New Zealand Fisheries
Assessment Report
2009/50
October 2009
ISSN 1175-1584

Determination of optimum frequency for SNA 8 snapper market sampling based on retrospective analysis

R. Bian
J. R. McKenzie
N. M. Davies

Determination of optimum frequency for SNA 8 snapper market sampling based on retrospective analysis

R. Bian
J. R. McKenzie
N. M. Davies

NIWA
Private Bag 99940
Auckland 1149

New Zealand Fisheries Assessment Report 2009/50
October 2009

Published by Ministry of Fisheries
Wellington
2009

ISSN 1175-1584

Bian, R.; McKenzie, J.R.; Davies, N.M. (2009).
Determination of optimum frequency for SNA 8 snapper market sampling based on retrospective analysis.
New Zealand Fisheries Assessment Report 2009/50. 15 p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

Bian, R.; McKenzie, J.R.; Davies, N.M. (2009). Determination of optimum frequency for SNA 8 snapper market sampling based on retrospective analysis.

New Zealand Fisheries Assessment Report 2009/50. **15 p.**

This work is to investigate the effect of market sampling frequency on snapper stock assessment using a retrospective method. Two models, which were derived from 2004–05 SNA8 stock assessment model, and three frequency scenarios, i.e., sampling every year and every 2 and 3 years, were applied.

Results show that if market sampling in SNA 8 had been carried out every 2 or 3 years during 1991 to 2004, there would have been little precision loss in the 2004–05 stock assessment in comparison with sampling every year. In contrast, the accuracy of biomass and relative abundance estimates would have been significantly affected if the 2002 tagging programme had not been undertaken. Sampling for catch-at-age every 3 years does not systematically cause greater uncertainty than sampling every 2 years. However, this conclusion assumes that future patterns in recruitment (year class strengths) are comparable to those observed over the last 15 years. The major concern with increasing the market sampling interval is the risk of failing to identify several consecutive weak year class strengths in time to take appropriate management measures. One way to assess this risk is through simulation projection modelling.

1. INTRODUCTION

It is difficult to determine the optimum combination of methods and frequency of data collection for stock assessment for deriving a comprehensive stock assessment of snapper that achieves acceptable precision. Techniques such as tagging programmes, trawl surveys, and catch-at-age sampling are often expensive and time consuming. Great benefit would be gained from an indication of the best combination of stock assessment techniques and the optimum frequency for carrying them out. This may also reduce unnecessary expense on techniques undertaken regularly that add little to the stock assessment.

Since the 1970s there has been considerable investment in the collection of information from New Zealand's two largest snapper stocks (SNA 1 & 8). Information available comes from trawl surveys, mark recapture programmes, and method specific catch-at-age. The annual series of catch-at-age data are unbroken from 1989 to the current fishing year (2008–09) and are intermittent back to the early 1970s.

Historically, SNA 1 and SNA 8 market sampling (predominantly longline in SNA 1 and single trawl in SNA 8) has been carried out in the spring and summer seasons only. However, in recent years sampling in SNA 1 has taken place over all four seasons in order to account for differences in gear selectivity, fish availability, and size structure between seasons.

Age structured population modelling forms the basis of SNA 1 & 8 stock assessments. Catch-at-age sampling and other stock monitoring programmes have largely been designed to meet the spatial and temporal modelling requirements. The basic premise, accepted by the Inshore Working Group, is that an evaluation of data collection frequency in SNA 1 & 8 should be with reference to model precision and accuracy.

The last SNA 8 stock assessment was undertaken in 2004 (Davies et al. 2006) using an age-structured model developed in 2002. The 2002 SNA 8 model is partitioned into one stock area and one season and recognises four method fisheries (single trawl, pair trawl, long line, recreational line).

The original scope of the SNA2006/07 project, as stated by the Ministry, was to assess the effect of changing the frequency of catch-at-age data collection for the two main snapper stocks. The intention was to use the latest SNA 1 & 8 stock assessment models for the simulations, but computational problems with the current SNA 1 CASAL model mean that simulation modelling of this stock is not currently tractable. The project was subsequently revised to be an evaluation of SNA 8 catch-at-age sampling frequency alone.

In the original NIWA proposal for the work two simulations were to be undertaken:

- A retrospective analysis to repeat the current SNA 8 stock assessment modelling under alternative scenarios of reduced catch-at-age frequencies and to compare changes in precision between scenarios.
- Simulation projections to compare future stock assessments undertaken using a model fitted to historical catch-at-age observations and to future observations that are simulated under alternative sampling frequency scenarios.

The retrospective analysis makes no assumption about the "true" status of the stock, i.e., whether the full-data assessment is correct. The purpose is to determine the degree to which precision deteriorates and the modelling conclusions change when data are removed.

The Ministry of Fisheries suspended the simulation modelling objective of SNA2006/07 until the results from the present retrospective analysis were obtained.

2. METHODS

Retrospective simulations were undertaken using 2004–05 SNA 8 stock assessment model, which was an updated version of the 2003–04 SNA 8 age-structured stock assessment model (Davies et al. 2006).

The basic idea of the retrospective analysis was to investigate the reduction in precision caused by sampling for catch-at-age less frequently than in the 2004–05 assessment.

2.1 Stock assessment

The 2004–05 SNA8 stock assessment model begins in 1931 and runs to 2010. Included in the model are: single trawl, pair trawl, and long line commercial catch; recreational catch; two absolute abundances from tagging programmes (1990, 2001); pair trawl and single trawl CPUE indices, and pair trawl and single trawl proportion-at-length and catch-at-age.

The 14-year series of single trawl catch-at-age data (1990–91 to 2003–04) were used to simulate alternative market sampling frequency scenarios. There were five years of pair trawl catch-at-age observations (1999–2000 to 2003–04) overlapped in time with the single trawl data. For simplicity these overlapping pair trawl data were excluded from the full-data analysis and from the reduced sampling frequency analyses.

