

Supporting Information

Empirical Length-at-Maturity for Northeast Atlantic Marine Fishes

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Table S1: Maturity coding schemes in the DATRAS data, by survey, country and scale, showing the codes classified as immature and mature. Country codes: BE, Belgium; DE, Germany; DK, Denmark; EE, Estonia; ES, Spain; FR, France; GB, United Kingdom; GB-NIR, Northern Ireland; GB-SCT, Scotland; LT, Lithuania; LV, Latvia; NL, Netherlands; NO, Norway; PL, Poland; PT, Portugal; RU, Russia; SE, Sweden.

Survey	Country	Scale	Years	Codes	N years	N obs	Immature	Mature
BITS	DE	M6	2015–2026	61, 62, 63, 64, 65	12	71702	61	62, 63, 64, 65
BITS	DE	Numeric	2000–2009	1, 2, 3, 4, 5	10	45826	1	2, 3, 4, 5
BITS	DE	Roman	2010–2015	I, III, IV, V, VI, VII, VIII	6	29050	I	III, IV, V, VI, VII, VIII
BITS	LV	M6	2000–2001, 2003–2007, 2009, 2015–2017, 2019–2023, 2025	61, 62, 63, 64, 65	17	19056	61	62, 63, 64, 65
BITS	LV	Numeric	2002	1, 2, 4, 5	1	142	1	2, 4, 5
BITS	LV	Roman	2002, 2006, 2008, 2010–2015, 2017–2018	I, III, IV, V, VI, VII	11	7730	I	III, IV, V, VI, VII
BITS	LV	SMSF	2024–2026	A, Ba, Bb, C, D, Db	3	785	A, Ba	Bb, C, D, Db
BITS	PL	M6	2021–2026	61, 62, 63, 64, 65	6	30184	61	62, 63, 64, 65
BITS	PL	Numeric	2000–2008, 2010	1, 2, 3, 4, 5	10	7671	1	2, 3, 4, 5
BITS	PL	Roman	2001–2002, 2004–2020	I, II, III, IV, V, VI, VII, VIII	19	47678	I*	III, IV, V, VI, VII, VIII
BITS	SE	M6	2000, 2020	61, 62, 63, 65	2	1933	61	62, 63, 65
BITS	SE	Numeric	2000–2007	1, 2, 3, 4, 5	8	14243	1	2, 3, 4, 5
BITS	SE	Roman	2007–2020	I, II, III, IV, V, VI, VII, VIII	14	26092	I*	III, IV, V, VI, VII, VIII
BITS	SE	SMSF	2021–2026	A, Ba, B, Bb, C, Ca, Cb, D, Da, Db, E	6	12080	A, Ba	B, Bb, C, Ca, Cb, D, Da, Db, E
BITS	RU	M6	2021	61, 62, 63, 64, 65	1	2764	61	62, 63, 64, 65
BITS	RU	Numeric	2000–2011	1, 2, 3, 4, 5	12	57156	1	2, 3, 4, 5
BITS	RU	Roman	2013, 2016–2018	I, II, III, IV, V, VI, VII, VIII	4	12070	I, II	III, IV, V, VI, VII, VIII
BITS	DK	M6	2004–2025	61, 62, 63, 64, 65	22	99280	61	62, 63, 64, 65
BITS	DK	Numeric	2000–2003	1, 2, 3, 4, 5	4	15389	1	2, 3, 4, 5
BITS	DK	SMSF	2025–2026	A, Ba, B, Bb, C, Ca, Cb, D, Da, Db, E	2	3638	A, Ba	B, Bb, C, Ca, Cb, D, Da, Db, E
BITS	EE	Numeric	2000, 2005–2011	1, 2, 3, 4, 5	8	5355	1	2, 3, 4, 5
BITS	EE	Roman	2012–2025	I, III, IV, V, VI	14	5239	I	III, IV, V, VI
BITS	LT	M6	2011–2015	61, 62, 63, 64, 65	5	3792	61	62, 63, 64, 65

