Initial Applications of Statistical Catch-at-Age Assessment Methodology to Atlantic redfish

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Summary

Age structured production model assessments are explored for four redfish populations. The reason for introducing age-structure into the models is to allow a sounder reality check of the estimates of the survey catchability coefficients q that result when the models are fit to data. The data fitted are the survey abundance trends plus catch-at-length information from both surveys and the commercial catches. The catches-at-length are used to estimate selectivity-at-age relationships, though some assumptions are required, particularly for the commercial information which is not available in species disaggregated form. Only for *S. fasciatus* in Unit 3 is the survey trend compatible with the expected impact of past catches in terms of a simple density-dependent population model, and the associated assessment results could be used to inform reference point determination for this population. However for the other three populations considered (*S. mentella* and *S. fasciatus* in Units 1+2 and *S. fasciatus* in 2J3K) further assumptions are needed (e.g. regime shifts related to changes in productivity) to achieve compatibility between model output and survey trends, so that population model-based assessment of the current status of these populations is problematic. The most immediate concern for these three populations would seem to be whether or not current levels of catch are sustainable, and a suggestion is made as to how that might be addressed.

Introduction

To our knowledge, McAllister and Duplisea (2011) reports the first attempt to use population model based assessments of the redfish populations in Atlantic Canada's EEZ to inform the determination of reference points. Clearly, in principle, the choice of management reference points, such as biomass LRPs, is best made on basis of the fits of such population models to available data.

However it is also important, before the results from such approaches might be adopted, to check that the models used do provide acceptable fits to these data. The estimates from these models also need to be checked for plausibility through considering their reasonable compatibility with comparative results for redfish populations elsewhere, and general understanding of the population monitoring data (such as abundance indices from surveys) to which the models are fit.

This paper presents the results of some initial applications of Statistical Catch-at-Age methodology (SCAA – sometimes known as Age Structured Production Models, or ASPM) to data for:

a) *S. mentella* in Units 1 + 2,
b) *S. fasciatus* in Units 1 + 2,
c) *S. fasciatus* in Divisions 2J3K, and
d) *S. fasciatus* in Unit 3.

The particular intent of this exercise is to perform the checks indicated above:

a) to examine whether models show consistency with trends in survey estimates of abundance (a diagnostic of particular importance in assessing the reliability of model results) for the simplest form of these models, or if not explore whether this consistency can be restored by admitting the possibility of simple changes over time in some model parameter; and
b) given that survey data have been analysed on a swept area basis, to provide estimates of abundance in absolute terms, to check whether the estimates of the values of the constants of proportionality (*q*) relating these to the biomass estimates provided by the population model fits appear plausible.

The special reason for moving from the age-aggregated production model framework of McAllister and Duplisea (2011) to SCAA is to be able to address b). Production models incorporate a somewhat artificial construction for the "biomass" which they estimate, and these estimates can be considerably biased as measures of the actual underlying resource abundance. In contrast, SCAA in the form of ASPM (with a deterministic stock recruitment function) provides the simplest approach which can claim to reflect the actual age-structure of the biomass being modelled and estimated, and hence provide estimates of *q* that would be expected to be close to 1 if all fish are available to the gear, and there is no appreciable herding by the net or avoidance behaviour by the fish. (Indeed redfish are semi-pelagic, and Power and Mowbray (2000) estimate that some 20% would be too high in the water column to be available to the research trawl gear, which lowers the value close to 1 just mentioned for *q* to 0.8.) We note, for example the recent estimates of *q* provided by NAFO XSA (age-structure based) assessments of redfish in Division 3M which range from 1.22 to 1.98, averaging 1.69 with a standard deviation of 0.41 (R Alpoim, pers. commn). An immediate expectation is that *q* estimates for assessments of the four stocks above should not differ greatly from these values unless some cogent rationale can be offered for the case in question.

Data and Methodology

The catch and survey based data (including catch-at-length information) and some biological data are listed in Tables in Appendix A.

The details of the SCAA assessment methodology are provided in Appendix B.

Particular difficulties for these redfish assessments arise from the facts that the commercial catches, and also information on their length distributions (in contrast to the situation for the surveys), do not distinguish the two species *S. mentella* and *S. fasciatus*. Thus catch by species information input to our assessments rests on assumptions and is open to question, while the combined species length distribution information likely reflects more smaller fish than in the actual *S. mentella* distribution, and *vice versa* for *S. fasciatus* (D Power, pers. commn). Though some of the SCAA models are fitted to combined species commercial catch length distributions, the inevitable errors that this involves should not be seen as necessarily a major impediment to the approach. This is because in moving to an ASPM approach for greater realism, the intent is to achieve this through use of a commercial selectivity-at-length function which is "in the right ball-park", rather than requiring exactitude.

In any case, in conducting these ASPM assessments, sensitivity to variations of the estimated selectivity-at-length function is investigated. Furthermore, for one of the three *S. fasciatus* stocks considered (Divisions 2J3K), commercial catch at length information was not available, so that the selectivity-at-length function estimated for *S. fasciatus* in Units 1+2 was used as a fixed input to this other ASPM assessment.

The decision was made to assume constant selectivity-at-length (though differing by species, and amongst surveys and commercial catches) for these assessments, as it seems likely to be more realistic than to assume constant selectivity-at-age in generating expected length distributions from the population model to fit to observed length distributions. The approach used assumes distributions of length-at-age that are invariant over time, leading to the effective selectivities-at-age age that are used in accounting for effect of catches on the age-structured population dynamics, as elaborated in Section B.3 of Appendix B.

Stock- specific features of the assessments and associated sensitivities conducted are as follows.

S. mentella in Units 1+2

As the simplest time-invariant ASPMs are unable to reflect the downward trends in the survey indices, a change in the unexploited equilibrium spawning biomass (*K*) is introduced, with the time (1982) of the change being determined so as to achieve the best fit to the data. Note that allowing *K* to change is effectively equivalent to changing expected recruitment levels in transitions between presumably different regimes with differing levels of productivity. For the Base Case chosen, the selectivity-at-length estimated from fitting to the commercial catch-at-length distributions is shifted to the right to allow qualitatively for the *S. mentella* tending towards the larger end of the combined species length distribution data (D. Power, pers. commn). Other sensitivities include:

- the time series commencing with the resource at different fractions of *K*,
- forcing the survey multiplicative bias factor *q* to be less than 1,
- allowing for error in the splitting of catches between species, both as an absolute percentage fixed over time, and as a trend over time, and
- increasing the natural mortality by 50% to 0.15.

S. fasciatus in Units 1+2

As above for *S. mentella*, a change in *K,* here from 1981, is needed to allow the model to reflect the downward trend in the survey in Unit 1 in the early 1990's. The Base Case shifts the estimated selectivity-at-length for the commercial catch to the left because the lengths of this species in this catch tend to be lower (D. Power, pers. commn). A sensitivity examines restricting the survey *q* to be less than 1, while another increases the natural mortality by 50% to 0.1875.

S. fasciatus in Divisions 2J3K

The approach here is similar to that for Units 1+2, and fixing the commercial selectivity-at-length to be the same as for the assessment for that region. Survey trends are, however, not compatible with a single change only in *K,* but require the more complex behaviour of a decrease from 1960 to 1970, followed later by an increase from 1990 to 2000 and constancy thereafter. The choice of this form was made by first conducting an assessment that allowed for a random walk in *K* from year to year, and then choosing a parsimonious parameterization of the temporal pattern that emerged.

S. fasciatus in Unit 3

Here there is some indication in the survey data of an upward response to the cutback in catches that occurred in the mid-1970s. Sensitivities focus mainly on varying the value of *q* for the standard assessment model without any change in *K* over time.

Results

S. mentella in Units 1+2

The results of the ASPM variants explored are listed in Table 1, with corresponding spawning biomass trajectories plotted in Fig. 1. The commercial and survey selectivities estimated for Cases 1 (M&D *K* and θ), 2 (*K* estimated and θ=1), 3a (as 2 but commercial selectivity-at-length shifted to the right by 5 cm) and the Base Case (as 2 but commercial selectivity-at-length shifted to the right by 10 cm) assessments are plotted in Fig. 2. (Note: the Base Case is what we would tentatively offer as the best of the various options we investigate for each population. In this case the allowance for a rightward shift in the commercial selectivity compared to that estimated from the length distribution for catches from the two species combined is an attempt to allowed for the difference in the length distributions, if disaggregated by species, as advised by D. Power.)

Cases 6 and 7 allow for error in the splitting of catches between species and the resulting assumed catch series are shown in Fig. 3.

The fit of the Base Case to the survey indices and the commercial and survey CAL are shown in Figs 4 and 5 respectively.

S. fasciatus in Units 1+2

The results of the ASPM variants explored for *S. fasciatus* in Units 1+2 are listed in Table 2, with corresponding spawning biomass trajectories plotted in Fig. 6. The commercial and survey selectivities estimated for Cases 3 (change in *K* in 1982), 4a (as 3 but commercial selectivity-at-length shifted to the left by 2 cm) and the Base Case (as 3 but commercial selectivity-at-length shifted to the left by 5 cm) assessments are plotted in Fig. 7.

The fit of the Base Case to the survey indices and the commercial and survey CAL are shown in Figs 8 and 9 respectively.

S. fasciatus in Division 2J3K

The results of the ASPM variants explored for *S. fasciatus* in Division 2J3K are listed in Table 3, with corresponding spawning biomass trajectories plotted in Fig. 10. The Base Case includes changes in carrying capacity over time and the resulting trajectory is also plotted in Fig. 10. The commercial and survey selectivities for the Base Case assessment are plotted in Fig. 11.

The fit of the Base Case to the survey index and the survey CAL are shown in Figs 12 and 13 respectively.

S. fasciatus in Unit 3

The results of the ASPM variants explored for *S. fasciatus* in Unit 3 are listed in Table 4, with corresponding spawning biomass trajectories plotted in Fig. 14. The commercial and survey selectivities for the Base Case assessment are plotted in Fig. 15.

The fit of the Base Case to the survey index and the commercial and survey CAL are shown in Figs 16 and 17 respectively.

Discussion

S. mentella 1+2: the Base Case provides a fit to the surveys that is just about acceptable (if one considers the earliest Unit 1 value an outlier – see Fig. 4). Once a change in *K* is admitted, the present resource status changes from highly depleted to generally above *K*. This arises because initially there are more older fish than would be present under pristine equilibrium conditions for the new lower *K*, with consequential lower recruitment, and catches after the drop in *K* take time to reduce this "reserve" of older fish. Other sensitivities make little qualitative difference. For the Unit 2 survey, *q* marginally exceeds 1 for the Base Case (Table 1).

S. fasciatus 1+2: a change in *K* is essential here to try to reflect the downward trend in the Unit 1 survey in the early 1990s, but the resultant fit to the data remains inadequate. The associated assessment suggests that while the resource had dropped to well below the original value of *K*, it is now above the MSY biomass level for the new lower *K*. For the Unit 2 survey, *q* for the Base Case is well above 1 at 3; for lower values of this *q*, the fits to the survey data trends deteriorate appreciably (Table 2).

S fasciatus 2J3K: this is an important case because after dropping to very low levels, the survey results have recently shown some increase (Fig. 12). This is not the case for either *S. mentella* or *S. fasciatus* in Unit 1+2 where the most recent survey results remain low, which could in turn suggest that some Allee effect might be in operation. This 2J3K case confirms that these redfish resources *can* recover from low survey values, which suggests that an Allee effect is less likely to be in operation for these populations. Similarly to the previous case, the Base Case model estimates *q* to be about 3, with substantial deterioration of fits to these data for lower *q* values (Table 3). This arises because lower *q* values mean larger abundances in absolute terms, and the catches taken then become too small to impact abundance and hence survey trends to the extent evident from the survey data.

S fasciatus Unit 3: Here the survey data are compatible with the standard population model, and the *q* estimate of 0.62 would seem perfectly plausible (Table 4). However because the data are fairly noisy, this estimate of *q* is not that precise, with a likelihood profile indicating a 95% CI range of [0.42; 0.87].

Generally fits to survey CAL data seem reasonable in terms of random patterns in residuals (except perhaps for *S. fasciatus* in 2J3K). There are however systematic effects for the commercial CAL data, which suggest changes over time in the selectivity pattern, but these seem unlikely to be sufficiently large to invalidate the utility of the results.

Increasing natural mortality, *M*, leads to lower estimates of *q*, but not always to improved fits to the data.

Concluding remarks

Only for one of the four cases considered (*S. fasciatus* in Unit 3) do these analyses suggest the survey data trends to be consistent with the impact of catches on abundance trends that is to be expected for a standard density-dependent population model. In this case the model fitted might be used to provide estimates of reference points.

However for the other three cases, one has either to assume a systematic change in *q* over time (which then really leaves little basis to draw inferences about population trends and statuses), or assume a shift to a less productive regime (lower *K* and lower recruitment), with a later reverse shift in one case.

While there are some aspects of these population model analyses which more complex approaches might resolve, these fundamental problems seem likely to remain, which raises the question of how then best to proceed? The most important management question for these other three resources would then seem to be whether or not current levels of catch are sustainable. One way of addressing that could be to select a plausible range for *q* based on existing satisfactory results (e.g. perhaps those for *S. fasciatus* in Unit 3 from this study and the NAFO analysis for 3M mentioned above), and use that information to provide ranges for current biomass in the other three cases considered here. Yield-per-recruit analyses, or the *S. fasciatus* Unit 3 analysis above, can provide estimates of sustainable fishing mortality levels. Combining these last with the biomass ranges would provide numbers that could be compared with current catch levels to reach some conclusions concerning their likely sustainability.

Acknowledgements

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References

McAllister M and Duplisea D. 2011. Production model fitting and projection for Atlantic redfish (*Sebastes fasciatus* and *Sebastes mentella*) to assess recovery potential and allowable harm.

Power D and Mowbray F. 2000. The status of redfish in Unit 2. DFO CSAS Res. Doc. 2000/136. 56pp.

Table 1: Results of fits of various SCAA variants for ***S. mentella* in Units 1 + 2**. Values fixed on input rather than estimated are shown in **bold**. Mass units are '000t. In cases where the value of the pre-exploitation spawning biomass *K* changes within the assessment period, the second column reports estimates for the latter period. M&D is McAllister and Duplisea (2011).

	Case 1		Case 2		Case 3a		Case 3b		Case 4a		Case 4b		Case 5a		Case 5b		Case 6a		Case 6b		Case 6c		Case 6d		Case 7a		Case 7b		Case 8	
	Initial as in M&D		Change in *K* in 1982		Comm Sel shifted 5cm to the right		**Base Case** Comm Sel shifted 10cm to the right		As BC, SR residuals estimated		As 4a, with $q<1$		As BC, θ=0.75		As BC, θ=0.5		As BC, +10% trend in catches		As BC -10% trend in catches		As BC, +100% trend in catches		As BC, -100% trend in catches		As BC, +10% in the proportion of *mentella*		As BC, -10% in the proportion of *mentella*		As BC, M=0.15	
-lnL: overall	293.3		42.6		81.1		152.0		94.9		114.6		165.7		176.5		145.3		157.5		141.3		182.3		151.4		152.6		144.0	
-lnL: survey	237.2		13.0		9.9		28.0		11.1		27.7		37.1		44.1		23.2		31.7		14.2		48.4		27.5		28.3		24.2	
-lnL: survCAL	24.8		7.2		19.1		5.3		12.9		3.7		5.9		6.9		5.6		5.5		13.7		7.8		5.3		5.4		8.2	
-lnL: comCAL	31.3		22.5		52.2		118.6		102.0		115.3		122.7		125.4		116.3		120.2		113.4		126.1		118.5		118.8		111.6	
-lnL: RecRes	0		0		0		0		-31.0		-32.1		0.0		0		0		0		0		0		0		0		0	
h	**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**	
M	**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.10**		**0.15**	
θ	**0.81**		**1.00**		**1.00**		**1.00**		**1.00**		**1.00**		**0.75**		**0.50**		**1.00**		**1.00**		**1.00**		**1.00**		**1.00**		**1.00**		**1.00**	
ζ	**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**	
K^{sp}	**1212**		800	34	715	35	793	36	802	31	799	48	1049	55	1552	87	742	33	834	40	630	50	1245	76	930	43	647	29	822	54
B^{sp}_{2009}	941		35		27		78		30		84		139		246		62		93		46		233		90		65		88	
B^{sp}_{2009}/K^{sp}	0.78		0.04	1.01	0.04	0.77	0.10	2.14	0.04	0.99	0.10	1.72	0.13	2.54	0.16	2.82	0.08	1.87	0.11	2.35	0.07	0.92	0.19	3.08	0.10	2.12	0.10	2.19	0.11	1.65
$MSYL^{sp}$	0.32		0.31		0.32		0.34		0.34		0.34		0.34		0.34		0.34		0.34		0.34		0.34		0.34		0.34		0.40	
B^{sp}_{MSY}	384		11		11		12		10		17		19		30		11		14		17		26		15		10		22	
MSY	43		1		1		1		1		2		2		4		1		2		2		3		2		1		3	
Survey	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}
Unit 1	0.07	(0.89)	0.71	(0.51)	0.96	(0.50)	0.36	(0.56)	0.83	(0.50)	0.35	(0.55)	0.21	(0.58)	0.13	(0.60)	0.44	(0.54)	0.31	(0.57)	0.55	(0.51)	0.14	(0.61)	0.31	(0.55)	0.44	(0.56)	0.27	(0.55)
Unit 2	0.13	(0.41)	2.29	(0.20)	3.11	(0.20)	1.02	(0.22)	2.68	(0.20)	1.00	(0.21)	0.59	(0.22)	0.34	(0.22)	1.28	(0.21)	0.87	(0.22)	1.73	(0.21)	0.36	(0.22)	0.88	(0.22)	1.24	(0.22)	0.86	(0.21)
σ_R_out	0		0		0		0		0.19		0.16		0		0		0		0		0		0		0		0		0	

Table 2: Results of fits of various SCAA variants for ***S. fasciatus* in Units 1 + 2**. Values fixed on input rather than estimated are shown in **bold**. Mass units are '000t. In cases where the value of the pre-exploitation spawning biomass *K* changes within the assessment period, the second column reports estimates for the latter period. M&D is McAllister and Duplisea (2011).

