Maturity of Yellowtail flounder

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Background

Geographic patterns in vital population parameters have long been used to identify separate management stocks, owing to variation in genotypic frequences and environmental controls (Begg et al 1999, Cadrin 2010). Several studies have shown geographic variability in maturation rates of yellowtail flounder with the southern range of the population significantly more fecund at length than yellowtail in the northern range (Pitt, 1971, Howell and Kleser, 1977). In the US, yellowtail on Cape Cod were estimated to generally mature at later age and larger in size compared to Georges Bank, Southern New England and the Mid-Atlantic and those patterns were identified to persist for over three decades (Begg et al. 1999). In this short working paper, length and age specific patterns in yellowtail flounder maturation ogive were re-evaluated to identify and capture any long-term changes in maturity for the yellowtail Research Track Assessment.

Approach

The data for this analysis were derived from the Northeast Fisheries Science Center (NEFSC) random stratified bottom trawl surveys conducted in spring and autumn from 1968 to 2022. For yellowtail flounder, only spring survey data (March to May) were included to align with peak spawning periods. In each stock area, available samples on length, sex, and maturity stage were utilized, classifying fish as either immature or mature by grouping all stages except immature.

In evaluating yellowtail flounder maturity at age across stock areas, we explored both traditional logistic regression methods and direct estimation of proportion at age. The Working Group recommended against using logistic regression due to its sensitivity to small sample sizes, which can introduce bias in parameter estimates, particularly at the age extremes where data may be sparse. This was of particular concern for GB and SNEMA yellowtail flounder stocks. Consequently, we opted for a direct estimation approach, calculating the female proportion mature at each age directly, rather than imposing a curve. This approach was applied across all three stocks of yellowtail flounder by decade, and examined for both 3-year and 9-year moving averages to identify the most stable indicators while balancing responsiveness to contemporary trends. Summary of analyses can be found in Figures 1-7 and Tables 1-13.

Summary and Recommendations

Results indicated variations in proportion mature at age and size over time, particularly for ages 2 and 3. Increases in maturity proportions were observed in the Cape Cod/Gulf of Maine (CCGOM) and Georges Bank (GB) stocks, while the Southern New England/Mid-Atlantic (SNEMA) stock showed a decline. Sample size limitations, especially in recent decades for GB and SNEMA, complicate interpretation, as these may not fully represent true stock dynamics. In contrast, CCGOM had relatively robust sample sizes, improving confidence in observed trends.

The WG's proposed recommendations for 2024 research track are as follows:

- For GB and SNEMA, use a time-series average proportion at age due to limited sample sizes.
- For CCGOM, apply a 3-year moving average smoother to leverage the larger sample size for finer temporal resolution.

While some evidence suggests trends in the proportion mature for ages 2 and 3, the Working Group concluded that using the time series mean would best capture the long-term maturation pattern while minimizing year-to-year variability, data gaps, and the effects of occasional low sample sizes. Although it is possible to explore different temporal means to distinguish between years with robust sampling and those with sparse data, our approach aims to provide a parsimonious and consistent method for characterizing maturity across the entire time series

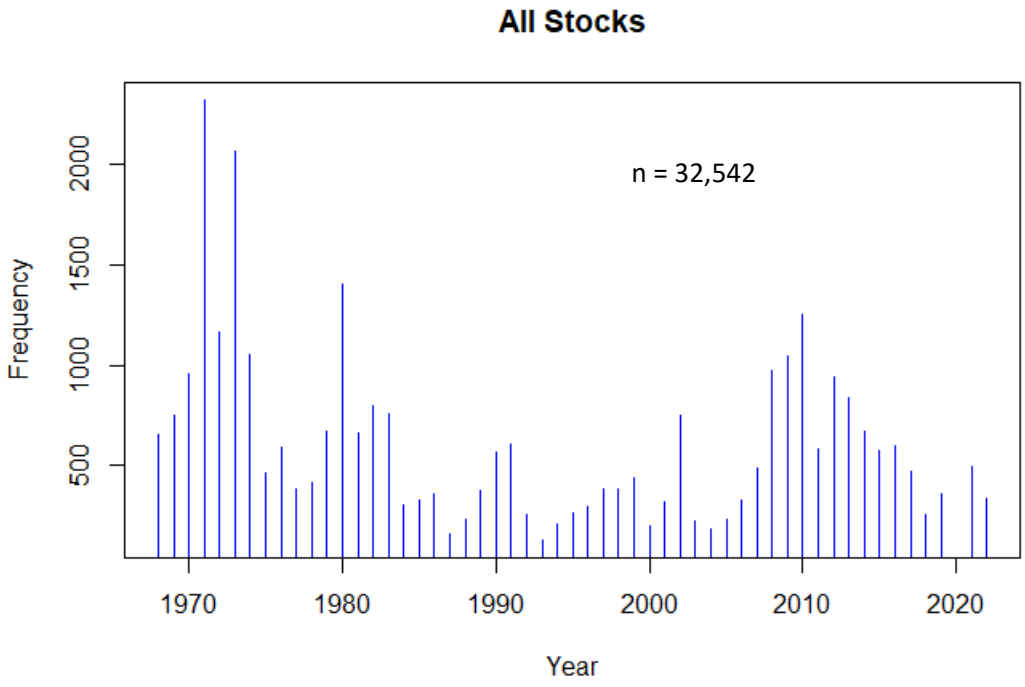

Figure 1. Total Sample size of fish used in the maturity analyses for all three stocks (1968-2022)