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Survey	Country	Scale	Years	Codes	N years	N obs	Immature	Mature
BITS	LT	Numeric	2005–2012	1, 2, 3, 4, 5	8	10749	1	2, 3, 4, 5
BITS	LT	Roman	2004, 2015–2020	I, II, III, IV, V, VI, VII, VIII	7	6395	I, II	III, IV, V, VI, VII, VIII
BITS	LT	SMSF	2021–2026	A, Ba, Bb, C, Da, Db, E	6	6553	A, Ba	Bb, C, Da, Db, E
BTS-VIII	FR	SMSF	2007–2025	A, Ba, B, Bb, C, Ca, D, Db, E	19	11446	A, Ba	B, Bb, C, Ca, D, Db, E
BTS	DE	Numeric	2008–2012, 2022–2025	1, 2, 3, 4	9	4726	1	2, 3, 4
BTS	NL	R1	2000	R1_1, R1_2	1	15	R1_1	R1_2
BTS	NL	R2	2001–2002, 2004–2010	R2_2, R2_4, R2_6, R2_8	9	7010	R2_2	R2_4, R2_6, R2_8
BTS	NL	SMSF	2011–2025	A, B, C, D, E	15	42209	A	B, C, D, E
BTS	BE	Numeric	2018–2019	1, 2, 3, 4	2	454	1	2, 3, 4
BTS	BE	SMSF	2020, 2022–2025	A, B, C, D	5	6360	A	B, C, D
DYFS	DE	M6	2004–2005, 2013–2025	61, 62	15	3771	61	62
DYFS	DE	Numeric	2016–2017, 2021	1	3	241	1	
DYFS	NL	R1	2000	R1_2	1	125		R1_2
DYFS	NL	R2	2003, 2005–2010	R2_2, R2_4, R2_6, R2_8	7	8019	R2_2	R2_4, R2_6, R2_8
DYFS	NL	SMSF	2011–2017, 2023–2025	A, B, C, D	10	5310	A	B, C, D
DYFS	BE	SMSF	2024–2025	A, B, C, D	2	894	A	B, C, D
EVHOE	FR	M6	2017–2020	61, 62, 63, 64, 65	4	12444	61	62, 63, 64, 65
EVHOE	FR	SMSF	2021–2025	A, B, C, Ca, D	5	16466	A	B, C, Ca, D
FR-CGFS	FR	M6	2006–2019	61, 62, 63, 64, 65	14	10698	61	62, 63, 64, 65
FR-CGFS	FR	SMSF	2020–2025	A, B, C, Ca, D	6	9471	A	B, C, Ca, D
FR-WCGFS	FR	SMSF	2018–2025	A, B, C, Ca, D, E	8	7141	A	B, C, Ca, D, E
NIGFS	GB-NIR	M6	2008–2025	61, 62, 63, 64	18	70793	61	62, 63, 64
NL-BSAS	NL	SMSF	2019, 2021–2022, 2025	A, B, C, D	4	1231	A	B, C, D
NS-IBTS	DE	M6	2008–2025	61, 62, 63, 64, 65	18	64415	61	62, 63, 64, 65
NS-IBTS	DE	Numeric	2000–2015, 2019, 2023	1, 2, 3, 4	18	48908	1	2, 3, 4
NS-IBTS	DE	SMSF	2021, 2024, 2026	A, Ba, B, Bb, C, Ca, Cb, D, Da, Db, E	3	4551	A, Ba	B, Bb, C, Ca, Cb, D, Da, Db, E
NS-IBTS	SE	M6	2006, 2009, 2011–2021	61, 62, 63, 64, 65	13	80879	61	62, 63, 64, 65
NS-IBTS	SE	Numeric	2000–2016	1, 2, 3, 4, 5	17	61804	1	2, 3, 4, 5
NS-IBTS	SE	SMSF	2013, 2022–2026	A, Ba, B, Bb, C, Ca, Cb, D, Da, Db, E	6	36898	A, Ba	B, Bb, C, Ca, Cb, D, Da, Db, E