The two estimates of absolute stock biomass are known to strongly influence the modelling results (Davies et al. 2006). To investigate the interactive effect of the catch-at-age data and the tagging estimates two sets of catch-sampling frequency analyses were undertaken; one including all available tagging data (labelled “incld-tag02”) and the other excluding the 2002 tagging programme estimates (“excl-tag02”).

2.2 Retrospective analyses

The full-data scenario was the model run including both the 1990 and 2002 tagging observations and the full sequence of single trawl catch-at-age data. For each tagging option (incld-tag02 and excl-tag02) the time series of the catch-at-age observations was then “thinned” by removing observations to simulate sampling on a two-yearly or three-yearly basis. The stock assessment model was then re-fitted to the thinned data sets and parameter precision was estimated. Given two tagging options and three sampling frequency scenarios, this produces six stock assessments.

The effect of the sampling frequencies on precision was assessed by comparing a number of stock assessment performance indicators (PIs). These were: unexploited equilibrium biomass (B0); current stock status (current Biomass/B0), predicted relative abundance indices for single trawl; recruitment year class strength (YCS) estimates. Precision of the PI estimates was derived from estimates of their posterior distributions generated using MCMCs.

Estimating the PIs in each of the six scenarios required modification of the model CASAL estimation.csl file, a maximum posterior density estimate (MPD) run of CASAL (Bull et al. 2008), and repetitive MCMC runs of CASAL. The estimating process was:

1. choose one of the six scenarios
2. prepare estimation.csl file by appropriately removing annual catch-at-age data for “freq1”, “freq2”, and “freq3” and removing tag observations for excl-tag02
3. run CASAL to estimate parameters

4. fix natural mortality rate and do 1.1 million MCMC runs, taking a set of parameters every 100 runs and dropping the first 1000 sets
5. project PIs for 1931 to 2010 with the 10 000 sets of MCMC parameters
6. repeat 1–5 until the 6 scenarios are covered.

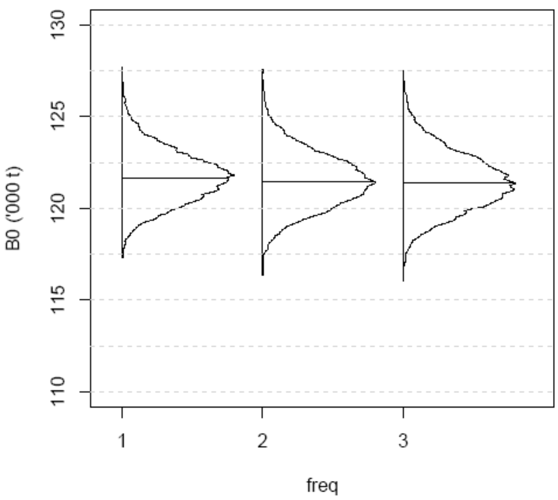
3. RESULTS

3.1 PI: unexploited equilibrium biomass (B0)

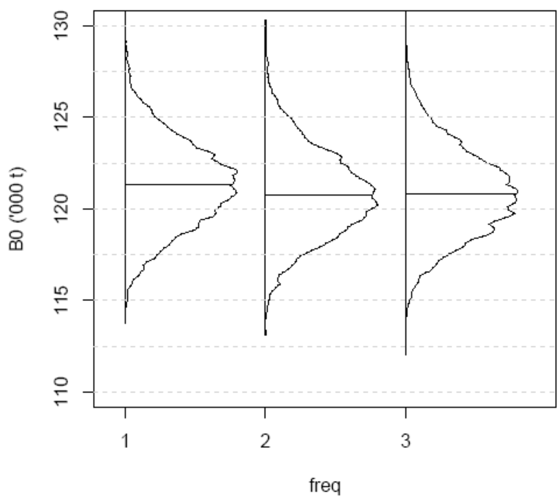
Posteriors and medians of unexploited equilibrium biomass (B0) for the six scenarios are shown in

Figure **1** (a) and (b). From the posterior plots we can see that the effect of sampling frequency on the estimate of B0 was very small. Excluding the 2002 tagging data has relatively greater impact on the estimates of B0 resulting in a 45% increase in c.v., see

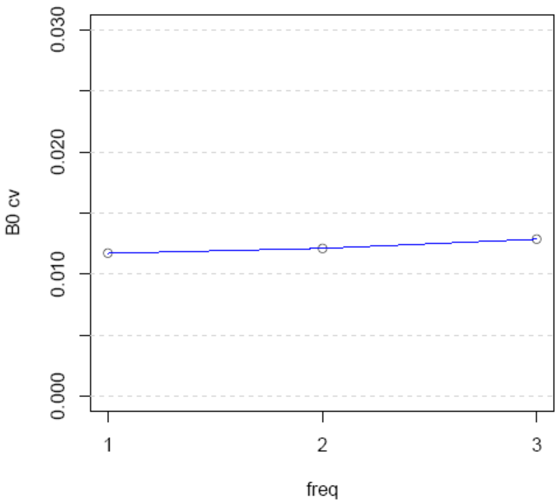
Figure **1** (a) to (d) and Tables 1 and 2.



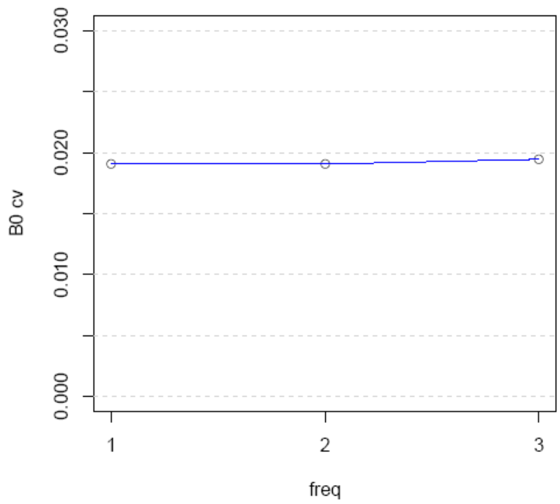
(a)



(b)



(c)

