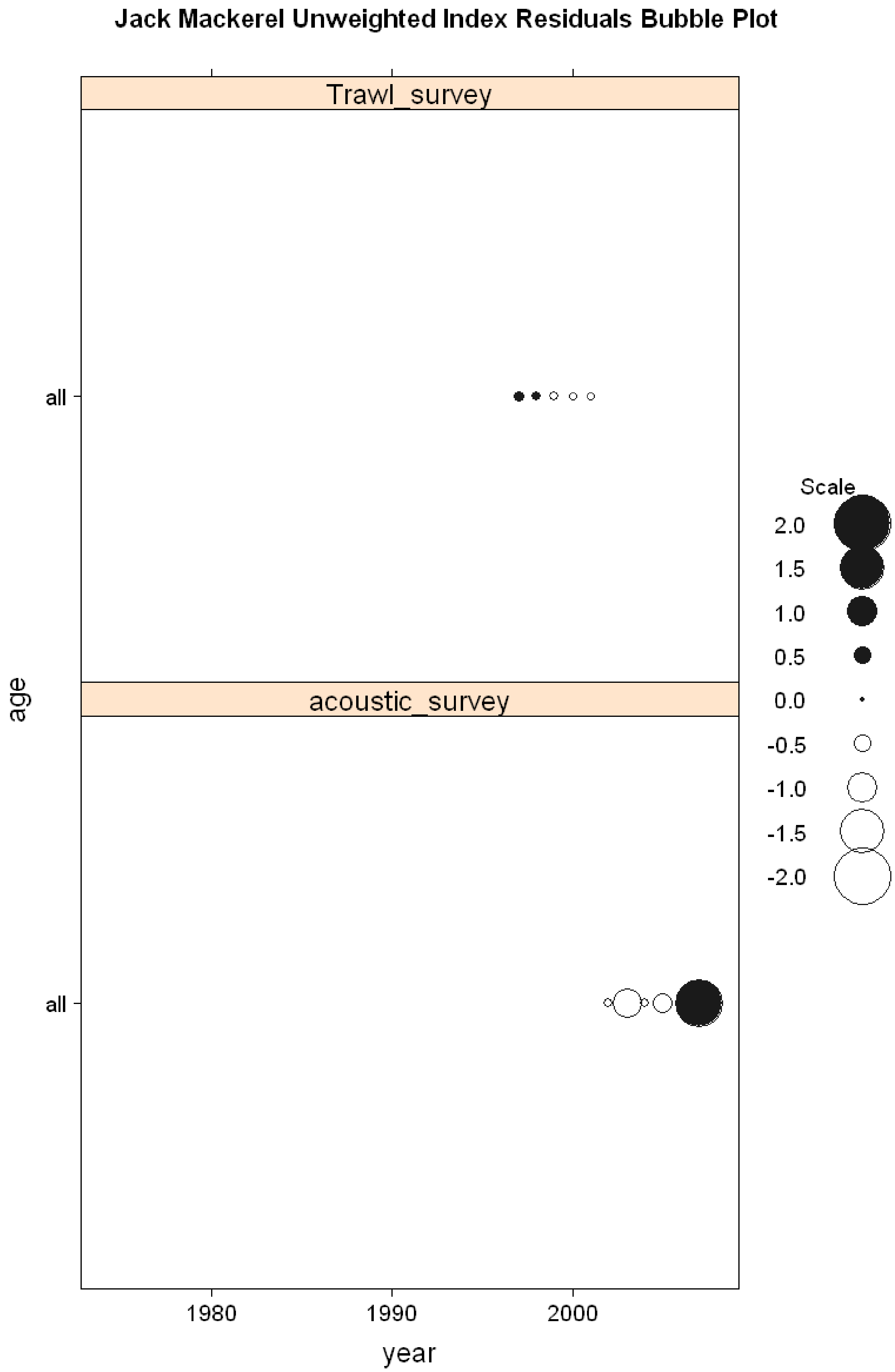

Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
0.0
0.5
1.0
1.5
2.0
2 3 4 5 6 7 8 9 10 11 12 all
Age

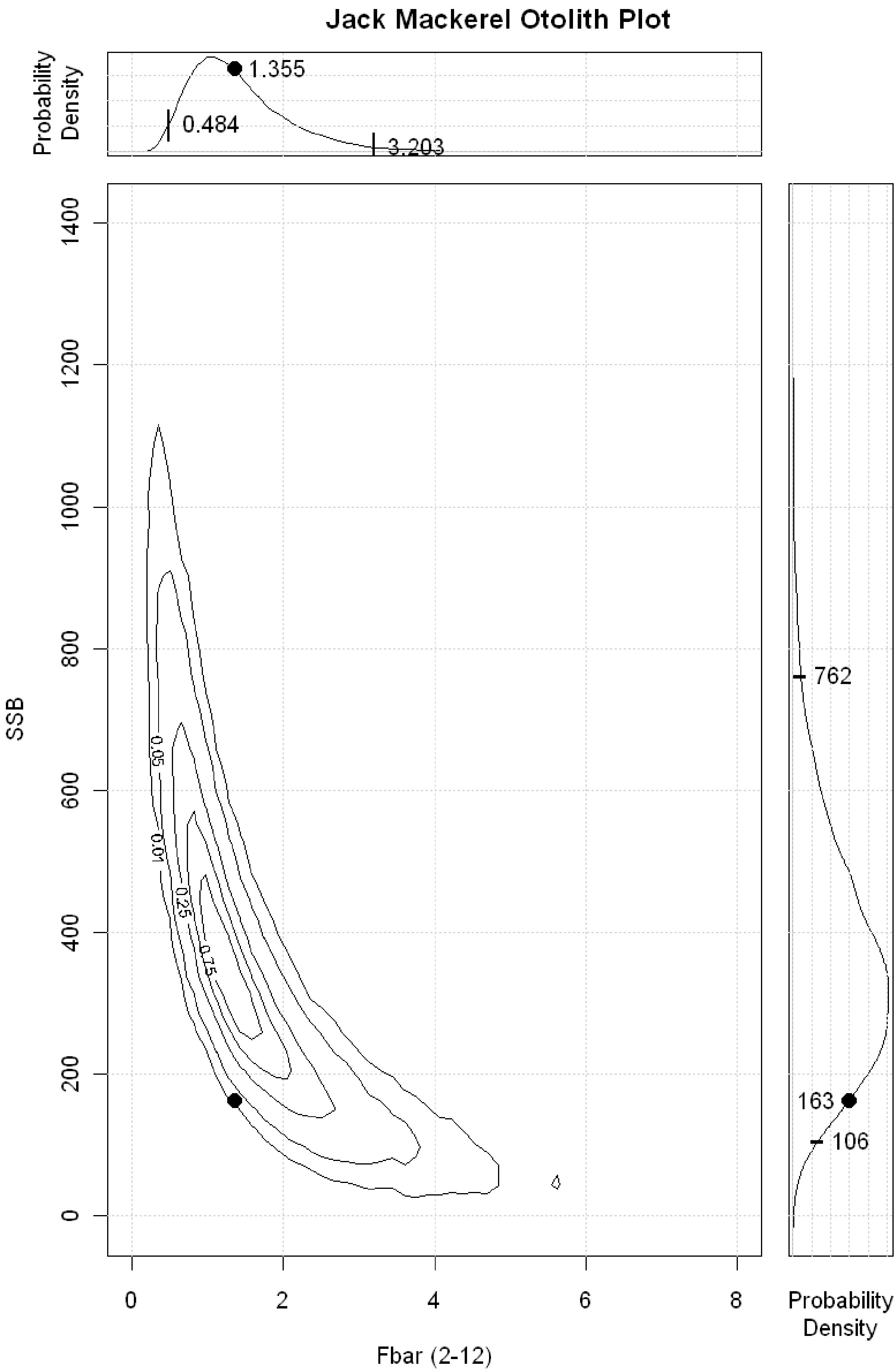


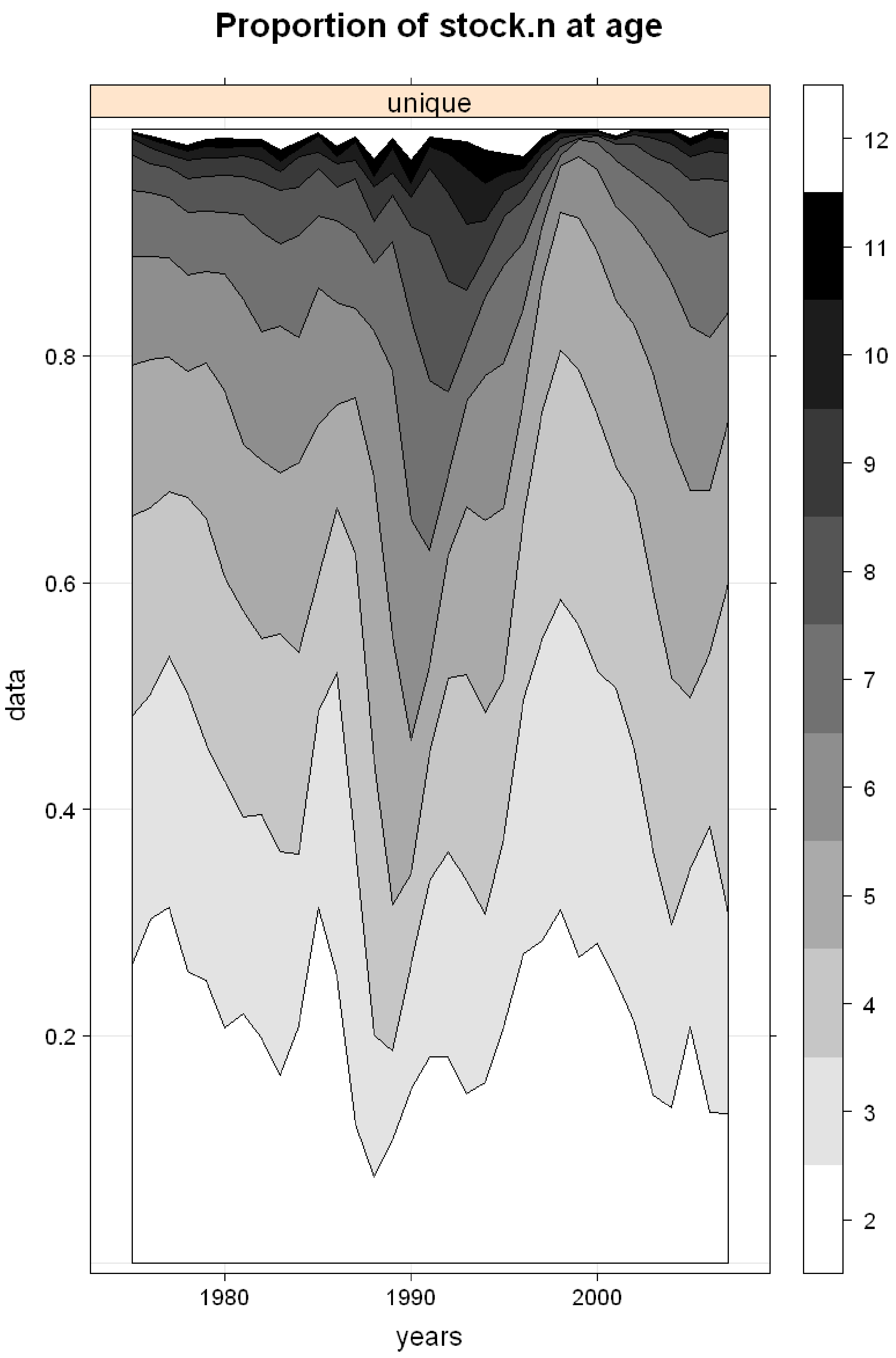
Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Year
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.5
1.5
2.0
2.5
1980
1990
2000

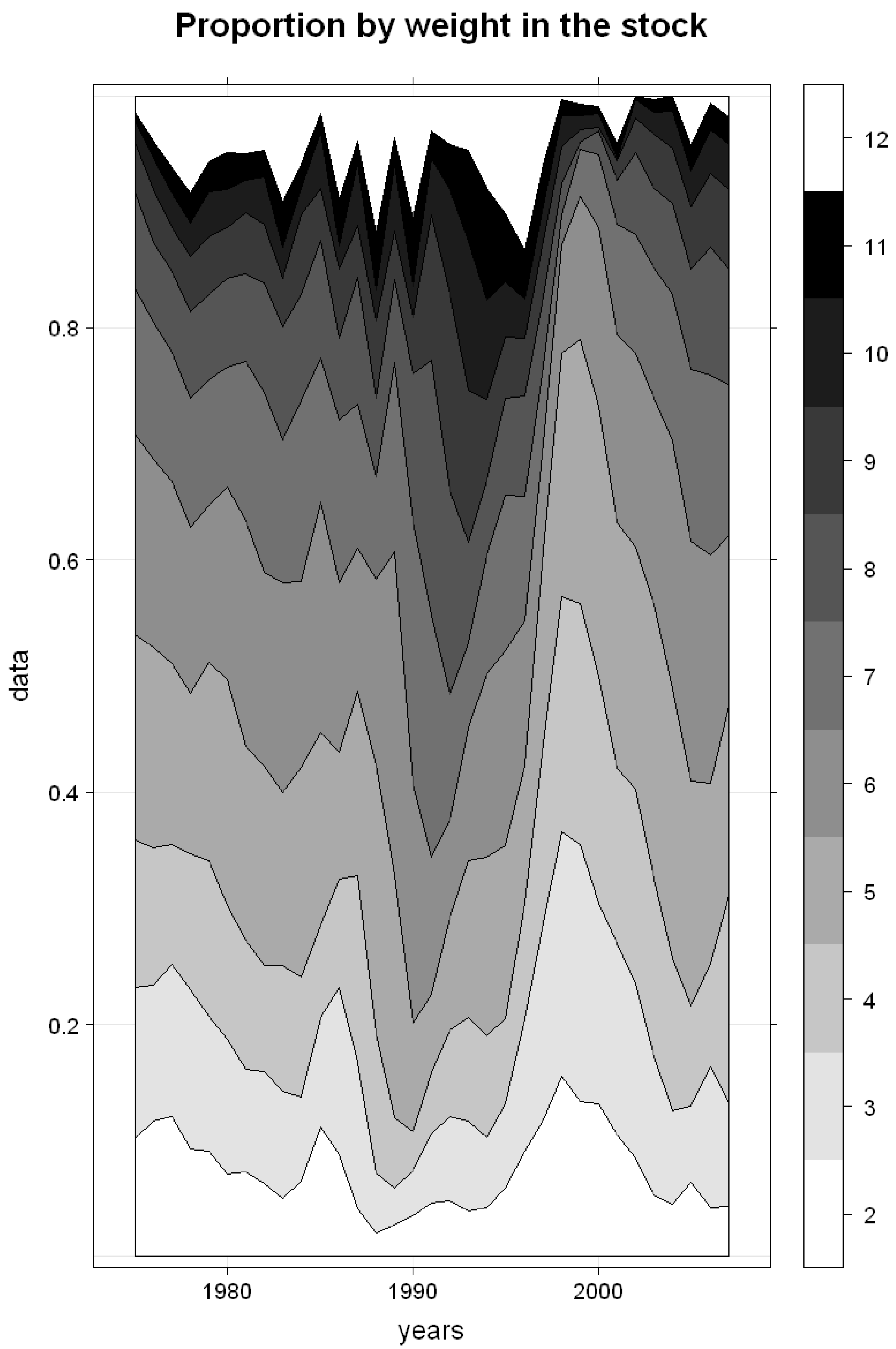

Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Cohort
1980
1990
2000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
1
2
3
0.5
1.5
2.0
2.5


Jack Mackerel Weighted Residuals Bubble Plot
Catch
Trawl_survey
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00


Jack Mackerel Unweighted Index Residuals Bubble Plot
Trawl_survey
acoustic_survey
all
all
age
1980
1990
2000
year
Scale
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0

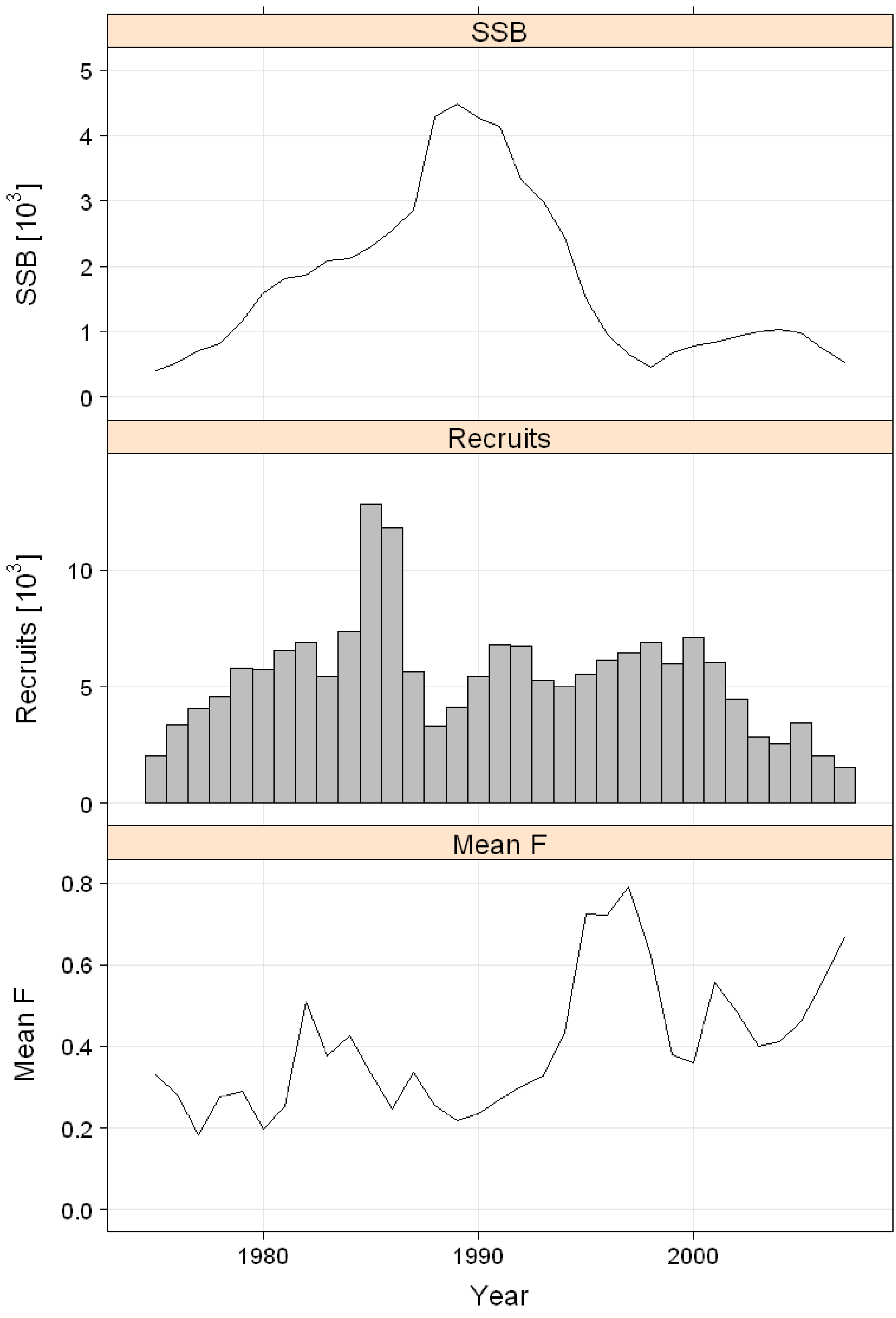

Jack Mackerel Otolith Plot
Probability Density
1.355
0.484
3.203
SSB
0
200
400
600
800
1000
1200
1400
0.05
0.01
0.25
0.75
762
163
106
0
2
4
6
8
Fbar (2-12)
Probability Density

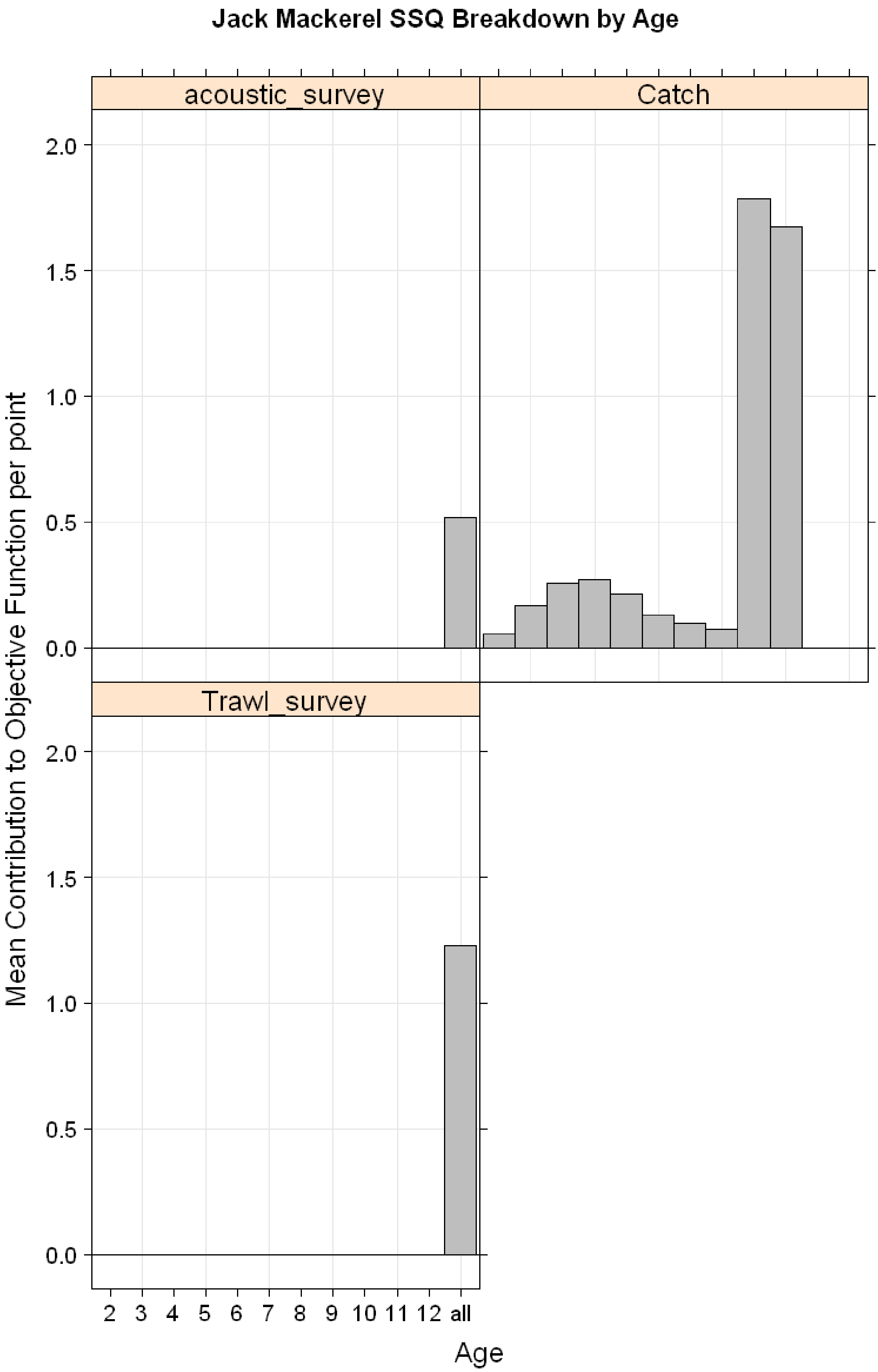

Proportion of stock.n at age
unique
0.8
0.6
0.4
0.2
data
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

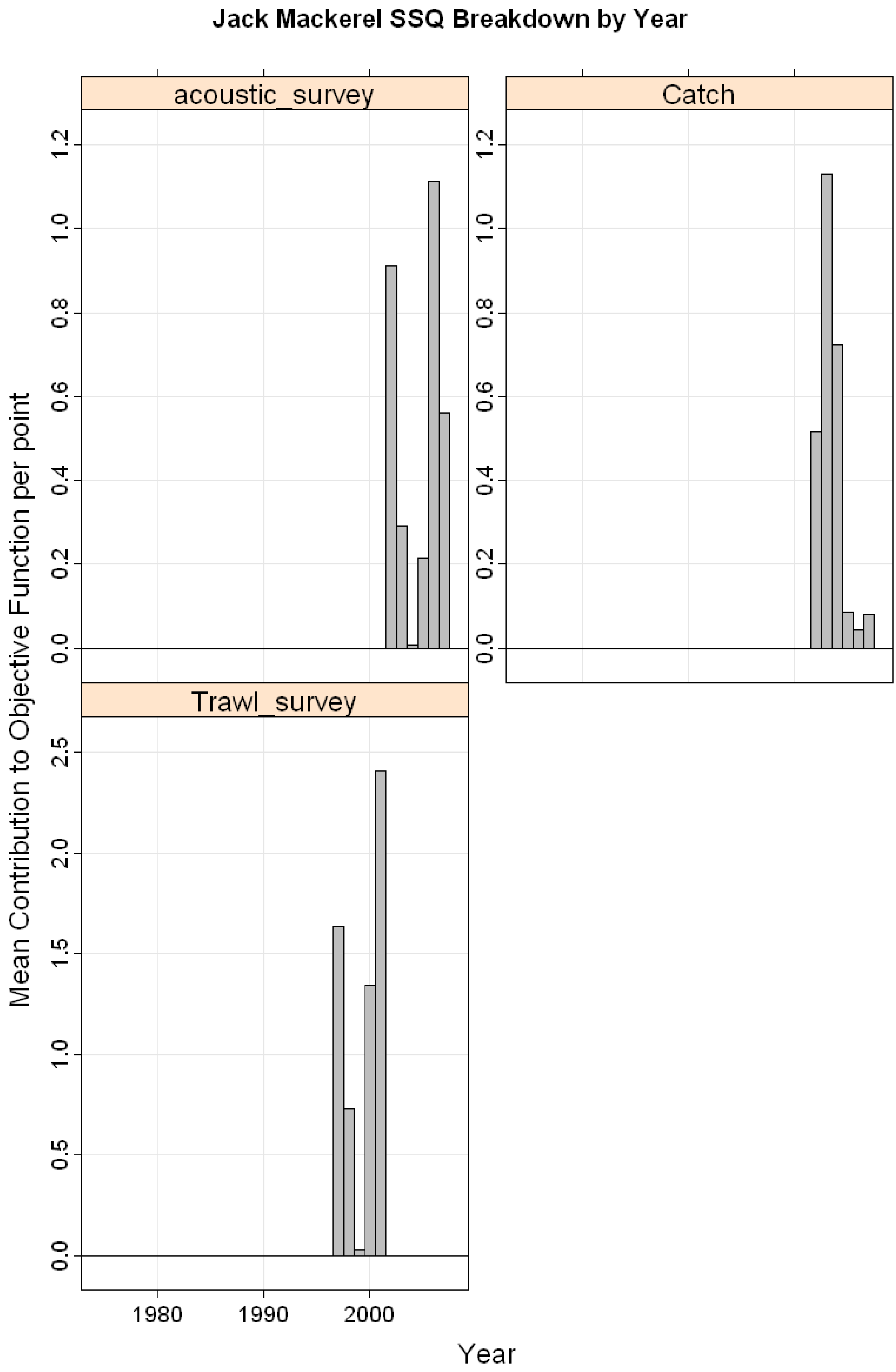

Proportion by weight in the stock
data
0.8
0.6
0.4
0.2
years
1980
1990
2000
12
11
10
9
8
7
6
5
4
3
2

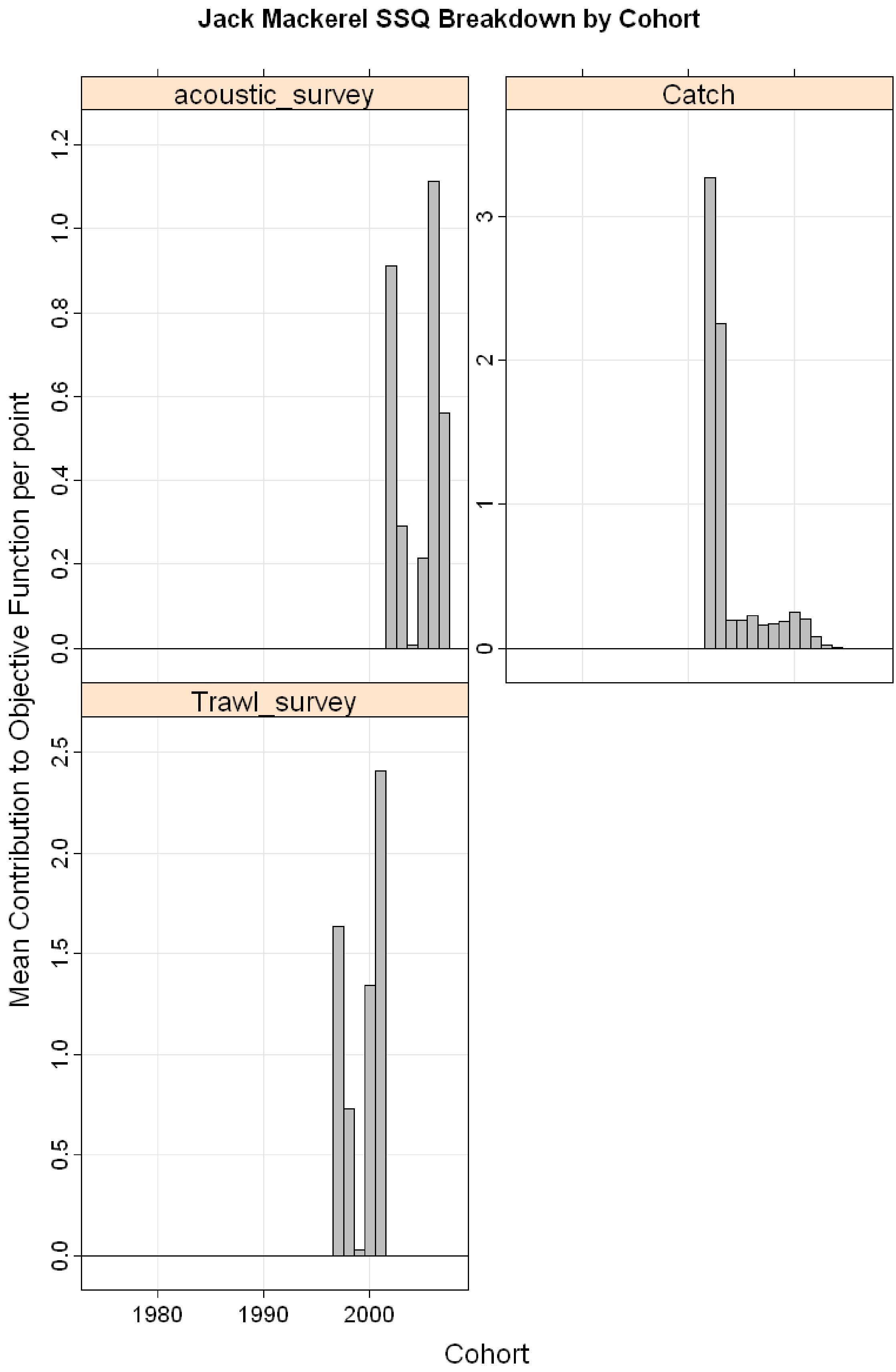
8.2.2 50%

Jack Mackerel Stock Summary Plot

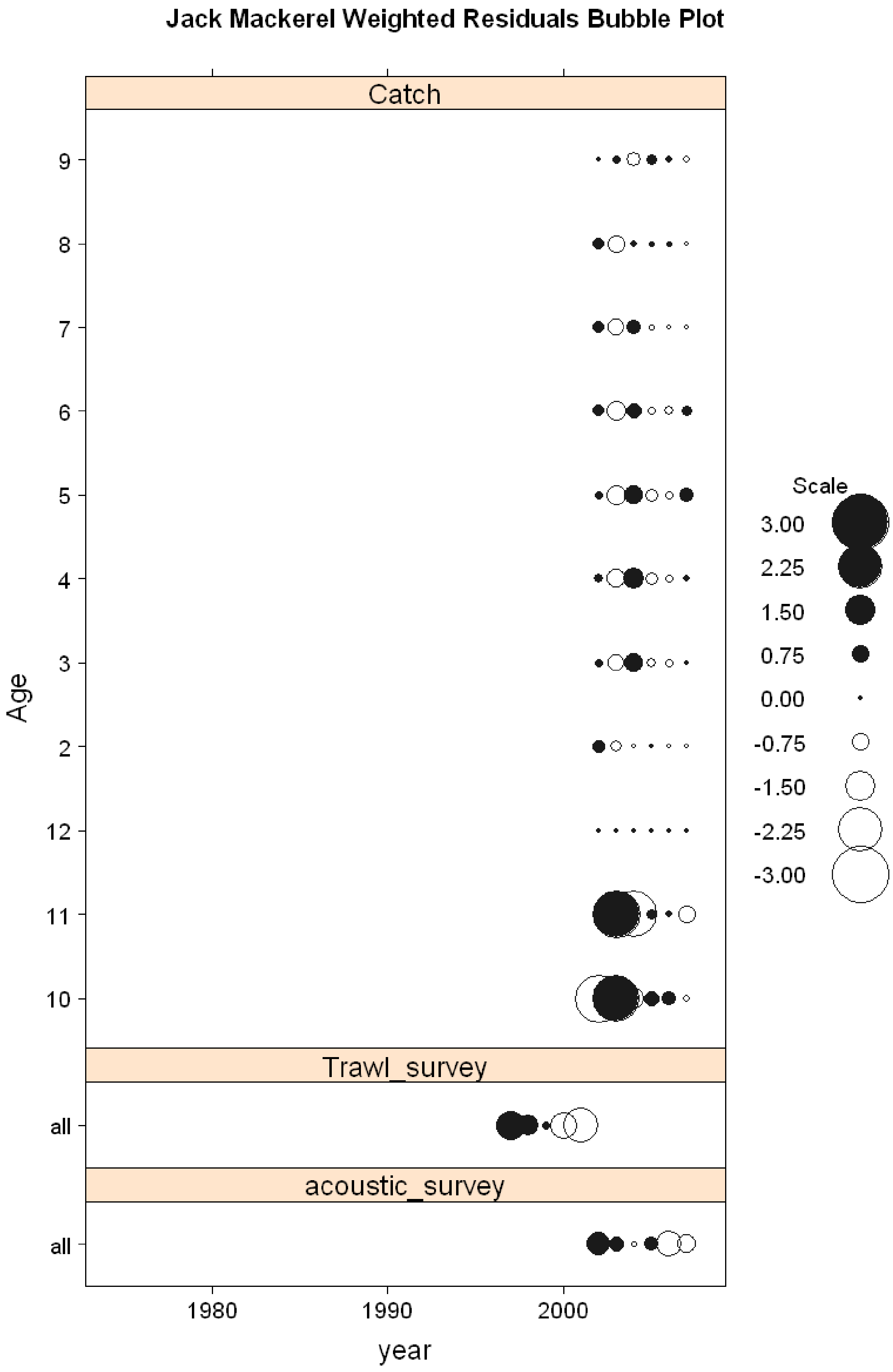


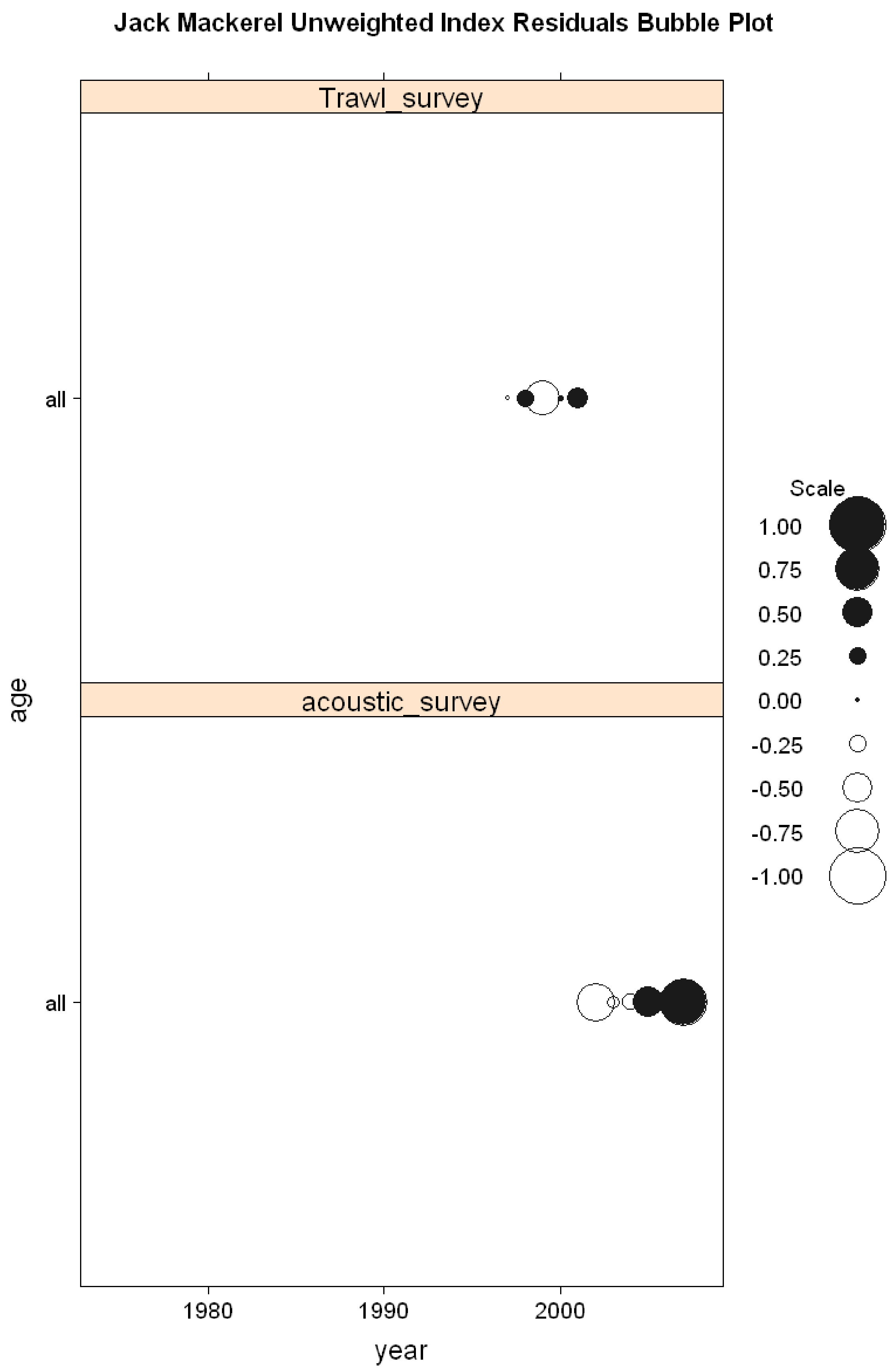

Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
0.0
0.5
1.0
1.5
2.0
2 3 4 5 6 7 8 9 10 11 12 all
Age

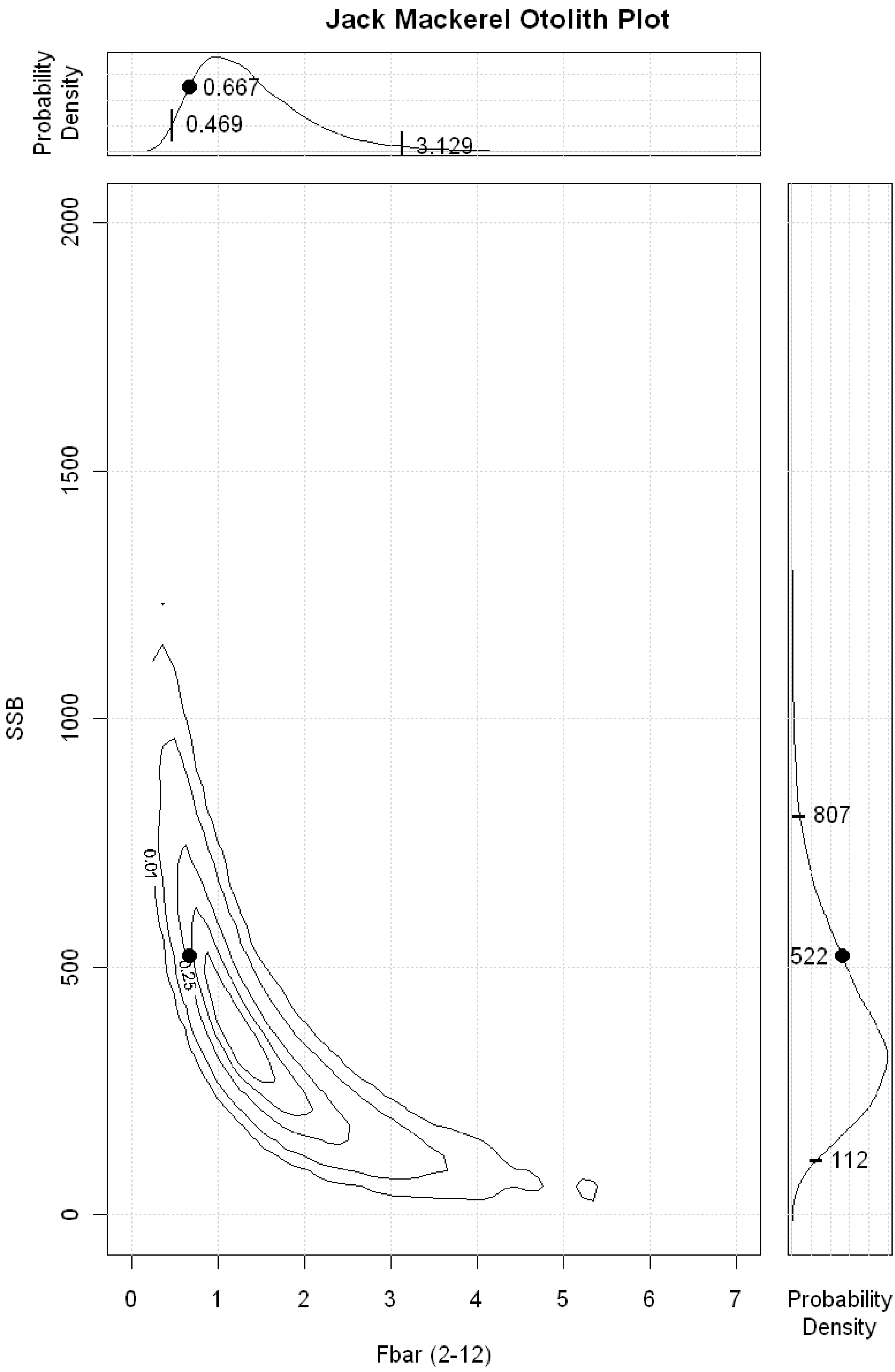

Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Year
1980
1990
2000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.5
1.5
2.0
2.5

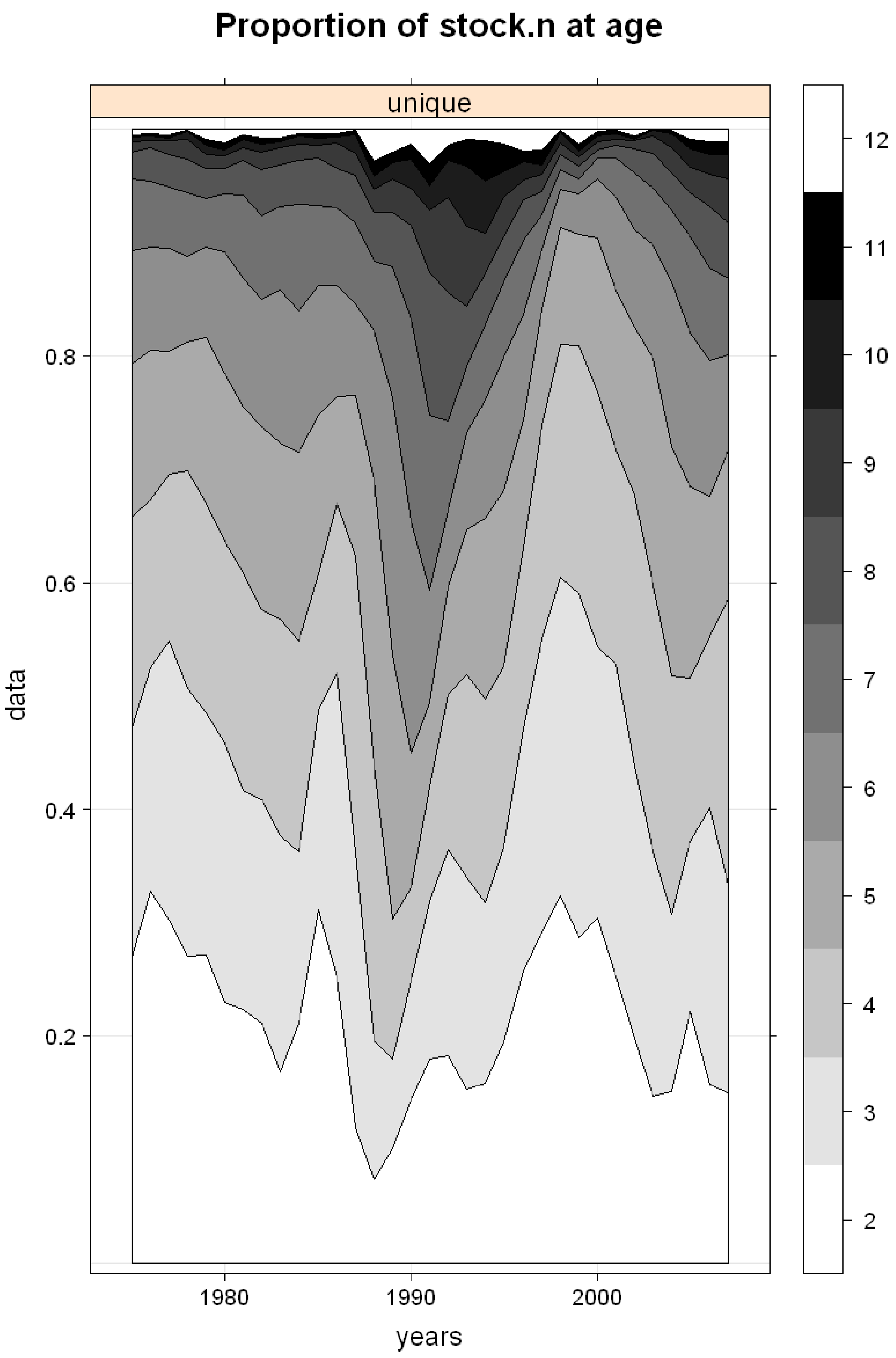


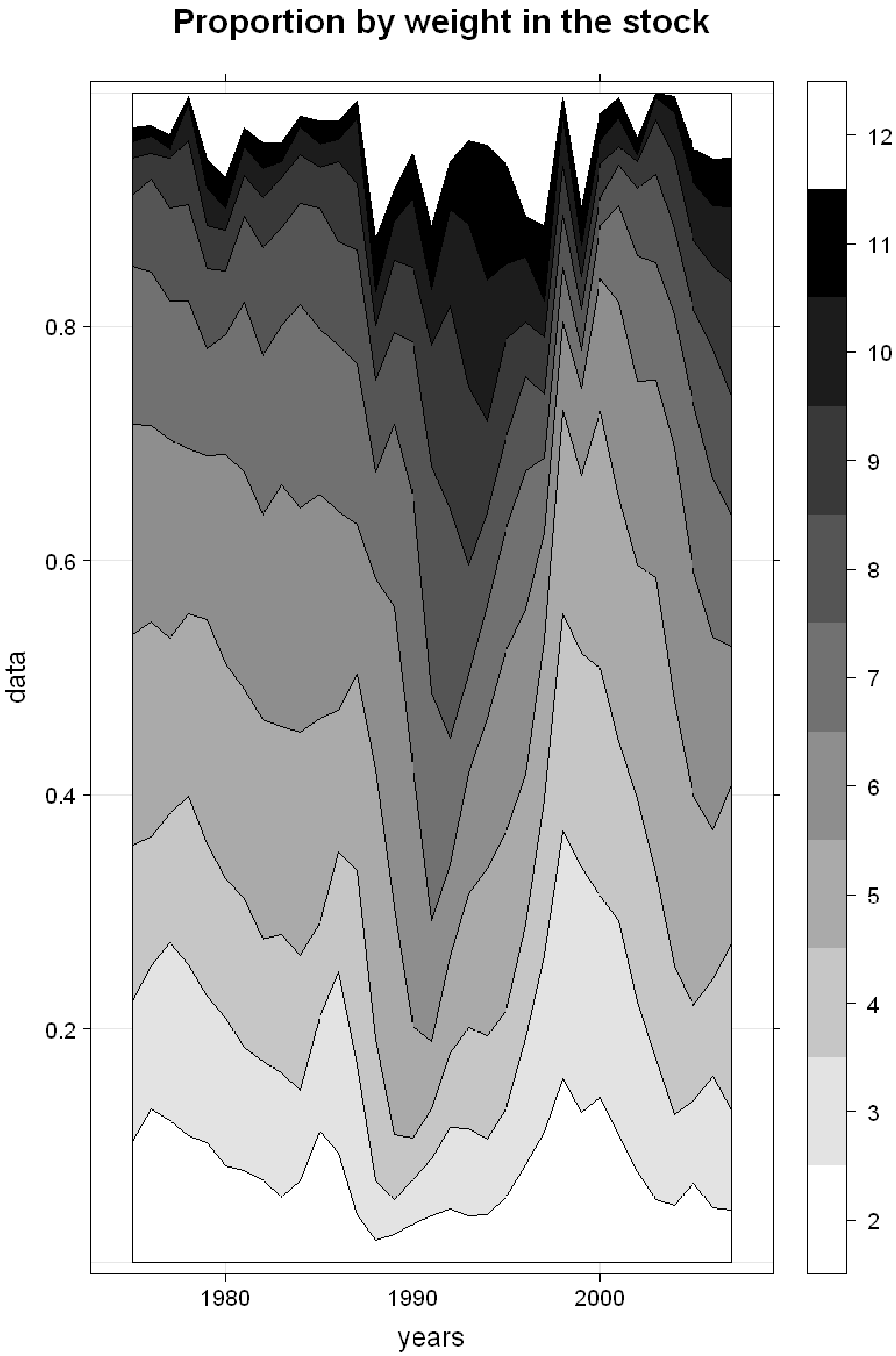
Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Cohort
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
1
2
3
0.5
1.5
2.0
2.5
1980
1990
2000


Jack Mackerel Weighted Residuals Bubble Plot
Catch
Trawl_survey
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00


Jack Mackerel Unweighted Index Residuals Bubble Plot
Trawl_survey
acoustic_survey
all
all
age
Scale
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
1980
1990
2000
year

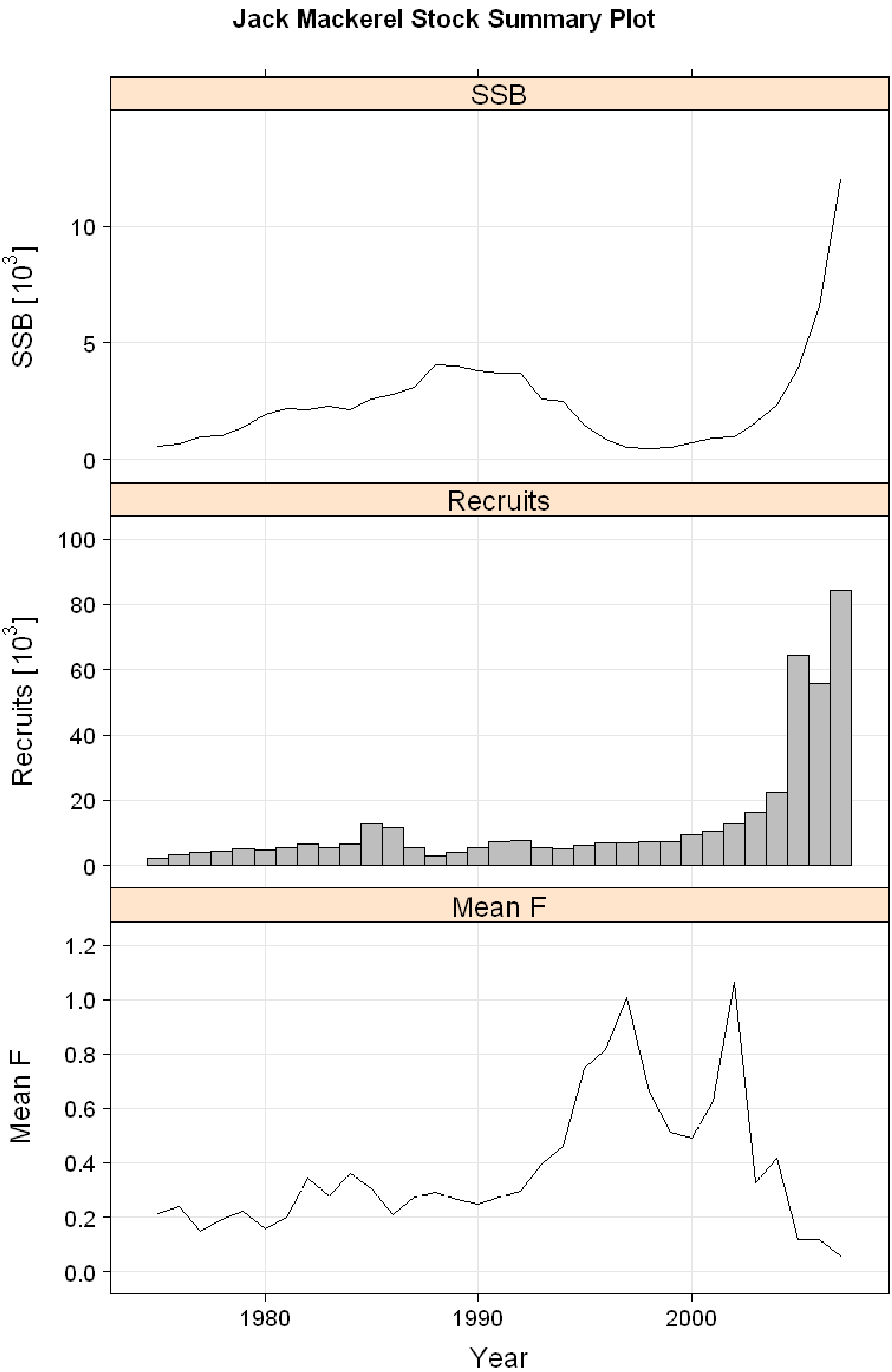

Jack Mackerel Otolith Plot
Probability Density
0.667
0.469
3.129
SSB
2000
1500
1000
500
0
0.01
0.25
0
1
2
3
4
5
6
7
Fbar (2-12)
807
522
112
Probability Density

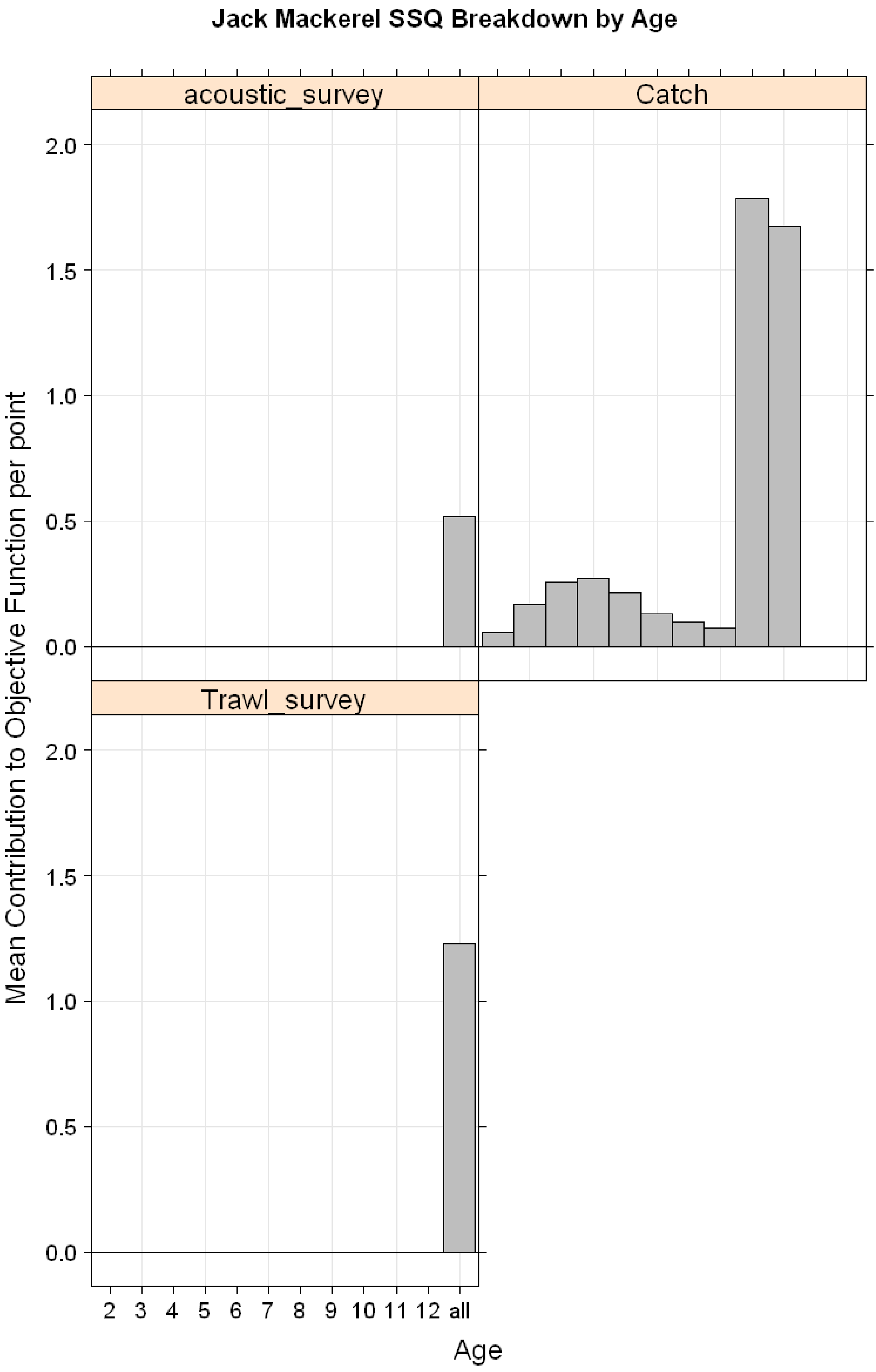

Proportion of stock.n at age
unique
data
years
0.2
0.4
0.6
0.8
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

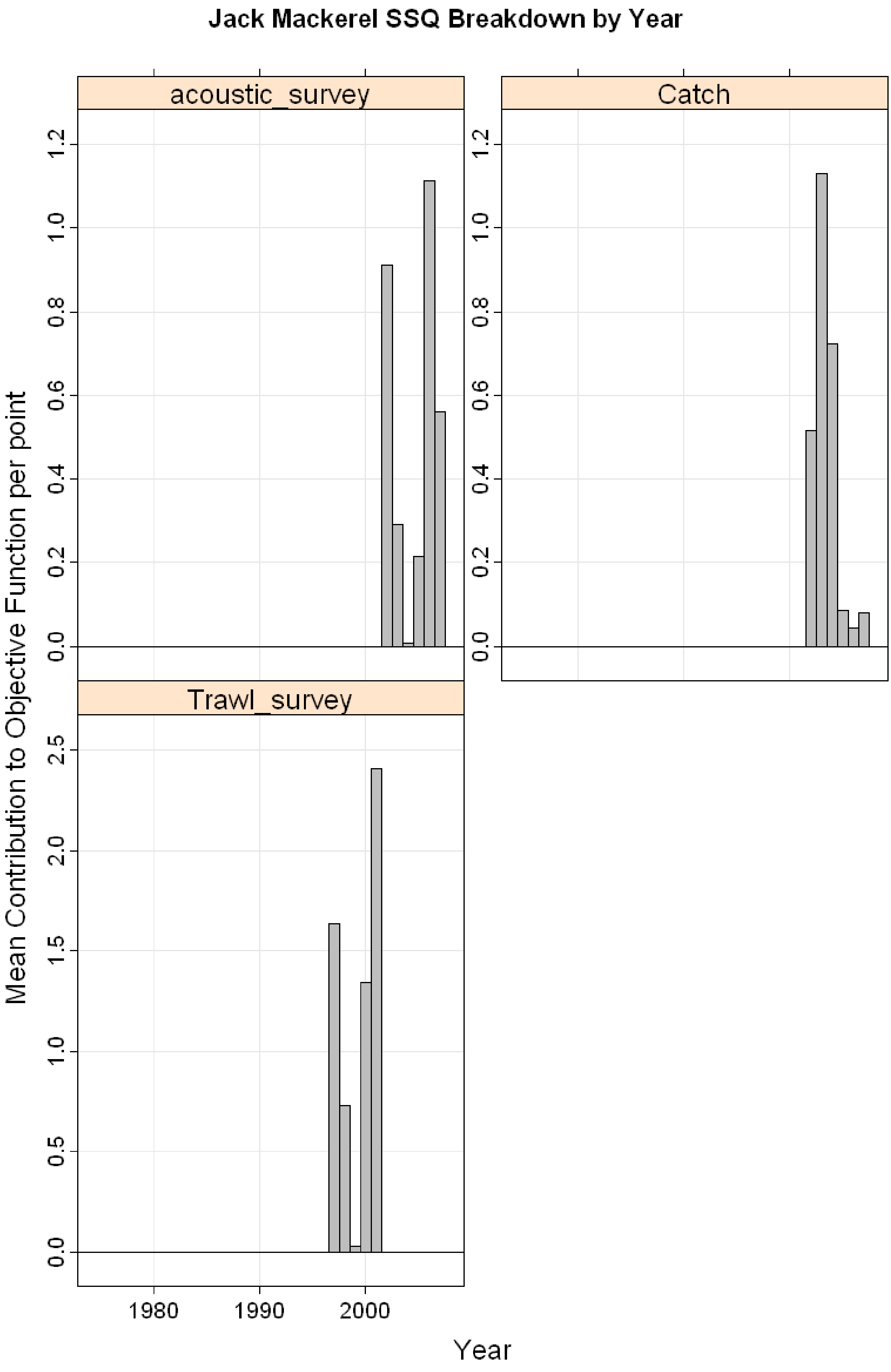


Proportion by weight in the stock
data
years
0.8
0.6
0.4
0.2
1980
1990
2000
12
11
10
9
8
7
6
5
4
3
2