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Survey	Country	Scale	Years	Codes	N years	N obs	Immature	Mature
NS-IBTS	DK	M6	2000–2021	61, 62, 63, 64, 65	22	63069	61	62, 63, 64, 65
NS-IBTS	DK	SMSF	2021–2026	A, Ba, B, Bb, C, Ca, Cb, D, Da, Db, E	6	20137	A, Ba	B, Bb, C, Ca, Cb, D, Da, Db, E
NS-IBTS	FR	M6	2011–2020	61, 62, 63, 64, 65	10	26720	61	62, 63, 64, 65
NS-IBTS	FR	Numeric	2000–2004, 2007–2010	1, 2, 3, 4	9	12975	1	2, 3, 4
NS-IBTS	FR	SMSF	2021–2026	A, B, C, D, E	6	13453	A	B, C, D, E
NS-IBTS	NL	M6	2011–2020	61, 62, 63, 64, 65	10	23415	61	62, 63, 64, 65
NS-IBTS	NL	Numeric	2000–2010	1, 2, 3, 4	11	24875	1	2, 3, 4
NS-IBTS	NL	SMSF	2021–2026	A, Ba, B, Bb, C, Ca, Cb, D, E	6	16428	A, Ba	B, Bb, C, Ca, Cb, D, E
NS-IBTS	GB	Numeric	2000–2003	1, 2, 3, 4	4	18715	1	2, 3, 4
NS-IBTS	GB-SCT	M6	2009–2023	61, 62, 63, 64, 65	15	58281	61	62, 63, 64, 65
NS-IBTS	GB-SCT	Numeric	2000–2013	1, 2, 3, 4	14	75968	1	2, 3, 4
NS-IBTS	GB-SCT	SMSF	2024–2026	A, Ba, B, Bb, C, Ca, Cb, D, Da, Db, E	3	11876	A, Ba	B, Bb, C, Ca, Cb, D, Da, Db, E
NS-IBTS	NO	M6	2004–2025	61, 62, 63, 64, 65	22	65336	61	62, 63, 64, 65
NS-IBTS	NO	Numeric	2000–2003, 2010–2015, 2023–2025	1, 2, 3, 4	13	11458	1	2, 3, 4
NS-IBTS	NO	SMSF	2026	A, Ba, Bb, Ca, Cb, Da, Db	1	2988	A, Ba	Bb, Ca, Cb, Da, Db
NSSS	DK	M6	2012–2025	61, 62, 63, 64, 65	14	55417	61	62, 63, 64, 65
NSSS	GB-SCT	M6	2017–2018, 2020–2025	61, 63	8	3094	61	63
PT-IBTS	PT	M6	2009–2011, 2013–2016, 2018	61, 62, 63, 64, 65	8	27643	61	62, 63, 64, 65
PT-IBTS	PT	Numeric	2002–2008	1, 2, 3, 4, 5	7	21024	1	2, 3, 4, 5
PT-IBTS	PT	SMSF	2022–2023	A, B, C, D	2	6739	A	B, C, D
ROCKALL	GB-SCT	Numeric	2001–2003, 2005–2007	1, 2, 3, 4	6	7445	1	2, 3, 4
SCOROC	GB-SCT	M6	2013, 2015, 2018–2019, 2021–2022	61, 62, 64	6	146	61	62, 64
SCOROC	GB-SCT	Numeric	2012	1, 4	1	44	1	4
SCOWCGFS	GB-SCT	M6	2011–2023	61, 62, 63, 64, 65	13	52175	61	62, 63, 64, 65
SCOWCGFS	GB-SCT	Numeric	2011–2013	1, 2, 3, 4	3	4203	1	2, 3, 4
SCOWCGFS	GB-SCT	SMSF	2023–2026	A, Ba, B, Bb, C, Ca, Cb, D, Da, Db, E	4	11946	A, Ba	B, Bb, C, Ca, Cb, D, Da, Db, E
SE-SOUND	SE	Roman	2011–2018, 2020	I, II, III, IV, V, VI	9	3445	I	II, III, IV, V, VI
SE-SOUND	SE	SMSF	2021–2023, 2025	A, Ba, Bb, Ca, Cb, Da, Db	4	1856	A, Ba	Bb, Ca, Cb, Da, Db