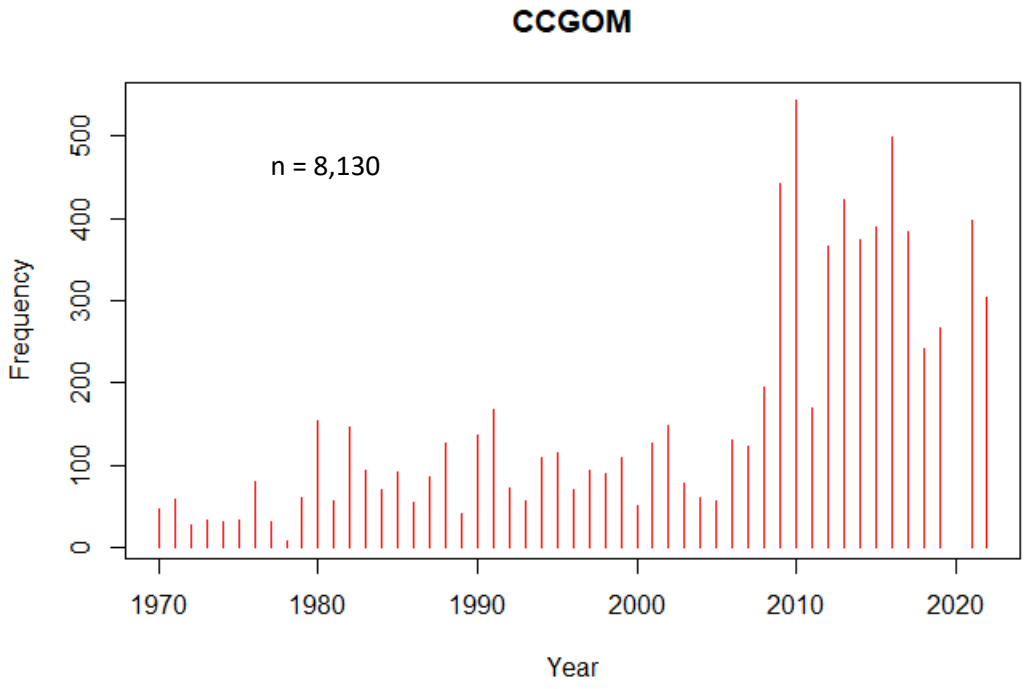

Figure 2. Total Sample size of fish used in the maturity analyses for CCGOM (1970-2022)

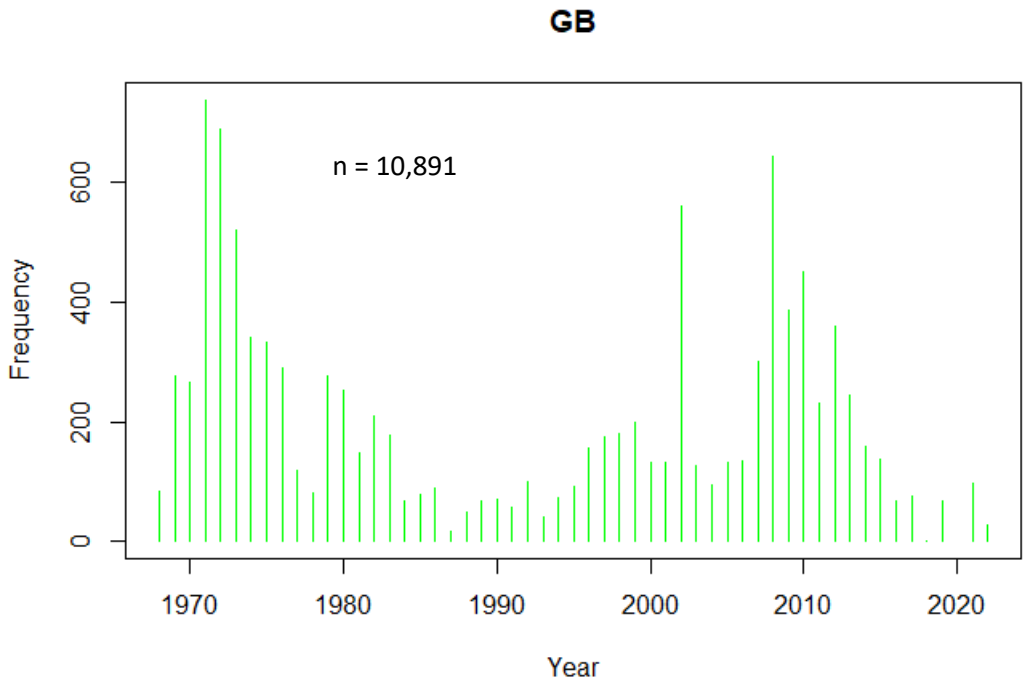

Figure 3. Total Sample size of fish used in the maturity analyses for GB (1968-2022)