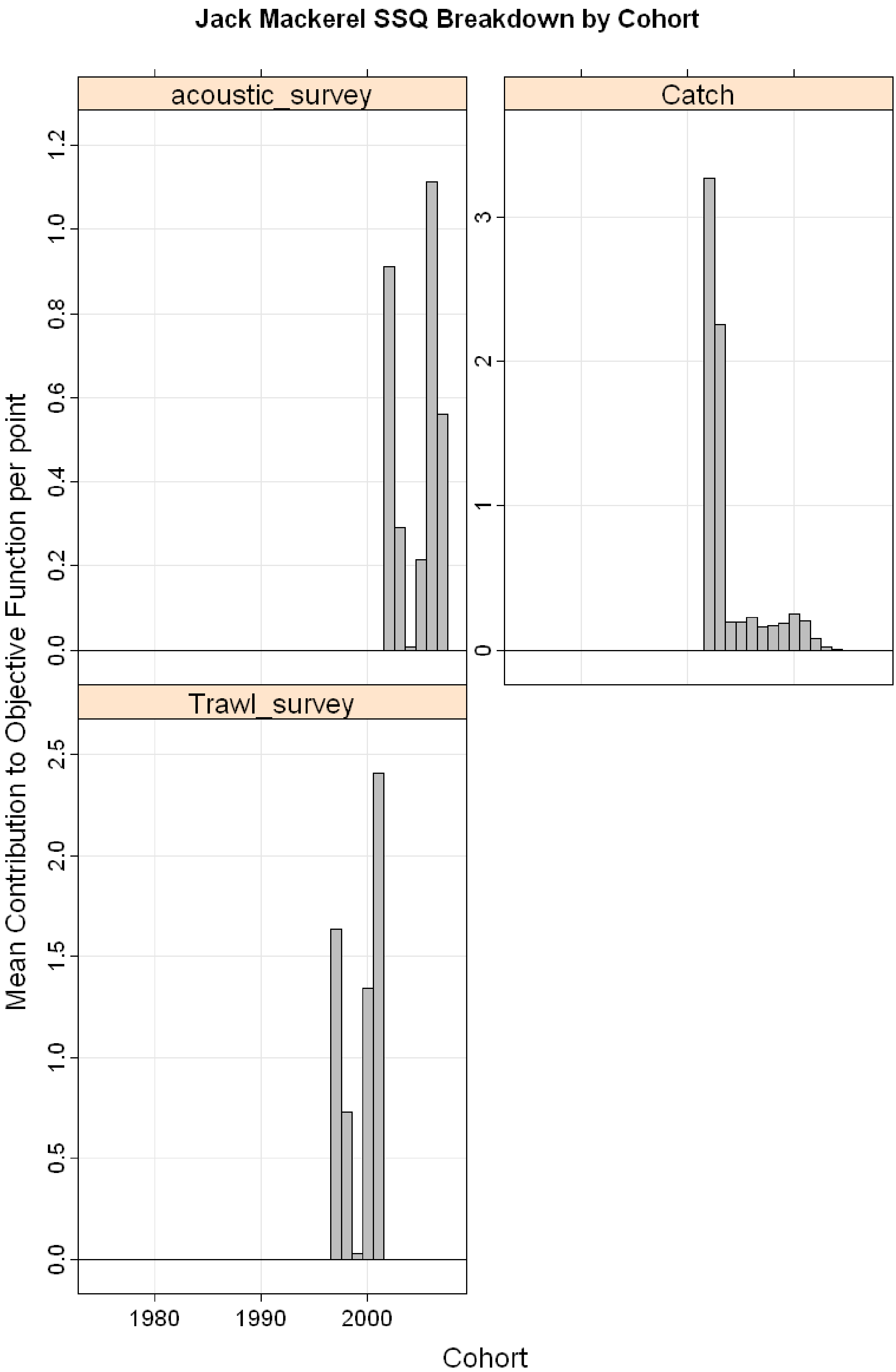
8.2.3 95%


Jack Mackerel Stock Summary Plot
SSB
SSB [10^3]
10
5
0
Recruits
Recruits [10^3]
100
80
60
40
20
0
Mean F
Mean F
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1980
1990
2000
Year

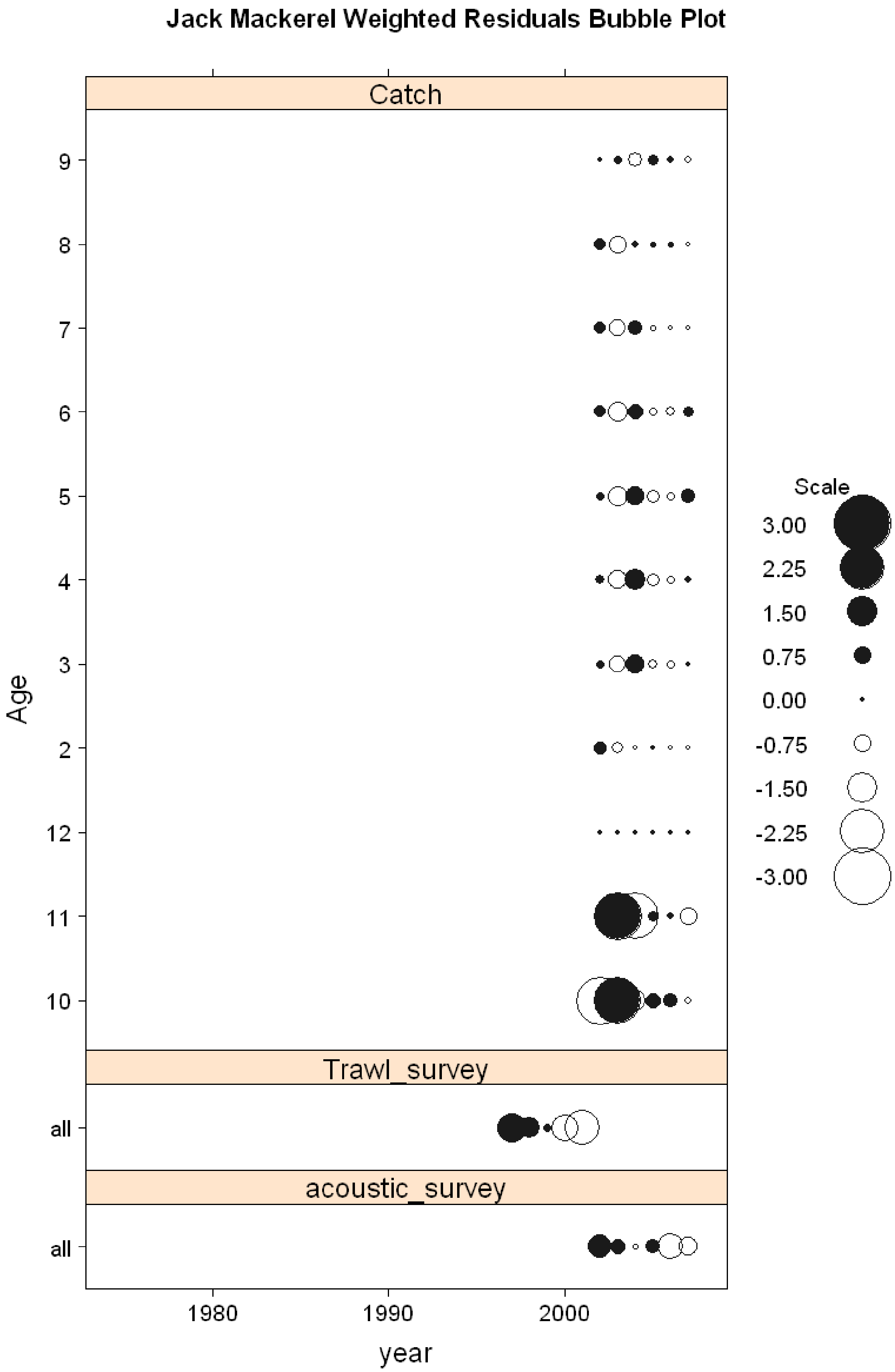

Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
0.0
0.5
1.0
1.5
2.0
2 3 4 5 6 7 8 9 10 11 12 all
Age



Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Year
1980
1990
2000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.5
1.5
2.0
2.5

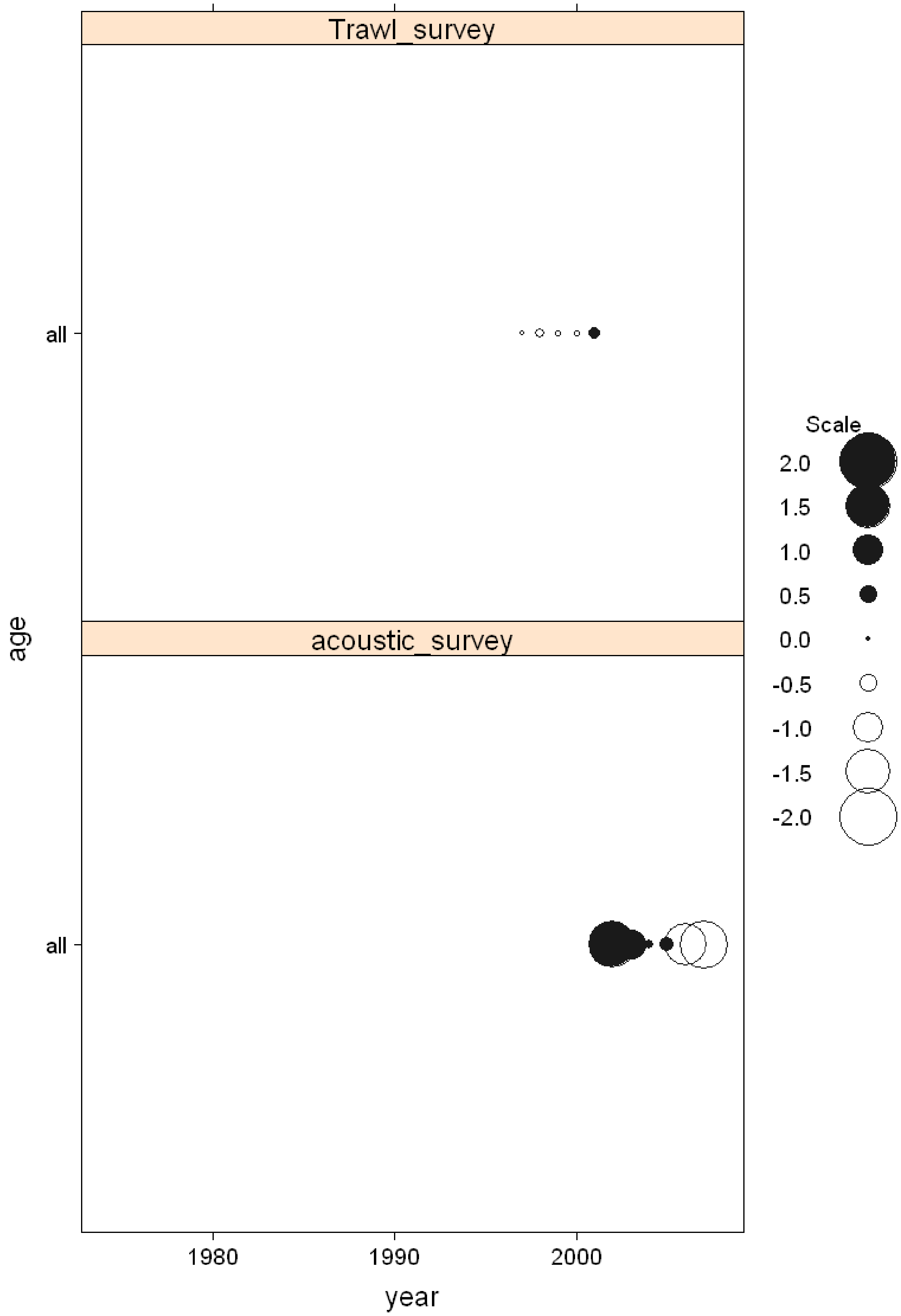


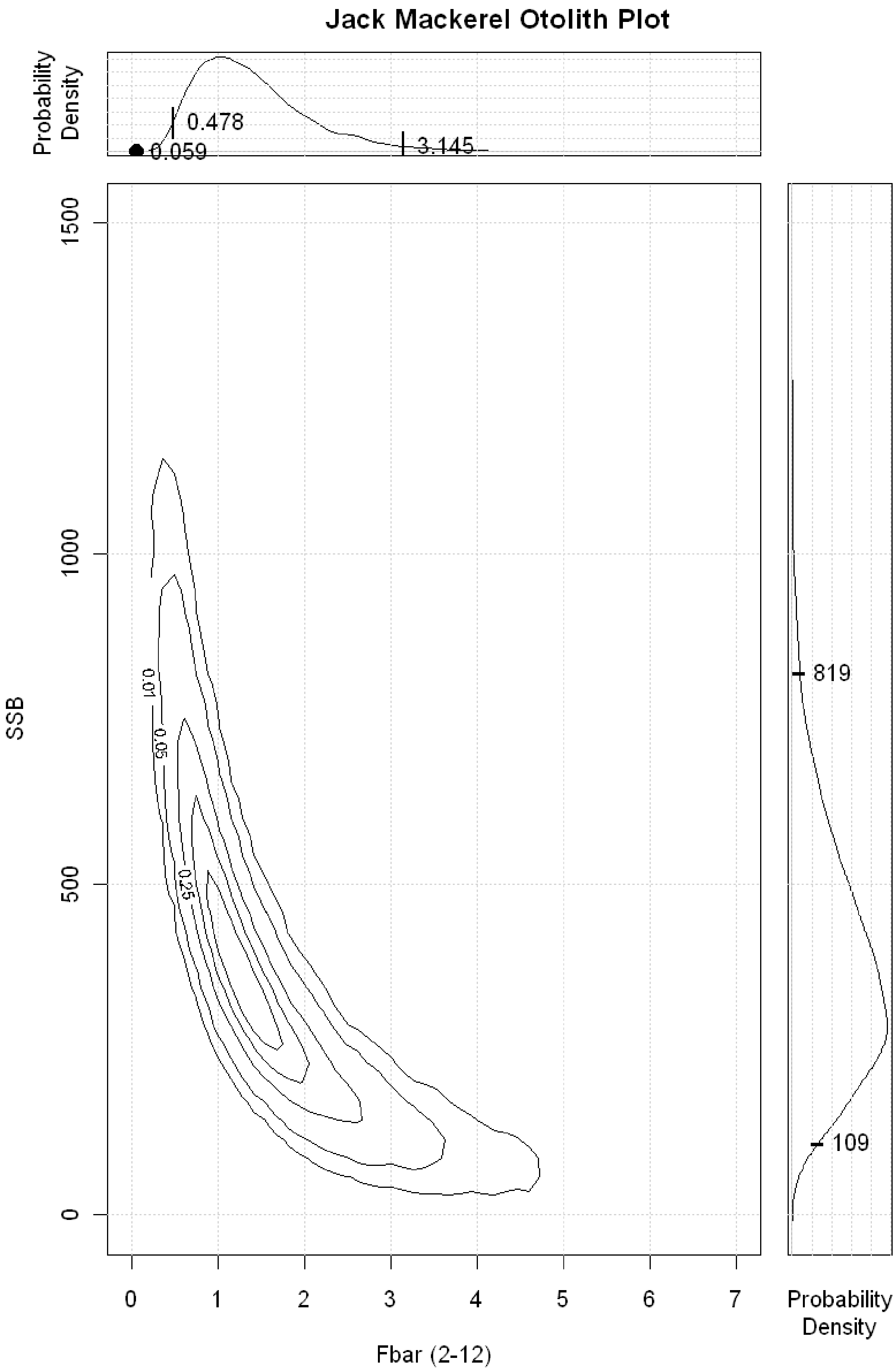
Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Cohort
1980
1990
2000



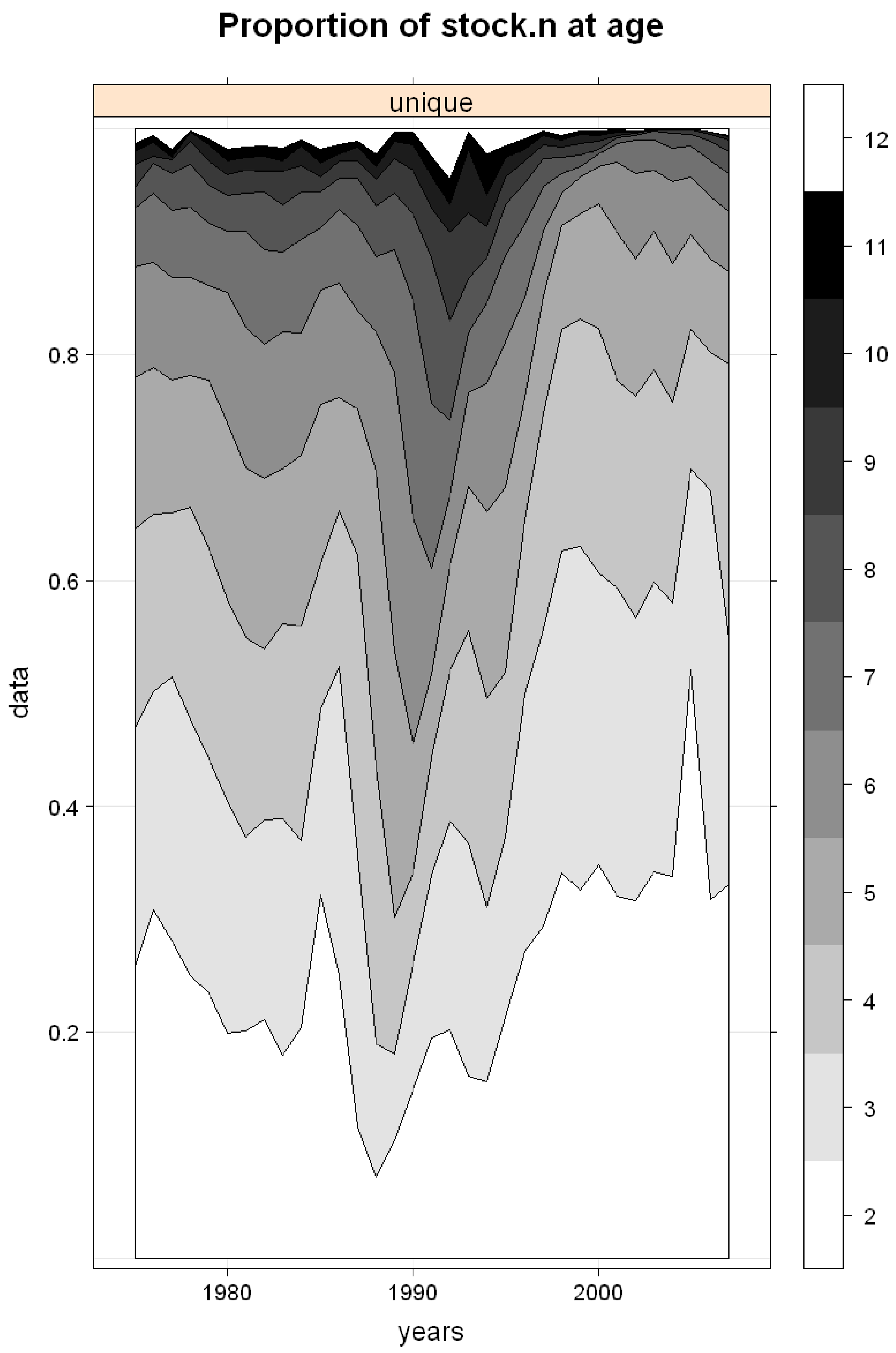
Jack Mackerel Weighted Residuals Bubble Plot
Catch
Trawl_survey
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00

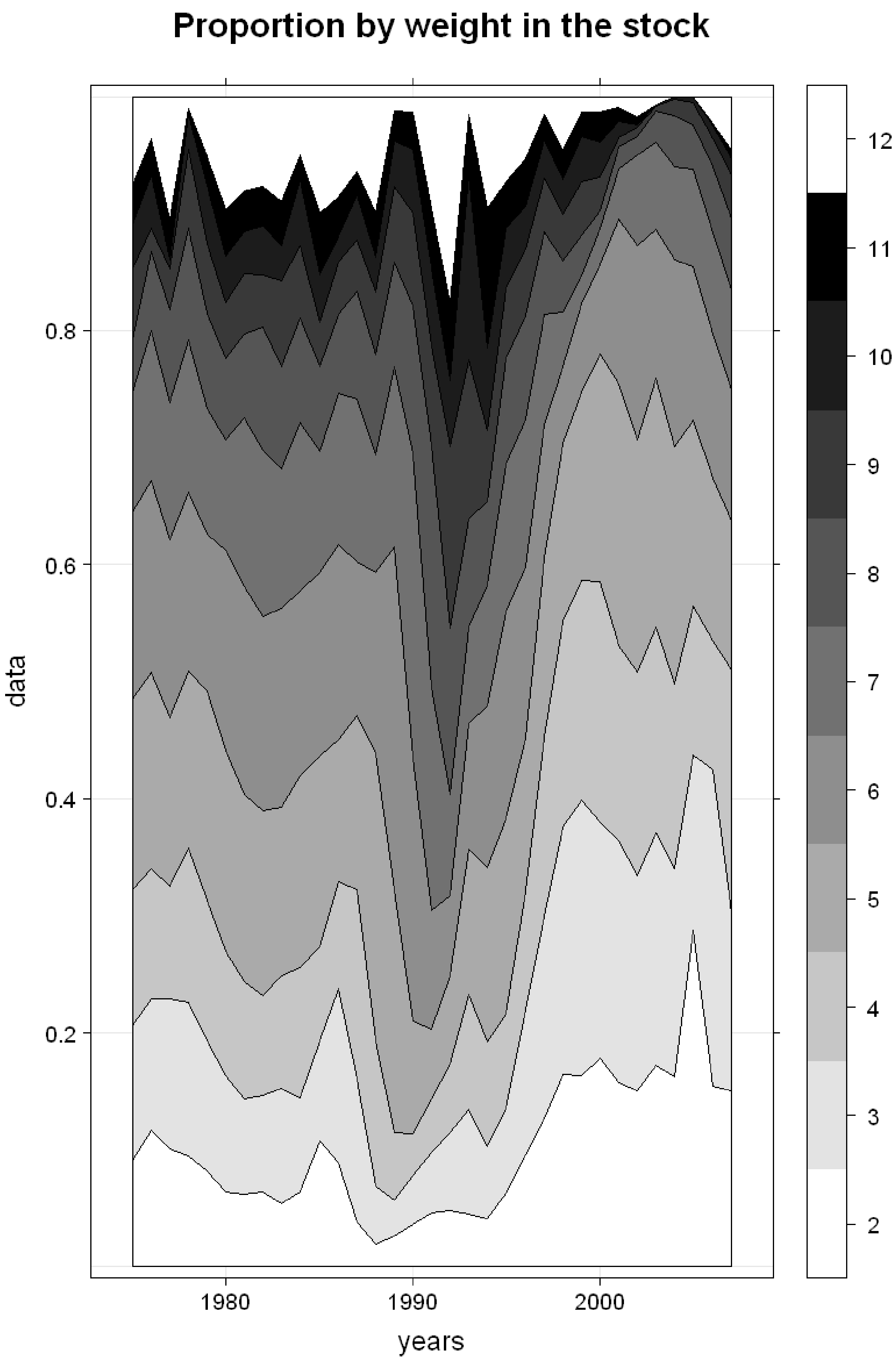
Jack Mackerel Unweighted Index Residuals Bubble Plot





Jack Mackerel Otolith Plot
Probability Density
0.478
0.059
3.145
SSB
1500
1000
500
0
0.01
0.05
0.25
819
109
0
1
2
3
4
5
6
7
Fbar (2-12)
Probability Density

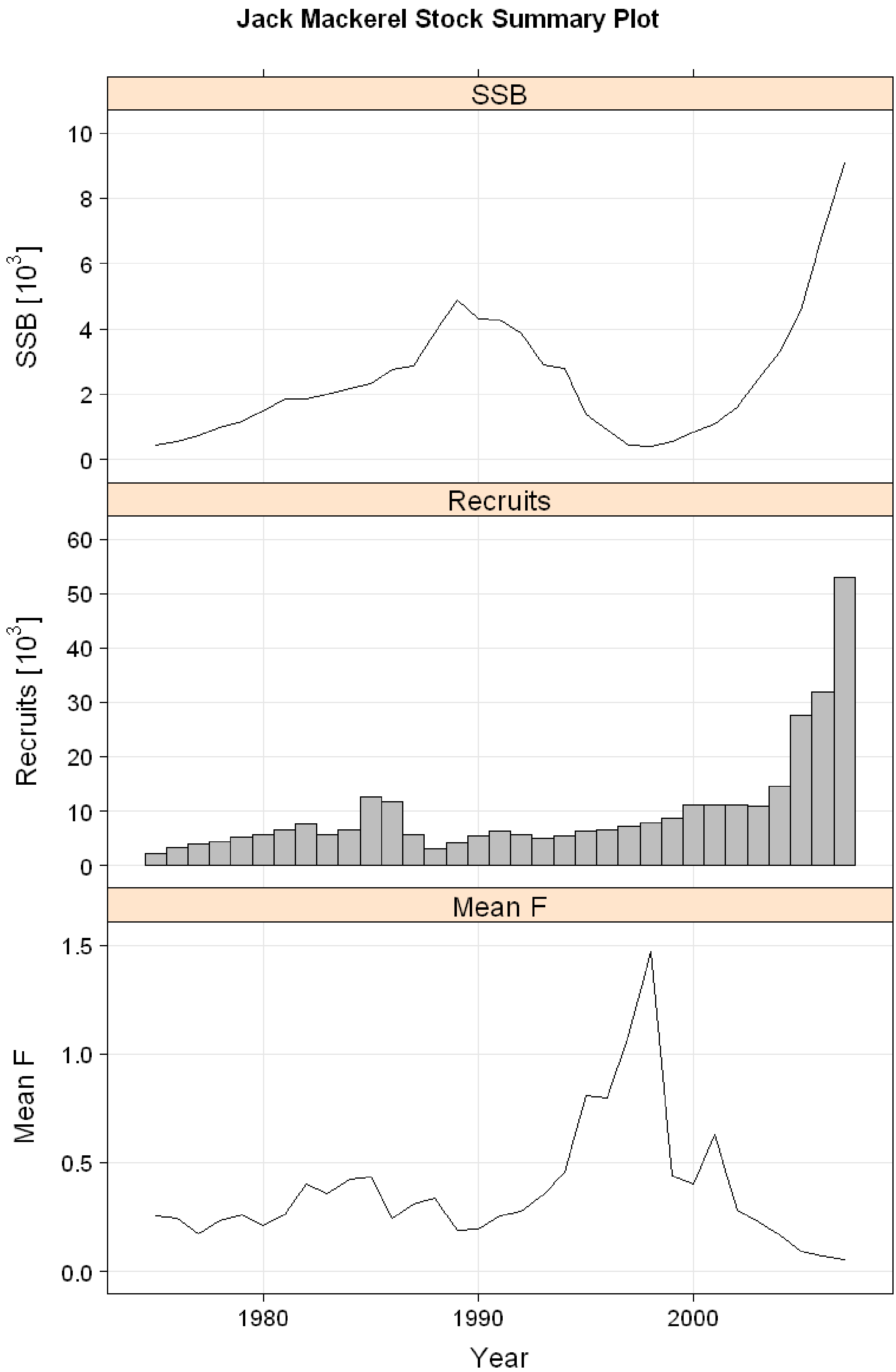

Proportion of stock.n at age
unique
data
0.8
0.6
0.4
0.2
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

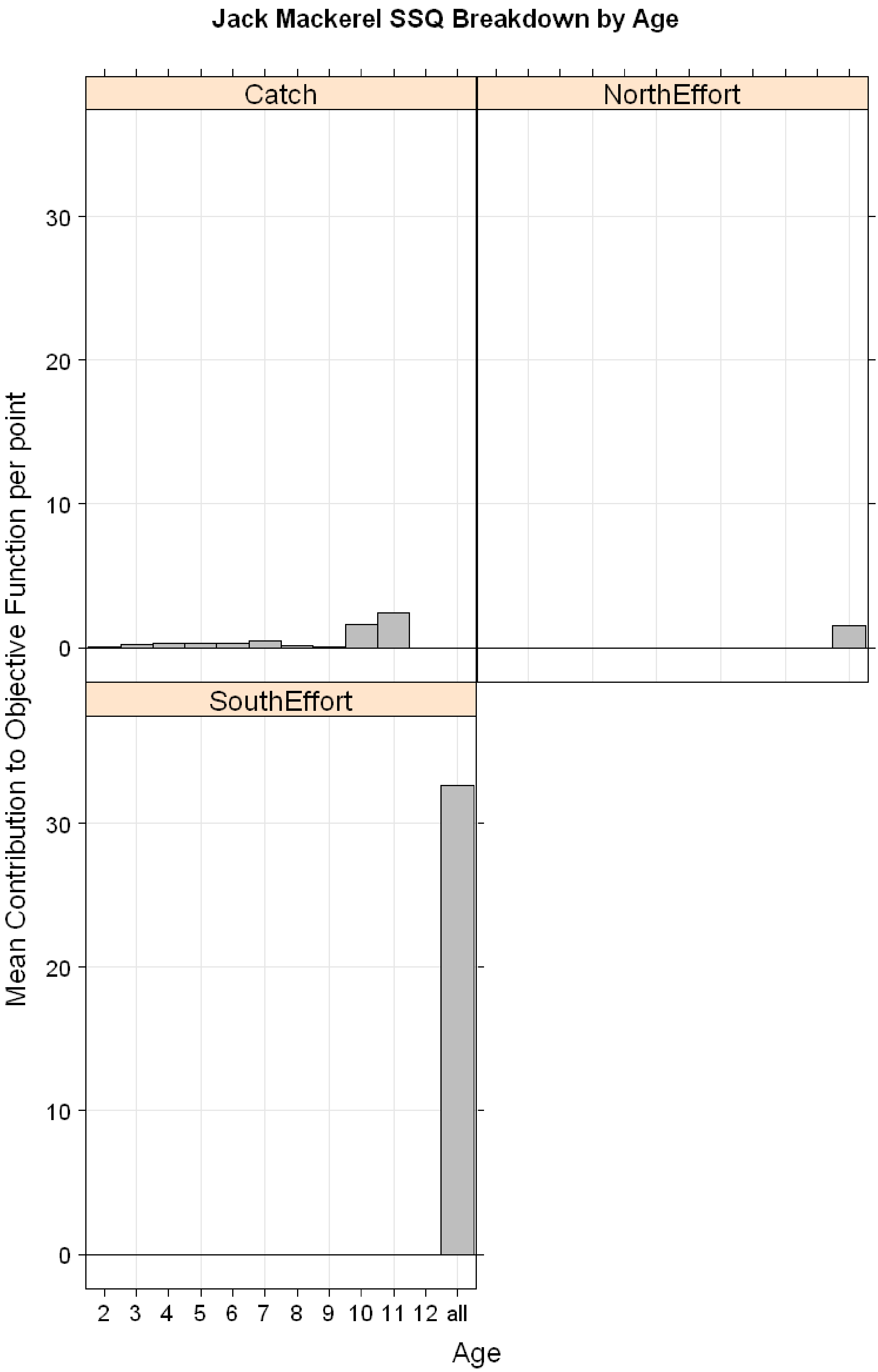


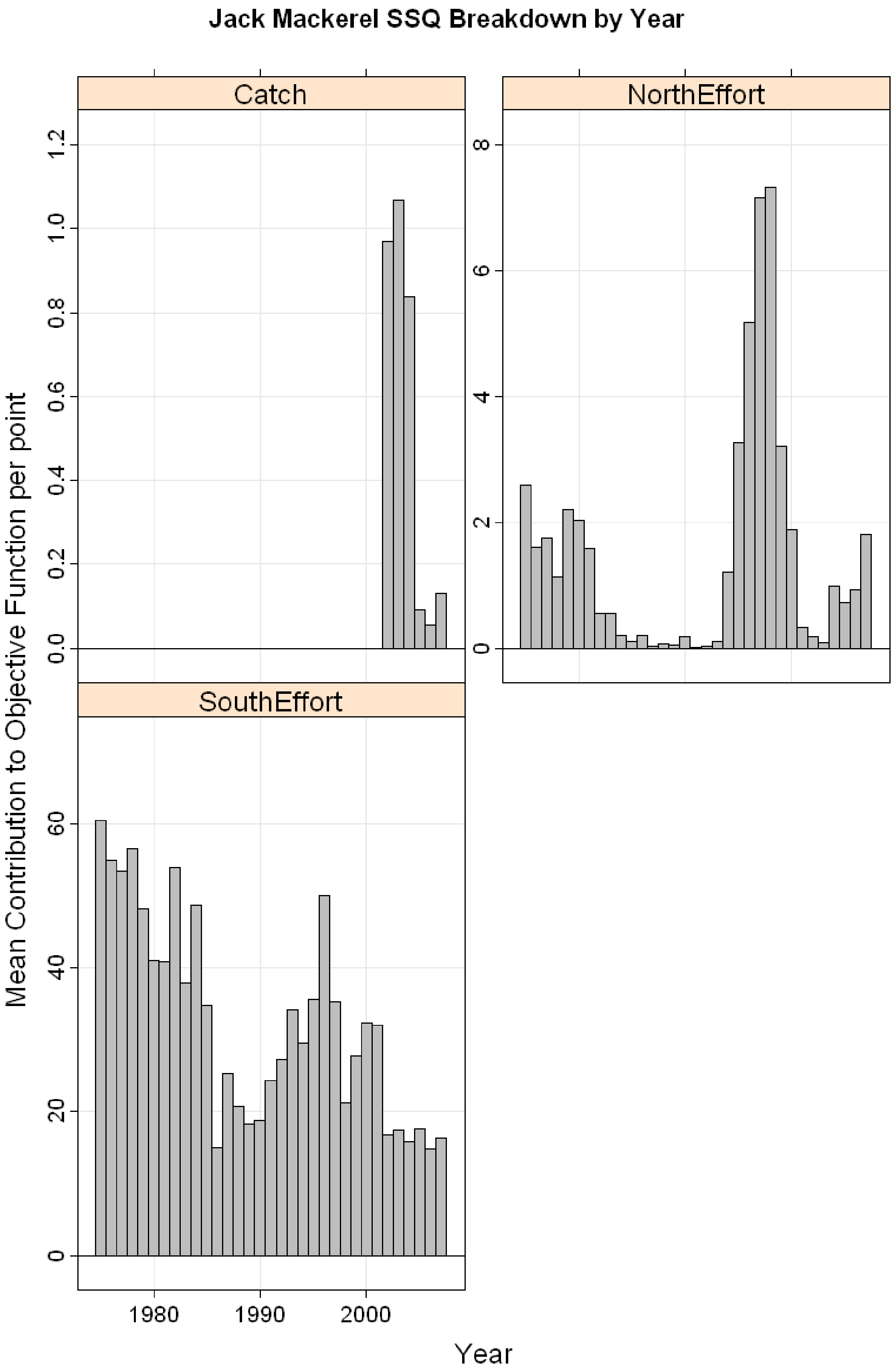
Proportion by weight in the stock
data
0.8
0.6
0.4
0.2
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

8.3 Scenario 3

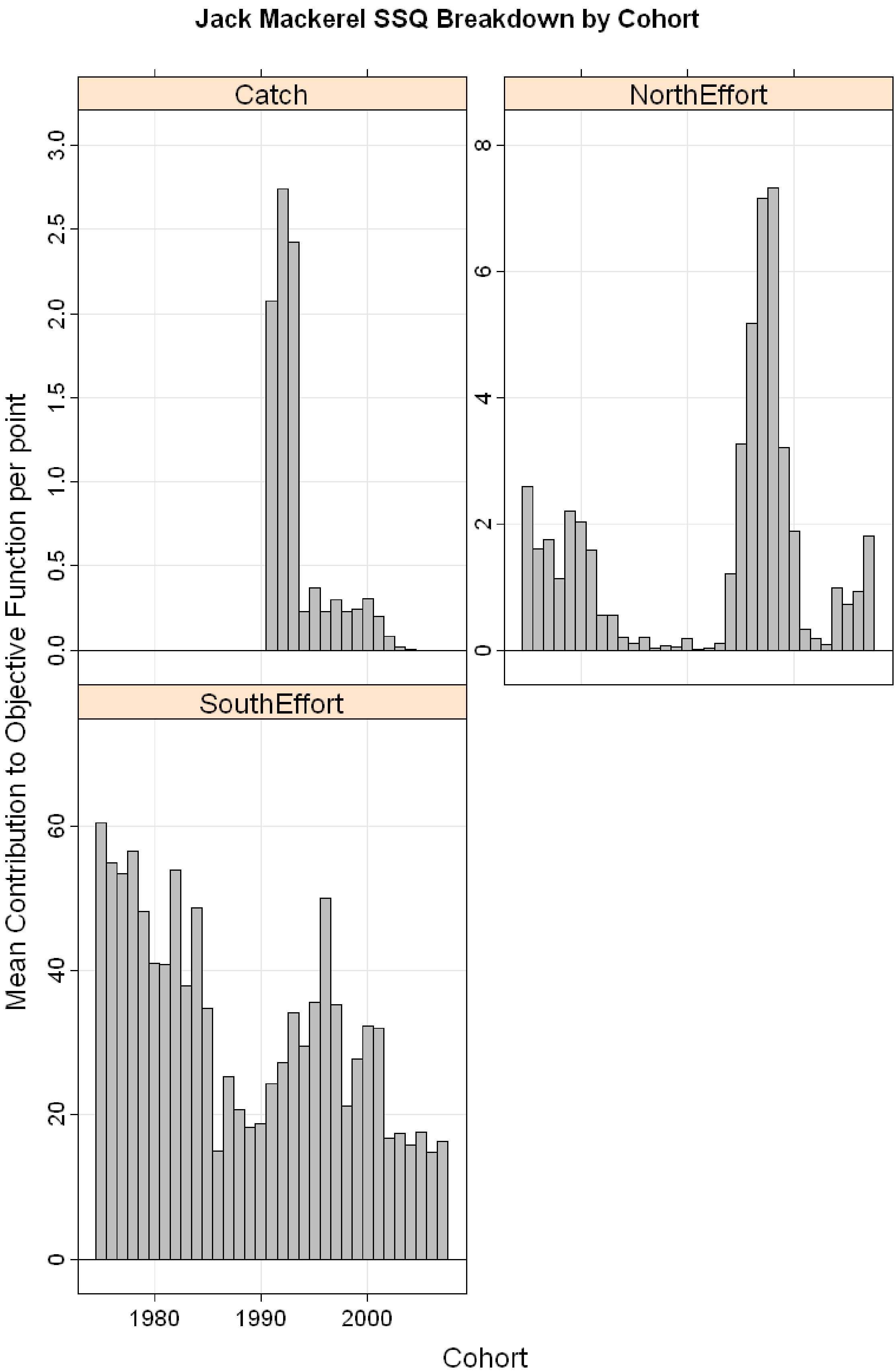
8.3.1 5%

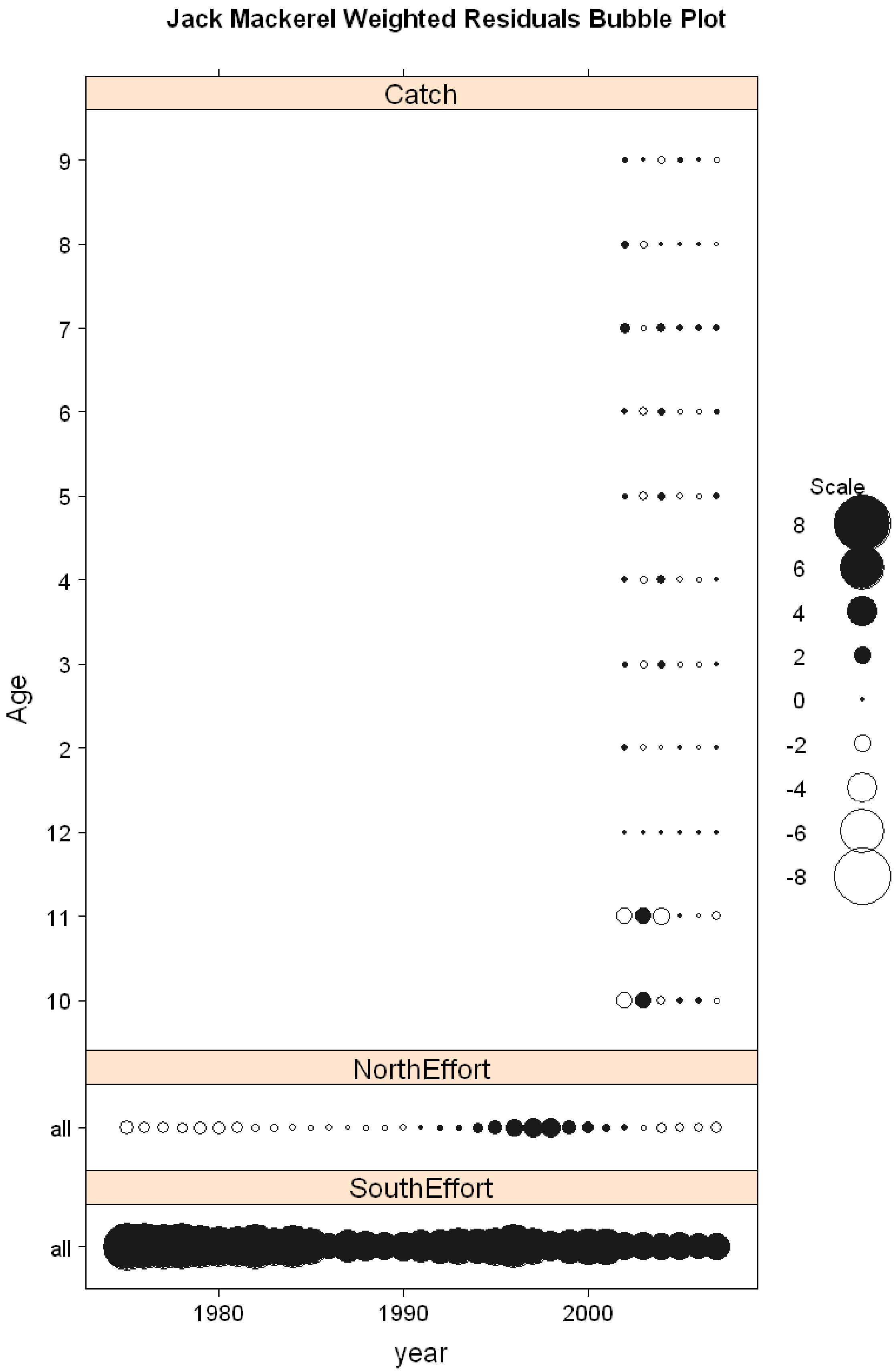

Jack Mackerel Stock Summary Plot
SSB
Recruits
Mean F
SSB [10^3]
Recruits [10^3]
Mean F
Year
1980
1990
2000
0
2
4
6
8
10
0
10
20
30
40
50
60
0.0
0.5
1.0
1.5

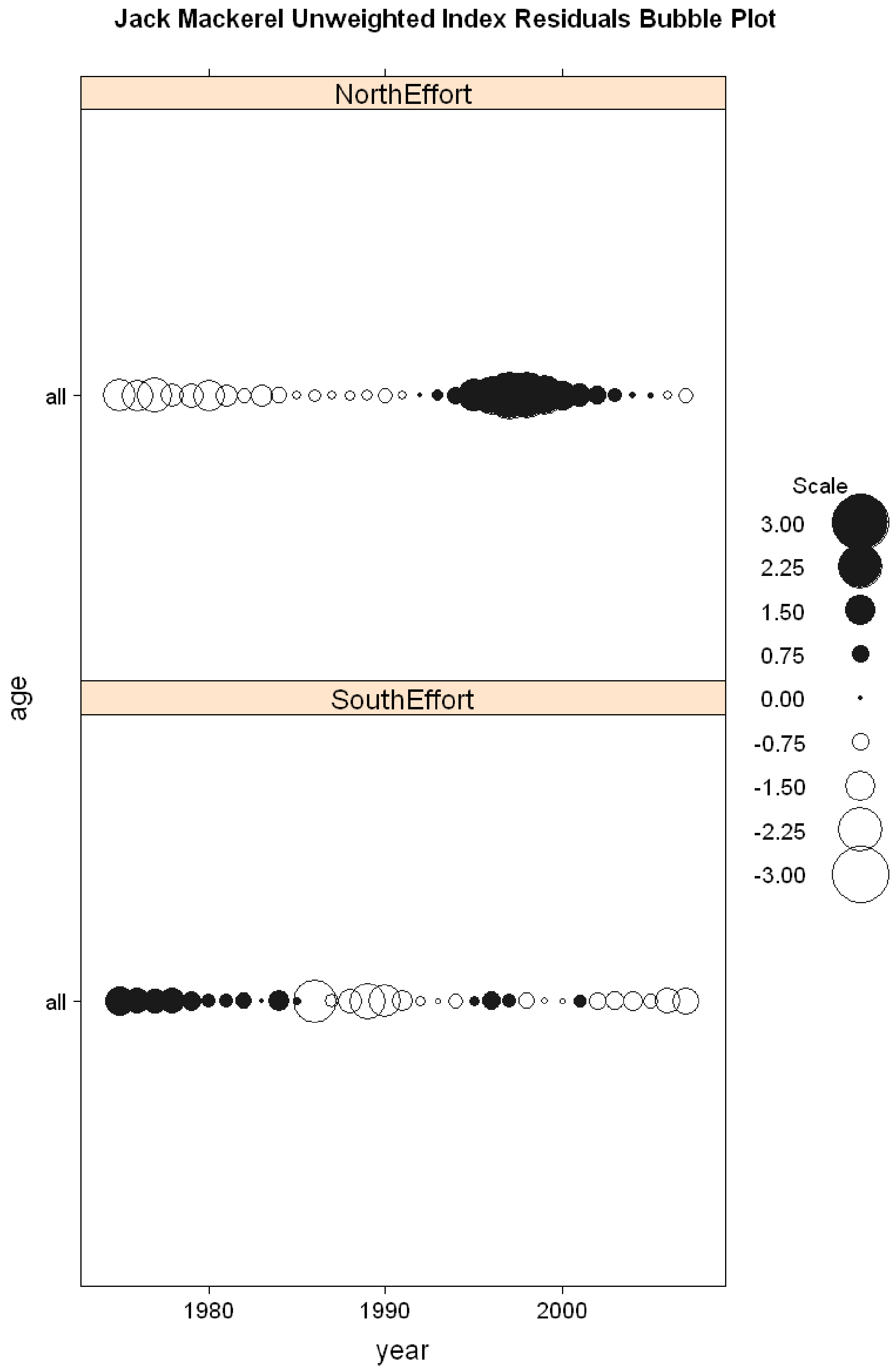

Jack Mackerel SSQ Breakdown by Age
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
0
10
20
30
2
3
4
5
6
7
8
9
10
11
12
all
Age



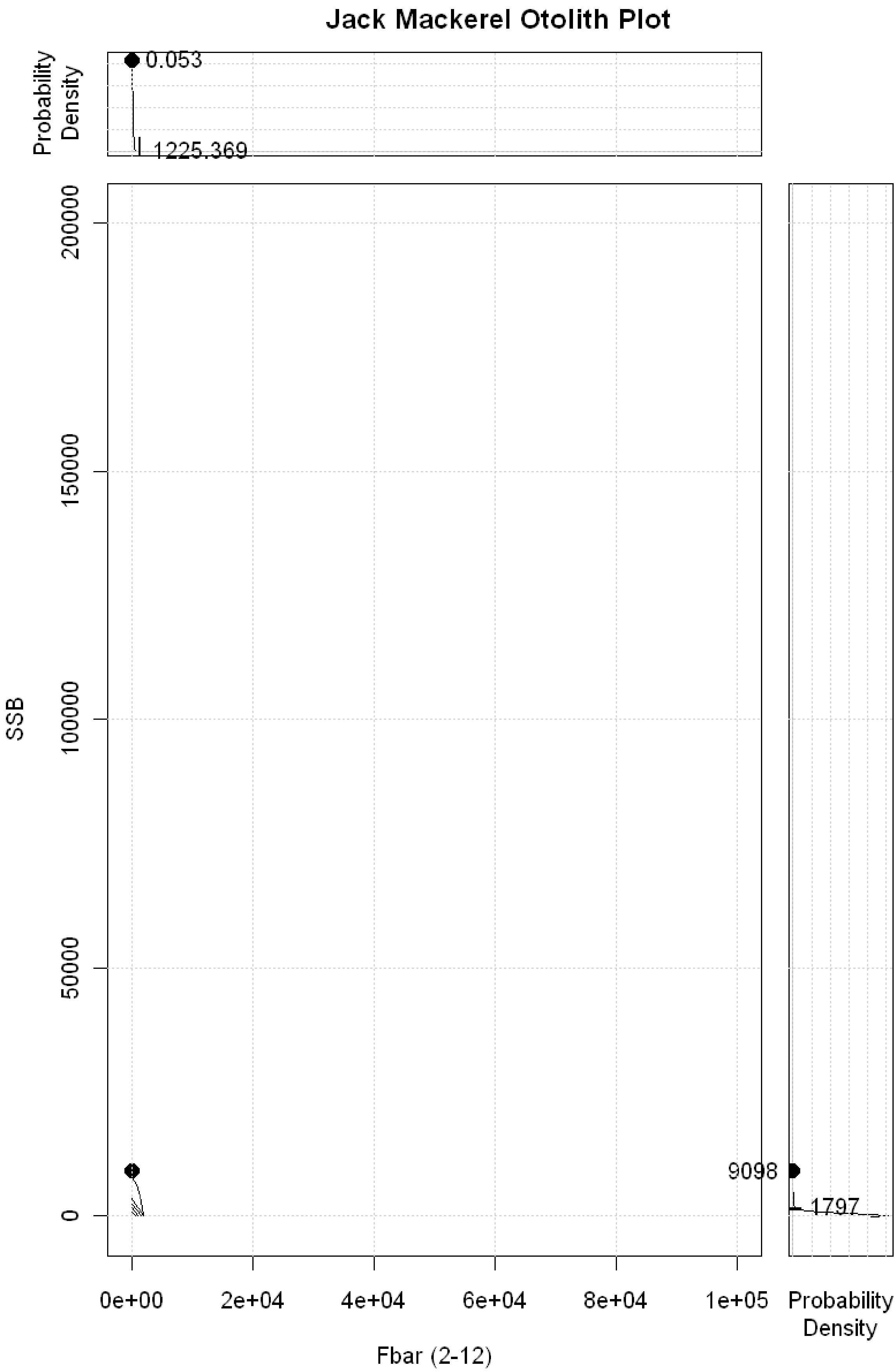
Jack Mackerel SSQ Breakdown by Year
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
Year
1980
1990
2000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
2
4
6
8
0
20
40
60

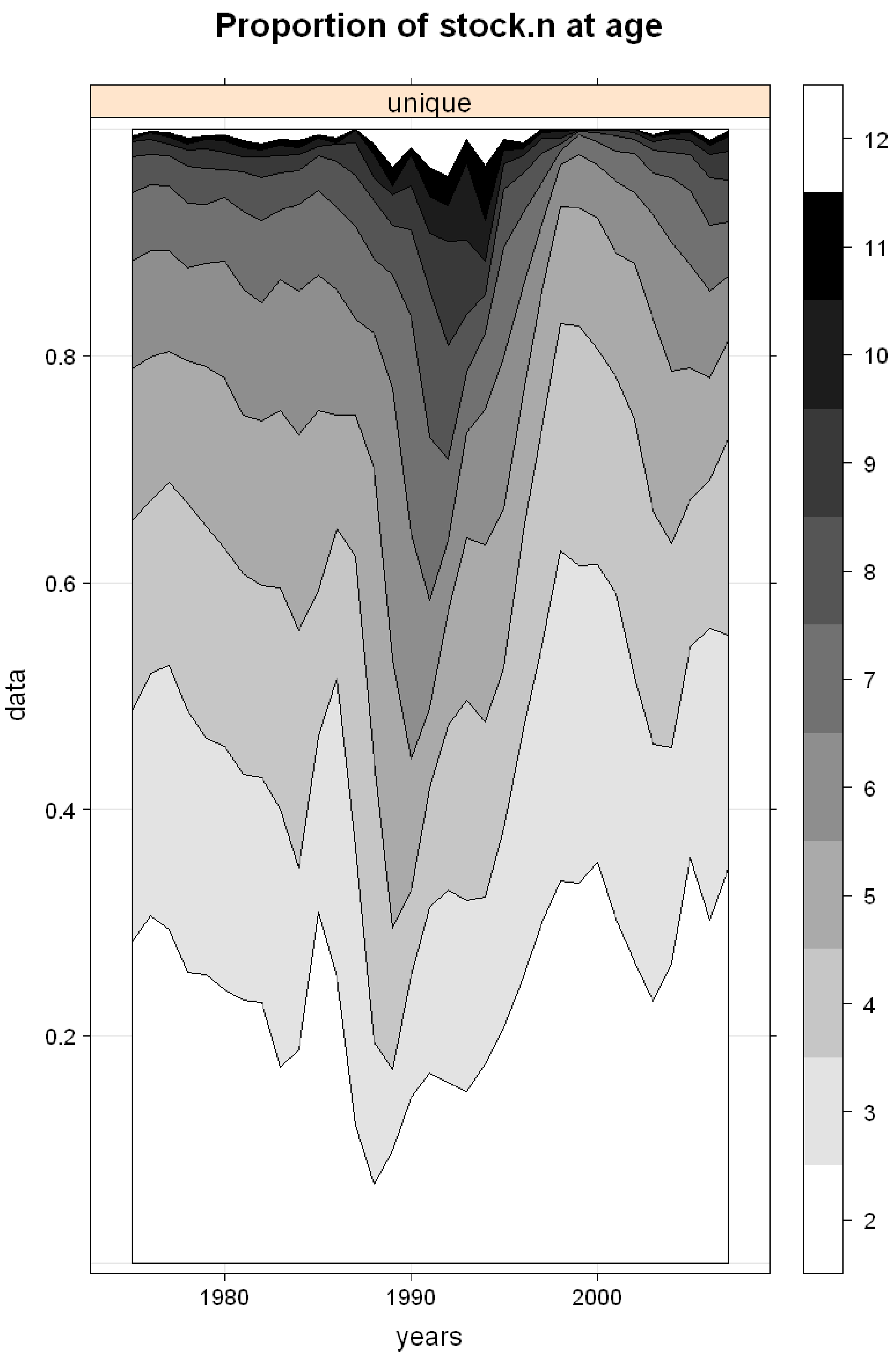

Jack Mackerel SSQ Breakdown by Cohort
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
Cohort
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
2
4
6
8
0
20
40
60
1980
1990
2000


Jack Mackerel Weighted Residuals Bubble Plot
Catch
NorthEffort
SouthEffort
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
8
6
4
2
0
-2
-4
-6
-8

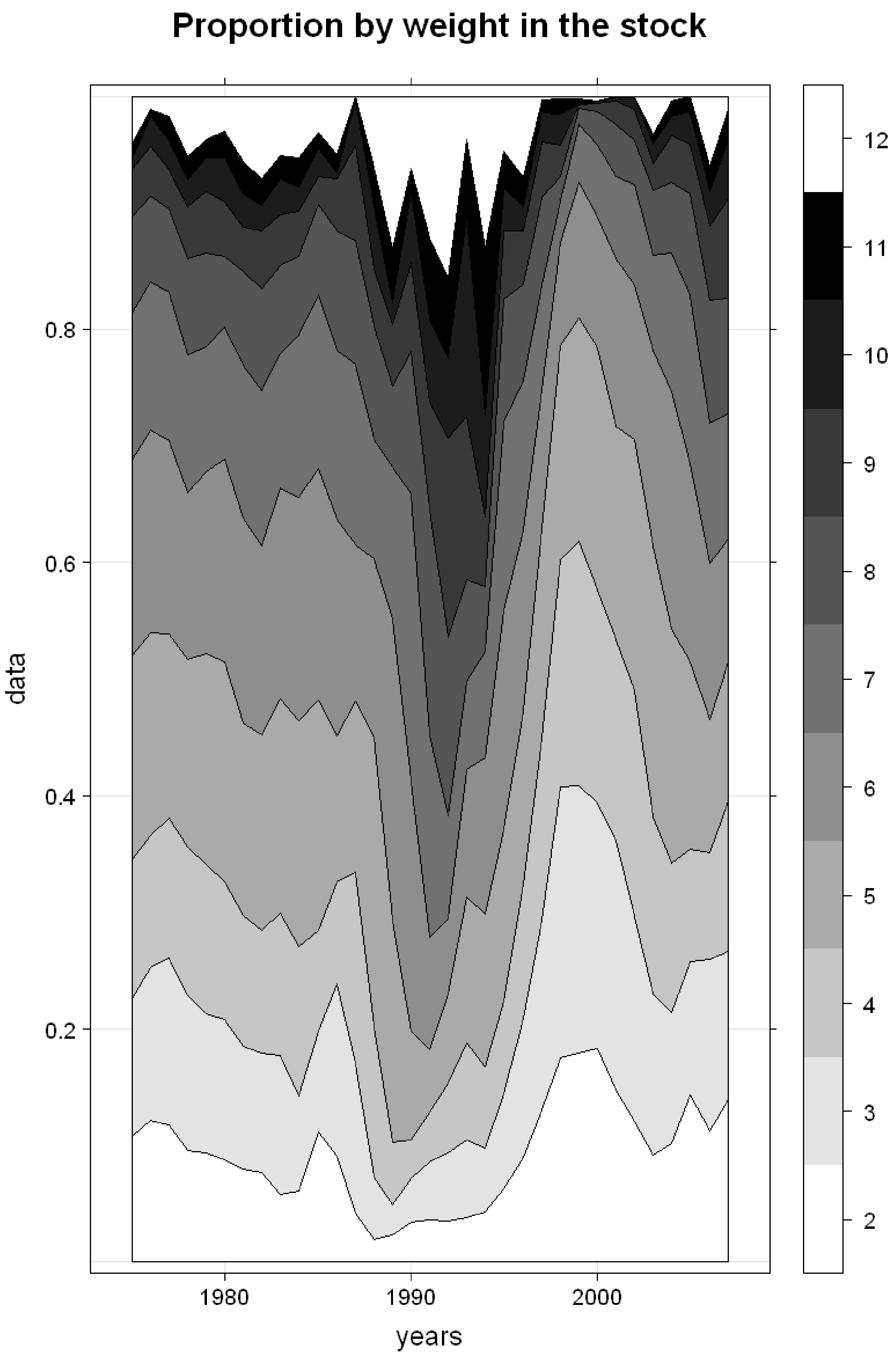


Jack Mackerel Unweighted Index Residuals Bubble Plot
NorthEffort
SouthEffort
all
all
age
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00


Jack Mackerel Otolith Plot
Probability Density
0.053
1225.369
SSB
200000
150000
100000
50000
0
9098
1797
0e+00
2e+04
4e+04
6e+04
8e+04
1e+05
Probability Density
Fbar (2-12)



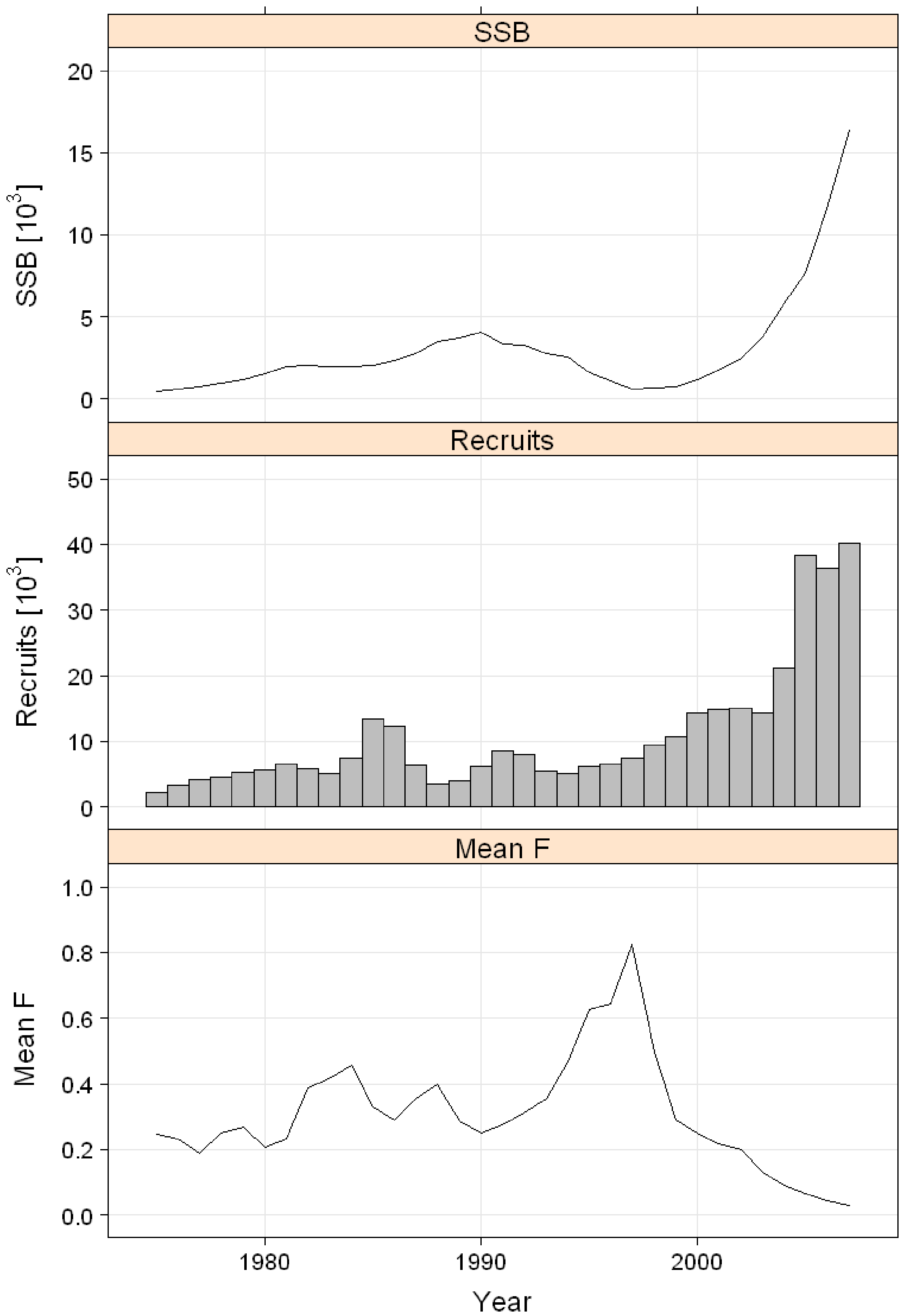
Proportion of stock.n at age
unique
data
0.8
0.6
0.4
0.2
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