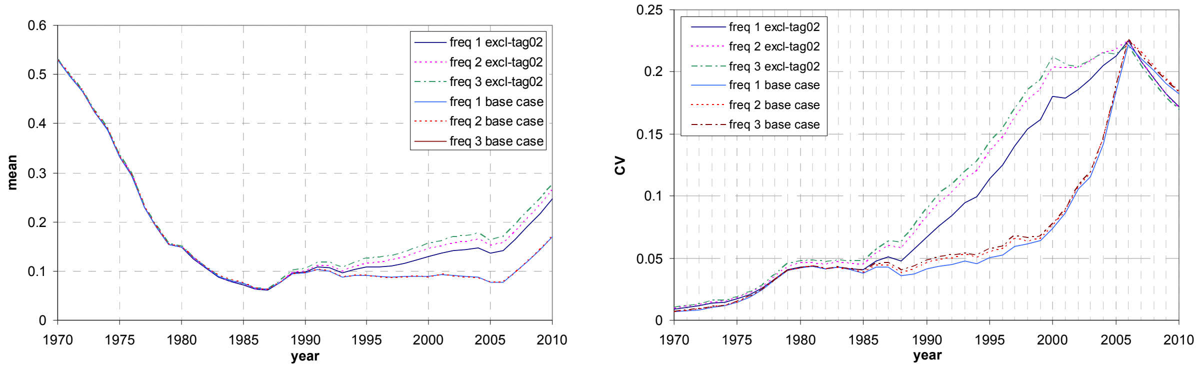


(d)

Figure 1: B0 posteriors (a, b) and c.v.s (c,d) for incld-tag02 and excl-tag02 scenarios by frequency sampling level.

3.2 PI: Current stock status (current Biomass/B0)

Means and c.v.s of current Biomass/B0 for 1970–2010 for the sampling frequencies from the full-data model are shown in Figure 2. Reducing market sampling frequency had little impact on the estimates of Biomass/B0 when the 2002 tagging estimate was included; there was a slight increase in the c.v.s between 1988 and 1999 (Figure 2(b)).



(a) (b)

Figure 2: Means (a) and c.v.s (b) of estimated Biomass/B0 ratio from 1970 to 2010 for the six scenarios.

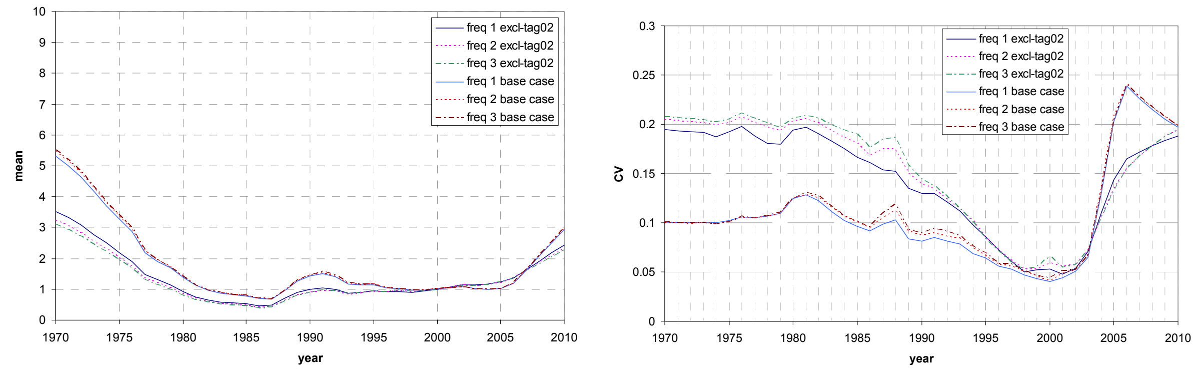
In contrast to sampling frequency, observations from the 2002 tagging programme had a stronger impact on the estimate of Biomass/B0. Excluding the 2002 tagging data caused increased variance in the estimates of Biomass/B0 and a significant change in values after 1995 (Figure 2).

Biomass/B0 posteriors, means and c.v.s for the full time series (1931–2010) are given in Appendices 1, 4 and 5.

3.3 PI: model predicted single trawl relative abundance indices

The exclusion of the 2002 tagging data again had the largest effect on the model estimates of single trawl relative abundance, whereas catch sampling frequency had only minimal effect (Figure 3).

Excluding the 2002 tagging observations affects only the estimates of Biomass/B0 for the years after 1985, while it influences estimates of relative abundance for all years.



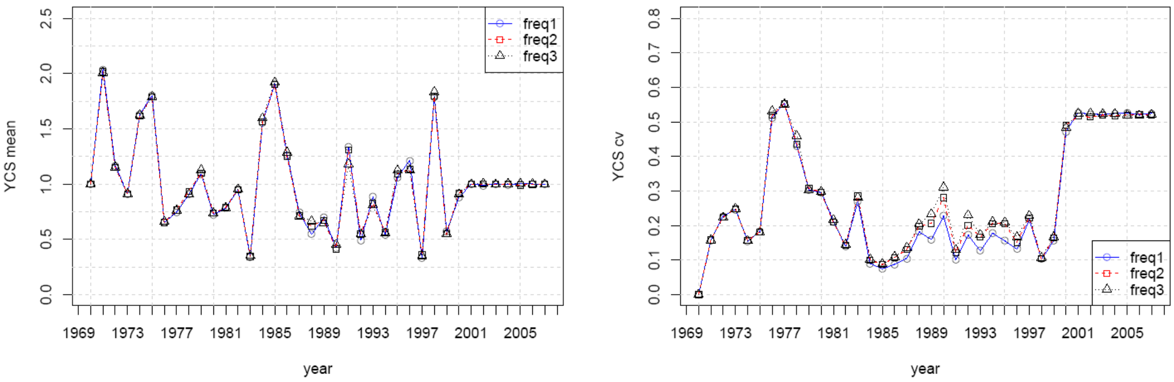
(a) (b)

Figure 3: Model estimates of single trawl relative abundance (a) mean (b) c.v.s.