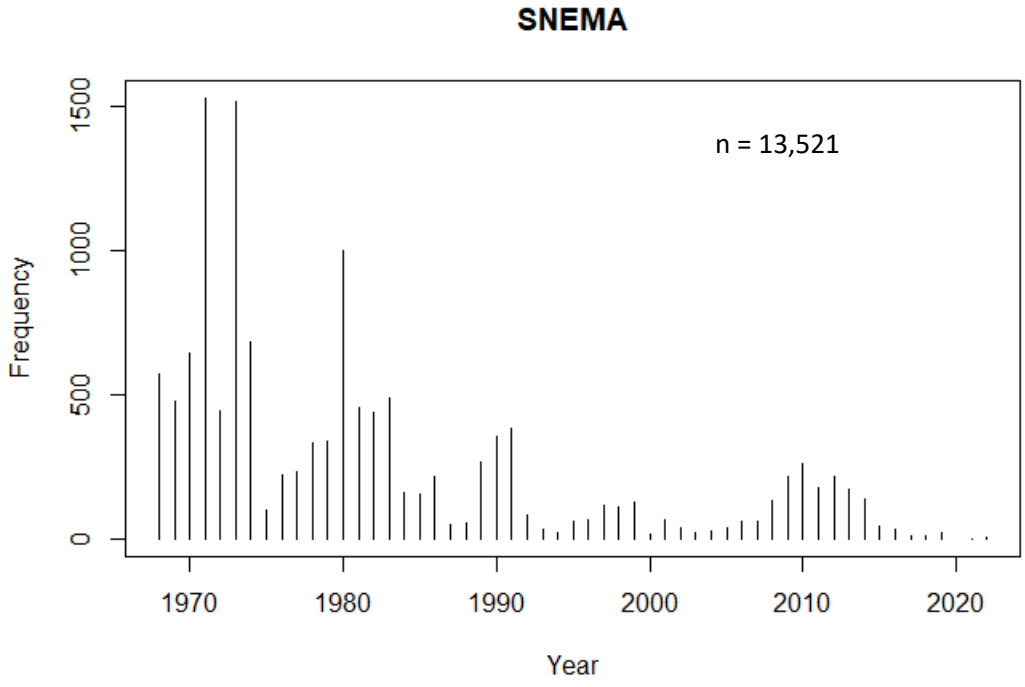

Figure 4. Total Sample size of fish used in the maturity analyses for SNEMA (1968-2022)

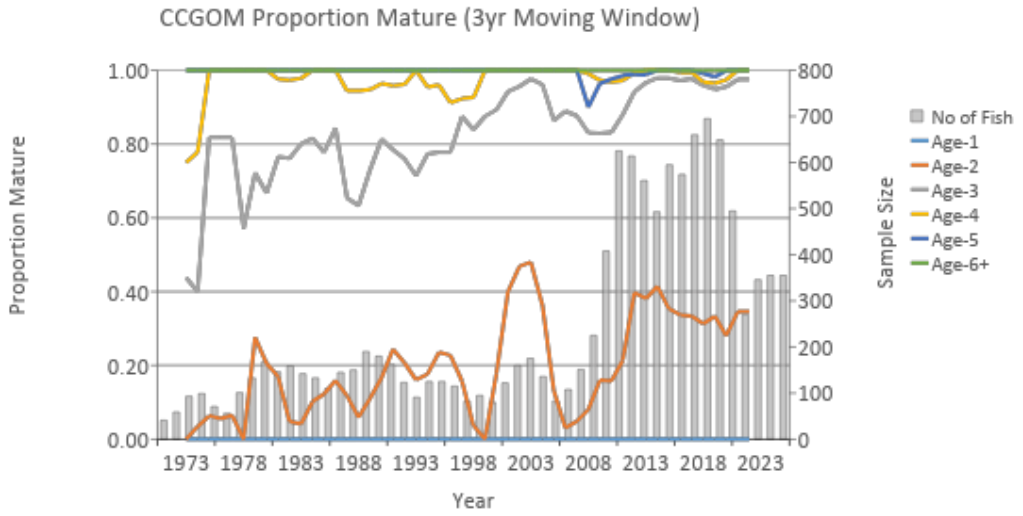

Figure 5. Sample size (bars) and proportion mature for CCGOM yellowtail from 1970-2022