	Case 1		Case 2		Case 3		Case 4a		Case 4b		Case 5		Case 6	
	Initial as in M&D (1+2+3LNO)		*K* est, θ=1		As 2, change in *K* in 1981		As 3, Comm Sel shifted 2 cm to the left		**Base Case** As 3, Comm Sel shifted 5 cm to the		As BC, but *q*<1		As BC, *M*=0.1875	
-lnL: overall	176		252.9		116.5		119.4		128.6		162.7		144.5	
-lnL: survey	142		216.9		93.3		94.1		95.0		137.3		105.5	
-lnL: survCAL	-1.21		-0.2		-3.3		-4.5		-5.8		-0.5		-5.8	
-lnL: comCAL	34.7		36.2		26.6		29.8		39.5		25.9		44.8	
-lnL: RecRes	0		0		0		0		0		0.0		0	
h	**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**	
M	**0.125**		**0.125**		**0.125**		**0.125**		**0.125**		**0.125**		**0.188**	
θ	**0.80**		**1.00**		**1.00**		**1.00**		**1.00**		**1.00**		**1.00**	
ζ	**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**	
K^{sp}	3328		24343*		559	69	569	69	587	71	684	134	569	68
$B^{sp}{}_{2009}$	3176		24229		39		40		40		119		54	
$B^{sp}{}_{2009}/K^{sp}$	0.95		1.00		0.07	0.57	0.07	0.57	0.07	0.56	0.17	0.89	0.09	0.79
$MSYL^{sp}$	0.32		0.32		0.34		0.34		0.33		0.33		0.32	
$B^{sp}{}_{MSY}$	1057		7725		24		23		23		44		22	
MSY	138		997		3		3		3		5		4	
Survey	*q*'s	σ_{surv}	*q*'s	σ_{surv}	*q*'s	σ_{surv}	*q*'s	σ_{surv}	*q*'s	σ_{surv}	*q*'s	σ_{surv}	*q*'s	σ_{surv}
Unit 1	0.01	1.00	0.00	0.99	0.69	0.69	0.67	0.70	0.64	0.70	0.24	0.81	0.43	0.73
Unit 2	0.04	0.32	0.01	0.32	3.18	0.33	3.14	0.33	3.09	0.33	1.00	0.33	2.09	0.34
σ_R_out	0		0		0		0		0		0		0	

* Estimate is infinity – the fitting algorithm stops at this value

Table 3: Results of fits of various SCAA variants for ***S. fasciatus* in Divisions 2J3K**. Values fixed on input rather than estimated are shown in **bold**. Mass units are '000t. In cases where the value of the pre-exploitation spawning biomass *K* changes within the assessment period, the second column reports estimates for the middle period (1970-1990) and the third column for the end of the assessment period. M&D is McAllister and Duplisea (2011).

	Case 1		Case 2		Case 3			Case 4			Case 5		
	Initial as in M&D		*K* est, θ=1		**Base Case** 3 changes in *K*			As BC, with *q*=1.0			As BC, with *M*=0.1875		
-lnL: overall	1305.8		1186.1		335.1			492.7			342.7		
-lnL: survey	1283.4		1156.5		288.8			436.8			301.4		
-lnL: survCAL	22.4		29.6		46.3			55.8			41.3		
-lnL: comCAL	0.0		0.0		0.0			0.0			0.0		
-lnL: RecRes	0		0		0			0			0		
-lnL: Kpen													
h	**0.67**		**0.67**		**0.67**			**0.67**			**0.67**		
M	**0.125**		**0.125**		**0.125**			**0.125**			**0.188**		
θ	**0.91**		**1.00**		**1.00**			**1.00**			**1.00**		
ζ	**0.00**		**0.00**		**0.00**			**0.00**			**0.00**		
K^{sp}	**151**		24343*		187	3	123	223	3	349	238	3	62
$B^{sp}{}_{2009}$	135		24333		6			24			9		
$B^{sp}{}_{2009}/K^{sp}$	0.89		1.00		0.03	1.58	0.05	0.11	6.64	0.07	0.04	2.43	0.15
$MSYL^{sp}$	0.33		0.33		0.33			0.33			0.32		
$B^{sp}{}_{MSY}$	49		7954		40			114			20		
MSY	6		1001		5			14			4		
Survey	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}		q's	σ_{surv}		q's	σ_{surv}	
2J3K	0.15	(2.32)	0.001	(2.18)	3.58	(1.16)		**1.00**	(1.29)		**2.82**	(1.19)	
σ_R_out	0		0		0			0			0		

Table 4: Results of fits of various SCAA variants for ***S. fasciatus* in Unit 3**. Values fixed on input rather than estimated are shown in **bold**. Mass units are '000t. M&D is McAllister and Duplisea (2011).

	Case 1		Case 2		Case 3a		Case 3b		Case 3c		Case 4	
	Initial as in M&D		**Base Case** as 1, K est, θ=1		As BC, q=0.5		As BC, q=1.0		As BC, q=1.5		As BC, with M=0.1875	
-lnL: overall	95.2		78.5		79.2		82.7		93.1		68.3	
-lnL: survey	5.5		7.8		7.3		8.7		8.1		5.5	
-lnL: survCAL	47.4		34.5		35.7		34.8		39.0		28.5	
-lnL: comCAL	42.3		36.1		36.2		39.2		46.0		34.2	
-lnL: RecRes	0		0		0		0		0		0	
h	**0.67**		**0.67**		**0.67**		**0.67**		**0.67**		**0.67**	
M	**0.125**		**0.125**		**0.125**		**0.125**		**0.125**		**0.188**	
θ	**0.82**		**1.00**		**1.00**		**1.00**		**1.00**		**1.00**	
ζ	**0.00**		**0.00**		**0.00**		**0.00**		**0.00**		**0.00**	
K^{sp}	**3134**		202		220		179		170		409	
B^{sp}_{2009}	3053		127		149		89		61		374	
B^{sp}_{2009}/K^{sp}	0.97		0.63		0.68		0.49		0.36		0.91	
$MSYL^{sp}$	0.31		0.31		0.31		0.31		0.31		0.29	
B^{sp}_{MSY}	967		62		68		55		53		121	
MSY	113		7		8		7		6		23	
Survey	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}	q's	σ_{surv}
Unit 3	0.02	(0.70)	0.62	(0.74)	**0.50**	(0.73)	**1.00**	(0.75)	**1.50**	(0.74)	0.16	(0.70)
σ_R_out	0		0		0		0		0		0	

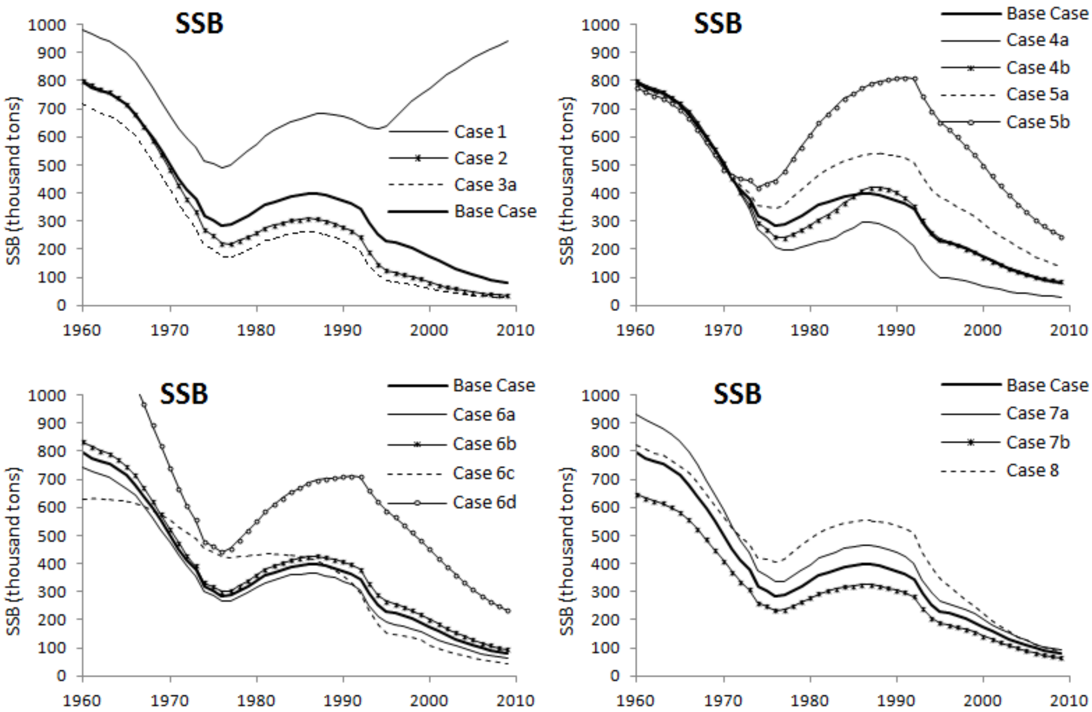

Figure 1: Spawning biomass trajectories in absolute terms for the different variants for ***S. mentella*** **in Unit 1 + 2**.

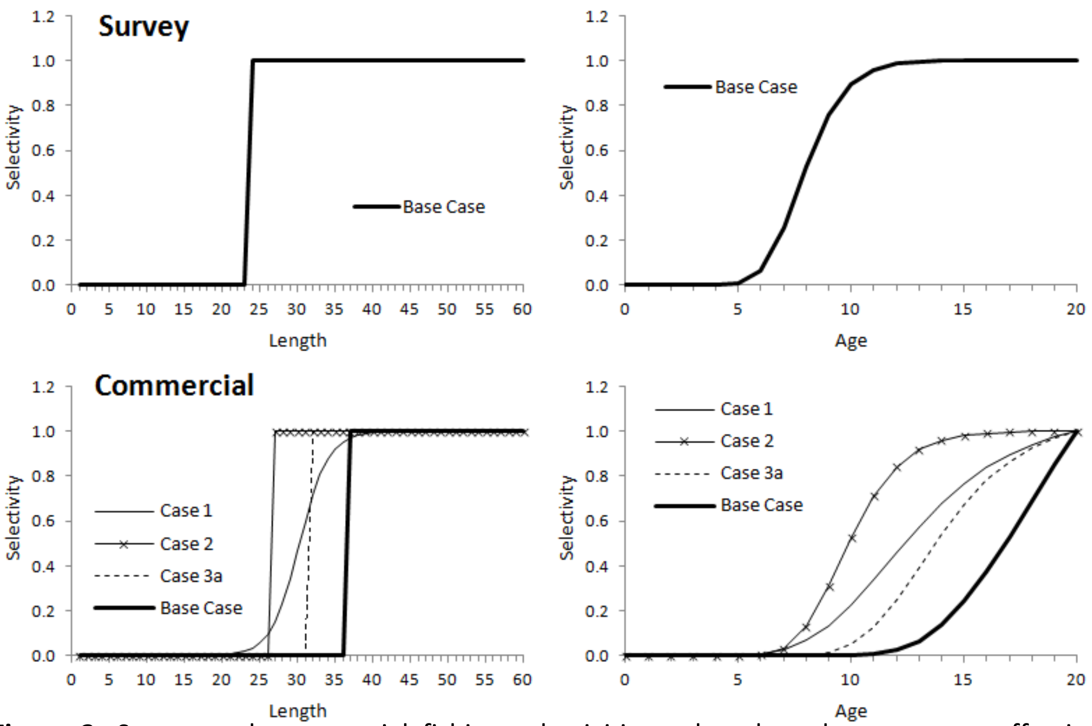

Figure 2: Survey and commercial fishing selectivities-at-length and consequent effective selectivities-at-age estimated for Cases 1, 2, 3a and the Base Case assessments for ***S. mentella*****, Units 1 + 2**. The survey selectivities for all four cases are set to be the same as for the Base Case.

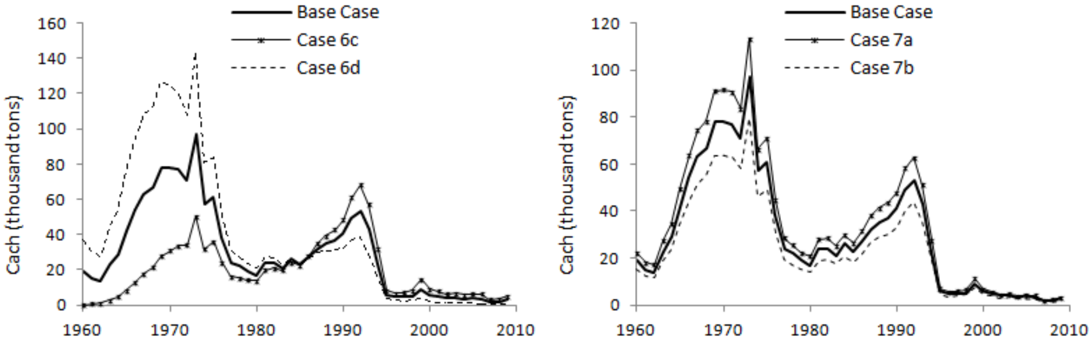

Figure 3: Total catch assumed for ***S. mentella*, Units 1 + 2** for the Base Case assessment, Cases 6c, 6d (Cases 6a and 6b lie between these and the Base Case) and Cases 7a, 7b.

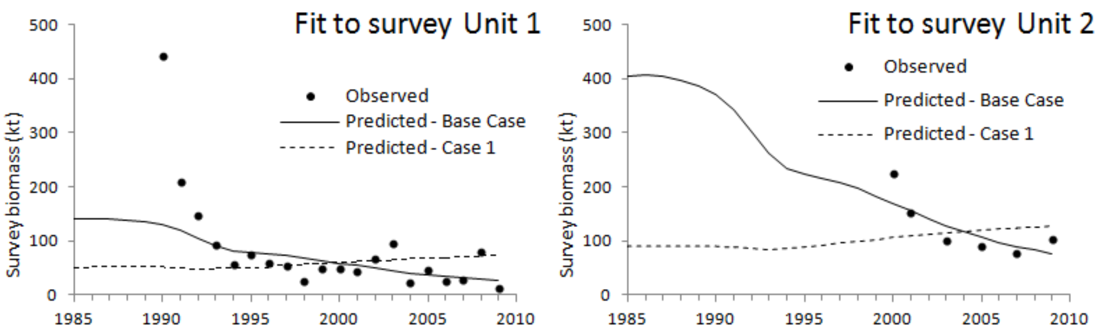

Figure 4: Fit to the survey abundance indices for the Base Case and Case 1 assessments for ***S. mentella* in Unit 1 + 2**.

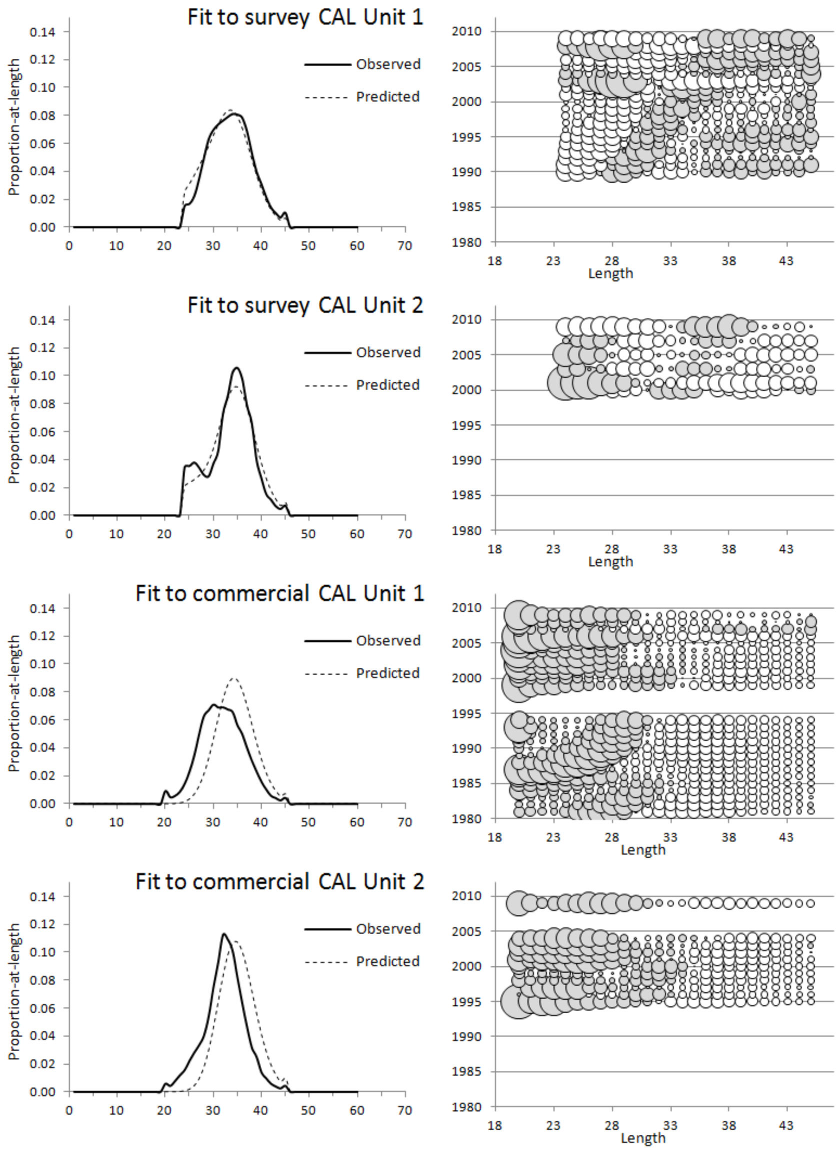

Figure 5: Fit of the Base Case assessment for ***S. mentella*** **in Unit 1 + 2** to the survey and commercial catch-at-length data. The left side plots compare the observed and predicted CAL as averaged over all years for which data are available, while the right side plots show the standardised residuals, with the size (area) of the bubbles being proportional to the magnitude of the corresponding standardised residuals. For positive residuals, the bubbles are grey, whereas for negative residuals, the bubbles are white.

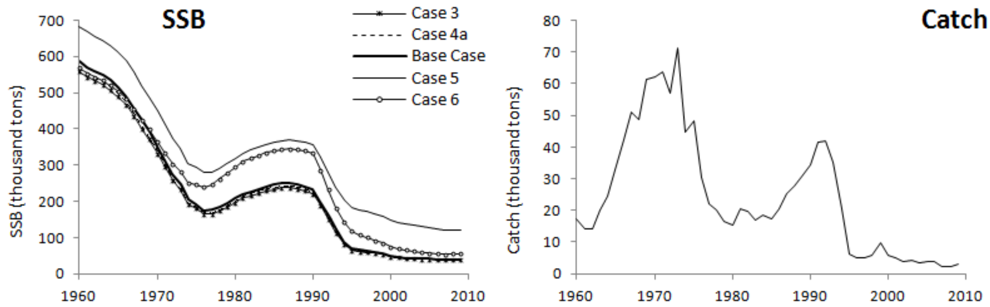

Figure 6: Spawning biomass trajectories in absolute terms for different variants of the assessment and total catch assumed for ***S. fasciatus* in Unit 1 + 2**.

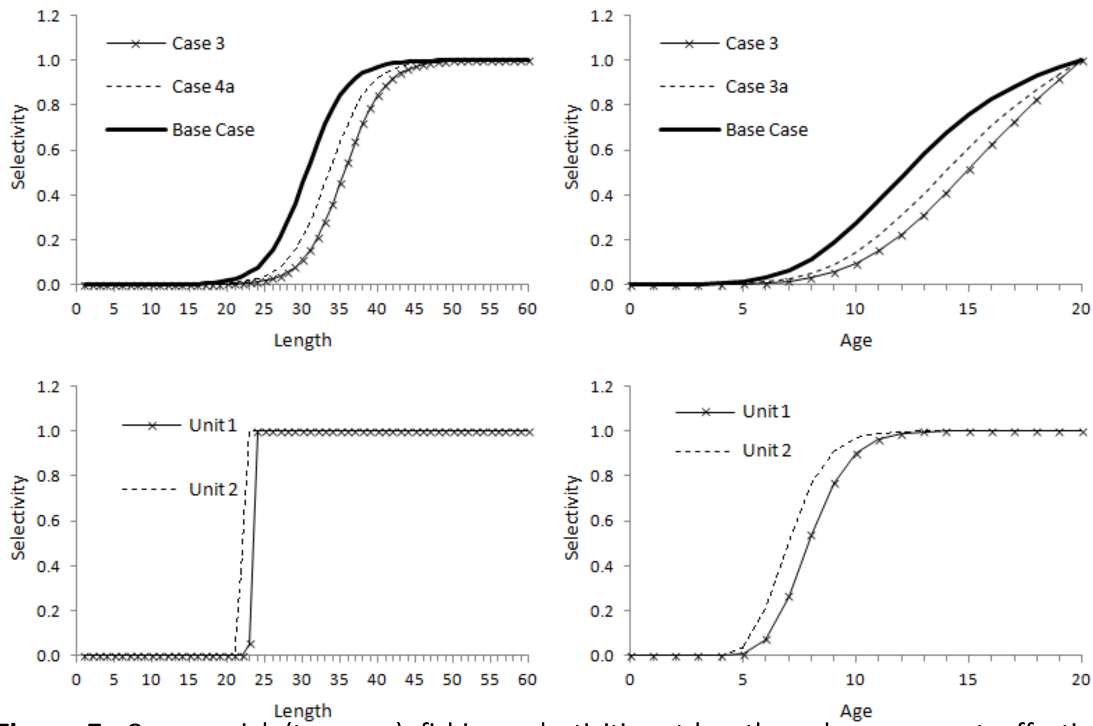

Figure 7: Commercial (top row) fishing selectivities-at-length and consequent effective selectivities-at-age estimated for Cases 3, 4a and the Base Case and survey (bottom row) fishing selectivities-at-length and at-age for the Base Case assessment for ***S. fasciatus*, Units 1 + 2**.