The posteriors, means, and c.v.s for relative abundance from 1931 to 2010 for incld-tag02 and excl-tag02 models are listed in Appendices 2, 6 and 7.

3.4 PI: YCS estimates

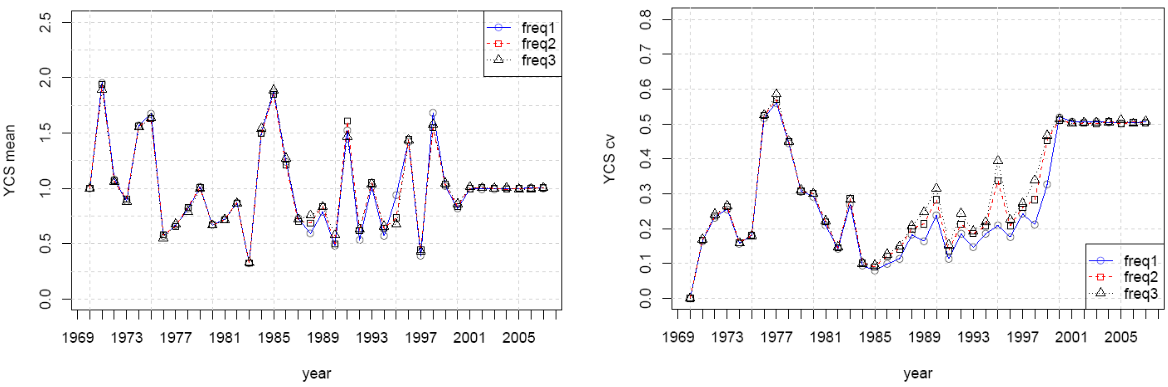
Reducing catch-at-age sampling frequency caused little change in the year class strength (YCS) estimates with all tagging data included (Figure 4(a)), although the variance of the estimates increased slightly for years 1984–1996 (Figure 4(b)).



(a) (b)

Figure 4: Estimated YCS (1970–2010) at various sampling frequencies with the 2002 tagging data included; (a) mean (b) c.v.s.

Excluding the 2002 tagging observations reduced precision of YCS estimates for 1995–99 (Figure 5(b)). The excl-tag02 data produced subtle changes in some of the YCS estimates, specifically the 1995 YCS index was higher and the 1999 YCS was lower in the excl-tag02 graphs (Figure 5 (a)). Reducing catch-sampling frequency resulted in a greater precision loss in some of the YCS indices for excl-tag02 than for incld-tag02 (Figure 5(b)).



(a) (b)

Figure 5: Estimated YCS (1970–2010) at various sampling frequencies with the 2002 tagging data excluded; (a) mean (b) c.v.s.

All the posteriors, means and c.v.s for YCS are given in Appendices 3, 8 and 9.

3.5 Single trawl catch sampling frequency: implications for 2004–05 stock assessment

Estimates of current biomass changed little in response to reduced catch sampling frequency when all tagging data were present in the model (Table 1). Removal of the 2002 tagging data essentially doubled the 2004–05 biomass estimates and also increased the relative effect of reducing catch sampling frequency (Table 1). The change in relative precision to the 2004–05 biomass estimates in contrast was minimal (c.v. range 0.18 to 0.22; Table 2). The precision of the relative abundance estimate is, perhaps surprisingly, improved (reduced c.v.) for excl-tag02. However, when this is expressed as a standard error the improvement is modest. It is also likely that for excl-tag02 there is increased bias in these estimates. Model estimates of B0 varied little under all data scenarios (Table 1) although the change in precision was marked for excl-tag02 (Table 2).

Table 1: Percent deviation in mean PI values for 2004–05 final stock assessment year (full-data scenario 1 shaded).

model	freq	Biomass ('000 t)		Biomass/B0		Relative abundance		B0 ('000 t)	
		mean	deviat	mean	deviat	mean	deviat	mean	deviat
incld-tag02	1	9.436		0.077		1.014		121.70	
	2	9.311	-1.3%	0.077	-1.1%	1.016	0.1%	121.50	-0.2%
	3	9.421	-0.2%	0.078	0.1%	1.022	0.7%	121.46	-0.2%
excl-tag02	1	16.590	75.8%	0.178	129.4%	1.227	20.9%	121.32	-0.3%
	2	18.338	94.3%	0.184	137.3%	1.221	20.3%	120.82	-0.7%
	3	19.745	109.2%	0.190	145.2%	1.230	21.3%	120.86	-0.7%

Table 2: c.v.s of the estimated PIs from 2004–05 final stock assessment year (full-data scenario 1 shaded).

model	freq	Biomass/B0		Relative abundance		B0	
		cv	cv inc	c v	cv inc	cv	cv inc
incld-tag02	1	0.184		0.203		0.012	
	2	0.187	1.6%	0.207	2.1%	0.012	3.5%
	3	0.187	1.4%	0.203	0.3%	0.013	9.9%
excl-tag02	1	0.213	15.3%	0.143	-29.4%	0.019	63.1%
	2	0.217	17.7%	0.133	-34.1%	0.019	62.9%
	3	0.214	16.0%	0.132	-34.6%	0.019	66.3%

4. DISCUSSION

The retrospective analyses showed that had SNA 8 catch sampling frequency been only every three years (a 66% cost saving), there would have been minimal difference in the 2004–05 stock assessment. In contrast, if the 2002 SNA 8 tagging programme had not been undertaken, the conclusions of the 2004–05 stock assessment would have markedly more optimistic. These analyses suggest that it would be highly advisable to undertake tagging programmes in SNA 8 at intervals not exceeding 10 years as serious biases are likely in SNA 8 stock assessments undertaken 10 years beyond the last available tagging estimate.

Assuming tagging estimates are available at least every 10 years, the retrospective analysis has shown that it might be feasible to adopt a less frequent catch-sampling strategy in SNA 8. However, the proviso of this conclusion is that future patterns in recruitment (year class strengths; YCS) are comparable to those observed over the last 15 years. The concern with increasing market sampling intervals (not addressed by the current study) is the risk of failing to identify several consecutive weak year classes in time to take appropriate management measures.