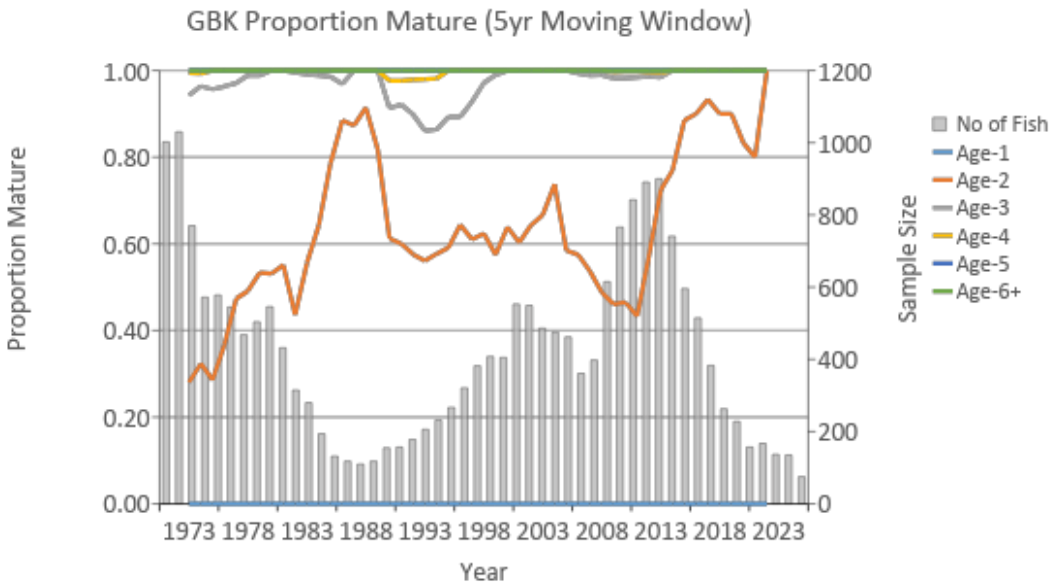

Figure6 . Sample size (bars) and proportion mature for GBK yellowtail from 1970-2022

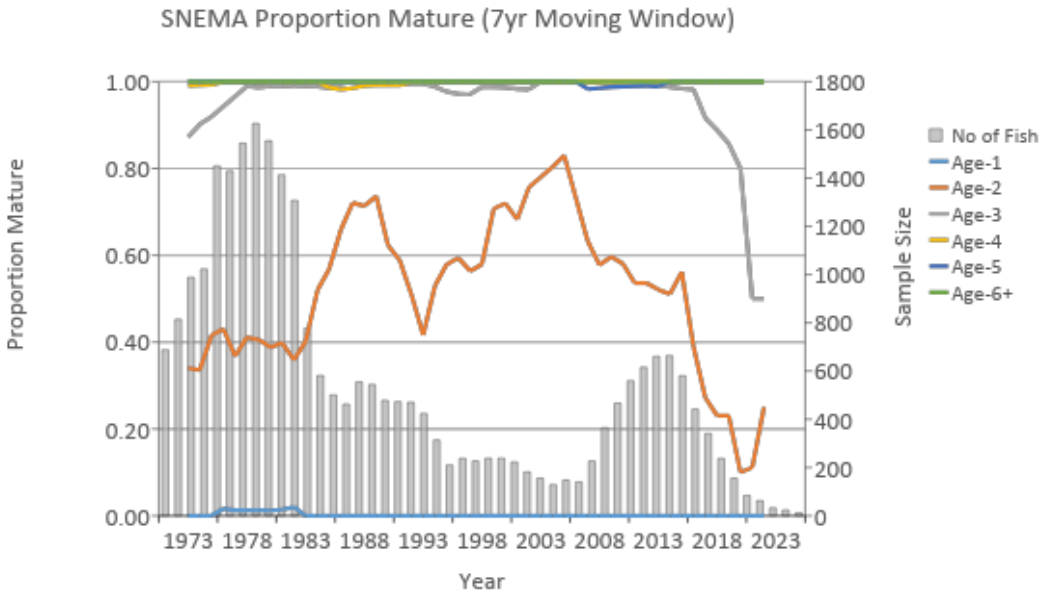

Figure 7. Sample size (bars) and proportion mature for SNEMA yellowtail from 1970-2022

Table 1. Sample size of fish by stock used in the maturity analyses (1968-2022). CCGOM started in 1970

Age	CCGOM	GB	SNEMA
1	141	217	147
2	2150	3047	3682
3	3153	3848	4322
4	1738	2404	3346
5	638	943	1235
6	168	274	563
7	64	108	165
8	48	36	45
9	16	7	11
10	7	4	3
11	6	3	2
12	1	0	0
Total	**8,130**	**10,891**	**13,521**

Table 2. Sample Size of fish by stock and sex used in the maturity analyses (1968-2022). CCGOM started in 1970

Stock	Male	Female	Total
CCGOM	4,243	3,887	8,130
GB	5,634	5,257	10,891
SNEMA	7,033	6,488	13,521
Total	16,910	15,632	32,542

Table 3: Sample size of male yellowtail flounder by age for CCGOM used in the maturity analyses.

Male CCGOM													
Age/Year	**Age-1**	**Age-2**	**Age-3**	**Age-4**	**Age-5**	**Age-6**	**Age-7**	**Age-8**	**Age-9**	**Age-10**	**Age-11**	**Age-12**	**Total**
1970		2	12	3		1		1					**19**
1971	1	24	5	3		1							**34**
1972		5	3	2	2								**12**
1973		5	10	3	1								**19**
1974		6	10	5	1								**22**
1975		13	2	1	1								**17**
1976		9	24	2	1	1			1				**38**
1977		5	3	2		1							**11**
1978			3		2								**5**
1979	1	2	10	6	1	1							**21**
1980		25	41	19	4								**89**
1981		9	8	7	4		1						**29**
1982		12	45	18	6	3	2						**86**
1983		11	17	10	1								**39**
1984		11	12	2	1			1					**27**
1985		14	18	5	3	1							**41**
1986		16	4	1									**21**
1987		15	25	5	4	6	4	1			1		**61**
1988	9	38	9	11	7	1	1						**76**
1989		4	12	2									**18**
1990		14	56	1									**71**
1991	1	29	43	20	5								**98**
1992		12	24	12									**48**
1993		11	12	8									**31**
1994	4	14	21	16	7	3							**65**
1995	1	14	25	20	2								**62**
1996		7	15	19	1								**42**
1997		8	28	20	2								**58**
1998		15	42	10	2								**69**
1999		10	35	16	4	1							**66**
2000	1	16	14										**31**
2001		12	41	10									**63**
2002		14	41	16	1								**72**
2003		9	20	16	1								**46**
2004	1	10	24	3	2								**40**
2005		5	23	5									**33**
2006		16	40	16	1								**73**