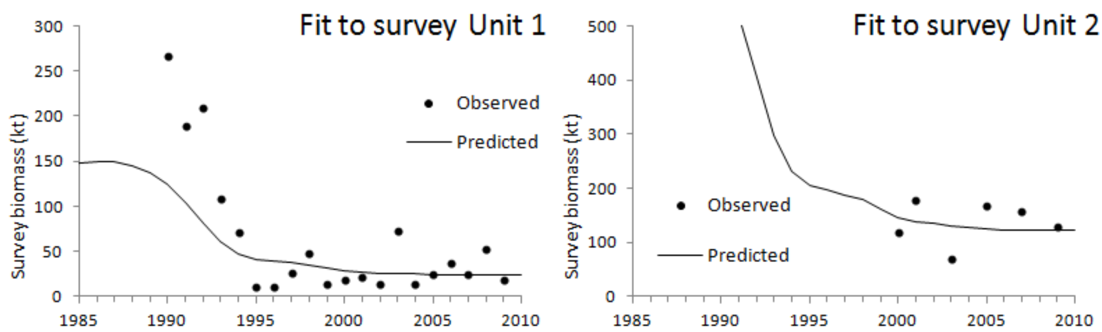

Figure 8: Fit to the survey abundance indices for the Base Case assessment for ***S. fasciatus* in Unit 1 + 2**.

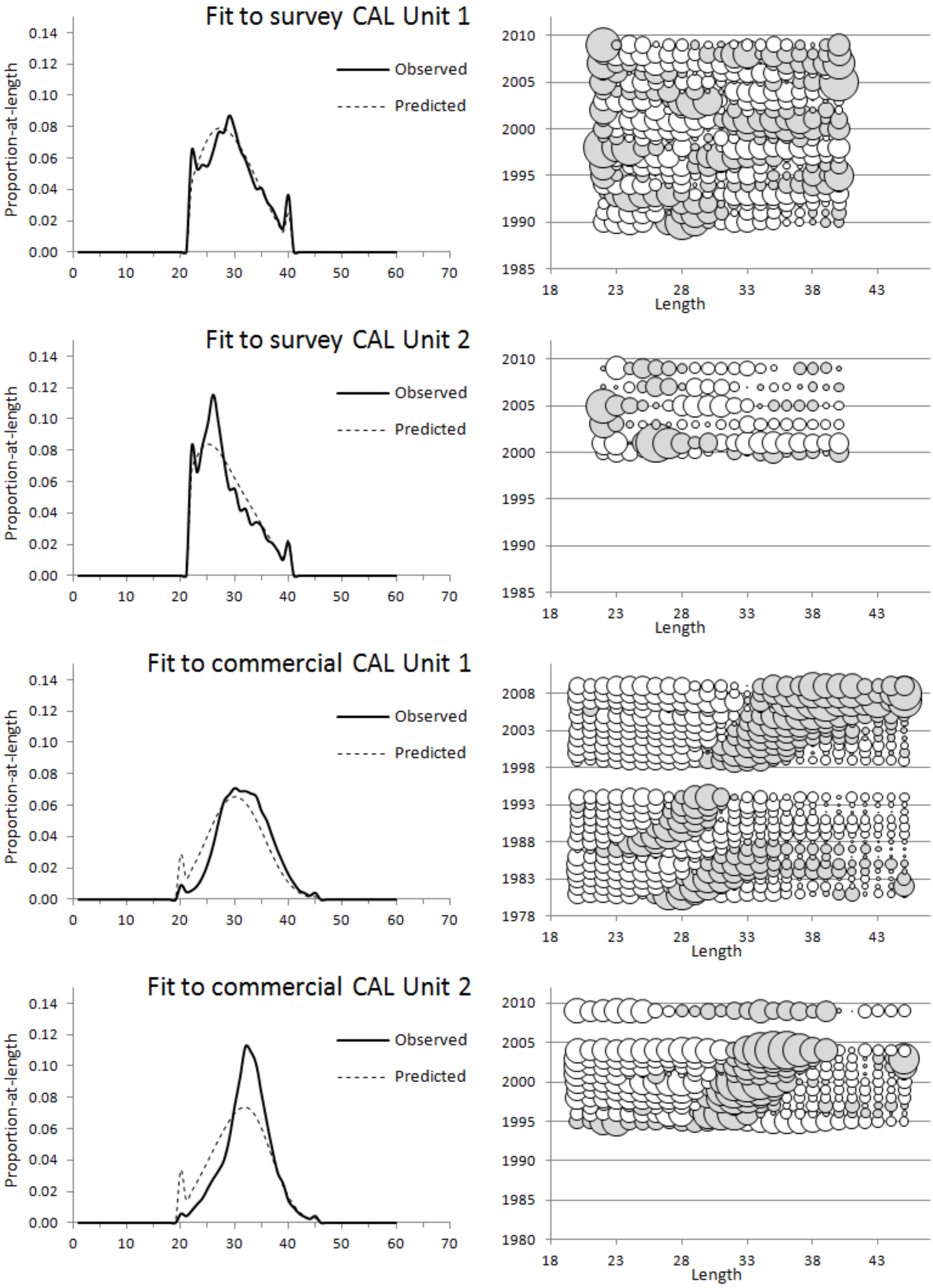

Figure 9: Fit of the ***S. fasciatus*** **Unit 1 + 2** Base Case assessment to the survey and commercial catch-at-length data. The left side plots compare the observed and predicted CAL as averaged over all years for which data are available, while the right side plots show the standardised residuals, with the size (area) of the bubbles being proportional to the magnitude of the corresponding standardised residuals. For positive residuals, the bubbles are grey, whereas for negative residuals, the bubbles are white.

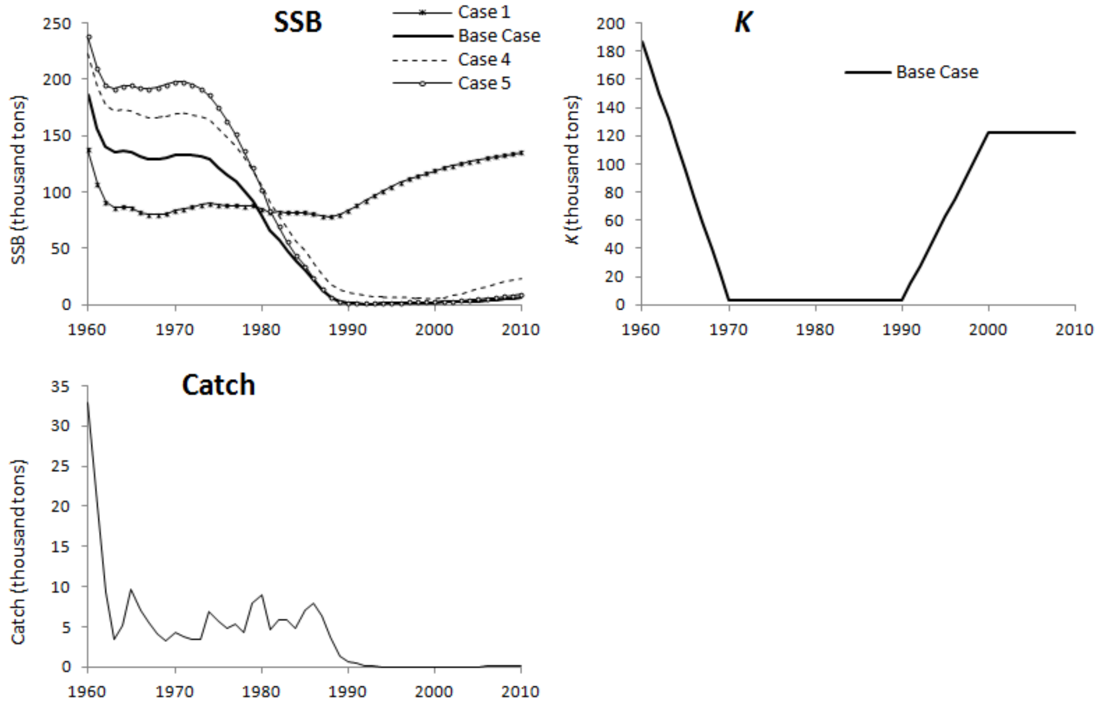

Figure 10: Spawning biomass trajectories in absolute terms for different variants of the assessment for ***S. fasciatus* in Divisions 2J3K**. The changes in carrying capacity for the Base Case are shown in the top right-hand plot. The total catch assumed is shown in the bottom plot.

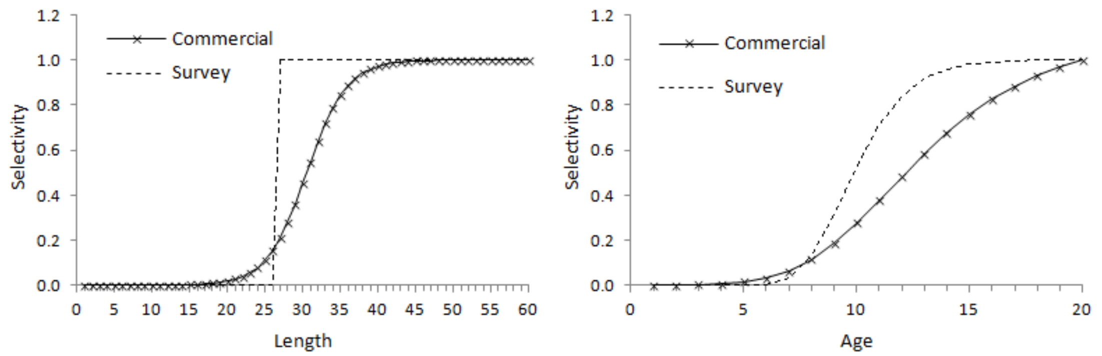

Figure 11: Commercial and survey fishing selectivities-at-length and consequent effective selectivities-at-age for the Base Case assessment for ***S. fasciatus*, Divisions 2J3K**.

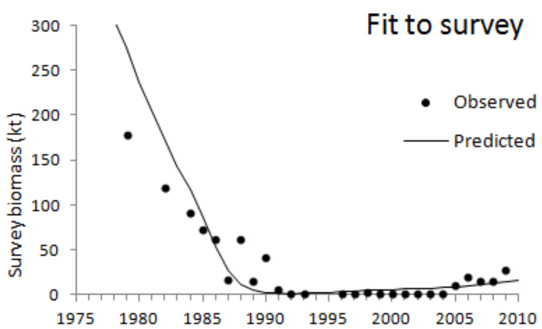

Figure 12: Fit to the survey abundance index for the Base Case assessment for ***S. fasciatus* in Divisions 2J3K**.

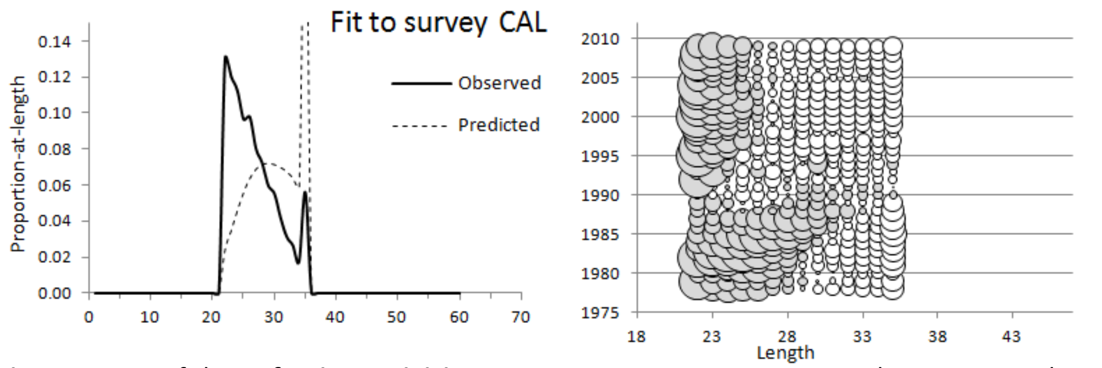

Figure 13: Fit of the ***S. fasciatus*** **Divisions 2J3K** Base Case assessment to the survey catch-at-length data. The left side plot compares the observed and predicted CAL as averaged over all years for which data are available, while the right side plot shows the standardised residuals, with the size (area) of the bubbles being proportional to the magnitude of the corresponding standardised residuals. For positive residuals, the bubbles are grey, whereas for negative residuals, the bubbles are white.

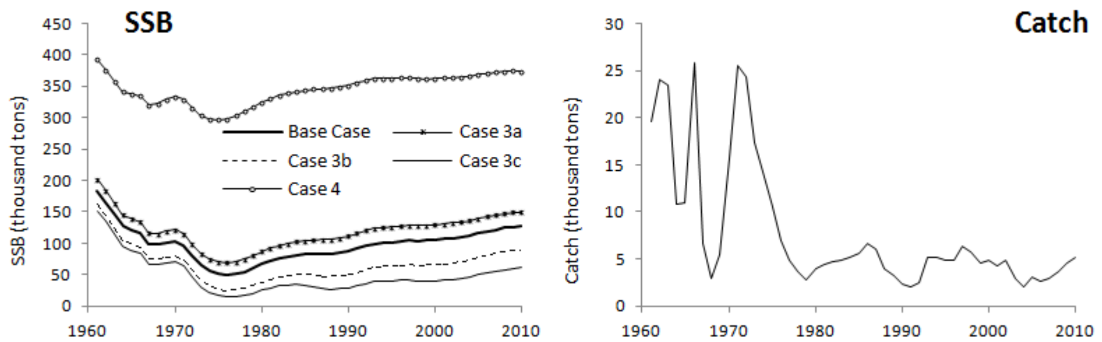

Figure 14: Spawning biomass trajectories in absolute terms for different variants of the assessment and total catch assumed for ***S. fasciatus*** **in Unit 3**.

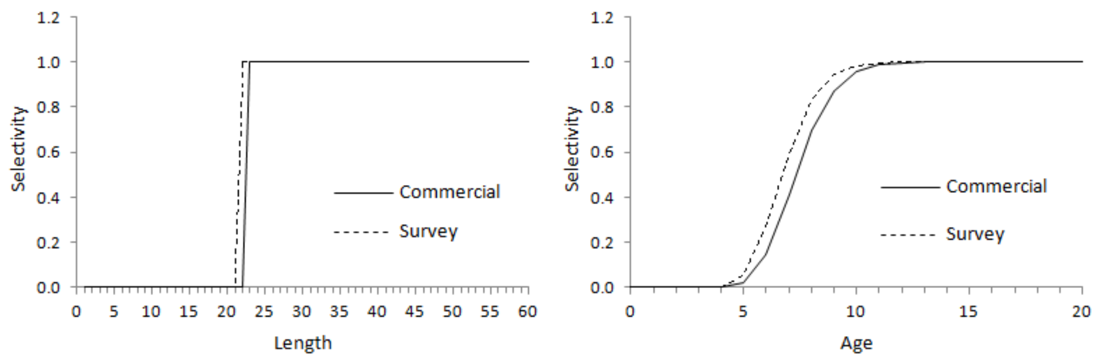

Figure 15: Commercial and survey selectivities-at-length and consequent effective selectivities-at-age estimated for the Base Case assessment for ***S. fasciatus*****, Units 1 + 2**.

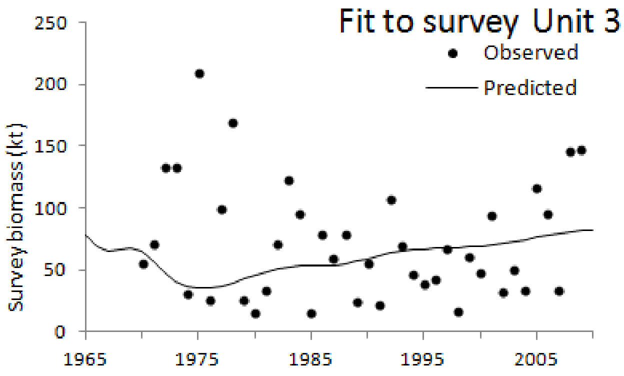

Figure 16: Fit to the survey abundance index for the Base Case assessment for ***S. fasciatus* in Unit 3**.

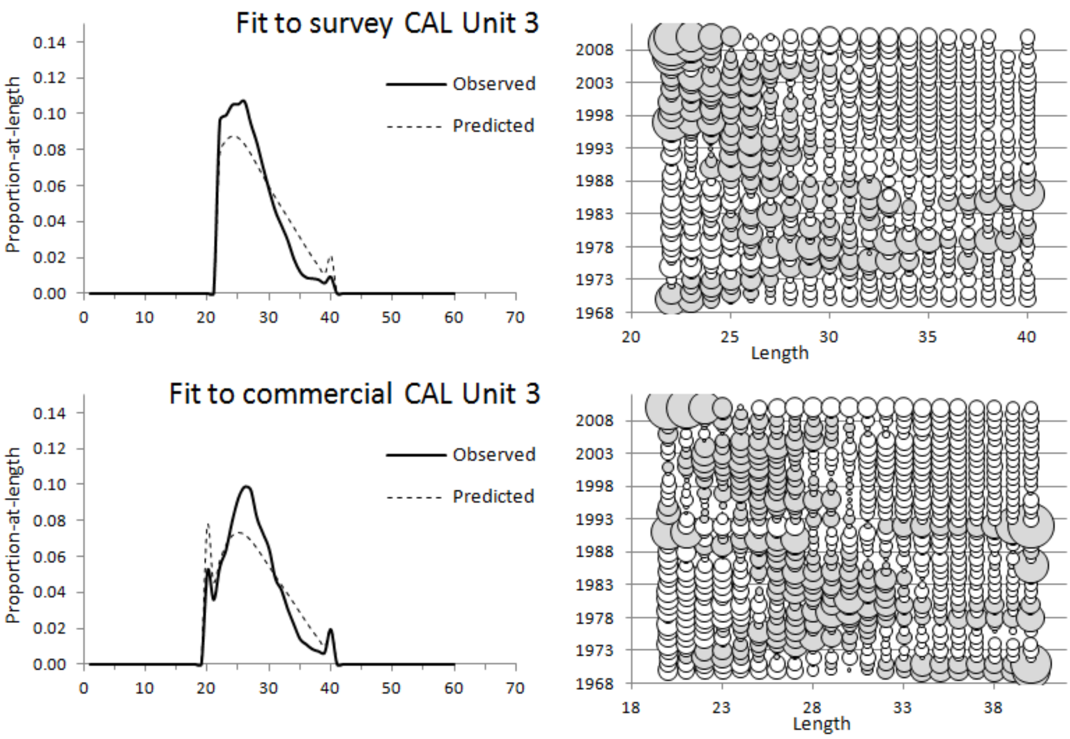

Figure 17: Fit of the ***S. fasciatus* Unit 3** Base Case assessment to the survey and commercial catch-at-length data. The left side plots compare the observed and predicted CAL as averaged over all years for which data are available, while the right side plots show the standardised residuals, with the size (area) of the bubbles being proportional to the magnitude of the corresponding standardised residuals. For positive residuals, the bubbles are grey, whereas for negative residuals, the bubbles are white.