There were originally two objectives to the current catch sampling frequency evaluation project: the first was a retrospective analysis (this report); the second was an assessment of the effect of reducing SNA 8 catch-at-age sampling frequency on future stock assessments under a range of future recruitment scenarios; i.e., a "future risk" evaluation. The Ministry of Fisheries dropped the second objective pending the results of the first. In light of the retrospective analysis results supporting less frequent catch sampling, undertaking the second objective is now justified. The SNA 8 stock has been severely depressed and now largely supported by only six/seven predominant age classes; even a short sequence of low recruitments (three or four years) could have a significantly detrimental effect on the stock. It would be incorrect and irresponsible to adopt a less frequent catch sampling strategy in SNA 8 without a thorough investigation of its consequences under "reasonable" future risk scenarios.

We recommend that any "future risk" evaluation project should investigate the effect of both changing the frequency of catch sampling and mark-recapture programmes on future SNA 8 assessments. Simulation outputs should take the form of decision rules intended to avert stock collapse. The simulations should assess the risk of failing to recognise that the decision rule threshold has been reached. There will need to be prior agreement by the Working Group as to the range of future recruitment (YCS) patterns investigated, the decision rules adopted, and the criteria for a satisfactory outcome.

5. ACKNOWLEDGMENT

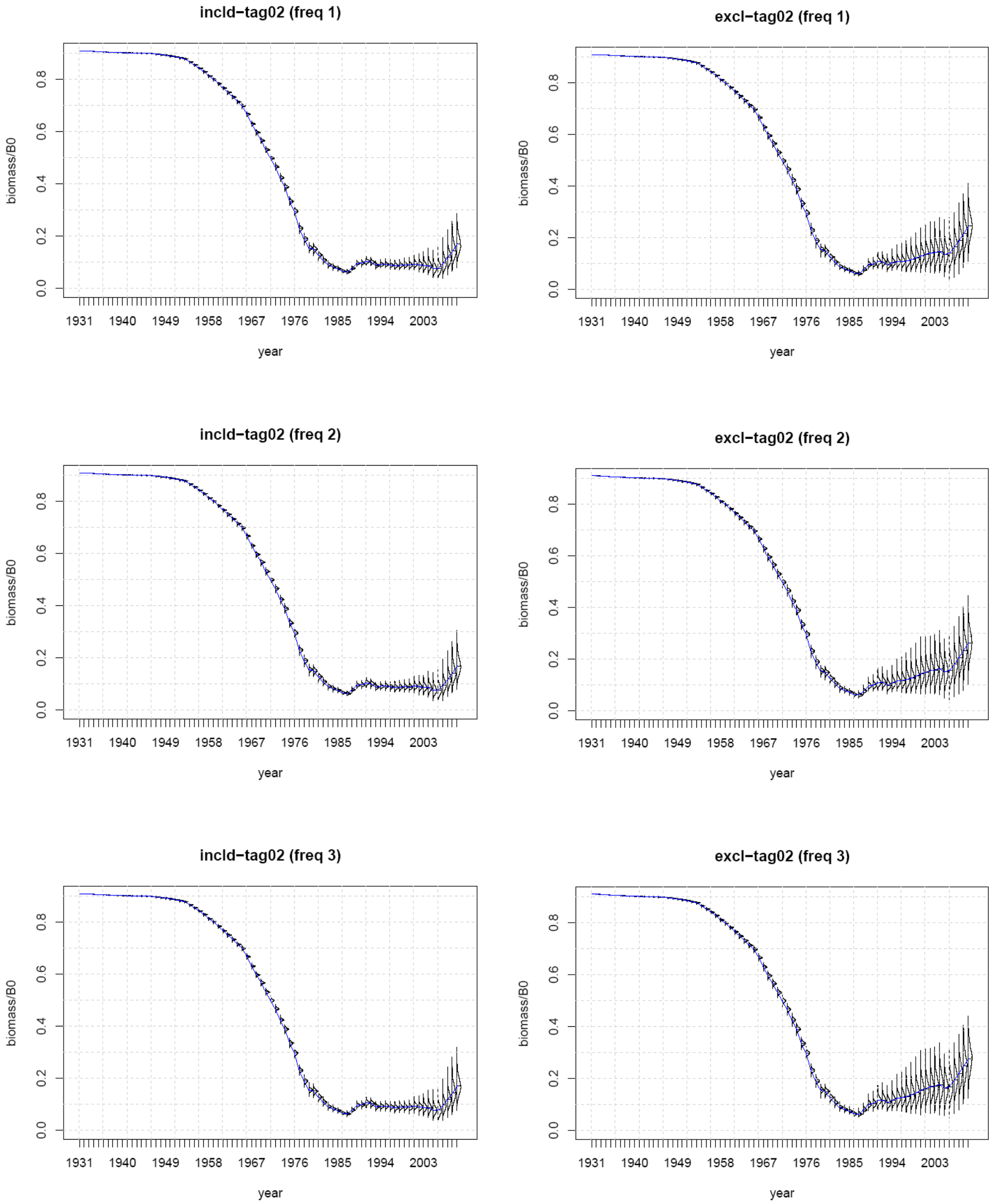
This work was funded by the Ministry of Fisheries under research project SNA2006/07, objective 1.