2007	1	19	24	14									**58**
2008		25	62	10	1	1							**99**
2009		86	96	49	6								**237**
2010		83	138	49	5								**275**
2011		13	49	27	2								**91**
2012	6	49	79	52	13	1	1						**201**
2013	2	77	73	47	13								**212**
2014	4	116	46	26	8								**200**
2015	2	96	92	28	6	1	1						**226**
2016	6	94	72	15	10	3	1						**201**
2017	4	57	69	30	14		1	2					**177**
2018		34	59	19	8	4	1						**125**
2019	4	35	41	27	13	5	1						**126**
2020	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0**
2021	8	55	74	27	11	9	7	9	2	2	3		**207**
2022	5	29	46	46	13	9	4	2	1				**155**
Total	**61**	**1310**	**1797**	**781**	**190**	**53**	**25**	**16**	**4**	**2**	**4**	**0**	**4243**

Table 4: Sample size of female yellowtail flounder by age for CCGOM used in the maturity analyses

Female CCGOM													
Age/Year	**Age-1**	**Age-2**	**Age-3**	**Age-4**	**Age-5**	**Age-6**	**Age-7**	**Age-8**	**Age-9**	**Age-10**	**Age-11**	**Age-12**	**Total**
1970		6	4	6	5	5		1	1				**28**
1971		11	4	5	2		2		1				**25**
1972		3	6	3	2	1			1				**16**
1973		4	7	3									**14**
1974		2	5	2	1								**10**
1975		10	3	4									**17**
1976		16	14	5	2	2	1		2				**42**
1977		9	6	3	1	1							**20**
1978			3	1									**4**
1979	1	11	14	11	2			1					**40**
1980		22	22	16	5								**65**
1981		4	9	8	3	4							**28**
1982		13	19	18	4	1	3			2		1	**61**
1983		15	23	15	1	1							**55**
1984		11	5	14	9	1	1	1	1				**43**
1985		22	17	8	3	1							**51**
1986	1	20	4	5	3								**33**
1987		3	11	3	2	3	3	1					**26**
1988	2	21	11	10	3	2	1	1					**51**
1989		7	8	5	3								**23**
1990		16	44	4		2							**66**
1991	5	15	23	22	4		1						**70**
1992	1	6	15	1	1								**24**
1993	1	4	15	6									**26**
1994	3	21	8	3	7	2							**44**
1995	3	9	21	13	6	1							**53**
1996	1	4	9	9	6								**29**
1997	1	9	8	12	6								**36**
1998		6	9	5	1								**21**
1999	1	12	14	13	2	1							**43**
2000		3	10	6	1	1							**21**
2001		13	33	11	6								**63**
2002		9	27	31	8	1			1				**77**
2003	1	10	8	4	8			1					**32**
2004	1	6	8	4	2								**21**
2005	1	5	11	6									**23**
2006	3	11	26	13	3			1					**57**

2007		15	27	20	4								**66**
2008	1	17	53	20	3	2							**96**
2009		57	74	70	3		1						**205**
2010	1	54	124	61	22	3	2	1					**268**
2011	1	3	27	27	16	3	2						**79**
2012	5	23	48	57	31	2							**166**
2013	4	47	46	60	42	9	2						**210**
2014	8	61	55	34	12	5							**175**
2015	1	28	89	33	11	1							**163**
2016	10	37	129	92	21	5	1	2					**297**
2017	14	25	60	36	55	12	3	2					**207**
2018		19	25	27	31	8	4	2					**116**
2019	1	33	34	29	25	16	4						**142**
2020	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0**
2021	7	23	56	48	32	5	6	10	2	1			**190**
2022	1	29	25	35	28	14	2	8	3	2	2		**149**
Total	**80**	**840**	**1356**	**957**	**448**	**115**	**39**	**32**	**12**	**5**	**2**	**1**	**3887**

Table 5: Sample size of male yellowtail flounder by age for GB used in the maturity analyses.