APPENDIX A – Data

Note: Units are throughout cm for length and yr for time.

Table A1: Catch in kt for *S. mentella* and *S. fasciatus* in the different management units.

	S. mentella		*S. fasciatus*	
Year	unit 1 + 2	unit 1 + 2	2J3K	unit 3
1960	18.68	17.44	33.00	20.10
1961	15.28	14.11	20.03	19.60
1962	14.34	14.11	9.30	24.00
1963	23.00	20.11	3.36	23.50
1964	29.24	24.48	5.12	10.80
1965	41.97	32.69	9.60	11.00
1966	54.13	42.22	7.13	25.90
1967	63.00	51.08	5.54	6.60
1968	66.62	48.81	4.13	2.90
1969	77.17	61.42	3.17	5.40
1970	77.56	62.35	4.29	15.70
1971	76.73	63.66	3.71	25.60
1972	70.81	56.94	3.35	24.40
1973	96.60	71.33	3.35	17.30
1974	56.27	44.85	6.93	14.20
1975	60.14	48.38	5.67	10.50
1976	37.79	30.30	4.73	7.00
1977	23.80	22.02	5.37	4.80
1978	21.48	20.00	4.33	3.70
1979	18.70	16.49	8.01	2.80
1980	17.40	15.27	8.93	4.00
1981	23.48	20.32	4.66	4.40
1982	24.06	19.70	5.88	4.70
1983	21.33	17.12	5.76	4.90
1984	25.32	18.65	4.84	5.20
1985	22.42	17.41	7.00	5.60
1986	26.83	20.34	7.88	6.60
1987	32.22	25.18	6.32	6.10
1988	35.02	27.60	3.83	3.90
1989	36.84	31.03	1.40	3.30
1990	40.43	34.25	0.67	2.30
1991	49.21	41.53	0.49	2.00
1992	53.16	41.76	0.10	2.50
1993	43.15	35.37	0.05	5.20
1994	23.26	20.46	0.02	5.20
1995	5.96	6.34	0.01	4.80
1996	4.61	4.87	0.00	4.80
1997	4.85	5.13	0.00	6.40
1998	5.40	5.64	0.00	5.80
1999	9.31	9.69	0.01	4.50
2000	5.64	5.77	0.01	4.80
2001	4.74	4.84	0.01	4.30
2002	3.80	3.87	0.01	4.80
2003	3.99	4.31	0.01	3.00
2004	3.28	3.55	0.02	2.10
2005	3.50	3.89	0.03	3.10
2006	3.32	3.84	0.05	2.70
2007	1.74	2.11	0.07	2.90
2008	1.87	2.27	0.06	3.60
2009	2.55	3.18	0.05	4.60

Table A2: Swept area mature (i.e. >24cm for *S. mentella*, and >22cm for *S. fasciatus*) biomass estimates (in kt) and coefficients of variation (CVs) for *S. mentella* in Units 1 and 2, from MacAllister and Duplisea (2011), table 4.

	S. mentella				*S. fasciatus*							
Year	Unit 1	CV	Unit 2	CV	Unit 1	CV	Unit 2	CV	2J3K	CV	Unit 3	CV
1970	-	-	-	-	-	-	-	-	-	-	55	0.7
1971	-	-	-	-	-	-	-	-	-	-	71	0.7
1972	-	-	-	-	-	-	-	-	-	-	133	0.7
1973	-	-	-	-	-	-	-	-	-	-	133	0.7
1974	-	-	-	-	-	-	-	-	-	-	31	0.7
1975	-	-	-	-	-	-	-	-	-	-	209	0.7
1976	-	-	-	-	-	-	-	-	-	-	26	0.7
1977	-	-	-	-	-	-	-	-	-	-	100	0.7
1978	-	-	-	-	-	-	-	-	438	0.477	169	0.7
1979	-	-	-	-	-	-	-	-	178	1.032	26	0.7
1980	-	-	-	-	-	-	-	-	552	1.073	15	0.7
1981	-	-	-	-	-	-	-	-	711	0.49	34	0.7
1982	-	-	-	-	-	-	-	-	120	0.377	71	0.7
1983	-	-	-	-	-	-	-	-	1064	0.421	123	0.7
1984	-	-	-	-	-	-	-	-	92	0.246	96	0.7
1985	-	-	-	-	-	-	-	-	73	0.248	15	0.7
1986	-	-	-	-	-	-	-	-	62	0.586	79	0.7
1987	-	-	-	-	-	-	-	-	17	0.254	59	0.7
1988	-	-	-	-	-	-	-	-	62	0.527	79	0.7
1989	-	-	-	-	-	-	-	-	16	0.526	25	0.7
1990	443.012	0.272	-	-	267.287	-	-	-	41	1.084	56	0.7
1991	208.702	0.209	-	-	188.551	-	-	-	6	0.35	22	0.7
1992	147.726	0.206	-	-	208.862	-	-	-	1	0.384	107	0.7
1993	93.656	0.370	-	-	108.936	-	-	-	1	0.106	69	0.7
1994	55.785	0.185	-	-	70.997	-	-	-	0	0.201	47	0.7
1995	73.626	0.112	-	-	11.269	-	-	-	0	0.086	38	0.7
1996	59.242	0.175	-	-	10.183	-	-	-	2	0.208	42	0.7
1997	52.723	0.131	-	-	26.261	-	-	-	1	0.915	67	0.7
1998	26.391	0.186	-	-	47.989	-	-	-	3	0.309	17	0.7
1999	47.859	0.235	-	-	13.266	-	-	-	2	0.166	61	0.7
2000	49.549	0.122	223.464	0.233	19.033	-	119.324	0.498	1	0.217	48	0.7
2001	43.549	0.139	151.356	0.140	21.572	-	177.111	0.7	2	0.179	94	0.7
2002	67.468	0.797	-	-	13.495	-	-	-	1	0.665	32	0.7
2003	95.821	0.609	100.795	0.196	71.947	-	69.214	0.144	1	0.105	50	0.7
2004	23.963	0.219	-	-	14.234	-	-	-	2	0.941	33	0.7
2005	46.166	0.106	90.993	0.118	24.429	-	168.187	0.277	11	0.287	116	0.7
2006	25.042	0.125	-	-	37.737	-	-	-	20	0.685	96	0.7
2007	28.034	0.094	76.633	0.185	24.09	-	158.346	0.145	15	0.223	33	0.7
2008	79.371	0.462	-	-	52.778	-	-	-	16	0.214	146	0.7
2009	11.550	0.147	103.860	0.164	18.683	-	127.709	0.694	28	0.277	147	0.7

Table A3a: Commercial catch-at-length (number) for Atlantic redfish (all species combined) in Unit 1 (Daniel Duplisea, pers. commn)

Length	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
10-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
15	0	0	0	25	9	5	34	24	4	18	5	20	69	8	3	0	1	2	1	0	2	0	0	0	0
16	0	5	12	78	15	85	23	11	4	33	56	108	1455	39	5	0	2	6	4	4	1	0	0	0	0
17	0	0	1	60	47	64	173	24	2	37	82	102	561	28	10	1	4	9	6	5	3	0	0	0	3
18	3	1	10	42	41	175	356	71	8	41	50	205	504	38	8	1	1	10	7	11	5	4	0	1	1
19	24	7	1	70	60	169	786	72	5	45	65	307	309	30	10	1	1	4	3	11	7	9	0	3	4
20	75	30	26	272	121	400	1378	189	30	22	50	313	227	46	14	3	7	5	4	14	10	28	0	1	6
21	157	73	78	429	330	790	2306	518	75	45	113	278	461	34	20	3	11	14	10	7	10	46	0	0	7
22	170	87	103	372	365	843	3988	1700	569	79	154	336	264	58	17	4	11	19	13	4	13	37	0	1	4
23	228	272	258	395	786	1232	5177	4603	1815	433	349	438	475	105	21	5	11	26	18	10	18	35	0	2	3
24	981	434	546	437	1354	2300	5919	10401	6025	1530	957	902	487	215	16	10	21	30	21	16	13	35	0	3	7
25	2987	1212	769	810	1620	3337	4300	15548	13354	5457	2220	1965	923	461	21	11	16	60	42	29	17	32	0	6	10
26	6335	2301	1338	1394	1600	4632	3519	14592	19007	15571	6771	6198	2684	949	24	15	25	50	35	31	22	80	0	5	27
27	10618	6007	2480	2286	1760	5415	3505	8669	19823	24636	15194	14648	6809	2001	37	21	47	60	42	37	42	103	0	8	29
28	10985	10642	5281	3829	2646	5341	3770	4675	13187	25363	22146	22907	15034	3773	51	27	69	66	47	58	45	128	1	16	36
29	7815	12281	8692	5891	3651	5150	4037	3825	7784	18290	20968	25930	19200	6063	86	74	102	50	35	38	40	106	2	18	55
30	4720	10130	9495	9479	5878	6821	4835	4659	6613	11038	16180	21442	17271	6834	192	129	167	69	49	56	63	144	1	27	52
31	2534	6544	8512	9733	6747	7889	6239	6345	6501	8279	11062	14932	11961	5340	216	196	225	132	93	94	69	121	2	34	51
32	2214	3939	6083	8760	7413	8111	7989	7396	7119	7951	8619	10861	7465	3946	282	283	258	185	130	111	88	102	4	36	60
33	2007	2778	3635	6919	6577	7587	8202	8843	7559	6839	7437	9490	5367	2901	252	304	270	227	160	140	122	92	10	37	60
34	1553	2045	2325	5168	5137	5996	8427	8570	6990	7107	7268	9020	4971	2314	244	221	265	256	180	180	139	99	13	48	74
35	950	1620	1803	3842	3473	4298	6745	7105	5347	5561	5970	7577	4405	2248	171	220	211	218	153	184	164	68	9	56	82
36	1154	1392	1437	3176	2524	3129	4972	4947	3997	4212	4080	6475	3481	1804	135	163	198	202	142	160	155	71	17	57	68
37	894	1286	1330	2531	1998	2182	3622	3794	2921	3020	3277	5148	3301	1070	93	103	114	141	100	136	145	57	19	53	54
38	743	632	910	2134	1783	1859	2974	2754	2053	2087	2367	3942	2529	814	70	73	75	100	71	80	114	42	15	47	67
39	640	445	580	1723	1057	1475	2051	2014	1465	1627	1746	3015	2124	634	48	49	36	67	47	63	86	25	15	39	46
40	622	338	403	1119	822	815	1489	1420	1004	988	1123	1977	1361	486	35	26	30	54	38	40	58	19	8	28	37
41	524	239	212	535	445	537	879	896	769	518	708	1334	810	173	20	25	9	39	27	18	33	11	6	23	27
42	120	133	100	367	353	356	663	561	439	275	390	951	551	118	11	9	3	18	12	10	22	4	4	14	12
43	25	81	83	114	219	198	323	363	271	200	224	534	295	45	5	13	3	14	10	8	13	3	5	7	7
44	2	84	46	66	188	127	168	249	119	100	108	320	155	29	2	8	2	9	6	8	10	2	1	7	8
45	8	72	25	59	58	44	77	91	47	38	73	128	122	12	1	5	1	3	2	1	3	3	2	7	3
46	0	54	37	28	23	53	47	43	27	15	33	76	49	8	0	3	1	1	1	2	2	1	1	2	3
47	8	89	51	12	20	26	28	26	9	15	12	29	13	5	0	1	0	2	1	2	2	1	1	5	1
48	1	81	31	7	11	7	23	26	1	2	2	15	3	0	0	2	1	1	1	1	1	0	0	2	1
49	1	67	43	10	16	4	1	6	5	0	0	0	1	2	0	1	0	1	1	0	0	0	0	2	0
50	0	95	13	14	14	2	6	1	0	16	0	6	8	0	0	1	3	0	0	0	0	0	0	0	1
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A3b: Commercial catch-at-length (numbers) for Atlantic redfish (all species combined) for Unit 2 (Don Power, pers. commn)

Length	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2009
10-	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	3	0	0
15	6	0	0	0	0	0	0	0	2	0	0
16	13	0	0	0	0	0	1	0	2	0	1
17	45	0	0	8	2	1	3	0	6	0	10
18	148	0	0	0	0	4	5	2	10	15	24
19	389	0	0	17	4	6	13	4	12	6	39
20	458	1	0	0	3	5	47	15	31	0	39
21	521	2	111	18	2	3	41	43	69	31	51
22	1104	1	259	17	14	9	101	65	100	52	22
23	1489	3	444	38	25	17	136	98	142	119	55
24	1123	5	628	49	50	14	356	129	232	156	141
25	1279	3	924	157	97	15	521	178	342	187	243
26	1708	3	483	273	132	17	745	236	445	264	519
27	1966	55	667	346	156	31	640	344	530	330	660
28	2592	323	739	487	226	78	643	343	531	267	923
29	3191	1266	1059	1059	593	212	565	298	543	302	944
30	3364	2321	1366	1793	1127	425	576	454	636	376	1064
31	3434	2756	1435	2471	1918	731	751	529	787	473	1001
32	2746	2817	1995	2886	2455	1138	914	632	1098	882	1082
33	1733	2106	1779	2562	2234	1244	1063	730	1299	1168	1007
34	1282	1421	1780	1958	2113	1100	998	657	1414	1405	1080
35	842	1199	1527	1599	1414	851	879	501	1257	1330	813
36	649	855	1063	1036	924	592	704	475	1053	1184	726
37	410	676	852	831	619	359	467	328	842	888	576
38	281	515	543	672	467	306	296	196	499	561	401
39	212	428	652	462	384	219	214	130	300	405	395
40	198	320	268	342	252	129	155	94	170	116	170
41	106	214	324	198	179	75	90	55	106	93	108
42	66	141	131	107	93	53	94	51	83	33	30
43	41	90	106	73	63	24	41	40	79	22	16
44	34	41	82	32	38	18	30	31	58	9	6
45	18	25	38	16	20	3	23	26	55	5	2
46	13	6	35	7	6	4	11	18	39	6	4
47	8	8	0	3	1	1	8	19	34	2	0
48	0	2	1	2	0	0	0	8	23	0	1
49	0	0	1	0	0	0	5	4	14	0	0
50	7	0	0	0	0	0	5	2	14	0	1
51	0	0	0	1	0	0	2	1	6	0	0
52	0	0	0	0	0	0	1	1	10	0	0
53	1	0	0	0	0	0	1	0	5	0	0
54	0	0	0	0	0	0	0	1	4	0	0
55+	0	0	0	0	0	0	8	0	4	0	0

Table A3c: Commercial catch-at-length (in thousands) for Atlantic redfish (assumed to be all *S. fasciatus*) for Unit 3 (Peter Comeau, pers. commn)