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Survey	Country	Scale	Years	Codes	N years	N obs	Immature	Mature
SNS	NL	R2	2001, 2005–2006, 2008–2009	R2_2, R2_4, R2_8	5	2882	R2_2	R2_4, R2_8
SNS	NL	SMSF	2017, 2024	A, B	2	10	A	B
SP-ARSA	ES	M6	2003–2011, 2013–2020, 2023, 2025	61, 62, 63, 64, 65	19	22493	61	62, 63, 64, 65
SP-NORTH	ES	M6	2000–2023, 2025	61, 62, 63, 64, 65	25	61209	61	62, 63, 64, 65
SP-PORC	ES	M6	2001–2023, 2025	61, 62, 63, 64, 65	24	42312	61	62, 63, 64, 65
SWC-IBTS	GB-SCT	M6	2009–2010	61, 62, 63, 64	2	3129	61	62, 63, 64
SWC-IBTS	GB-SCT	Numeric	2000–2010	1, 2, 3, 4	11	72223	1	2, 3, 4

* For herring (*Clupea harengus*) in the Swedish and Polish IBTS, Roman stage II is also classed immature; for all other species it is dropped as ambiguous.

Table S2: Deviation of each Roman-numeral stage-II rule from the reference-key L_{50} (BITS numeric, M6, SMSF), pooled per species and ICES subdivision. A positive deviation means the rule overestimates L_{50} relative to the reference key. n is the number of species-by-subdivision comparisons.

Stage-II rule	n	Median dev. (cm)	Median dev. (cm)	Max dev. (cm)
Stage II mature	13	-1.7	1.8	8.6
Stage II excluded	15	-0.1	1.9	6.5
Stages I and II immature	15	5.0	5.0	17.6

