

STATISTICAL CATCH AT LENGTH ASSESSMENT METHODOLOGY FOR ATLANTIC BLUEFIN TUNA

D S Butterworth¹ and R A Rademeyer¹

Summary

A description of the Statistical catch at Length (SCAL) assessment methodology is given, covering both the formulation of the population dynamics and the penalised log likelihood used for fitting to data. Parameter value inputs for recent applications to East Atlantic and Mediterranean as well as to West Atlantic bluefin tuna are provided, together with the data used on those occasions.

Introduction

The Statistical Catch at Length (SCAL) assessment methodology is described in detail below. The current model specifications used for the Eastern Atlantic and Mediterranean (Butterworth and Rademeyer 2015) and for the Western Atlantic (Butterworth and Rademeyer 2014) are given in Appendix A, with the corresponding data given in Appendices B and C respectively.

The Statistical Catch-at-Length Model

The text following sets out the equations and other general specifications of the Statistical Catch at Length (SCAL) assessment model, 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. These are as have been most recently applied both to give assessment results, and to provide Operating Models for simulation testing of Management Procedures. Quasi-Newton minimization may then be applied to minimize the total (penalised) negative log-likelihood function to estimate parameter values (the package AD Model Builder™ (Fournier *et al.* 2011) is used for this purpose).

1. Population dynamics

1.1 Numbers-at-age

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

$$N_{y+1,1} = R_{y+1} \tag{1}$$

$$N_{y+1,a+1} = N_{y,a} e^{-Z_{y,a}} \quad \text{for } 1 \leq a \leq m-2 \tag{2}$$

$$N_{y+1,m} = N_{y,m-1} e^{-Z_{y,m-1}} + N_{y,m} e^{-Z_{y,m}} \tag{3}$$

¹ Marine Resource Assessment and Management Group, University of Cape Town, South Africa, doug.butterworth@uct.ac.za.

where

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

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

R_y is the recruitment (number of 1-year-old fish) at the start of year y ,

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

$Z_{y,a} = \sum_f F_y^f S_{y,a}^f + M_a$ is the total mortality in year y on fish of age a , where

F_y^f is the fishing mortality of a fully selected age class in year y for fishery f , and

$S_{y,a}^f$ is the commercial selectivity at age a for year y for fishery f .

1.2. Recruitment

The number of recruits (i.e. new 1-year olds) at the start of year y is assumed to be related to the spawning stock size (i.e. the biomass of mature fish) at the mid-point of the preceding year by a Beverton-Holt or a “hockey-stick” stock-recruitment relationship, allowing for annual fluctuation about the deterministic relationship:

For the Beverton-Holt relationship:

$$R_y = \frac{\alpha B_{y-1}^{\text{sp}}}{\beta + B_{y-1}^{\text{sp}}} e^{(\zeta_y - (\sigma_R)^2/2)} \quad (4a)$$

and for the “hockey-stick” relationship:

$$R_y = \begin{cases} \frac{\mu}{B_\mu} B_{y-1}^{\text{sp}} e^{(\zeta_y - (\sigma_R)^2/2)} & \text{if } B_{y-1}^{\text{sp}} \leq B_\mu \\ \mu e^{(\zeta_y - (\sigma_R)^2/2)} & \text{if } B_{y-1}^{\text{sp}} > B_\mu \end{cases} \quad (4b)$$

where

α , β , μ and B_μ are spawning biomass-recruitment relationship parameters,

ζ_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 in year y , computed as:

$$B_y^{\text{sp}} = \sum_{a=1}^m f_{y,a} w_{y,a}^{\text{sp}} N_{y,a} e^{-Z_a \frac{T^s}{12}} \quad (5)$$

where

spawning for the stocks under consideration is taken to occur T^s months after the start of the year (here $T^s = 6$) and some natural mortality has therefore occurred,

$w_{y,a}^{\text{sp}}$ is the mass of fish of age a during spawning, and

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

For the Beverton-Holt stock-recruit relationship, the estimation is carried out in terms of parameters h (steepness) (though this may be fixed on input) and pre-exploitation equilibrium spawning biomass K^{sp} , which are related to the parameters α and β of equation 4a by:

$$R_0 = K^{\text{sp}} / \text{SPR}_0 \quad (6)$$

where

$$SPR_0 = \sum_{a=1}^{m-1} f_a w_a^{sp} e^{-\frac{T_a}{12} \sum_{a'=1}^{a-1} M_{a'}} + f_m w_m^{sp} \frac{e^{-\frac{T_m}{12} \sum_{a'=1}^{m-1} M_{a'}}}{1 - e^{-\frac{T_m}{12} M_m}} \quad (7)$$

and

$$\begin{aligned} \alpha &= 4hR_0 / (5h - 1) \\ \beta &= K^{sp} (1 - h) / (5h - 1) \end{aligned} \quad (8)$$

The parameters μ and B_μ of the Hockey-stick stock recruitment relationship are estimated directly in the model fitting procedure (alternatively B_μ may be fixed externally).

1.3. Total catch and catches-at-age

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

$$C_y^f = \sum_{a=0}^m w_{y,a}^f C_{y,a}^f = \sum_{a=0}^m w_{y,a}^f N_{y,a} S_{y,a}^f F_y^f (1 - e^{-Z_{y,a}}) / Z_{y,a} \quad (9)$$

where

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

$S_{y,a}^f$ is the commercial selectivity of fleet f (i.e. combination of availability and vulnerability to fishing gear) at age a for year y ; when $S_{y,a}^f = 1$, the age-class a is said to be fully selected,

F_y^f is the proportion of a fully selected age class that is fished by fleet f , and

$w_{y,a}^f$ denotes the selectivity-weighted mid-year weight of fish of age a landed in year y by fleet f , computed as:

$$\tilde{w}_{y,a}^f = \sum_l S_{y,l}^f w_l A_{a,l} / S_{a,l}^f \quad (10)$$

with

w_l is the weight of fish of length l ; and

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

The matrix $A_{a,l}$ is calculated under the assumption that length-at-age is normally distributed about a mean given by the von Bertalanffy equation, i.e.:

$$L_a \sim N[L_\infty (1 - e^{-\kappa(a-t_o)}); \theta_a^2] \quad (11)$$

where

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.:

$$\theta_a = \beta_a L_\infty (1 - e^{-\kappa(a-t_o)}) \quad (12)$$

with β_a either fixed on input or estimated, and either age-independent or a linear function of age.

Selectivity is estimated as a function of length and then converted to an effective selectivity-at-age:

$$S_{y,a}^f = \sum_l S_{y,l}^f A_{a,l} \quad (13)$$

1.4. Initial conditions

For the first year (y_0) considered in the model, the numbers-at-age are estimated directly for ages 1 to a^{est} , with a parameter ϕ which mimics recent average fishing mortality for ages above a^{est} , i.e.:

$$N_{y_0,a} = N_{start,a} \quad \text{for } 1 \leq a \leq a^{est} \quad (14)$$

and

$$N_{start,a} = N_{start,a-1} e^{-M_{a-1}} (1 - \phi S_{a-1}) \quad \text{for } a^{est} < a \leq m-1 \quad (15)$$

$$N_{start,m} = N_{start,m-1} e^{-M_{m-1}} (1 - \phi S_{m-1}) / (1 - e^{-M_m} (1 - \phi S_m)) \quad (16)$$

2. The (penalised) likelihood function

The model is fitted to CPUE and commercial catch-at-length data to estimate model parameters (which may include residuals about the stock-recruitment function, facilitated through the incorporation of a penalty function described below). Contributions by each of these to the negative of the (penalised) log-likelihood ($-\ell n L$) are as follows.

2.1 Relative abundance data

The likelihood is calculated assuming that the index observed for a particular fishing fleet is log-normally distributed about its expected value:

$$I_y^i = \hat{I}_y^i \exp(\varepsilon_y^i) \quad \text{or} \quad \varepsilon_y^i = \ln(I_y^i) - \ln(\hat{I}_y^i) \quad (17)$$

where

I_y^i is the index of biomass or abundance index for year y for gear/flag combination i ,

$\hat{I}_y^i = \hat{q}^i \sum_{a=1}^m w_{y,a}^i S_{y,a}^i N_{y,a} e^{-Z_{y,a}/2}$ is the corresponding model estimate of biomass or

$\hat{I}_y^i = \hat{q}^i \sum_{a=1}^m S_{y,a}^i N_{y,a} e^{-Z_{y,a}/2}$ is the corresponding model estimate of abundance in numbers, or, in the case of

the larval indices:

$$\hat{I}_y^i = \hat{q}^i B_y^{sp}$$

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

ε_y^i from $N(0, (\sigma^i)^2)$.