Length	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
10-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	2	0	0	0	0	0	0	0	0	3	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	30	4	0	0	0	0	0	0	0	2	0	0	5	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	19	57	10	0	0	0	0	0	0	0	5	21	5	0	0	0	1
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	9	50	78	24	0	0	2	4	0	3	0	12	30	11	11	5	0	24
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	27	0	0	61	0	18	111	146	49	10	15	9	2	0	19	2	14	69	22	12	9	3	88
17	0	0	18	144	0	0	0	0	0	0	0	0	0	0	0	10	11	18	2	23	0	245	0	63	314	197	74	13	27	3	14	0	36	0	20	134	97	42	33	42	190
18	0	25	0	96	0	0	0	0	0	0	0	0	2	0	0	13	62	6	0	75	33	294	0	69	501	261	97	72	147	51	61	0	117	47	20	235	260	91	74	138	777
19	24	0	87	776	0	0	17	0	0	15	8	31	18	7	5	26	150	135	85	72	68	453	0	304	565	381	173	176	204	151	277	1	270	98	51	176	259	249	291	543	2537
20	50	0	703	2147	191	41	17	87	0	46	23	86	104	23	9	114	232	221	89	244	71	563	0	379	660	655	275	654	303	519	705	3	814	304	205	166	241	374	504	1030	5198
21	386	39	1213	2278	667	53	94	211	25	60	35	165	117	53	35	123	387	663	73	478	165	1037	6	289	703	638	426	635	630	588	813	3	1229	523	354	244	233	377	754	1108	5508
22	549	151	2289	6714	2911	383	583	414	48	30	106	453	76	241	103	102	419	898	396	1014	216	508	19	874	942	775	696	1335	934	1144	1223	5	2061	1162	712	547	320	481	787	1054	4443
23	734	623	2286	7013	3716	1398	2106	690	112	147	123	560	163	228	161	248	473	1123	456	1202	534	575	19	696	1015	1071	868	1792	1182	1105	1367	5	1696	1065	601	873	478	656	1152	1081	2870
24	1011	1094	1749	6676	4582	2770	2357	1613	315	224	226	742	495	633	366	672	625	1387	530	1013	855	357	6	1295	1460	1256	1129	1984	1777	1641	1651	6	2400	1146	815	1156	524	772	1133	1185	1686
25	890	1705	1513	5927	4828	3499	3238	1233	475	576	363	815	994	956	767	1624	871	1897	768	1174	1176	418	16	1277	1634	1736	1771	1737	1673	1622	1584	6	2141	1263	1001	1183	660	809	1269	1156	1087
26	736	1699	1319	4768	4984	4121	2679	1661	750	838	435	1266	1430	1454	1266	1876	1331	2144	1077	1288	973	416	35	1115	1449	1842	2143	1891	1787	1578	1682	5	1845	1096	1015	1138	678	821	1072	1074	737
27	876	1883	1094	5328	6449	3540	2378	1619	812	803	733	950	1739	1575	1462	2263	1305	2027	1012	1110	1167	451	71	1119	1418	1646	2009	1544	1736	1285	1528	4	1413	933	727	1221	720	754	1002	1236	616
28	1182	2641	614	4038	3193	4357	1500	1282	534	867	644	1162	1305	1427	1722	1783	1201	1526	670	528	529	413	189	1270	1203	1363	1750	1318	1266	1075	990	3	959	520	560	1186	758	946	992	1138	538
29	1128	2764	682	3056	2520	2745	1143	972	590	1190	840	1143	985	1375	1103	1782	1038	1476	653	492	310	353	203	1298	1106	1209	1545	1199	1165	886	1002	2	776	443	444	872	633	710	944	1017	448
30	1258	2006	486	2650	2854	1940	987	855	620	873	783	1746	1000	1163	1229	1570	1140	1471	809	298	181	272	200	960	846	850	894	1106	1022	857	982	2	782	327	257	657	508	637	626	887	341
31	1425	2561	392	1927	1493	1707	1255	858	486	482	883	710	1078	953	1222	1116	869	953	396	403	226	168	190	678	498	463	447	556	594	424	464	1	424	195	134	298	463	531	455	693	315
32	1681	2457	538	1848	1299	1111	364	443	426	422	671	821	862	874	1119	882	752	842	555	326	242	113	241	638	467	448	319	528	533	295	397	1	291	172	125	169	356	426	416	532	371
33	1443	2620	511	1539	1350	1322	388	405	323	170	436	289	511	501	720	616	514	449	473	268	158	176	302	670	278	273	200	428	446	291	259	0	189	125	68	72	258	261	284	362	237
34	1835	3259	519	835	919	427	358	261	258	61	361	239	141	328	408	354	262	247	391	150	83	178	270	387	248	158	128	296	301	208	214	0	96	97	42	38	199	95	152	232	184
35	1732	2298	304	431	600	153	134	242	202	47	231	65	76	161	117	182	152	163	273	40	24	72	222	120	167	107	78	207	253	136	144	0	58	65	28	27	122	77	72	129	82
36	1351	2064	292	409	398	76	139	198	282	29	204	8	95	102	54	29	104	141	121	11	22	66	189	103	108	83	27	203	131	121	134	0	49	67	17	24	104	31	43	71	42
37	1050	1675	156	275	259	53	165	35	236	12	163	6	28	90	23	6	123	64	92	8	6	14	176	153	137	73	24	190	126	105	114	0	26	56	21	5	47	20	13	23	27
38	1090	1383	96	214	135	0	161	17	158	0	183	7	22	45	18	2	260	4	110	7	5	13	180	108	76	63	18	134	89	70	71	0	16	56	14	4	19	2	9	22	23
39	959	1208	65	40	110	0	93	0	141	1	93	4	5	16	10	2	169	9	109	3	2	0	285	79	47	39	10	88	80	67	65	0	12	44	8	4	18	5	7	19	9
40	898	1599	55	105	18	0	66	0	17	0	100	2	4	6	5	0	222	0	130	4	0	0	349	24	46	40	7	112	59	65	51	0	9	35	6	2	3	2	6	14	4
41	890	1512	77	0	18	0	36	0	145	0	34	0	1	2	2	0	143	0	67	1	0	0	163	0	35	13	3	60	31	38	31	0	7	22	5	1	0	0	1	8	2
42	806	1021	63	0	0	0	4	0	21	0	7	0	1	1	0	0	245	0	40	2	0	0	84	0	31	11	3	70	28	26	33	0	8	24	6	2	3	1	1	6	0
43	322	732	18	0	0	0	0	0	60	0	22	0	0	3	0	0	116	0	22	1	0	0	33	1	33	5	2	73	21	19	16	0	3	18	3	1	1	0	0	2	1
44	194	466	7	0	0	0	0	0	39	0	11	0	0	1	0	0	193	0	16	0	0	0	3	0	23	2	0	58	24	14	17	0	1	14	2	1	0	0	0	1	0
45	101	60	4	0	0	0	0	0	49	0	25	0	0	0	0	0	205	0	10	0	0	0	0	0	5	2	0	50	17	10	4	0	1	12	1	1	2	0	0	3	0
46	44	119	0	0	0	0	0	0	23	0	7	0	0	0	0	0	103	0	14	0	0	0	0	0	15	1	0	24	17	7	3	0	0	6	0	1	0	0	0	1	0
47	0	0	0	0	0	0	0	0	11	0	11	0	0	0	0	0	90	0	12	0	0	0	0	0	7	0	0	16	7	1	0	0	0	4	0	0	0	0	0	0	0
48	11	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	13	0	5	0	0	0	0	0	0	0	0	5	3	2	2	0	0	1	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	5	3	0	1	0	0	1	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A4a: Survey catch-at-length (numbers) for *S. mentella* for Unit 1 and Unit 2 (Daniel Duplisea, pers. commn)

	Unit 1																					Unit 2					
Length	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2000	2001	2003	2005	2007	2009
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.006	0.003	0.011	0.000	0.000	0.000	0.000	0.000	0.016	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.138	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.573	0.165	0.140	0.017	0.000	0.019	0.056	0.015	0.058	0.006	0.030	0.011	0.000	0.000	0.000	0.715	0.002	0.002	0.006	0.000	0.002	0.004	0.000	0.054	0.378	0.032	0.092
8	23.080	1.628	0.195	0.043	0.000	0.159	0.266	0.025	0.458	0.108	0.634	0.143	0.012	0.031	0.000	2.852	0.006	0.047	0.035	0.011	0.020	0.000	0.778	0.266	7.180	0.073	0.237
9	72.781	2.569	0.682	0.345	0.007	0.541	1.229	0.196	0.957	0.582	1.715	0.353	0.154	0.176	0.020	12.212	0.030	0.229	0.143	0.009	0.027	0.000	3.738	0.301	15.815	0.059	0.430
10	21.101	19.418	0.556	0.190	0.019	0.251	0.812	0.246	1.556	0.644	0.627	0.343	0.322	0.371	0.072	10.155	0.502	0.489	0.099	0.009	0.023	0.292	17.513	0.147	9.910	0.182	0.280
11	0.658	65.248	1.751	0.138	0.141	0.026	0.261	0.256	0.344	0.554	0.160	0.090	0.296	0.143	0.036	1.753	3.453	0.043	0.049	0.005	0.024	0.255	19.679	0.235	2.382	0.017	0.580
12	0.674	118.381	7.019	0.323	0.545	0.067	0.481	0.576	0.228	1.261	0.626	0.566	0.584	0.207	0.083	0.132	8.219	0.232	0.109	0.064	0.078	0.497	4.630	1.020	1.761	0.415	0.717
13	1.185	62.509	13.365	1.065	1.043	0.191	0.772	0.942	0.525	2.870	1.714	1.148	0.443	1.229	0.160	0.097	5.164	3.995	0.099	0.136	0.087	0.634	8.134	1.412	1.013	2.720	2.416
14	1.888	6.927	13.987	0.888	0.961	0.282	0.517	1.080	0.565	2.434	2.182	0.894	0.295	2.152	0.219	0.173	0.733	14.497	0.070	0.127	0.081	1.042	8.960	2.873	1.137	16.205	5.122
15	3.282	1.927	6.140	1.593	1.005	0.462	0.171	0.676	0.809	1.013	1.661	0.373	0.235	1.610	0.178	0.163	0.036	35.305	0.112	0.056	0.191	2.248	8.492	3.155	0.975	56.719	5.859
16	4.975	2.194	0.709	2.040	1.373	0.680	0.220	0.456	0.787	0.452	1.378	0.693	0.395	0.909	0.302	0.250	0.030	37.413	0.247	0.053	0.250	3.409	12.158	2.596	2.309	26.708	3.381
17	7.019	2.617	0.573	1.827	1.360	1.200	0.365	0.605	0.664	0.478	2.115	0.939	0.663	0.722	0.880	0.267	0.066	13.978	0.606	0.090	0.385	4.677	19.240	2.388	5.351	11.535	3.682
18	5.372	2.274	0.786	0.564	0.886	0.905	0.349	0.531	0.633	0.392	1.844	0.688	0.409	0.346	1.154	0.338	0.117	1.862	0.731	0.106	0.296	6.096	22.243	1.538	9.410	3.591	5.453
19	1.721	1.547	0.683	0.375	0.609	0.724	0.555	0.349	0.439	0.375	0.697	0.766	0.471	0.365	0.816	0.393	0.176	0.131	0.334	0.112	0.370	8.379	17.505	1.480	13.214	1.267	4.837
20	0.650	0.747	0.553	0.169	0.341	0.625	0.660	0.243	0.301	0.240	0.396	0.692	0.409	0.529	0.474	0.530	0.188	0.163	0.284	0.140	0.360	5.508	13.945	2.193	14.337	1.743	3.793
21	0.592	0.767	0.615	0.258	0.128	0.331	0.554	0.186	0.148	0.297	0.380	0.763	0.359	0.559	0.276	0.647	0.339	0.217	0.204	0.129	0.609	3.593	16.192	1.757	12.097	1.623	1.843
22	0.844	0.505	0.694	0.244	0.179	0.254	0.481	0.219	0.185	0.287	0.258	0.391	0.352	0.432	0.204	0.750	0.121	0.273	0.406	0.060	0.512	2.328	11.980	2.543	9.456	1.450	0.487
23	1.023	0.558	1.201	0.211	0.140	0.193	0.362	0.252	0.128	0.205	0.250	0.184	0.290	0.483	0.207	0.491	0.186	0.244	0.752	0.032	1.460	1.694	9.932	2.767	6.705	2.069	0.394
24	2.176	0.790	1.582	0.155	0.159	0.194	0.211	0.168	0.080	0.148	0.202	0.046	0.240	1.572	0.218	0.381	0.085	0.215	2.186	0.016	1.415	2.376	12.382	2.641	4.664	1.911	0.650
25	5.389	1.281	1.701	0.220	0.224	0.037	0.150	0.160	0.096	0.140	0.216	0.110	0.187	1.431	0.220	0.251	0.109	0.194	2.819	0.029	2.994	3.038	12.137	2.793	3.870	2.733	0.484
26	11.972	2.455	2.594	0.419	0.387	0.134	0.093	0.159	0.157	0.110	0.165	0.133	0.089	3.019	0.148	0.223	0.092	0.178	3.627	0.063	3.644	3.232	12.542	2.001	4.293	3.559	0.847
27	22.362	6.029	5.490	0.929	0.676	0.220	0.230	0.073	0.102	0.166	0.172	0.164	0.083	4.367	0.237	0.319	0.095	0.220	5.616	0.044	4.270	2.786	9.966	2.590	3.557	3.331	0.953
28	35.122	11.062	9.966	2.799	0.876	0.740	0.366	0.275	0.085	0.129	0.188	0.200	0.069	7.265	0.278	0.268	0.043	0.273	5.095	0.034	5.037	2.553	8.449	1.702	3.018	2.863	1.172
29	33.783	14.903	11.077	4.878	1.973	2.104	0.780	0.576	0.189	0.238	0.278	0.268	0.089	8.706	0.209	0.241	0.101	0.241	4.996	0.040	4.506	4.528	8.584	1.646	2.446	1.868	1.554
30	22.904	13.858	10.435	7.867	3.053	3.476	1.790	1.240	0.360	0.578	0.382	0.258	0.422	5.650	0.212	0.264	0.062	0.192	3.299	0.093	4.712	7.217	8.155	2.714	3.262	2.289	2.841
31	14.262	10.580	7.241	9.038	2.916	4.024	2.549	2.487	0.777	1.202	0.815	0.430	0.632	2.227	0.304	0.390	0.118	0.228	0.920	0.143	1.917	12.009	9.136	3.365	3.871	2.502	3.326
32	8.846	6.101	5.660	5.922	2.569	3.325	3.001	2.601	1.366	1.700	1.089	1.001	1.517	2.620	0.305	0.776	0.151	0.224	0.555	0.137	0.825	21.620	10.624	6.370	6.253	4.080	4.728
33	6.960	4.691	3.312	4.114	1.609	2.736	2.632	2.840	1.261	2.074	1.870	1.188	2.970	1.256	0.407	0.944	0.382	0.368	0.759	0.188	0.612	24.614	12.358	7.278	6.460	4.929	6.776
34	8.007	3.947	3.245	3.038	1.585	1.873	2.272	1.966	0.993	2.406	1.636	1.625	3.792	1.118	0.571	1.381	0.480	0.509	1.423	0.236	1.482	26.932	13.032	9.733	7.937	6.387	8.410
35	9.197	4.035	2.971	2.090	1.398	1.872	1.618	1.731	1.109	1.753	2.084	1.785	2.915	1.391	0.705	1.600	0.641	0.606	1.418	0.276	0.577	24.998	11.736	9.642	8.816	6.568	10.620
36	10.800	4.164	2.213	1.833	1.263	2.000	1.233	1.364	0.674	1.455	1.796	1.678	2.795	1.714	0.681	1.429	0.882	0.781	1.677	0.415	0.695	17.598	10.802	9.371	8.053	7.368	10.420
37	7.912	3.444	2.214	1.230	1.088	1.223	1.174	1.064	0.522	1.051	1.556	1.375	2.152	1.777	0.616	1.631	0.929	0.744	1.598	0.388	0.818	11.117	7.875	7.194	7.006	6.275	9.500
38	7.113	3.141	1.378	1.139	0.910	1.174	0.950	0.805	0.545	0.709	1.016	1.011	1.218	1.324	0.550	1.133	0.754	0.730	1.482	0.244	0.305	9.737	5.179	5.932	5.377	5.458	9.018
39	6.422	1.940	1.064	0.707	0.747	0.760	0.627	0.725	0.299	0.459	0.801	0.639	0.950	1.241	0.326	0.851	0.557	0.564	0.986	0.266	0.421	4.607	3.090	3.289	3.134	3.411	6.115
40	2.982	1.797	0.821	0.391	0.508	0.734	0.766	0.388	0.152	0.485	0.688	0.455	0.450	0.963	0.267	0.708	0.424	0.560	0.707	0.207	0.248	3.602	2.641	2.315	1.960	2.353	3.537
41	3.632	1.595	0.642	0.191	0.279	0.466	0.349	0.263	0.142	0.170	0.417	0.361	0.411	0.592	0.321	0.466	0.271	0.473	0.456	0.105	0.294	2.073	1.998	1.384	1.303	1.047	1.944
42	1.361	0.839	0.349	0.131	0.204	0.263	0.270	0.221	0.099	0.295	0.173	0.247	0.282	0.200	0.186	0.281	0.211	0.244	0.347	0.092	0.237	2.025	1.222	1.293	0.617	0.723	1.435
43	0.871	0.603	0.226	0.087	0.250	0.115	0.200	0.113	0.102	0.193	0.190	0.131	0.102	0.186	0.094	0.176	0.151	0.191	0.200	0.092	0.148	2.025	0.747	0.576	0.369	0.341	0.732
44	0.885	0.391	0.089	0.116	0.150	0.130	0.162	0.075	0.059	0.108	0.287	0.110	0.066	0.119	0.078	0.149	0.089	0.081	0.152	0.050	0.098	1.599	0.499	0.559	0.308	0.205	0.302
45	0.243	0.281	0.043	0.041	0.016	0.095	0.046	0.052	0.039	0.079	0.062	0.068	0.062	0.132	0.091	0.100	0.074	0.046	0.216	0.014	0.080	0.762	0.141	0.371	0.129	0.117	0.388
46	0.069	0.177	0.069	0.024	0.019	0.088	0.028	0.056	0.005	0.027	0.026	0.055	0.036	0.021	0.042	0.038	0.047	0.062	0.040	0.014	0.020	0.413	0.141	0.197	0.052	0.063	0.100
47	0.020	0.117	0.030	0.000	0.036	0.053	0.012	0.005	0.000	0.028	0.038	0.012	0.058	0.021	0.022	0.055	0.011	0.037	0.028	0.000	0.059	0.360	0.066	0.109	0.061	0.052	0.116
48	0.024	0.012	0.000	0.000	0.010	0.019	0.000	0.025	0.027	0.014	0.057	0.025	0.027	0.003	0.009	0.072	0.011	0.011	0.000	0.002	0.026	0.259	0.084	0.074	0.057	0.015	0.034
49	0.002	0.105	0.003	0.000	0.005	0.000	0.000	0.017	0.000	0.000	0.000	0.039	0.000	0.000	0.018	0.046	0.000	0.000	0.006	0.002	0.000	0.104	0.041	0.068	0.009	0.000	0.017
50	0.013	0.000	0.000	0.008	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.022	0.000	0.003	0.000	0.000	0.000	0.094	0.038	0.054	0.000	0.000	0.014
51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.009	0.001	0.000	0.000	0.000	0.000	0.000	0.021	0.026	0.043	0.000	0.000	0.013
52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.021	0.057	0.040	0.000	0.000	0.000
53	0.007	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.023	0.024	0.000	0.000	0.000
54	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.018	0.000	0.000	0.000
55	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000
56	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.004	0.000	0.000	0.000	0.000	0.008	0.000	0.029	0.000	0.000	0.000	0.000
57	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
58	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
59	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.000	0.000

Table A4b: Survey catch-at-length (numbers) for *S. fasciatus* for Unit 1 and Unit 2 (Daniel Duplisea, pers. commn)