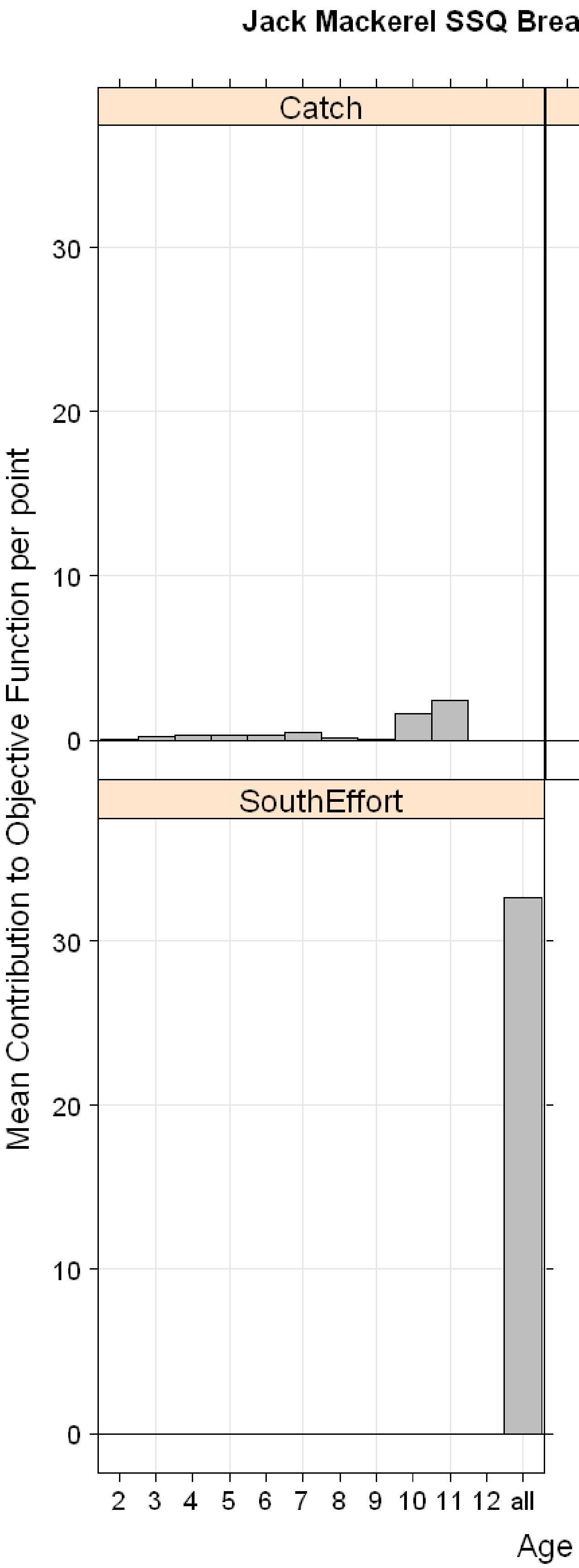


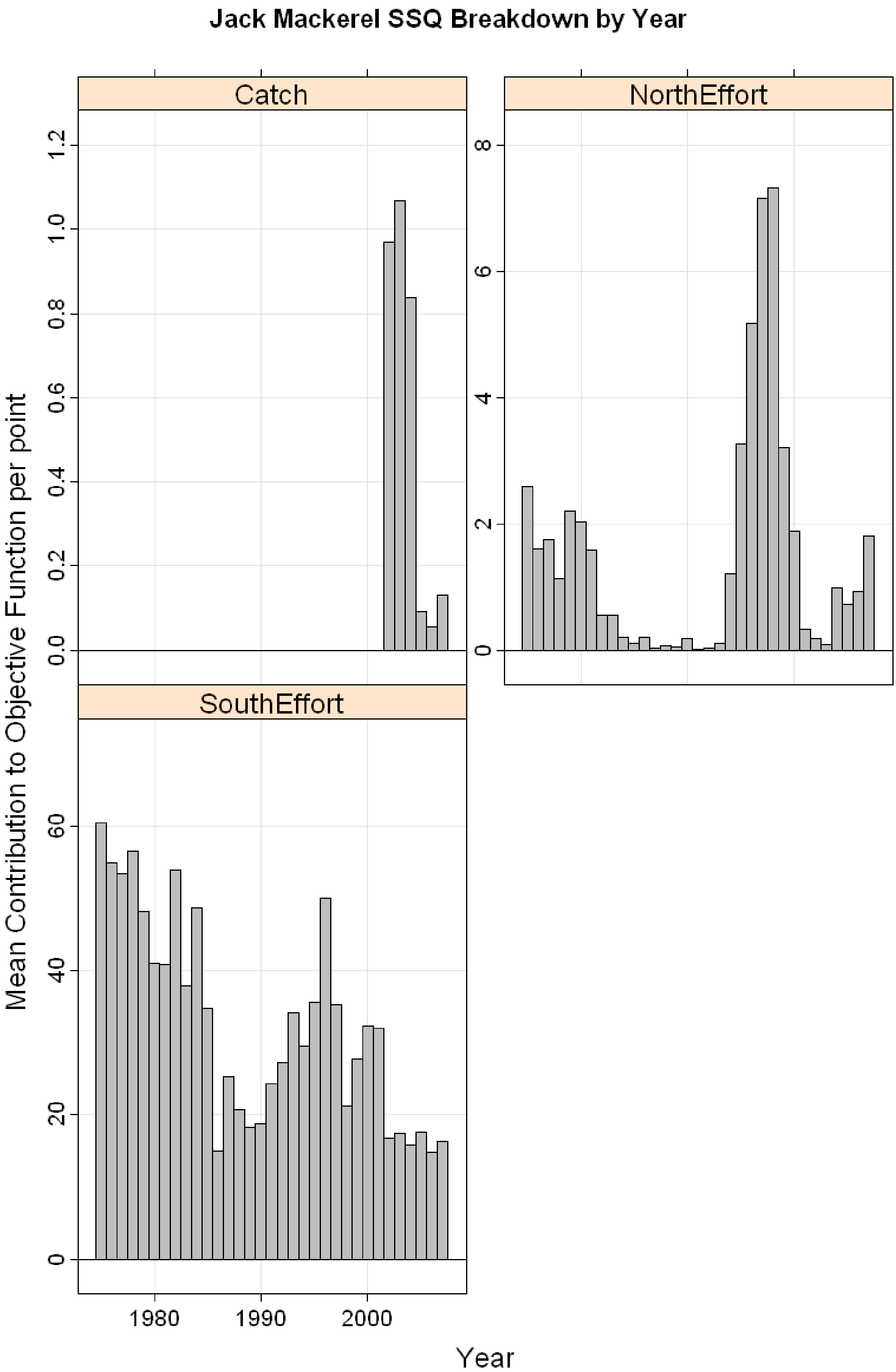
Proportion by weight in the stock
data
0.2
0.4
0.6
0.8
1980
1990
2000
years
2
3
4
5
6
7
8
9
10
11
12

8.3.2 50%

Jack Mackerel Stock Summary Plot

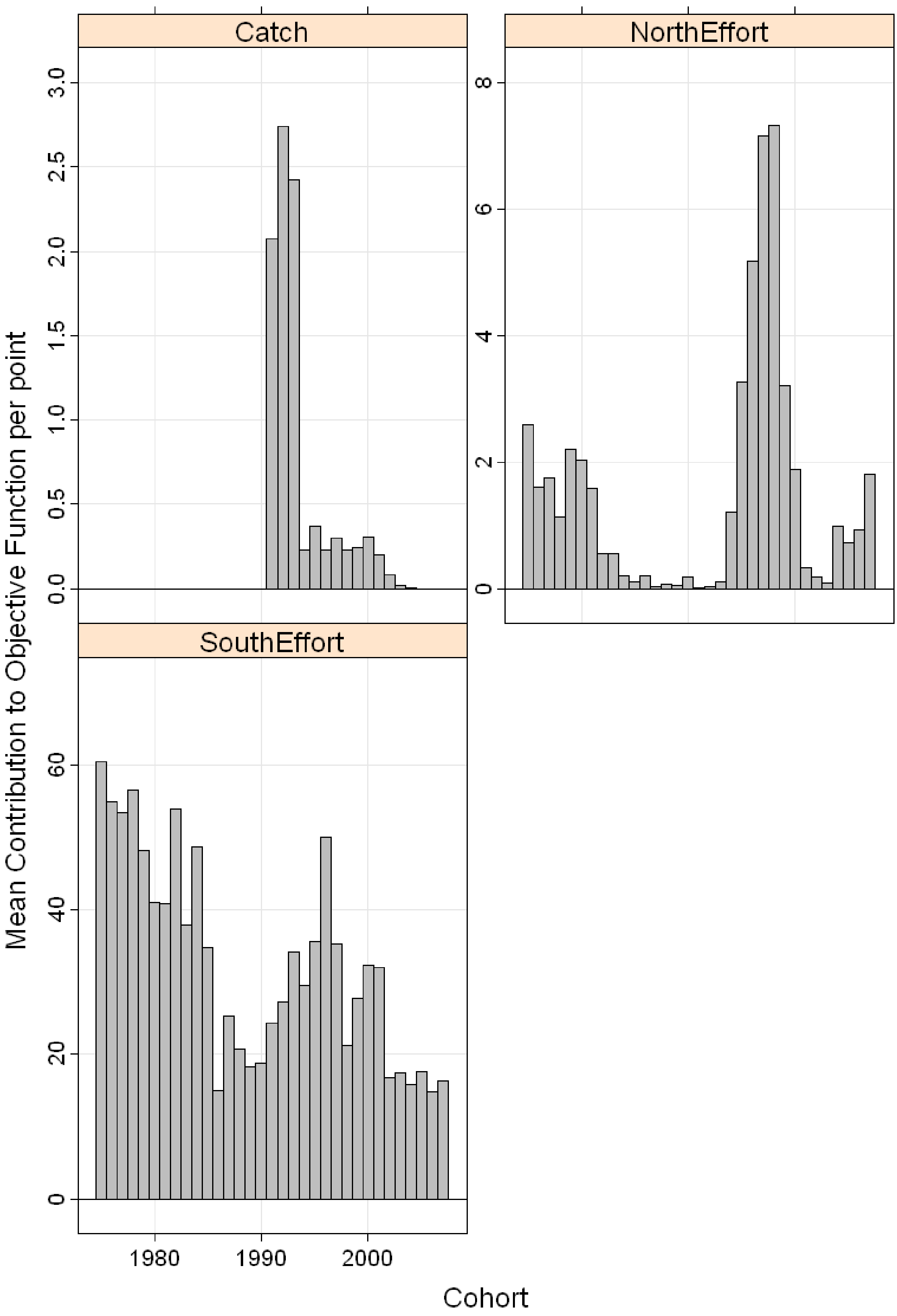


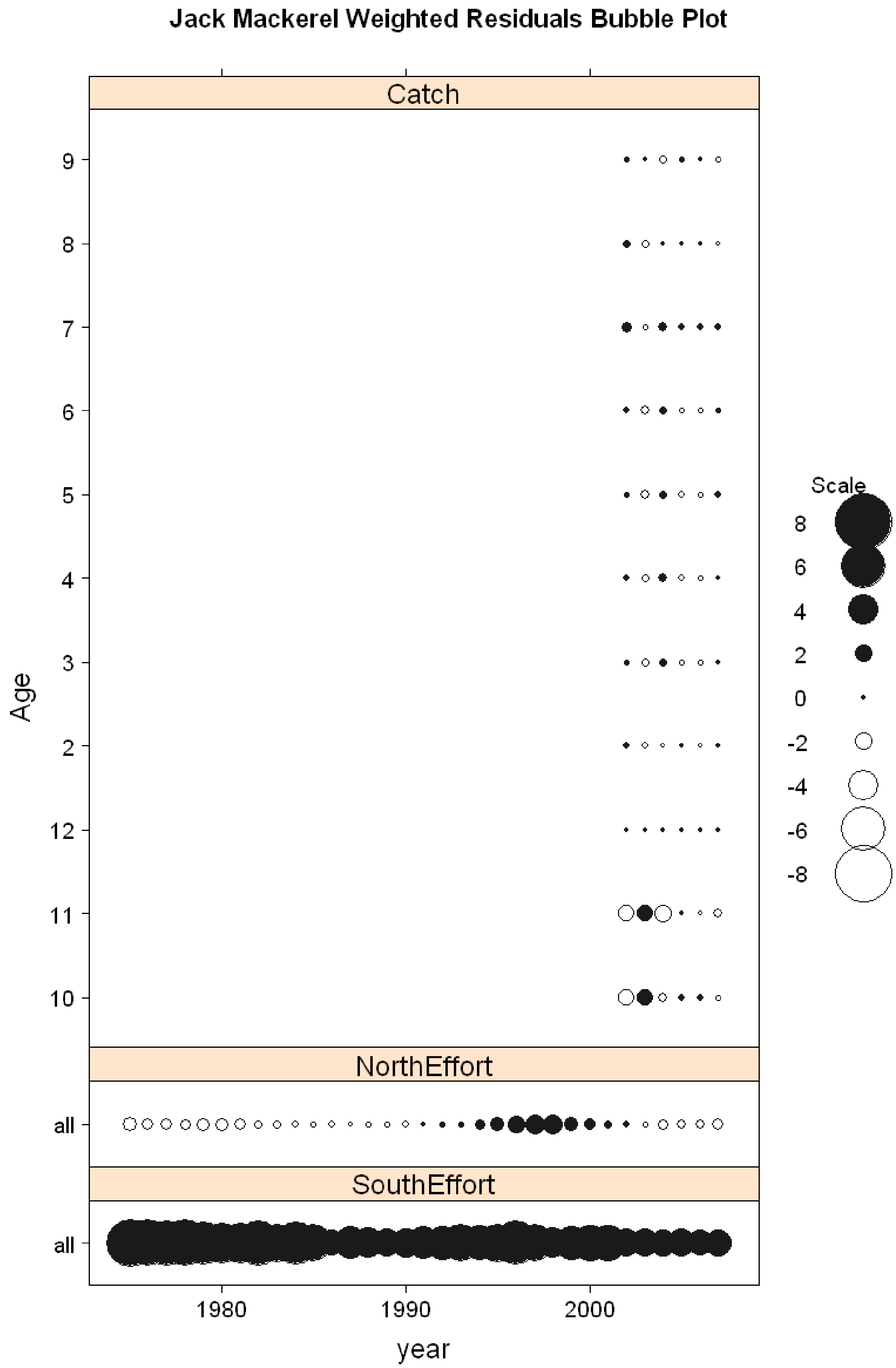

Jack Mackerel SSQ Breakdown by Age
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
0
10
20
30
2
3
4
5
6
7
8
9
10
11
12
all
Age



Jack Mackerel SSQ Breakdown by Year
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
Year
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
2
4
6
8
0
20
40
60
1980
1990
2000

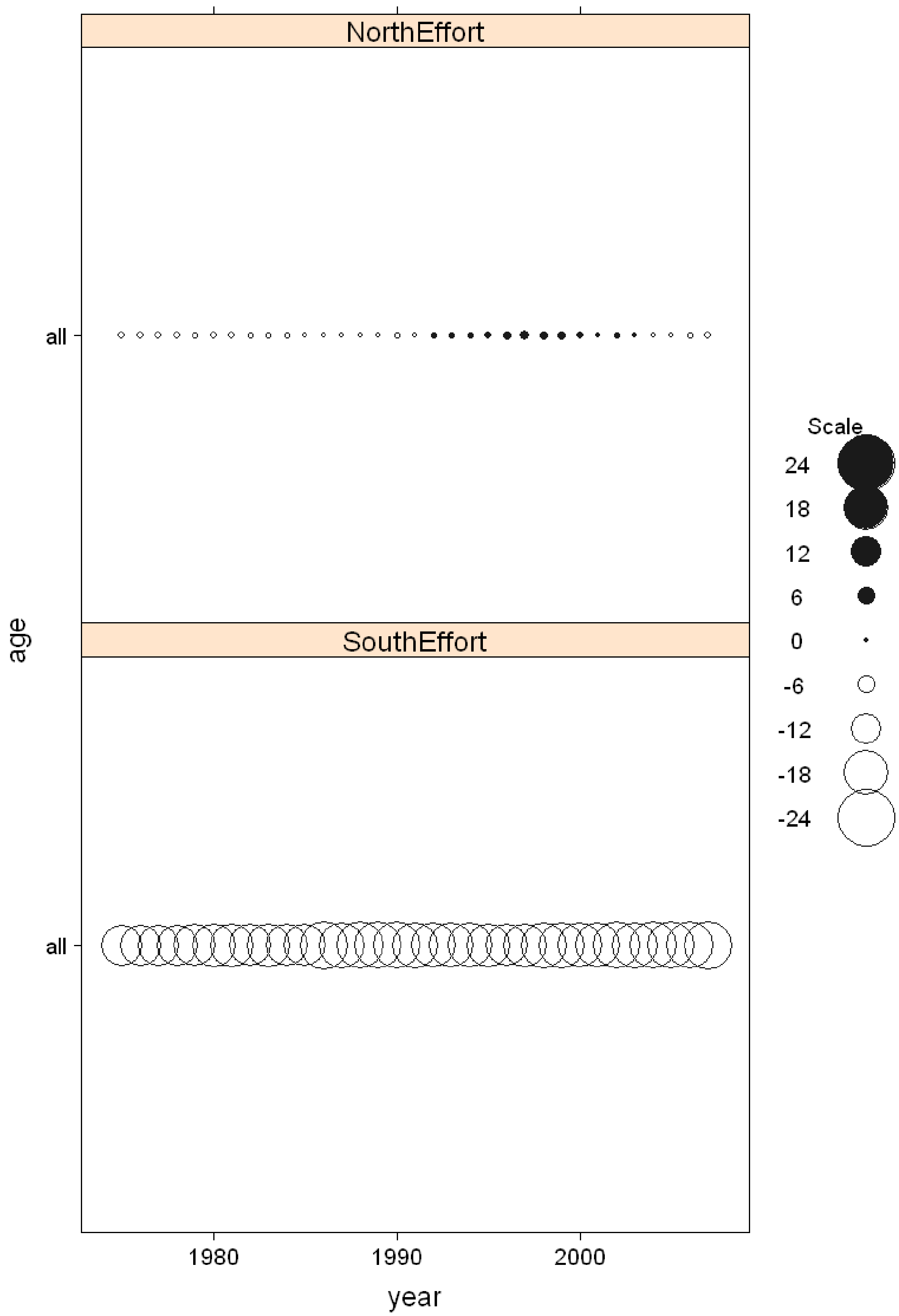
Jack Mackerel SSQ Breakdown by Cohort

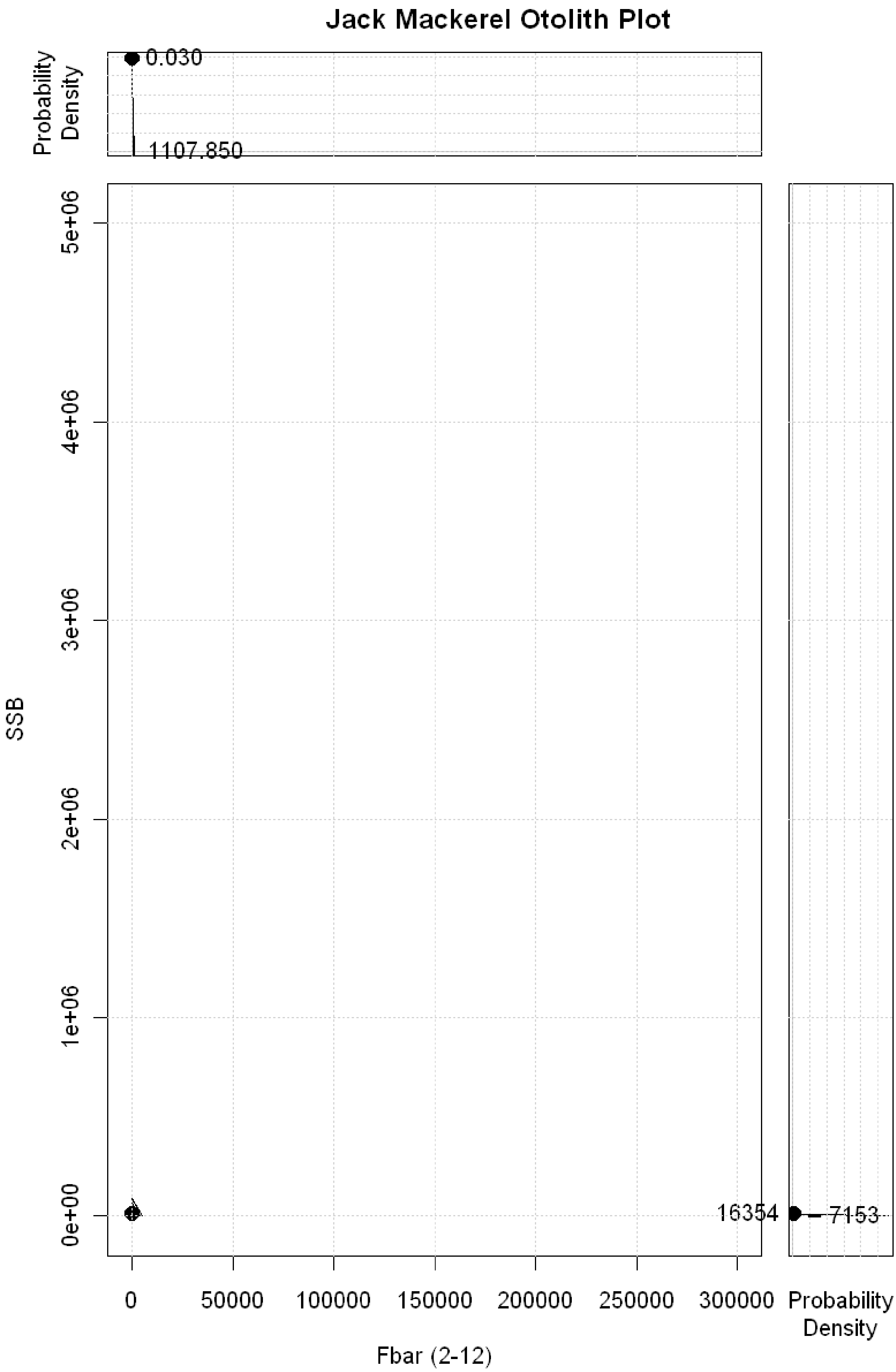


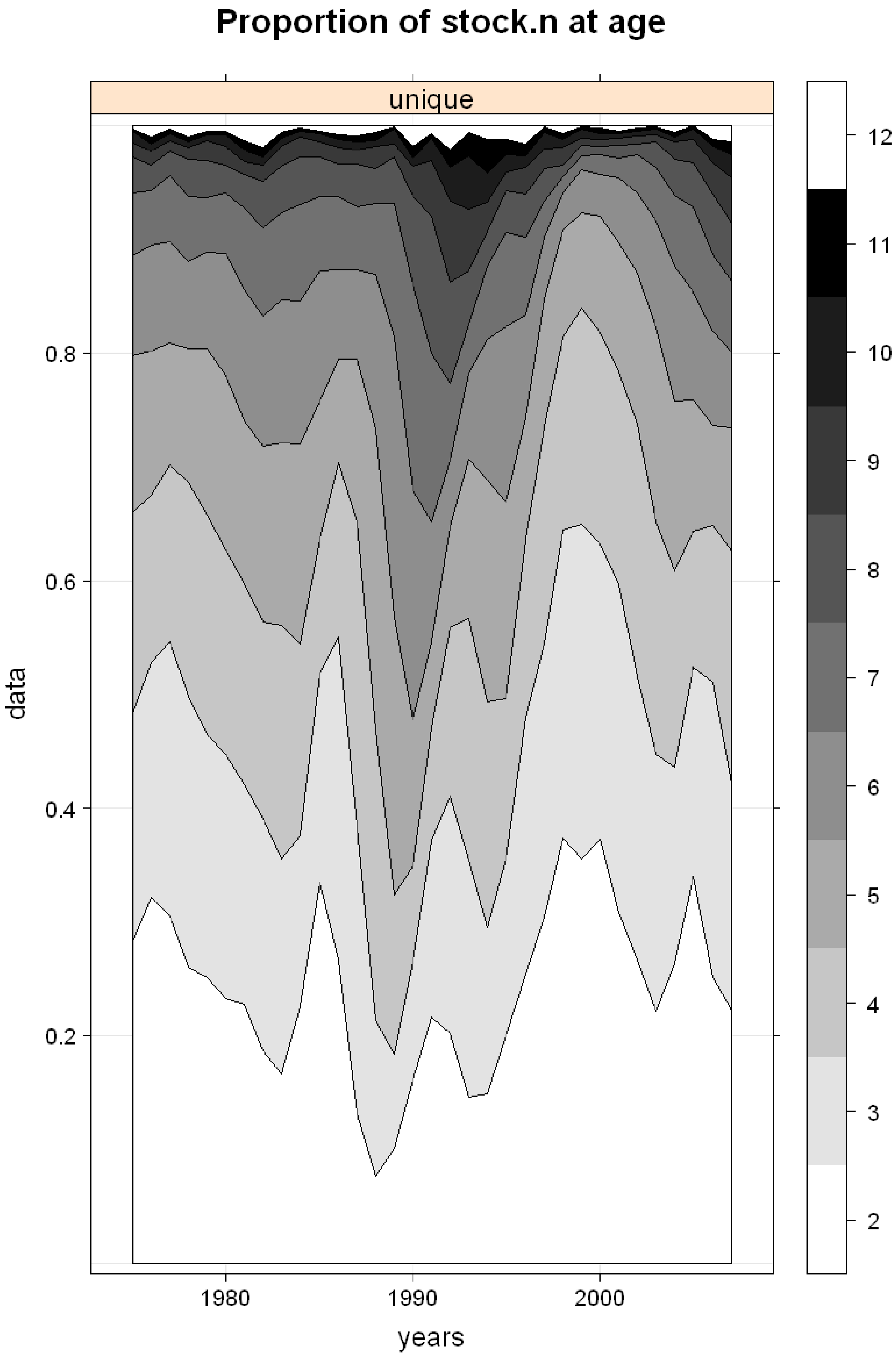


Jack Mackerel Weighted Residuals Bubble Plot
Catch
NorthEffort
SouthEffort
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
8
6
4
2
0
-2
-4
-6
-8

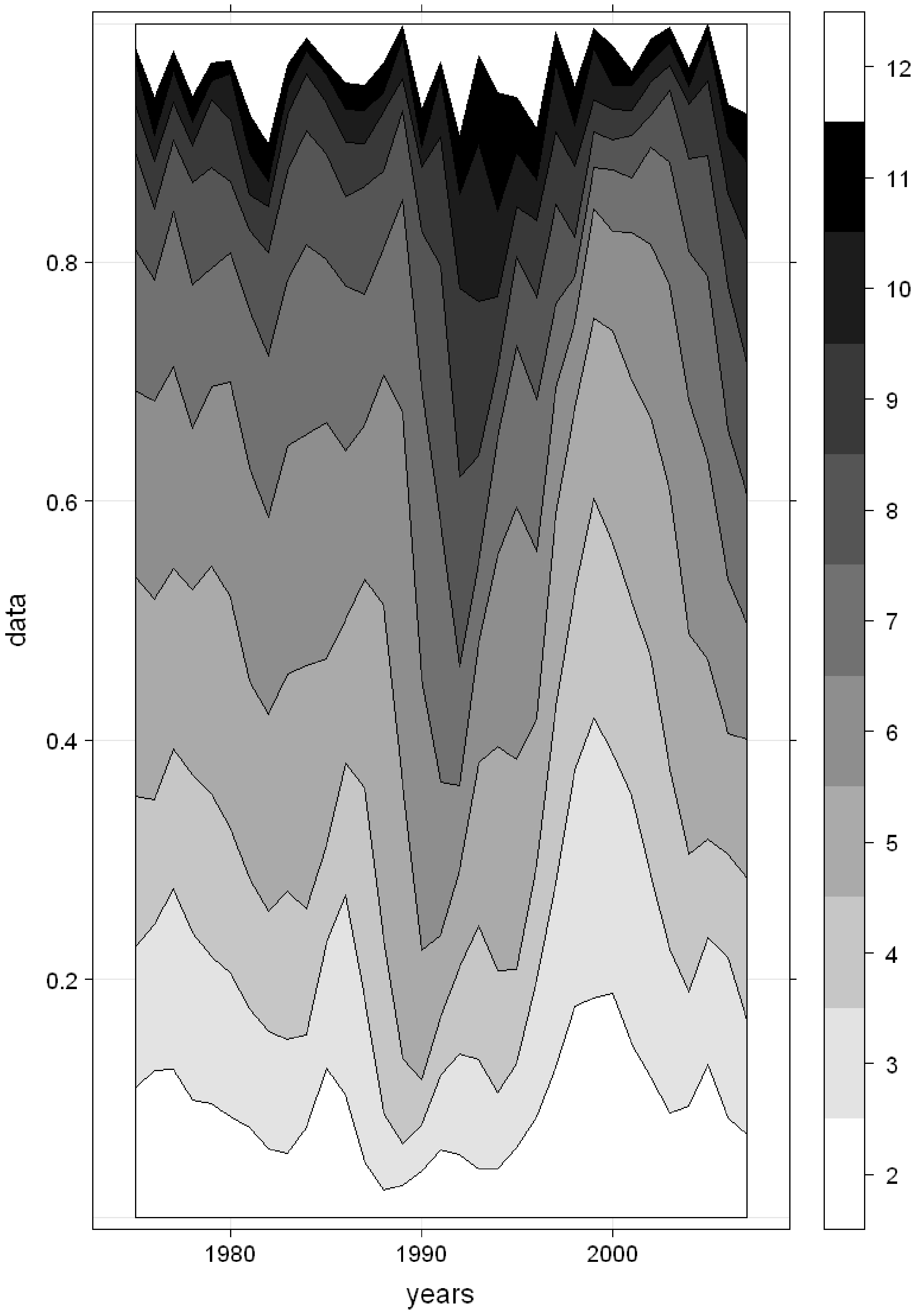
Jack Mackerel Unweighted Index Residuals Bubble Plot




Jack Mackerel Otolith Plot
Probability Density
0.030
1107.850
SSB
5e+06
4e+06
3e+06
2e+06
1e+06
0e+00
16354
7153
0
50000
100000
150000
200000
250000
300000
Probability Density
Fbar (2-12)

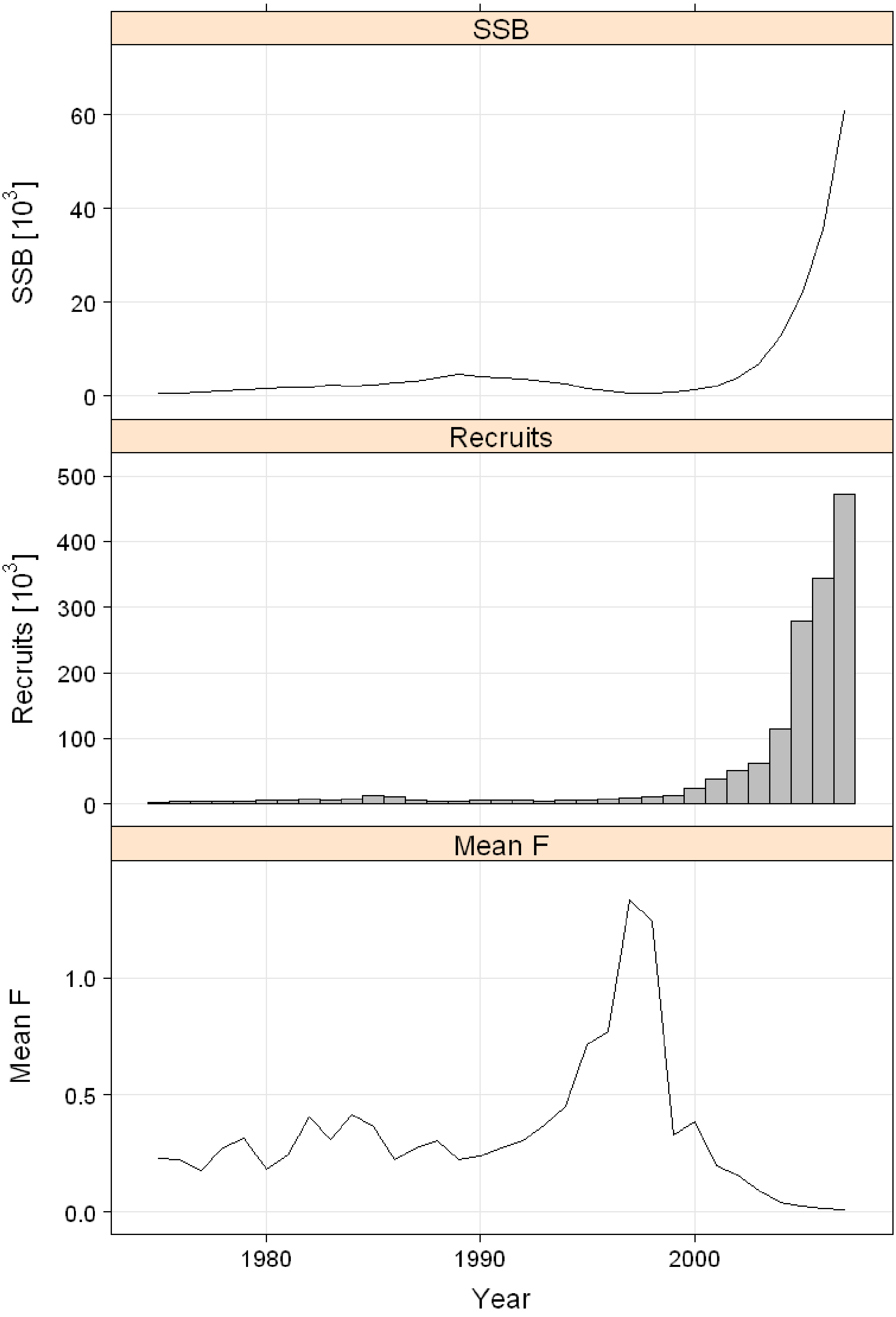

Proportion of stock.n at age
unique
0.8
0.6
0.4
0.2
data
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

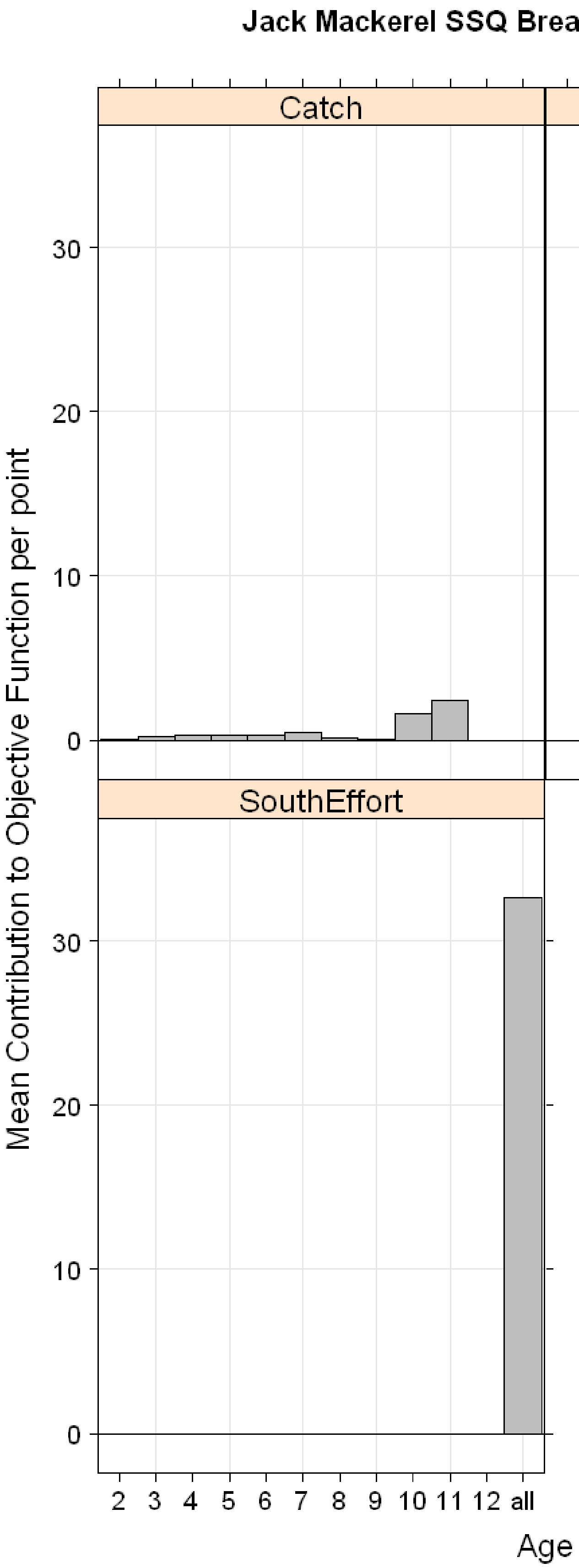
Proportion by weight in the stock



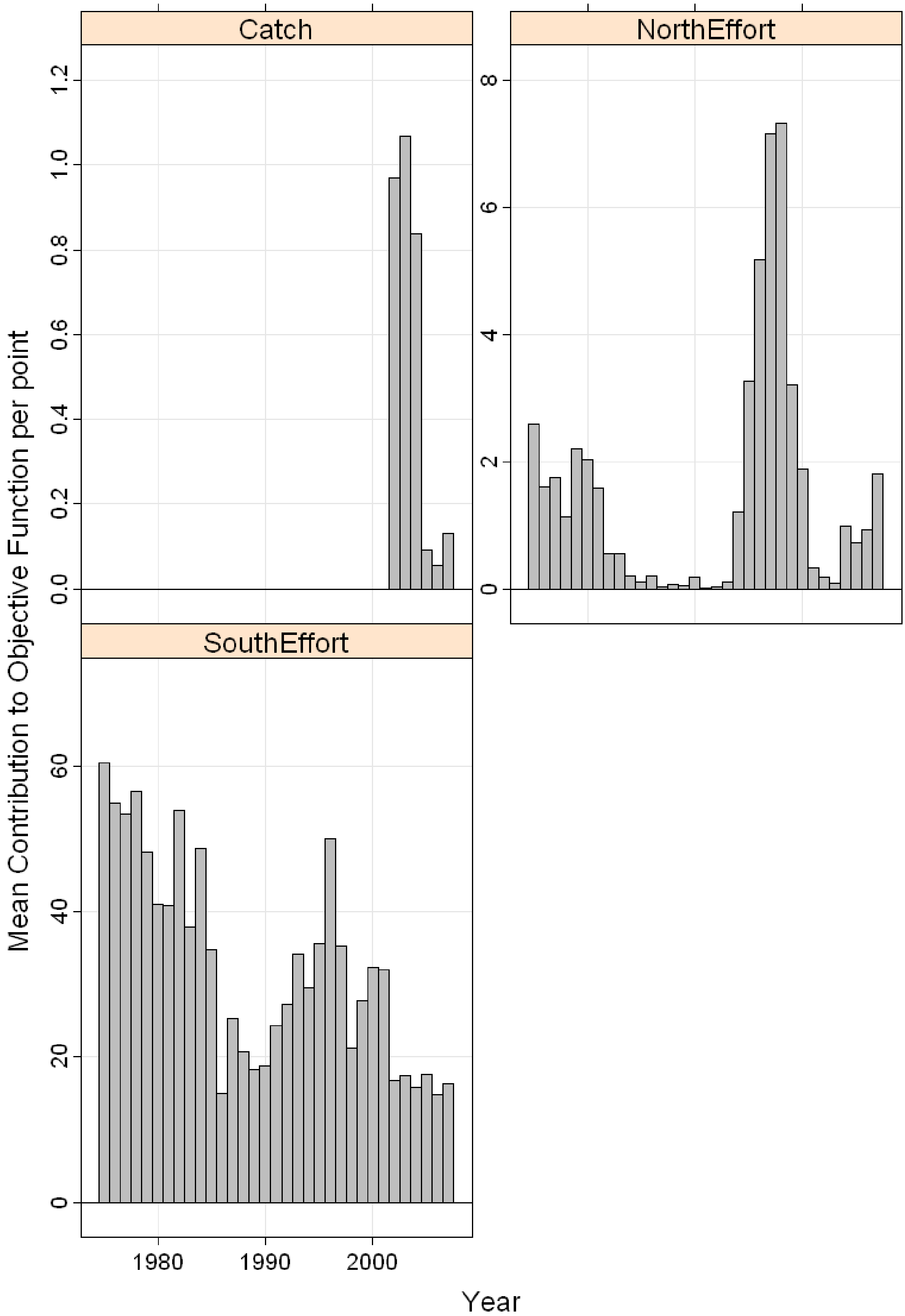
8.3.3 95%

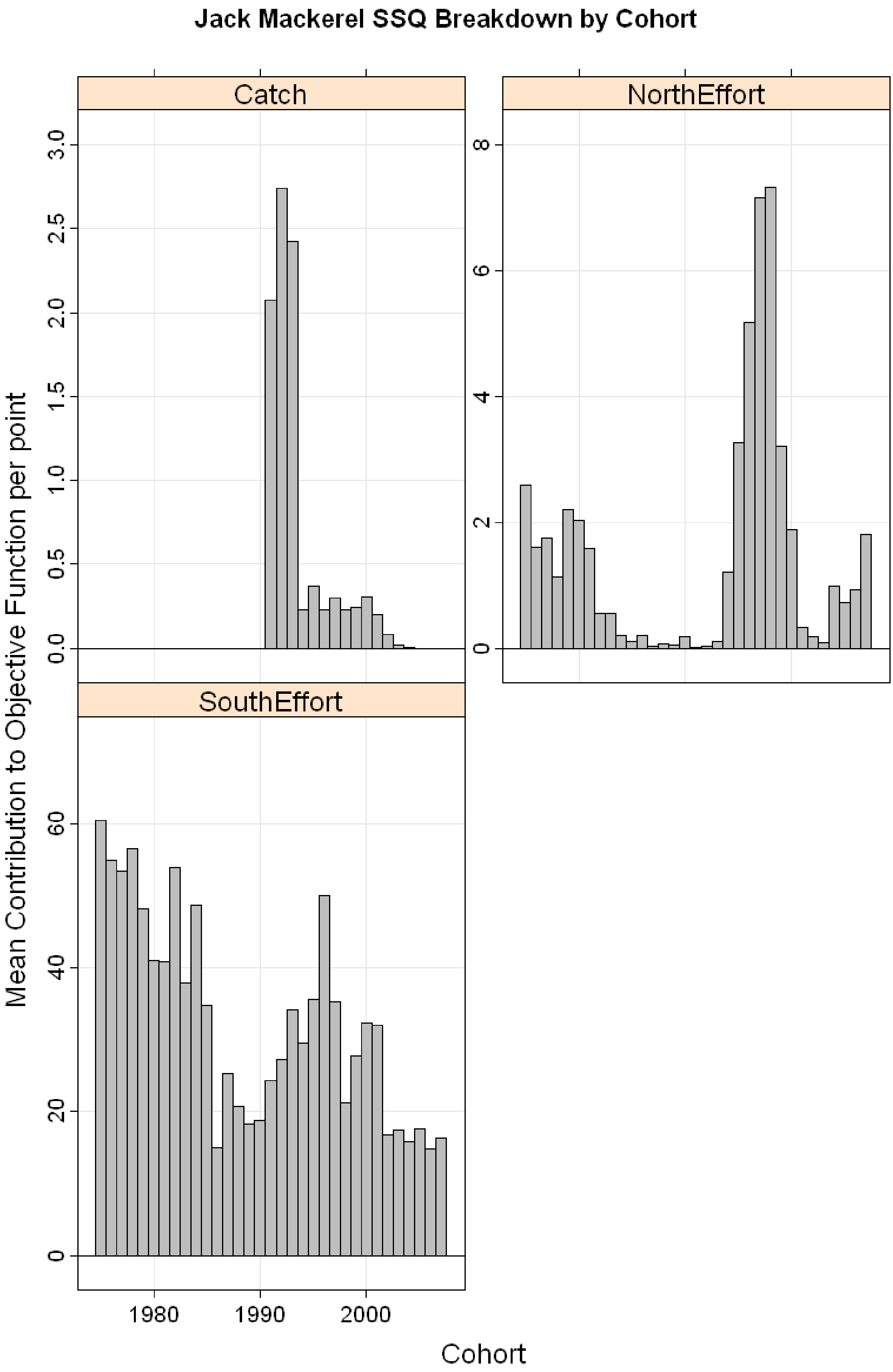
Jack Mackerel Stock Summary Plot



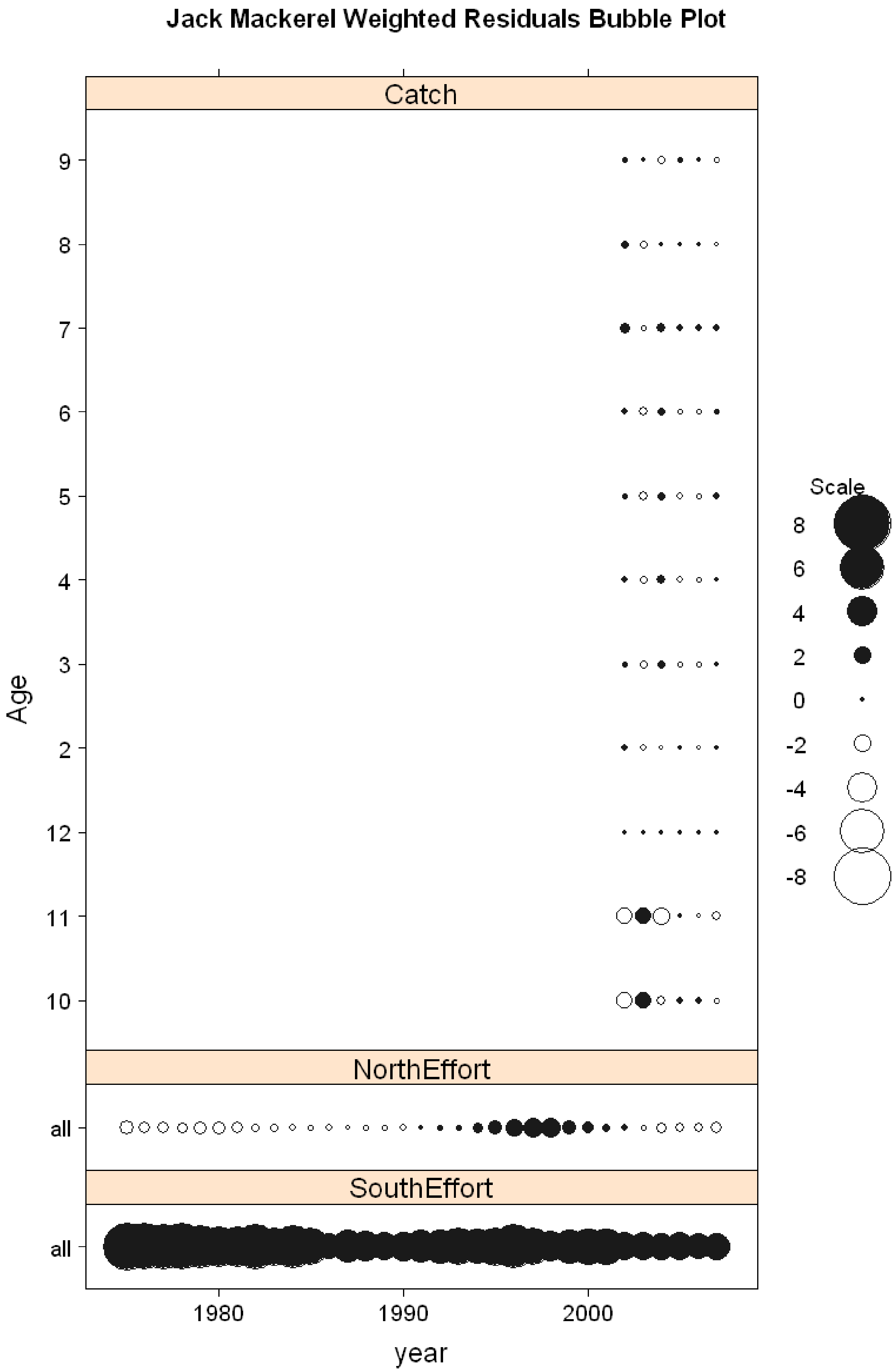

Jack Mackerel SSQ Breakdown by Age
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
0
10
20
30
2
3
4
5
6
7
8
9
10
11
12
all
Age

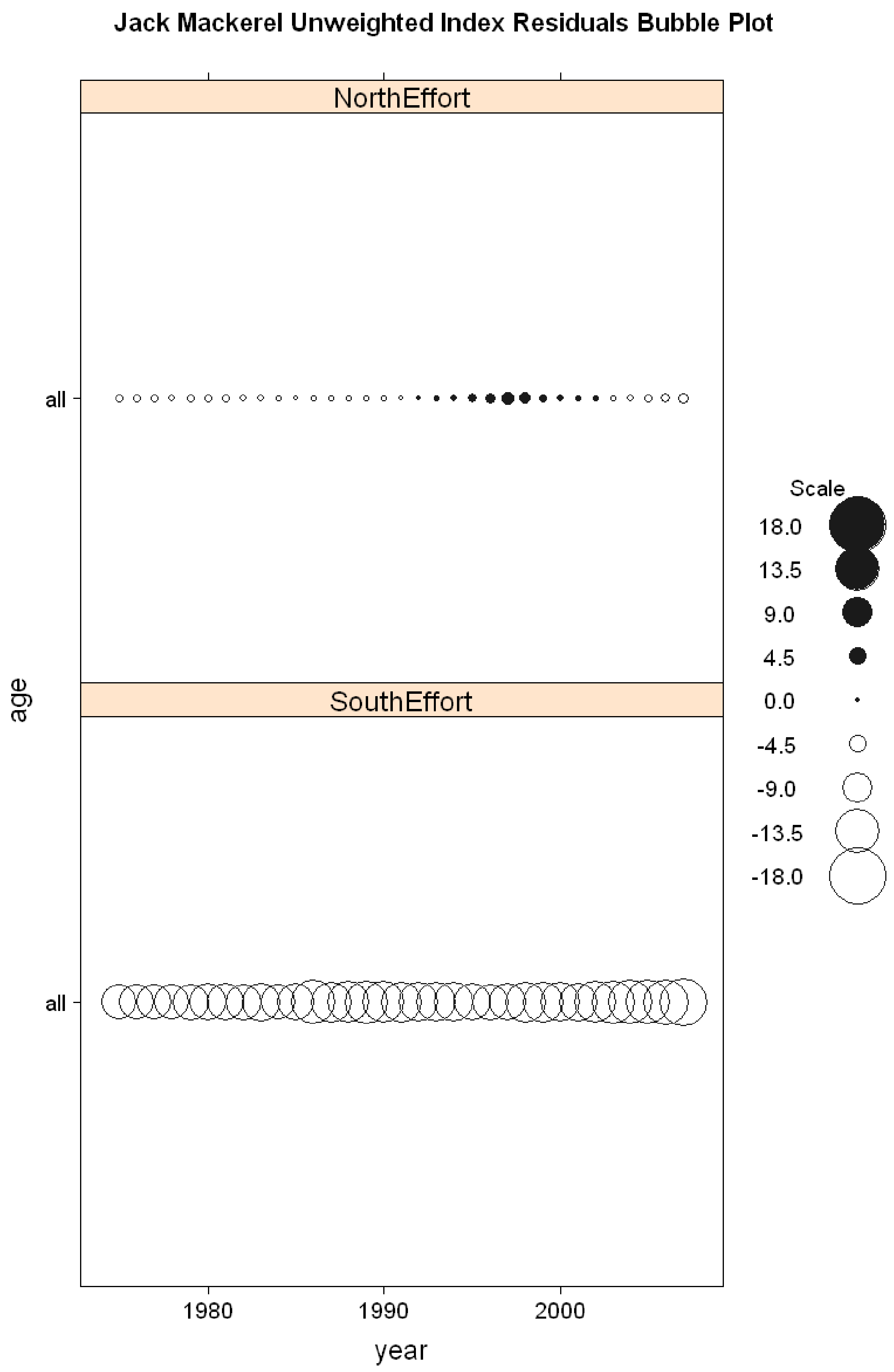
Jack Mackerel SSQ Breakdown by Year

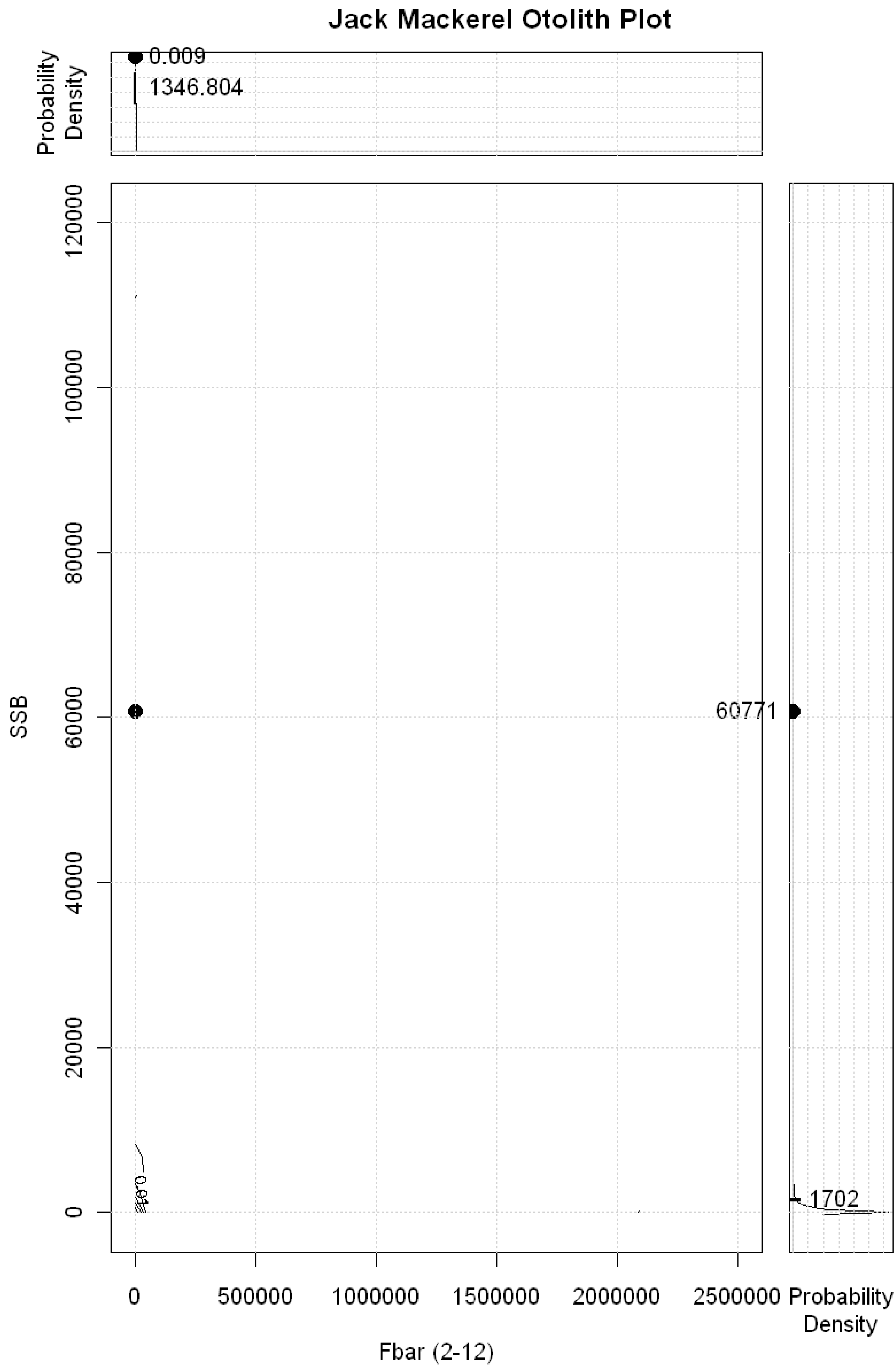


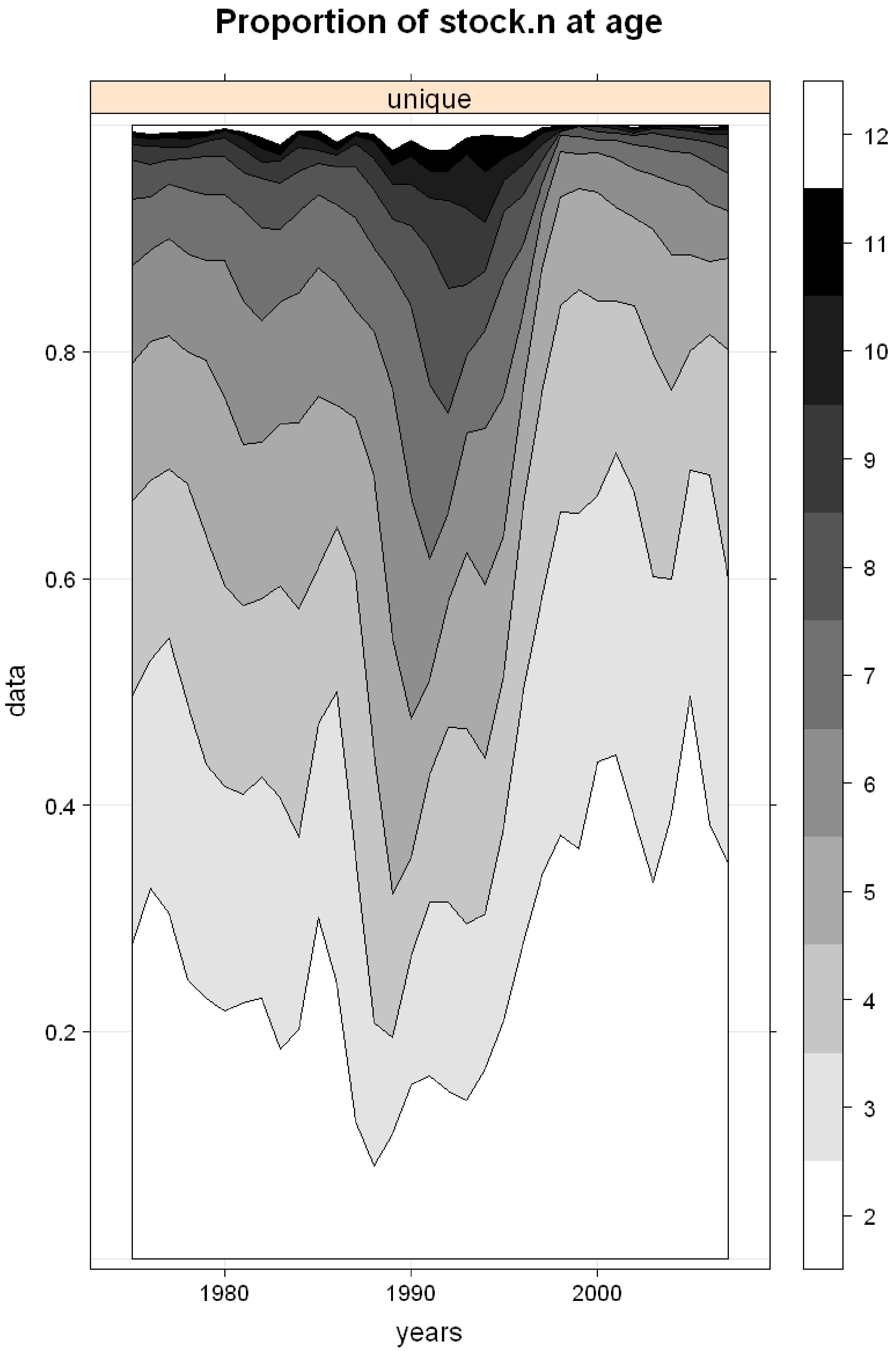


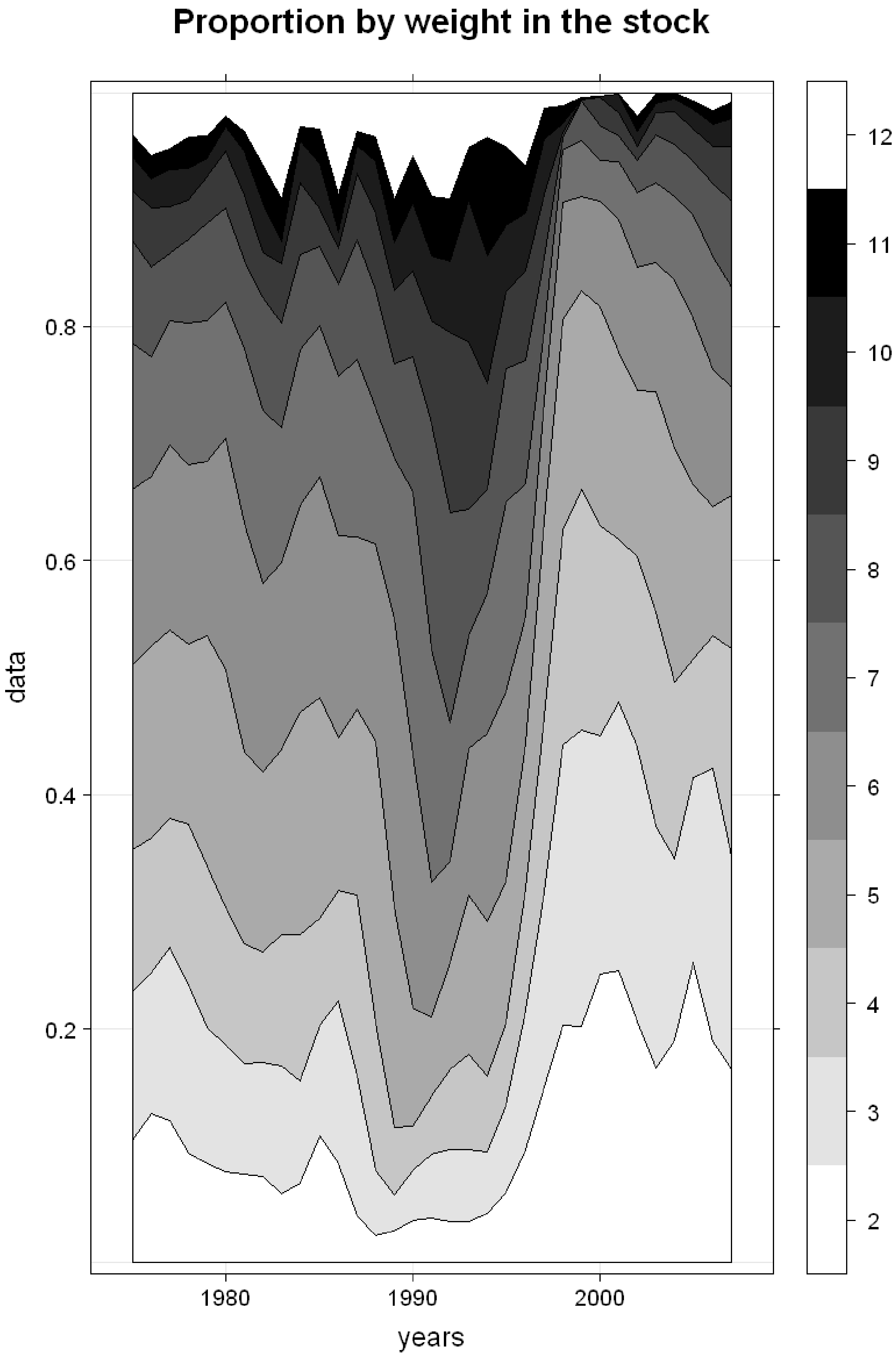
Jack Mackerel SSQ Breakdown by Cohort
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
Cohort
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
2
4
6
8
0
20
40
60
1980
1990
2000