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

$$-\ell n L^i = \sum_y \left\{ \ell n \left(\sqrt{(\sigma^i)^2 + (\sigma_{Add}^i)^2} \right) + \frac{(\varepsilon_y^i)^2}{2[(\sigma^i)^2 + (\sigma_{Add}^i)^2]} \right\} \quad (18)$$

where

σ^i is the standard deviation of the residuals for the logarithm of index i , estimated by its maximum likelihood value:

$$\hat{\sigma}^i = \sqrt{1/n_i \sum_y (\ln(I_y^i) - \ln(q^i I_y^i))^2}$$

where n_i is the number of data points for index i , and

σ_{Add}^i is the square root of the additional variance for the CPUE series, which can be estimated in the model fitting procedure but has been set to a fixed value (which might be zero) on input..

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

$$\ell n \hat{q}^i = 1/n_i \sum_y (\ln I_y^i - \ln \hat{I}_y^i) \quad (19)$$

Note that for the applications considered to date, selectivity at age $S_{y,a}^f$ is year-invariant over the period for which values of the index are available. More complex formulations are necessary should selectivity-at-age change during such periods. The indices' selectivities are taken to be the same as for the overall gear type.

2.3. 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 (Punt and Kennedy 1997) is given by:

$$-\ell n L^{CAL} = w_{len} \sum_f \sum_y \sum_l \left[\ell n \left(\sigma_{len}^f / \sqrt{p_{y,l}^f} \right) + p_{y,l}^f (\ell n p_{y,l}^f - \ell n \hat{p}_{y,l}^f)^2 / 2(\sigma_{len}^f)^2 \right] \quad (20)$$

where

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

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

where

$$\hat{C}_{y,l}^f = \sum_a N_{y,a} A_{a,l} S_{y,l}^f e^{-Z_{y,a}/2} \quad (21)$$

and

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

$$\hat{\sigma}_{com}^f = \sqrt{\sum_y \sum_l p_{y,l}^f (\ell n p_{y,l}^f - \ell n \hat{p}_{y,l}^f)^2 / \sum_y \sum_l 1} \quad (22)$$

Commercial catches-at-length are grouped with the next length class if the proportion is less than 2%.

The W_{len} weighting factor may be set to a value less than 1 to downweight the contribution of the catch-at-length data (which tend to be positively correlated between adjacent length groups) to the overall negative log-likelihood compared to that of the CPUE data.

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:

$$-\ell nL^{\text{pen}} = \sum_{y=y_1+1}^{y_2} \left[\zeta_y^2 / 2\sigma_R^2 \right] \quad (23)$$

where

ζ_y is the recruitment residual for year y , which is estimated for year y_1 to y_2 (see equation (4)),

σ_R is the standard deviation of the log-residuals, which is input.

3. Estimation of precision

The Hessian may be used to provide 95% confidence interval estimates.

4. Model parameters

4.1. Input parameters

The model input parameter values used in the most recent applications are given in Appendix A.

4.2. Fishing selectivity

Fishing selectivities-at-length are estimated using a four parameters double-logistic form:

$$S_l = \left(1 + e^{-a_1(l-b_1)}\right)^{-1} \left[1 - \left(1 + e^{-a_2(l-b_2)}\right)^{-1}\right] \quad (24)$$

5. Next steps

Responses are sought from the meeting regarding the following.

- Whether any modifications to the methodology are desired.
- Whether the fleet groupings suggested in Appendix A are acceptable or should be modified.

It is assumed that the data listed in Appendices B and C will be updated during the meeting.

REFERENCES

- Butterworth, D.S. and Rademeyer, R.A. 2014. An updated Statistical Catch-At-Length assessment for Western Atlantic Bluefin Tuna. Doc. No. SCRS/2014/188. 22p.
- Butterworth, D.S. and Rademeyer, R.A. 2015. An illustrative example of a Management Procedure for Eastern North Atlantic Bluefin Tuna. Doc. No. SCRS/2015/167. 28p.
- Fournier, D.A., Skaug, H.J., Ancheta, J., Ianelli, J., Magnusson, A., Maunder, M.N., Nielsen, A. and Sibert, J. 2011. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optimization Methods & Software. doi: 10.1080/10556788.2011.597854.
- ICCAT. 2012. Report of the 2012 Atlantic bluefin stock assessment session. Madrid, Spain. Doc. No. SCI-033/2012. 124p.
- Punt, A.E. and Kennedy, R.B. 1997. Population modeling of Tasmanian rock lobster, *Jasus edwardsii*, resources. Mar. Freshw. Res. 48, 967–980.

Appendix A – Model specifications used for the most recent SCAL applications**A.1. Model parameter values input**

The model input parameter values used in the most recent applications are given in Table A1 below.

Table A1: Input parameters (units are gm, cm and year as appropriate) (length-weight, von Bertalanffy growth, maturity and natural mortality at age from ICCAT, 2012).

	Eastern Atlantic and Mediterranean	Western Atlantic
Initial year (y_0)	1950	1970
Model plus group (m)	15	16
Length-weight	$a=0.0000295$, $b=2.899$ (≤ 100 cm) and $a=0.0000196$, $b=3.009$ (>100 cm)	$a=0.00002861$, $b=2.929$
von Bertalanffy growth	$\kappa=0.093$, $L_{\text{inf}}=319$, $t_0=-0.97$	$\kappa=0.089$, $L_{\text{inf}}=315$, $t_0=-1.13$
Maturity-at-age	50% maturity at age 4, 100% maturity at age 5	100% maturity at age 9
Natural mortality (yr ⁻¹)	1 2-5 6 7 8 9 10+	1+
	0.49 0.24 0.2 0.18 0.15 0.13 0.1	0.14
Stock-recruitment	Beverton-Holt, $h=0.98^*$, $\sigma_R=0.5$	Beverton-Holt, $h=0.98^{**}$, $\sigma_R=0.6$
β (eqn 12)	0.1 for age 1, 0.2 for age 15 and changing linearly for the intermediate	0.25
w_{len} (eqn 20)	0.5	0.05

* This high value was specified on input rather than estimated in the fit of the model given the absence of any clear trend in the stock-recruitment plot.

** Used as a simple approach to approximate a hockey-stick form in this instance; more generally either the Beverton-Holt or hockey-stick would be used where their parameter values were estimated.

A.2. Fleet groupings

The different fleets have been grouped into bait boat, longline; purse seine, traps and other for the Eastern Atlantic and into longline; purse seine, traps, sport and other for the Western Atlantic

Appendix B - The data for the Eastern Atlantic and Mediterranean, as used in Butterworth and Rademeyer (2015)

Table B1: Catches in mt.

	Baitboat	Longline	Purse seine	Traps	Other
1950	2865.0	0	2856.9	12198.0	6948.7
1951	3979.0	0	7259.3	9717.0	7840.1
1952	3786.0	0	15752.8	9831.0	7600.3
1953	3556.0	0	11281.0	14626.0	7866.3
1954	4430.0	0	13390.5	11576.0	5455.6
1955	4448.0	0	14294.6	11671.0	9199.3
1956	2791.0	0.0	5932.5	16323.0	2375.2
1957	3154.0	33.0	7057.6	20026.0	4045.0
1958	2829.0	2.0	7004.1	20918.0	2116.6
1959	3052.0	56.0	3628.8	14443.0	3512.5
1960	1198.0	481.0	6725.8	13320.0	2235.5
1961	1453.0	223.0	12019.0	10619.0	2553.2
1962	1537.0	2484.0	10777.3	11875.0	1884.0
1963	1178.0	2418.0	3119.1	6531.0	2244.1
1964	1079.0	882.0	4781.1	8140.0	1697.1
1965	1820.0	834.0	3846.8	9044.0	1313.4
1966	3347.0	581.0	4653.7	5373.0	702.0
1967	1805.0	441.0	6981.9	7877.0	2203.0
1968	1474.0	808.0	4547.0	4872.0	918.0
1969	1826.0	601.0	5148.7	5988.0	894.0
1970	3017.0	343.0	3269.3	3180.0	857.0
1971	3055.0	383.0	4586.8	2211.0	720.0
1972	3032.0	497.0	5045.5	1837.0	276.0
1973	3142.0	611.0	5257.5	1546.0	182.0
1974	2348.0	4651.0	9577.7	2382.0	168.0
1975	2918.5	4323.0	11677.0	2027.0	266.3
1976	1709.8	3291.0	14830.0	2008.0	354.6
1977	2813.3	2445.0	10989.0	1717.0	753.3
1978	3593.0	912.0	7556.0	1458.0	1125.5
1979	2033.9	970.0	6369.0	1350.0	1500.2
1980	1499.8	1255.0	8978.0	1642.0	875.5
1981	1222.5	917.0	8795.0	2011.0	828.1
1982	884.3	4255.0	12786.0	3673.0	809.8
1983	1882.4	3606.0	10746.0	3254.0	2293.9
1984	3961.1	2737.0	10261.0	4507.0	2961.0
1985	2281.5	1778.6	11305.0	2390.0	4255.1
1986	1413.8	1644.8	9609.0	1740.0	4839.6
1987	1820.8	1723.3	8857.0	1953.0	3865.5
1988	1935.9	2396.0	11198.0	3658.0	4929.7
1989	1970.6	2083.2	9450.0	2789.0	4768.1
1990	1717.9	2522.0	11304.0	4376.0	3326.7
1991	1592.6	6066.3	13291.0	2993.0	2485.7
1992	1298.6	6416.2	18269.0	2186.0	3679.1
1993	3495.1	5058.9	19321.0	2001.0	4391.7
1994	1979.6	9223.7	26296.0	2834.0	6406.8
1995	2807.4	12867.2	24046.0	1924.0	5645.0
1996	4989.6	12959.0	26344.0	2522.0	3992.1
1997	3524.9	10206.0	25006.0	4367.0	4050.3
1998	2561.5	7049.1	21983.0	4259.0	3865.1
1999	1496.0	6483.2	15636.0	3711.0	5128.9
2000	1821.7	7052.3	17341.3	3735.3	3814.7
2001	2275.0	7053.0	17324.4	4762.6	3190.1
2002	2568.0	5510.8	18540.3	3750.6	3400.5
2003	1379.5	5226.5	17657.4	2302.4	4596.6
2004	1807.0	4638.2	19862.5	2137.3	2935.2
2005	2022.9	5814.6	23345.9	2522.7	2139.4
2006	1115.6	4649.6	20352.1	2717.6	1854.4
2007	2031.5	4360.8	22951.5	3883.0	1288.3
2008	1794.4	4740.5	12641.3	3317.2	1343.0
2009	1297.7	3301.9	11394.5	3308.3	752.9
2010	645.5	2068.9	5057.9	2587.8	787.0
2011	635.9	2025.7	4305.9	2301.6	503.6
2012	282.25	1750.15	6105.19	2436.58	276.57
2013	245.02	620.8	5113.22	1825.17	288.44