	Unit 1																					Unit 2					
Length	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2000	2001	2003	2005	2007	2009
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.017	0.132	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.020	0.033	0.061	0.000	0.000	0.017	0.019	0.000	0.219	0.007	0.002	0.000	0.000	0.000	0.028	0.009	0.000	0.310	0.036	0.014	0.000	0.000	0.000	0.000	0.187	0.000	0.000
7	4.208	0.576	0.600	0.075	0.000	0.275	0.360	0.468	3.187	0.053	0.313	0.282	0.010	0.027	0.174	0.735	0.010	0.125	0.479	0.745	0.192	0.060	0.000	0.010	3.499	0.152	0.080
8	119.052	4.755	0.668	0.205	0.018	0.952	1.093	0.855	12.224	0.279	3.789	1.488	0.038	0.412	0.395	126.070	0.325	4.052	1.702	5.668	1.338	0.071	0.290	0.391	61.827	0.583	0.429
9	289.666	9.383	1.123	0.467	0.080	2.150	1.650	0.729	8.141	1.212	7.785	6.190	0.328	0.375	0.674	552.076	1.819	42.487	2.351	10.414	2.482	0.072	1.470	0.334	140.467	0.911	0.767
10	63.496	66.314	1.364	0.354	0.294	0.781	1.085	1.174	3.517	2.777	4.015	11.232	1.152	0.533	0.900	192.448	9.015	11.445	3.149	6.285	2.596	0.331	6.210	0.169	74.066	1.102	0.746
11	1.562	206.499	6.053	0.320	0.380	0.276	0.808	2.295	1.831	5.628	1.740	4.151	1.990	1.009	0.549	11.096	24.348	0.766	6.376	0.846	3.757	0.820	6.069	0.232	12.727	0.435	0.788
12	1.377	355.845	21.390	0.518	0.912	0.435	0.796	2.851	1.701	7.587	3.656	1.563	3.618	2.620	1.198	0.933	119.218	3.765	28.003	1.256	9.753	0.839	1.842	0.997	6.901	9.796	1.784
13	2.370	179.842	41.364	0.955	0.998	0.529	0.855	2.277	2.011	6.309	6.902	2.235	6.596	4.293	1.737	1.055	176.801	29.879	16.814	2.390	10.983	0.985	2.900	1.598	5.992	59.957	4.698
14	3.969	20.317	42.606	2.461	1.192	0.589	0.526	1.549	2.186	4.678	10.968	2.063	5.311	8.878	2.322	2.119	46.190	81.378	6.749	3.625	5.390	1.714	3.256	2.563	7.096	182.403	9.255
15	7.191	7.285	19.065	5.797	2.055	0.766	0.517	0.958	2.961	3.155	10.896	1.818	1.586	10.177	3.291	1.777	7.487	130.437	5.685	5.789	2.875	3.055	4.895	3.844	6.889	240.143	14.248
16	9.977	7.241	1.347	8.428	2.467	0.698	0.427	0.616	2.381	2.369	4.770	2.364	1.000	8.084	3.315	1.793	1.612	70.727	10.320	6.111	2.951	3.437	6.823	4.002	10.074	120.990	16.145
17	14.364	7.989	1.262	6.582	2.539	0.927	0.462	0.450	1.327	1.755	3.346	2.148	1.181	4.784	3.530	1.420	0.552	19.580	10.806	2.572	2.959	5.827	10.228	4.435	22.083	37.332	46.546
18	11.123	6.566	1.728	2.453	2.002	0.700	0.460	0.424	1.099	1.157	2.710	1.425	1.051	2.218	3.640	1.875	1.150	3.256	9.988	3.188	3.149	7.767	12.458	5.120	37.597	15.961	84.143
19	3.876	4.305	1.217	0.856	0.893	0.552	0.694	0.469	0.846	0.778	1.246	1.011	0.840	1.465	2.174	2.044	1.229	1.907	3.692	3.360	2.487	9.533	11.138	6.331	50.166	10.533	83.373
20	1.582	2.148	1.120	0.600	0.440	0.500	0.560	0.450	1.636	0.401	1.009	0.694	0.879	1.103	1.263	2.018	1.348	1.752	1.369	2.338	2.149	9.798	10.626	8.022	50.734	13.346	59.069
21	1.222	1.963	1.313	0.813	0.185	0.367	0.630	0.366	1.406	0.346	0.390	0.559	0.697	0.964	0.596	1.365	1.422	2.194	0.635	1.716	1.516	8.069	10.094	10.871	37.204	10.305	29.014
22	1.524	1.307	1.810	2.039	0.219	0.356	0.376	0.352	4.929	0.328	0.582	0.582	0.685	1.039	0.563	1.006	1.468	1.044	0.521	1.205	1.321	6.802	7.924	13.986	27.164	11.562	11.604
23	1.753	1.631	3.170	4.818	0.389	0.264	0.239	0.251	3.871	0.447	0.310	0.336	0.407	0.965	0.612	0.594	2.151	0.776	0.544	0.664	0.862	6.001	10.150	10.622	19.816	12.633	5.769
24	3.181	2.298	4.075	8.224	0.603	0.250	0.185	0.347	5.376	0.381	0.440	0.333	0.350	1.454	0.781	0.453	1.629	0.802	0.823	0.448	0.418	7.882	25.295	9.675	18.605	12.181	15.870
25	6.559	3.464	4.070	7.765	0.764	0.346	0.130	0.264	3.136	0.336	0.321	0.307	0.556	1.779	0.813	0.453	2.209	0.480	0.915	0.536	0.374	9.976	37.601	8.813	16.561	16.012	20.152
26	13.683	5.013	5.560	7.992	1.508	0.299	0.183	0.284	2.974	0.374	0.221	0.376	0.286	2.750	0.930	0.658	2.851	0.287	1.383	0.746	0.660	11.383	65.737	10.033	15.436	19.007	17.919
27	22.599	9.103	9.703	9.571	2.167	0.237	0.152	0.343	2.477	0.487	0.278	0.294	0.500	3.749	0.984	0.764	2.432	0.507	1.244	0.675	0.739	10.200	47.704	8.738	12.501	17.462	16.557
28	28.886	13.078	14.215	7.937	1.545	0.233	0.159	0.703	1.298	0.424	0.213	0.202	0.383	5.810	0.628	0.630	1.956	0.431	1.260	0.626	0.807	8.029	32.294	7.496	8.120	13.448	14.291
29	22.941	15.507	14.714	5.745	2.436	0.345	0.406	0.930	2.401	0.437	0.346	0.295	0.398	7.156	0.796	0.582	1.638	0.451	1.489	0.773	0.915	7.236	23.948	7.172	4.922	7.557	10.712
30	13.174	12.140	12.670	6.036	3.072	0.300	0.492	1.216	2.331	0.421	0.473	0.314	0.441	5.158	0.565	0.549	1.414	0.341	2.175	0.610	0.387	7.494	26.153	6.663	5.574	8.138	9.081
31	7.520	8.361	9.134	4.958	2.319	0.348	0.404	1.464	1.920	0.276	0.446	0.665	0.370	1.908	0.517	0.558	0.856	0.265	1.915	0.624	0.496	7.481	10.925	5.396	4.168	6.666	8.268
32	4.622	5.607	8.374	2.606	2.708	0.258	0.380	1.212	0.572	0.307	0.510	0.826	0.463	2.306	0.219	0.573	0.731	0.255	2.491	0.485	0.397	8.830	9.416	4.748	5.852	7.385	7.008
33	3.425	3.643	4.935	1.636	2.397	0.195	0.310	1.084	0.666	0.358	0.661	0.885	0.258	0.802	0.156	0.511	0.538	0.335	2.395	0.386	0.214	7.006	3.172	2.908	5.949	7.342	5.370
34	4.006	2.716	3.766	0.963	1.866	0.230	0.196	0.887	0.484	0.373	0.505	0.695	0.311	0.685	0.051	0.450	0.439	0.351	1.154	0.319	0.379	7.938	2.791	3.133	6.746	6.537	5.569
35	3.331	2.503	3.208	0.620	1.478	0.280	0.220	0.821	0.808	0.313	0.465	0.700	0.342	0.459	0.105	0.509	0.284	0.381	1.572	0.204	0.578	8.769	1.635	2.809	6.516	4.566	5.133
36	3.614	2.241	1.655	0.342	1.425	0.206	0.175	0.418	0.291	0.283	0.524	0.476	0.311	0.522	0.032	0.284	0.330	0.424	1.044	0.198	0.507	5.125	1.509	2.184	5.120	3.688	4.370
37	2.555	1.655	2.130	0.312	1.180	0.172	0.137	0.198	0.228	0.290	0.363	0.591	0.202	0.469	0.091	0.289	0.341	0.318	0.748	0.238	0.436	5.039	1.077	1.522	4.309	3.297	4.452
38	2.357	1.749	0.907	0.162	1.056	0.200	0.134	0.110	0.196	0.092	0.351	0.310	0.132	0.677	0.047	0.281	0.279	0.281	0.497	0.145	0.197	3.786	0.376	1.311	3.195	2.842	3.351
39	1.990	1.188	1.056	0.072	0.771	0.097	0.097	0.124	0.160	0.101	0.182	0.165	0.146	0.527	0.027	0.143	0.159	0.262	0.429	0.157	0.179	2.300	0.244	0.943	1.678	1.846	2.361
40	1.165	0.970	0.675	0.054	0.414	0.100	0.074	0.121	0.091	0.079	0.152	0.158	0.055	0.409	0.023	0.178	0.169	0.148	0.417	0.135	0.141	1.961	0.242	0.640	1.219	1.615	1.535
41	1.051	0.717	0.278	0.041	0.183	0.098	0.042	0.029	0.054	0.049	0.116	0.114	0.057	0.151	0.036	0.137	0.112	0.103	0.250	0.091	0.226	0.867	0.122	0.383	0.603	0.715	0.805
42	0.500	0.381	0.180	0.041	0.084	0.065	0.027	0.035	0.041	0.031	0.067	0.045	0.025	0.113	0.067	0.064	0.086	0.074	0.110	0.061	0.091	1.301	0.089	0.278	0.581	0.619	0.427
43	0.322	0.224	0.105	0.008	0.096	0.018	0.020	0.045	0.029	0.021	0.056	0.048	0.006	0.026	0.028	0.032	0.052	0.046	0.108	0.054	0.056	1.047	0.037	0.162	0.223	0.302	0.268
44	0.242	0.190	0.055	0.016	0.038	0.029	0.012	0.017	0.027	0.013	0.037	0.005	0.007	0.033	0.006	0.082	0.016	0.021	0.037	0.019	0.027	0.790	0.038	0.135	0.154	0.187	0.168
45	0.095	0.116	0.021	0.001	0.017	0.007	0.002	0.014	0.013	0.022	0.018	0.029	0.008	0.024	0.017	0.037	0.012	0.121	0.020	0.012	0.012	0.357	0.005	0.107	0.092	0.083	0.122
46	0.037	0.054	0.029	0.000	0.013	0.008	0.000	0.002	0.000	0.005	0.005	0.004	0.000	0.004	0.004	0.017	0.050	0.019	0.024	0.008	0.012	0.072	0.009	0.059	0.015	0.075	0.038
47	0.011	0.026	0.012	0.000	0.004	0.002	0.008	0.000	0.007	0.001	0.006	0.005	0.000	0.000	0.002	0.049	0.000	0.000	0.003	0.000	0.014	0.073	0.006	0.042	0.032	0.022	0.041
48	0.006	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.001	0.002	0.002	0.000	0.027	0.002	0.139	0.016	0.003	0.000	0.002	0.011	0.141	0.010	0.043	0.021	0.008	0.071
49	0.007	0.020	0.001	0.000	0.007	0.000	0.000	0.013	0.008	0.000	0.000	0.000	0.000	0.000	0.002	0.045	0.000	0.000	0.001	0.005	0.009	0.033	0.009	0.035	0.007	0.003	0.006
50	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.002	0.049	0.000	0.007	0.066	0.000	0.000	0.000	0.007	0.032	0.000	0.000	0.011
51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.015	0.021	0.000	0.010	0.012
52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.000	0.000	0.000	0.000	0.000	0.024	0.002	0.016	0.000	0.000	0.000
53	0.015	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.013	0.012	0.000	0.000	0.000
54	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000
55	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000
56	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.010	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
57	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
58	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
59	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000

Table A4c: Survey catch-at-length (numbers) for *S. fasciatus* for Unit 2J3K (Don Power, pers. commn)

2J3K

Length	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	194.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1774.62	0.00	0.00	55.60	504.51	0.00	0.00	0.00	0.00	0.00	355.62	0.00	0.00	0.00	0.00	0.00
7	19550.79	0.00	0.00	77.80	1909.77	0.00	0.00	927.54	0.00	62.40	328.66	209.64	496.06	75.25	0.00	0.00
8	65920.15	1270.11	1897.57	87.20	89.40	592.05	515.99	345.93	465.59	0.00	994.23	0.00	776.35	275.21	225.40	0.00
9	57398.59	3147.62	3624.07	392.64	841.87	1465.42	1955.60	432.33	674.99	560.88	3394.86	51.80	82.40	2613.47	1721.92	283.36
10	61805.98	2012.90	6448.82	77.80	1067.38	2329.31	3666.50	893.07	1541.18	966.02	6048.06	1056.24	336.44	3242.18	1042.81	0.00
11	136788.05	2105.70	3439.42	315.69	374.40	634.75	5604.51	519.10	1025.95	439.68	2058.82	2053.98	295.35	490.36	1296.55	219.79
12	228508.88	11072.59	1547.92	2071.03	810.82	273.61	8525.13	1737.04	1266.19	1135.52	1081.97	2401.27	257.45	240.33	1159.98	400.46
13	200965.22	16074.03	2785.30	2228.13	1391.58	548.69	7643.79	2180.92	2674.91	342.89	852.81	2518.40	542.50	622.23	347.97	573.43
14	101817.36	25715.47	4972.78	2304.09	1147.24	220.08	2928.95	3885.38	2678.21	948.52	706.36	2263.82	507.38	182.90	747.40	995.17
15	67769.53	43986.69	8740.02	681.74	1686.15	214.11	833.57	3435.72	3741.67	677.01	1298.89	1317.93	1167.48	1151.26	383.35	351.39
16	128572.12	55322.48	12116.88	1478.36	1590.69	1155.80	1283.48	1717.76	5034.31	1178.06	746.96	503.61	1598.23	560.86	268.95	516.83
17	239556.28	34071.71	33501.33	2180.23	2495.31	680.65	1157.65	438.85	5067.65	1485.21	1035.53	627.28	1331.24	1091.94	548.72	240.72
18	309602.27	22268.69	40642.18	4634.60	1948.55	1716.45	1796.59	760.08	3406.71	1651.53	1482.95	717.66	698.53	870.47	381.53	224.16
19	227611.34	27674.02	58829.33	8292.32	3273.70	1423.72	2641.51	727.36	1576.33	3186.67	1422.48	1089.11	263.05	821.20	328.50	244.98
20	67831.39	34919.48	33718.25	22174.03	7426.58	1897.30	3470.82	1424.96	969.82	2707.80	3362.52	1683.97	586.43	427.10	602.73	409.64
21	39750.39	55659.14	18722.49	32265.58	15558.70	10217.97	4589.75	3407.88	1327.99	1249.60	5586.57	1972.76	1479.31	636.18	1071.88	280.74
22	56507.23	51853.32	23116.14	62189.45	31501.95	81091.37	7065.42	4219.28	2114.46	1064.73	4134.31	2370.01	3093.51	456.56	866.92	170.37
23	92256.55	34282.96	35627.56	89138.01	38319.82	377798.00	14940.02	4709.43	3065.60	1089.94	3494.37	3350.54	4120.86	1001.49	302.16	479.91
24	147446.11	29109.99	40071.89	173097.43	42425.42	640295.84	24937.19	11733.97	3245.98	1683.46	3576.21	2825.04	5521.88	1613.16	284.24	211.39
25	159074.95	29250.76	64705.27	324161.30	38629.37	889440.23	31507.24	21363.08	6245.67	2203.70	3853.98	2130.17	3114.34	1243.83	180.33	101.04
26	173879.46	37892.59	61860.74	430785.56	47745.51	701325.10	32413.40	34386.18	12317.90	3311.14	6344.40	1912.87	4487.62	1475.70	282.10	295.74
27	112189.99	42270.16	59160.62	314686.60	46822.01	424583.19	30747.42	30341.80	15785.84	4965.34	6154.47	2631.52	5879.47	1403.82	112.73	79.47
28	109428.95	38585.50	74301.65	197586.67	40756.49	361969.73	25726.66	31263.98	22663.45	6140.23	10440.59	3419.53	8318.08	1804.95	309.04	120.76
29	81920.01	38726.72	75639.03	108606.27	27447.93	154624.61	23626.47	20124.58	20224.63	5652.74	11624.17	3822.75	9931.07	1898.86	140.05	45.22
30	73602.83	35061.39	79609.03	90855.30	17342.98	149560.91	20313.28	13083.42	14926.57	4884.68	16112.68	3786.33	10539.30	1623.69	94.18	113.62
31	56252.62	34584.86	91408.09	113385.35	11554.87	70868.72	15725.58	10650.81	13599.17	3394.47	14334.24	2462.44	8063.03	945.13	59.70	36.84
32	53506.94	25464.20	83226.31	86853.87	9542.25	43819.68	12256.38	7763.48	9744.52	2453.22	15642.03	2048.30	6366.28	823.17	16.69	22.67
33	41315.07	17049.76	73736.75	72211.46	7519.42	21890.53	7825.59	6114.94	9335.97	2108.90	11818.82	2114.98	5773.61	694.91	19.82	1.91
34	30784.70	10645.88	59708.39	42131.34	4999.91	19368.50	5607.00	5105.14	5808.05	1614.14	7385.71	1731.53	4858.08	585.12	18.34	10.60
35	27630.48	10552.09	55541.35	31353.02	4707.23	12817.13	3616.25	3012.28	3499.09	1264.22	6526.19	1149.57	4866.95	350.67	15.97	7.87
36	18083.51	9965.26	43065.29	27950.97	3922.37	9471.68	3241.61	2481.38	2402.87	722.20	4366.06	1136.74	3994.21	280.54	6.36	3.11
37	13829.90	9965.56	53799.37	23879.25	3938.74	10627.69	2502.53	1576.10	1436.86	545.91	2299.66	818.39	2382.46	82.54	8.14	2.84
38	14578.64	6875.11	44909.14	14644.98	3942.33	9943.98	2034.53	1408.72	2597.85	516.62	2145.44	640.43	1776.32	57.74	4.23	3.32
39	9736.88	4535.77	37248.58	6035.10	2620.00	8339.35	1708.89	1187.51	1607.55	292.93	2002.73	469.50	911.23	77.80	15.03	0.05
40	5166.41	2817.05	19644.92	4823.58	1637.27	4036.46	1154.43	691.27	1210.67	251.32	1537.32	352.97	584.11	26.74	1.43	0.04
41	3132.32	1552.97	11620.44	3728.95	653.50	1752.73	590.31	663.34	617.23	197.06	1196.06	246.23	424.73	24.74	0.11	0.80
42	3702.76	1947.68	5221.04	1236.15	494.57	1375.39	586.38	201.57	286.64	115.91	985.89	140.35	390.36	10.89	0.96	1.00
43	2411.51	1436.03	6721.60	713.28	330.09	1092.59	374.65	104.54	571.28	92.58	652.19	81.11	421.32	16.04	0.70	27.72
44	3382.76	1383.07	12347.68	866.26	533.92	1257.73	269.57	188.26	336.90	103.65	554.17	106.79	160.22	2.40	0.00	0.05
45	2171.46	1918.79	11374.41	838.85	444.32	858.26	351.65	389.45	346.52	26.98	234.29	95.49	158.49	0.00	0.05	0.00
46	2250.65	1759.59	2753.48	980.75	340.95	649.70	319.30	208.26	278.51	17.00	103.06	66.21	89.72	2.40	0.72	0.00
47	1480.85	812.32	1458.77	874.31	263.92	1091.93	270.19	120.53	39.25	40.04	163.33	59.00	102.20	0.00	0.00	0.07
48	1315.06	482.40	2014.61	436.15	165.87	640.29	312.67	140.70	155.52	50.67	3.38	30.73	89.60	3.61	1.29	0.00
49	523.78	421.30	255.03	548.41	180.01	268.77	178.11	61.01	122.78	6.93	0.05	15.20	25.82	0.00	0.00	0.00
50	195.80	348.13	134.44	99.91	45.79	157.66	17.00	75.42	21.60	27.87	15.72	29.60	21.00	0.00	0.00	0.00
51	106.38	243.26	231.27	34.20	41.65	99.19	10.20	33.20	3.30	4.60	6.80	15.20	0.00	0.00	0.00	0.00
52	25.51	97.40	85.38	4.60	0.00	22.20	31.43	27.28	14.22	0.00	0.00	14.40	6.20	0.00	0.00	0.00
53	0.00	0.00	79.18	34.20	37.25	22.86	10.60	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	0.00	10.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	10.20	0.00	0.00	0.00	0.00
55	0.00	0.00	0.00	29.20	0.00	10.45	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	0.00	0.00	0.00	0.00	0.00	7.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Length	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	25.34	0.00	210.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	112.05	100.22	1245.33	266.01	323.74	2558.87	6864.06	2490.19	508.53	1615.48	277.13	1501.06	2539.29	218.01	844.33
6	170.00	1131.86	1636.37	1437.04	2925.13	2480.77	7822.50	28575.58	8922.36	5775.38	19639.96	2139.41	9185.93	14951.10	1266.79	2609.71
7	0.00	620.43	3581.87	119.79	1040.57	266.14	4872.74	5230.16	2229.49	8506.79	5620.79	2112.18	8727.54	22330.57	3930.23	2475.48
8	0.00	2058.17	391.12	911.38	1811.09	521.10	2428.84	5643.68	3179.77	16112.17	4707.03	4483.10	6076.36	26896.58	16484.14	7054.09
9	910.23	2014.13	9803.61	3672.04	8651.37	1967.68	6886.90	17215.21	12756.04	37634.45	18783.80	13070.48	17973.30	49593.35	32816.78	16736.63
10	147.68	940.37	8833.16	11727.61	14521.06	5239.95	10870.32	31671.50	23262.47	45771.02	35368.40	36010.41	15484.54	79595.19	63769.51	20054.99
11	24.20	398.07	4951.34	7621.65	6601.56	3877.73	3016.94	18072.88	15499.41	17546.36	45013.63	21370.28	9649.03	40424.79	79687.31	17487.46
12	108.54	1006.96	5096.92	1121.68	1815.21	2549.27	988.54	4039.80	9209.60	6659.68	44081.30	12585.65	13588.85	12840.33	75789.66	23514.88
13	10.69	3409.55	4766.77	2265.15	4456.27	5136.04	1587.13	5319.07	7476.42	9296.35	47384.39	17174.93	20169.04	13806.62	31866.36	35987.24
14	270.23	2869.78	2426.38	2166.84	9495.53	8291.86	2857.54	4656.89	7384.78	10325.75	38273.09	32853.83	24093.39	13417.05	22586.43	49593.58
15	118.54	980.50	3094.76	1527.72	5469.81	4709.39	2940.05	2291.35	5025.92	6467.58	14088.43	35045.10	21188.06	12865.65	10979.71	50697.82
16	240.31	1148.92	2098.79	1126.34	1848.07	1959.18	2651.39	749.47	1636.67	3801.32	8787.09	28363.31	11723.18	11043.17	6779.08	16124.49
17	143.79	1128.63	2250.19	903.32	2247.59	2329.71	3207.10	1279.72	1314.01	2978.53	9600.27	22526.37	14113.17	16871.69	7708.38	9682.73
18	130.87	1576.17	1216.91	1021.31	2089.57	3258.09	2563.00	1988.25	661.65	2123.02	8415.75	17079.18	14596.88	20147.10	7388.51	5315.92
19	215.50	1521.65	1193.67	1680.05	1253.72	2523.29	1966.16	1723.97	856.43	1296.24	7906.86	9966.59	9951.77	17985.00	8338.01	4887.32
20	252.55	1226.40	1588.07	1503.73	770.53	1934.08	1427.16	1628.12	1147.41	388.60	4404.85	8495.48	7853.80	17522.48	10272.18	5615.09
21	69.84	1142.75	2008.14	903.18	1109.81	1567.50	1640.46	1388.81	1291.63	397.84	3589.38	6356.70	9567.24	19442.88	16041.11	10047.22
22	128.94	594.34	2006.41	675.42	1368.53	1292.61	1157.07	1413.76	1255.83	502.99	2469.75	4885.50	8243.11	16189.30	16397.03	13088.12
23	64.19	307.26	1701.96	1039.28	1250.05	1267.27	668.73	1386.47	1003.51	582.70	1491.58	3639.33	9851.24	13201.98	14226.99	19162.80
24	161.70	148.18	1202.40	1153.27	1027.86	1155.69	621.62	1322.01	979.97	421.42	932.48	4006.27	8603.18	9450.64	12273.38	17765.01
25	120.41	72.33	581.52	868.84	957.43	717.36	421.10	1059.16	928.12	256.37	863.85	2885.14	7094.22	6851.61	9568.80	16231.34
26	91.23	144.68	257.59	712.78	684.50	714.68	410.84	682.80	499.22	290.05	721.61	3174.40	7228.03	4721.08	6686.99	11562.88
27	137.65	104.87	442.23	410.94	433.73	644.59	212.11	348.66	423.62	159.51	663.53	3508.88	5136.31	3931.55	5408.76	11105.32
28	51.38	81.50	329.93	215.72	391.38	504.60	207.32	185.45	117.29	111.96	338.73	2257.54	4938.61	2438.28	3219.10	6386.86
29	107.96	110.10	74.00	140.09	503.20	324.81	120.27	80.25	108.27	95.28	336.81	1929.50	4229.67	1936.08	2117.56	4364.26
30	201.89	10.59	214.12	90.31	741.40	202.17	53.48	89.20	67.09	52.30	197.38	1481.23	5407.21	1300.66	1023.09	3157.05
31	53.15	60.60	74.23	84.26	699.40	150.24	74.48	105.21	34.62	75.77	91.55	2087.90	3361.53	779.76	669.41	1915.62
32	2.48	36.98	281.74	25.18	275.66	37.89	54.28	85.98	33.68	15.99	37.72	1663.13	2162.97	593.73	563.69	2315.64
33	7.72	5.56	55.40	92.70	540.36	87.34	27.24	18.79	52.06	18.12	48.07	2491.07	1238.86	613.18	309.60	1012.04
34	4.83	0.14	31.14	44.41	208.10	46.37	2.55	17.12	10.17	9.38	85.00	441.23	1498.87	531.37	442.09	609.69
35	2.60	2.89	7.47	0.48	270.91	28.24	3.42	7.26	3.78	0.33	5.47	372.99	817.36	269.37	95.52	433.95
36	1.56	0.00	0.22	2.93	147.08	0.95	6.52	7.58	7.17	6.64	13.27	110.46	286.03	250.27	81.71	664.90
37	8.46	0.05	1.05	12.70	135.88	1.18	0.08	2.92	0.23	6.37	48.77	115.68	627.77	117.15	5.73	208.83
38	6.01	0.05	6.35	0.57	57.80	32.93	0.00	17.92	0.05	0.12	5.38	0.39	67.22	103.04	8.82	96.69
39	0.11	0.08	0.72	3.30	56.97	0.21	20.60	0.97	0.00	0.00	0.00	324.56	13.97	50.53	16.62	241.63
40	1.31	0.00	0.10	0.88	61.04	6.85	27.64	10.04	3.78	0.07	0.24	0.35	13.86	19.79	6.00	0.00
41	0.03	0.00	0.00	1.05	0.00	0.07	0.00	0.00	0.00	0.00	0.16	0.40	2.58	6.99	1.33	44.48
42	56.06	5.40	0.72	1.45	14.40	0.00	0.00	0.00	0.10	0.00	0.00	11.36	7.49	0.00	2.41	0.00
43	0.80	0.00	0.00	0.00	29.02	0.33	0.00	0.00	0.00	0.00	0.00	2.93	246.00	18.40	4.06	0.63
44	0.03	0.00	0.00	0.00	0.09	0.00	0.00	0.06	3.78	0.00	0.04	0.00	0.08	28.20	1.32	0.00
45	0.00	0.00	0.05	0.11	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	55.60	16.80	0.00	0.00
46	0.14	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	11.40	0.00	1.53	0.00
47	0.00	0.00	0.00	0.00	0.00	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.60	0.00
49	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.22	18.40	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.40	0.00	0.00
51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00
55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A4d: Survey catch-at-length (numbers) for *S. fasciatus* for Unit 3 (Peter Comeau, pers. commn)