6. REFERENCES

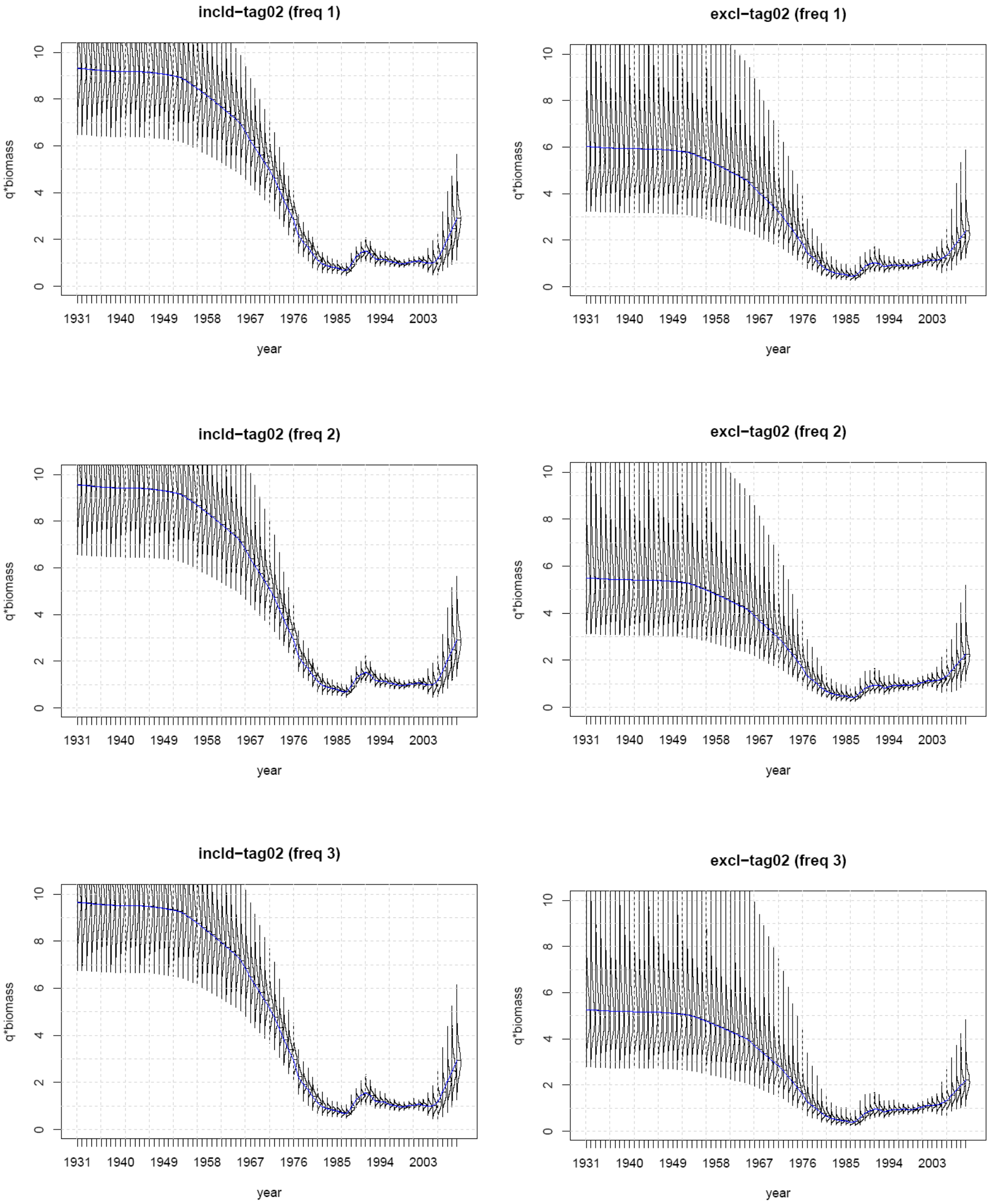
Bull, B.; Francis, R.I.C.C.; Dunn, A.; McKenzie, A.; Gilbert, D.J.; Smith, M.H.; Bian, R. (2008). CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.20-2008/02/14. *NIWA Technical Report 130*. 275 p.

Davies, N.M.; McKenzie, J.R.; Gilbert, D.J. (2006). Assessment of the SNA 8 stock for the 2003-2004 fishing year. *New Zealand Fisheries Assessment Report 2006/9.* 58 p.

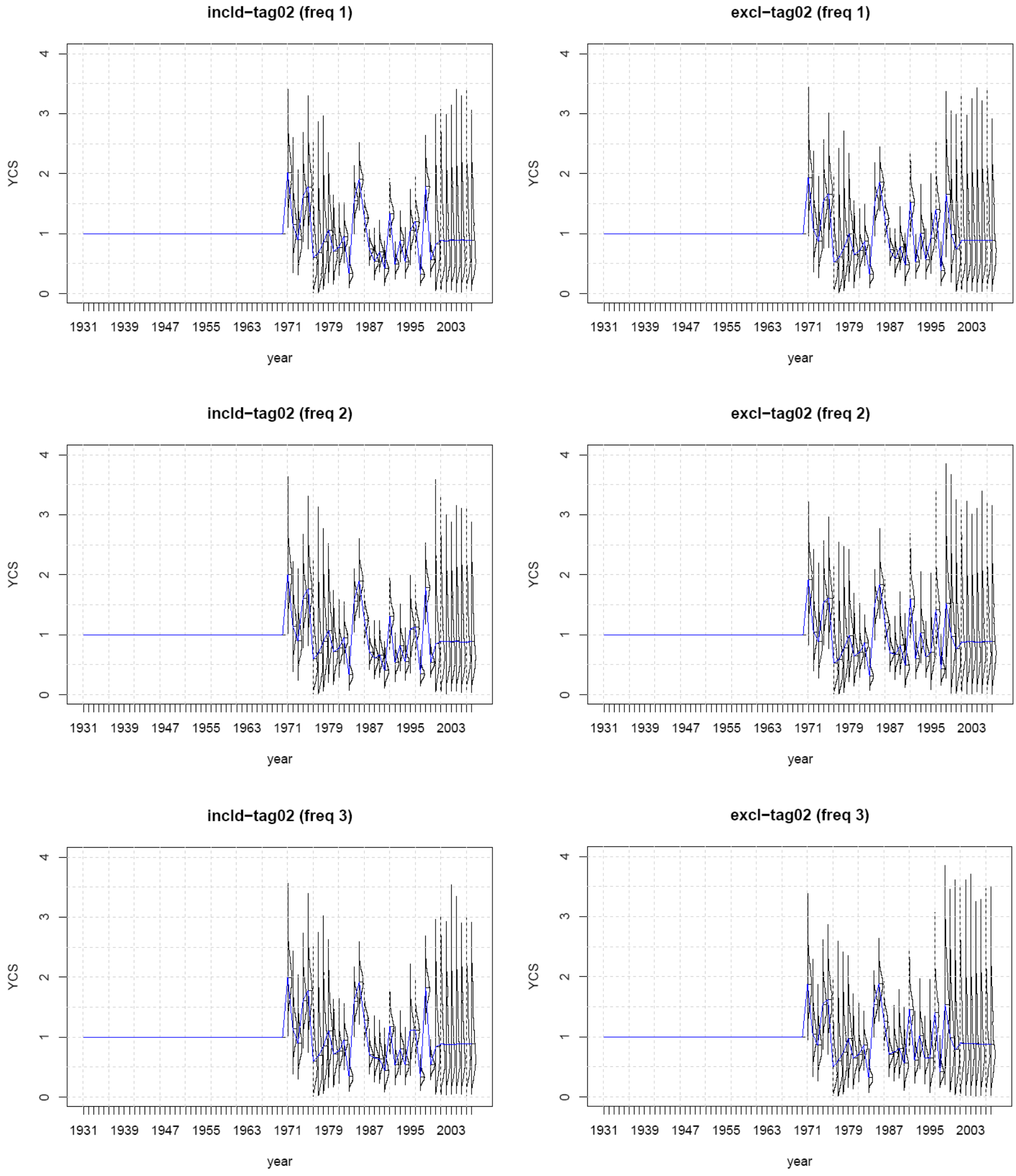
Appendix 1: Posteriors of Biomass/B0 from incld-tag02 and excl-tag02 models for the frequency scenarios (freq1, freq2 and freq3) for fishing years 1930–31 to 2009–10