Table B2: Commercial fleet catch-at-length numbers for each fleet considered

Baitboat	30-	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250+
1954	0	0	0	0	2117	614	1622	237	1072	678	7239	28317	23200	7524	4097	1216	0	0	0	0	0	0	0
1955	0	0	1558	9646	22421	25314	19711	47609	13532	12049	6220	12395	8230	2567	1320	391	0	0	0	0	0	0	0
1956	0	0	747	4624	11063	12226	9690	22858	6647	5877	4058	10152	7395	2349	1242	368	0	0	0	0	0	0	0
1957	0	0	826	5118	12277	13541	10749	25301	7372	6515	4603	11673	8542	2716	1438	426	0	0	0	0	0	0	0
1958	0	0	731	4526	10878	11982	9523	22379	6531	5768	4141	10600	7781	2476	1311	389	0	0	0	0	0	0	0
1959	0	0	1111	6877	15931	18032	14011	33936	9621	8573	4251	8121	5281	1640	837	248	0	0	0	0	0	0	0
1960	0	0	359	2225	4499	4977	3578	8641	3673	3507	1913	4243	2998	945	508	160	11	0	0	0	0	0	0
1961	0	0	560	3469	6754	7634	5342	13262	5668	5462	2314	3967	2501	768	410	136	18	0	0	0	0	0	0
1962	0	0	620	3840	7499	8501	5964	14845	6224	5986	2435	3929	2394	730	386	131	20	0	0	0	0	0	0
1963	0	0	440	2722	5556	6265	4527	11127	4305	4080	1837	3340	2161	669	354	114	11	0	0	0	0	0	0
1964	0	0	423	2620	5486	6215	4561	11215	4021	3769	1649	2859	1793	551	288	91	8	0	0	0	0	0	0
1965	0	0	739	4570	9564	10941	8019	19902	6879	6429	2434	3319	1769	522	260	89	13	6	63	231	334	196	63
1966	0	0	817	5061	32126	37110	22927	55835	10589	8630	2570	2154	533	118	12	2	1	3	36	182	388	270	94
1967	0	0	531	3281	11290	13043	12605	30794	6477	5401	730	292	91	71	90	63	44	7	42	158	347	355	151
1968	0	0	2637	16322	10057	11619	3841	10077	5772	5798	2302	1976	508	57	10	24	22	1	8	114	264	311	393
1969	0	0	3939	24398	31940	36897	6302	15508	3713	3255	552	423	178	85	0	0	0	0	6	154	356	503	221
1970	0	0	4875	30200	29454	34025	5243	14152	8899	6825	4147	3855	1751	1132	828	165	0	0	11	81	522	983	957
1971	0	0	226	1402	25215	29127	6081	15317	6207	6281	5945	7042	1974	822	495	100	0	3	15	102	434	973	1512
1972	0	0	141	873	24452	28309	2484	5236	2247	2346	2045	6787	3332	3133	2487	800	302	0	11	102	545	1201	1689
1973	0	0	187	1154	22101	25530	4649	11289	1999	1607	605	1691	1574	1380	3235	2994	2512	343	3	40	351	985	1951
1974	0	0	233	1443	24206	27961	10221	24887	4727	3840	1124	1104	309	120	33	22	37	55	38	114	257	545	1628
1975	0	0	2148	13305	51018	58935	2955	7512	2983	2872	646	669	220	93	12	20	4	3	70	141	343	932	3042
1976	0	0	48	1747	15067	26840	5989	6034	697	858	665	733	676	346	95	33	0	1	173	171	594	2047	
1977	0	0	1004	8262	25875	57885	8458	11623	4915	2146	574	164	110	128	111	51	0	38	1	154	539	584	2939
1978	0	0	4486	50605	37076	30788	2753	6750	4484	9557	3854	2632	1003	201	46	21	102	219	352	831	1496	1473	2187
1979	0	0	1608	10625	3253	8504	5594	9821	5434	9069	2111	2229	843	484	250	20	750	354	82	163	246	331	1304
1980	0	0	6917	42530	9928	13560	3512	4275	1122	1014	1062	1970	1517	956	743	64	101	39	131	304	236	201	701
1981	0	0	3746	26170	25012	12064	1614	2876	1061	598	409	375	381	331	160	86	17	37	111	520	553	222	541
1982	0	66	2472	14151	9864	18638	3906	4427	1770	1151	1232	600	386	355	277	205	46	0	2	52	16	33	121
1983	0	713	33283	138203	8596	38473	5072	2069	1089	524	281	10	78	17	20	25	2	72	119	438	345	232	235
1984	0	0	2096	37819	19063	110343	31182	17669	9195	2754	6322	2623	3166	1584	445	284	23	192	97	2	1	0	95
1985	0	0	7873	50417	60121	28682	17876	16842	3045	3943	1010	703	480	164	22	0	0	26	39	130	247	104	65
1986	0	0	14743	80489	5464	25899	13489	3096	1282	3646	750	480	290	55	0	11	29	14	34	75	129	36	38
1987	0	0	3619	25170	61326	56370	4348	1638	932	2729	598	1818	1036	138	120	0	62	102	62	86	21	51	51
1988	0	671	88434	113618	32376	29472	4621	4225	1422	1368	1061	789	415	493	36	8	0	0	0	0	0	0	0
1989	0	23	5904	108768	79781	30949	8687	3062	1412	1116	920	428	344	95	29	4	3	0	0	0	0	0	0
1990	0	278	13833	56317	12620	31672	12851	11964	1800	2372	4191	1652	432	14	1	3	5	0	0	0	0	0	0
1991	0	0	712	45513	21585	43736	6971	1694	5090	2447	2576	447	523	471	251	128	32	122	32	16	35	0	0
1992	0	751	11062	26333	6624	43517	21949	1765	1505	1050	756	281	548	22	43	0	28	0	0	0	0	0	0
1993	0	238	3737	20099	68898	93411	15071	31935	8758	8528	2843	1253	726	661	7	7	0	0	0	0	0	0	0
1994	0	0	1434	27341	91397	11178	17943	4131	4814	3327	4088	1513	433	62	10	31	14	29	14	22	43	36	72
1995	0	0	24040	114513	18446	28001	64910	12177	5121	2299	725	282	210	19	7	3	0	0	0	0	0	0	93
1996	0	319	83794	160460	52815	42532	46611	26816	15497	17219	6598	2735	234	78	33	37	88	83	45	41	31	101	
1997	0	171	26486	65516	21274	24129	57618	12041	5315	6645	3395	1951	237	106	42	106	205	360	237	288	382	382	1414
1998	0	157	34295	19312	25058	27809	15701	12909	20225	7688	1112	517	734	490	289	44	31	56	105	257	153	159	362
1999	0	2	1418	5458	2582	2444	2404	939	7163	5196	11015	3791	1733	1037	194	86	67	44	50	30	37	13	46
2000	0	0	607	31951	18065	8663	5900	4265	4281	2291	2305	4470	2488	624	758	1158	833	390	179	98	51	16	88
2001	0	0	0	631	41603	62489	10869	13175	3619	2682	1211	570	1233	1421	334	249	554	339	236	216	126	36	48
2002	0	0	176	28862	15099	59540	38584	20500	4075	1656	1005	359	158	71	156	383	375	420	260	177	91	47	39
2003	54	0	321	1296	20266	11152	11821	6210	828	399	593	1428	674	141	111	386	1142	1149	546	308	93	43	16
2004	0	0	65	38085	50135	33680	3922	5413	4912	1528	952	766	412	324	178	72	141	451	551	323	109	62	37
2005	0	0	0	82599	71765	7065	25822	3295	2495	1384	2010	1118	422	59	139	62	54	107	238	183	37	13	12
2006	0	0	0	8312	31898	7005	13495	1525	6101	1471	779	312	631	686	239	85	64	61	218	51	114	36	0
2007	0	0	1	0	5008	27117	3795	11733	16827	5635	2964	4011	1238	844	299	115	103	551	187	120	69	21	17
2008	0	0	1	11	11100	16097	19278	11538	8305	7541	2782	429	54	246	257	212	233	339	272	270	158	96	52
2009	0	0	0	47	930	8964	8222	7721	6143	2275	1252	1404	2325	1535	418	372	278	213	210	121	53	34	21
2010	0	0	0	66	1731	7823	12847	2035	2911	2001	1250	346	151	441	375	102	86	102	59	20	14	23	20
2011	0	0	0	0	656	5006	758	2895	2445	1379	1393	2119	1009	426	126	232	103	83	105	67	33	12	5
2012	0	0	0	0	0	0	117	1683	2215	1268	1450	148	82	61	24	26	47	50	42	60	53	24	2
2013	0	0	0	0	8	0	441	10	216	411	237	247	22	223	27	116	31	73	156	172	212	95	41