Unit 3

Length	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6207	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	197323	13965	0	6207	6572	0	0	0	0
6	0	0	75505	0	0	0	0	0	0	0	0	0	466876	0	0	0	0	23001	0	174032	0
7	0	0	81712	0	0	0	0	0	11518	0	0	47538	877224	7199	128932	0	68332	148637	49898	279094	110350
8	0	9598	196928	39592	6062	0	0	0	48743	0	0	0	661806	169767	114800	29824	196581	616668	157179	158215	591329
9	0	0	223842	19196	11526	0	39182	0	60244	6775	0	61741	599687	339635	0	89473	309595	1498602	597402	445544	1810130
10	86095	73830	410204	78893	66257	0	22129	18827	48743	75369	42636	48317	427834	1309596	320900	173008	554128	1408661	1159672	1182506	1365759
11	357184	49910	108885	379547	170457	0	0	109178	57675	27519	90591	0	322115	3283671	898235	34713	941518	812804	2059182	2179730	732296
12	70482	459192	406080	489867	332041	7980	0	160885	20490	27312	42636	0	338580	2071165	1181626	312472	758952	131973	5740587	2961668	745376
13	19196	253735	372533	1236338	1838556	54297	53050	194836	131706	14005	19475	0	234090	606977	2859043	504737	554830	515013	6056755	3129740	1174802
14	358996	1150409	541517	1245130	5552519	166963	0	82790	175094	54313	32235	123172	192621	803997	6713216	1590811	556675	206648	1692772	3291009	1445525
15	1840797	1487561	314910	234900	14930508	207373	5759	165187	488732	78601	23158	76487	225710	453609	10789260	2584524	581986	314619	782531	2201116	1017089
16	3458498	2210358	555258	440371	22357270	378361	250586	38805	1198477	370196	36254	641122	622773	162315	12125780	3004433	1099283	287251	697327	2609353	1837410
17	9466424	11366836	2059214	170869	24303134	320587	939992	106732	353697	534050	156638	436298	684464	508583	7846761	3354144	1723078	420048	424193	2792221	4910129
18	20242115	30057765	6371871	1050130	12642409	735776	1424167	183966	152488	546391	0	823940	2700657	438352	4447717	3147922	3160778	539163	370129	2159350	6274797
19	30426886	27038532	13993192	3865163	4286730	622955	4895591	1397990	567564	1045406	1255930	291018	2206538	609832	1823832	2209770	4261185	1026939	1221502	1817224	8243895
20	48930586	40944498	16629918	1276174	1772169	5500048	3387431	34108	554124	954334	938060	5700077	388125	1617725	2050135	7500036	2293997	1198805	1177499	10662664	3102888
21	53586281	38333456	34158792	12392050	2165382	3258812	7148094	5506015	82851	885122	1878104	1149446	5616079	1944718	2555367	1424575	10609745	3372375	3929525	1338924	9110181
22	53366300	41483809	41124477	39644145	7335126	5394013	7364934	15694629	941824	736182	2659888	1933445	6691944	2584793	2069312	675569	10960235	4444456	8216726	1611686	10101261
23	41725039	41290995	57367507	76648499	7068714	18238760	5113079	26220958	5141850	510766	3517169	4116575	16495643	5407636	4467021	404688	7116835	3951493	12139852	3498409	15809292
24	30417436	36836853	71077862	76892816	6850946	43298620	2994483	37059700	11888381	1250817	5780905	4452511	21716784	15326495	4762010	379249	9512944	4881436	16762173	4345079	26268964
25	23035707	38929644	54802378	82260655	6554041	63702354	1443428	32283240	26549466	1740157	6370128	6469720	25444594	25762846	12928106	728216	8206110	7261950	25881702	3812315	30858304
26	17558337	31423698	44436318	72226991	5956873	82346597	1604372	33057808	56862786	2664938	8432509	4902336	23721928	53561021	11934796	1006539	14217565	14484422	27814983	4969723	22705642
27	14590071	24953543	29024455	53684728	6686691	76890739	2401130	25997411	65849876	3838860	4341821	7598910	16044489	60667826	21060610	2041975	14392916	18363050	27799214	3057830	22095174
28	12347468	12657854	22357403	30732355	5825400	74470670	2896851	29452628	74338656	3346459	4560874	8887111	9962975	34142751	24880158	2521600	13416643	15912366	22932733	3801318	11252789
29	8833589	10477722	20531329	19870707	5740060	63165452	4099267	30302824	63297276	3307232	3743261	10067277	10273373	25453325	15831078	2930703	10793918	14769411	18571070	3359607	6953130
30	9014271	11998185	22359459	14236849	4242303	37777599	5267318	21544319	47241913	3104535	1757999	8092368	15094202	24890964	13396189	2500646	11162321	12970317	15480421	3192779	7363192
31	6198025	6469515	20784491	9150943	5628910	45333966	4360721	11790419	29026847	3229022	1192439	5435913	11513736	19783592	13977498	2151224	8482896	14051859	15278312	3929162	6144965
32	4424703	4195342	10287982	8451616	4635130	5088147	5005238	9504517	16575230	2677926	649440	3414056	16436788	21196956	17318867	2380770	8728459	16474488	11100440	3196248	3986397
33	2039105	3914222	11079466	5820353	3605729	15644529	5140953	5164039	17786069	5338364	559954	1750545	4346390	10681660	14379856	2990679	5006873	6492403	7096381	2509323	2429614
34	2497046	3491061	8148458	2908767	2800414	10643823	3360600	2022475	7287158	3999766	424183	1625496	3275377	6082529	10444752	1062441	5574765	3740167	4194384	1832244	2518501
35	2069079	2534130	7390668	1741160	1358378	3603776	1864943	2700669	2591623	2732365	420360	1539740	1165414	4351960	4702714	1111847	2657658	2716218	3807714	1609267	962205
36	1087653	1152474	11094075	2508189	2033047	1231170	1591492	1536432	1609264	1492242	148357	1093436	1279065	1086053	4214677	1433070	1908935	958220	2056514	1080574	1099958
37	1495161	1204447	8575753	1188433	1028751	2496082	2086376	2781117	985579	1344929	154766	995799	1114012	3165210	5746991	1318554	2287914	609284	1136022	1044237	588104
38	562620	426900	3294984	832929	1436779	3094801	1016752	883025	909279	2105234	151196	1115236	904575	1120183	3617271	1579993	4724217	367050	1030823	1211358	274449
39	269964	242986	1820191	343274	1099072	2800777	915552	882714	566786	1407114	63475	1048296	248953	1181689	2424191	643652	7102244	126929	395220	957116	337969
40	302357	228131	349394	297462	438038	2102049	683151	639237	611578	571127	99674	946334	482491	752128	1626038	407154	6920072	111915	361156	841906	121588
41	181896	138065	0	61543	249331	995992	24827	348366	83755	202263	72882	491551	265616	493320	1246474	110844	5162816	76151	183962	378798	242302
42	214290	168960	0	15436	533137	567045	25735	255062	168993	32193	63475	362560	67786	336293	80140	45280	2504389	31732	45572	427968	39628
43	118777	39447	0	58903	339601	116346	64044	180277	18867	64208	0	214531	75132	78523	124309	22640	1076656	24654	46408	277668	47871
44	64787	19724	0	0	80857	566583	0	144640	78894	0	0	185231	45079	27660	24654	67195	239257	26842	0	31753	0
45	43192	19724	0	0	16171	450238	5759	80315	0	0	0	10969	30053	0	0	0	0	0	0	31753	0
46	0	0	0	0	6399	360190	0	0	0	0	0	0	15026	13830	0	0	0	0	0	63506	0
47	0	0	0	0	0	360190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	270143	0	0	0	0	0	0	0	0	122605	0	0	55958	0	0	0
49	0	0	0	0	0	450238	0	0	0	0	0	0	0	0	0	0	0	0	0	32193	0
50	0	0	0	0	0	270143	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Length	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0	0	0	0	0	175735	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	10474	0	0	0	0	0	0	0	28243	38303	0	0	0	0	0	0	0	0	19321	0
4	46528	0	0	0	0	0	0	315289	208287	373424	0	39707	175361	0	156467	40388	0	548986	972636	137539
5	0	20236	9576	0	0	0	0	160035	204359	2029251	644007	76116	470751	407073	1193689	111795	19373	944654	1263906	533424
6	107412	20236	84415	44302	65122	225602	30330	143026	189313	326311	47257	172388	154055	1618922	238391	105349	38746	165930	51811	487392
7	50067	17164	319684	151071	46750	387127	44011	767397	161469	17239	104401	1095154	1500796	1061478	161350	199815	126336	217390	547327	721976
8	1058007	6745	1371337	428579	177062	463133	213366	1619585	267643	97285	104401	3506090	2150781	2155824	1928727	524331	587636	105572	1276710	1665323
9	905499	93068	2554752	793665	315407	1030674	216842	966810	1305871	247999	227885	3152960	908498	4649888	5507535	814593	293816	193692	1462262	2058851
10	3744632	303381	1179957	2420664	352921	636844	450861	636064	1271534	140654	20194	2727926	6668026	7311360	8204953	2019646	518731	228390	729831	1944523
11	10480668	493675	1539371	5146429	886153	2187146	729904	247760	905056	582600	94888	1108321	45178638	6536353	6971129	5227818	339458	60539	467237	759888
12	11617931	285477	1552809	9140692	894603	5297602	422263	684245	2114598	1146540	411529	897651	81618891	4722885	3017645	6006680	628402	289843	1101060	1219591
13	1708445	192340	1478006	9678941	1402691	5198744	844546	1827293	2641555	1944967	711385	1063189	20615978	3119036	6940186	3272361	391456	580367	4399730	2733769
14	1792579	73471	2083994	9926319	1621339	2690677	1304259	3131677	2436125	2702222	866251	606537	8592425	5230786	10120026	4682137	2702176	2965078	2657581	2245253
15	1809554	400540	1825710	8491664	2531356	2236894	4438932	4283633	1261886	3636908	965918	469336	2926878	7218102	9957873	10267842	2835603	1291433	4748740	2794656
16	1642826	417555	1701336	6806156	1886927	3714263	8525382	3295585	1551955	6306215	1763267	633315	2345082	5411008	7987711	24632110	5786391	4200634	10970013	2740556
17	1462930	224025	1576179	5585691	2665519	6863454	17067535	5615412	3354350	4974305	1337732	1256370	2368609	3397136	8239690	62300526	9157632	35551576	18744808	2827757
18	2163785	1340894	2303595	4309473	6634483	6946490	31773744	13173393	4679471	5792658	1569713	2139154	4643623	3171650	10619594	90664421	37943995	77589246	70847955	5469987
19	2626922	1375452	2127487	2798372	9683304	11325756	51235512	13277965	10486463	12247788	1979676	2145546	4348339	2423774	5544931	71181733	66579885	153301280	227219691	10635189
20	682865	2418059	2184636	6249213	14174231	84387750	5269126	21968960	30266123	3544019	[illegible]	5259066	8654248	4024715	7733781	42481259	84044828	265475753	384431344	26654405
21	3780988	1638567	4418553	3310622	11986228	10733700	82258586	5973312	25517229	26329747	6717354	6991563	10321446	7493509	8875305	26792124	61948073	254140365	419608591	56437440
22	4946298	1372426	6430519	4750621	11436313	11904232	77788169	10155560	35455589	28323398	30675733	14779226	18812947	14641030	9839779	27734084	42397819	169516871	288469437	63229362
23	5958652	18441633	9844560	7638971	11515623	17698921	51407840	6297256	40483094	21537987	35960656	18932307	26019744	22607602	15857252	24818632	30559363	107737979	205189420	54582264
24	5934922	28280597	15160671	12144259	14327677	16713591	54867465	7992028	35048139	19194450	46796738	19714610	33207724	16834310	28340025	23552296	21728043	87782451	122826891	45816873
25	5817910	50057966	19554333	19803361	16242417	16086719	23752740	7590232	33314995	15026139	50691626	14728014	30601972	15893392	40297603	29630868	15335372	48552651	61777636	36058670
26	5751515	53776698	19728643	22820073	10239183	16451771	14519259	9425007	25979242	17900061	49007789	12638175	29086478	14523463	47654026	29873073	14225537	46754795	39590602	20016174
27	4959035	36149871	17182292	17097903	9006937	16043120	17227526	5611637	22297425	17619903	33272794	9602434	17548761	12732694	44668085	31746964	9300715	35033107	29854667	19148775
28	4380614	42227254	19049649	15113369	11126353	15472833	13392089	6544762	17903213	17079169	21598611	8571033	11437448	6958234	43037967	26042496	6785917	32848074	28857467	12414856
29	3152842	24049409	15696970	10950284	9584264	11570489	11300568	2964806	14436679	15546883	19801436	5523479	8311845	5699313	35729352	29232863	7338494	33172517	22939071	9187416
30	2452184	17646989	13319320	9907047	5873549	9208769	11181303	1743249	7916152	13097567	16035731	3860718	4949036	4284584	28825783	18164845	4087784	32349877	16476355	4450692
31	3525310	11156678	8354031	5023528	3787479	3335358	8351481	1111303	5843865	7468928	11023024	2319843	2097781	3076302	22165929	17363104	3529854	22473510	10511412	7654495
32	2752016	8105519	9109475	3628279	4934472	4649122	6692940	1655796	3188187	3862897	4709318	1424579	2384981	2482390	11310164	10938428	1574835	12588200	7996018	4765627
33	1879513	10952874	7306540	2901758	3357833	1553420	5365998	1031868	2016822	4029108	3562456	645475	1569183	1298448	8008262	13038802	1122576	8974513	4707020	3197477
34	726942	6049760	6376592	1393890	2506339	854242	2305494	181170	1821514	456546	3261840	1206020	1800512	1620875	3349431	7022283	771582	6019344	2489861	2845139
35	588016	3023875	2887780	785535	2141787	341642	2052571	171252	761746	295152	1739818	680131	133990	808345	1210778	3452711	403137	2547994	786135	1568256
36	374058	1637117	2431243	816122	454113	539187	839954	94767	613095	403118	873460	632873	139289	498477	1267214	747000	333195	647840	261647	480498
37	737693	711021	1388195	373367	959625	291379	387525	140578	543983	160887	1348239	592140	76648	116115	602601	241387	104015	315199	84796	324400
38	506365	709736	1180156	592991	989406	0	210667	139752	258252	262356	165342	625158	65719	154198	177069	107550	131243	289529	79537	200709
39	698528	594798	867259	180971	342677	0	265850	74729	71034	81813	177279	696237	69206	128938	23069	114542	131242	0	0	0
40	503821	654311	616673	291836	45604	29991	179747	130046	149481	22161	22161	217025	122221	86779	123127	47691	78838	0	0	0
41	187026	21915	0	113354	43446	0	87264	195068	22541	110118	137876	81054	46137	41660	23069	0	98008	22413	0	0
42	150226	84090	328355	113354	45604	0	0	109901	28862	44832	0	82205	115343	125893	0	0	32618	0	0	131180
43	217561	81899	0	68012	0	0	0	131576	0	22161	0	69247	46137	33077	23069	0	39419	22038	0	80159
44	32078	124350	269452	45342	22802	50205	0	43349	29824	22671	0	22413	0	21915	69206	0	0	0	61920	44076
45	87660	0	0	0	0	0	0	21674	22541	0	22161	21556	50670	0	23069	0	0	0	0	22038
46	0	0	0	0	0	0	0	23204	0	0	0	0	23069	19745	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	20453	0	0	0	9872	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A5: Life history parameters assumed for *S. mentella* and *S. fasciatus*.