Jack Mackerel Weighted Residuals Bubble Plot
Catch
NorthEffort
SouthEffort
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
8
6
4
2
0
-2
-4
-6
-8


Jack Mackerel Unweighted Index Residuals Bubble Plot
NorthEffort
SouthEffort
all
all
age
year
1980
1990
2000
Scale
18.0
13.5
9.0
4.5
0.0
-4.5
-9.0
-13.5
-18.0


Jack Mackerel Otolith Plot
Probability Density
0.009
1346.804
SSB
120000
100000
80000
60000
40000
20000
0
60771
1702
0
500000
1000000
1500000
2000000
2500000
Probability Density
Fbar (2-12)


Proportion of stock.n at age
unique
data
0.2
0.4
0.6
0.8
1980
1990
2000
years
2
3
4
5
6
7
8
9
10
11
12

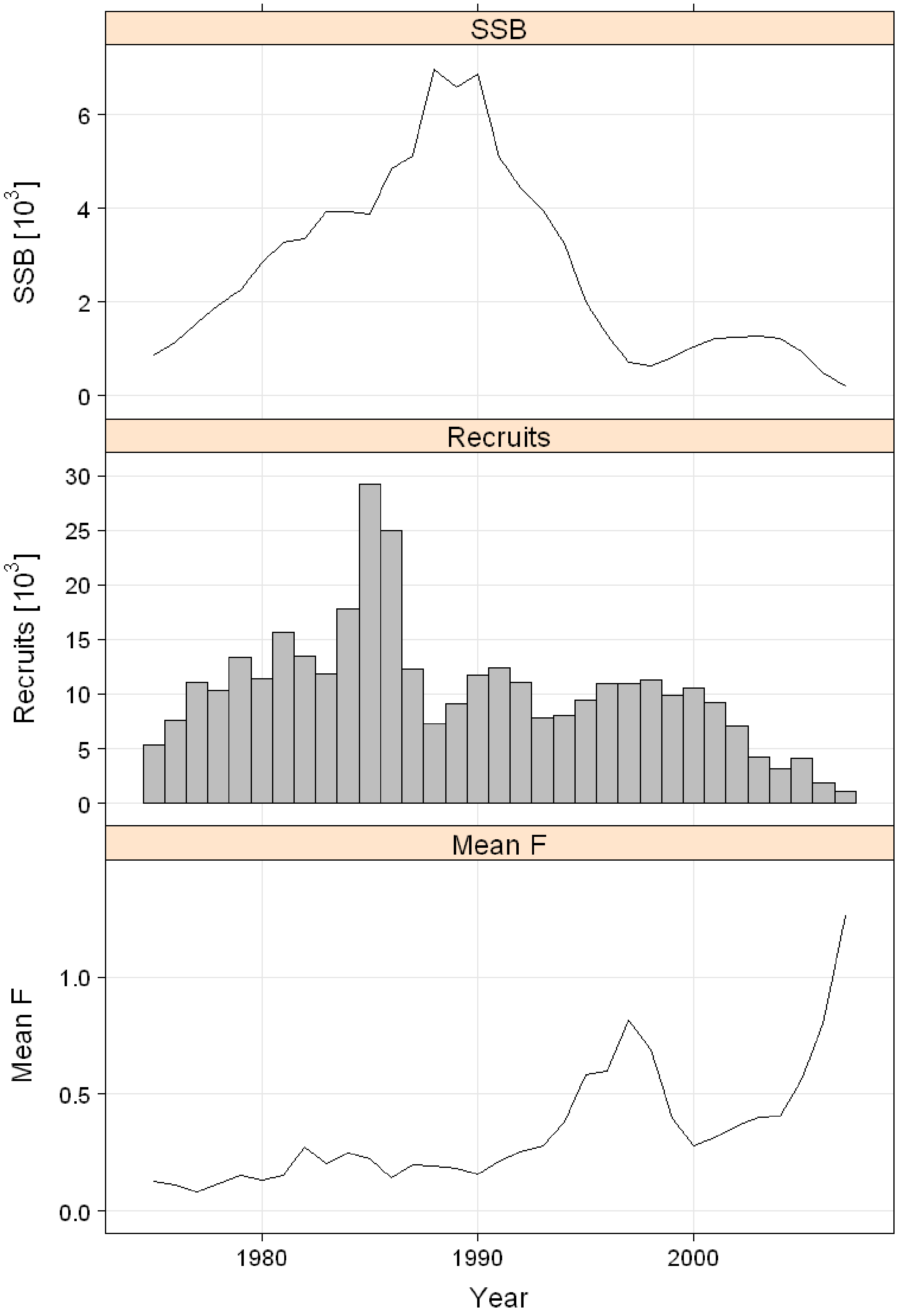


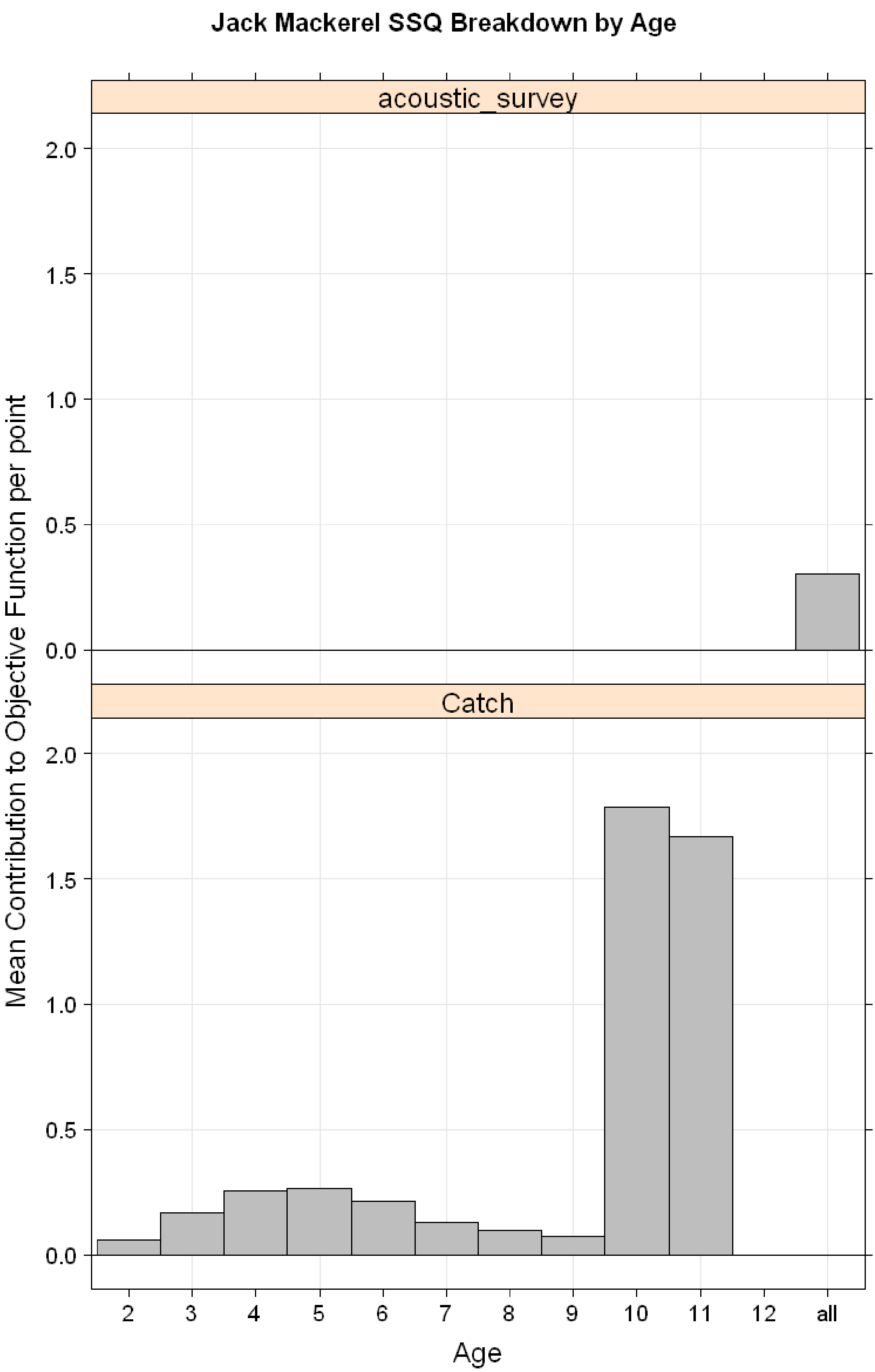
Proportion by weight in the stock
data
0.8
0.6
0.4
0.2
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

8.4 Scenario 4

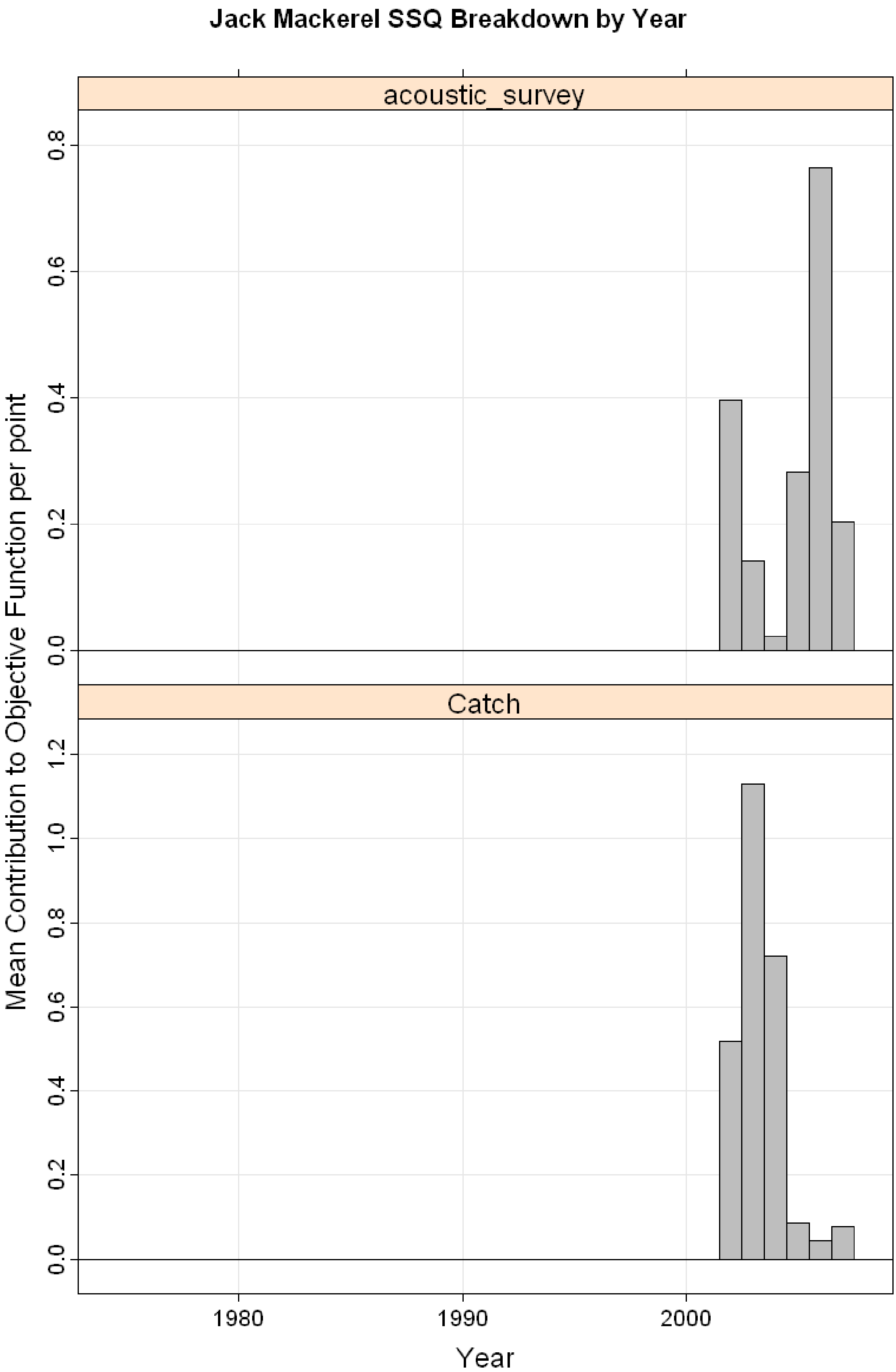
8.4.1 5%

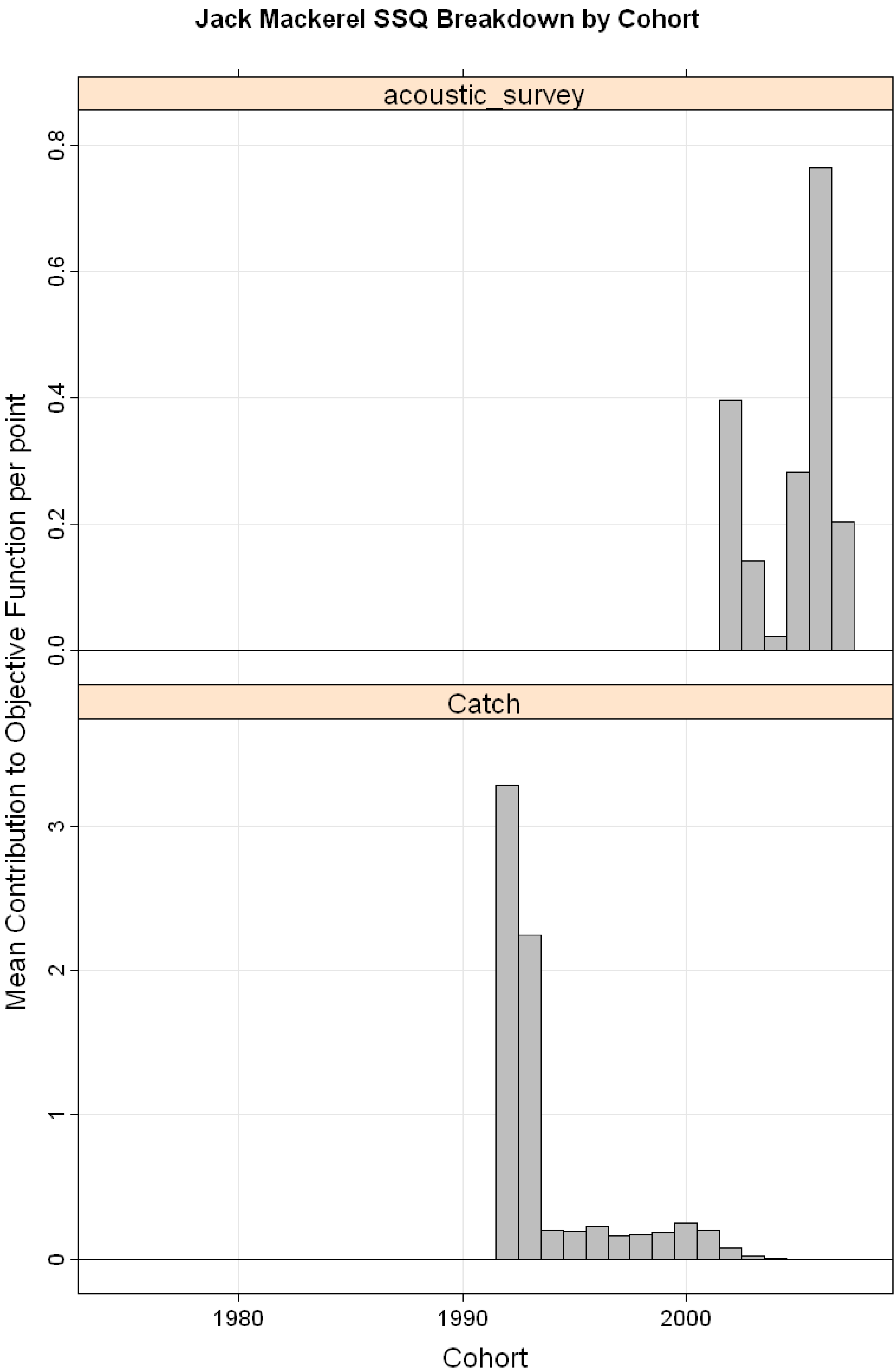
Jack Mackerel Stock Summary Plot



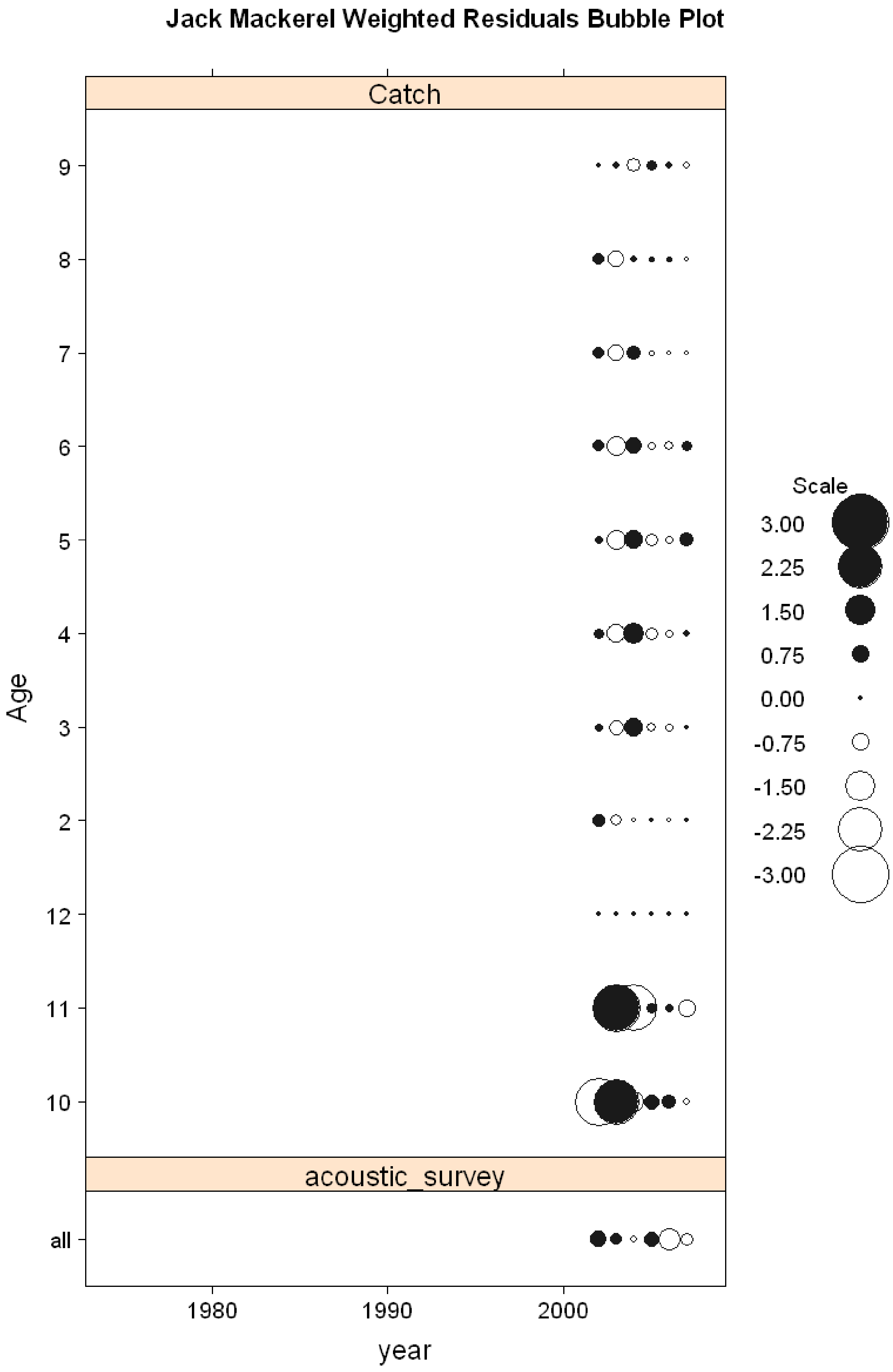


Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Mean Contribution to Objective Function per point
Age
0.0
0.5
1.0
1.5
2.0
2
3
4
5
6
7
8
9
10
11
12
all


Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Mean Contribution to Objective Function per point
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1980
1990
2000
Year

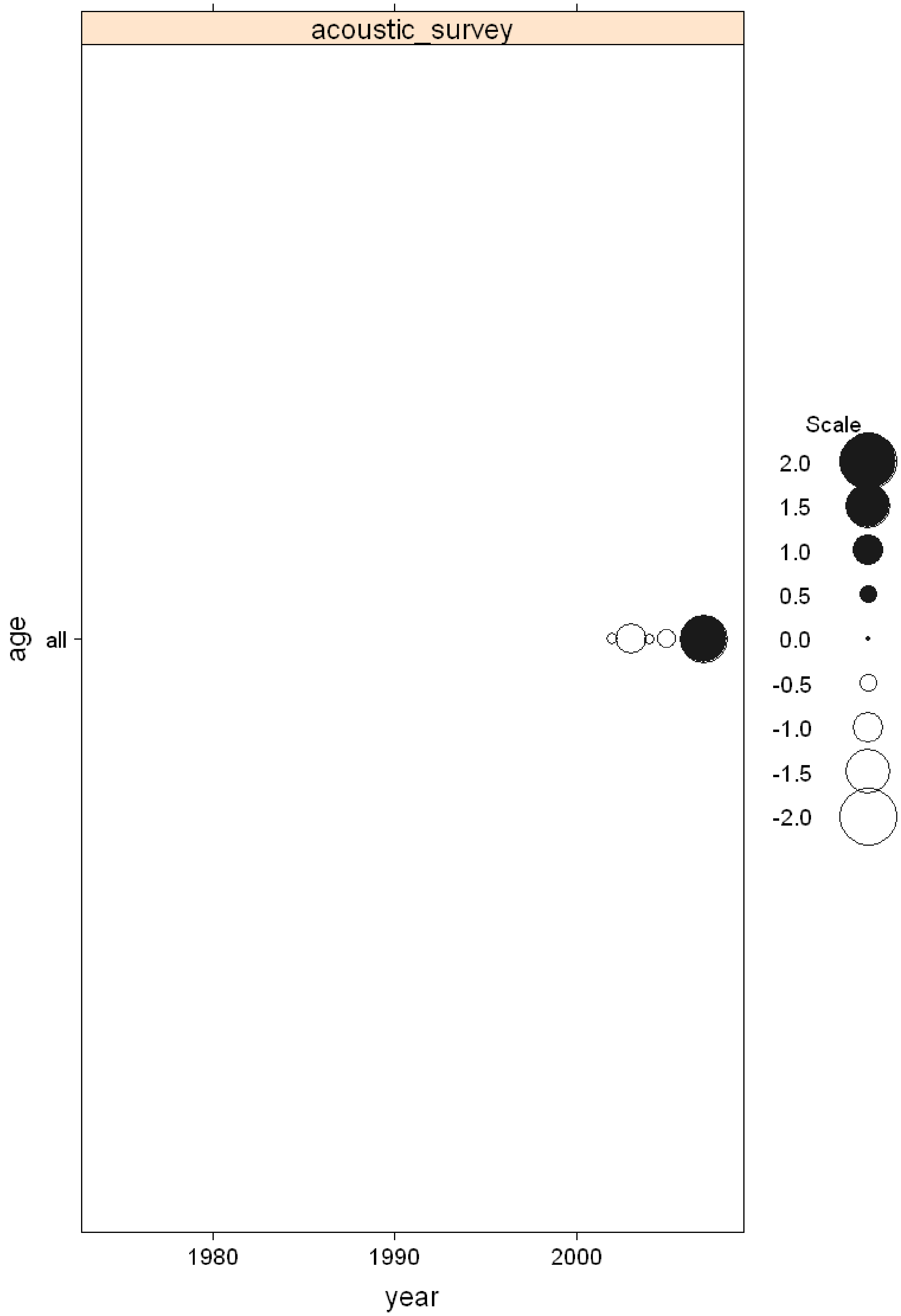


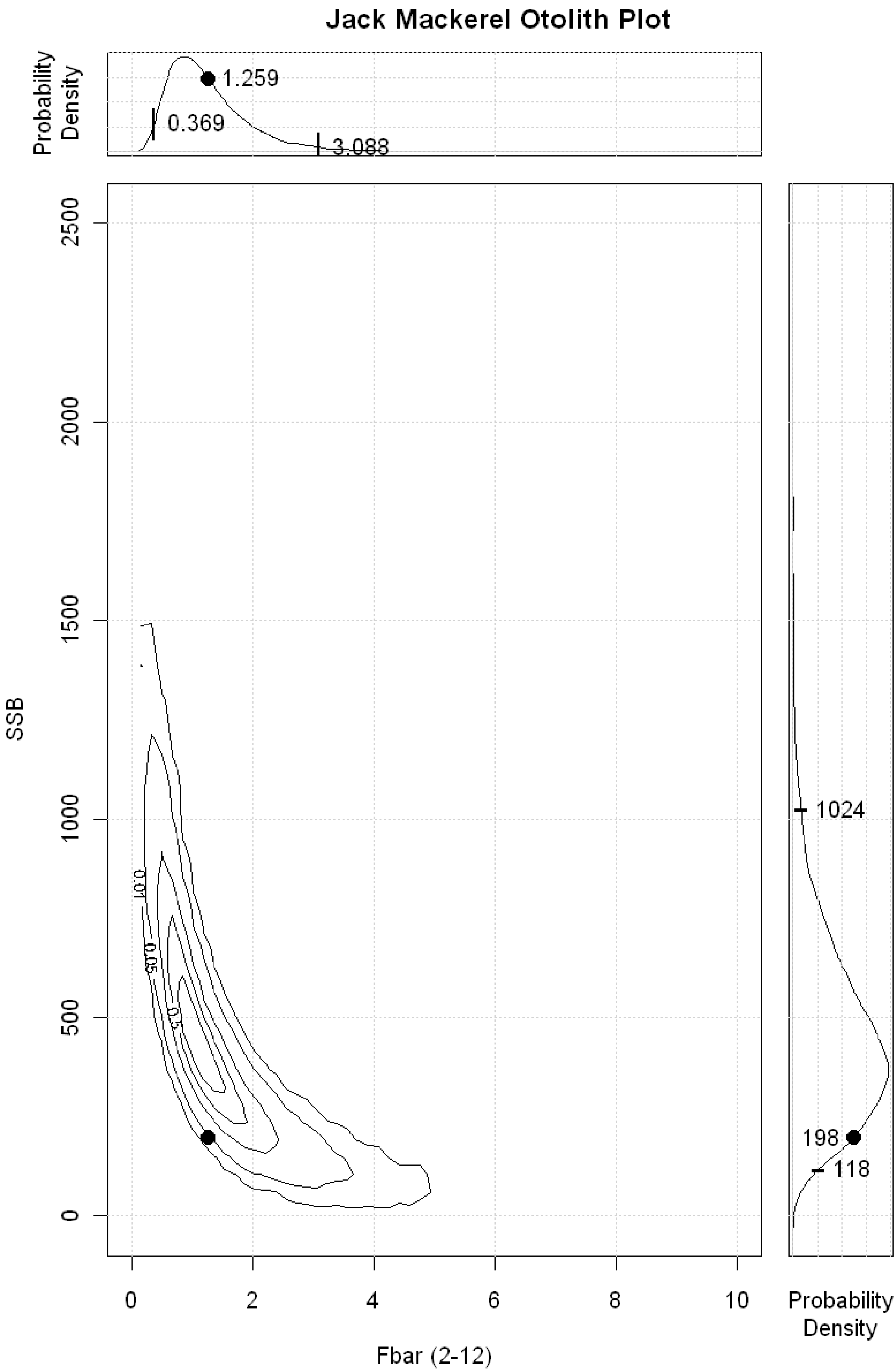
Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Mean Contribution to Objective Function per point
Cohort
0.0
0.2
0.4
0.6
0.8
0
1
2
3
1980
1990
2000

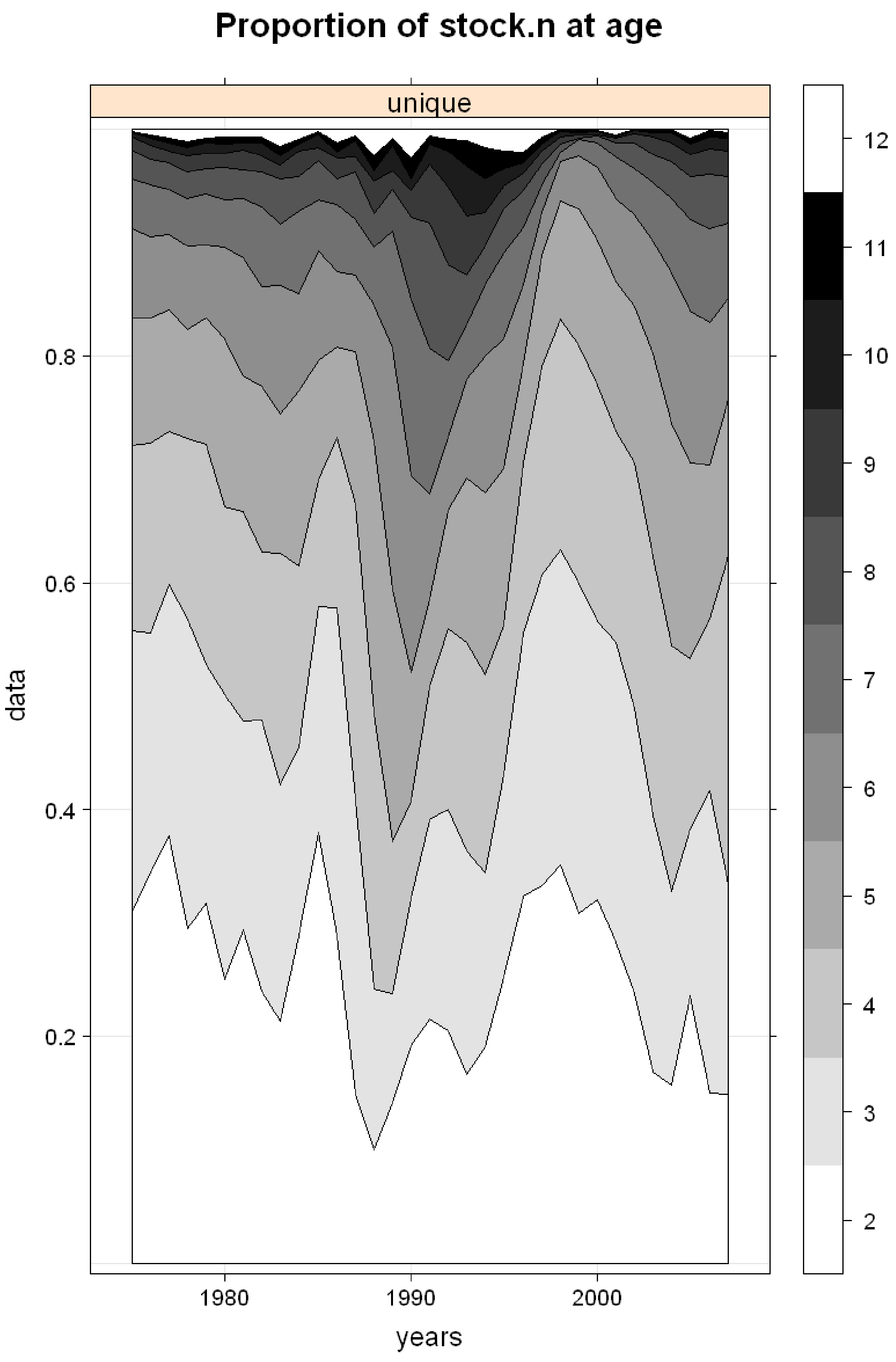


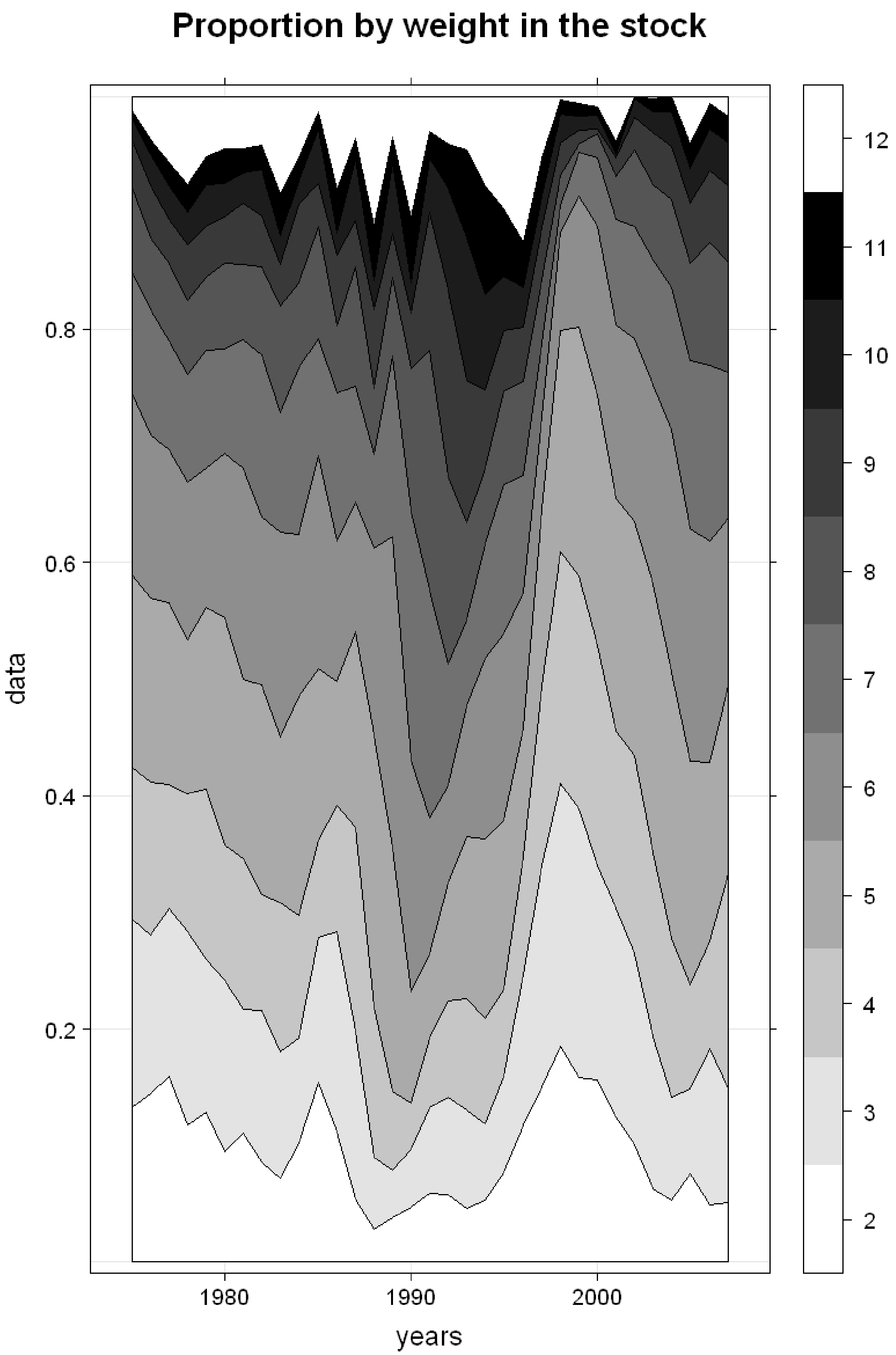
Jack Mackerel Weighted Residuals Bubble Plot
Catch
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00

Jack Mackerel Unweighted Index Residuals Bubble Plot

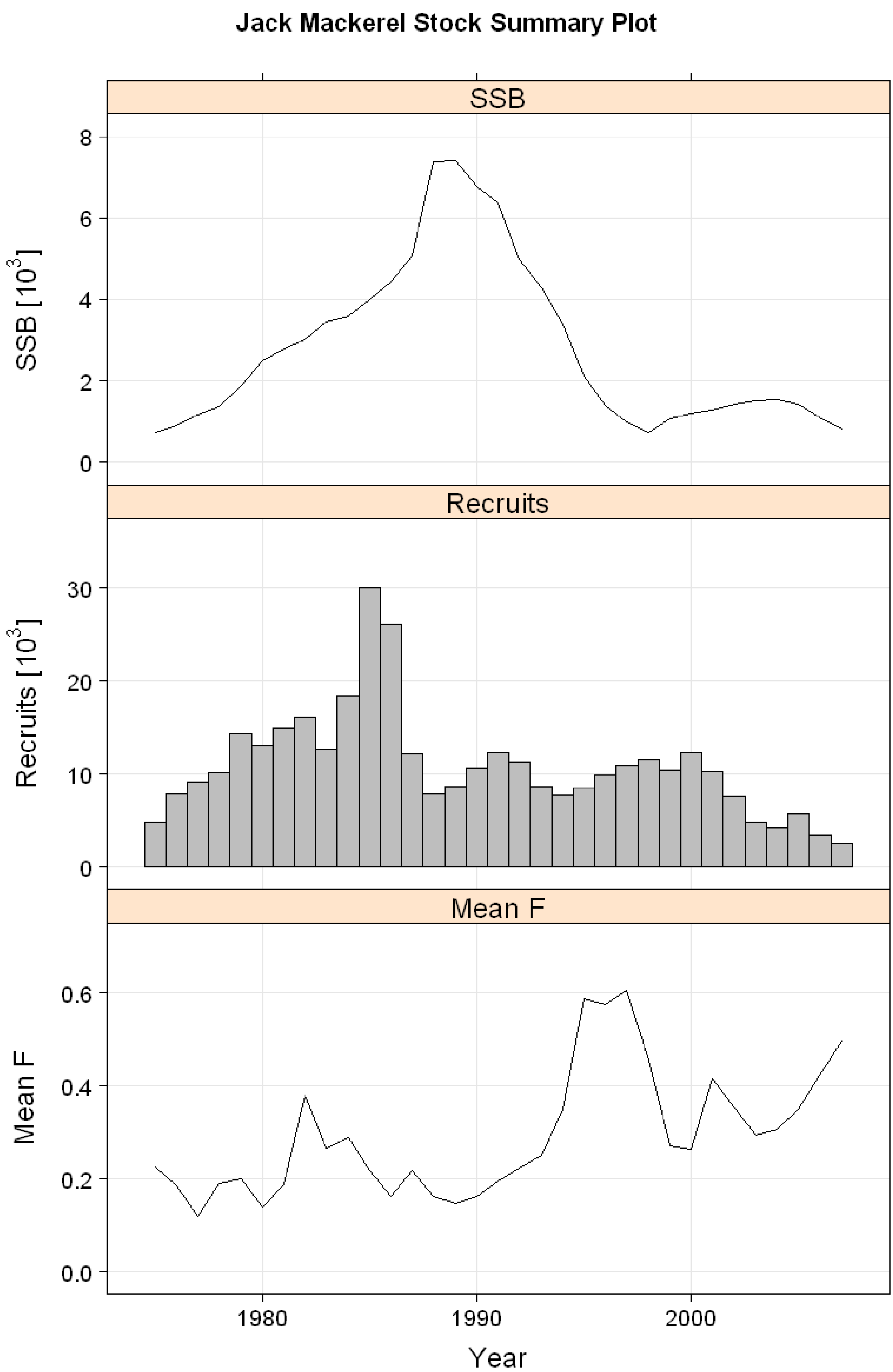



Jack Mackerel Otolith Plot
Probability Density
1.259
0.369
3.088
2500
2000
1500
1000
500
0
SSB
0.01
0.05
0.5
1024
198
118
0
2
4
6
8
10
Fbar (2-12)
Probability Density

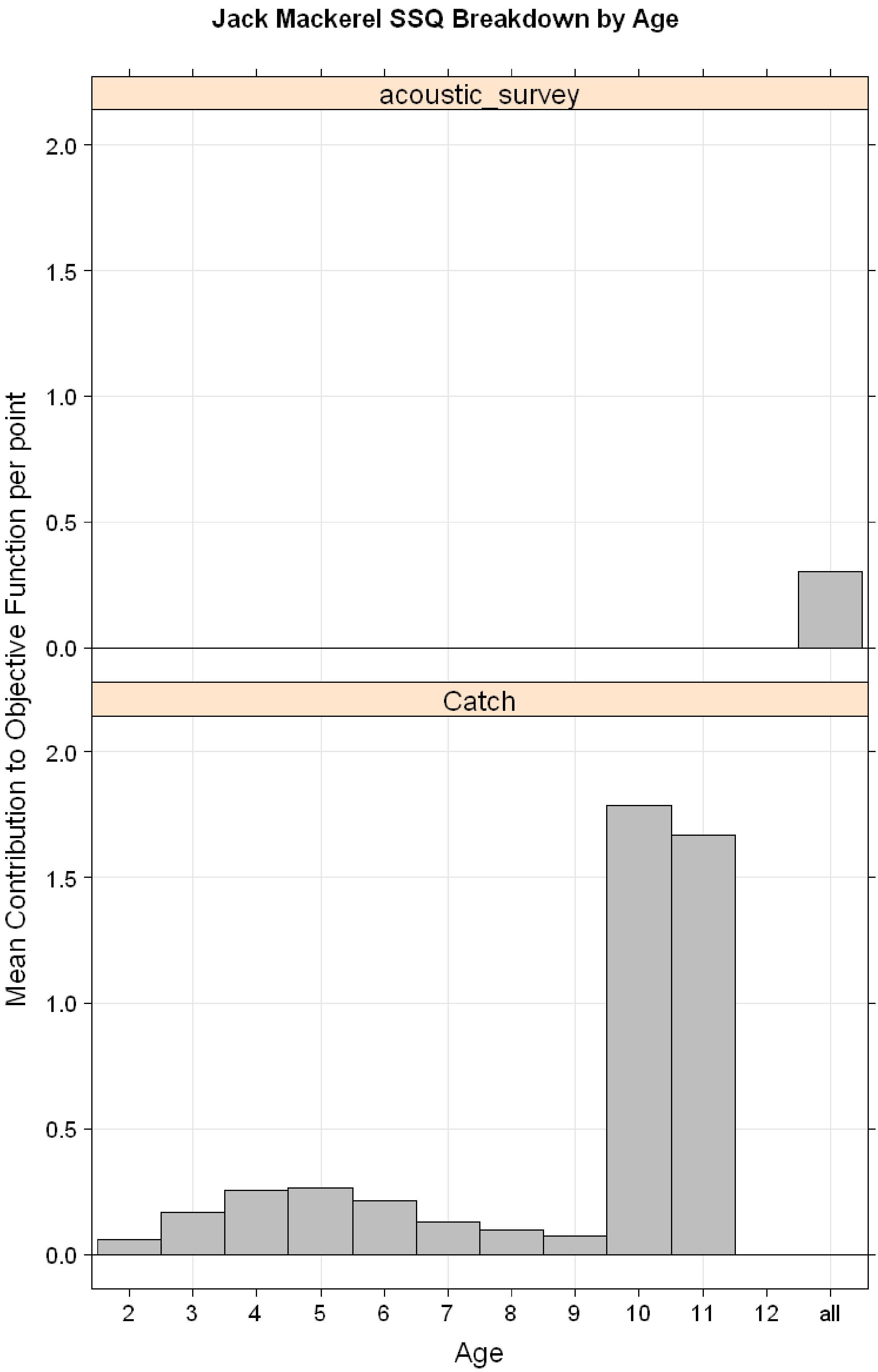

Proportion of stock.n at age
unique
0.8
0.6
0.4
0.2
data
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

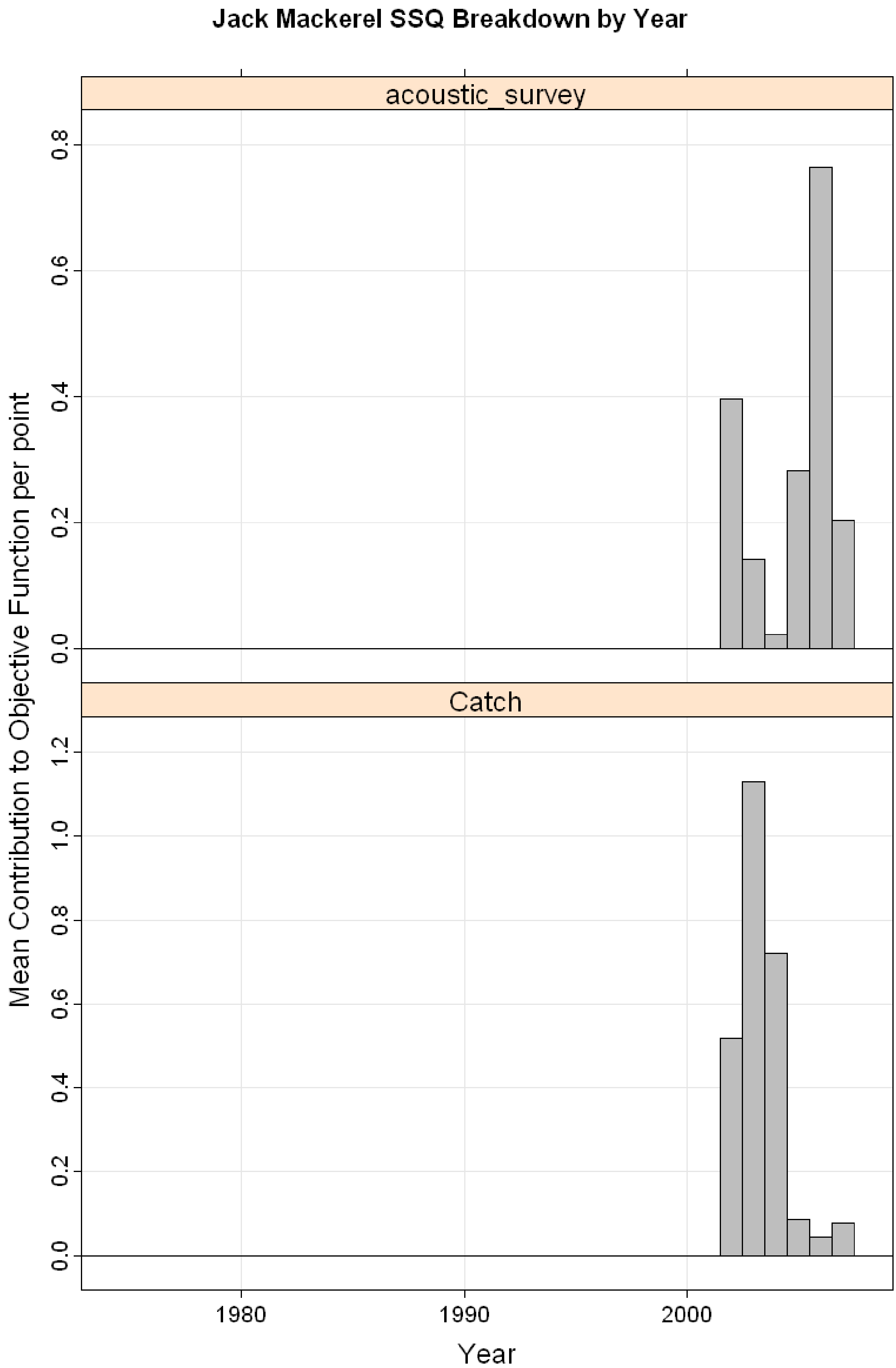

Proportion by weight in the stock
data
0.2
0.4
0.6
0.8
1980
1990
2000
years
2
3
4
5
6
7
8
9
10
11
12

8.4.2 50%

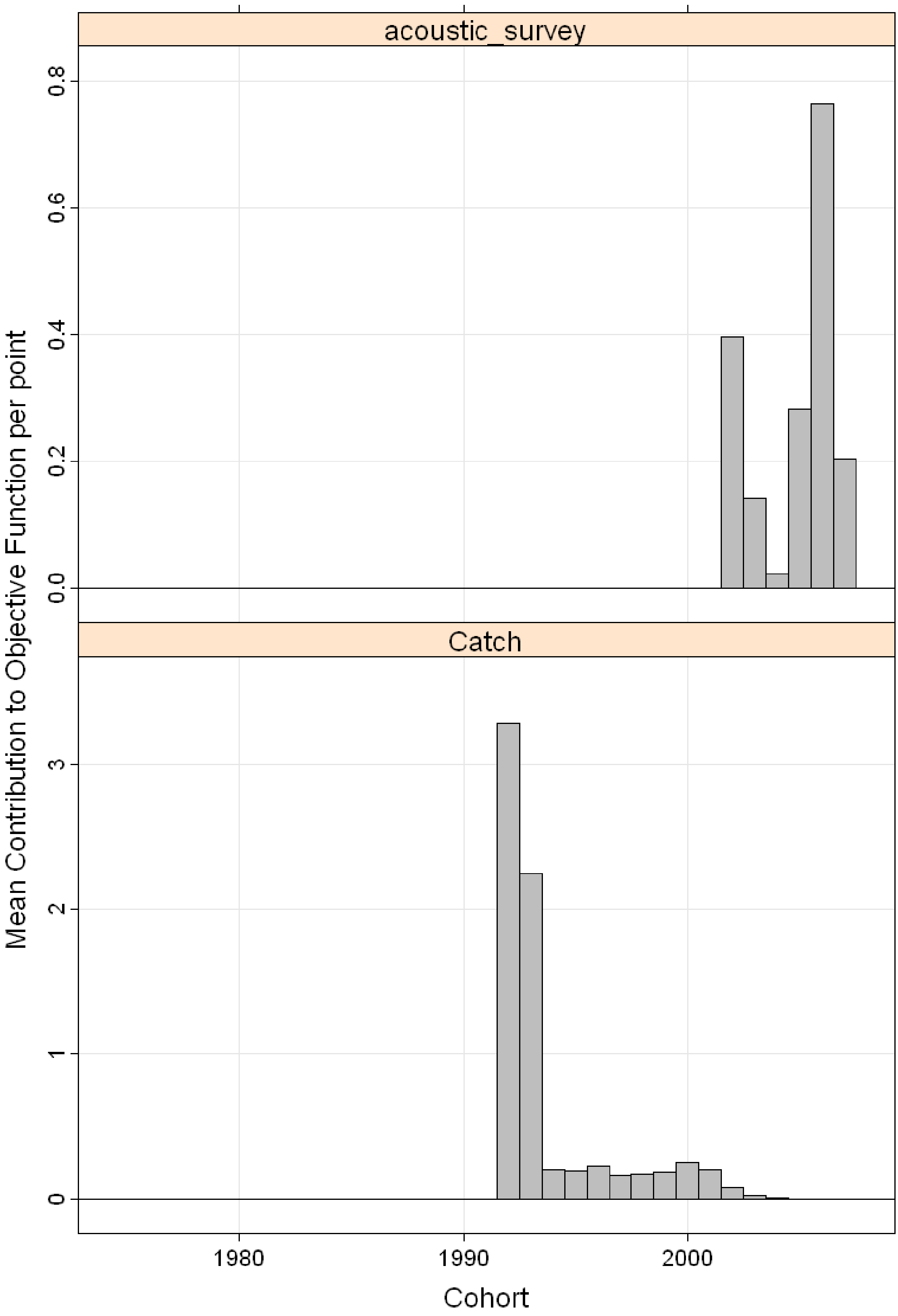


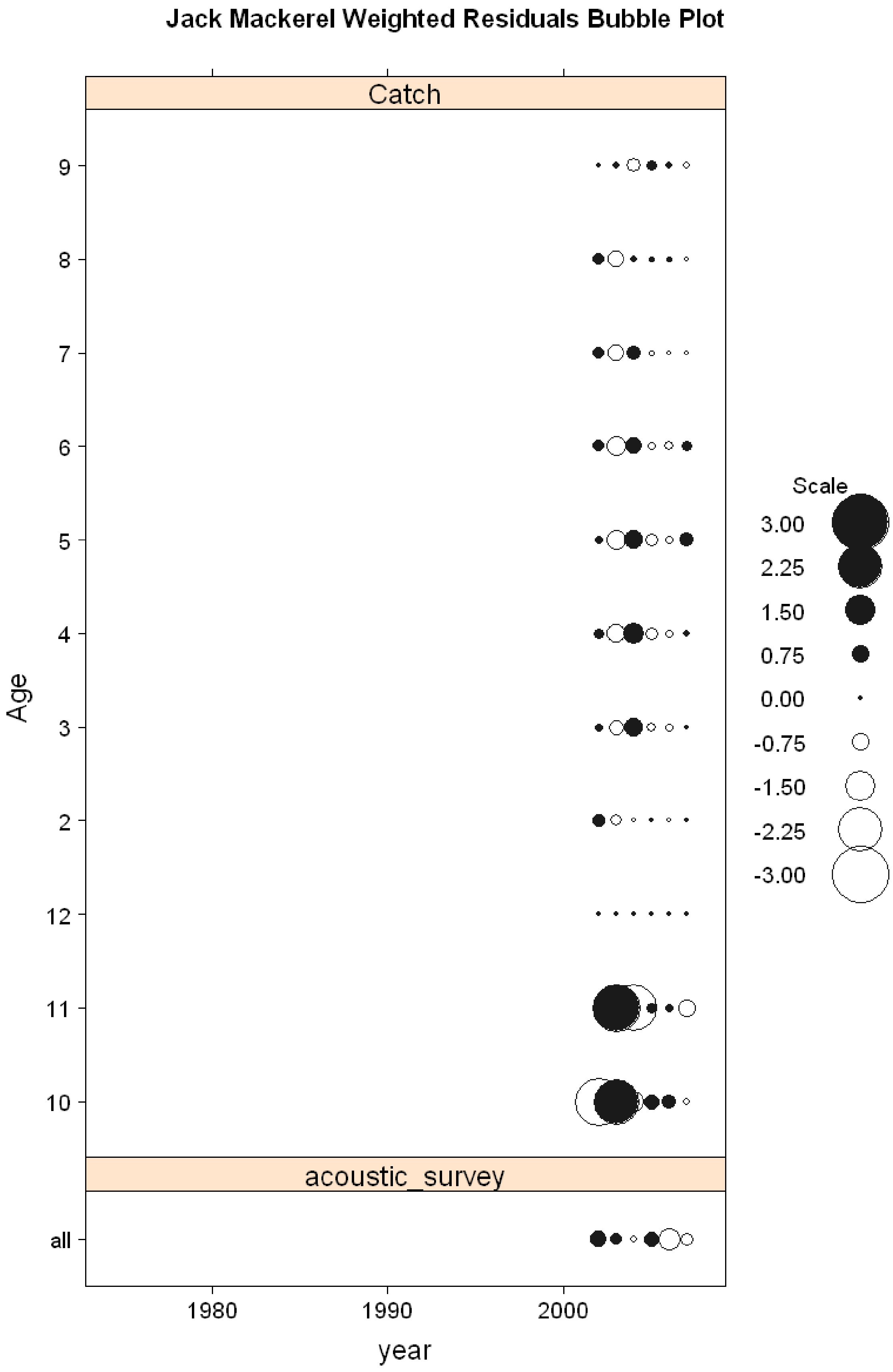
Jack Mackerel Stock Summary Plot
SSB
SSB [10^3]
8
6
4
2
0
Recruits
Recruits [10^3]
30
20
10
0
Mean F
Mean F
0.6
0.4
0.2
0.0
1980
1990
2000
Year


Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Mean Contribution to Objective Function per point
0.0
0.5
1.0
1.5
2.0
2
3
4
5
6
7
8
9
10
11
12
all
Age

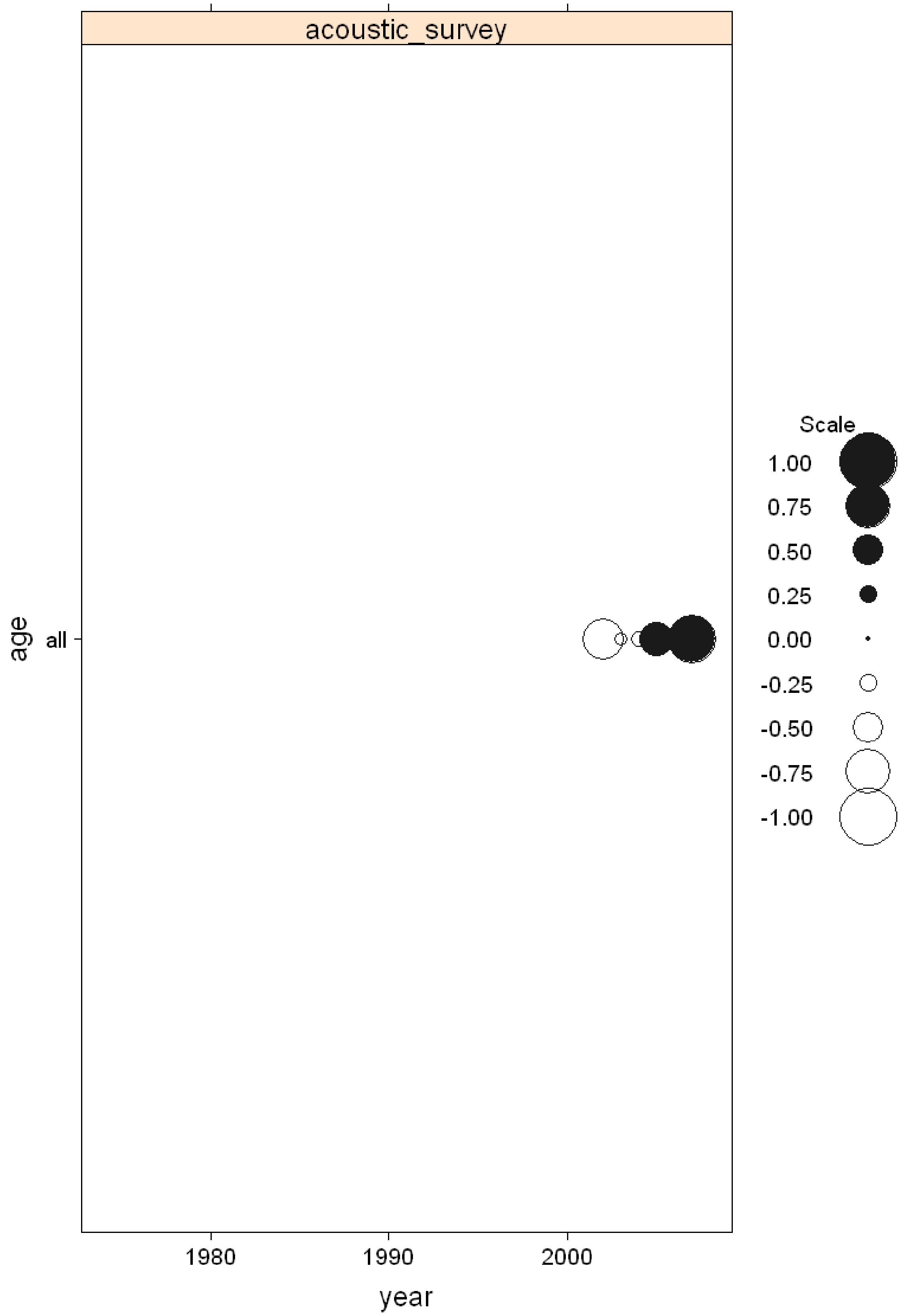

Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Mean Contribution to Objective Function per point
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1980
1990
2000
Year