Table B2: Continued

Longline	30-	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250+
1960	0	0	0	0	0	0	0	0	0	0	78	116	140	54	75	683	1065	591	153	308	4	0	0
1961	0	0	0	0	0	0	0	0	0	0	32	49	59	23	31	286	448	255	74	151	23	17	9
1962	0	0	0	0	0	0	0	0	0	0	395	591	713	281	388	3461	5387	2998	778	1555	23	0	0
1963	0	0	10	59	32	37	34	89	52	89	382	439	814	228	408	2776	4267	3034	1019	1715	386	37	146
1964	0	0	8	47	24	29	10	27	16	16	8	31	172	103	119	1019	1657	994	539	618	155	73	15
1965	0	0	17	94	51	59	12	34	34	34	75	103	145	97	126	632	992	582	236	589	528	323	178
1966	0	0	12	76	41	47	21	58	42	44	12	41	94	67	84	213	390	399	334	400	408	237	168
1967	0	0	3	21	12	15	15	32	20	29	16	15	57	96	105	228	404	503	299	190	179	109	171
1968	0	0	14	83	23	51	30	79	56	58	17	49	112	82	93	240	410	790	541	437	443	480	266
1969	0	0	9	56	15	34	20	53	37	39	17	51	86	75	137	409	410	445	249	333	324	238	326
1970	0	0	1	3	2	2	0	1	1	2	5	15	20	21	146	174	121	139	48	66	69	61	633
1971	0	0	0	0	0	0	0	5	2	2	3	14	47	75	81	103	214	217	248	195	162	102	318
1972	0	0	1	16	6	7	11	22	11	18	4	108	48	27	79	187	338	370	192	285	327	174	113
1973	0	0	2	13	8	8	10	25	20	29	8	24	61	43	79	177	251	394	256	608	447	304	358
1974	0	0	2	10	271	5	1288	1291	1071	1168	774	2086	1956	1386	456	1414	1225	3115	2597	3931	4681	3502	2389
1975	0	0	1	13	115	102	82	100	361	714	462	466	491	363	502	889	880	2822	4101	5822	5999	4401	4150
1976	0	0	0	4	9	52	79	24	73	147	226	265	297	264	276	459	511	1171	1836	2414	4462	2458	2866
1977	0	0	0	0	20	5	35	7	44	39	69	177	238	426	974	1133	1674	1760	1900	1649	1574	1590	1172
1978	0	0	0	0	0	0	24	10	107	88	176	147	132	370	102	172	276	124	39	178	376	1927	909
1979	0	0	0	0	2	28	20	20	110	76	92	369	943	1070	2007	1717	1230	386	136	126	59	51	73
1980	0	0	0	0	15	48	62	50	40	75	189	197	295	514	606	979	763	1123	714	373	143	120	
1981	0	2	0	4	17	5	26	55	18	26	88	42	208	241	564	753	701	592	705	774	287	224	393
1982	0	0	0	0	0	34	0	75	292	81	80	185	581	563	3897	2159	646	813	2838	2678	7119	1526	1725
1983	0	0	5	17	45	143	170	239	183	455	745	717	991	1529	1945	1741	1840	3953	1957	1722	1954	1297	482
1984	0	0	12	9	58	81	85	80	163	160	232	332	526	785	1081	1858	3548	2493	2078	1242	706	493	629
1985	0	5	20	16	97	113	130	136	138	128	225	329	406	456	589	380	593	797	1077	1354	1524	1179	1231
1986	0	0	0	12	104	211	78	389	202	222	537	495	641	440	518	491	704	1384	1634	1564	1081	517	182
1987	0	0	0	0	58	87	26	89	104	100	120	292	501	735	748	785	798	982	972	1234	1212	1219	779
1988	0	0	0	0	25	86	72	289	178	250	132	190	479	1016	1019	1510	1419	1600	1811	1419	1132	877	602
1989	0	0	0	0	188	409	292	753	501	358	469	564	694	1110	1271	1257	1104	1080	1189	668	925	667	1054
1990	0	7	357	73	182	803	392	555	394	325	330	616	899	1002	1342	1961	2276	2524	1988	1149	741	594	723
1991	4004	4142	243	213	293	538	432	603	295	393	740	561	876	1562	1940	3163	7074	6294	7236	2934	1494	638	1761
1992	17	441	529	612	1246	736	507	798	795	611	1101	1626	1456	1300	2068	1972	4766	3505	6209	4302	3648	2606	1982
1993	1111	1389	589	1345	7248	1275	1448	193	870	1209	1545	2249	2031	1532	1469	1402	1648	2778	3231	2786	1841	1436	3345
1994	621	11959	16776	2929	15369	4554	1147	2425	2678	1811	950	2212	1587	4737	5024	4476	4870	3979	4574	5167	3527	3022	4136
1995	49	525	138	102	578	438	326	430	887	1014	2009	1902	5326	6157	3949	4328	6760	4635	5219	6939	6438	4144	9777
1996	0	0	26	748	892	2414	371	401	384	915	1001	1340	1628	2788	4487	5298	7443	7058	7374	7054	5938	4538	9220
1997	0	0	25767	3842	8745	19794	6727	3274	1632	2504	3042	902	2357	3224	4156	6057	8248	7305	7212	5408	3318	2479	4211
1998	0	0	0	0	0	39	3	114	317	140	159	422	677	1556	1790	2742	3731	8142	7759	5016	3284	2085	2525
1999	0	0	70	473	137	96	385	543	739	1412	1860	3253	1431	2142	3822	5816	5854	6237	5677	4341	1945	1053	1212
2000	0	105	541	71	892	226	111	1239	1748	1507	1920	1419	2409	2519	2494	4142	6846	6745	4953	3762	4280	1990	741
2001	0	0	141	481	859	511	9577	2534	803	971	926	846	2614	5903	7414	7681	6610	6239	4747	2933	1531	1149	701
2002	85	931	591	75	2239	2285	2267	1671	1140	867	744	811	958	1737	3013	6813	7805	4708	3909	2720	1717	588	547
2003	0	1402	6852	1466	2927	3631	2957	3592	1926	1731	1616	1622	2555	2304	2392	3075	4651	6289	4993	2461	1201	649	542
2004	0	893	938	844	2627	1167	1544	1161	690	1523	1118	1293	972	1763	3415	2933	2834	3446	4396	3071	1600	735	1072
2005	0	45	25	82	456	393	1355	481	552	710	996	1553	1890	1731	2495	2756	4546	5812	5905	3476	1897	713	616
2006	1	46	31	2720	7883	6933	11872	6473	1296	786	624	1094	1402	2249	2643	2275	2197	2174	2747	1578	1151	847	475
2007	0	735	434	56	3164	27042	2109	4510	2548	1824	1377	1063	1395	1221	2390	3838	3319	2946	3103	2053	1279	824	531
2008	1	0	22	215	14760	9765	6566	4278	3821	2183	3161	2714	2062	1636	4727	4840	3434	3723	3109	2034	1462	931	854
2009	1	4	143	652	558	6618	3094	1231	1259	1275	768	636	2808	6578	1697	2517	3156	2020	1357	869	534	330	324
2010	0	1	46	15	188	105	1261	1421	3425	3306	2318	1059	730	554	2139	5138	2240	867	826	589	268	144	116
2011	0	0	0	0	74	23	80	580	1108	770	1256	750	598	309	318	714	3591	3358	1075	748	593	256	177
2012	0	0	6	7	74	139	294	384	2132	1271	351	198	127	180	488	422	924	2551	3088	1025	327	173	181
2013	1	11	3	30	36	39	265	411	2122	2224	807	353	262	177	153	1092	1608	1709	2253	1589	445	87	92