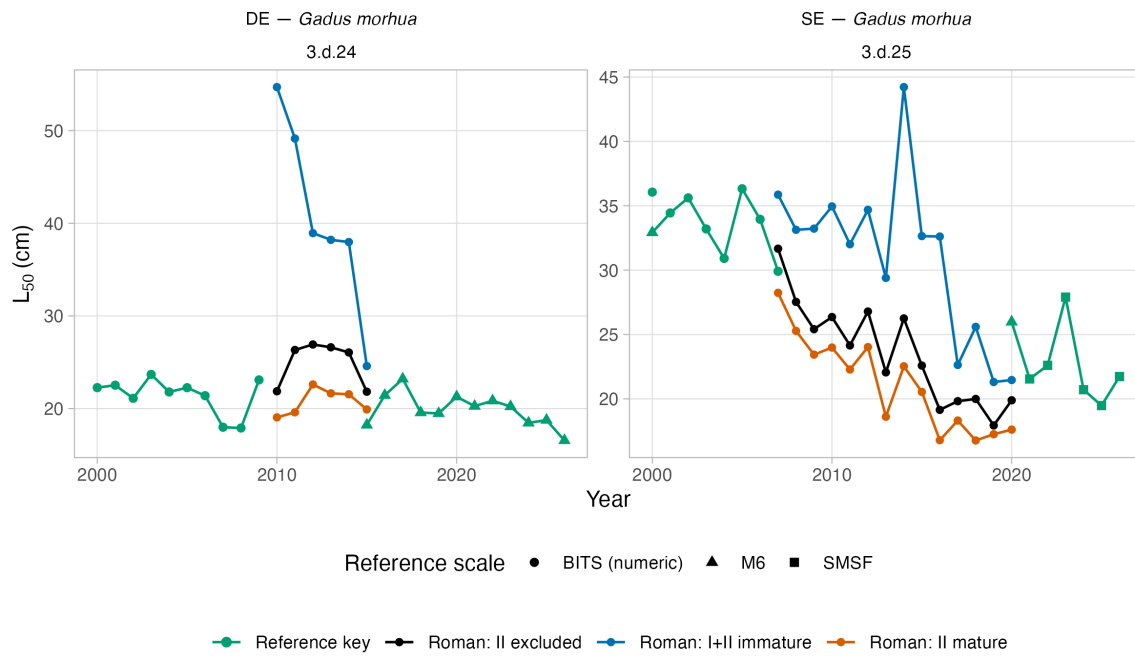


Figure S1: Sensitivity of length at maturity (L_{50}) to the treatment of Roman-numeral stage II in the BITS survey, shown by year for two well-sampled cod cases from Germany (DE) and Sweden (SE) (ICES subdivision below). In the Roman-coded years, stage II is either excluded, treated as immature, or treated as mature; these are compared with the estimates from the reference keys used in other years (BITS numeric, M6, SMSF). Treating stage II as immature inflates L_{50} well above the reference keys, whereas excluding it keeps the estimates continuous with them, supporting the decision to drop stage II.