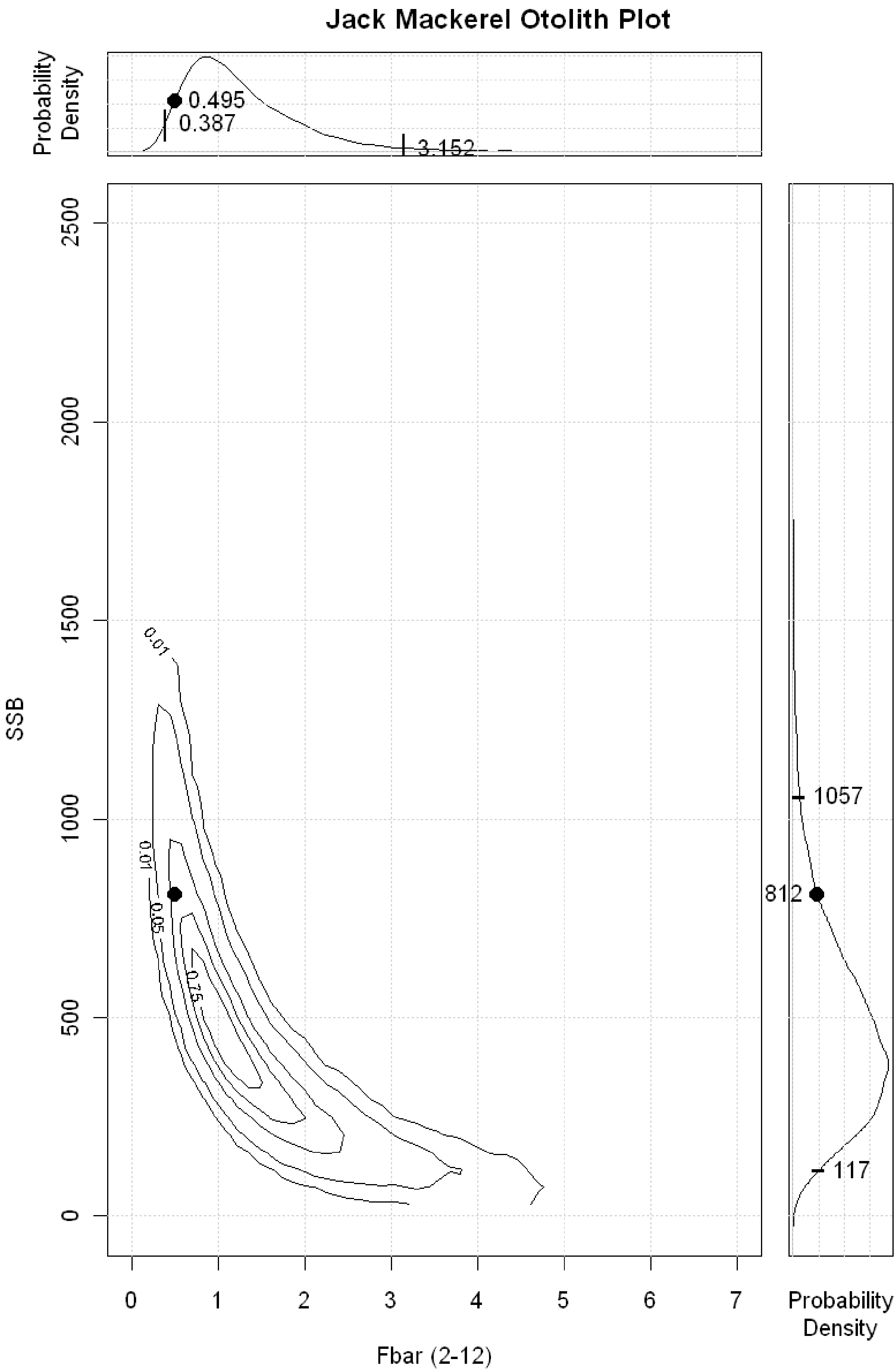
Jack Mackerel SSQ Breakdown by Cohort

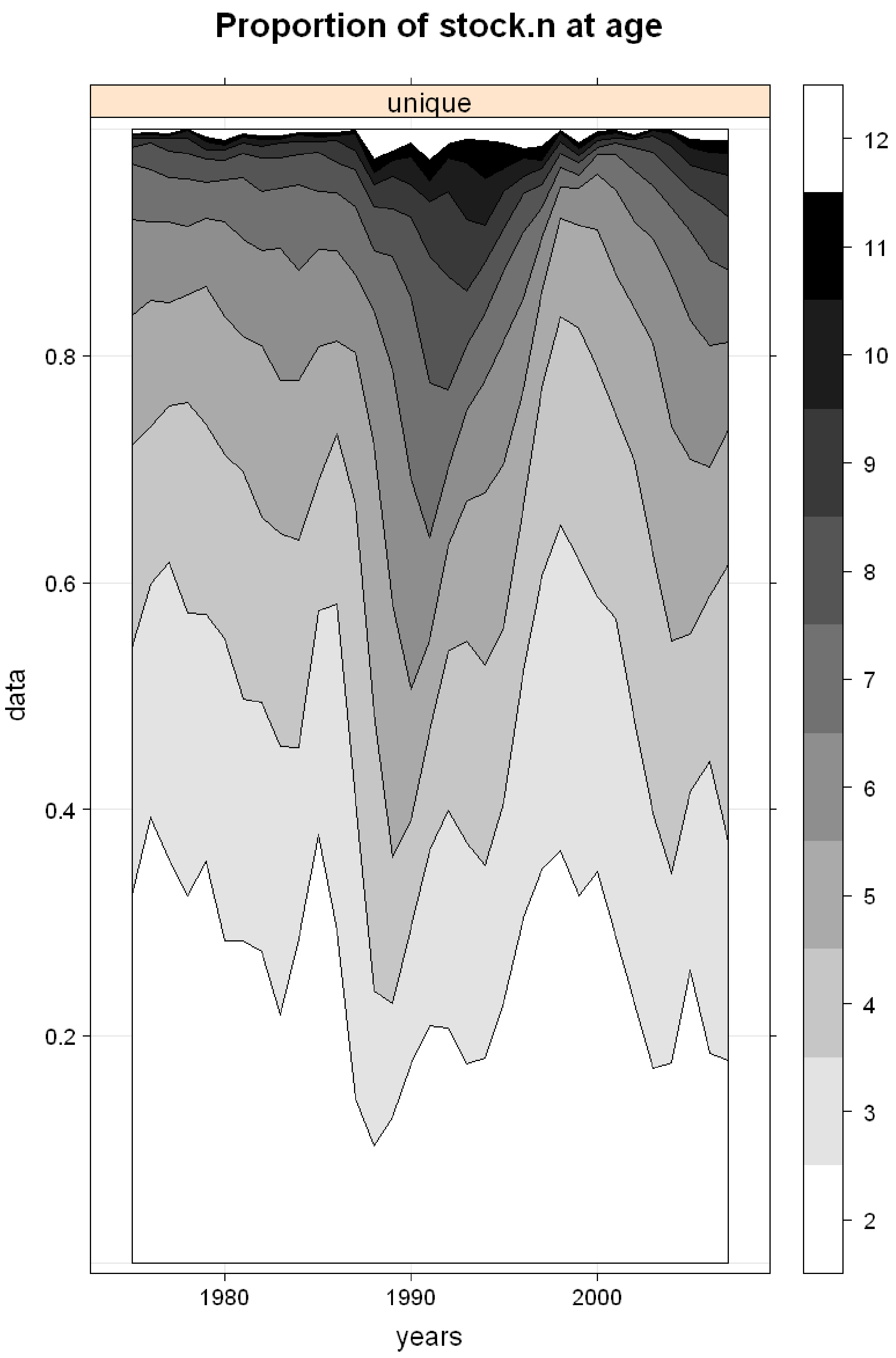


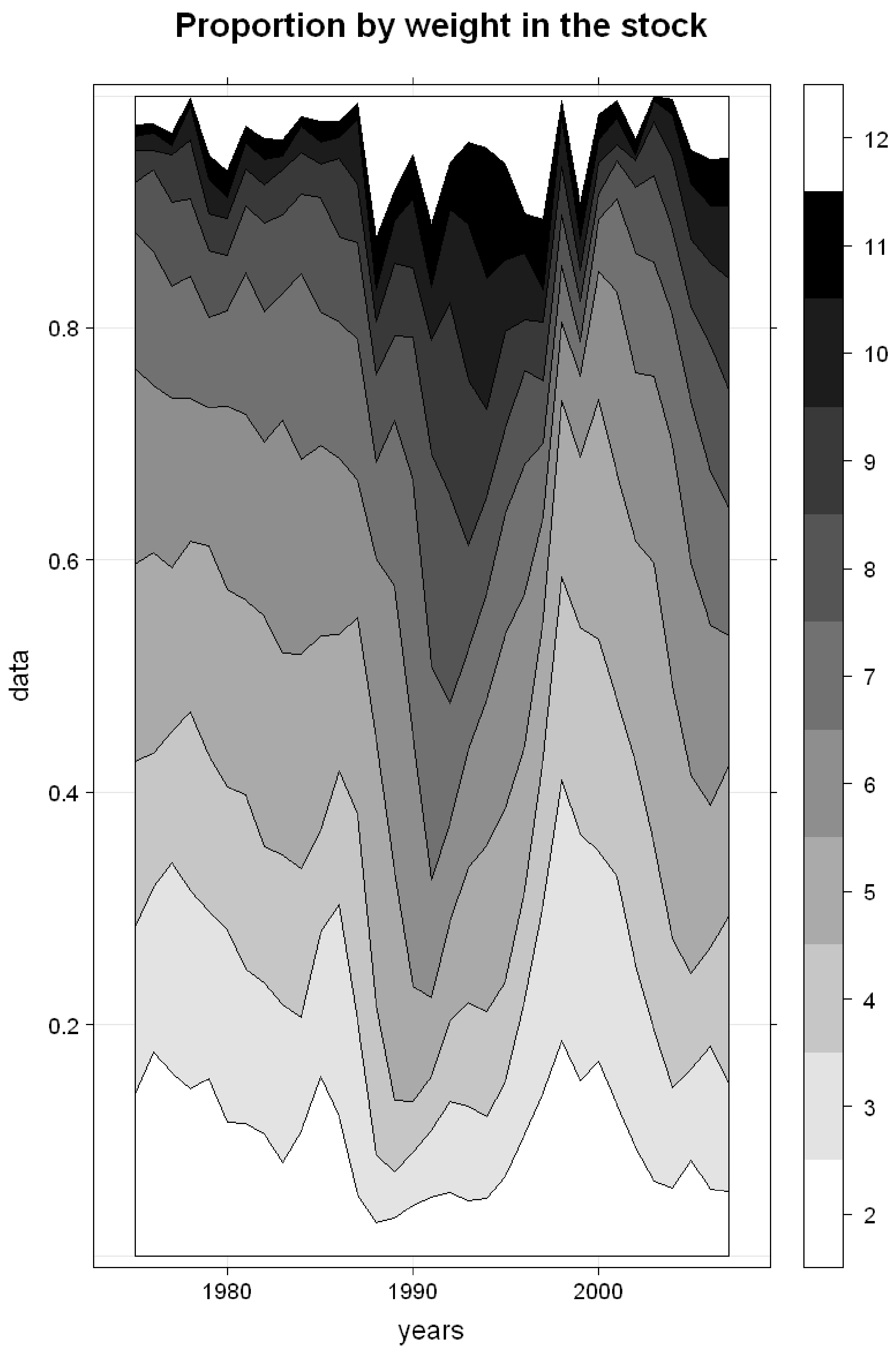

Jack Mackerel Weighted Residuals Bubble Plot
Catch
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00

Jack Mackerel Unweighted Index Residuals Bubble Plot



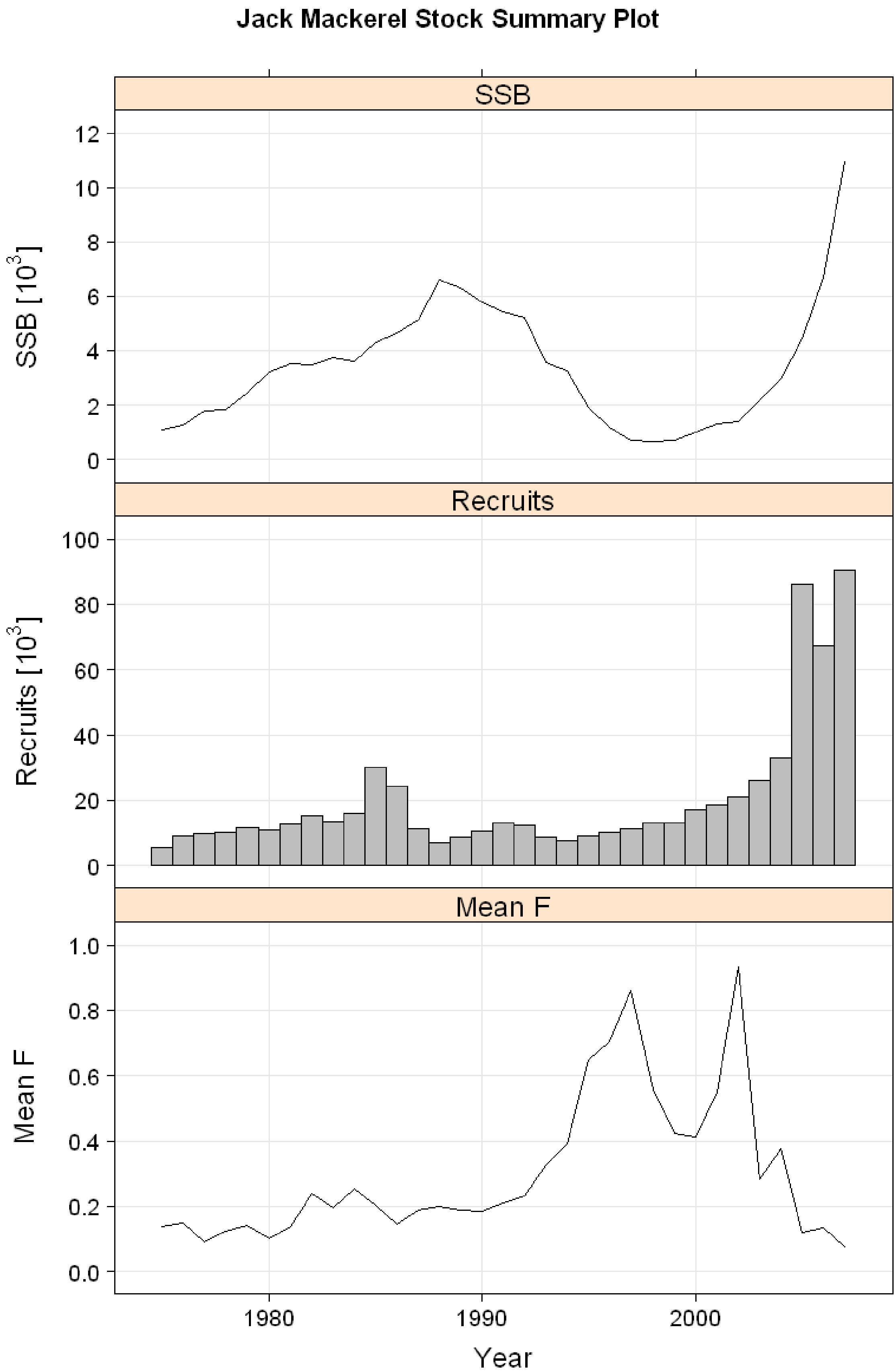

Jack Mackerel Otolith Plot
Probability Density
0.495
0.387
3.152
SSB
2500
2000
1500
1000
500
0
0.01
0.01
0.05
0.25
0
1
2
3
4
5
6
7
Fbar (2-12)
1057
812
117
Probability Density

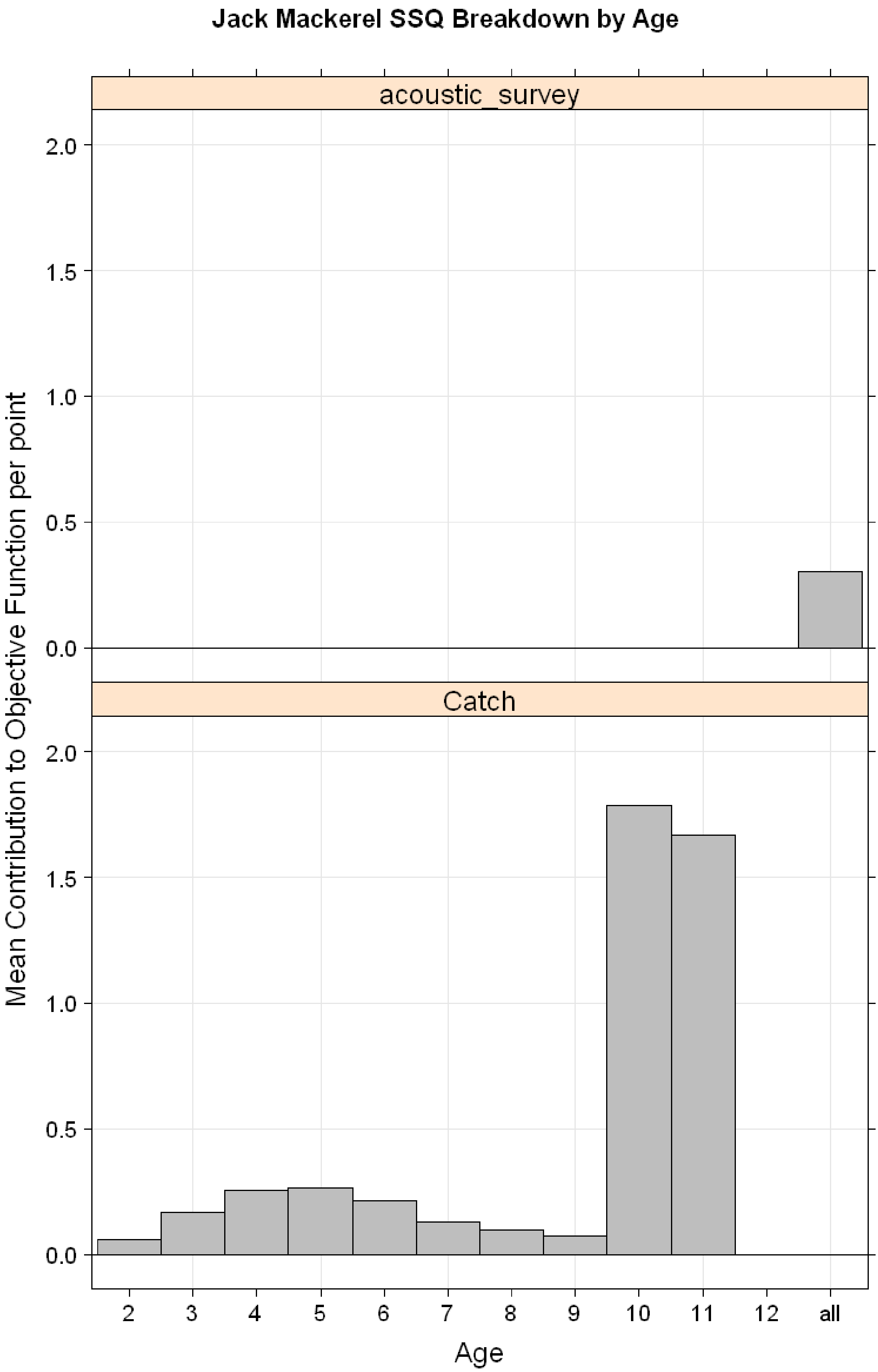

Proportion of stock.n at age
unique
data
0.8
0.6
0.4
0.2
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

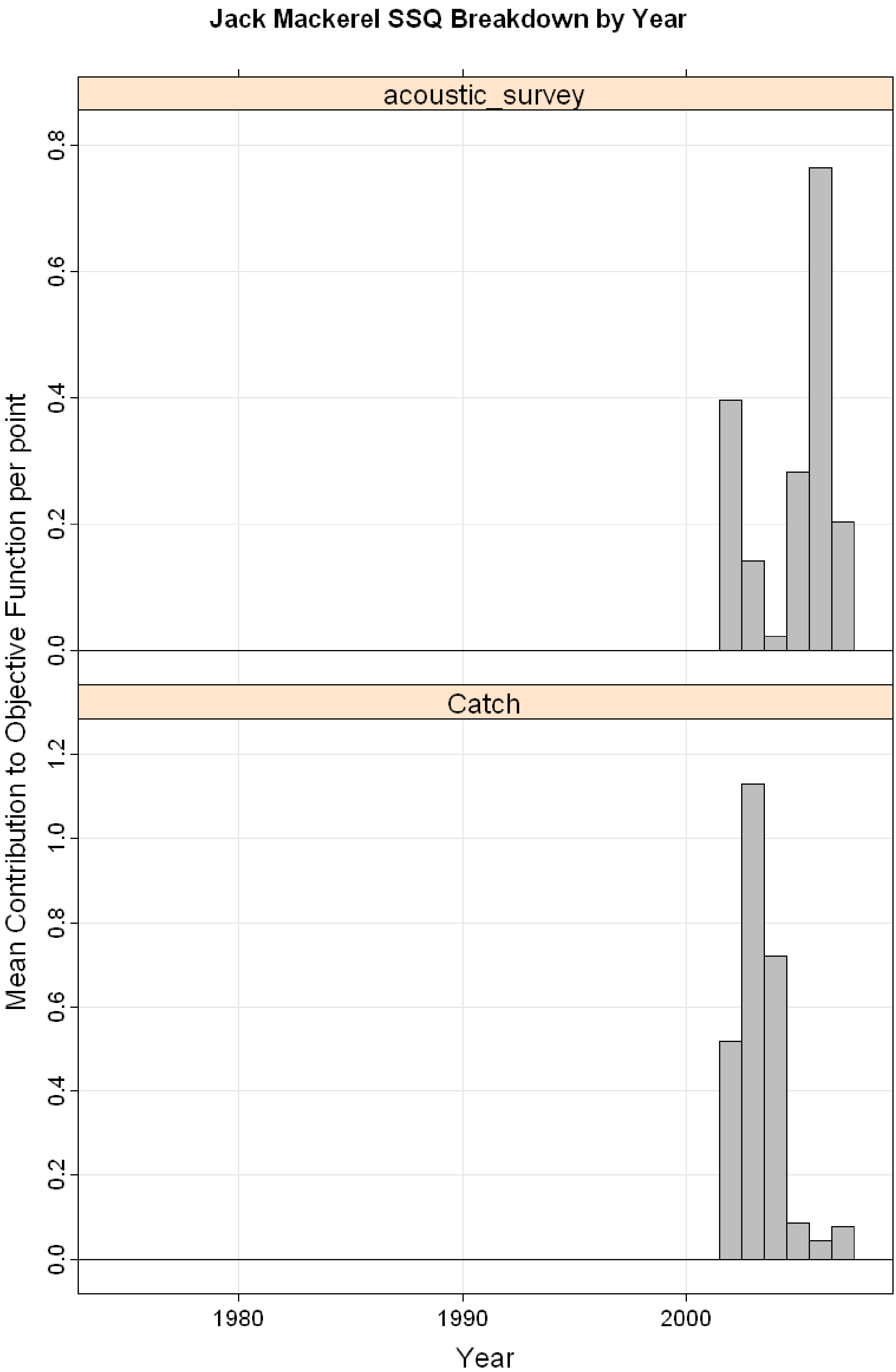


Proportion by weight in the stock
data
years
0.2
0.4
0.6
0.8
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

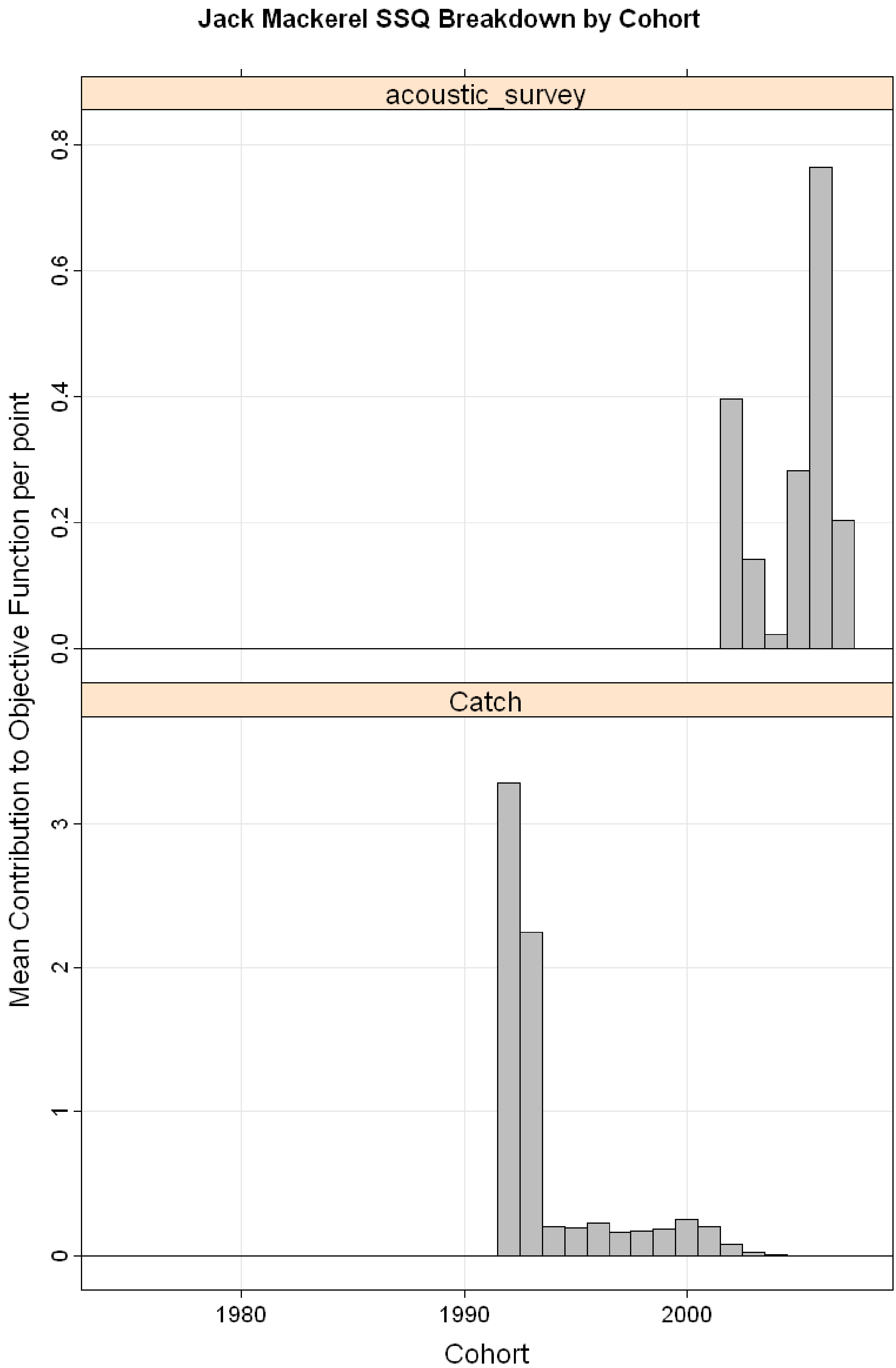
8.4.3 95%

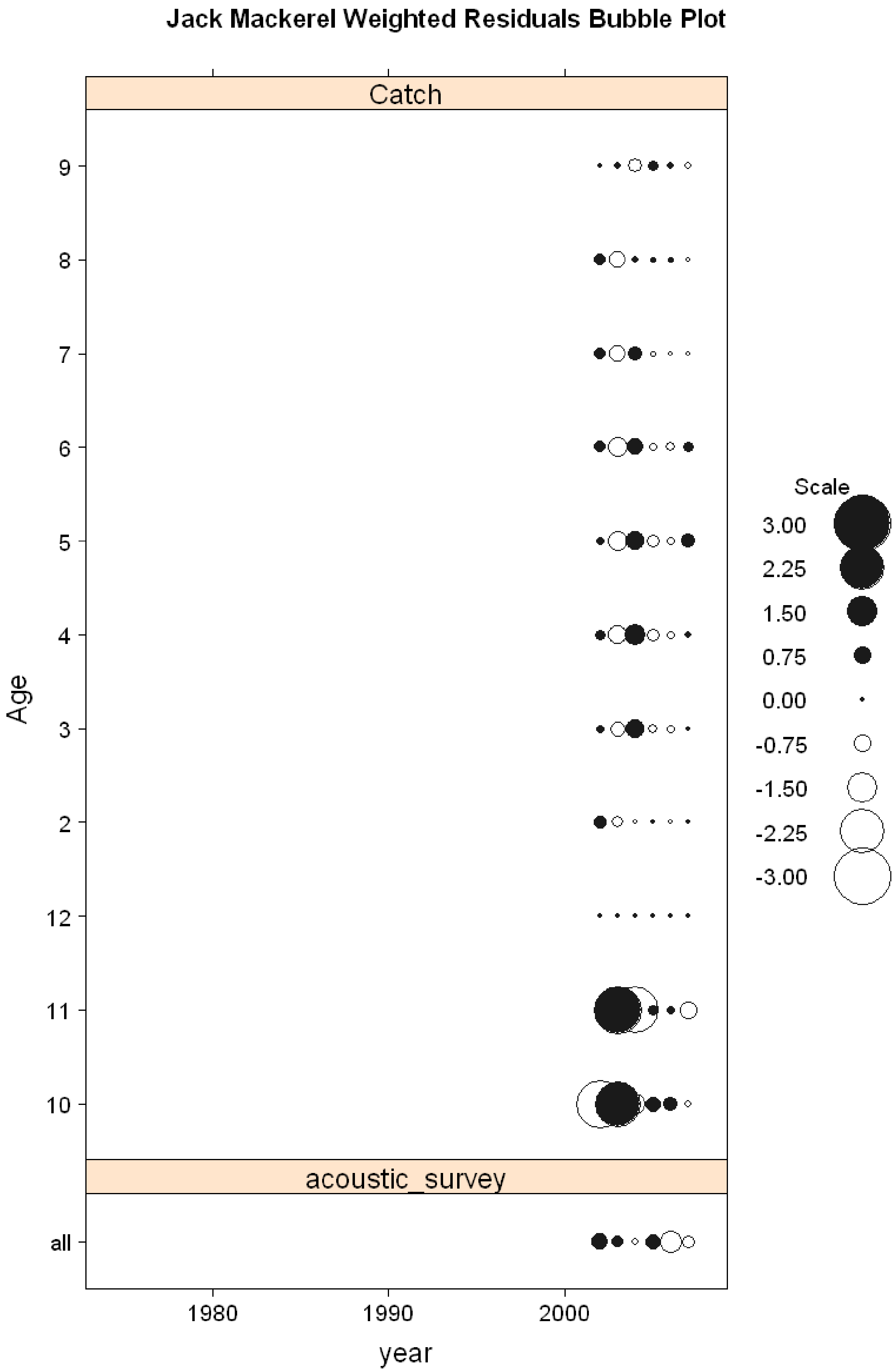

Jack Mackerel Stock Summary Plot
SSB
Recruits
Mean F
SSB [10^3]
Recruits [10^3]
Mean F
Year
1980
1990
2000

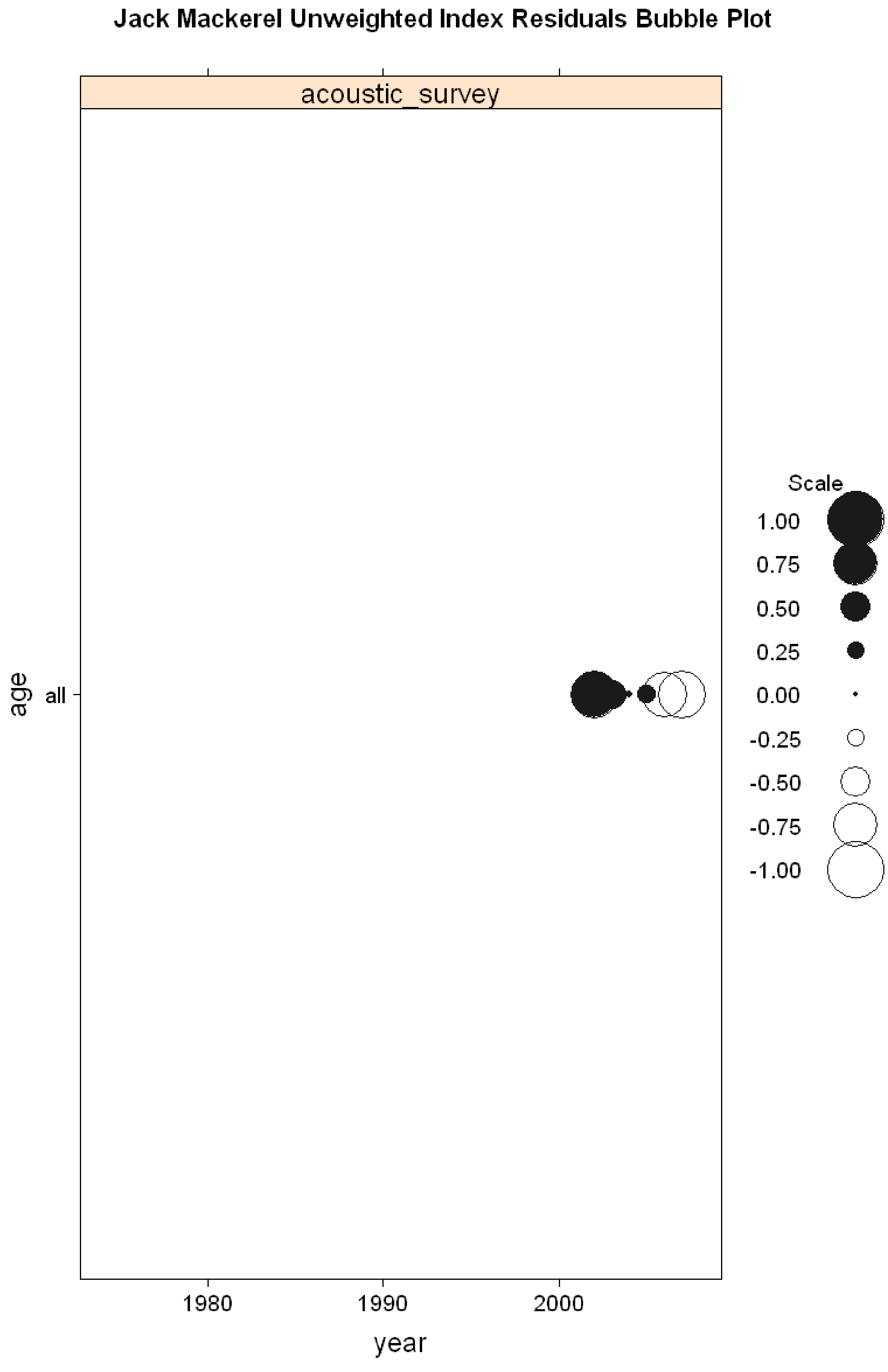

Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Mean Contribution to Objective Function per point
0.0
0.5
1.0
1.5
2.0
2
3
4
5
6
7
8
9
10
11
12
all
Age

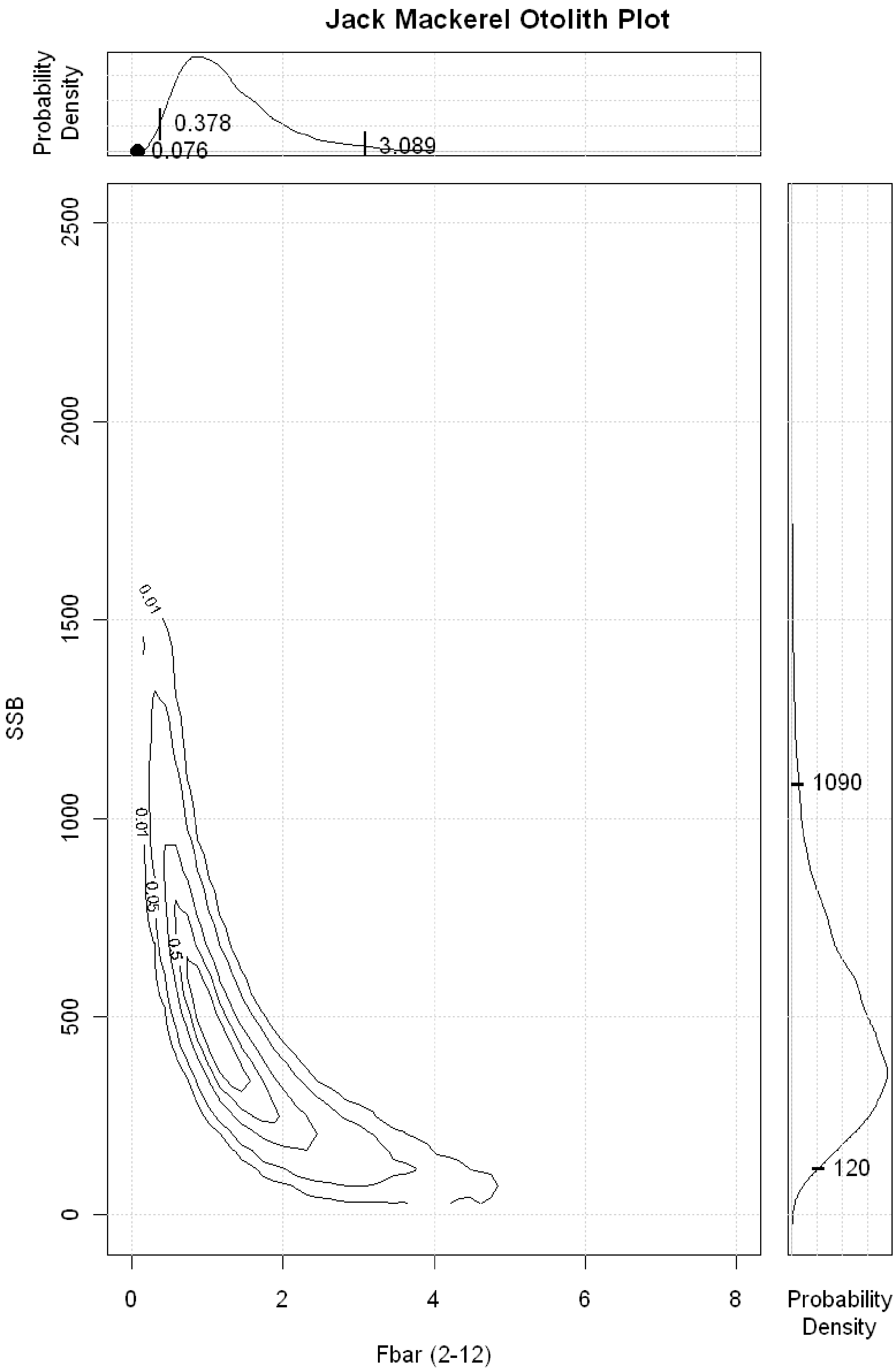


Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Mean Contribution to Objective Function per point
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1980
1990
2000
Year

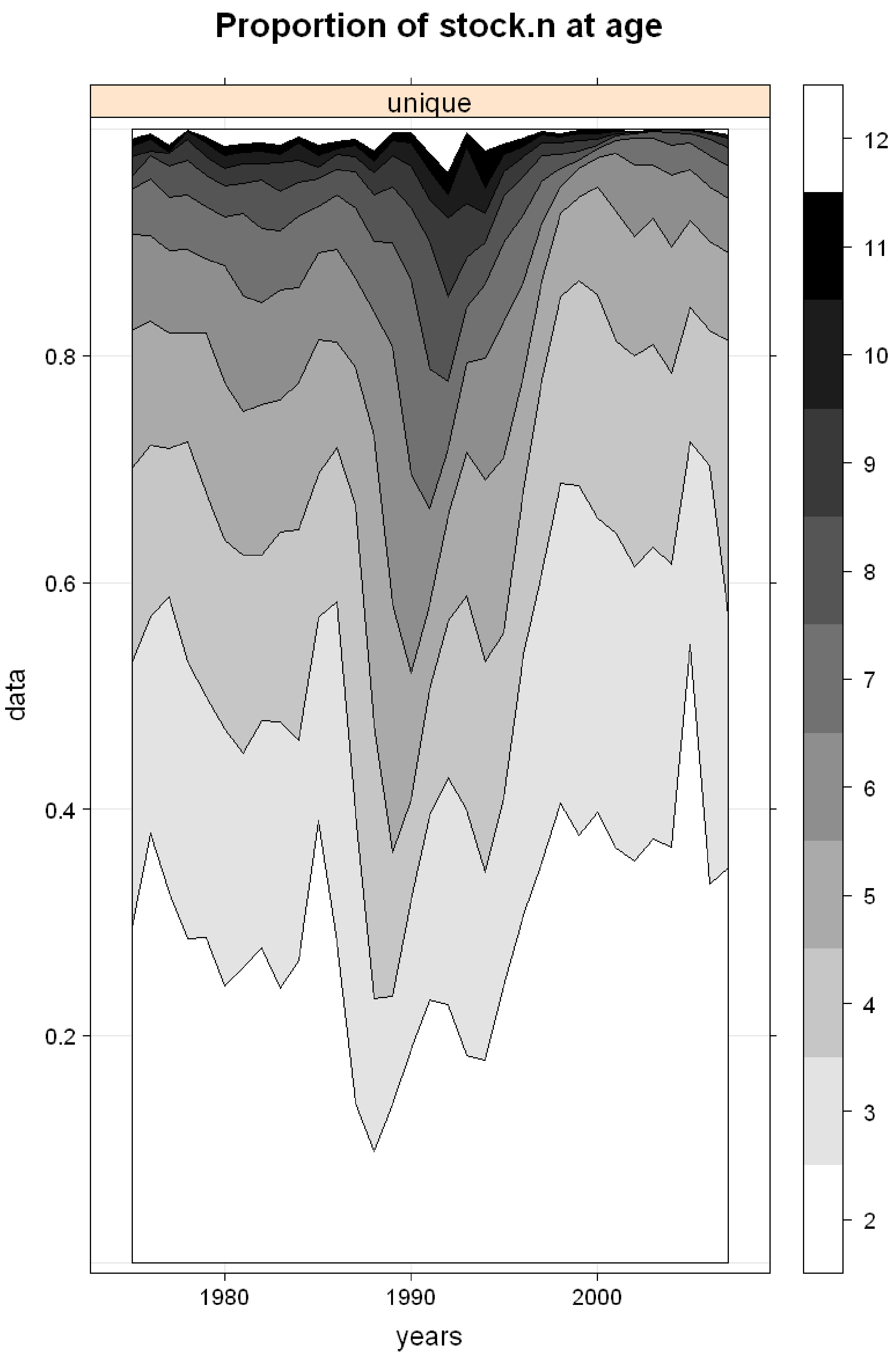

Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Mean Contribution to Objective Function per point
0.0
0.2
0.4
0.6
0.8
0
1
2
3
1980
1990
2000
Cohort


Jack Mackerel Weighted Residuals Bubble Plot
Catch
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00


Jack Mackerel Unweighted Index Residuals Bubble Plot
acoustic_survey
age
all
1980
1990
2000
year
Scale
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00

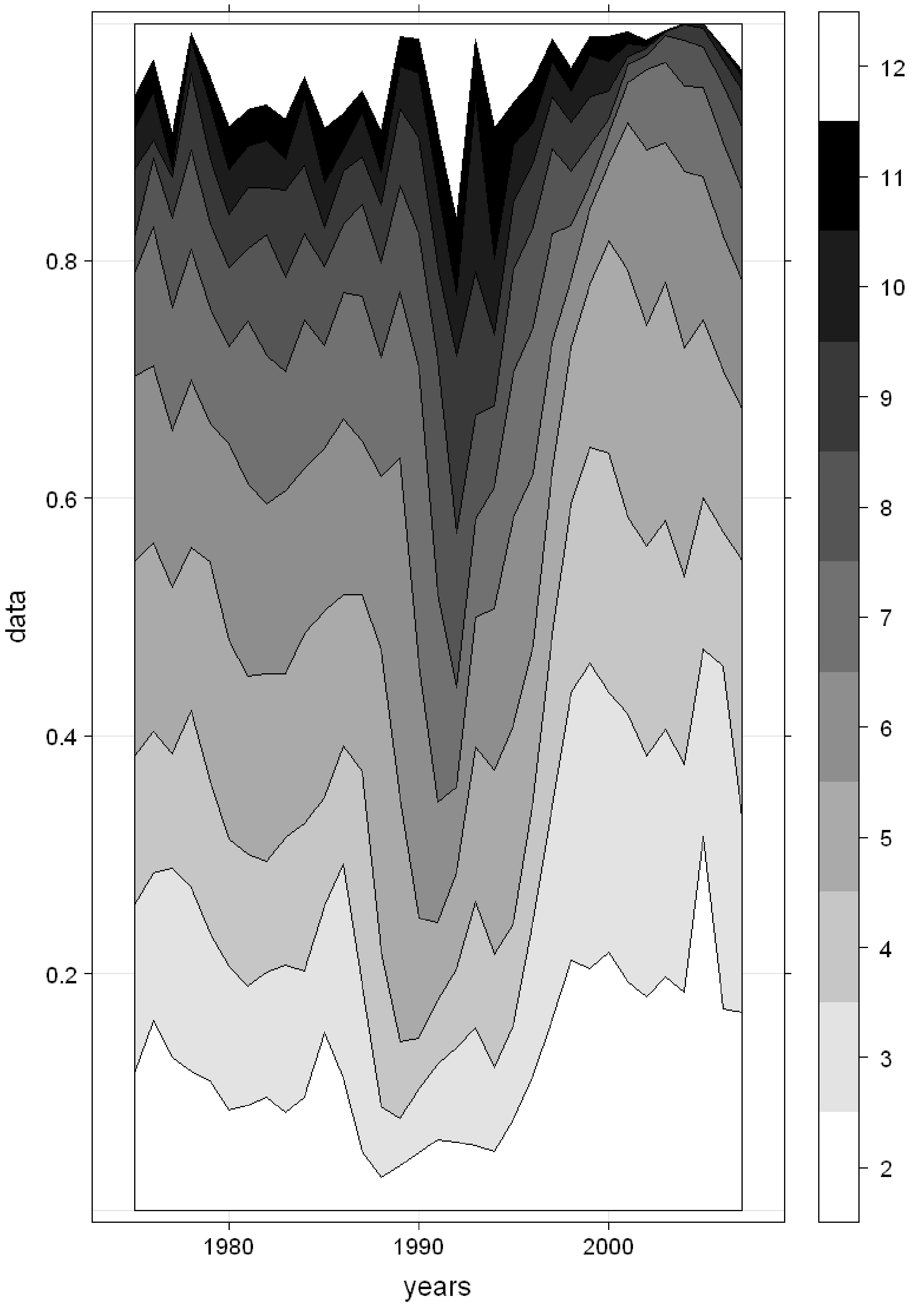


Jack Mackerel Otolith Plot
Probability Density
0.378
0.076
3.089
SSB
2500
2000
1500
1000
500
0
0.01
0.05
0.5
1090
120
0
2
4
6
8
Fbar (2-12)
Probability Density



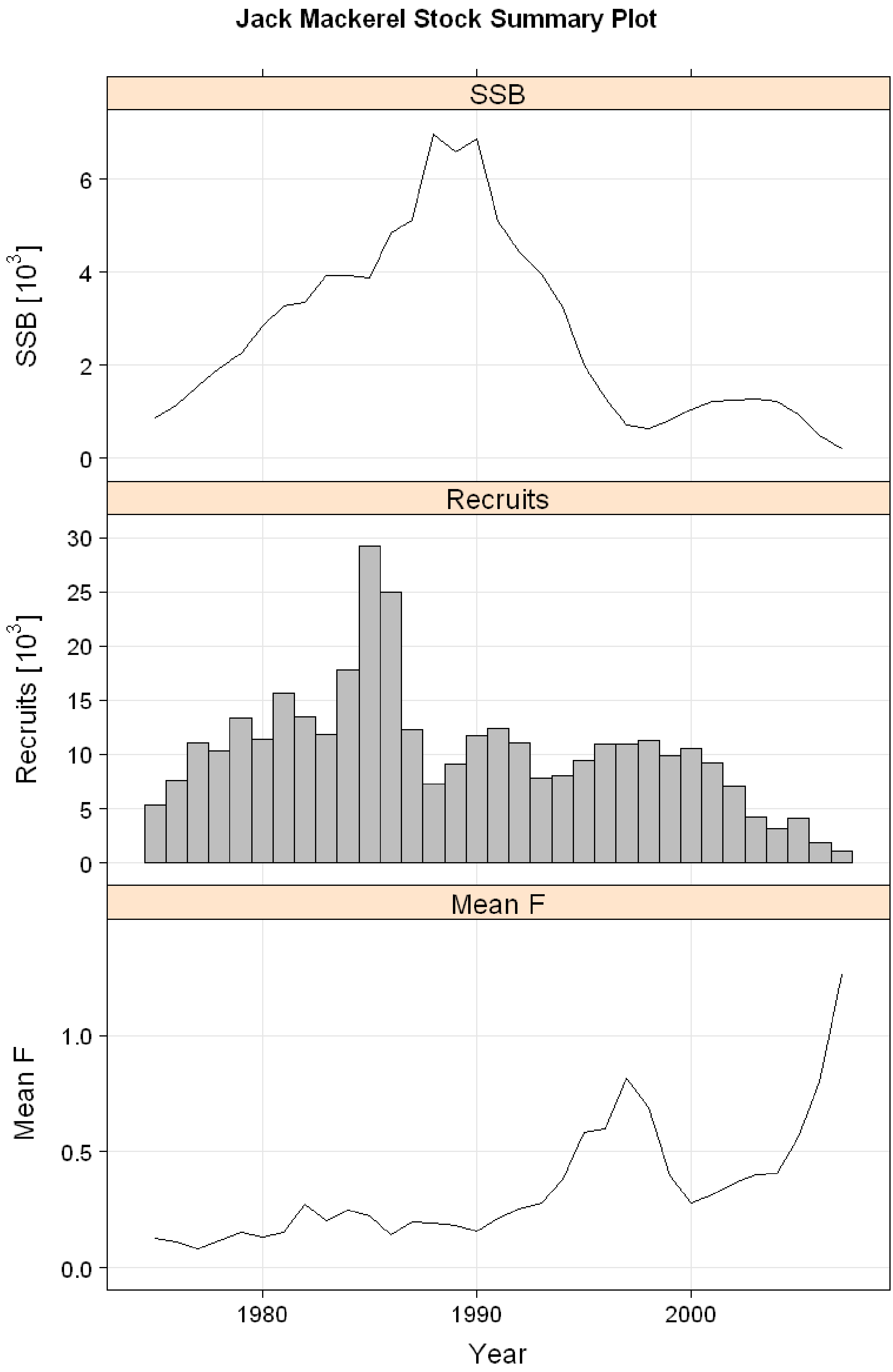
Proportion of stock.n at age
unique
data
years
0.2
0.4
0.6
0.8
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

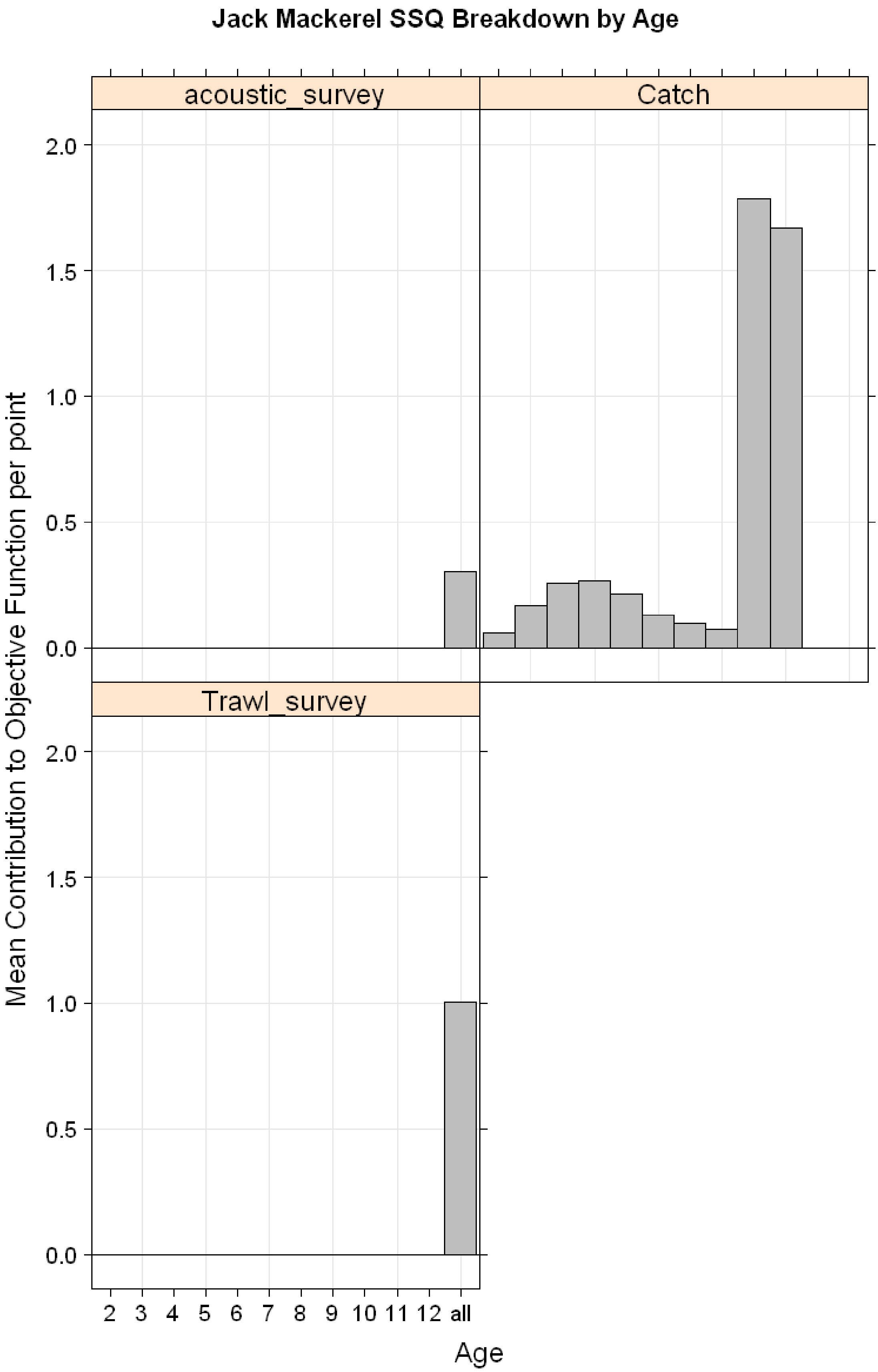
Proportion by weight in the stock

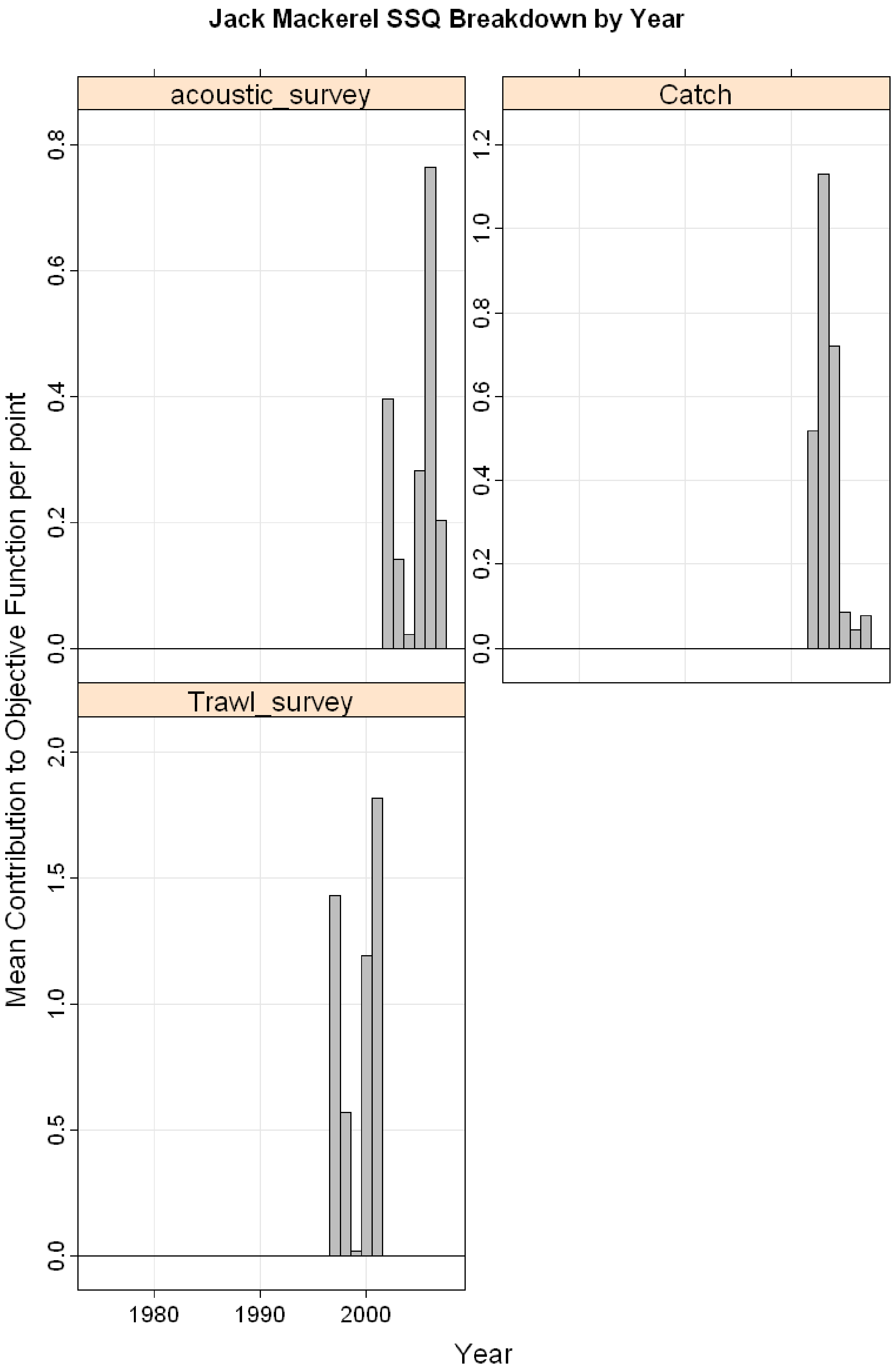


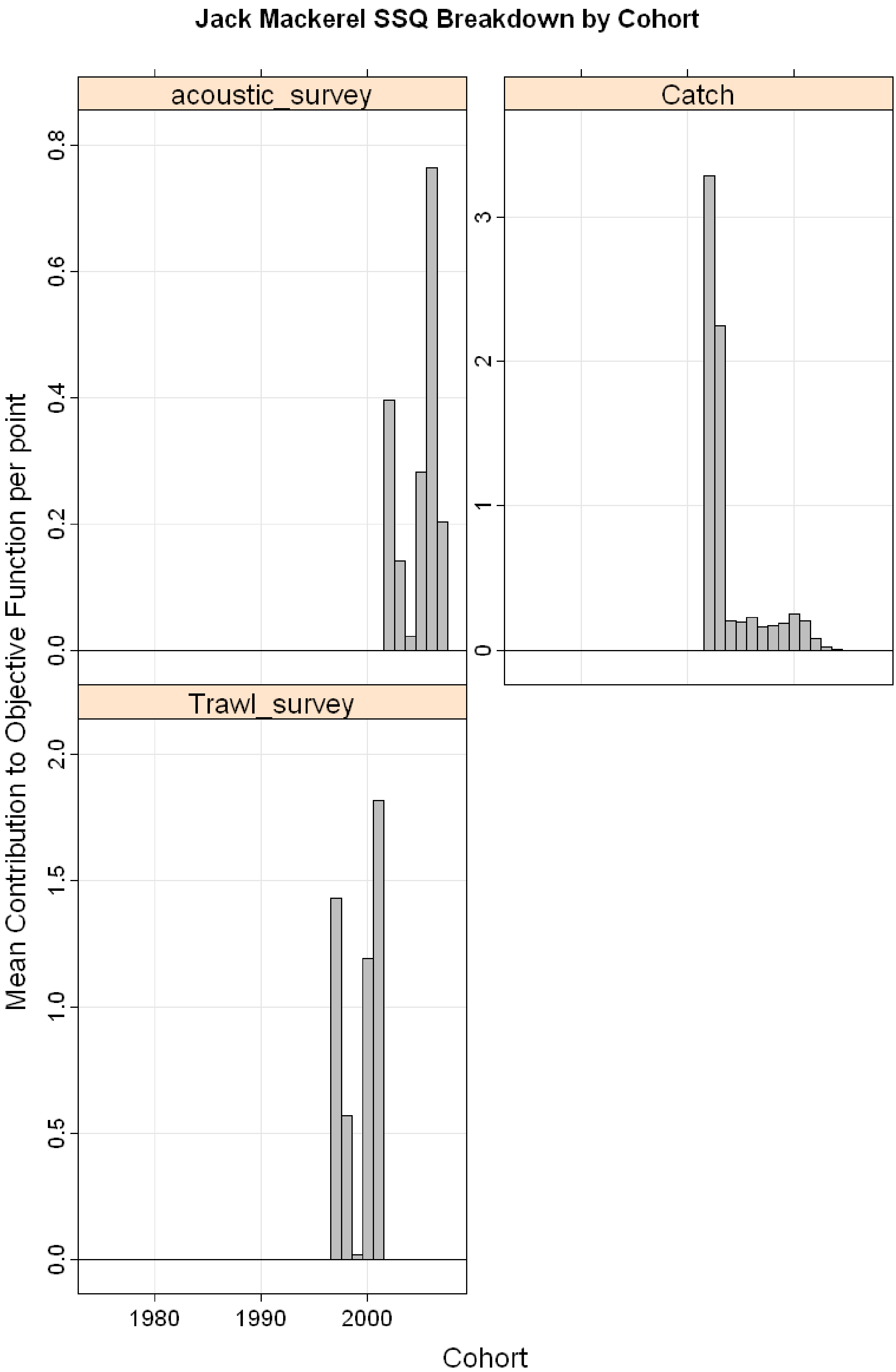
8.5 Scenario 5

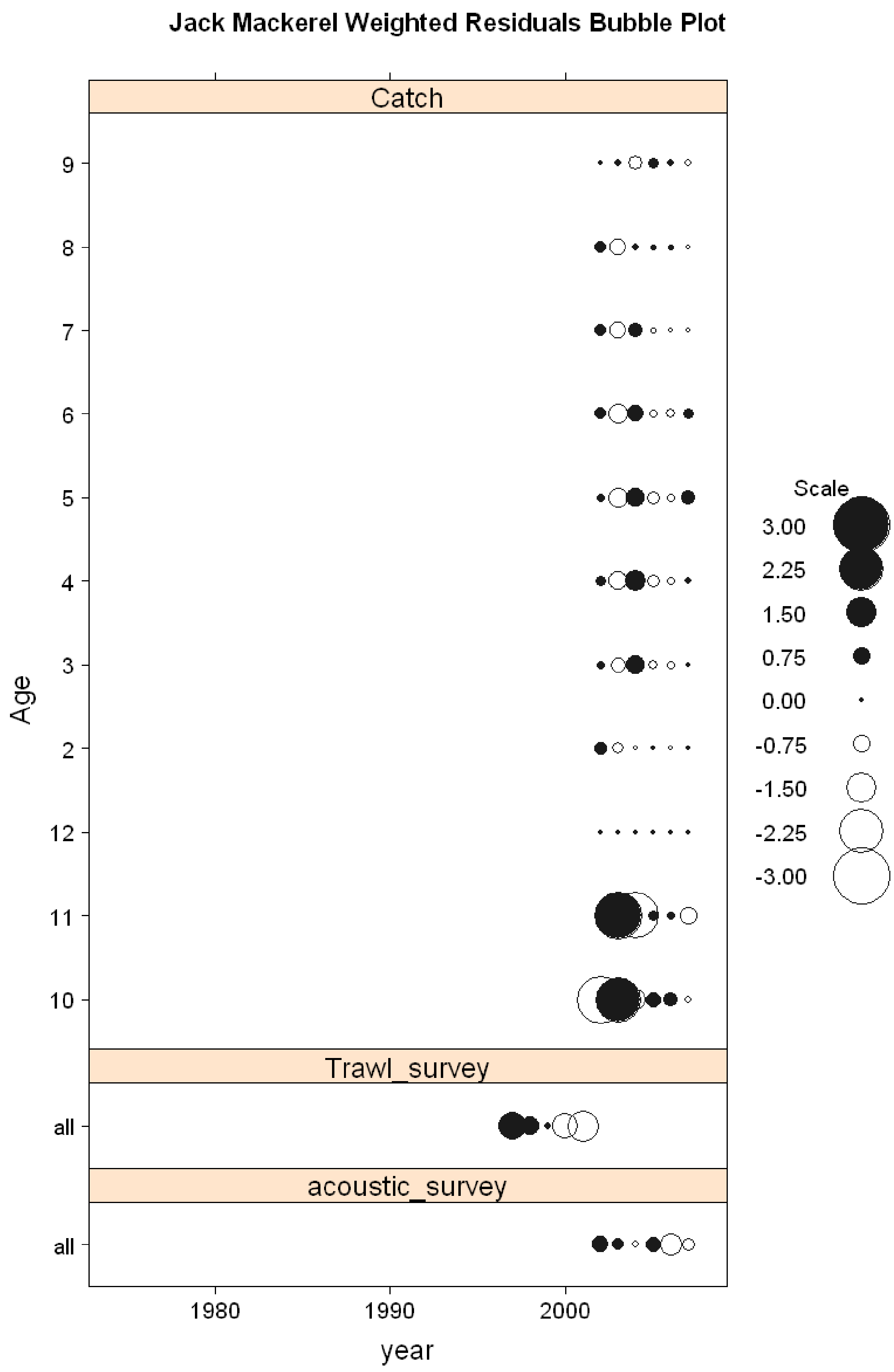
8.5.1 5%


Jack Mackerel Stock Summary Plot
SSB
SSB [10^3]
Recruits
Recruits [10^3]
Mean F
Mean F
1980
1990
2000
Year