Table B2: Continued

Purse seine	30-	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250+
1950	15217	0	3996	24752	13339	15409	72	188	112	492	501	1479	15066	10046	1617	549	226	340	206	242	116	68	28
1951	4230	0	480	2978	1605	1854	543	1450	867	1770	1867	5822	12989	23212	19212	11284	2924	680	1097	268	266	153	62
1952	385	0	123	770	410	474	288	1512	469	478	672	1295	12483	26269	18404	50877	25607	6586	2241	1283	715	389	163
1953	54178	0	366	2306	1228	1422	496	1315	776	867	693	5543	9218	13057	17819	29184	16276	7308	2433	1191	710	378	151
1954	192	0	558	3451	1861	2150	24	62	51	60	713	1267	1625	4409	9771	4098	9438	19339	15313	12094	5815	2789	782
1955	0	0	41	407	203	5653	18961	5360	6544	3060	5343	2016	7911	8645	5872	6781	9157	10610	12209	15183	8128	3604	609
1956	0	0	28	279	140	3884	12993	3660	4471	1846	355	437	1674	826	1081	599	653	1537	2242	5856	6530	4747	1892
1957	0	0	28	280	140	3897	13035	3672	4487	1850	352	302	1131	5666	9236	3843	5372	5608	4975	6151	3245	1312	234
1958	0	0	129	904	2683	5766	14816	6814	5802	2937	4391	15575	13290	4783	4283	3710	3488	2816	2149	2387	2102	2442	1593
1959	0	0	18	175	88	2435	8144	2294	2802	1156	177	140	67	238	650	297	957	1675	1808	3383	3562	2985	1004
1960	1195	0	264	1631	4107	3962	3961	8390	3497	3211	3886	12531	10017	3250	2100	1771	2271	2983	3523	4531	3854	2866	1183
1961	12870	0	478	2915	6832	6971	6496	14409	5541	5082	5065	15395	12180	3954	2196	1007	1540	3622	4574	10119	9706	7722	4139
1962	142608	0	355	1774	4593	4806	4070	8970	3105	3718	3035	7681	5977	1931	1067	503	334	586	1526	6536	11035	11222	6903
1963	796865	0	355	2183	5061	5509	4436	10305	3108	2867	2370	5941	4537	1451	825	356	454	1417	1519	788	405	284	384
1964	18917	0	1540	9538	12200	13708	9249	22389	7447	6831	3259	7171	5124	1673	901	366	186	598	1248	1213	1140	1867	3007
1965	623	0	1188	7057	7797	8908	5151	12888	4877	4550	1660	2349	1502	498	239	68	42	58	102	294	1127	3072	5119
1966	288479	51234	1156	7396	13653	18705	22747	32255	14697	13785	4031	4690	1534	499	156	35	0	142	421	305	469	903	2491
1967	461321	76221	1121	7232	15032	21799	29851	37512	18530	17082	4942	6281	2162	1052	116	214	137	245	275	364	718	1358	5848
1968	505125	0	261	2035	3476	11373	30581	15147	17357	16081	3625	6396	2050	338	354	214	28	50	134	182	229	443	2353
1969	15750	0	2653	16037	8955	23080	32763	27999	14022	15229	6025	2373	1347	474	810	788	689	326	241	454	471	800	3121
1970	24546	0	348	2366	4714	7212	6284	9364	3232	2756	1776	2045	2221	1836	1602	1207	1653	1486	1910	1148	157	189	1398
1971	42316	29	300	3894	10746	24662	18520	6368	3692	1581	369	330	856	2053	2879	3688	2984	1793	917	488	471	772	2756
1972	936	92	1727	2361	15722	78723	45952	19205	18530	6023	1745	1035	860	666	367	512	1326	317	260	340	543	846	2171
1973	0	4	369	5504	10924	27533	41597	17780	8909	2550	1532	1368	1325	1430	2475	3056	3388	925	612	506	666	946	2474
1974	2368	1856	30586	11324	15647	68069	20418	18964	22849	24327	5008	3452	1750	1677	1671	2347	4633	2871	945	1181	1671	2388	5274
1975	38651	2140	35017	25602	44238	170434	60000	35634	3235	2933	6798	5269	4480	3165	1459	2072	1855	2106	1056	2491	3183	2430	4938
1976	948	354	1973	9731	28920	65206	188745	90429	34500	21526	13818	5217	3018	2795	1225	1006	1524	1442	1072	1576	2176	2508	5910
1977	9294	10629	26910	33865	49962	67050	76900	34646	33622	12614	6076	3302	3101	2222	1278	481	308	508	974	1216	1849	2529	7390
1978	0	46	3593	17286	82729	18357	75981	52700	21243	5001	813	1256	371	1564	703	824	594	1368	1524	959	946	1152	3165
1979	2250	208	1041	1147	4851	17233	45098	24310	27690	12169	3552	1500	392	187	136	300	184	1156	1004	669	1947	1829	3524
1980	81	3128	28454	47949	46319	55725	76951	35518	24805	7587	4143	2256	1001	763	765	683	672	1477	1572	1749	2076	2141	3535
1981	2302	518	8893	25701	103975	109991	126060	34802	11862	3241	6870	4154	1367	1747	1117	1018	1000	980	1294	1186	714	560	1152
1982	818	6547	93867	165261	191120	99394	136240	75149	42118	13856	4985	2026	944	819	662	993	933	1104	1390	1860	1175	920	962
1983	49	2966	86318	125536	67865	73439	87736	54804	21574	9828	5821	4590	1853	2040	4542	2087	1614	4650	1367	1568	1471	1326	461
1984	0	11993	16004	29307	167398	196676	55555	20144	12111	9413	5747	2819	1857	1331	1643	1373	912	1470	1563	1986	2795	1528	1797
1985	5	376	10996	22281	63193	105627	101615	130493	52281	18280	6565	2948	2076	1366	246	247	221	525	912	1284	1027	530	380
1986	25	2705	84553	230356	44262	68595	100731	36862	52184	16171	5821	3370	2094	1477	989	557	576	391	476	980	834	602	453
1987	5	1305	29211	113214	57404	204733	99814	32360	20252	12436	4802	3135	1171	1088	654	516	612	1051	623	489	407	209	133
1988	26	3665	131094	221809	63191	52024	135034	78720	38254	19046	6998	4416	2178	1600	1349	892	761	1594	850	581	341	146	168
1989	12	1179	26450	108467	91955	161437	62390	44125	34774	31219	6675	1250	587	853	1851	654	394	794	354	395	342	196	353
1990	451	19816	129498	123270	142757	108799	129969	44950	30551	25430	5080	14087	532	335	631	652	1074	1433	721	413	385	188	270
1991	1097	4668	66390	79907	144042	143551	139795	51972	32565	25817	3928	20904	569	349	559	922	2002	2957	2361	1099	701	377	558
1992	0	19	17385	55207	123473	291451	157803	106628	47660	8459	2370	10274	4478	5399	5647	4800	3673	4656	5113	2082	869	296	348
1993	1711	916	111274	65736	205047	307925	191623	69950	28451	10931	10441	6936	4615	5560	5011	4986	3868	5182	5040	2005	819	639	1027
1994	30	943	16598	101541	229485	130521	101885	65507	29146	19142	15591	13516	14150	10457	8841	8218	11202	14130	14015	11078	3050	1302	1487
1995	3	236	34305	120037	56630	139232	169571	104514	29434	20176	15228	30112	13824	8257	7435	6468	4878	6102	12817	9486	3203	795	385
1996	0	3	27991	83352	367363	160007	157086	72772	#####	33163	18630	12035	10211	7229	4337	5479	6477	6664	13303	6565	3245	311	120
1997	0	33	8380	95729	74332	232981	96151	53662	62233	37438	31065	27505	18525	12331	9742	12939	12927	16596	3492	641	426	461	644
1998	0	0	32641	287929	42811	196631	204229	60696	50905	56336	28135	41297	35771	2756	1427	1369	705	1070	1054	1165	1345	410	826
1999	786	5369	46618	132168	85863	169699	29859	82298	50611	24897	11595	5427	3176	2062	1306	1665	14563	8363	1385	1675	1315	719	459
2000	0	87799	463700	187730	157066	204495	162048	28463	17553	20894	17967	19011	13519	3823	2090	1776	1421	1161	1192	1094	935	876	1692
2001	0	0	0	43	221989	84959	48545	53459	41932	12894	10113	5793	5559	14488	3201	4706	2255	11482	15577	1665	930	683	1513
2002	1630	188	71	11674	140779	166268	134667	43093	27164	20102	11715	13694	8624	3098	1507	2500	3303	4827	15787	2803	2058	1543	3086
2003	5545	511	0	310	52588	54176	24506	16035	8127	15824	16463	17040	11940	9622	4080	6538	2869	8350	15766	10699	2614	2269	2535
2004	0	0	0	28003	87411	69545	107822	32115	15651	11505	5120	3717	8986	17616									