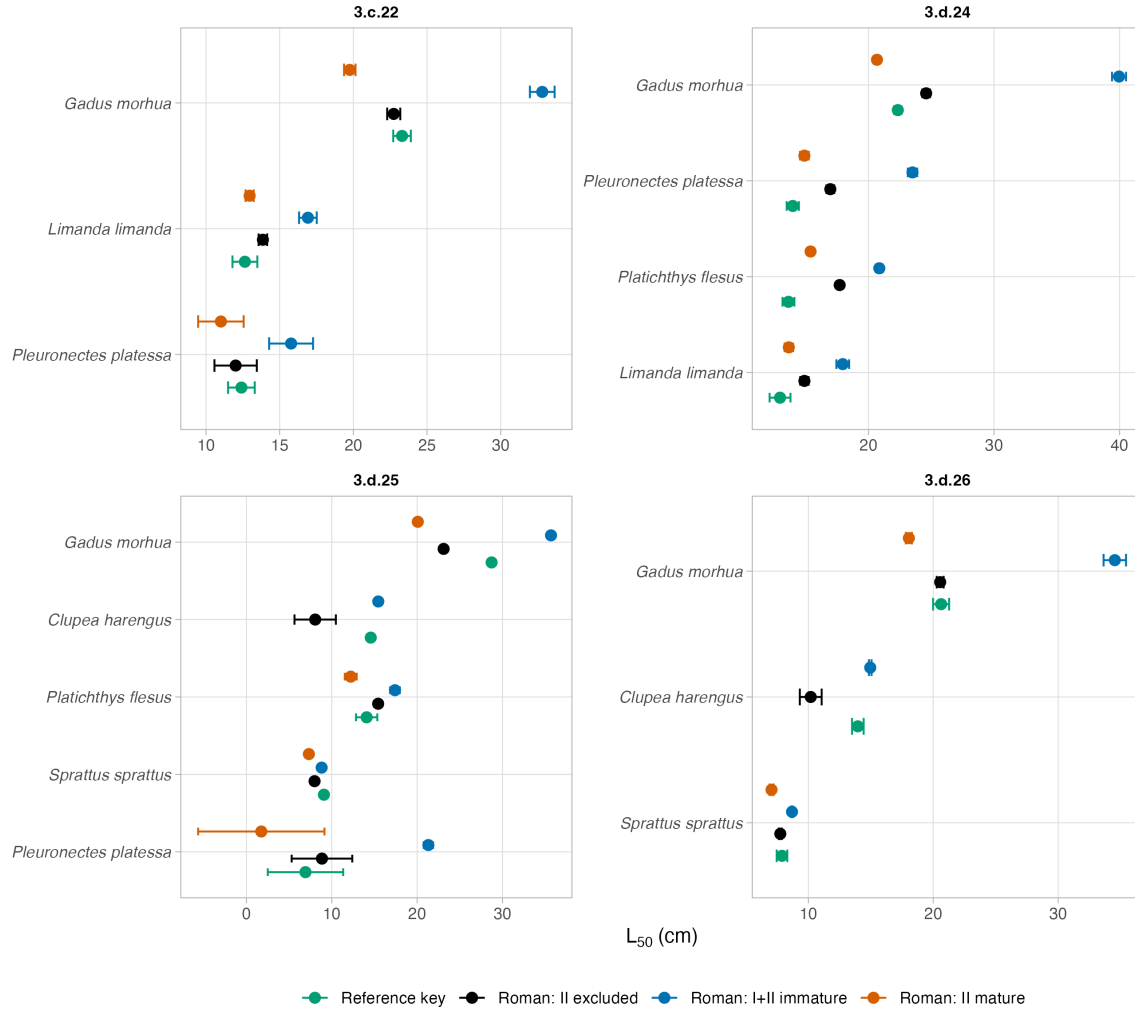


Figure S2: Sensitivity of length at maturity (L_{50}) to the treatment of Roman-numeral stage II in the BITS survey. Pooled length at maturity (L_{50} , points; 95% confidence intervals, horizontal bars) per species and maturity-coding rule, in four ICES subdivisions, for species carrying both Roman-coded and reference-key records. For each species the reference key (BITS numeric, M6, SMSF; green) is compared with three treatments of Roman-numeral stage II: excluded (black), stages I and II immature (blue), and stage II mature (orange). Reference records are restricted to each species' Roman coverage window so the estimates are time-comparable, and records are pooled across countries within a subdivision. Treating stage II as immature inflates L_{50} well above the reference key across species and subdivisions, whereas excluding it stays closest to the reference (see Table S2).