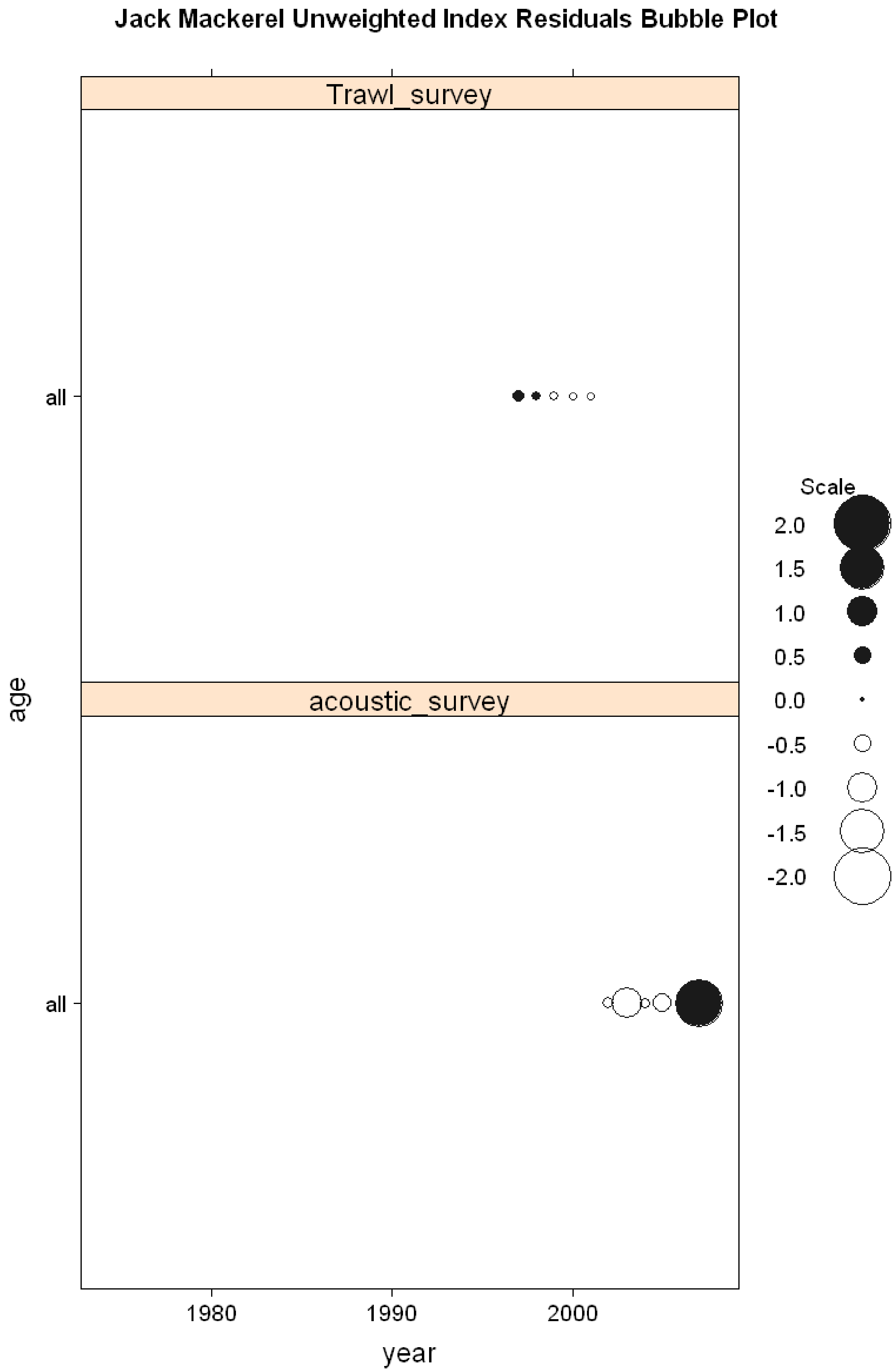

Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
0.0
0.5
1.0
1.5
2.0
2 3 4 5 6 7 8 9 10 11 12 all
Age

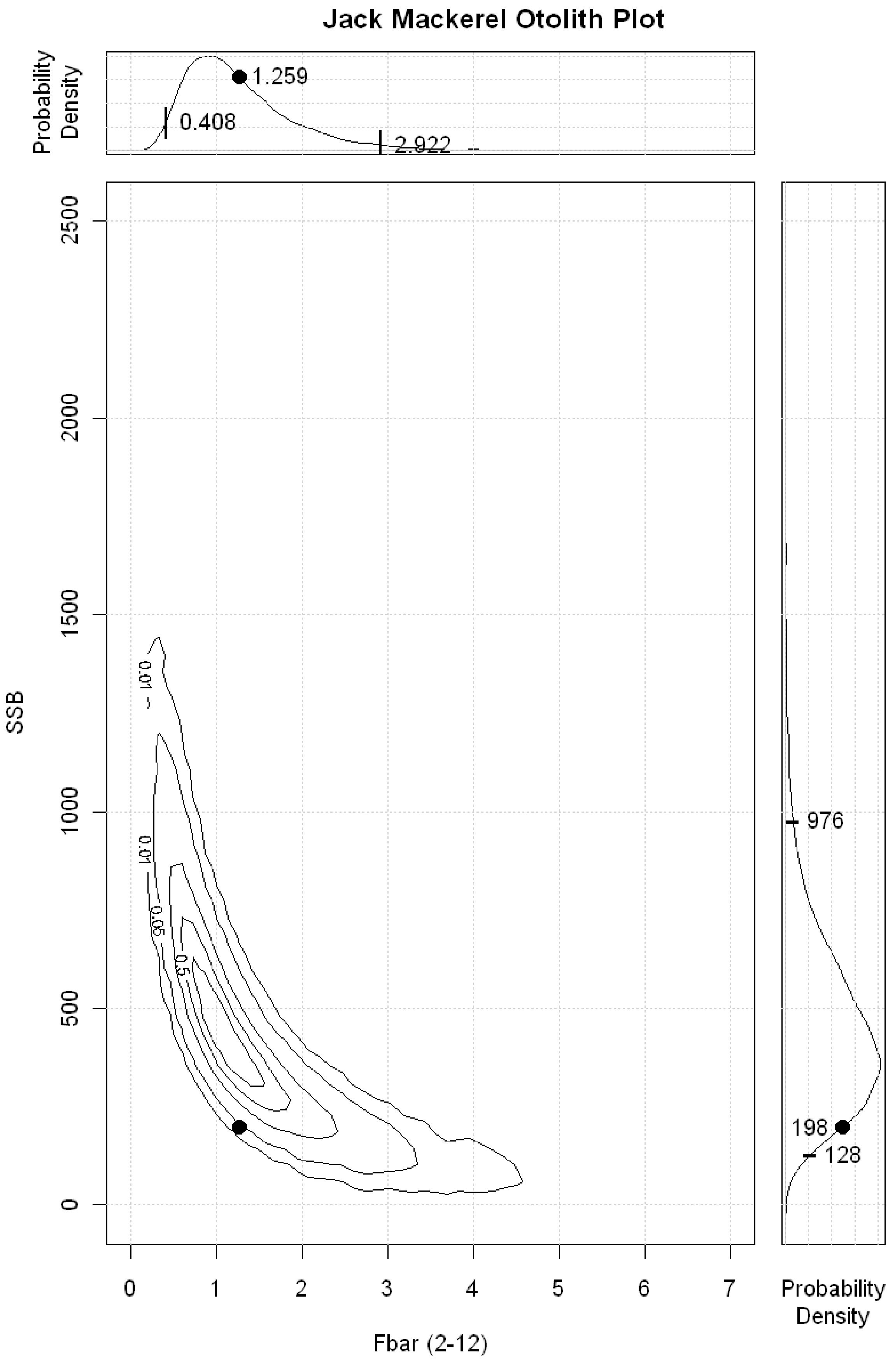

Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Year
1980
1990
2000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.5
1.5
2.0


Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Cohort
0.0
0.2
0.4
0.6
0.8
0
1
2
3
0.0
0.5
1.0
1.5
2.0
1980
1990
2000

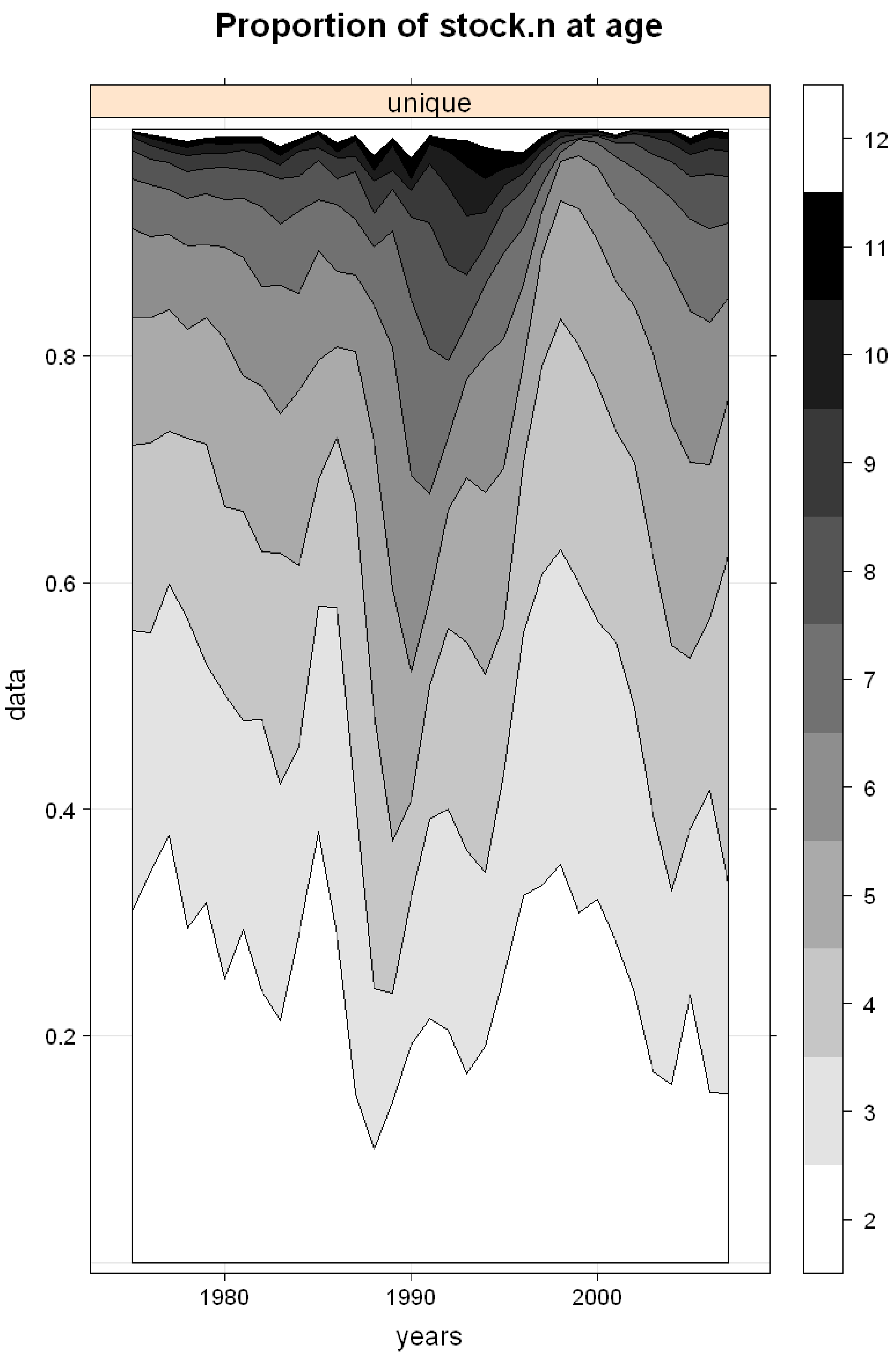


Jack Mackerel Weighted Residuals Bubble Plot
Catch
Trawl_survey
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00

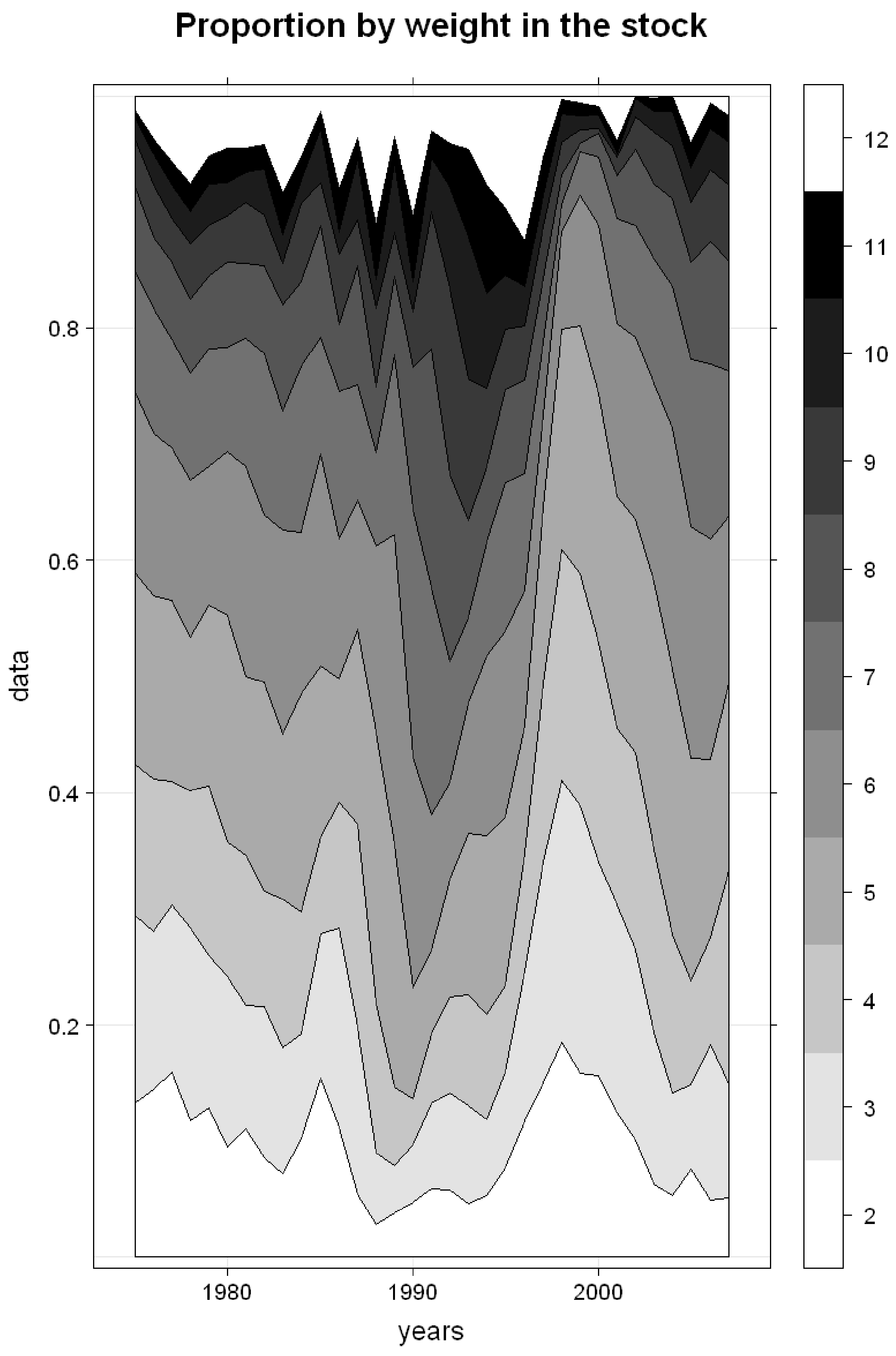

Jack Mackerel Unweighted Index Residuals Bubble Plot
Trawl_survey
acoustic_survey
all
all
age
year
1980
1990
2000
Scale
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0



Jack Mackerel Otolith Plot
Probability Density
1.259
0.408
2.922
SSB
2500
2000
1500
1000
500
0
0.01
0.01
0.05
0.5
0
1
2
3
4
5
6
7
Fbar (2-12)
976
198
128
Probability Density

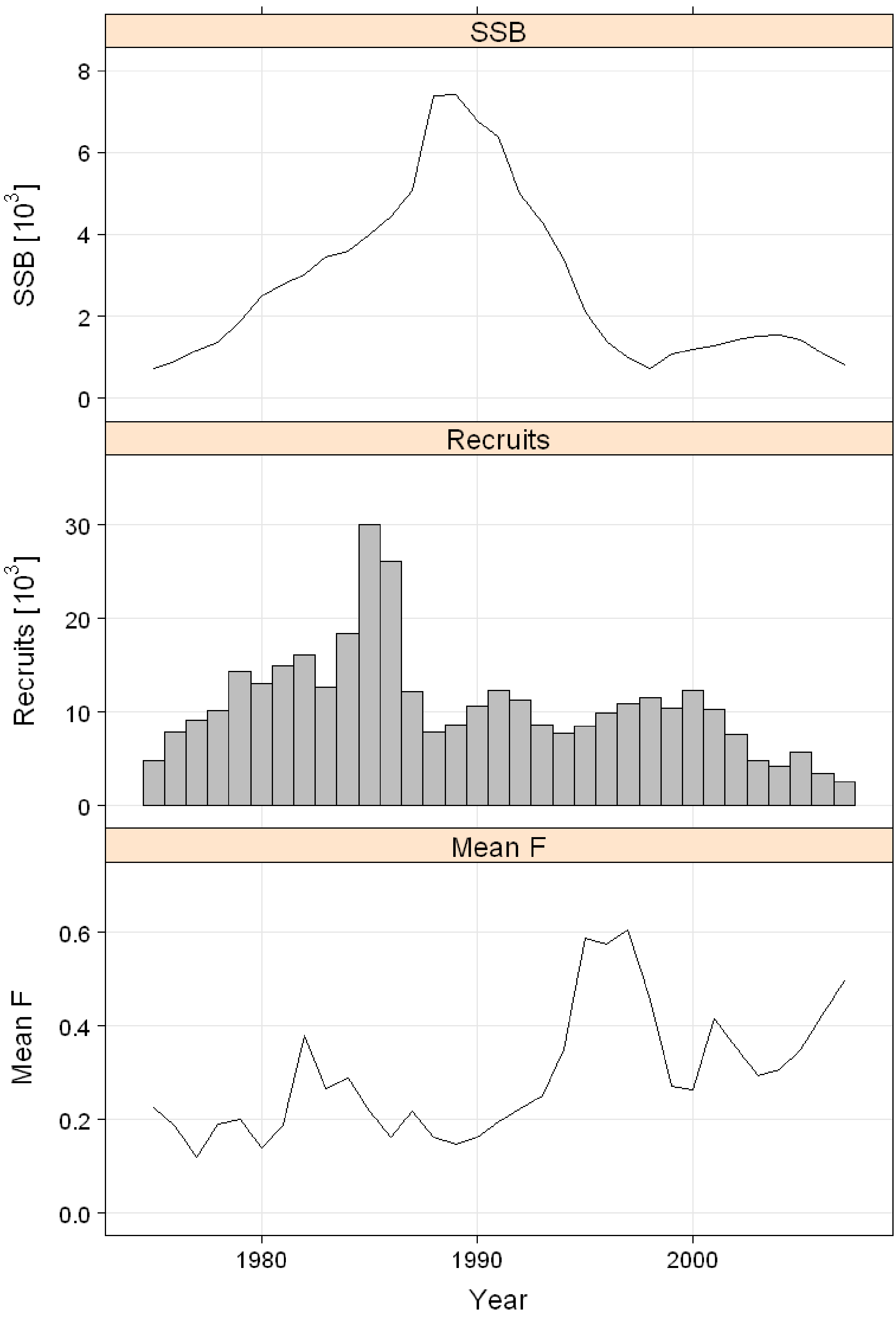


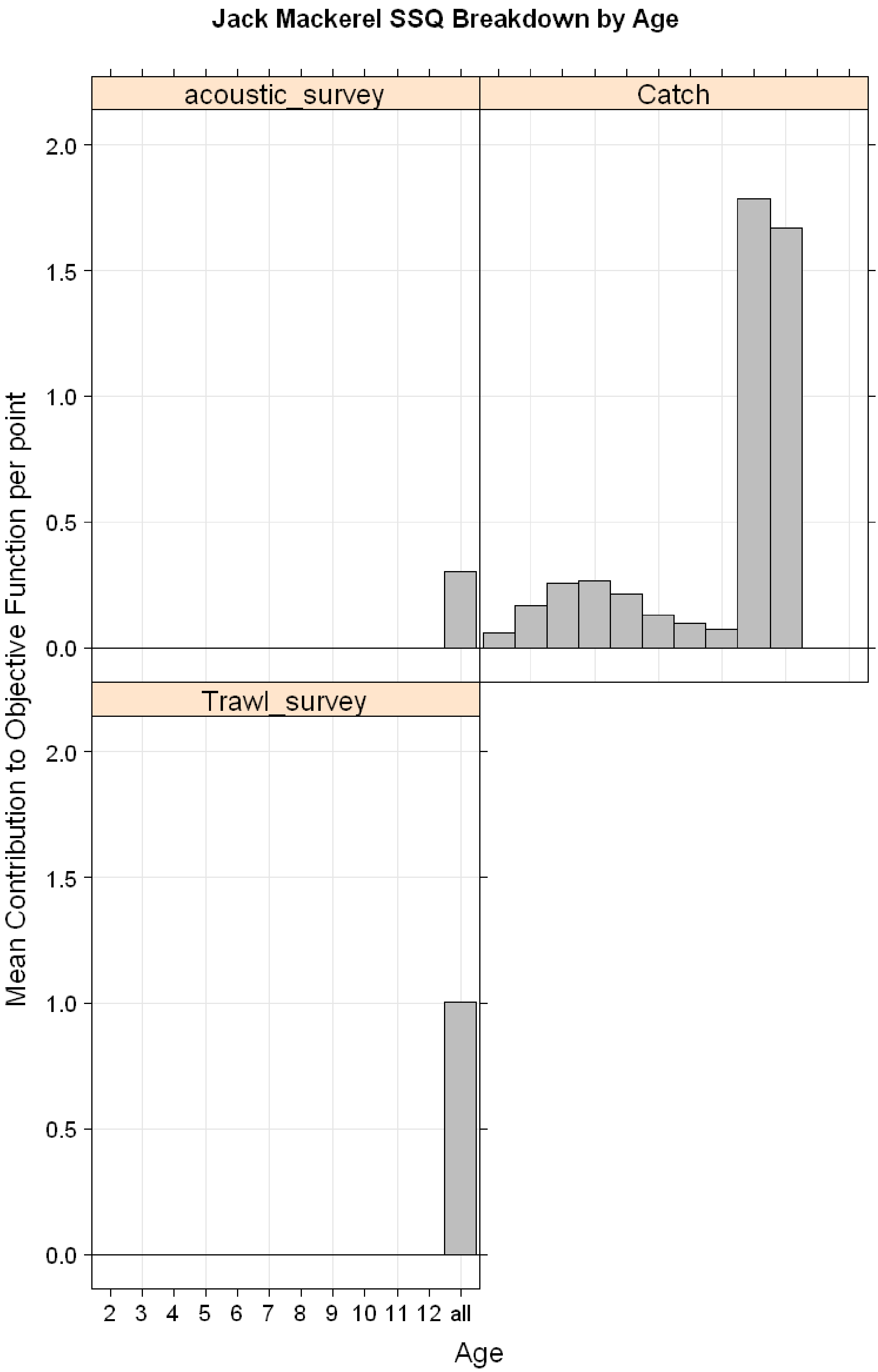
Proportion of stock.n at age
unique
data
0.2
0.4
0.6
0.8
years
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

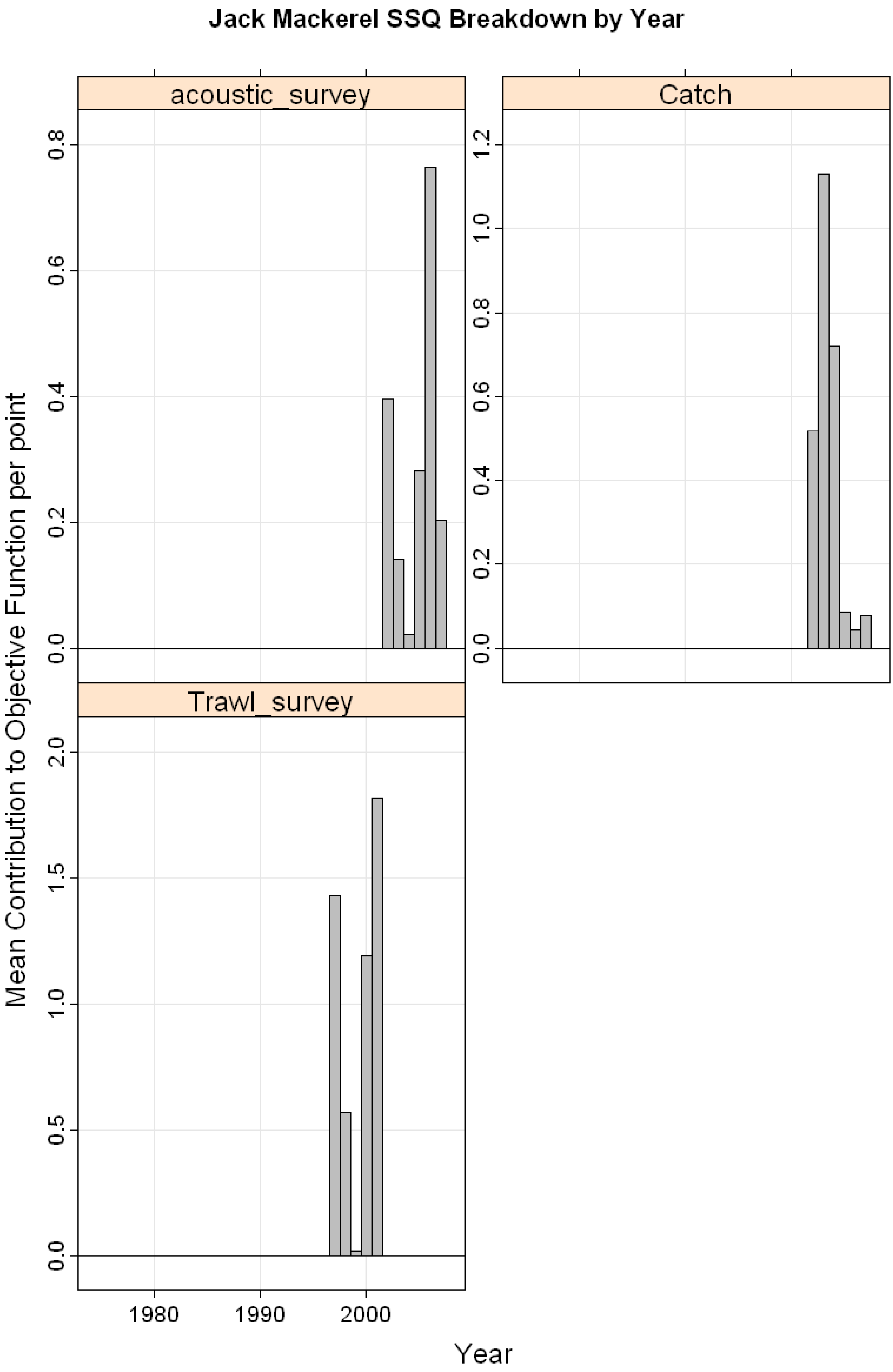

Proportion by weight in the stock
data
0.2
0.4
0.6
0.8
1980
1990
2000
years
2
3
4
5
6
7
8
9
10
11
12

8.5.2 50%

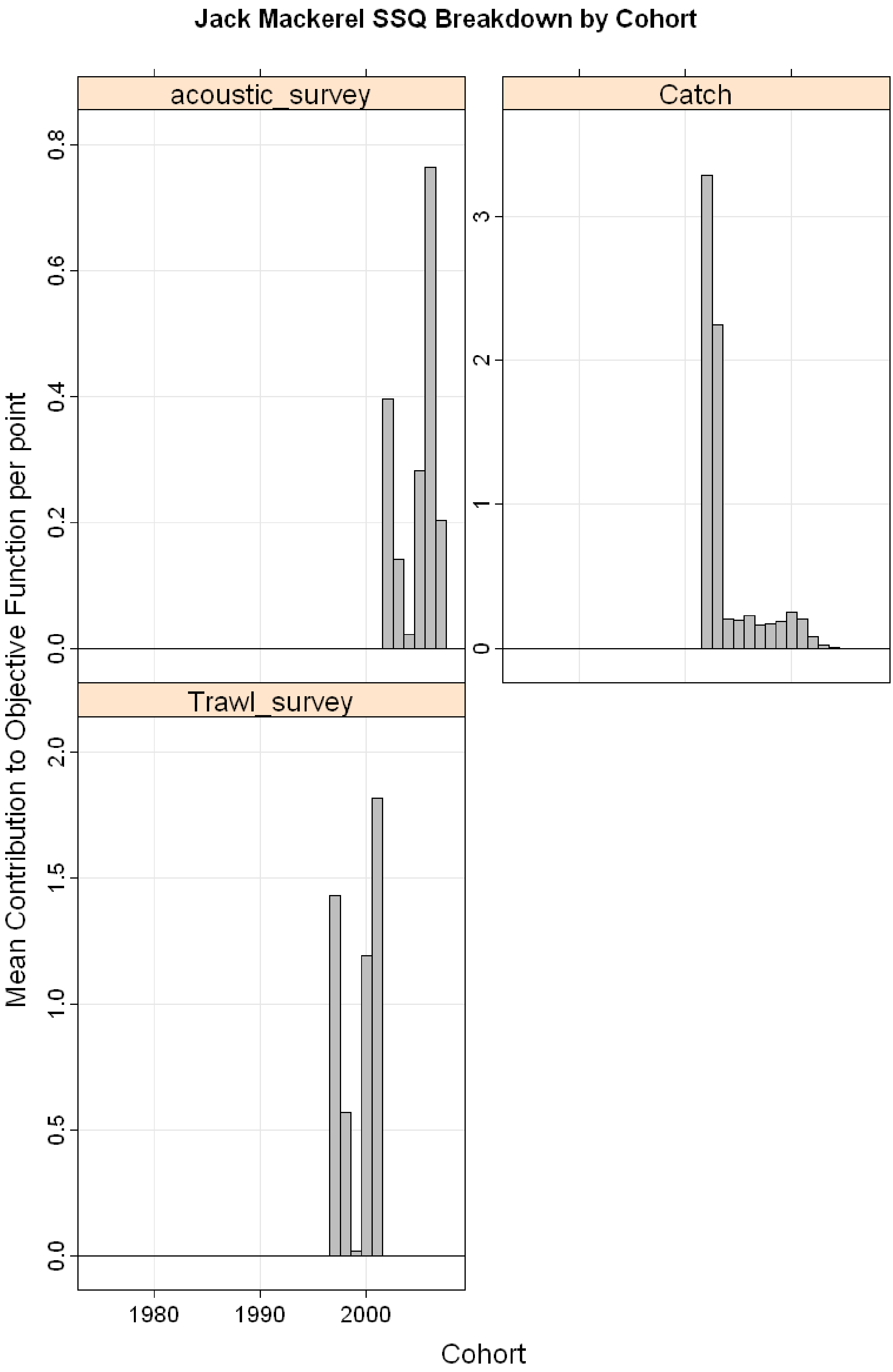
Jack Mackerel Stock Summary Plot

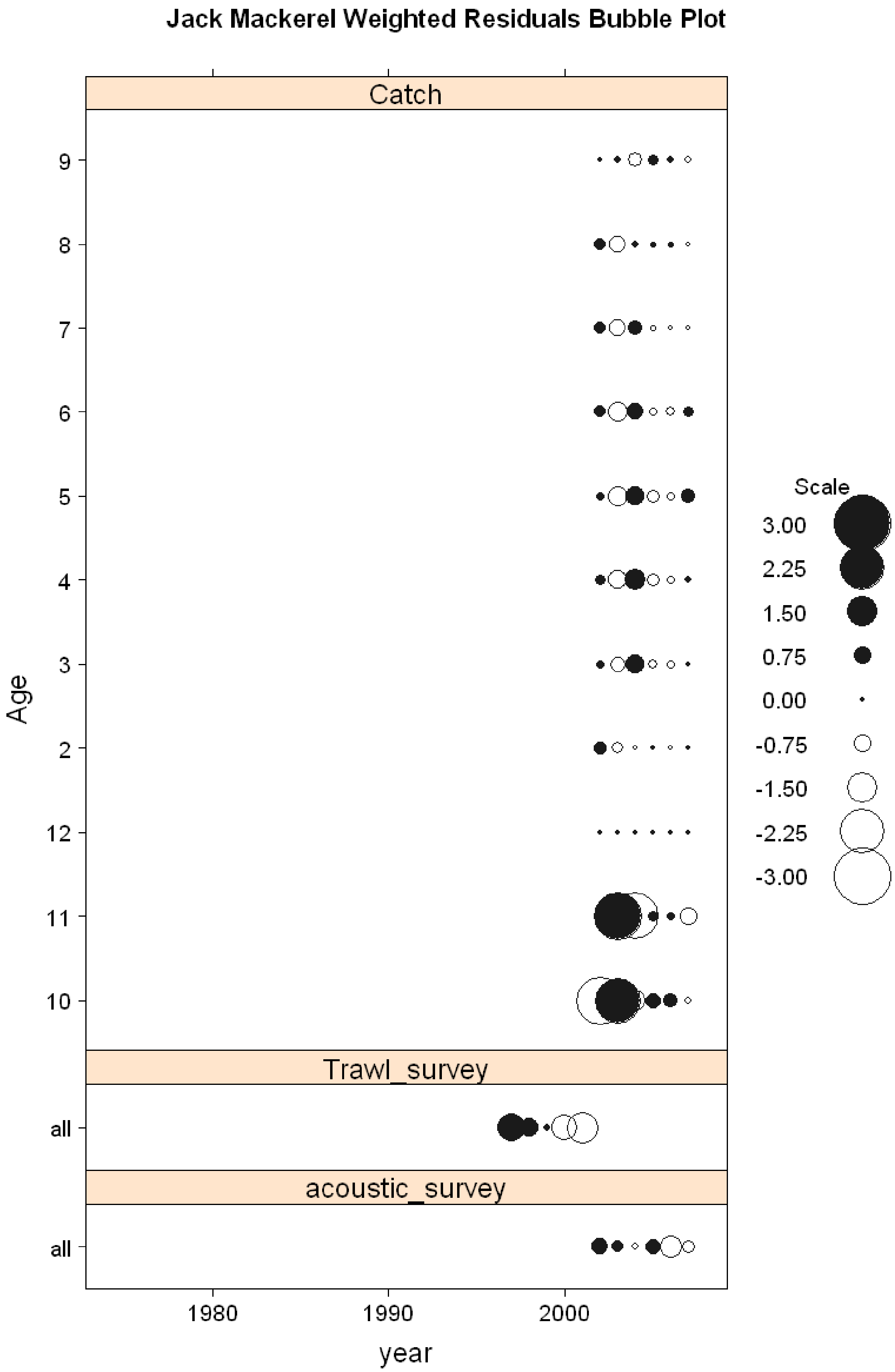


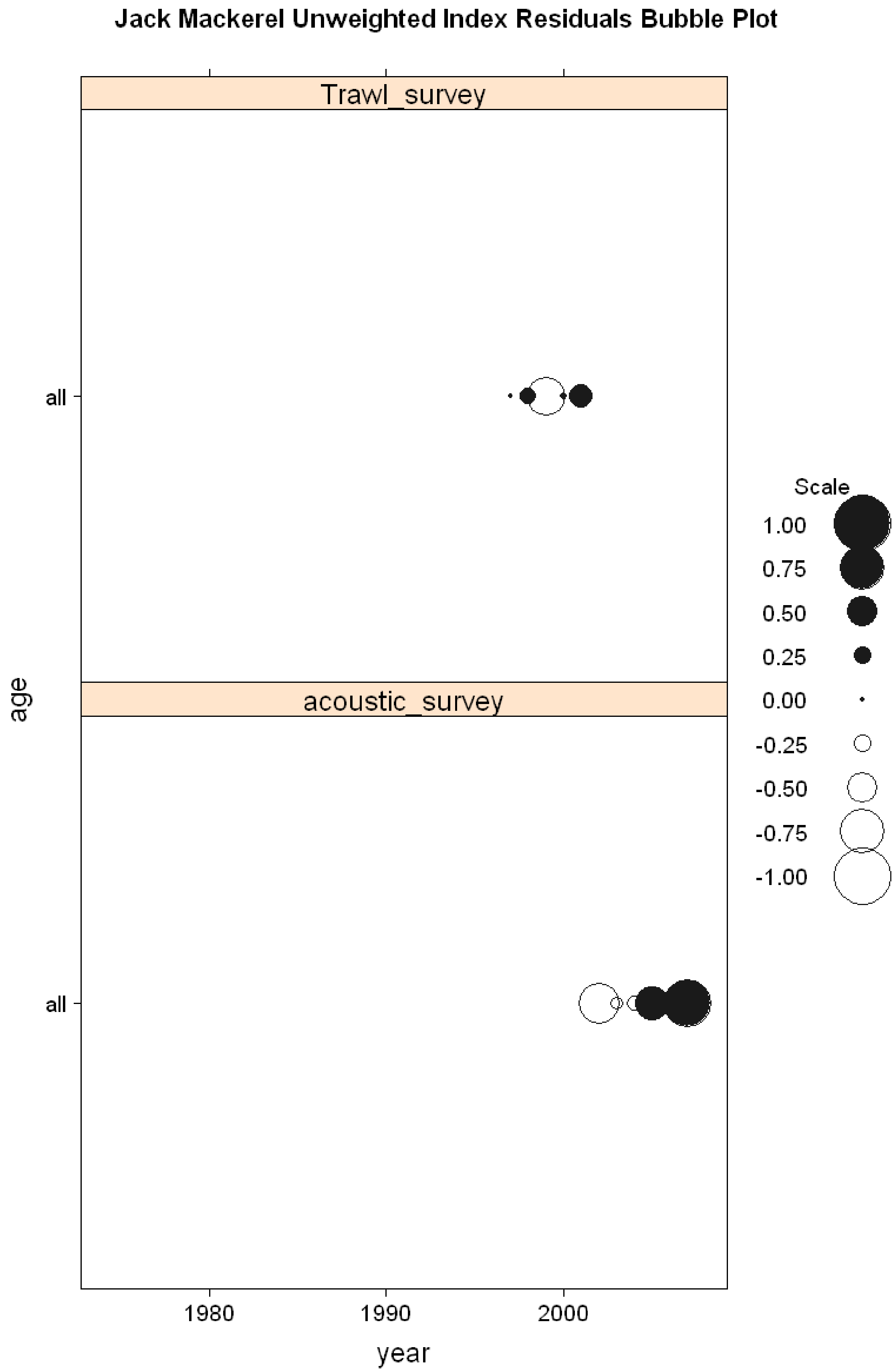

Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
2.0
1.5
1.0
0.5
0.0
2 3 4 5 6 7 8 9 10 11 12 all
Age

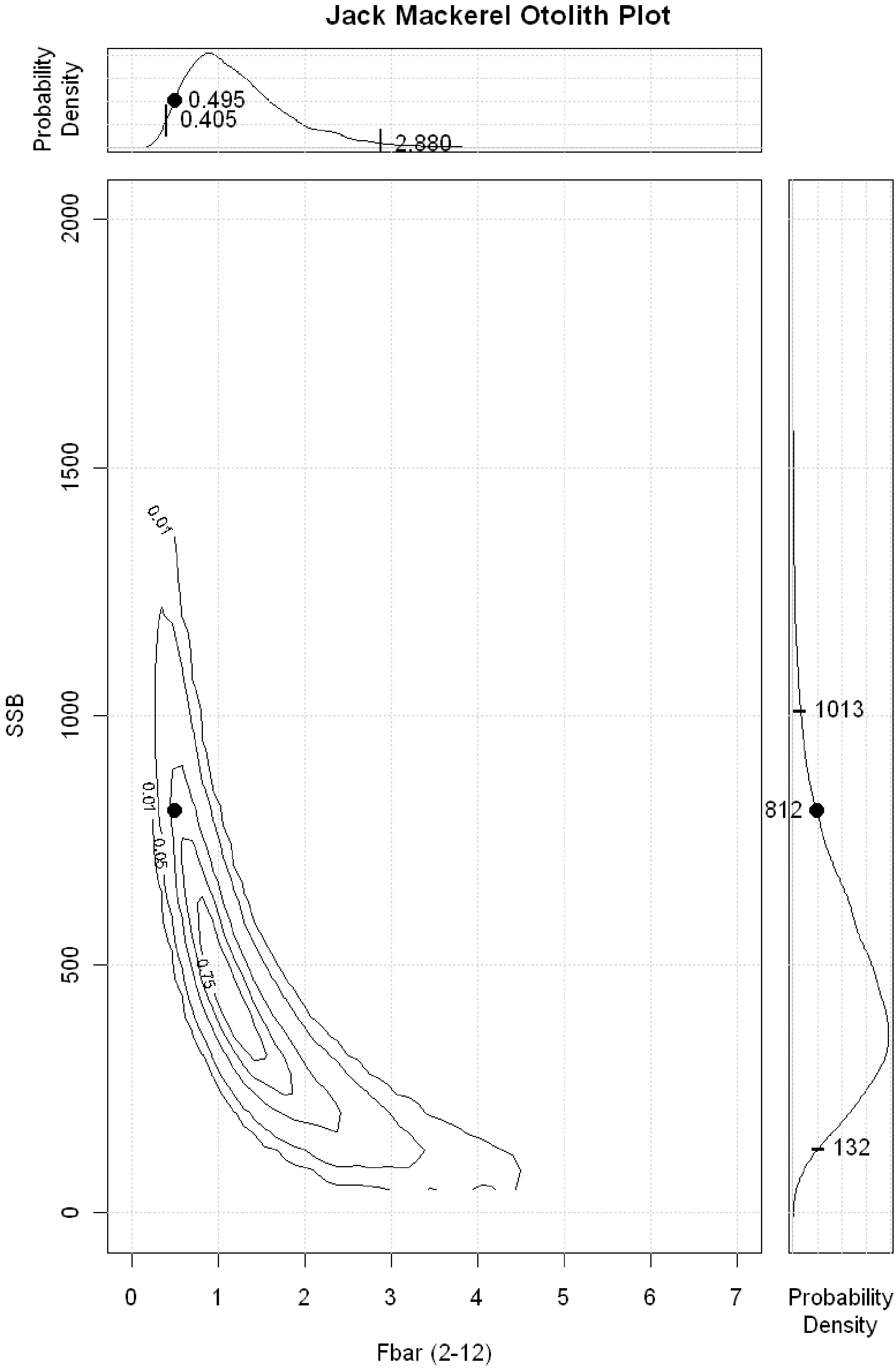


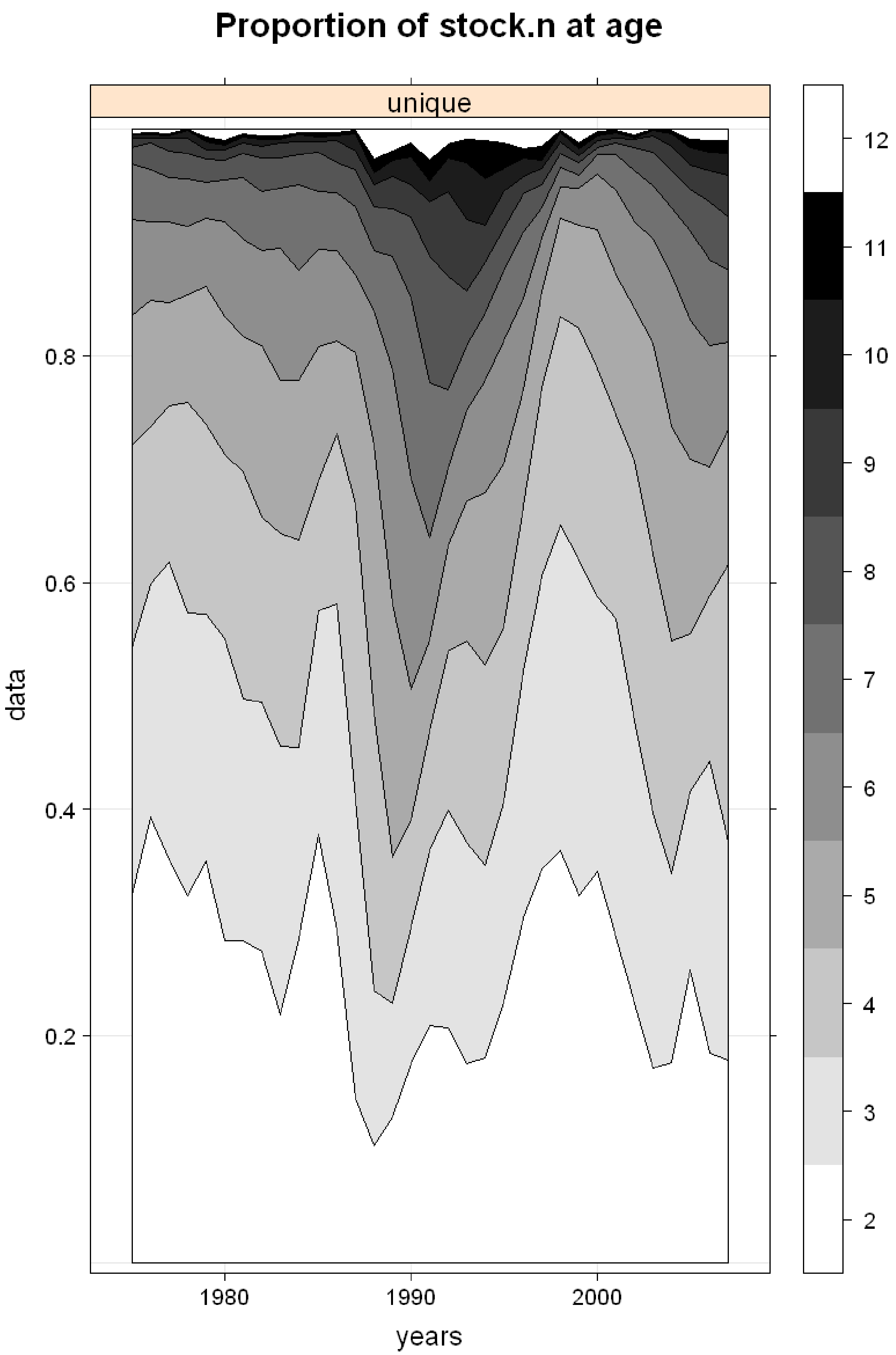
Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Year
1980
1990
2000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.5
1.5
2.0

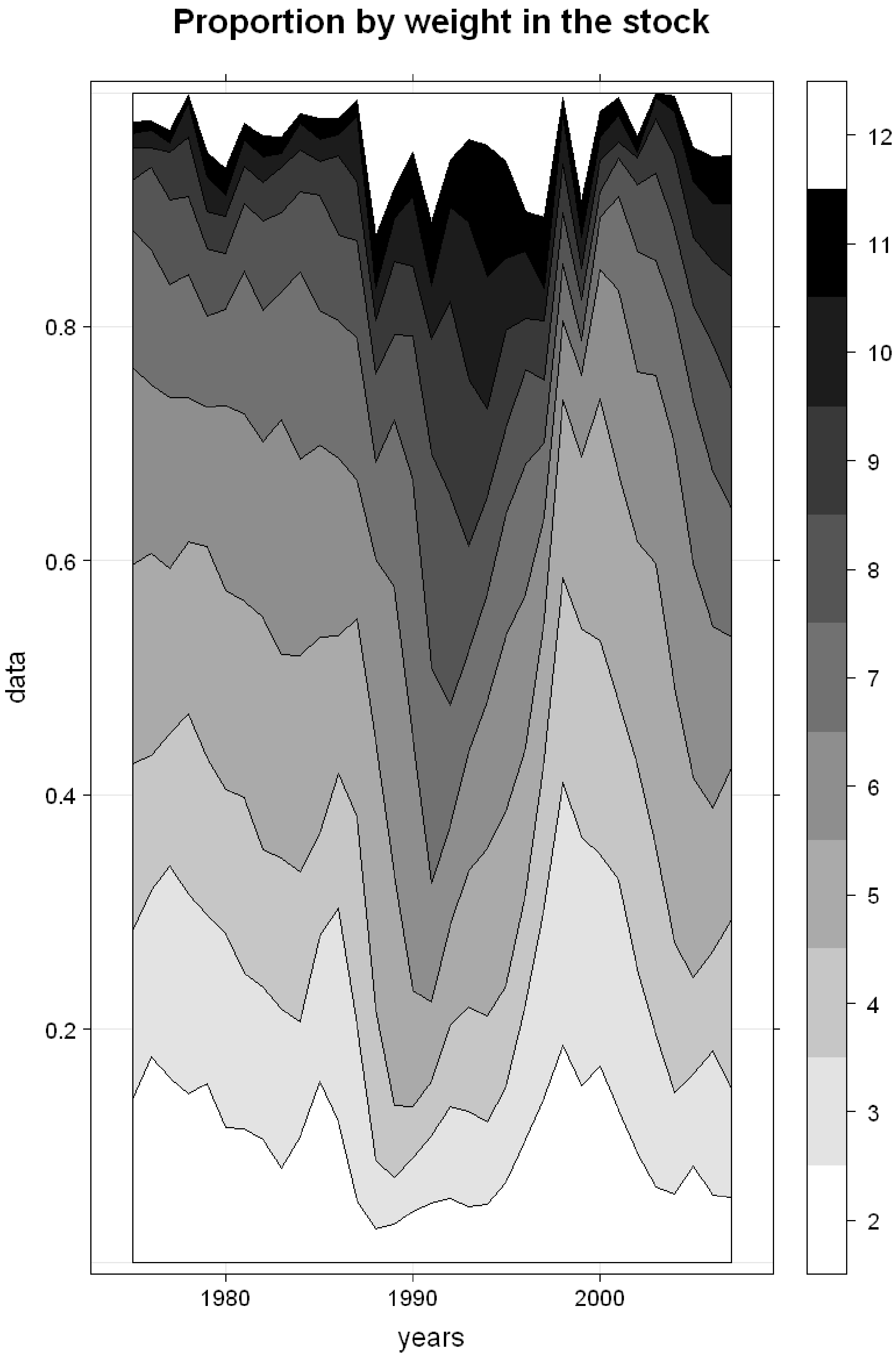

Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Cohort
0.0
0.2
0.4
0.6
0.8
0
1
2
3
0.0
0.5
1.0
1.5
2.0
1980
1990
2000


Jack Mackerel Weighted Residuals Bubble Plot
Catch
Trawl_survey
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00


Jack Mackerel Unweighted Index Residuals Bubble Plot
Trawl_survey
acoustic_survey
all
all
age
1980
1990
2000
year
Scale
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00

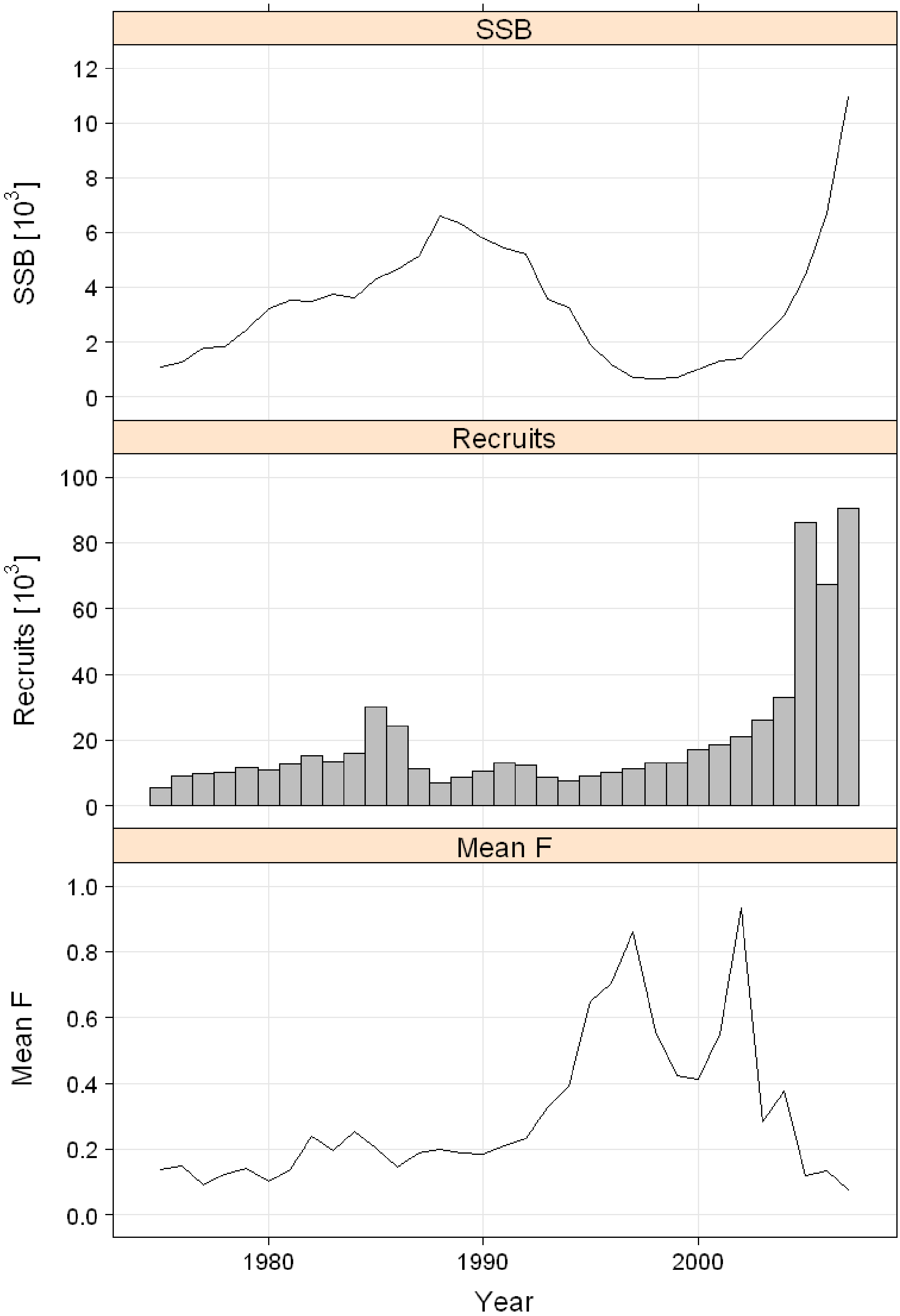

Jack Mackerel Otolith Plot
Probability Density
0.495
0.405
2.880
SSB
2000
1500
1000
500
0
0.01
0.05
0.75
Fbar (2-12)
0
1
2
3
4
5
6
7
1013
812
132
Probability Density

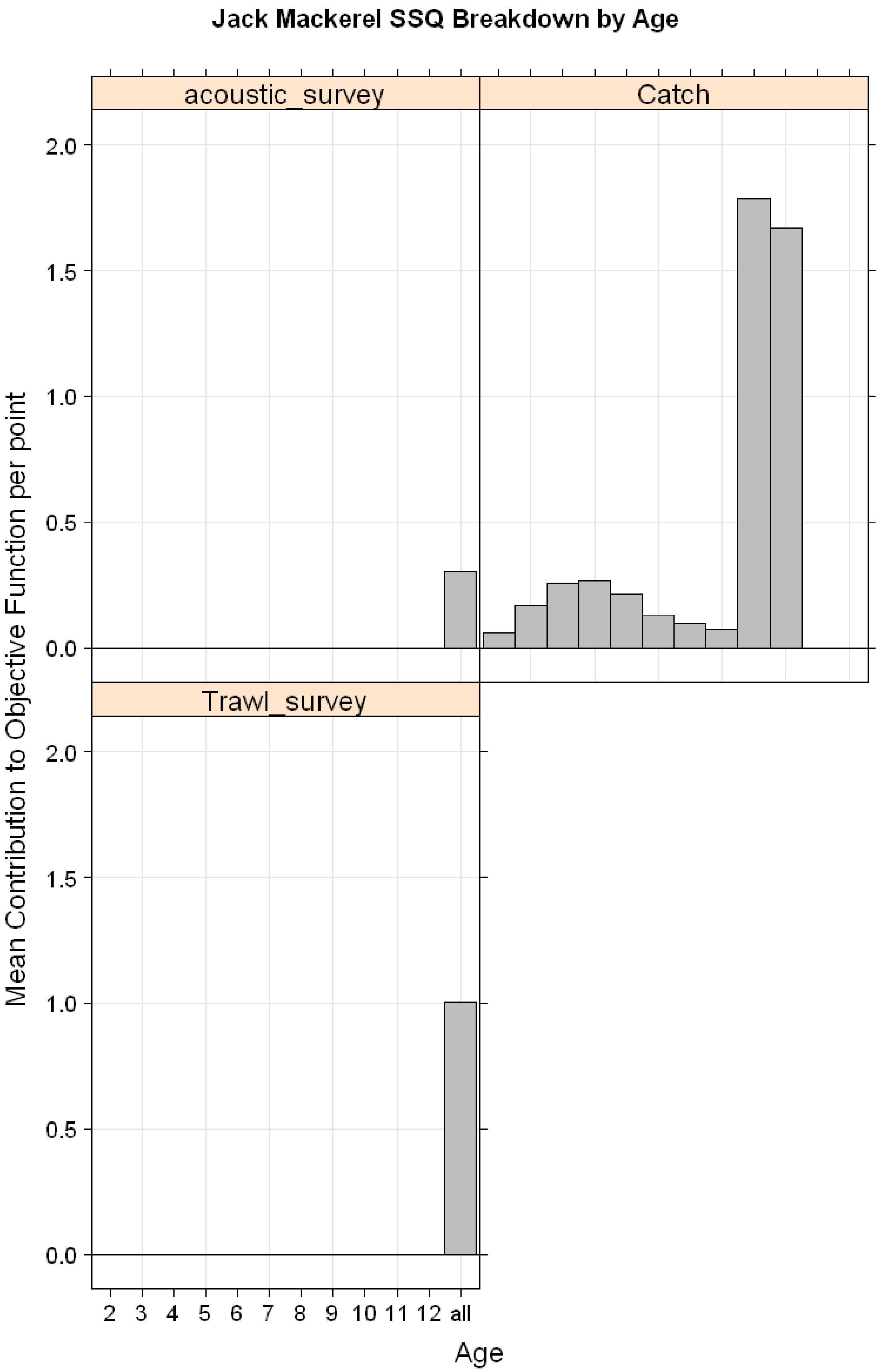

Proportion of stock.n at age
unique
data
years
0.2
0.4
0.6
0.8
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

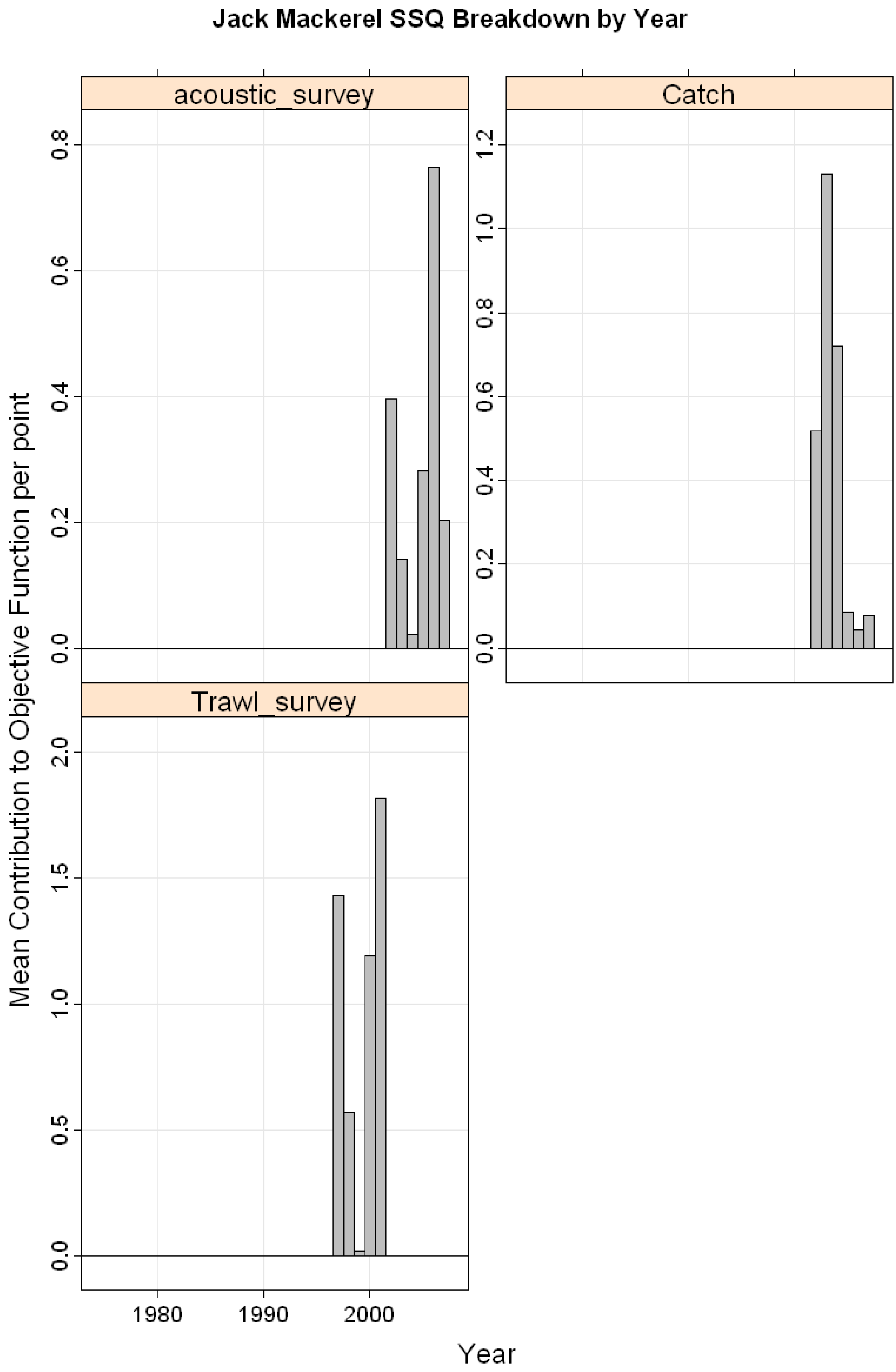

Proportion by weight in the stock
data
years
0.8
0.6
0.4
0.2
1980
1990
2000
12
11
10
9
8
7
6
5
4
3
2