Table B2: Continued

Other	30-	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250+
1950	23324	0	6125	37937	20445	23618	251	335	344	1145	2119	2579	10355	10715	6438	7262	10519	6486	2555	607	178	104	43
1951	10483	0	1191	7381	3978	4594	1485	3639	2322	2797	2513	3361	5989	11532	10619	10135	11605	6908	3102	1025	658	378	154
1952	563	0	180	1127	601	694	521	2247	809	977	1498	1584	4054	8366	7165	13770	12412	6415	2834	1512	1260	933	453
1953	91604	0	619	3899	2077	2405	982	2271	1487	1788	2047	2403	3602	6888	7420	10104	12939	8148	3889	1806	1272	788	331
1954	231	0	671	4148	2238	2585	96	97	144	256	972	1076	1582	3165	3678	4188	6675	5630	3773	2936	2113	1199	656
1955	427	0	326	2112	1133	6005	16666	4868	5977	2885	2701	2346	3570	6452	6293	8075	12046	8208	5085	4400	3157	1508	544
1956	0	0	15	149	74	2064	6906	1946	2472	1052	155	210	474	110	264	714	1164	1971	1611	1073	1640	1146	561
1957	0	0	28	278	139	3925	12944	3742	4482	1931	365	283	396	869	1136	766	1424	2103	2347	2816	3190	1786	1070
1958	0	0	13	133	66	1848	6189	1795	2497	1143	721	439	207	666	1009	956	1280	659	499	870	1176	1167	795
1959	0	0	17	173	87	2413	8082	2467	2927	1221	251	800	375	330	470	594	1688	1356	1571	1475	3142	2673	1346
1960	767	0	35	275	141	1339	4810	2366	3257	3402	1767	1479	765	1857	1321	1192	1195	1242	545	532	930	813	286
1961	5649	0	44	352	165	1961	6997	3033	4701	4540	1276	2080	2229	1864	552	1831	1298	1389	984	540	400	640	544
1962	57663	0	31	51	48	666	2428	758	1589	2058	1451	2249	2441	1730	1846	1008	1148	658	198	356	436	418	432
1963	410364	0	13	186	75	2053	7420	2190	4358	4530	1176	3360	1745	2458	976	1280	102	653	606	530	148	410	11
1964	5187	0	261	1776	911	3855	10889	4051	6553	6123	1301	2592	1253	1692	730	530	277	166	111	557	19	50	89
1965	223	0	299	1806	960	2255	4525	2005	3315	4207	1004	1711	1205	1748	2110	182	223	262	151	39	38	75	151
1966	62116	11032	50	323	174	199	87	249	202	733	410	3089	1544	654	710	225	56	34	102	70	71	25	1
1967	73867	12205	8	58	33	58	114	333	225	233	476	1361	1378	2587	426	380	516	986	808	765	714	841	1298
1968	106840	0	0	0	0	0	0	33	62	269	549	407	469	1010	1504	343	184	107	181	188	299	137	421
1969	0	0	0	0	0	0	0	0	0	226	411	1286	613	358	748	835	188	282	161	262	314	246	519
1970	12004	0	68	477	273	307	0	171	239	373	220	2	88	5	106	221	698	845	1111	729	181	155	37
1971	42857	0	0	0	0	0	0	0	13	21	13	31	35	147	124	145	131	160	139	182	347	584	716
1972	19971	0	17	153	85	102	85	205	155	175	45	23	18	40	29	42	39	30	31	57	129	224	297
1973	39327	1646	5	28	268	309	65	161	43	43	20	23	18	39	27	37	30	22	26	46	65	94	120
1974	39327	1646	2	13	8	8	9	26	22	25	13	14	14	29	24	36	29	44	31	52	78	88	91
1975	39185	1640	11	72	951	1097	407	999	228	202	80	77	42	31	28	60	73	91	53	87	117	82	67
1976	39293	1645	6	36	66	106	29	49	28	34	20	26	32	34	19	21	35	116	153	195	252	168	204
1977	122251	14043	2	62	80	355	66	80	54	49	17	43	98	124	155	128	119	269	363	436	251	352	544
1978	102821	11606	44	5902	6303	3470	947	1427	684	1787	835	580	251	91	66	74	101	150	152	191	294	463	1104
1979	29621	1160	6	96	188	851	944	1149	890	1448	785	235	226	318	802	515	645	433	512	443	448	703	1536
1980	36353	854	2033	15607	3917	5477	1588	1911	612	585	653	1189	960	627	537	284	319	178	187	166	134	97	118
1981	6214	0	1382	21952	7487	7414	2258	2046	1396	435	500	92	96	123	249	250	181	207	293	330	159	117	116
1982	83125	8032	1343	10506	4820	3448	1573	1343	839	239	193	97	87	118	112	140	140	168	215	249	230	249	404
1983	226640	106617	40671	188731	9138	8926	1859	1332	408	391	279	107	92	139	204	136	183	520	356	329	232	192	60
1984	1638	310	13374	33705	19455	37527	11850	2575	3100	1352	1573	544	453	323	330	467	652	966	1063	1113	926	701	743
1985	9187	16855	6433	10595	10554	13263	10991	15134	4675	2066	1002	899	1132	715	938	1141	1388	1520	2097	1929	1418	1604	1142
1986	20718	12931	29570	126968	16245	10464	6009	2541	4503	1853	500	990	600	631	551	645	1239	1550	1607	2410	2296	2309	1069
1987	83027	25633	10699	31922	14467	21290	3583	3205	2858	2321	1473	2395	1688	2935	3096	1432	872	1484	1493	1418	787	695	838
1988	27855	4081	71561	112611	22198	7800	8587	5410	2791	1291	1200	758	2095	3614	3329	1263	1261	1517	1662	2562	1101	666	810
1989	17029	1547	63118	80361	38199	33531	3179	6864	4444	1315	1599	861	939	1725	1817	1029	816	1189	1090	1915	1924	597	1379
1990	33841	35563	14727	57764	10724	12003	5959	2591	1325	1385	2281	1860	1261	947	1005	1420	1652	1473	1727	1393	626	321	610
1991	34622	75604	5314	25324	10979	8391	1281	1841	1646	950	1070	578	528	399	318	643	1817	1535	2563	1130	386	67	194
1992	35183	14342	52263	65952	7106	25371	9740	2132	1898	1148	969	320	631	779	788	1654	2087	3627	2244	1074	254	443	259
1993	11208	6126	27173	47400	30475	58166	11387	10004	5372	2451	1784	2432	2145	1298	1001	605	1128	944	1784	1543	588	465	897
1994	10841	13227	11224	39672	17131	12240	14488	12456	4813	2845	2844	2910	2131	2693	2898	3934	3504	3189	3013	2498	1253	988	1467
1995	30057	29177	15465	103578	10468	11448	14914	4482	3082	3404	4790	5457	6170	3589	1898	2436	1963	2310	1486	1754	791	784	1050
1996	26950	25008	39116	29808	23464	13882	6680	6360	4483	3703	3181	2518	2455	1958	885	903	1225	1244	1717	1135	967	833	793
1997	556	4515	38508	29760	9039	17819	11211	5676	3515	2926	4518	4566	3621	1641	1610	1276	1723	1853	1447	905	743	480	615
1998	0	1878	34342	42496	10185	23127	24712	6734	5062	2017	655	3502	4473	973	1024	2630	3003	1830	686	363	219	217	176
1999	351	1648	5854	43401	25118	36145	3662	10743	5392	2785	4301	2415	1989	1382	1190	1316	5352	3165	1202	641	270	213	1379
2000	0	1559	22131	27542	25787	15476	9188	4556	3881	5593	6045	6579	3613	1303	1191	1282	1570	1089	1108	807	561	256	413
2001	0	0	1393	1274	27980	31838	10875	11919	5255	2651	1866	1692	1673	1665	876	1798	1403	1839	1523	354	182	105	206
2002	0	147	2152	10684	14018	31970	21573	10110	3824	2584	1629	1656	1638	1679	1084	1395	1598	1388	1512	640	551	298	308
2003	672	16	724	2713	35391	21438	14368	6705	2565	2066	1863	3513	2175	1967	1448	1442	1574	2817	4543	2108	674	328	167
2004	7952	2570	11469	15694	16741	18275	6469	4381	3015	1605	1176	634	1572	1862	1445	688	976	1429	2315	734	484	351	562
2005	459	2496	5718	48716	71889	28998	22402	6145	3231	730	862	1424	678	98	77	46	17	137	222	75	62	35	60
2006	243	1298	2475	12155	62554	20174	26017	2550	3523	748	473	753	980	799	291	93	47	192	303	143	94	73	123
2007	0	59	61	188	366	2790	902	1451	3561	1808	1325	924	1201	1478	682	718	969	556	1084	369	65	42	27

Table B3: Index series used – values followed by associated standard errors (where available) are given.