Male_GB													
Year/Age	**Age-1**	**Age-2**	**Age-3**	**Age-4**	**Age-5**	**Age-6**	**Age-7**	**Age-8**	**Age-9**	**Age-10**	**Age-11**	**Age-12**	**Total**
1968		11	18	2	1	1							**33**
1969		62	56	18	1								**137**
1970		45	46	22	6	2	1						**122**
1971		133	155	97	23	7	2						**417**
1972	2	132	151	68	16	2							**371**
1973	56	79	83	38	16	6		1					**279**
1974	9	67	61	44	12	7	1						**201**
1975	3	103	30	15	13	2							**166**
1976		104	28	11	5	1	1						**150**
1977		16	27	13	3	1							**60**
1978		21	17	3									**41**
1979	18	83	26	13	5	5							**150**
1980		57	48	4									**109**
1981		19	34	17	7	1							**78**
1982		71	20	18	5								**114**
1983		37	47	8	2								**94**
1984		1	9	16	10	1							**37**
1985		38	3	6	3								**50**
1986		44	9	2									**55**
1987		2	3	3									**8**
1988	1	10	5	4	6								**26**
1989		15	25	8	3	1							**52**
1990		2	33	9	3	1	1						**49**
1991	2		6	16	7								**31**
1992		18	20	9	3	1							**51**
1993		7	6	3	1								**17**
1994		16	7	10	1	1							**35**
1995	2	6	23	8	3								**42**
1996		19	32	31	3								**85**
1997		18	53	21	1								**93**
1998		35	22	33	10	1							**101**
1999		48	41	8	3								**100**
2000		23	23	7	2								**55**
2001		17	36	11	2								**66**
2002	2	61	236	33	3		1						**336**
2003	1	28	29	3									**61**
2004		14	32	10	2								**58**

2005		21	31	16									**68**
2006	6	15	41	17	2								**81**
2007		88	64	26	1								**179**
2008		97	171	45	7	1							**321**
2009		18	106	30		1							**155**
2010		29	78	108	21	1	1						**238**
2011		11	50	37	7								**105**
2012	4	21	76	76	7								**184**
2013	1	20	38	55	10	2							**126**
2014		9	28	21	5	1							**64**
2015		13	26	20	7								**66**
2016	1	2	9	6		1							**19**
2017	2	7	10	8	7	1							**35**
2018	NA	NA	NA	NA	NA	NA	NA	NA					**0**
2019	4	2	3	1	2	1							**13**
2020	NA	NA	NA	NA	NA	NA	NA	NA					**0**
2021			26	8	1	2		1					**38**
2022		1	2	5	2	2							**12**
Total	**114**	**1816**	**2259**	**1121**	**260**	**54**	**8**	**2**	**0**	**0**	**0**	**0**	**5634**

Table 6: Sample size of female yellowtail flounder by age for GB used in the maturity analyses.

Female_GB													
Year/Age	**Age-1**	**Age-2**	**Age-3**	**Age-4**	**Age-5**	**Age-6**	**Age-7**	**Age-8**	**Age-9**	**Age-10**	**Age-11**	**Age-12**	**Total**
1968		9	27	5	2	3	4						**50**
1969		41	73	12	7	4	1	1		1			**140**
1970	1	42	57	26	11	3	4						**144**
1971	1	78	117	92	22	5	4			1			**320**
1972		113	100	70	30	1	4						**318**
1973	50	86	58	29	12	5	1						**241**
1974	8	51	42	25	9	2	3				1		**141**
1975	4	93	36	9	12	7	4	1					**166**
1976		83	39	8	6	1	1	1	1				**140**
1977		16	35	7	2								**60**
1978		16	12	8	2		1						**39**
1979	11	72	15	20	3	2	3						**126**
1980		47	82	11	2	1			1				**144**
1981		14	31	21	2	2		1					**71**
1982		41	18	18	14	2	1	1					**95**
1983		21	46	9	2	1	2	4					**85**
1984		2	13	6	7	3							**31**
1985		19	4	4	2								**29**
1986		23	4	1	3	3							**34**
1987		2	2	2	2	2							**10**
1988	2	4	8	7	2	1							**24**
1989		4	7	5			1						**17**
1990			10	9	3								**22**
1991	1		5	16	4	1							**27**
1992		23	16	7	4								**50**
1993		3	13	8									**24**
1994		8	15	9	5	2							**39**
1995		8	23	11	7	1							**50**
1996	1	11	21	21	14	2							**70**
1997	1	14	12	38	14	3							**82**
1998		32	13	7	16	11	1						**80**
1999	1	12	28	19	23	9	6		1				**99**
2000	2	16	30	15	6	7	1						**77**
2001		13	15	20	6	9	4						**67**
2002		10	52	81	55	13	12	3					**226**
2003		22	12	17	5	2	5	4					**67**
2004		10	13	8	2	1	1	1					**36**

2005		9	28	16	7	2	2	1					**65**
2006	9	10	6	19	6	3							**53**
2007		38	30	33	16	5	1						**123**
2008		60	152	78	30	2	1						**323**
2009		4	59	113	47	8							**231**
2010		11	39	82	55	20	4	2					**213**
2011		3	38	51	26	6	1						**125**
2012	4	5	29	73	52	11	1						**175**
2013	1	7	22	35	45	9	1						**120**
2014	2	9	19	26	24	10	1	3					**94**
2015		5	18	17	27	4		1					**72**
2016			12	20	7	9	1						**49**
2017		5		6	12	9	6	3					**41**
2018		1						1					**2**
2019	3	4	6	5	2	12	15	5	3		1		**56**
2020	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		**0**
2021	1		25	23	6			1	1	2			**59**
2022		1	2	5	3	1	2				1		**15**
Total	**103**	**1231**	**1589**	**1283**	**683**	**220**	**100**	**34**	**7**	**4**	**3**	**0**	**5257**

Table 7: Sample size of male yellowtail flounder by age for SNEMA used in the maturity analyses.