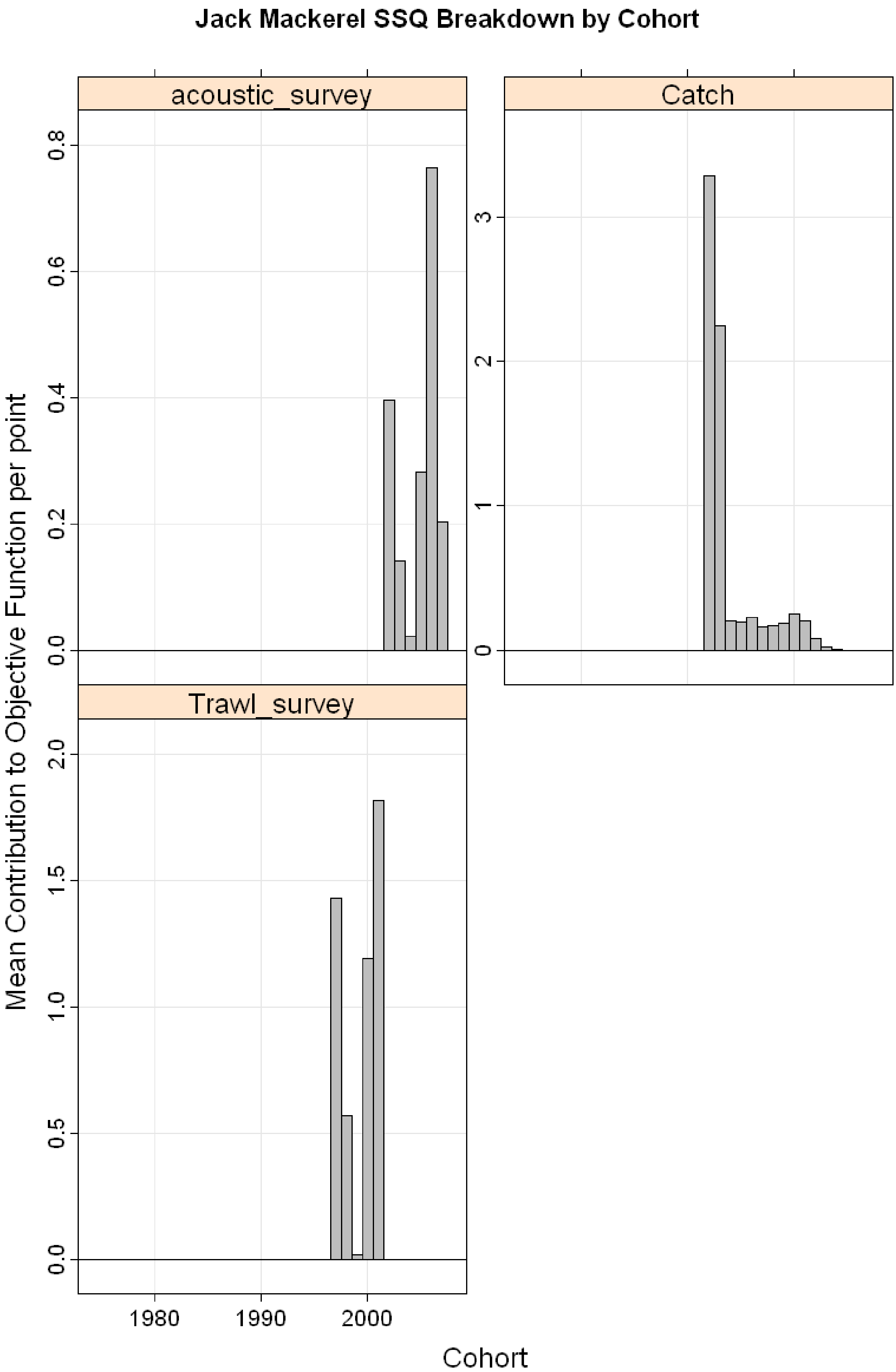
8.5.3 95%

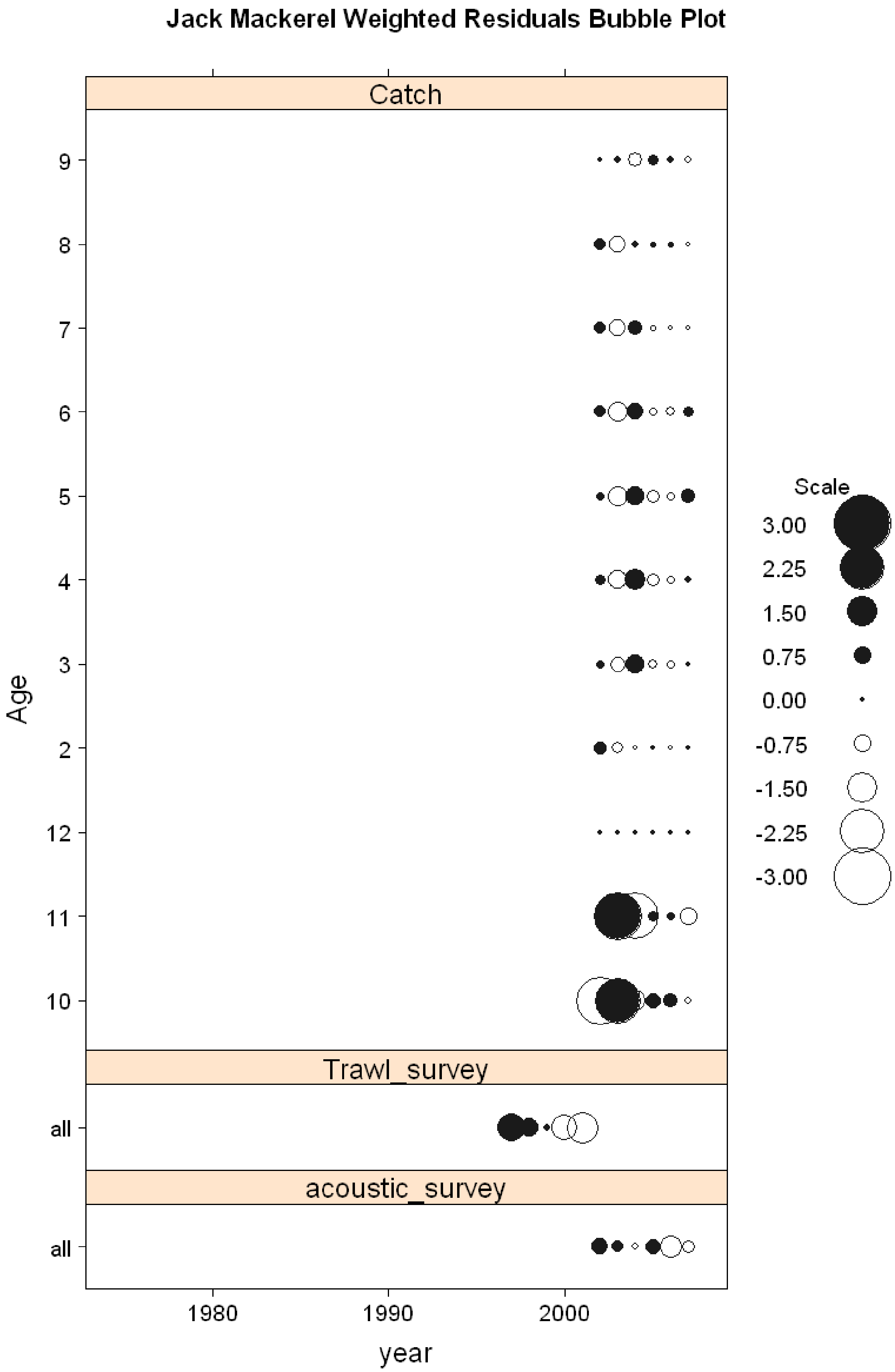
Jack Mackerel Stock Summary Plot




Jack Mackerel SSQ Breakdown by Age
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
0.0
0.5
1.0
1.5
2.0
2 3 4 5 6 7 8 9 10 11 12 all
Age

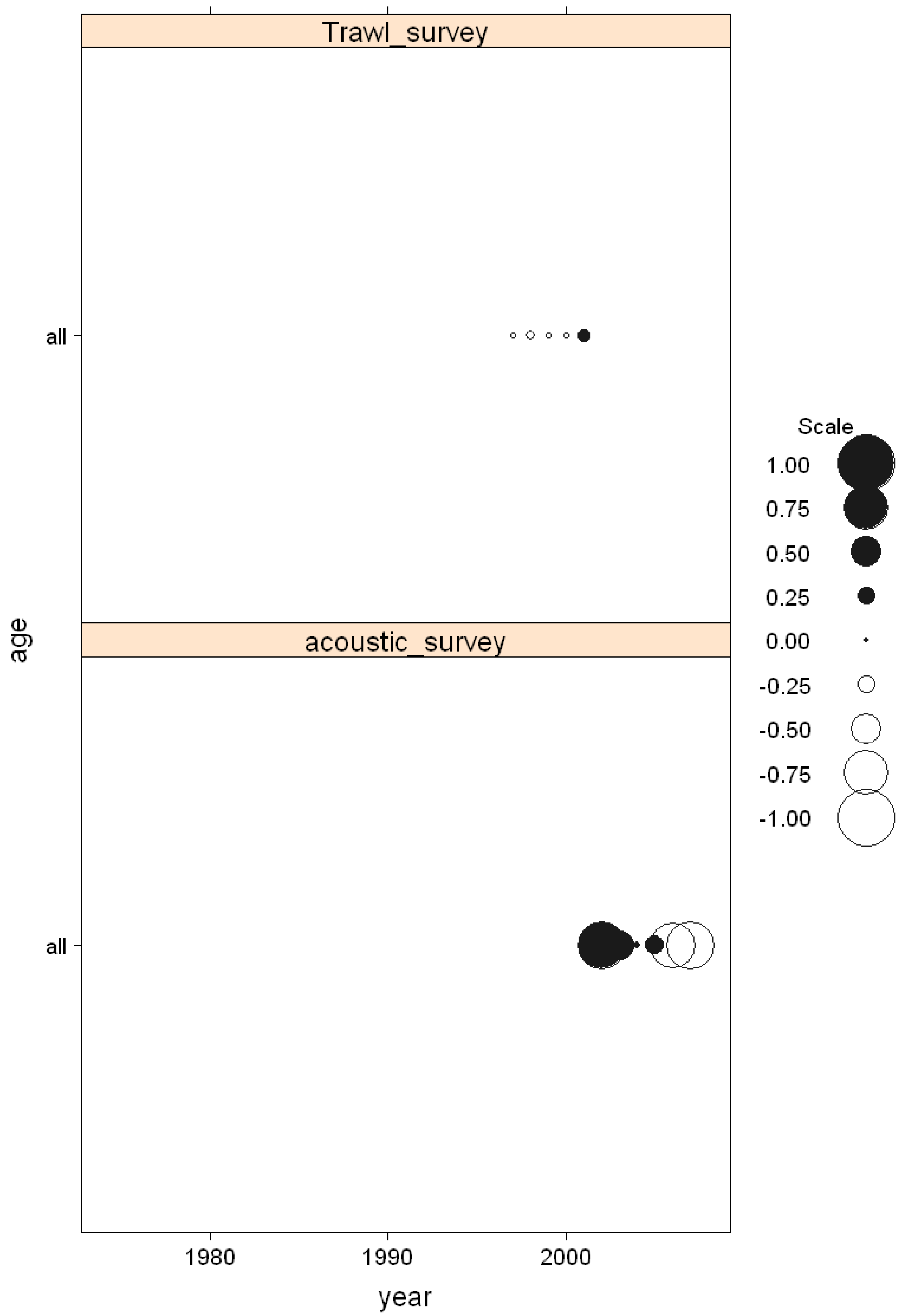

Jack Mackerel SSQ Breakdown by Year
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Year
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.5
1.5
2.0
1980
1990
2000

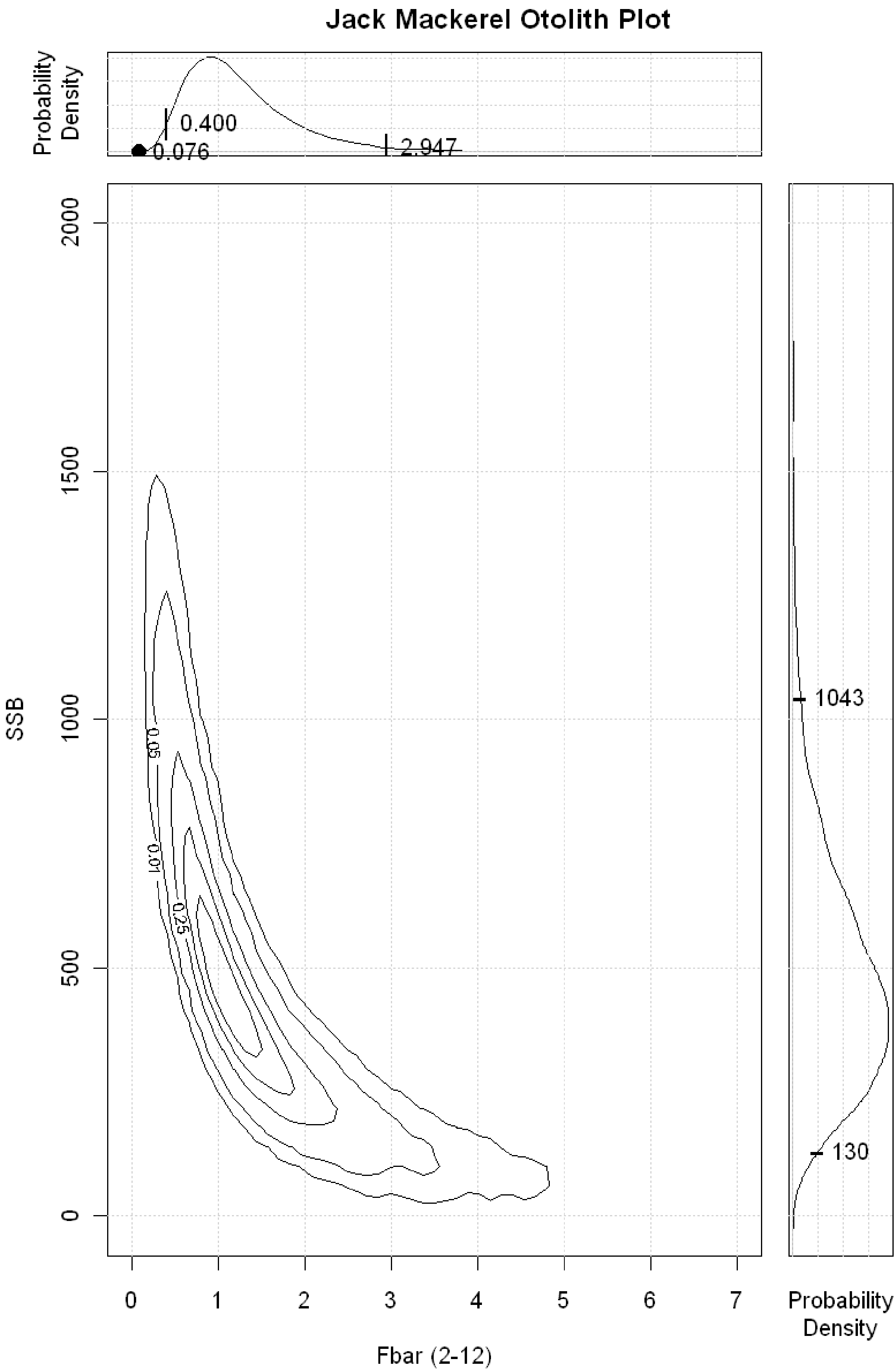

Jack Mackerel SSQ Breakdown by Cohort
acoustic_survey
Catch
Trawl_survey
Mean Contribution to Objective Function per point
Cohort
0.0
0.2
0.4
0.6
0.8
0
1
2
3
0.0
0.5
1.0
1.5
2.0
1980
1990
2000

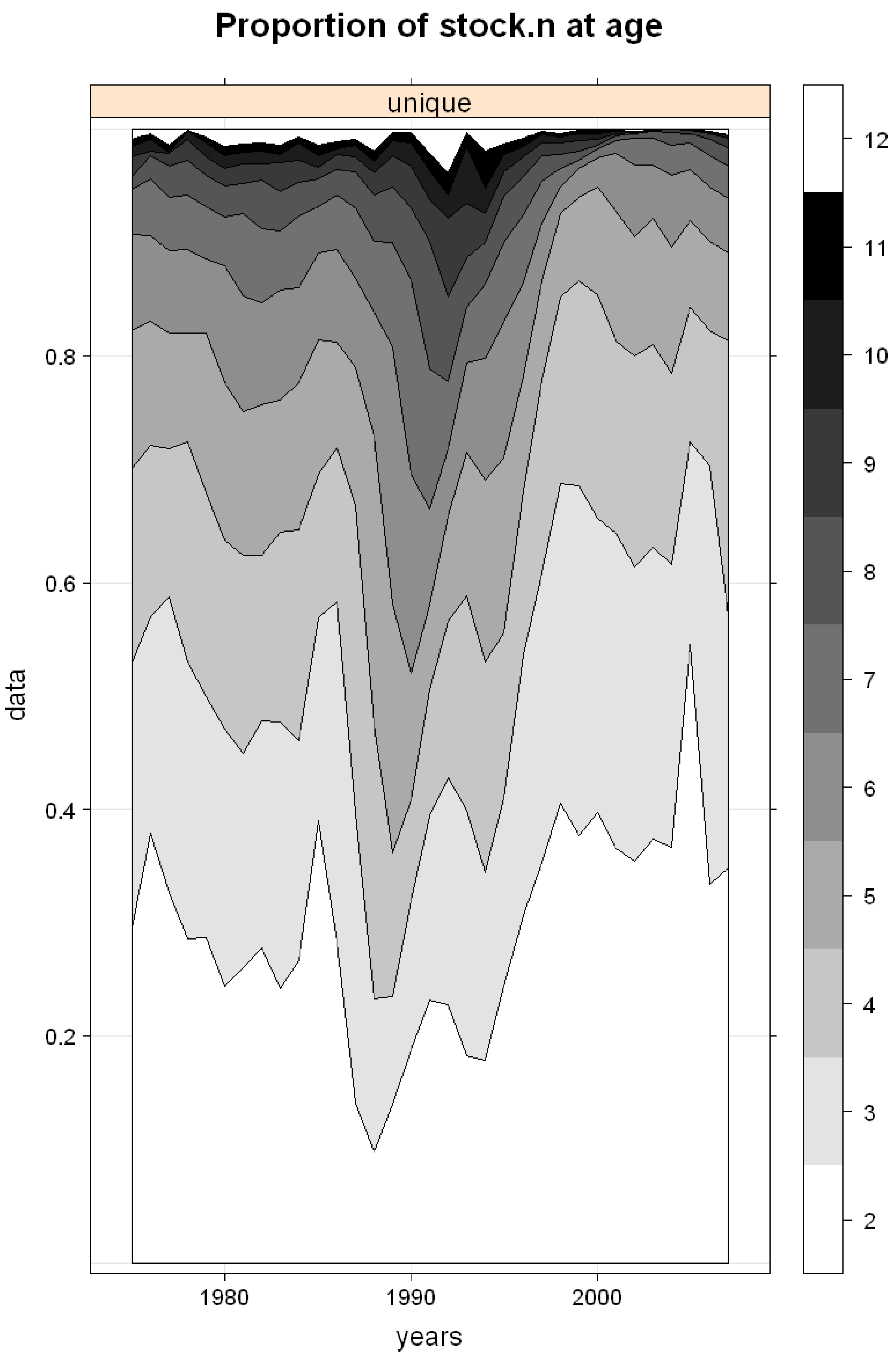


Jack Mackerel Weighted Residuals Bubble Plot
Catch
Trawl_survey
acoustic_survey
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00

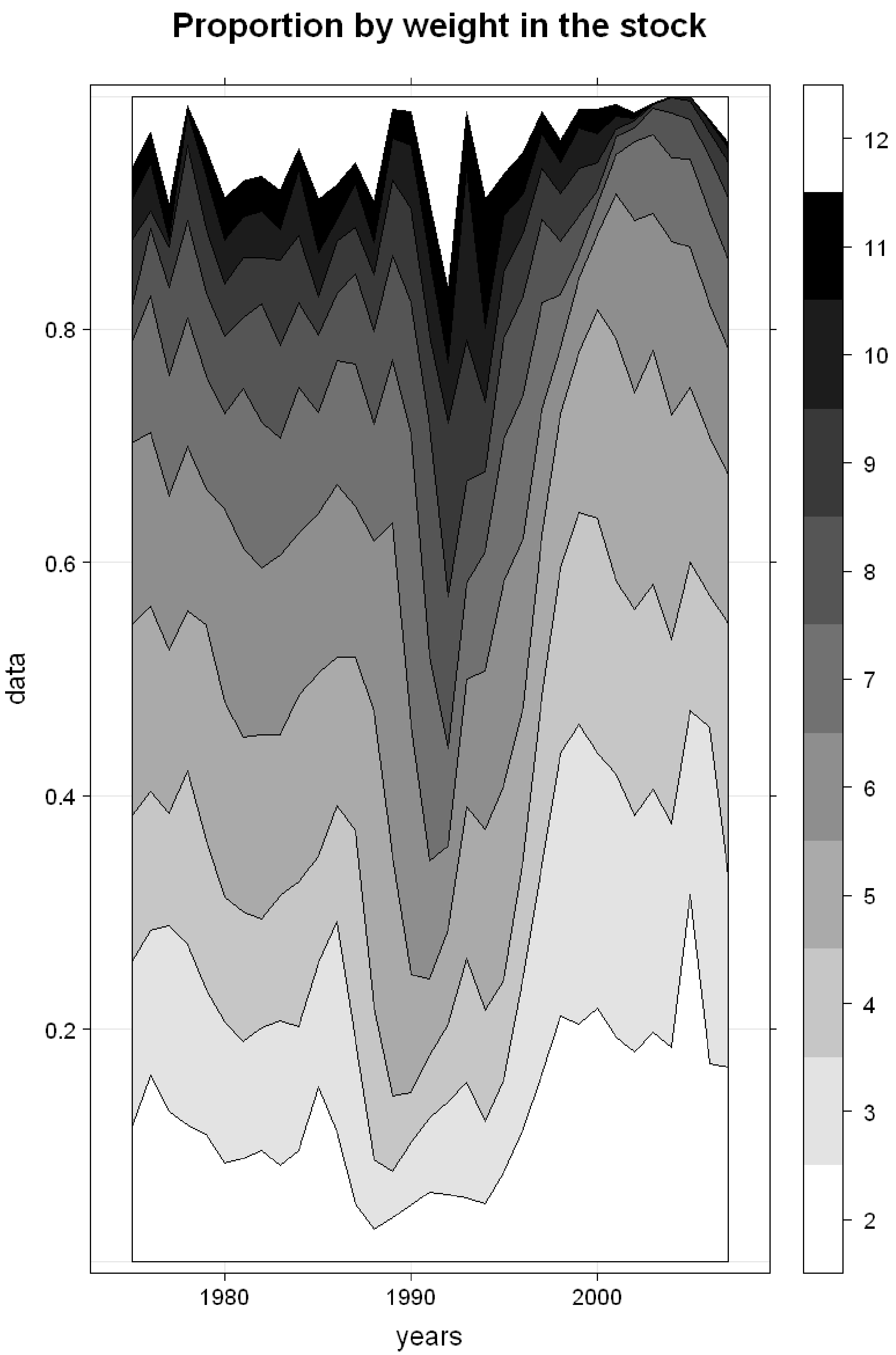
Jack Mackerel Unweighted Index Residuals Bubble Plot




Jack Mackerel Otolith Plot
Probability Density
0.400
0.076
2.947
SSB
2000
1500
1000
500
0
0.05
0.01
0.25
1043
130
0
1
2
3
4
5
6
7
Fbar (2-12)
Probability Density



Proportion of stock.n at age
unique
data
0.2
0.4
0.6
0.8
years
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

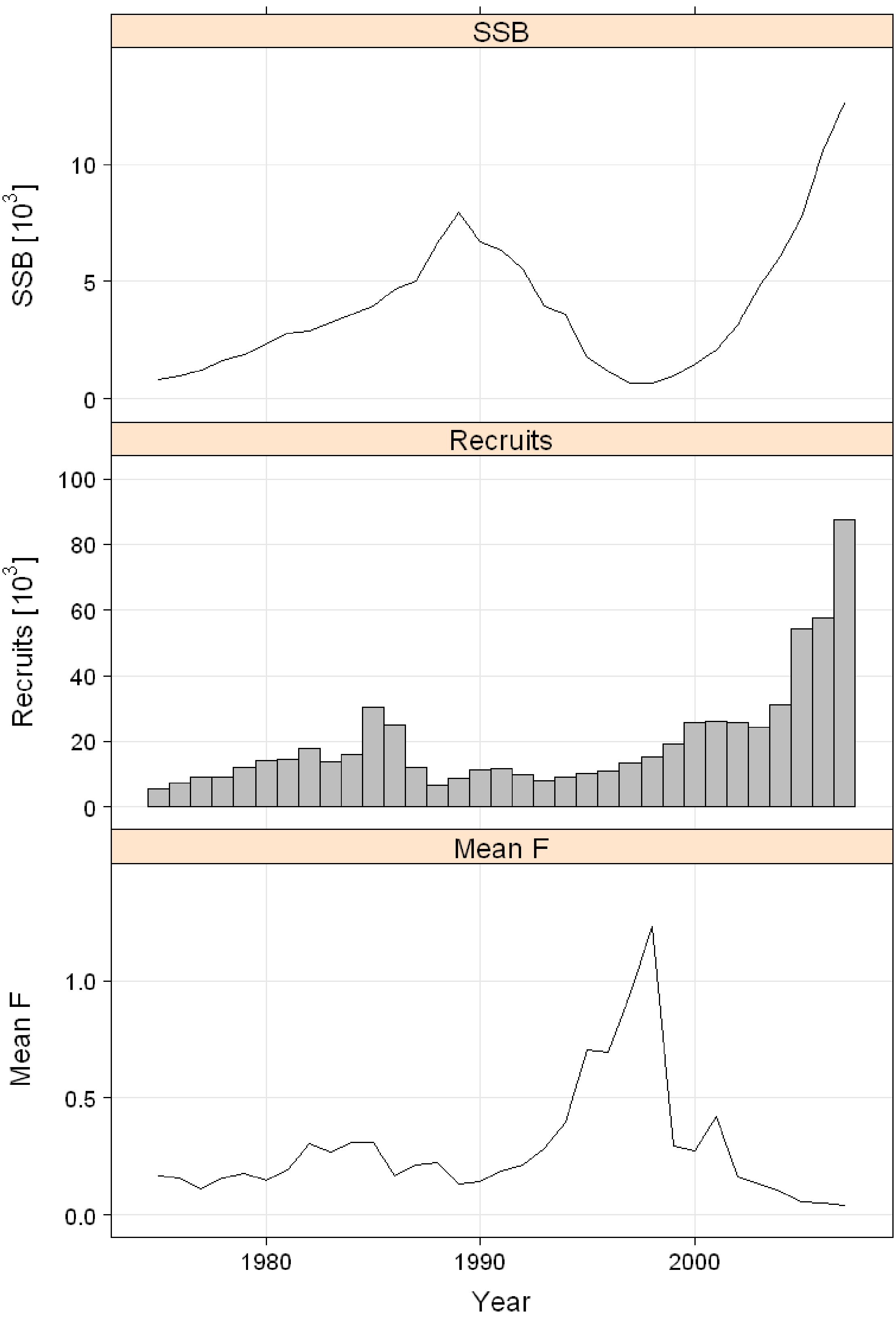


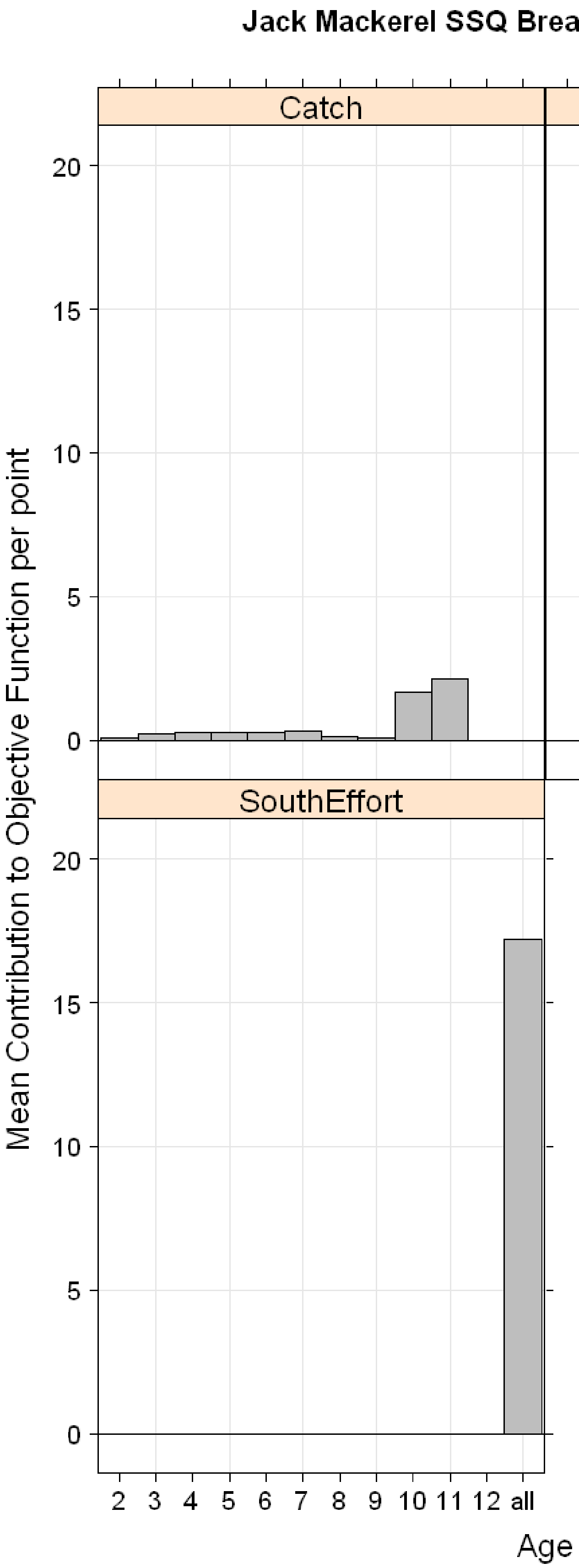
Proportion by weight in the stock
data
0.8
0.6
0.4
0.2
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

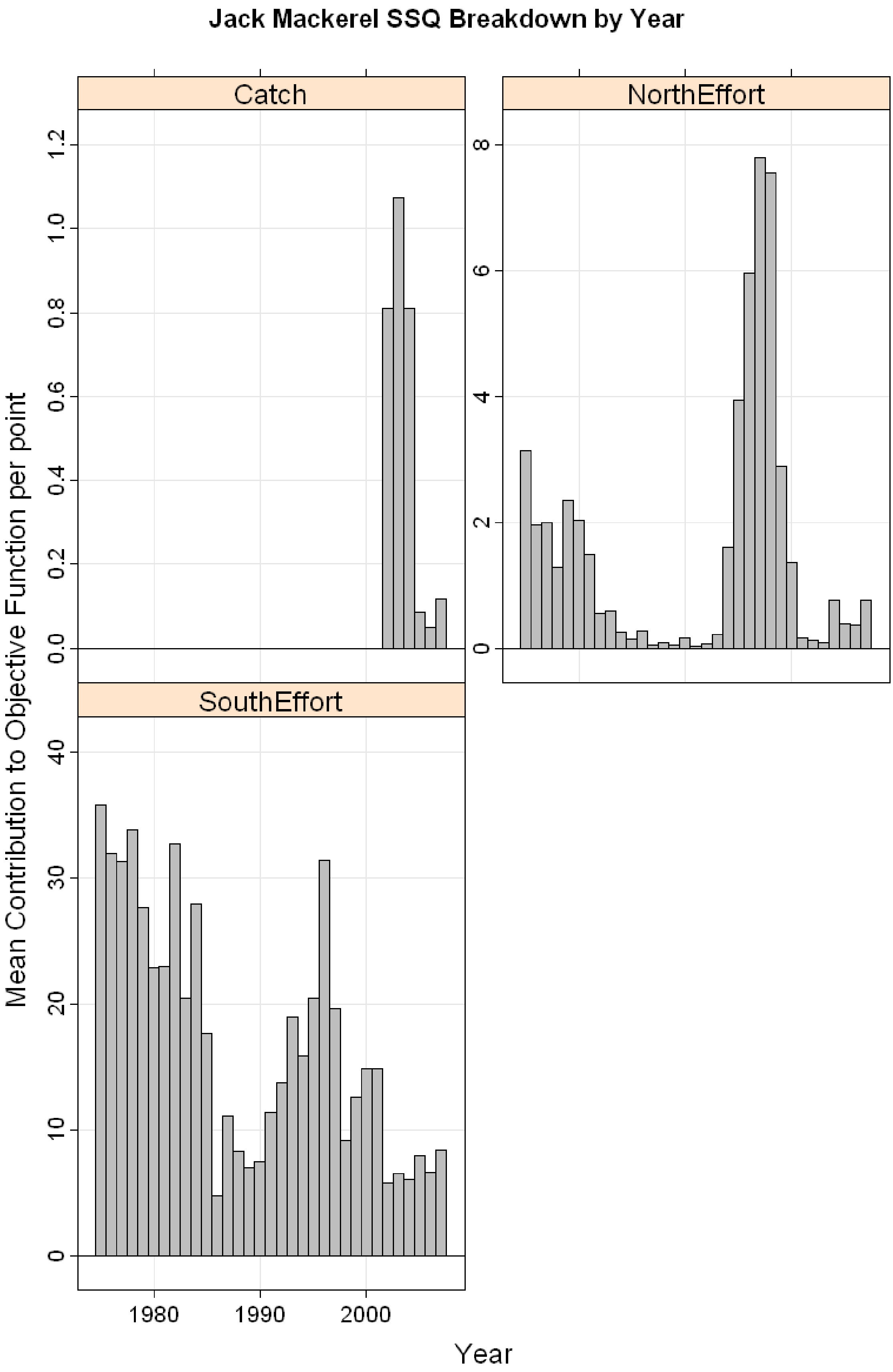
8.6 Scenario 6

8.6.1 5%

Jack Mackerel Stock Summary Plot

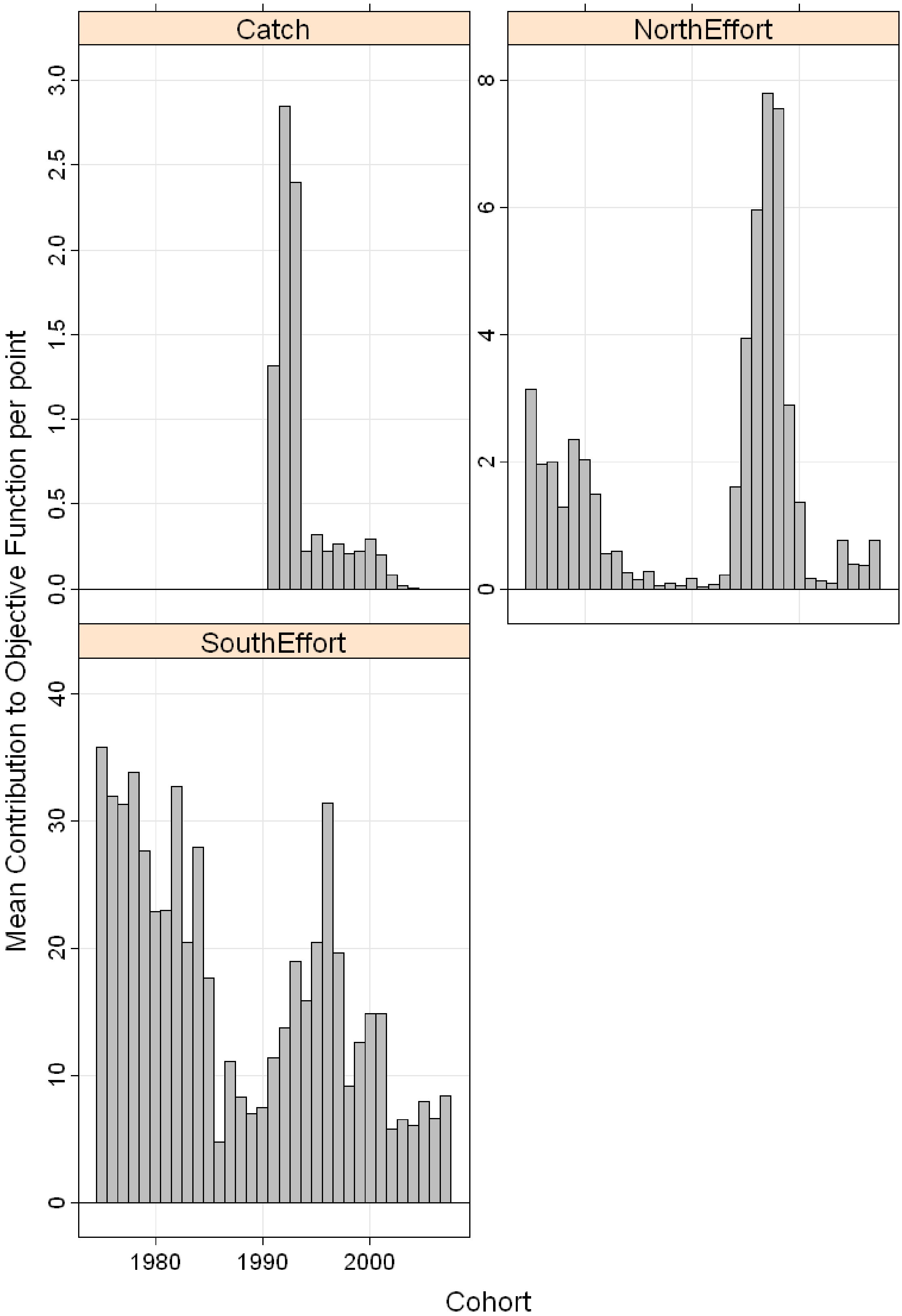


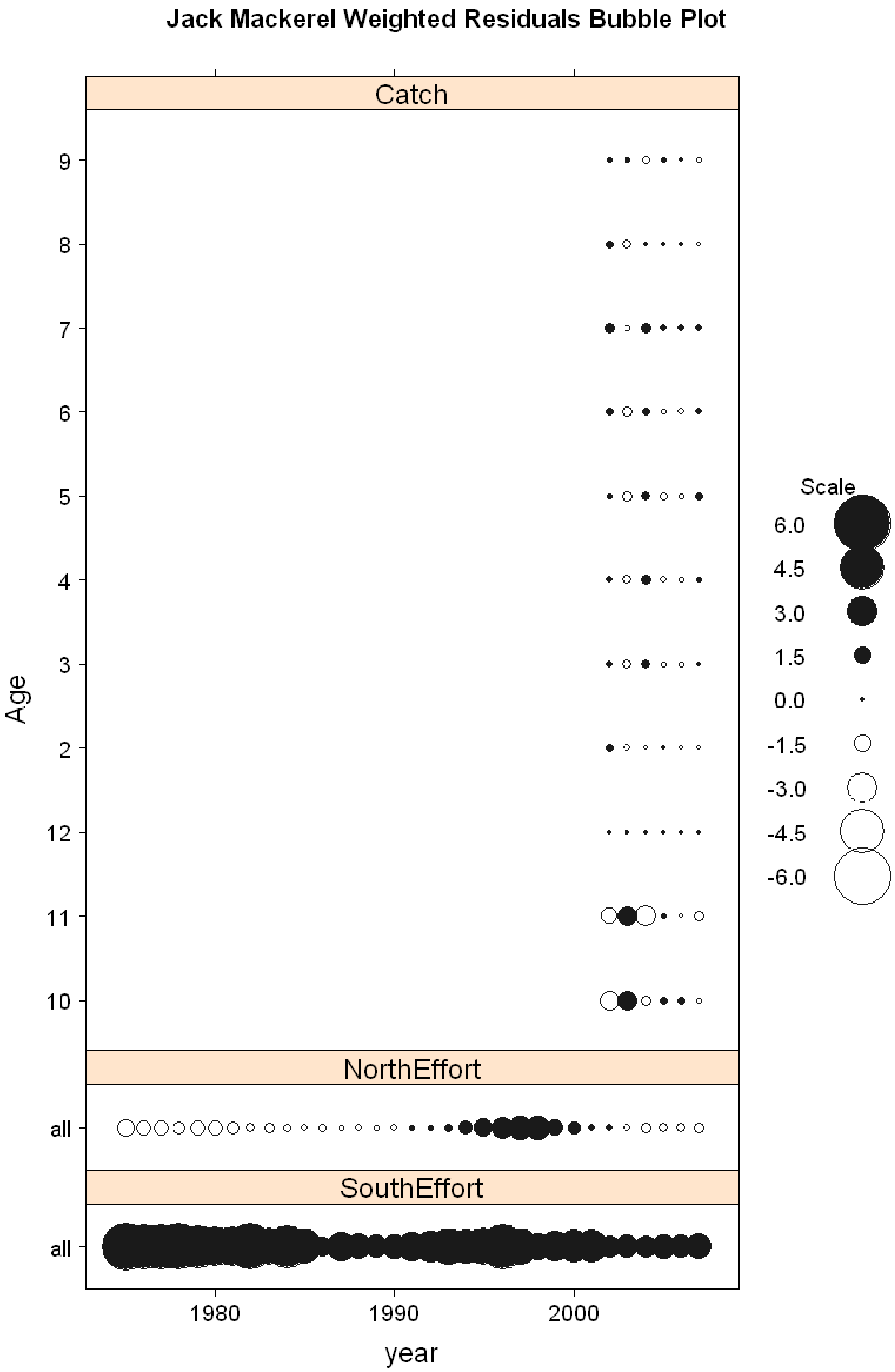

Jack Mackerel SSQ Breakdown by Age
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
Age
0
5
10
15
20
2 3 4 5 6 7 8 9 10 11 12 all



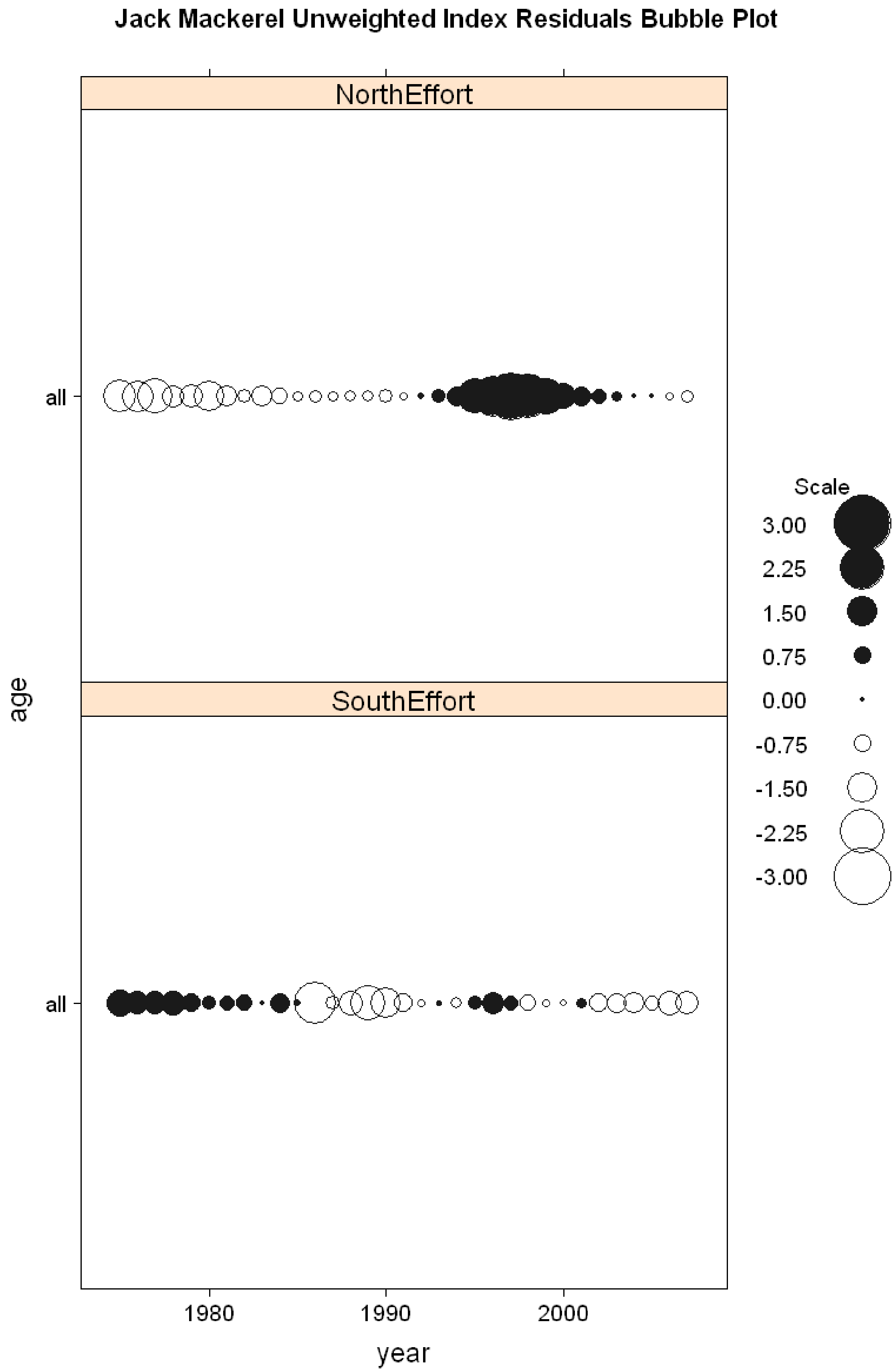
Jack Mackerel SSQ Breakdown by Year
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
Year
1980
1990
2000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
2
4
6
8
0
10
20
30
40

Jack Mackerel SSQ Breakdown by Cohort

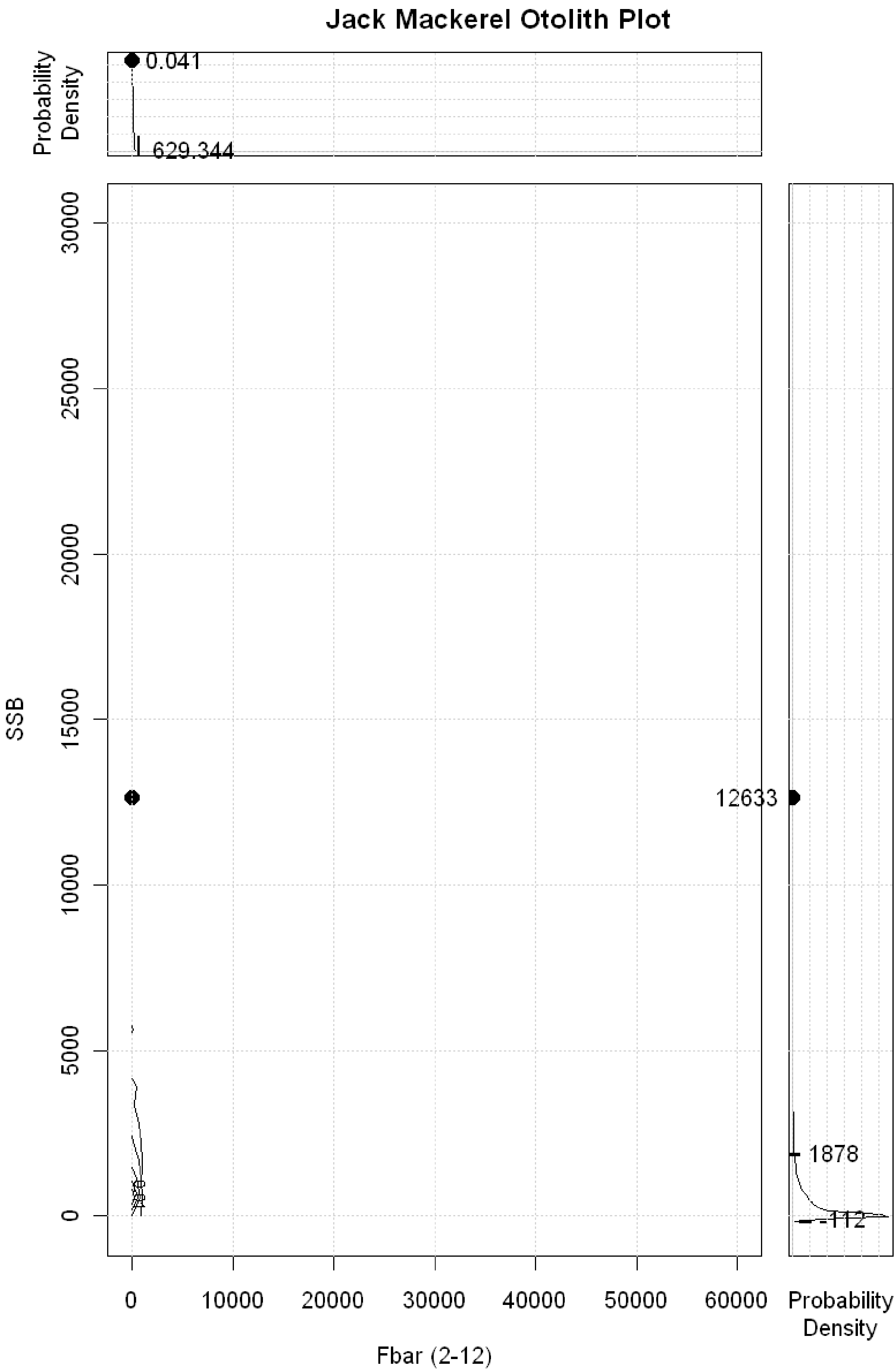


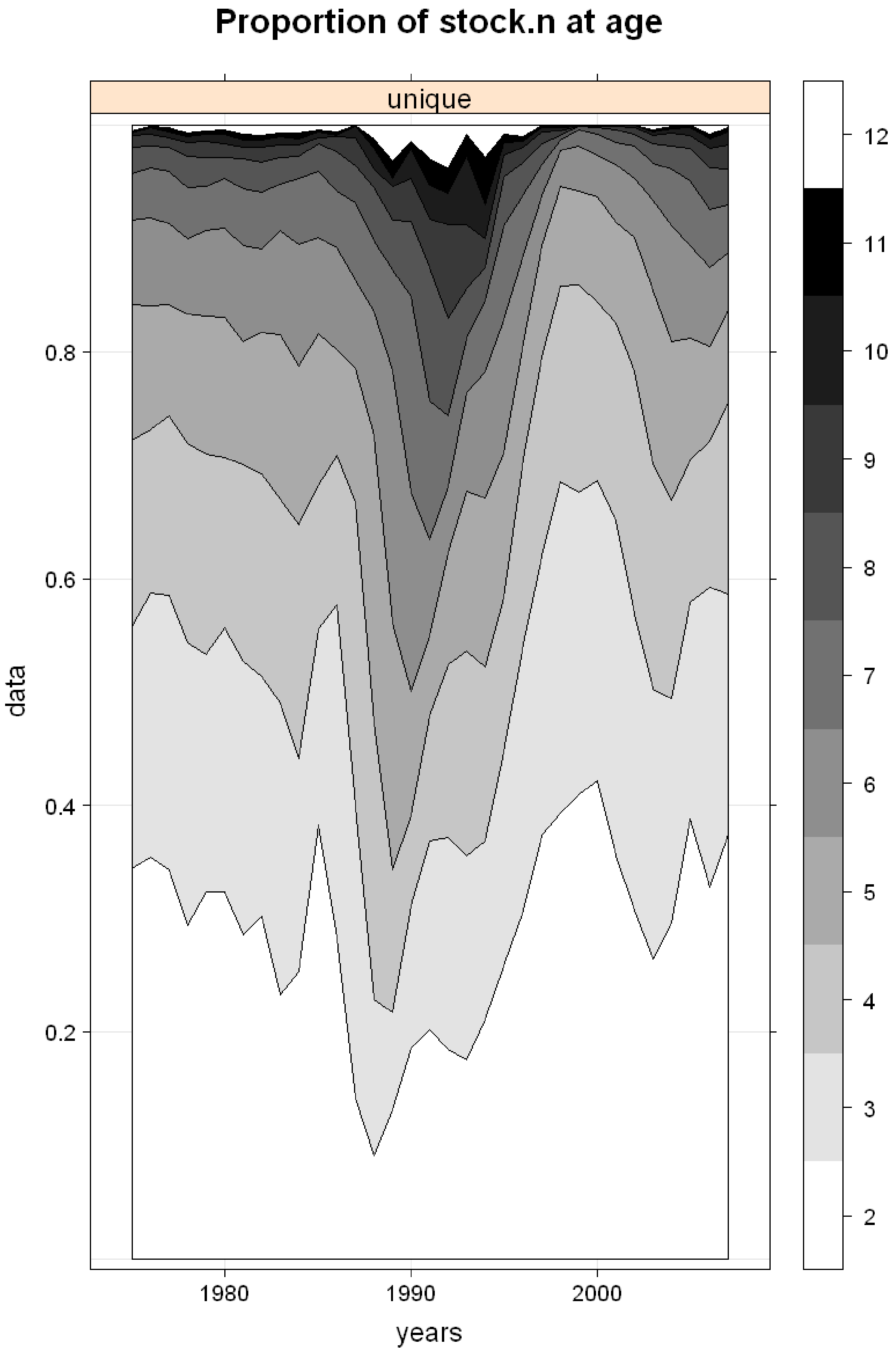


Jack Mackerel Weighted Residuals Bubble Plot
Catch
9
8
7
6
5
4
3
2
12
11
10
Age
NorthEffort
all
SouthEffort
all
1980
1990
2000
year
Scale
6.0
4.5
3.0
1.5
0.0
-1.5
-3.0
-4.5
-6.0

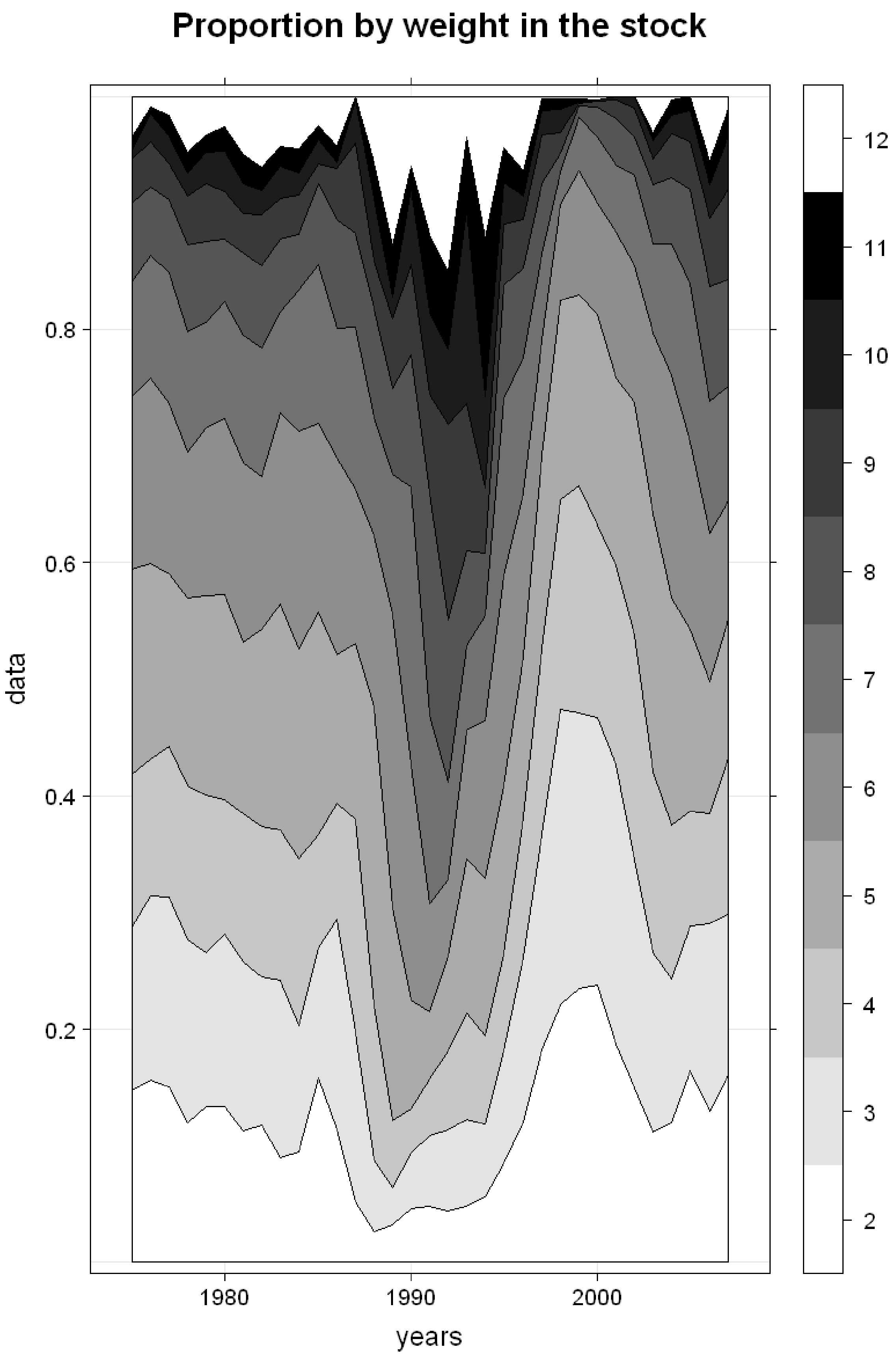


Jack Mackerel Unweighted Index Residuals Bubble Plot
NorthEffort
SouthEffort
all
all
age
1980
1990
2000
year
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00


Jack Mackerel Otolith Plot
Probability Density
0.041
629.344
SSB
30000
25000
20000
15000
10000
5000
0
12633
1878
-112
0
10000
20000
30000
40000
50000
60000
Probability Density
Fbar (2-12)

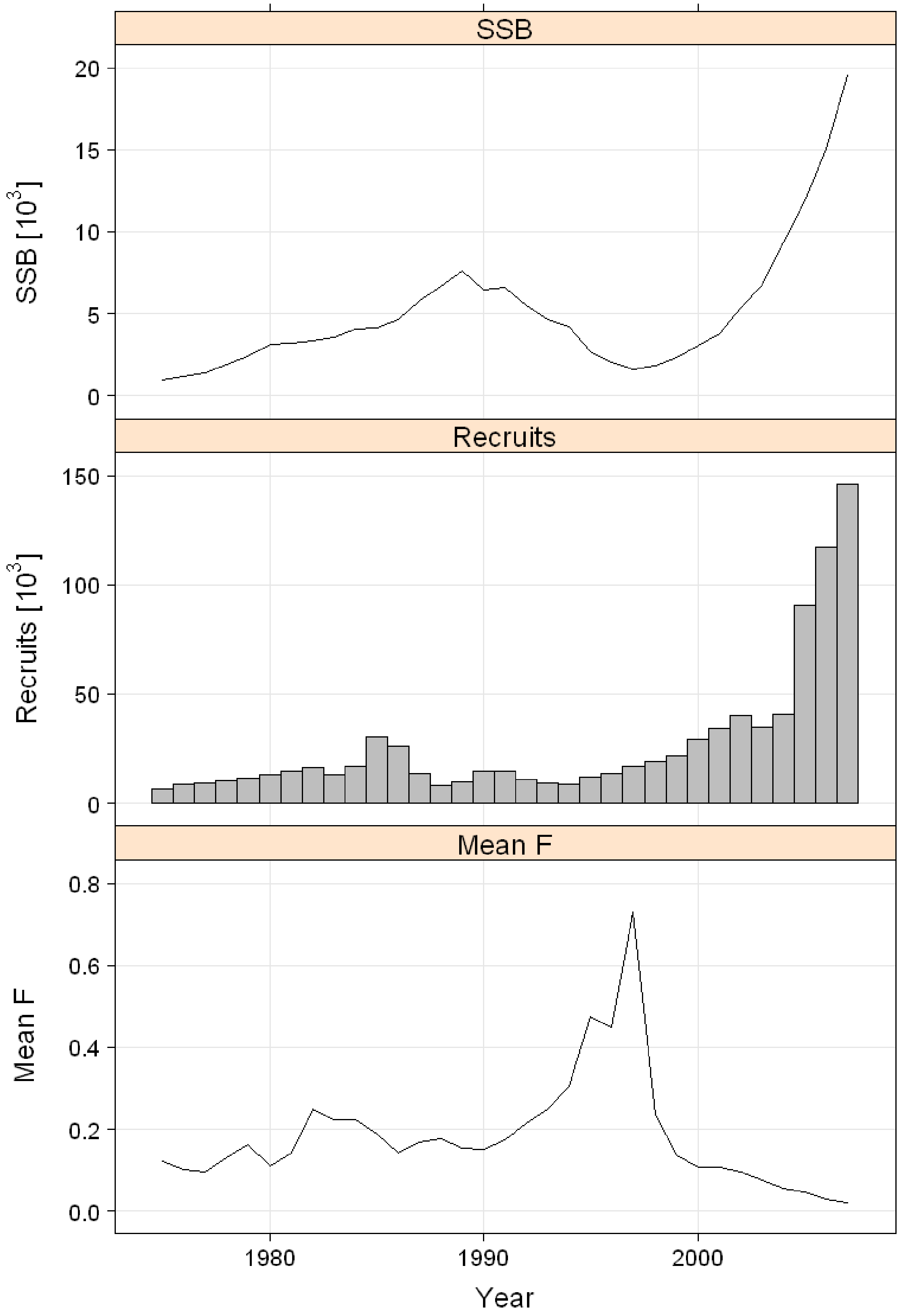


Proportion of stock.n at age
unique
data
years
0.2
0.4
0.6
0.8
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