Units	Mor&Sp_Trap		SpBB1		SpBB2		SpBB3		JPLL_EastMed		NorPS		JPLL_NEA1		Larval index	
	numbers		biomass		biomass		biomass		numbers		biomass		numbers		biomass	
1952	-	-	179.22	0.43	-	-	-	-	-	-	-	-	-	-	-	-
1953	-	-	184.74	0.53	-	-	-	-	-	-	-	-	-	-	-	-
1954	-	-	226.46	0.41	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	-	187.01	0.42	-	-	-	-	-	-	36.20	-	-	-	-	-
1956	-	-	470.53	0.43	-	-	-	-	-	-	21.25	-	-	-	-	-
1957	-	-	315.05	0.41	-	-	-	-	-	-	28.61	-	-	-	-	-
1958	-	-	252.25	0.41	-	-	-	-	-	-	24.13	-	-	-	-	-
1959	-	-	506.79	0.41	-	-	-	-	-	-	32.41	-	-	-	-	-
1960	-	-	485.16	0.43	-	-	-	-	-	-	46.83	-	-	-	-	-
1961	-	-	327.29	0.41	-	-	-	-	-	-	51.84	-	-	-	-	-
1962	-	-	180.12	0.46	-	-	-	-	-	-	64.67	-	-	-	-	-
1963	-	-	-	-	312.09	493.00	-	-	-	-	1.67	-	-	-	-	-
1964	-	-	-	-	457.40	415.00	-	-	-	-	33.98	-	-	-	-	-
1965	-	-	-	-	228.91	0.41	-	-	-	-	69.60	-	-	-	-	-
1966	-	-	-	-	349.10	421.00	-	-	-	-	35.70	-	-	-	-	-
1967	-	-	-	-	345.89	414.00	-	-	-	-	61.06	-	-	-	-	-
1968	-	-	-	-	447.00	422.00	-	-	-	-	23.53	-	-	-	-	-
1969	-	-	-	-	610.62	401.00	-	-	-	-	28.06	-	-	-	-	-
1970	-	-	-	-	594.66	431.00	-	-	-	-	42.76	-	-	-	-	-
1971	-	-	-	-	744.71	403.00	-	-	-	-	43.52	-	-	-	-	-
1972	-	-	-	-	525.63	413.00	-	-	-	-	43.05	-	-	-	-	-
1973	-	-	-	-	535.63	396.00	-	-	-	-	42.15	-	-	-	-	-
1974	-	-	-	-	245.39	439.00	-	-	-	-	45.72	-	-	-	-	-
1975	-	-	-	-	484.22	0.41	-	-	1.90	0.15	38.00	-	-	-	-	-
1976	-	-	-	-	483.96	414.00	-	-	2.15	0.12	21.16	-	-	-	-	-
1977	-	-	-	-	547.56	407.00	-	-	3.53	0.14	42.44	-	-	-	-	-
1978	-	-	-	-	705.26	412.00	-	-	1.50	0.15	12.28	-	-	-	-	-
1979	-	-	-	-	623.01	409.00	-	-	2.70	0.14	3.75	-	-	-	-	-
1980	-	-	-	-	634.81	446.00	-	-	1.69	0.16	20.14	-	-	-	-	-
1981	768.36	57.19	-	-	510.66	422.00	-	-	1.63	0.17	-	-	-	-	-	-
1982	1038.12	34.63	-	-	503.78	418.00	-	-	3.32	0.13	-	-	-	-	-	-
1983	1092.05	34.63	-	-	625.14	432.00	-	-	2.12	0.13	-	-	-	-	-	-
1984	1200.27	34.63	-	-	331.71	449.00	-	-	1.62	0.12	-	-	-	-	-	-
1985	814.46	34.64	-	-	1125.74	407.00	-	-	1.75	0.15	-	-	-	-	-	-
1986	394.33	28.05	-	-	751.21	419.00	-	-	1.32	0.14	-	-	-	-	-	-
1987	433.53	28.05	-	-	1008.43	415.00	-	-	2.16	0.13	-	-	-	-	-	-
1988	1014.56	28.03	-	-	1394.68	419.00	-	-	1.35	0.14	-	-	-	-	-	-
1989	531.45	26.09	-	-	1285.60	0.40	-	-	1.05	0.16	-	-	-	-	-	-
1990	614.37	22.60	-	-	986.51	407.00	-	-	1.41	0.14	-	0.08	0.32	-	-	-
1991	727.86	22.59	-	-	901.20	422.00	-	-	1.21	0.13	-	0.10	0.27	-	-	-
1992	313.95	22.63	-	-	695.16	427.00	-	-	1.03	0.14	-	0.22	0.16	-	-	-
1993	325.36	22.62	-	-	2093.55	403.00	-	-	1.04	0.14	-	0.23	0.14	-	-	-
1994	341.90	22.62	-	-	1007.03	419.00	-	-	1.12	0.16	-	0.26	0.16	-	-	-
1995	223.43	22.65	-	-	1235.91	405.00	-	-	1.42	0.15	-	0.29	0.13	-	-	-
1996	375.22	24.62	-	-	1739.29	398.00	-	-	0.50	0.22	-	0.77	0.13	-	-	-
1997	992.41	24.59	-	-	2246.41	404.00	-	-	0.53	0.21	-	0.50	0.13	-	-	-
1998	925.14	24.59	-	-	879.51	409.00	-	-	0.71	0.17	-	0.24	0.16	-	-	-
1999	1137.45	24.59	-	-	339.77	436.00	-	-	0.64	0.22	-	0.35	0.15	-	-	-
2000	739.23	22.59	-	-	960.44	402.00	-	-	0.74	0.20	-	0.38	0.12	-	-	-
2001	1284.62	22.58	-	-	704.49	447.00	-	-	0.96	0.17	-	0.45	0.12	0.39	0.40	-
2002	1130.42	22.58	-	-	687.42	423.00	-	-	2.05	0.15	-	0.34	0.13	0.61	0.49	-
2003	662.66	23.68	-	-	444.91	482.00	-	-	1.70	0.13	-	0.34	0.14	1.07	0.45	-
2004	332.36	22.62	-	-	1210.46	417.00	-	-	0.82	0.18	-	0.32	0.12	0.11	0.29	-
2005	677.39	22.59	-	-	2383.57	0.40	-	-	0.88	0.15	-	0.23	0.11	0.14	0.24	-
2006	633.94	22.60	-	-	850.09	0.48	-	-	1.91	0.15	-	0.28	0.11	-	-	-
2007	1000.60	22.59	-	-	-	-	1177.62	419.00	0.94	0.19	-	0.28	0.11	-	-	-
2008	634.18	22.60	-	-	-	-	2144.54	304.00	1.22	0.17	-	0.33	0.11	-	-	-
2009	876.71	22.59	-	-	-	-	955.29	305.00	1.04	0.24	-	0.48	0.11	-	-	-
2010	1042.24	23.66	-	-	-	-	2109.08	309.00	-	-	-	2.04	0.05	-	-	-
2011	674.97	22.59	-	-	-	-	2762.62	306.00	-	-	-	2.87	0.06	-	-	-
2012	1187.75	23.66	-	-	-	-	2216.18	390.00	-	-	-	4.81	0.07	2.96	0.22	-
2013	4285.56	33.12	-	-	-	-	1571.64	445.00	-	-	-	4.46	0.06	1.71	0.25	-

Appendix C - The data for the Western Atlantic, as used in Butterworth and Rademeyer (2014)**Table C1:** Catches in mt.

	Longline	Other	Purse seine	Sport	Traps
1970	268.0	83.0	4288.0	644.0	183.0
1971	1390.0	182.0	3769.0	1144.0	106.0
1972	339.0	186.0	2011.0	1354.0	58.0
1973	1127.0	115.0	1656.0	816.0	157.0
1974	946.0	256.0	960.0	2955.0	276.0
1975	1562.4	24.0	2320.0	1022.0	144.0
1976	3066.0	311.0	1582.0	752.0	172.0
1977	3753.4	194.0	1502.0	874.0	372.0
1978	3219.1	191.0	1230.0	904.0	221.0
1979	3691.0	196.0	1381.0	956.0	31.0
1980	3972.5	131.0	758.0	893.0	47.0
1981	3878.0	133.0	910.0	808.0	41.0
1982	360.0	323.0	232.0	459.0	68.0
1983	829.0	514.0	384.0	808.0	7.0
1984	823.0	377.0	401.0	676.0	3.0
1985	1229.0	293.0	377.0	750.0	20.0
1986	1272.0	166.0	360.0	518.0	0.0
1987	1237.0	156.0	367.0	726.0	17.0
1988	1473.3	425.0	383.0	601.0	14.0
1989	817.6	769.0	385.0	786.0	1.0
1990	854.1	536.0	384.0	1004.0	2.0
1991	1022.3	578.0	237.0	1083.0	0.0
1992	885.0	509.3	300.0	586.0	1.0
1993	783.0	406.0	295.0	854.0	29.0
1994	621.3	307.2	301.0	804.0	79.0
1995	602.0	384.0	249.0	1114.0	72.0
1996	713.6	436.0	245.0	1029.0	90.0
1997	537.0	293.0	250.0	1195.3	59.0
1998	887.0	342.0	249.0	1111.0	68.0
1999	1074.5	281.0	248.0	1123.4	44.5
2000	1079.5	284.4	275.2	1119.7	16.1
2001	714.7	201.9	195.9	1655.7	15.8
2002	940.0	107.5	207.7	2035.1	28.1
2003	418.1	139.3	265.4	1398.3	84.0
2004	824.8	97.1	31.8	1138.8	32.0
2005	556.2	89.1	178.3	924.5	8.4
2006	714.4	85.3	3.6	1005.1	3.0
2007	519.9	63.1	27.9	1022.9	3.6
2008	764.7	81.9	0.0	1129.9	23.0
2009	573.2	120.7	11.4	1250.6	23.5
2010	703.1	106.7	0.0	1008.9	38.8
2011	944.5	147.1	0.0	887.3	26.3
2012	701.2	117.3	1.7	916.3	16.6
2013	67.4	76.3	0.0	325.2	11.4

Table C2: Commercial fleet catch-at-length used in the SCAL.