SNEMA_Males												
Age/Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10	Age-11	**Total**
1968		88	141	57	6							**292**
1969		46	99	69	16	2						**232**
1970		38	84	110	22	6	2		1			**263**
1971		157	162	455	73	6						**853**
1972		49	46	42	74	7	2					**220**
1973	15	78	300	189	132	136	9	3				**862**
1974	18	42	58	132	68	28	26	2	1			**375**
1975		13	7	11	17	6		2				**56**
1976		66	13	6	10	5	3	1				**104**
1977	7	31	49	7	2	2	2	2				**102**
1978		89	35	13	5	5	5	3				**155**
1979	19	77	58	13	6			2			1	**176**
1980	5	192	154	126	14				1			**492**
1981		102	70	43	8							**223**
1982		108	58	21	6							**193**
1983		89	151	9	2							**251**
1984		10	21	51	6	4						**92**
1985		41	14	21	27	4						**107**
1986		81	21	7	3							**112**
1987		2	18	7								**27**
1988	3	11	7	5	10							**36**
1989		156	14	4								**174**
1990		4	162	16	1							**183**
1991		21	67	135	5	1						**229**
1992		3	12	42								**57**
1993		2	1	12								**15**
1994		5		1	2							**8**
1995		26	3	2	1	1						**33**
1996		9	19	5	2							**35**
1997		25	35	6								**66**
1998		49	13	4								**66**
1999		22	45	7	1							**75**
2000		2	7									**9**
2001			31	3								**34**
2002		7	7	1								**15**
2003		2	7	4								**13**
2004		3	12	3								**18**
2005	4	8	4	3	3							**22**
2006	1	23	8	4								**36**

2007		12	19	3								**34**
2008		6	40	12								**58**
2009		28	35	47	11							**121**
2010		43	53	21	10							**127**
2011		27	26	20	5							**78**
2012	1	52	19	16	7		1					**96**
2013	3	7	45	18	6	4						**83**
2014	1	9	24	25	4	1						**64**
2015		2	9	9	3							**23**
2016		1	3	4	4							**12**
2017		2			2		2					**6**
2018		2		1								**3**
2019	6	7			1							**14**
2020	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		**0**
2021		1	1									**2**
2022				1								**1**
Total	**83**	**1976**	**2287**	**1823**	**575**	**218**	**52**	**15**	**3**	**0**	**1**	**7033**

Table 8: Sample size of female yellowtail flounder by age for SNEMA used in the maturity analyses.

SNEMA_Females												
Age/Year	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10	Age-11	**Total**
1968		72	125	74	7	1	2					**281**
1969		33	108	88	13	1	1					**244**
1970	1	44	115	138	62	17	3					**380**
1971	1	127	124	320	84	14	1			1		**672**
1972		35	48	25	65	47	6					**226**
1973	8	49	228	105	93	141	22	5	3			**654**
1974	8	45	52	85	59	23	31	4				**307**
1975		19	5	5	4	6	2	1				**42**
1976		75	16	9	3	12	3	1				**119**
1977	1	49	57	5	5	6	3	2		2		**130**
1978	4	94	38	27	7		2	3	1			**176**
1979	15	65	62	12	5	1	1					**161**
1980	2	163	171	137	19	12	1	1	1		1	**508**
1981		114	66	35	14	3						**232**
1982		121	82	22	15	7	1					**248**
1983		33	179	17	6							**235**
1984		8	18	36	6	3						**71**
1985		28	7	2	9	2	1					**49**
1986		66	25	6	4	1						**102**
1987		4	19	2								**25**
1988	1	7		5	3	2						**18**
1989	1	82	8	3								**94**
1990		4	141	27	2							**174**
1991	1	5	49	72	23	2						**152**
1992			8	17								**25**
1993		10	4	4	1							**19**
1994	1	9	1		4	1						**16**
1995		22		3		1		1	1			**28**
1996		4	14	14	2							**34**
1997		23	15	10	3							**51**
1998	2	32	5	5	2	1						**47**
1999		6	34	9	3		1					**53**
2000		4	3	2								**9**
2001		4	14	7	4	1						**30**
2002		13	2	6	3							**24**
2003		3	2	1	2							**8**
2004		4	2	1	2		1					**10**
2005	1	8	1	2	6		1					**19**
2006	1	20	2	2			1	1				**27**

2007		11	17	1								**29**
2008		3	28	43	2							**76**
2009		26	15	28	24	2	1					**96**
2010		53	37	11	27	3						**131**
2011	1	22	20	28	11	17	2	1				**102**
2012	2	44	7	21	20	9	16	2				**121**
2013	5	10	49	10	9	3	5					**91**
2014		20	3	36	9	1	2	1	1			**73**
2015	2		3	3	15							**23**
2016	2	3	2	1	3	5	1	2				**19**
2017		1	2				2	1				**6**
2018	1	5						4				**10**
2019	2	4	1	1					1			**9**
2020	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0**
2021	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0**
2022	1		1									**2**
Total	**64**	**1706**	**2035**	**1523**	**660**	**345**	**113**	**30**	**8**	**3**	**1**	**6488**