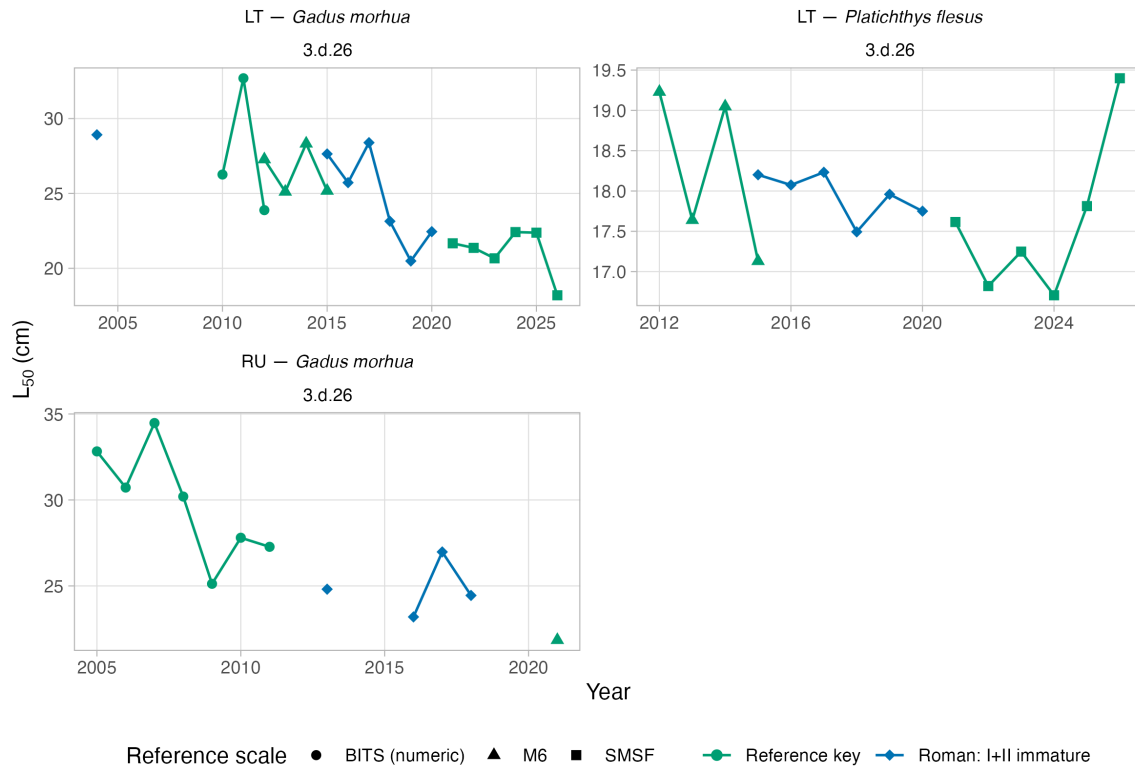


Figure S3: Length at maturity (L_{50}) by year for Lithuania (LT) and Russia (RU) in the BITS survey, shown for example species (ICES subdivision below). For these two countries, which record almost no stage-I fish, stages I and II together are treated as immature on the Roman-numeral national key; this estimate falls within the range of the same country's reference-key estimates in every panel, supporting the I+II-immature rule.

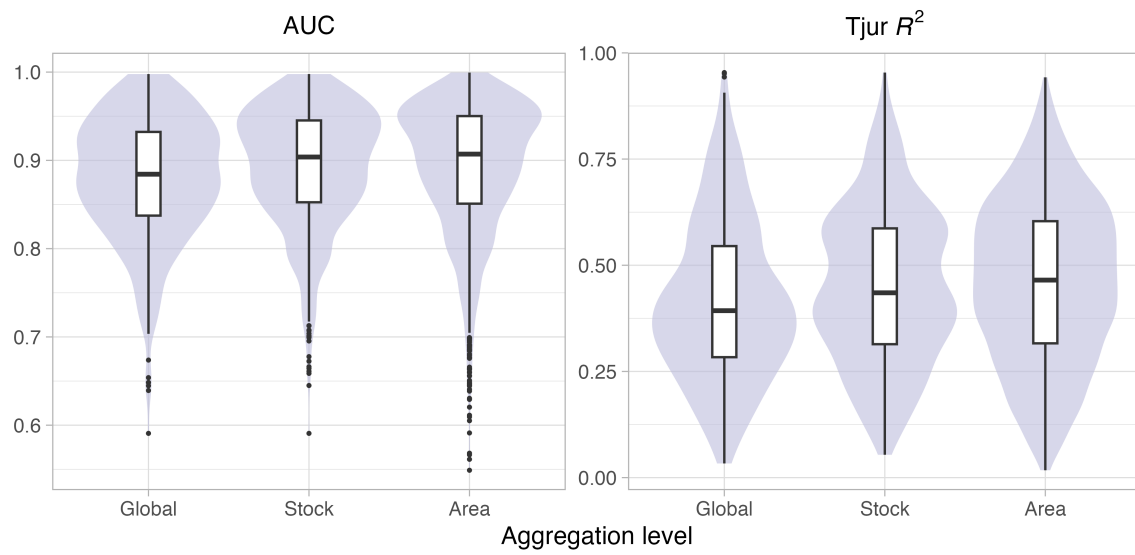


Figure S4: AUC and Tjur's R^2 of the retained length-at-maturity ogives, by aggregation level (global, stock, ICES area). Violins show the distribution across ogives; boxplots show the median and interquartile range.