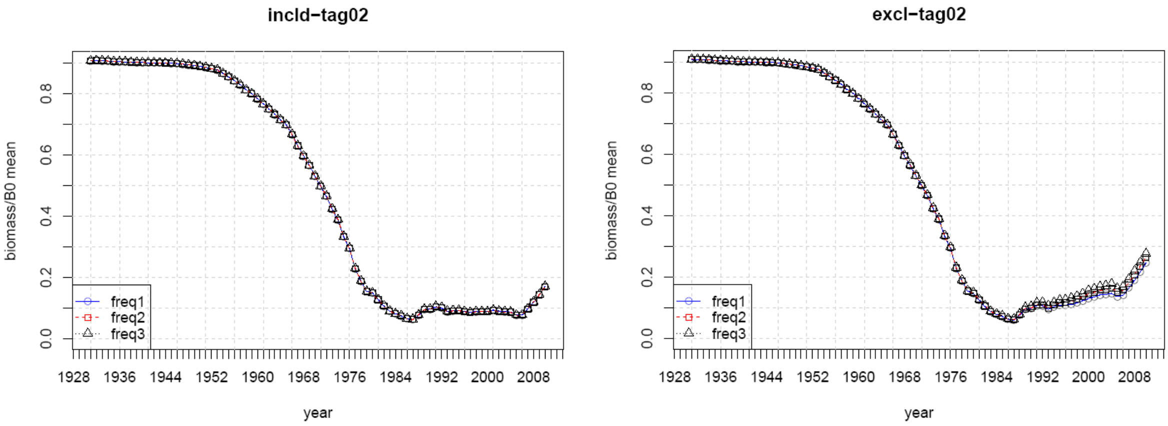
Appendix 2: Posteriors of relative abundance from incld-tag02 and excl-tag02 models for the frequency scenarios (freq1, freq2 and freq3) for fishing years 1930–31 to 2009–10



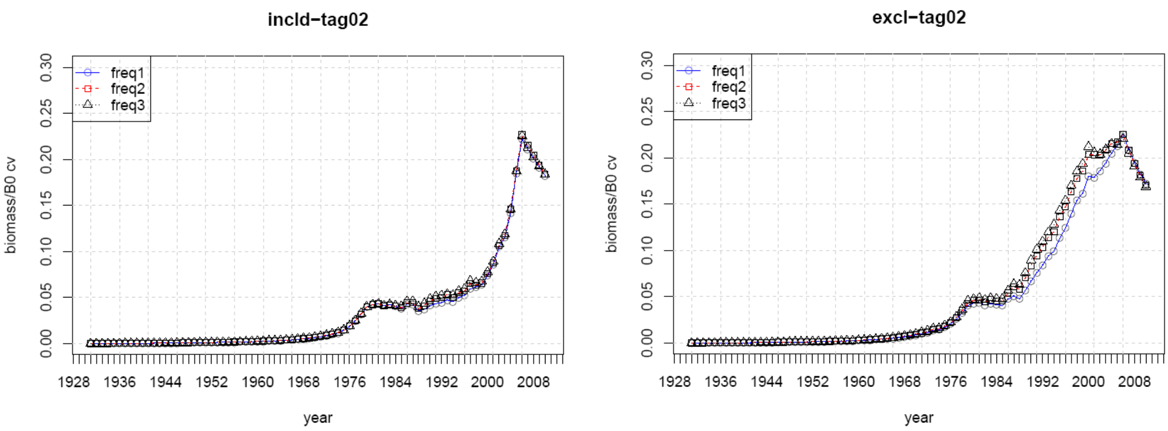
Appendix 3: Posteriors of recruitment YCS from incld-tag02 and excl-tag02 models for the frequency scenarios (freq1, freq2 and freq3) for fishing years 1930–31 to 2009–10