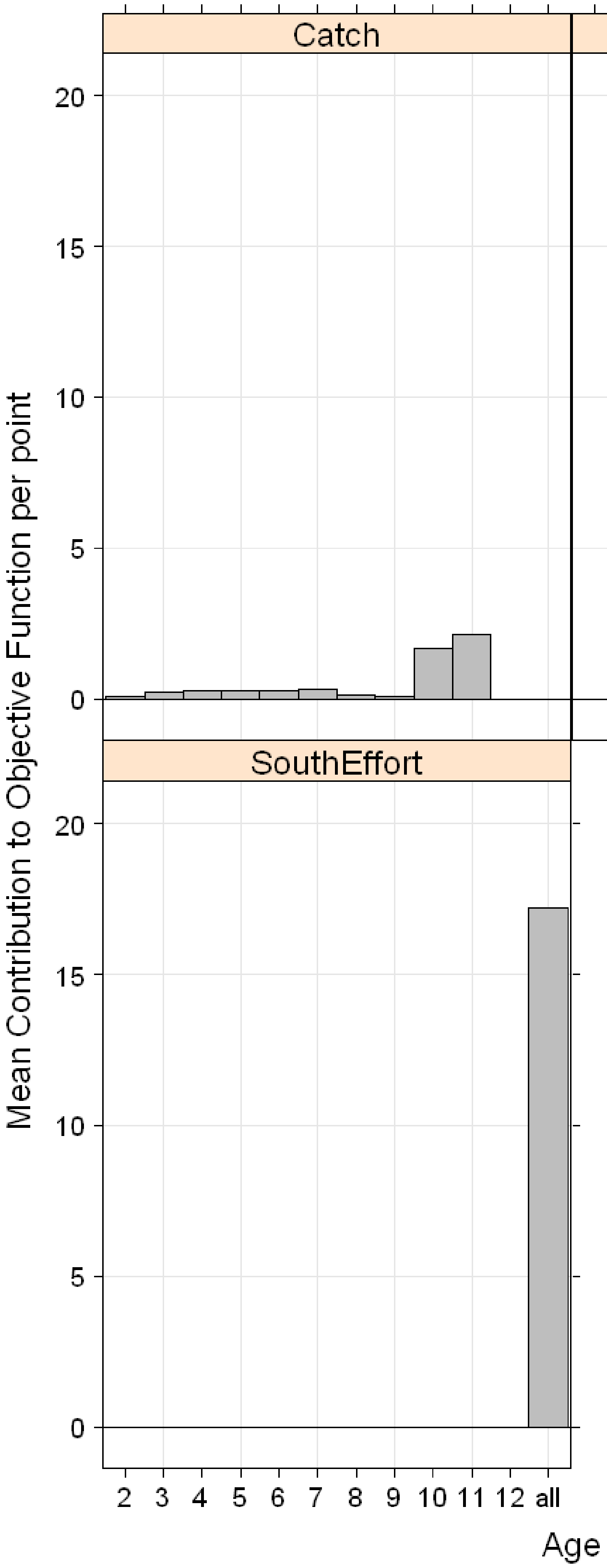

Proportion by weight in the stock
data
0.8
0.6
0.4
0.2
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

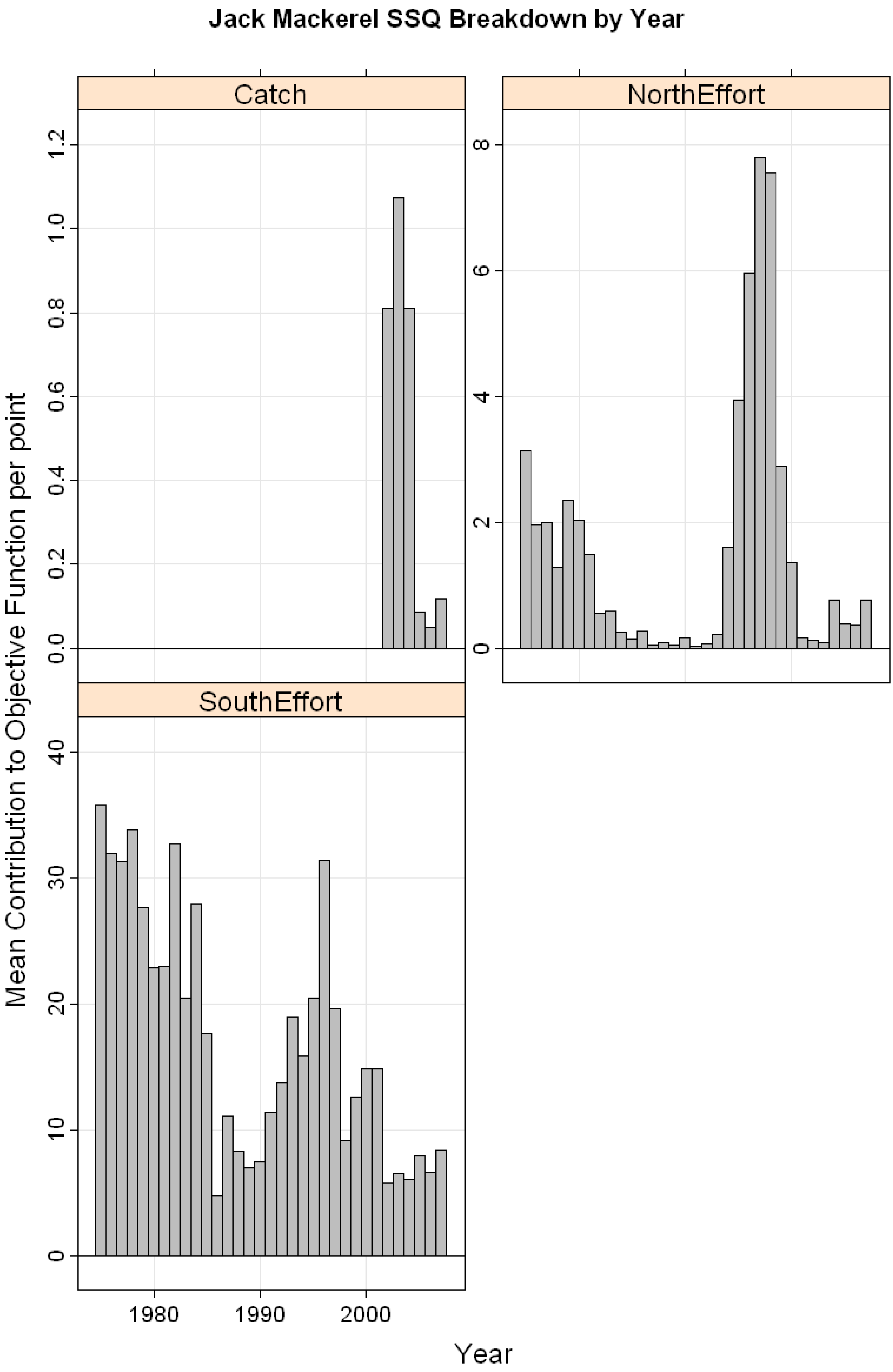
8.6.2 50%

Jack Mackerel Stock Summary Plot



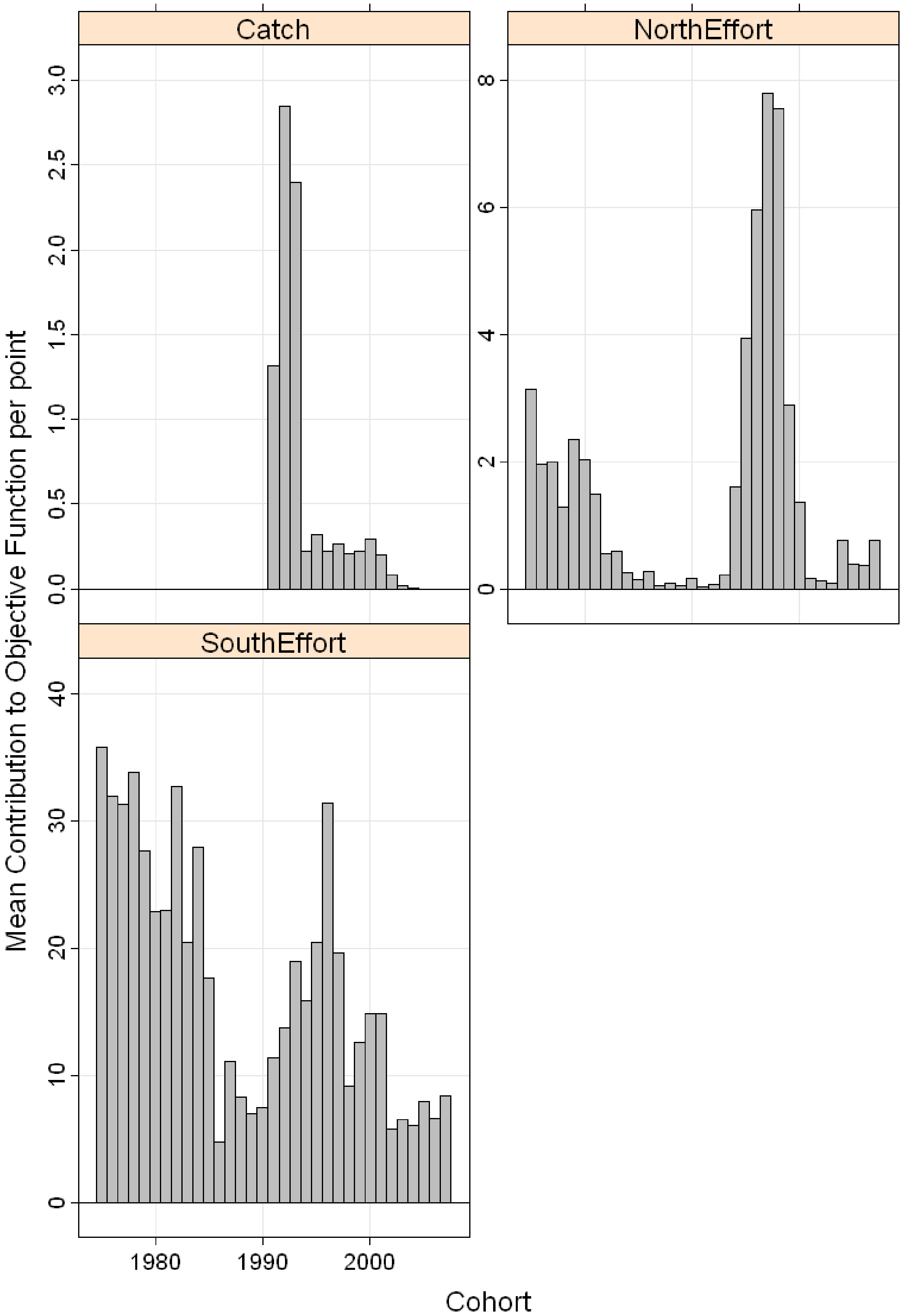
Jack Mackerel SSQ Breakdown by Age

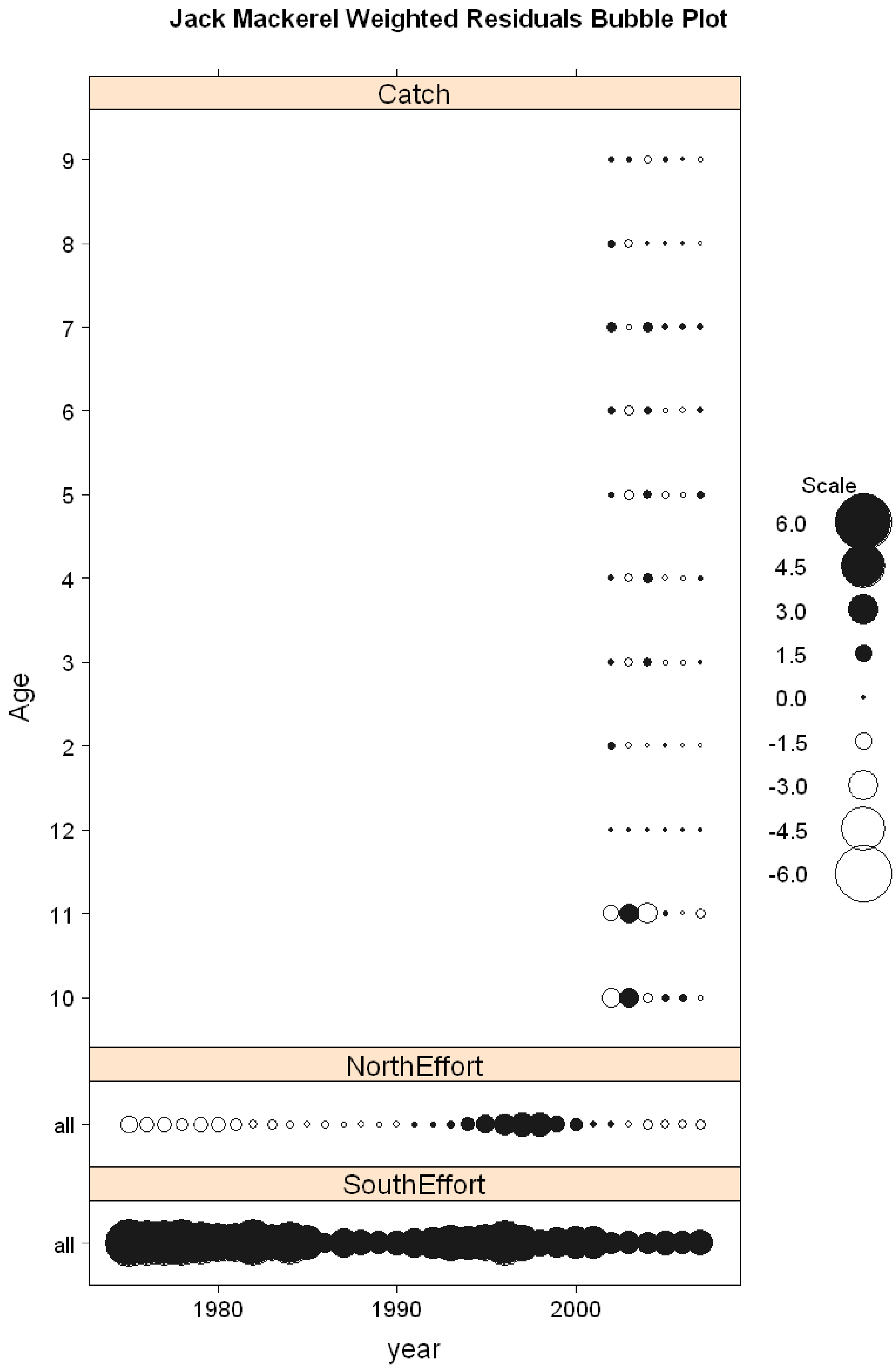




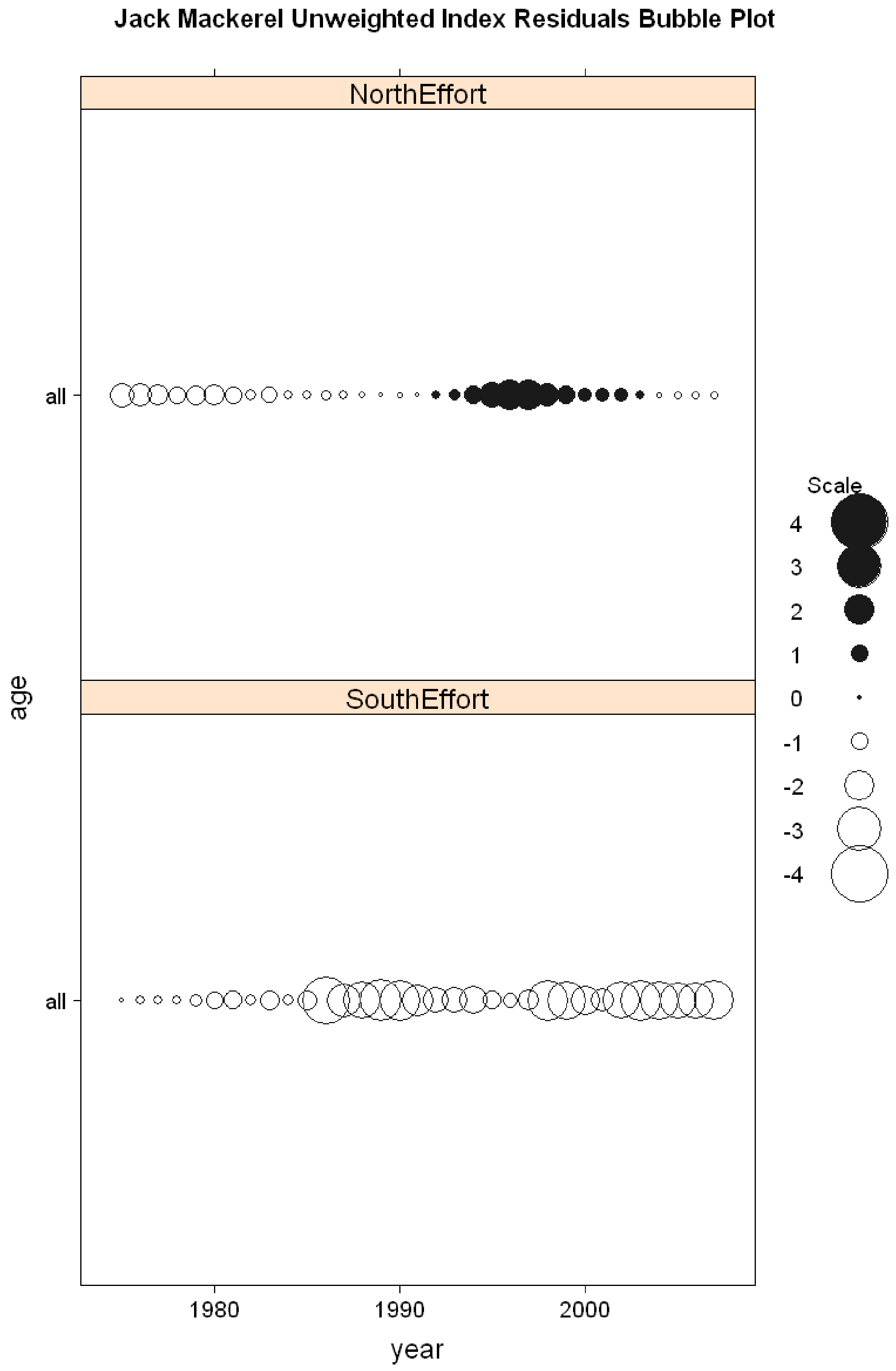
Jack Mackerel SSQ Breakdown by Year
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
Year
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
2
4
6
8
0
10
20
30
40
1980
1990
2000

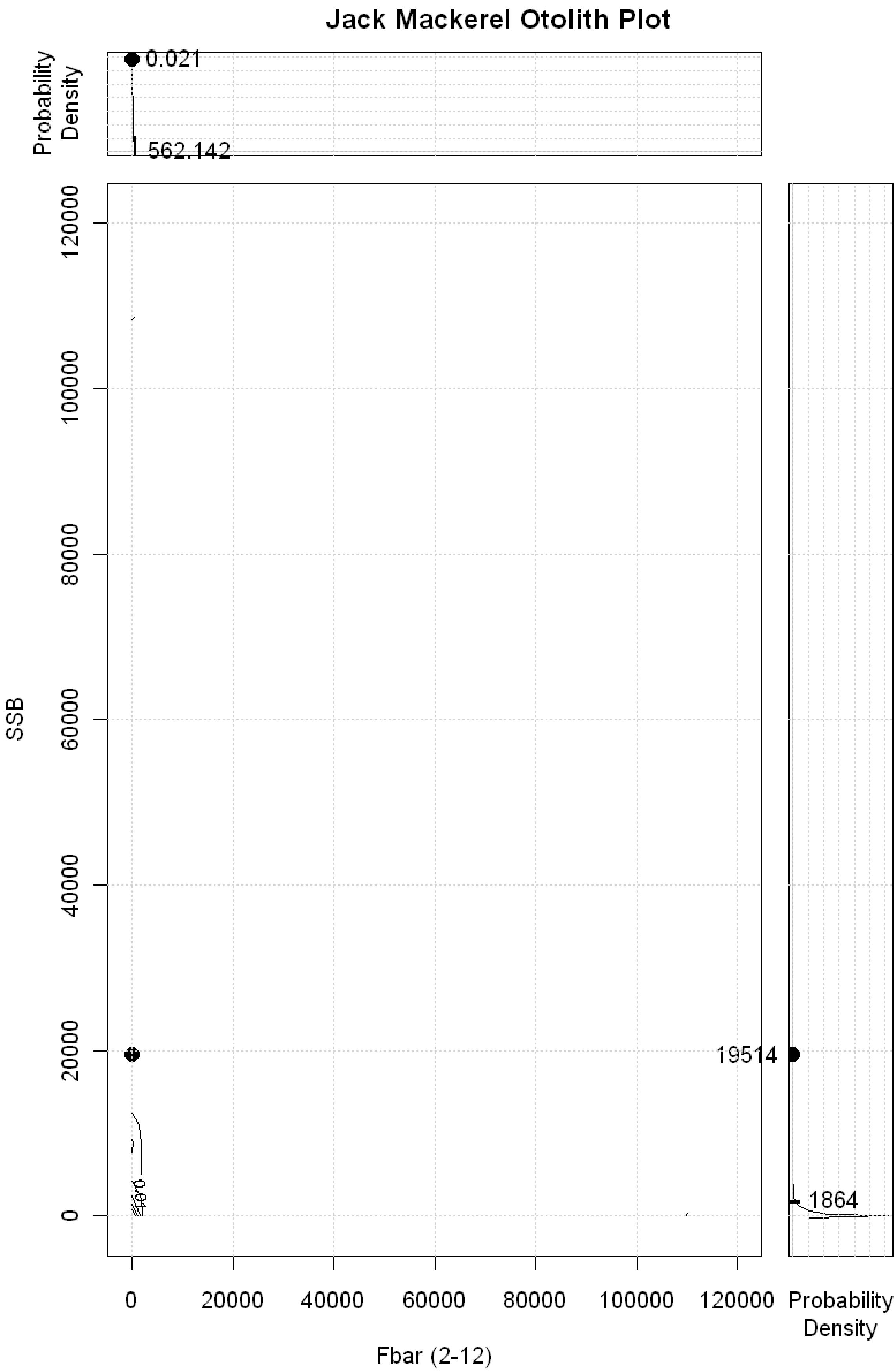
Jack Mackerel SSQ Breakdown by Cohort



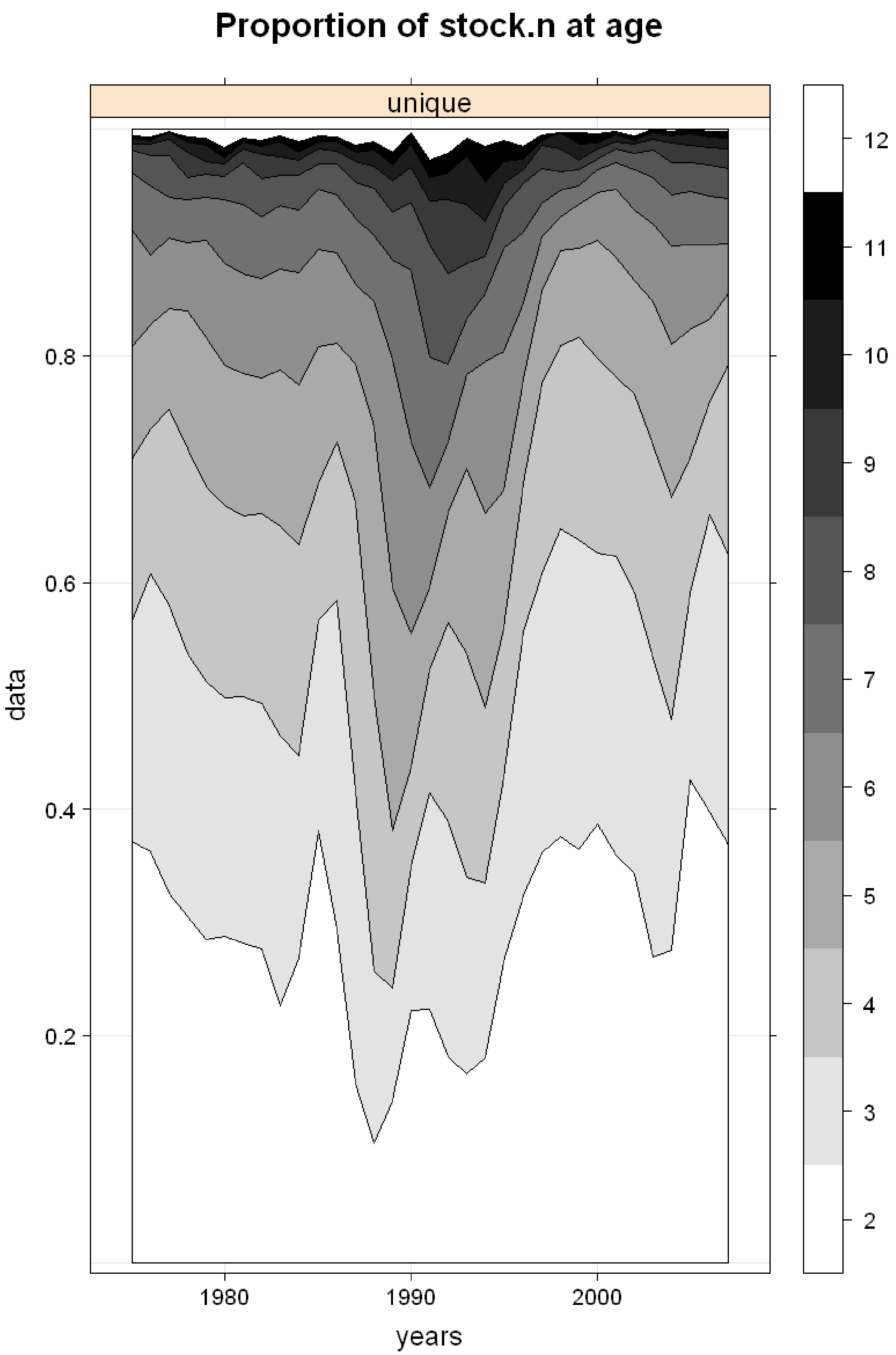


Jack Mackerel Weighted Residuals Bubble Plot
Catch
NorthEffort
SouthEffort
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
6.0
4.5
3.0
1.5
0.0
-1.5
-3.0
-4.5
-6.0

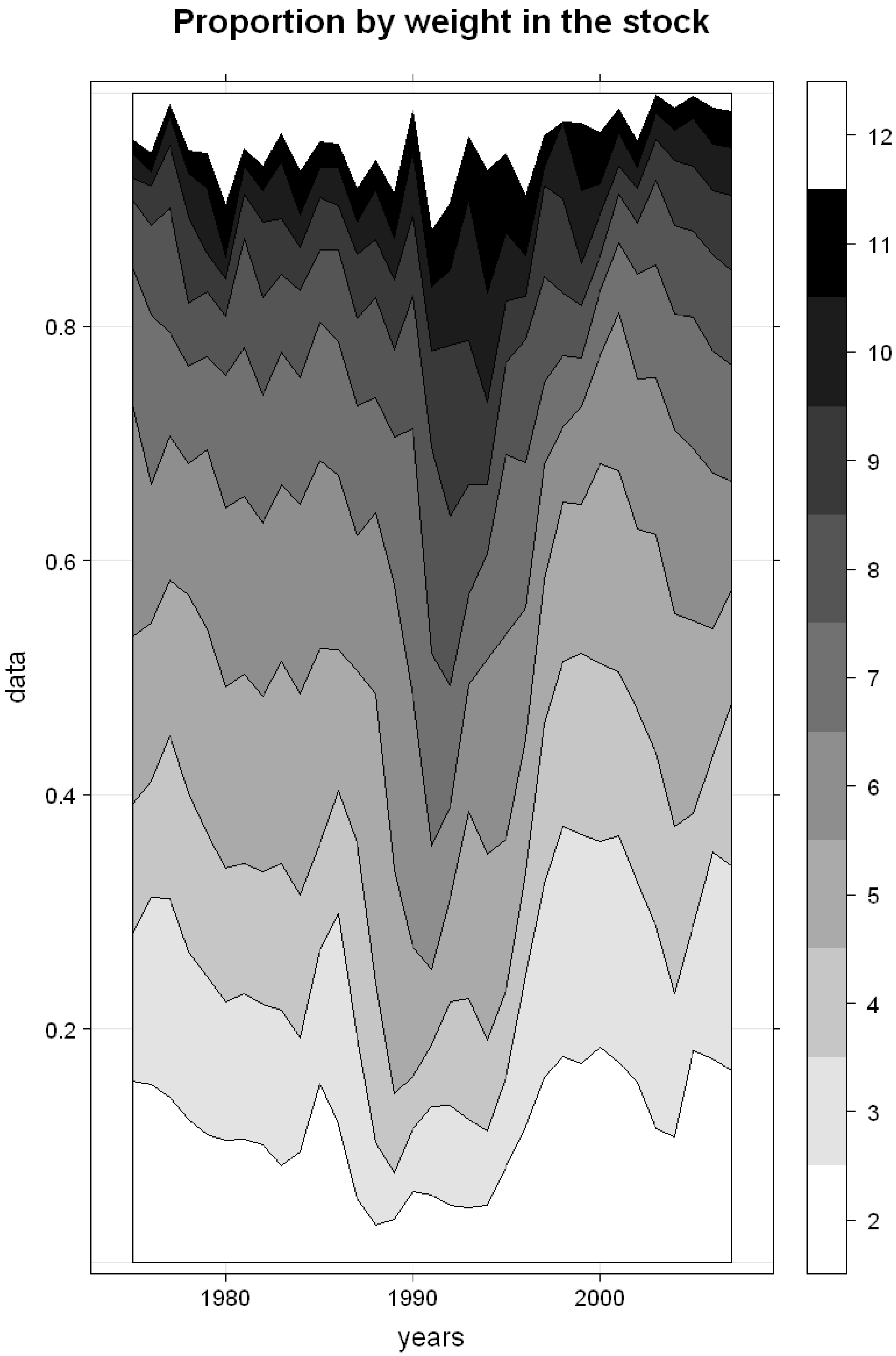

Jack Mackerel Unweighted Index Residuals Bubble Plot
NorthEffort
SouthEffort
all
all
age
1980
1990
2000
year
Scale
4
3
2
1
0
-1
-2
-3
-4



Jack Mackerel Otolith Plot
Probability Density
0.021
562.142
SSB
120000
100000
80000
60000
40000
20000
0
19514
1864
0
20000
40000
60000
80000
100000
120000
Probability Density
Fbar (2-12)

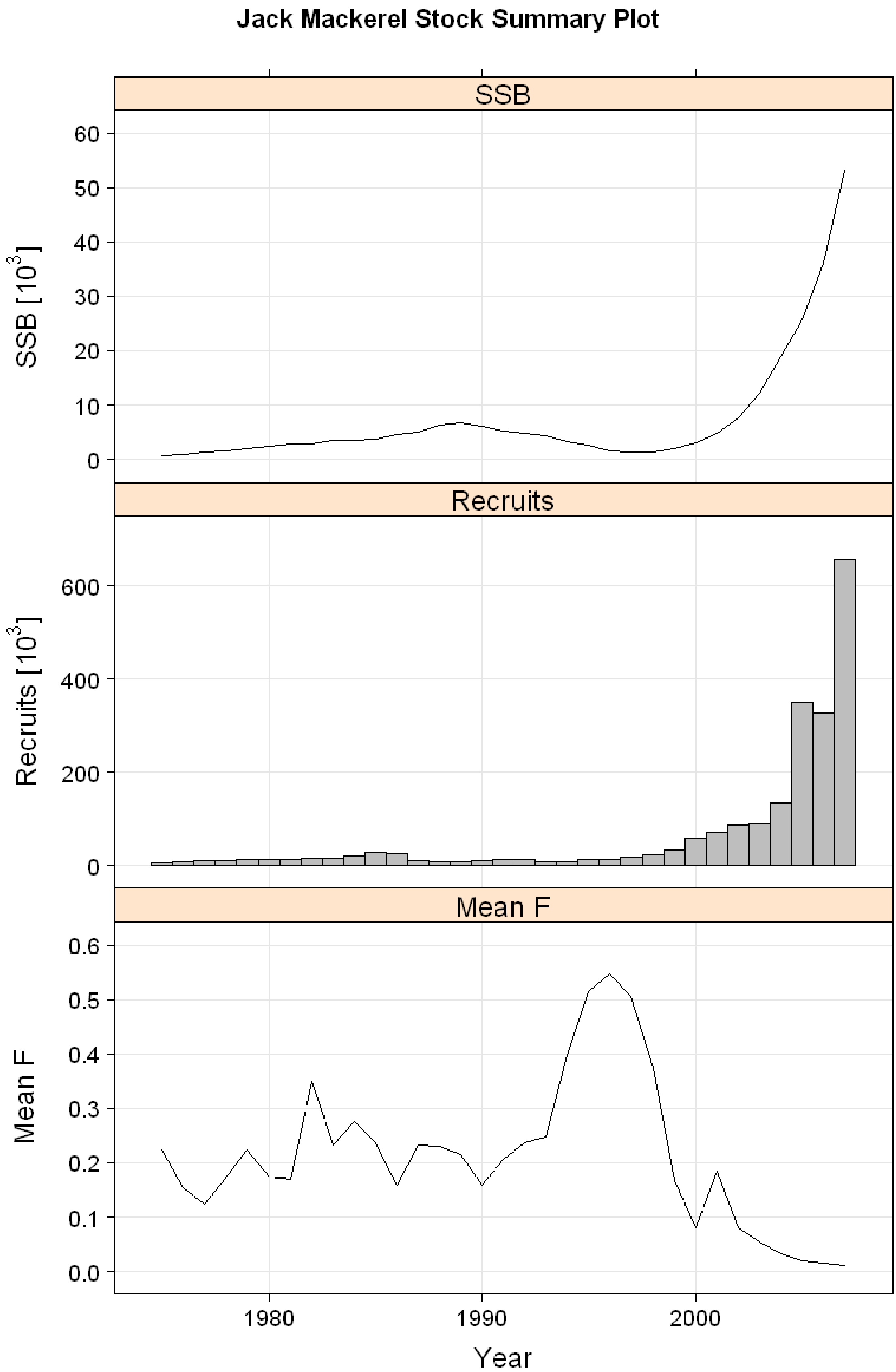


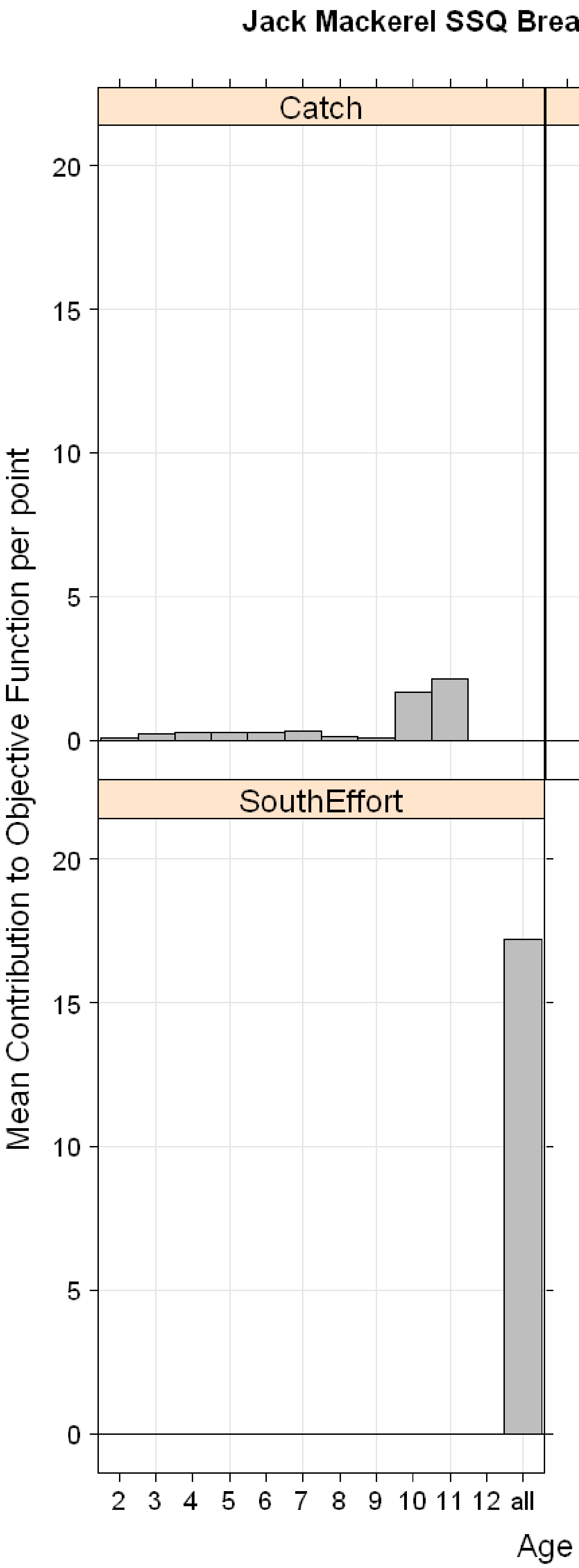
Proportion of stock.n at age
unique
data
years
0.2
0.4
0.6
0.8
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

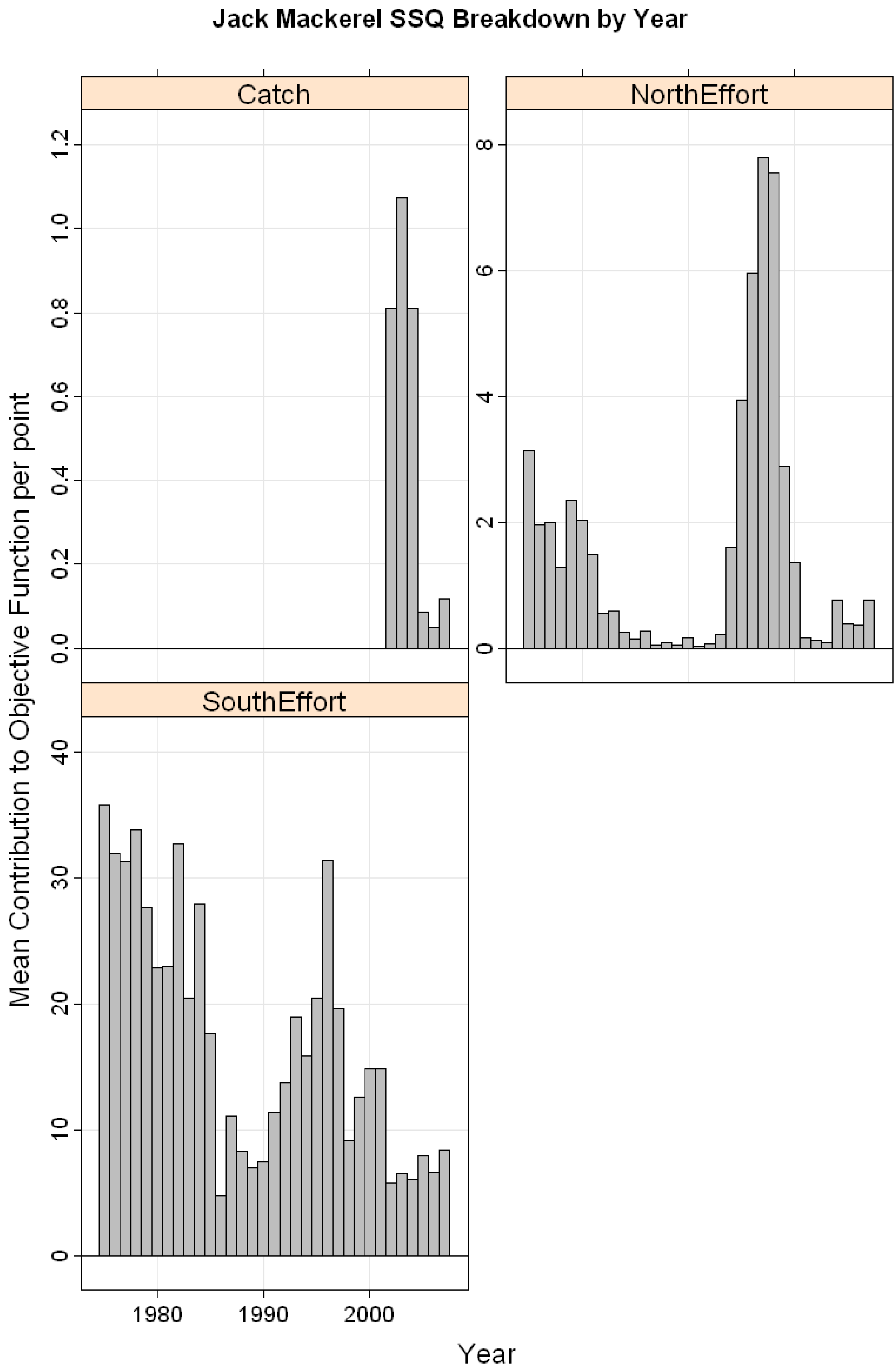


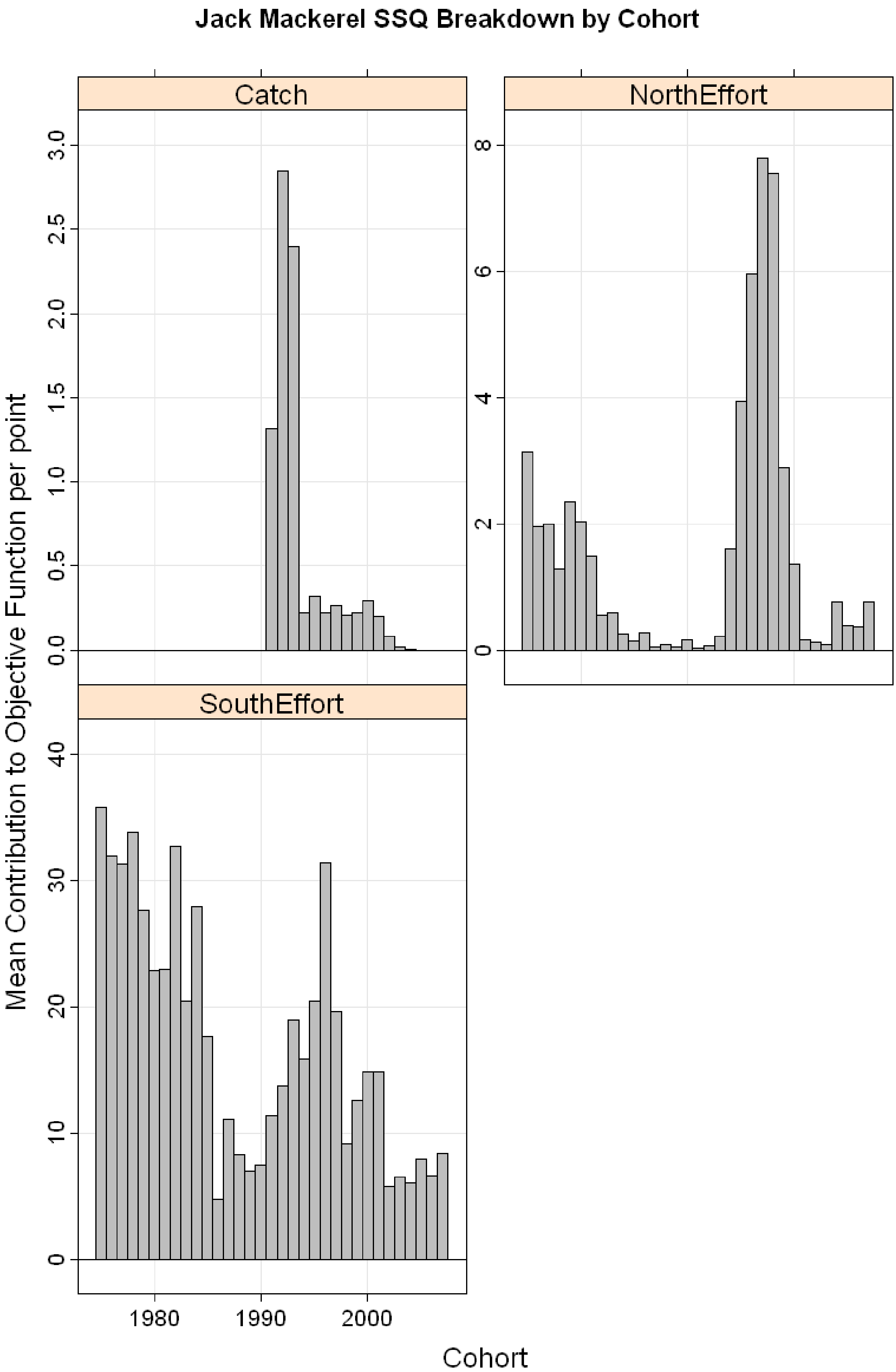
Proportion by weight in the stock
data
0.2
0.4
0.6
0.8
years
1980
1990
2000
2
3
4
5
6
7
8
9
10
11
12

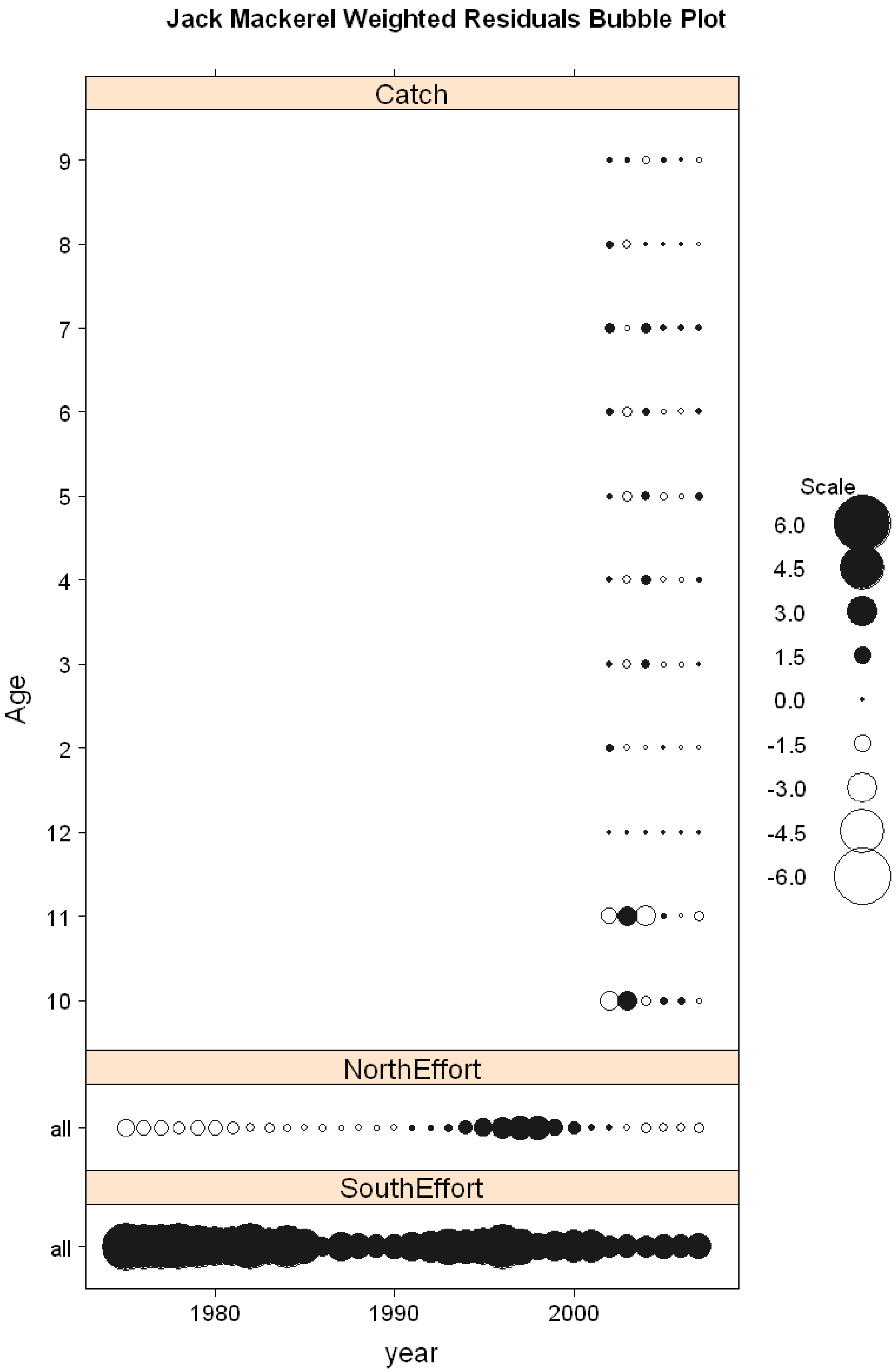
8.6.3 95%


Jack Mackerel Stock Summary Plot
SSB
Recruits
Mean F
SSB [10^3]
Recruits [10^3]
Mean F
60
50
40
30
20
10
0
600
400
200
0
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1980
1990
2000
Year

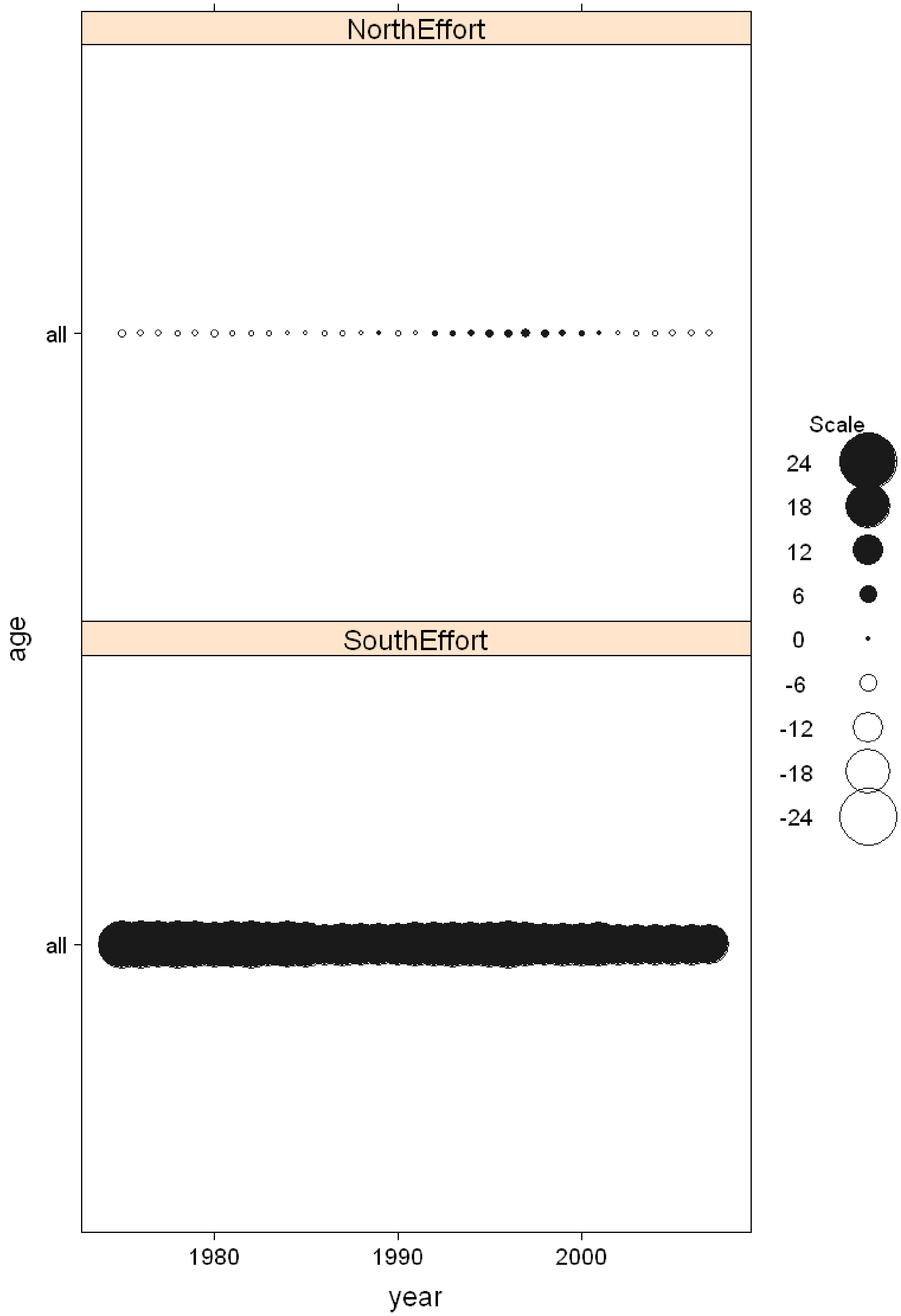

Jack Mackerel SSQ Breakdown by Age
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
0
5
10
15
20
2 3 4 5 6 7 8 9 10 11 12 all
Age

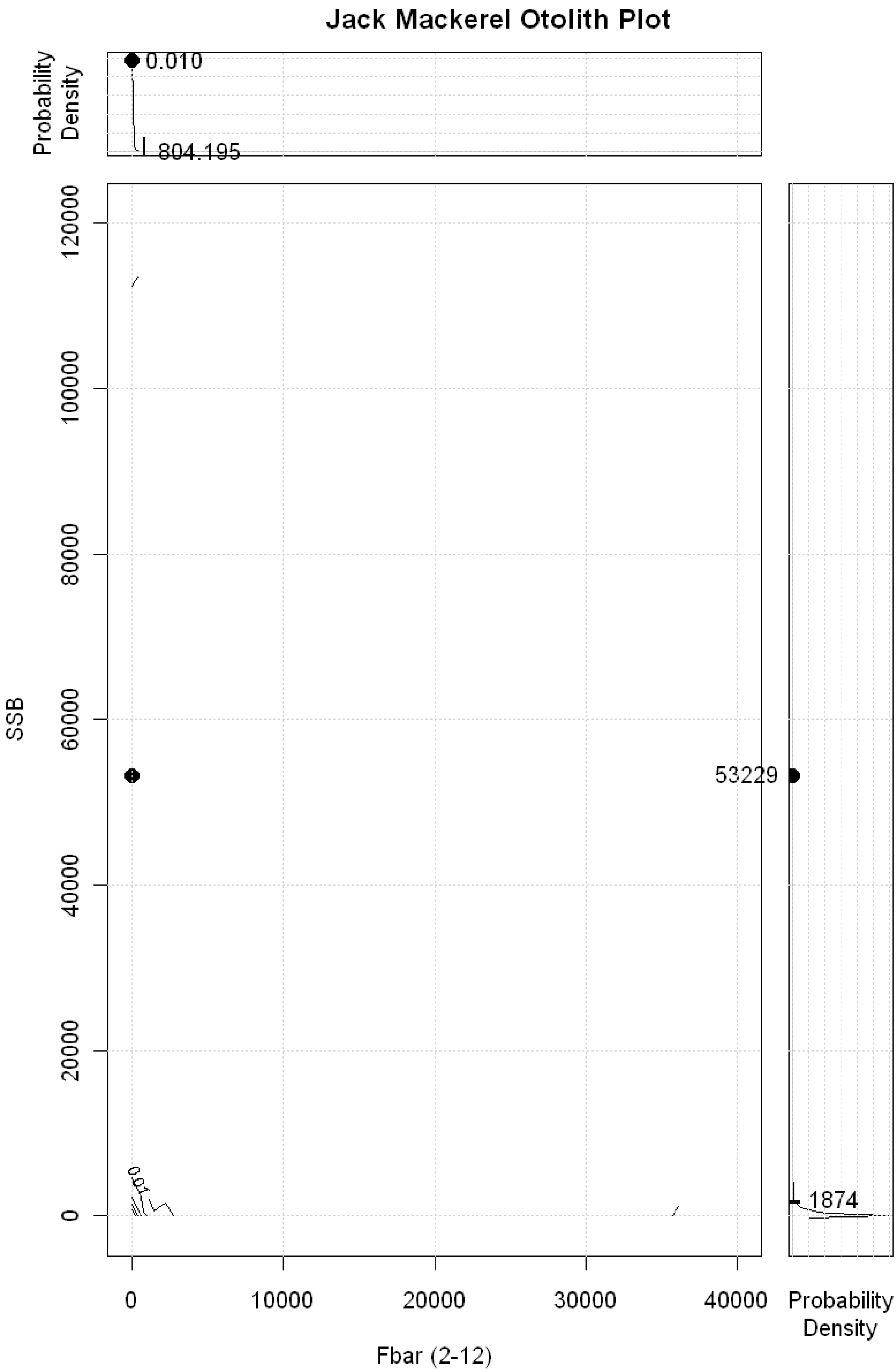

Jack Mackerel SSQ Breakdown by Year
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
Year
1980
1990
2000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
2
4
6
8
0
10
20
30
40


Jack Mackerel SSQ Breakdown by Cohort
Catch
NorthEffort
SouthEffort
Mean Contribution to Objective Function per point
Cohort
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
2
4
6
8
0
10
20
30
40
1980
1990
2000

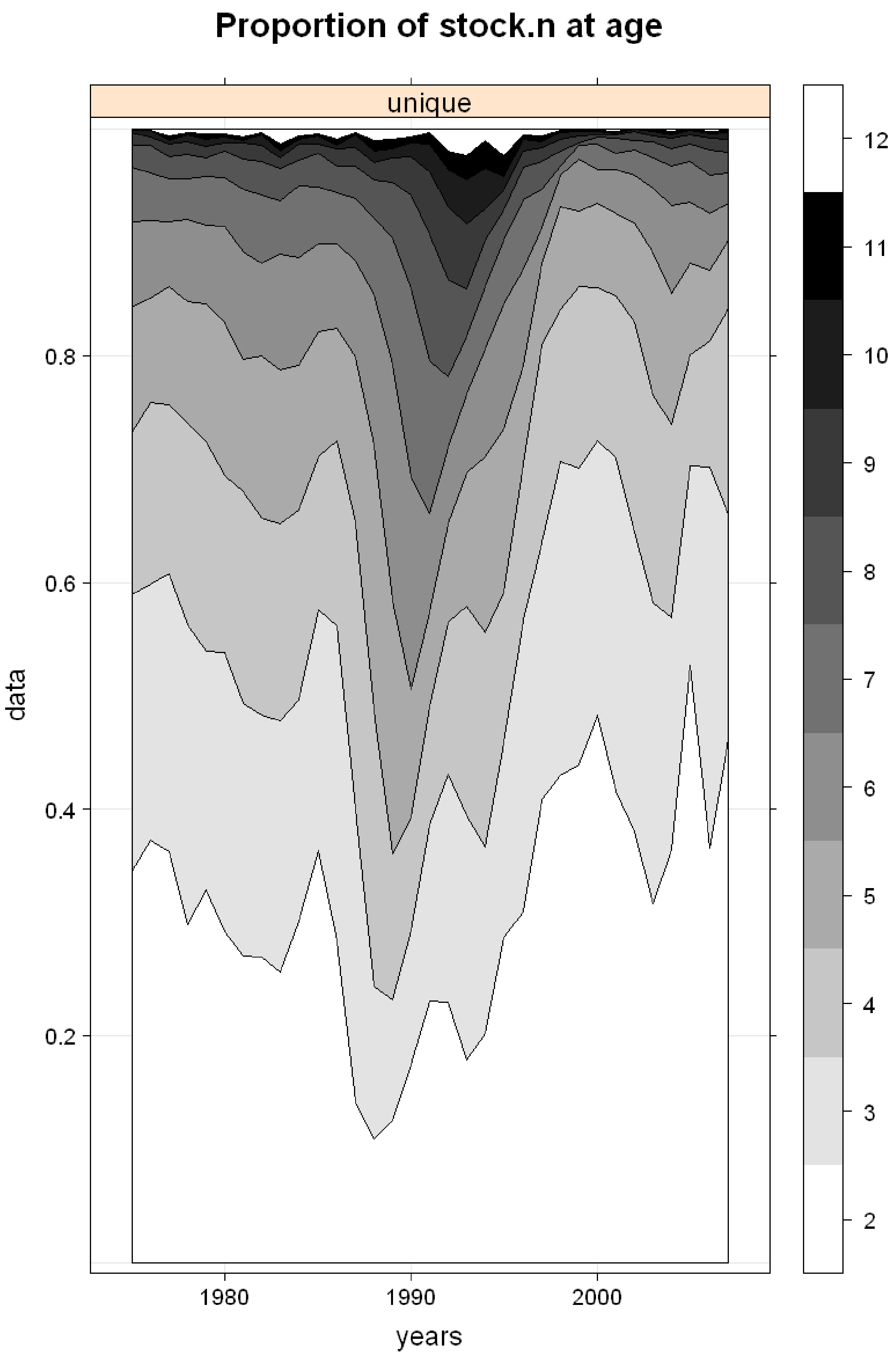

Jack Mackerel Weighted Residuals Bubble Plot
Catch
NorthEffort
SouthEffort
Age
9
8
7
6
5
4
3
2
12
11
10
all
all
1980
1990
2000
year
Scale
6.0
4.5
3.0
1.5
0.0
-1.5
-3.0
-4.5
-6.0

Jack Mackerel Unweighted Index Residuals Bubble Plot





Jack Mackerel Otolith Plot
Probability Density
0.010
804.195
SSB
120000
100000
80000
60000
40000
20000
0
0.01
53229
1874
0
10000
20000
30000
40000
Probability Density
Fbar (2-12)


Proportion of stock.n at age
unique
0.8
0.6
0.4
0.2
data
1980
1990
2000
years
12
11
10
9
8
7
6
5
4
3
2

Proportion by weight in the stock