Table 9: Estimate of L50 of yellowtail by stock and sex

Area	L50_Male (cm)	L50_Female (cm)
CCGOM	19.71	26.30
GB	20.02	27.50
SNEMA	17.98	23.55
All	19.35	25.50

Table 10. Estimate of A50 of yellowtail flounder by stock and sex

Area	A50_Male (cm)	A50_Female (cm)
CCGOM	1.58	2.34
GB	1.49	1.96
SNEMA	1.42	1.90
All	1.41	2.00

Table 11. Comparing age and size at maturity from O'Brien et al. 1993 to 2024 Research values

Comparison to 1993 O'Brien

Stock	**A_50 (O'Brien 1993)**	**A_50 (2024 RT)**	**L_50 (O'Brien 1993)**	**L_50 (2024 RT)**

	Male	Female	Male	Female	Male	Female	Male	Female
CCGOM	1.3	2.6	1.6	2.3	26.8	27.3	19.7	26.3
GB	2.6	1.8	1.5	2.0	21.4	25.8	20.0	27.5
SNEMA	1.8	1.6	1.4	1.9	19.6	25.5	18.0	23.6

Table 12. Chi square test for differences in stock area of size and age at maturity for yellowtail flounder

A) Chi Sq. Test Female A50

	Df	Deviance	AIC	LRT	Pr(>Chi)	
<none>		6965.5	6977.5			
age	1	8948.2	8958.2	1982.68	< 2.2e-16	***
region	2	6966.1	6974.1	0.62	0.7341	
age:region	2	6991.3	6999.3	25.79	**2.51E-06**	***

B) Chi Sq. Test Male A50

<none>		4584.6	4596.6			
age	1	5356.5	5366.5	771.91	< 2.2e-16	***
region	2	4639.6	4647.6	55	1.14E-12	***
age:region	2	4706.4	4714.4	121.81	**< 2.2e-16**	***

C) Chi Sq. Test Female L50

	Df	Deviance	AIC	LRT	Pr(>Chi)	
<none>		7488.6	7500.6			
length	1	9731.5	9741.5	2242.88	< 2.2e-16	***
region	2	7577.2	7585.2	88.55	< 2.2e-16	***
length:region	2	7550.6	7558.6	61.93	**3.56E-14**	***

D) Chi Sq. Test Male L50

	Df	Deviance	AIC	LRT	Pr(>Chi)	
<none>		4206.5	4218.5			
length	1	5131.1	5141.1	924.64	< 2.2e-16	***
region	2	4230.9	4238.9	24.37	5.10E-06	***
length:region	2	4240.3	4248.3	33.85	**4.47E-08**	***

Table 13. Chi square test for differences in time periods (pre and post 1993) of age at maturity for yellowtail flounder

Chi Sq. test for time difference(pre and Post 1990) CCGOM_male L50						
	Df	Deviance	AIC	LRT	Pr(>Chi)	
<none>		1741.8	1749.8			
length	1	2450.5	2456.5	708.7	< 2.2e-16	***
period	1	1747.5	1753.5	5.67	0.01725	*
length:period	1	1767.8	1773.8	25.95	3.50E-07	***

Chi Sq. test for time difference(pre and post 1990) CCGOM_Femal L50						
	Df	Deviance	AIC	LRT	Pr(>Chi)	
<none>		1802.1	1810.1			
length	1	3391.4	3397.4	1589.32	< 2.2e-16	***
period	1	1815.7	1821.7	13.57	0.000229	***
length:period	1	1826.9	1832.9	24.77	6.45E-07	***

Chi Sq. test for time difference(pre and Post 1990) GB_male L50						
	Df	Deviance	AIC	LRT	Pr(>Chi)	
<none>		592.6	600.6			
length	1	920.85	926.85	328.25	< 2.2e-16	***
period	1	609.17	615.17	16.56	4.71E-05	***
length:period	1	607.99	613.99	15.39	8.73E-05	***

Chi Sq. test for time difference(pre and Post 1990) GB_female L50						
	Df	Deviance	AIC	LRT	Pr(>Chi)	
<none>		2062.8	2070.8			
length	1	2718.9	2724.9	656.06	< 2.2e-16	***
period	1	2121.9	2127.9	59.12	1.49E-14	***
length:period	1	2134.1	2140.1	71.25	< 2.2e-16	***

Chi Sq. test for time difference(pre and Post 1990) SNEMA_male L50						
	Df	Deviance	AIC	LRT	Pr(>Chi)	
<none>		1548.5	1556.5			
length	1	1721.3	1727.3	172.875	< 2e-16	***
period	1	1554.9	1560.9	6.436	1.12E-02	*
length:period	1	1554.6	1560.6	6.157	1.31E-02	*

Chi Sq. test for time difference(pre and Post 1990) SEMA_female L50						
	Df	Deviance	AIC	LRT	Pr(>Chi)	
<none>		3358.2	3366.2			
length	1	3753.9	3759.9	395.66	< 2.2e-16	***
period	1	3397.9	3403.9	39.74	2.90E-10	***
length:period	1	3391.9	3397.9	33.67	6.52E-09	***