S. mentella				
M	0.1			MacAllister and Duplisea (2011)
h	0.67			MacAllister and Duplisea (2011)
Age-at-maturity	10			Knife-edged, Don Power, pers. commn
Fraction of *M* that occurs before spawning (M^s)	0.25			
	L_{inf}	κ	t_0	
Length-at-age	45.23	0.0698	-1.64	$L_a = L_{\inf}\left(1 - e^{-\kappa(a-t_0)}\right)$, Don Power, pers. commn
	α	β		
Weight-at-age	0.00944	3.107		$W_a = \alpha(L_a)^\beta$, MacAllister and Duplisea (2011)
S. fasciatus				
M	0.125			MacAllister and Duplisea (2011)
h	0.67			MacAllister and Duplisea (2011)
Age-at-maturity	9			Knife-edged, Don Power, pers. commn
Fraction of *M* that occurs before spawning (M^s)	0.25			
	L_{inf}	κ	t_0	
Length-at-age	45.23	0.0698	-1.64	$L_a = L_{\inf}\left(1 - e^{-\kappa(a-t_0)}\right)$, Don Power, pers. commn
	α	β		
Weight-at-age	0.01106	3.08		$W_a = \alpha(L_a)^\beta$, MacAllister and Duplisea (2011)

Appendix B - The Age-Structured Production Model

The model used for these assessments is an Age-Structured Production Model (ASPM) (e.g. Hilborn, 1990). Models of this type fall within the more general class of Statistical Catch-at-Age Analyses. The approach used in an ASPM assessment involves the construction of an age-structured model of the population dynamics and fitting it to the available abundance indices by maximising the likelihood function. The general specifications of the model and its equations are described below, followed by details of the contributions to the (penalised) log-likelihood function from the different sources of data available and assumptions concerning the stock-recruitment relationship. Quasi-Newton minimization is used to minimize the total negative log-likelihood function (the package AD Model Builder™, Otter Research, Ltd is used for this purpose).

B.1. Population dynamics

B.1.1 Numbers-at-age

The resource dynamics are modelled by the following set of population dynamics equations:

$$N_{y+1,0} = R_{y+1} \quad \text{(B1)}$$

$$N_{y+1,a+1} = \left(N_{y,a}\, e^{-M_a/2} - C_{y,a}\right) e^{-M_a/2} \qquad \text{for } 0 \le a \le m-2 \quad \text{(B2)}$$

$$N_{y+1,m} = \left(N_{y,m-1}\, e^{-M_{m-1}/2} - C_{y,m-1}\right) e^{-M_{m-1}/2} + \left(N_{y,m}\, e^{-M_m/2} - C_{y,m}\right) e^{-M_m/2} \quad \text{(B3)}$$

where

$N_{y,a}$ is the number of fish of age *a* at the start of year *y* (which refers to a calendar year),

R_y is the recruitment (number of 0-year-old fish) at the start of year *y*,

M_a denotes the natural mortality rate for fish of age *a*,

$C_{y,a}$ is the predicted number of fish of age *a* caught in year *y*, and

m is the maximum age considered (taken to be a plus-group), *m*=20.

These equations reflect Pope's form of the catch equation (Pope, 1972) (the catches are assumed to be taken as a pulse in the middle of the year) rather than the more customary Baranov form (Baranov, 1918) (for which catches are incorporated under the assumption of steady continuous fishing mortality). Pope's form has been used in order to simplify computations. As long as mortality rates are not too high, the differences between the Baranov and Pope formulations will be minimal.

B.1.2. Recruitment

The number of recruits at the start of year *y* is assumed to be related to the spawning stock size (i.e. the biomass of mature fish) by a Beverton-Holt stock-recruitment relationship (Beverton and Holt, 1957), parameterised in terms of the "steepness" of the stock-recruitment relationship, *h*, and the pre-exploitation equilibrium spawning biomass, K^{sp}, and recruitment, R_0 and allowing for annual fluctuation about the deterministic relationship:

$$R_y = \frac{4hR_0 B_y^{sp}}{K^{sp}(1-h)+(5h-1)B_y^{sp}} e^{(\varsigma_y - \sigma_R^2/2)} \qquad \text{(B4)}$$

where

ς_y reflects fluctuation about the expected recruitment for year *y*, which is assumed to be normally distributed with standard deviation σ_R (which is input in the applications considered here); these residuals are treated as estimable parameters in the model fitting process.

B_y^{sp} is the spawning biomass at the start of year *y*, computed as:

$$B_y^{sp} = \sum_{a=1}^{m} f_{y,a} w_{y,a}^{strt} N_{y,a} e^{-M_a M^s} \qquad \text{(B5)}$$

where

$w_{y,a}^{strt}$ is the mass of fish of age *a* during spawning,

$f_{y,a}$ is the proportion of fish of age *a* that are mature

M^s . is the fraction of mortality that occurs before spawning (Table A5).

In the fitting procedure, K^{sp} is estimated while *h* has thus far been fixed at 0.67 for consistency with McAllister and Duplisea (2011).

B.1.3. Total catch and catches-at-age

The catch by mass in year *y* is given by:

$$C_y = \sum_{a=1}^{m} w_a^{mid} C_{y,a} = \sum_{a=1}^{m} w_a^{mid} N_{y,a} e^{-M_a/2} S_a F_y \qquad \text{(B6)}$$

where

w_a^{mid} denotes the mass of fish of age *a*+1/2,

$C_{y,a}$ is the catch-at-age, i.e. the number of fish of age *a*, caught in year *y*,

S_a is the commercial selectivity (i.e. combination of availability and vulnerability to fishing gear) at age *a*; when S_a = 1, the age-class *a* is said to be fully selected, and

F_y is the proportion of a fully selected age class that is fished.

The model estimate of the mid-year exploitable ("available") component of biomass is calculated by converting the numbers-at-age into mid-year mass-at-age (using the individual weights of the landed fish) and applying natural and fishing mortality for half the year:

$$B_y^{ex} = \sum_{a=1}^{m} w_a^{mid} S_a N_{y,a} e^{-M_a/2} (1 - S_a F_y / 2) \qquad \text{(B7)}$$

whereas for survey estimates of biomass:

$$B_y^{surv,i} = \sum_{a=1}^{m} w_a^{mid} S_a^{surv,i} N_{y,a} e^{-M_a \frac{m^{surv,i}}{12}} \left(1 - S_a F_y \frac{m^{surv,i}}{12}\right) \quad \text{(B8)}$$

where

$S_a^{surv,i}$ is the survey selectivity for age *a* for survey *i*, and

$m^{surv,i}$ is the month in which survey *i* takes place, see Table below.

Survey	Month (m^{surv})
Unit 1	8
Unit 2	8
Division 2J3K	9
Unit 3	7

B.1.4. Initial conditions

For the first year (y_0) considered in the model therefore, the stock is assumed to be at a fraction (θ) of its pre-exploitation biomass, i.e.:

$$B_{y_0}^{sp} = \theta \cdot K^{sp} \quad \text{(B9)}$$

with the starting age structure:

$$N_{y_0,a} = R_{start} N_{start,a} \qquad \text{for } 0 \le a \le m \quad \text{(B10)}$$

where

$$N_{start,0} = 1 \quad \text{(B11)}$$

$$N_{start,a} = N_{start,a-1} e^{-M_{a-1}} (1 - \phi S_{a-1}) \qquad \text{for } 1 \le a \le m-1 \quad \text{(B12)}$$

$$N_{start,m} = N_{start,m-1} e^{-M_{m-1}} (1 - \phi S_{m-1}) \big/ (1 - e^{-M_m} (1 - \phi S_m)) \quad \text{(B13)}$$

where ϕ characterises the average fishing proportion over the years immediately preceding y_0.

Unless indicated otherwise though, the stock is assumed to be at pristine equilibrium in 1960, i.e. θ=1 and ϕ =0 for the results reported here.

B.2. The (penalised) likelihood function

The model can be fit to (a subset of) CPUE and survey abundance indices, and commercial and survey catch-at-age data to estimate model parameters (which may include residuals about the stock-recruitment function, the fishing selectivities, the annual catches or natural mortality, facilitated through the incorporation of penalty functions described below). Contributions by each of these to the negative of the (penalised) log-likelihood (- ℓnL) are as follows.

B.2.1. Survey abundance data

The likelihood is calculated assuming that the observed survey index is log-normally distributed about its expected value:

$$I_y^i = \hat{I}_y^i \exp\left(\varepsilon_y^i\right) \quad \text{or} \quad \varepsilon_y^i = \ell\text{n}\left(I_y^i\right) - \ell\text{n}\left(\hat{I}_y^i\right) \tag{B14}$$

where

I_y^i is the survey biomass index for year *y* and survey *i*,

$\hat{I}_y^i = \hat{q}^i \hat{B}_y^{surv,i}$ is the corresponding model estimate, where $\widehat{B}_y^{surv,i}$ is the model estimate of survey biomass, given by equation (B8),

$\hat{q}^i$ is the constant of proportionality (catchability) for survey series *i*, and

ε_y^i from $N\left(0,\left(\sigma_y^i\right)^2\right)$.

The contribution of the survey biomass data to the negative of the log-likelihood function (after removal of constants) is then given by:

$$-\ell\text{n}\, L^{surv} = \sum_i \sum_y \left[\ell\text{n}\left(\sigma_y^i\right) + \left(\varepsilon_y^i\right)^2 / 2\left(\sigma_y^i\right)^2\right] \tag{B15}$$

where

σ_y^i is the standard deviation of the residuals for the logarithm of survey index *i* in year *y*.

The catchability coefficient q^i for survey index *i* is estimated by its maximum likelihood value:

$$\ell n\, \hat{q}^i = 1/n_i \sum_y \left(\ln I_y^i - \ln \hat{B}_y^{surv,i}\right) \tag{B16}$$

B.2.2. Commercial catches-at-length

The contribution of the catch-at-length data to the negative of the log-likelihood function under the assumption of an "adjusted" lognormal error distribution is given by:

$$-\ell\text{n}\, L^{CAL} = W^{CAL} \sum_y \sum_l \left[\ell n\left(\sigma_{com} / \sqrt{p_{y,l}}\right) + p_{y,l}\left(\ell n\, p_{y,l} - \ell n\, \hat{p}_{y,l}\right)^2 / 2\left(\sigma_{com}\right)^2\right] \tag{B17}$$

where

$p_{y,l} = C_{y,l} / \sum_{l'} C_{y,l'}$ is the observed proportion of fish caught in year *y* that are of length *l*,

$\hat{p}_{y,l} = \hat{C}_{y,l} / \sum_{l'} \hat{C}_{y,l'}$ is the model-predicted proportion of fish caught in year *y* that are of length *l*,

where

$$\hat{C}_{y,l} = \sum_a \hat{C}_{y,a} A_{a,l} \tag{B18}$$

where

$$\hat{C}_{y,a} = N_{y,a}\ e^{-M_a/2}\ S_a\ F_y\ (1 - S_y F_y\ /\ 2) \qquad \text{(B19)}$$

and

$A_{a,l}$ is the proportion of fish of age a that fall in the length group *l* (i.e. $\sum_a A_{a,l} = 1$ for all ages *a*)

The matrix *A* is calculated under the assumption that length-at-age is normally distributed about a mean given the von Bertalanffy equation, i.e.:

$$L_a \sim N\left[L_\infty\left(1 - e^{-\kappa(a-t_0)}\right); \theta_a^2\right] \qquad \text{(B20)}$$

where

N is the normal distribution, and

θ_a is the standard deviation of length-at-age *a*, which is modelled to be proportional to the expected length at age *a*, i.e.:

$$\theta_a = \beta L_\infty\left(1 - e^{-\kappa(a-t_0)}\right) \qquad \text{(B21)}$$

with β = 0.1.

σ_{com} is the standard deviation associated with the catch-at-length data, which is estimated in the fitting procedure by:

$$\hat{\sigma}_{com} = \sqrt{\sum_y \sum_l p_{y,l}\left(\ell n\ p_{y,l} - \ell n\ \hat{p}_{y,l}\right)^2 / \sum_y \sum_l 1} \qquad \text{(B22)}$$

The log-normal error distribution underlying equation (B17) is chosen on the grounds that (assuming no ageing error) variability is likely dominated by a combination of interannual variation in the distribution of fishing effort, and fluctuations (partly as a consequence of such variations) in selectivity-at-age, which suggests that the assumption of a constant coefficient of variation is appropriate. However, for ages poorly represented in the sample, sampling variability considerations must at some stage start to dominate the variance. To take this into account in a simple manner, motivated by binomial distribution properties, the observed proportions are used for weighting so that undue importance is not attached to data based upon a few samples only.

Commercial catches-at-length are incorporated in the likelihood function using equation (B17), for which the summation over age *l* is taken from length l_{minus} (considered as a minus group) to l_{plus} (a plus group), see Table B1.

B.2.3. Survey catches-at-length

The survey catches-at-age are incorporated into the negative of the log-likelihood in an analogous manner to the commercial catches-at-age, assuming an adjusted log-normal error distribution (equation (B17)) where:

$p_{y,l}^i = C_{y,l}^{surv,i} / \sum_{l'} C_{y,l'}^{surv,i}$ is the observed proportion of fish of length *l* in year *y* for survey series *i*,

$\hat{p}_{y,l}^i$ is the expected proportion of fish of length *l* in year *y* in the survey *i*, given by:

$\hat{p}_{y,l}^i = \hat{C}_{y,l}^i / \sum_{l'} \hat{C}_{y,l'}^i$ is the model-predicted proportion of fish caught in year *y* and survey *i* that are of length *l*,

where

$$\hat{C}_{y,l}^i = \sum_a \hat{C}_{a,l}^i A_{a,l} \tag{B23}$$

where

$$\hat{C}_{y,a}^i = N_{y,a}\ S_a^{surv,i}\ e^{-M_a \frac{m^{surv,i}}{12}}\ (1 - S_a F_y\ \frac{m^{surv,i}}{12}) \tag{B24}$$

Survey catches-at-length are incorporated in the likelihood function using equation (B17), for which the summation over age *l* is taken from length l_{min} (not considered as a minus group) to l_{plus} (a plus group), see Table B1.

B.2.4. Stock-recruitment function residuals

The stock-recruitment residuals are assumed to be log-normally distributed. Thus, the contribution of the recruitment residuals to the negative of the (now penalised) log-likelihood function is given by:

$$-\ell n L^{SRpen} = \sum_{y=y1}^{y2} \left[\varepsilon_y^2 / 2\sigma_R^2 \right] \tag{B25}$$

where

ε_y from $N(0,(\sigma_R)^2)$, which is estimated for year *y*1 to *y*2 (see equation (B4)), and

σ_R is the standard deviation of the log-residuals, which is input ($\sigma_R = 0.5$)

Table B1: Minus and plus length groups (in cm) for the commercial and survey CAL. Note: l_{min} for the surveys is not taken as a minus group.

	S. mentella		*S. fasciatus*	
	Units 1+2	Units 1+2	Division 2J3K	Unit 3
Commercial CAL:				
l_{minus}	20	20	no comm.	20
l_{plus}	45	45	CAL	40
Survey CAL:				
l_{min}	24	22	22	22
l_{plus}	45	40	35	40

B.3. Model parameters

B.4.1. Fishing selectivity-at-length:

The commercial and survey fishing selectivity-at-length, S_l and $S_l^{surv,i}$ are estimated in terms of a logistic curve:

$$S_l = \left[1 + \exp\left(-\left(l - l_c\right)/\delta\right)\right]^{-1} \qquad \text{(B26)}$$

where

l_c^f cms is the length-at-50% selectivity,

δ^f cm^{-1} defines the steepness of the ascending limb of the selectivity curve.

The selectivities-at-length are then converted to an effective selectivity at age $\tilde{S}_a$:

$$\tilde{S}_a = \tilde{w}_a^{mid} / w_a^{mid} \qquad \text{(B27)}$$

with

$$\tilde{w}_a^{mid} = \sum_l S_l \, w_l \, A_{a+1/2,l} \qquad \text{(B28)}$$

$\tilde{w}_a^{mid}$ is the selectivity-weighted mid-year weight-at-age *a*, and

w_l is the weight of fish of length *l*;

REFERENCES

Baranov, F.T. 1918. On the question of the dynamics of the fishing industry. Nauchnyi issledovatelskii iktiologisheskii Institut Izvestia, I: 81–128.

Beverton, R.J.H., and Holt, S.J. 1957. On the dynamics of exploited fish populations. Fisheries Investment Series 2, Vol. 19, U.K. Ministry of Agriculture and Fisheries, London. 533pp.

Hilborn, R. 1990. Estimating the parameters of full age-structured models from catch and abundance data. International North Pacific Fisheries Commission Bulletin, 50: 207-213.

Pope, J.G., 1972. An investigation of the accuracy of Virtual Population Analysis using cohort analysis. International Commission for the North Atlantic Fisheries Research Bulleting, 9: 65–74