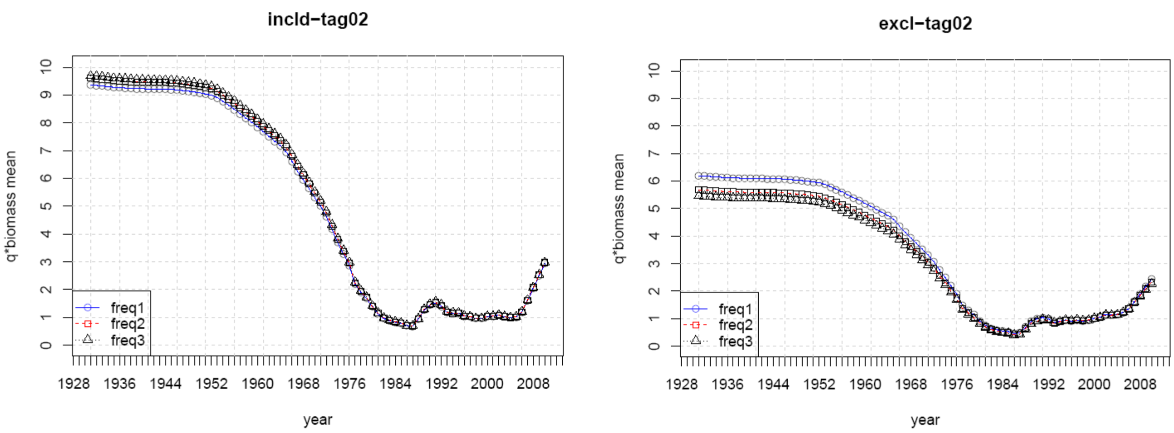
Appendix 4: Estimates of Biomass/B0 from incld-tag02 and excl-tag02 models for the frequency scenarios (freq 1, freq2 and freq3) for fishing years 1930–31 to 2009–10



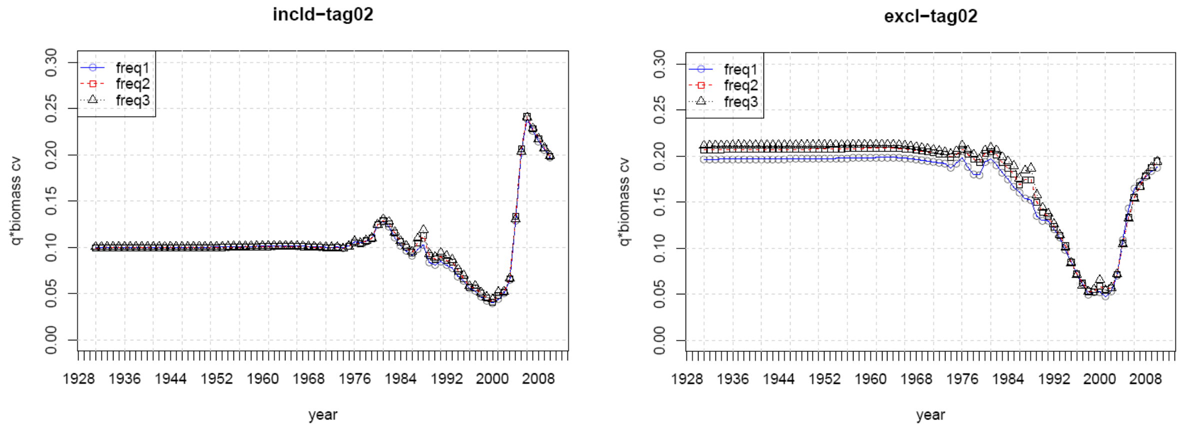
Appendix 5: Estimate c.v.s of Biomass/B0 from incld-tag02 and excl-tag02 models for the frequency scenarios (freq1, freq2 and freq3) for fishing years 1930–31 to 2009–10



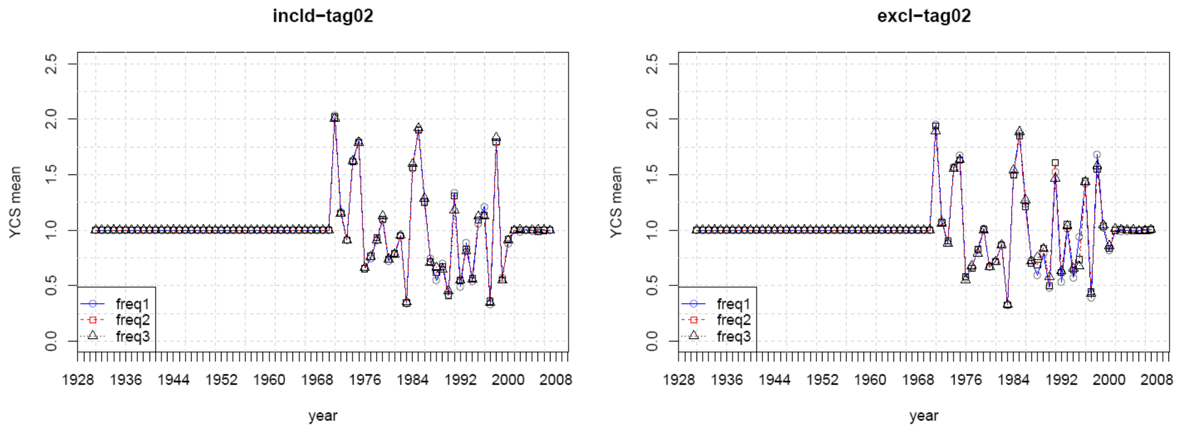
Appendix 6: Estimates of relative abundance from incld-tag02 and excl-tag02 models for the frequency scenarios (freq1, freq2 and freq3) for fishing years 1930–31 to 2009–10



Appendix 7: Estimate c.v.s of relative abundance from incld-tag02 and excl-tag02 models for the frequency scenarios (freq1, freq2 and freq3) for fishing years 1930–31 to 2009–10



Appendix 8: Estimates of recruitment YCS from incld-tag02 and excl-tag02 models for the frequency scenarios (freq1, freq2 and freq3) for fishing years 1930–31 to 2009–10



Appendix 9: Estimate c.v.s of recruitment YCS from incld-tag02 and excl-tag02 models for the frequency scenarios (freq1, freq2 and freq3) for fishing years 1930–31 to 2009–10