Longline	30-	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300+	
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	181	181	273	273	362	91	0	0	0	0	0	0	
1971	0	0	0	70	14	140	61	0	108	37	10	189	195	573	1116	1247	902	764	571	622	283	294	35	19	0	0	0	0	
1972	0	0	4	25	0	66	46	0	6	11	33	132	37	19	55	309	247	107	53	86	100	106	18	15	0	0	0	0	
1973	0	0	47	20	45	284	165	94	601	274	422	435	142	124	262	805	1029	509	182	360	432	105	116	97	0	0	0	0	
1974	0	20	79	735	1451	2671	485	485	1026	257	540	49	27	350	699	154	789	397	469	540	446	292	136	55	6	1	0	0	
1975	0	0	1	1	6	19	37	27	32	55	195	6	6	13	130	225	566	1154	939	1082	1312	1249	751	300	29	6	0	0	
1976	0	8	36	81	300	835	2223	2075	3494	2131	1300	419	418	195	78	137	634	731	733	1633	2843	2470	1700	882	159	8	8	4	
1977	0	0	56	126	256	414	3247	5120	5347	1728	1223	1424	1600	750	274	130	204	186	357	561	1649	2517	2439	1317	372	77	31	23	
1978	0	0	0	59	64	303	879	1133	1813	1645	1420	1735	841	788	322	220	221	195	354	580	1104	1901	2179	1662	592	200	37	6	
1979	0	0	16	40	52	202	479	420	1343	649	519	980	1660	1597	1258	731	367	301	446	848	1637	1968	1599	1058	556	192	55	12	
1980	0	0	21	70	89	274	1123	1517	1614	873	390	827	1143	1330	3812	3147	1591	663	601	727	1147	2370	2704	1505	594	192	22	8	
1981	0	7	35	344	801	1385	5091	2604	2912	2947	1608	2184	1876	1842	1690	1467	1227	554	757	815	804	1261	1081	1351	944	491	185	273	
1982	0	6	60	4	119	48	93	68	167	73	98	271	248	237	202	214	201	154	176	201	170	43	66	32	26	14	7	6	
1983	0	0	0	0	12	125	1454	615	281	252	531	529	445	454	700	661	505	415	187	230	136	96	46	27	25	9	0	17	
1984	2	0	3	12	58	543	1074	259	733	1076	724	835	991	950	415	228	371	250	217	119	214	136	95	39	50	16	2	10	
1985	10	7	17	17	701	2187	3696	663	1375	2409	1974	2662	1670	707	346	295	246	174	207	296	330	282	148	83	40	11	2	7	
1986	0	2	1	1	8	43	134	671	1097	1117	1606	680	496	891	637	422	317	359	195	300	321	446	487	353	168	101	85	2	
1987	45	4	2	33	25	143	534	645	1420	1556	2268	2186	2064	1219	916	936	570	401	232	146	154	166	121	90	51	30	24	12	
1988	48	0	12	75	92	460	965	1125	2802	2754	1798	1757	2327	1933	1376	956	484	353	199	238	213	160	203	94	31	23	9	25	
1989	64	1	1	31	10	41	270	159	349	844	716	536	692	747	892	820	396	318	205	218	207	140	122	66	32	21	0	0	
1990	68	0	0	35	48	328	492	82	299	967	1025	721	761	646	465	616	413	419	343	235	143	159	145	71	43	15	15	7	
1991	77	0	0	37	32	38	262	161	438	975	955	1192	1003	1020	1052	666	373	373	357	225	234	217	131	64	42	55	10	0	
1992	92	3	7	44	11	67	261	81	320	966	445	421	1053	748	860	902	503	329	205	274	217	160	133	64	27	31	0	6	
1993	34	0	0	16	4	23	170	156	935	714	733	1161	1051	789	586	649	573	291	204	143	102	89	93	56	18	3	0	0	
1994	53	0	0	25	3	11	232	350	939	1555	984	956	691	455	430	544	348	170	132	90	53	87	57	26	18	6	2	0	
1995	110	0	0	52	59	3	260	30	75	757	789	299	1716	1639	436	234	287	135	77	76	76	49	37	32	21	7	0	2	
1996	102	0	0	52	9	157	202	179	473	1081	855	400	607	499	841	641	278	176	250	250	174	138	84	55	47	6	0	0	
1997	70	0	0	33	3	5	99	80	73	583	365	424	647	561	682	664	478	186	100	95	105	75	41	18	19	3	0	0	
1998	51	0	0	24	2	16	135	191	305	662	278	445	828	562	433	870	1115	965	328	185	184	54	118	26	19	8	0	0	
1999	60	0	0	29	3	4	115	23	104	633	450	822	655	437	520	906	764	460	578	670	411	248	145	88	63	3	11	0	
2000	46	0	0	22	2	3	378	151	309	1781	1459	582	1846	1614	934	847	411	201	174	206	142	120	68	65	32	6	5	0	
2001	12	0	0	8	54	6	28	28	9	104	47	136	218	482	962	691	363	397	316	376	214	147	91	60	15	2	1	14	
2002	0	0	0	8	23	6	13	6	27	56	60	106	201	356	870	1028	1159	977	541	332	174	270	52	28	10	0	0	0	
2003	0	0	0	9	3	4	11	12	10	242	170	167	389	182	136	331	191	203	222	227	150	205	66	19	27	0	0	0	
2004	0	0	0	4	3	4	0	22	169	858	927	1427	1011	929	740	453	329	220	213	340	162	237	56	48	14	10	0	0	
2005	0	0	0	6	22	124	361	422	317	310	498	285	417	536	460	422	278	234	385	284	163	194	61	23	26	2	0	0	
2006	0	0	0	0	87	359	76	104	527	334	264	952	727	446	701	973	704	561	455	266	252	416	129	45	27	18	1	7	
2007	0	0	0	0	3	49	1809	2115	486	452	636	508	591	303	213	259	155	168	241	203	132	133	54	35	20	1	1	10	
2008	0	0	0	1	0	4	47	105	180	225	579	441	337	531	799	905	678	521	481	332	198	229	82	16	34	13	15	8	
2009	0	0	0	2	0	0	12	0	0	39	0	23	250	57	147	438	378	315	360	185	160	215	97	41	33	6	4	20	
2010	0	0	0	8	63	0	67	17	64	55	137	28	337	97	265	738	484	457	545	336	224	231	106	66	39	10	6	8	
2011	0	0	0	0	0	0	0	0	0	41	551	590	270	342	502	931	1136	790	306	355	371	255	227	132	51	33	7	1	5
2012	0	0	0	0	0	0	0	0	0	1	123	9	259	389	140	444	376	643	570	342	176	269	133	66	54	12	1	22	
2013	0	0	0	0	0	0	0	0	0	15	4	127	56	72	249	120	272	640	513	295	260	123	45	36	11	1	1	5	

Other	30-	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300+
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	25	52	32	20	27	130	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	8	8	8	8	105	168	235	102	36	8	0	0	0
1972	0	0	0	3	0	9	6	0	1	3	6	17	11	7	8	39	32	24	36	116	222	163	81	31	8	0	0	0
1973	0	0	2	1	2	12	7	4	25	11	17	18	6	5	13	33	46	26	13	28	44	67	92	63	17	1	0	0
1974	0	1	4	36	71	131	24	24	51	13	27	3	1	18	37	8	41	26	29	82	178	258	201	60	4	2	0	0
1975	0	0	0	0	0	1	1	1	1	1	3	0	0	0	2	3	8	16	13	15	18	17	10	4	1	0	0	0
1976	0	0	1	2	18	17	51	39	42	28	25	11	8	4	11	28	47	52	99	144	184	174	101	35	8	4	2	
1977	0	0	5	21	8	10	15	28	23	10	6	5	6	3	2	1	1	2	4	6	27	72	129	161	86	25	1	0
1978	0	0	0	6	2	6	8	11	17	15	13	16	8	7	5	2	3	5	7	41	111	175	145	52	8	3	1	0
1979	0	0	0	0	1	2	3	3	10	5	4	7	12	11	9	5	5	10	7	31	67	112						

Table C2: Continued.

Purse seine	30-	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300+
1970	0	2502	55630	6208	77805	27229	89488	25635	4549	13654	5293	1992	975	384	73	92	24	0	0	0	0	0	0	0	0	0	0	0
1971	0	531	47526	19660	118397	9569	10049	28661	30564	14676	248	106	460	424	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	15	13521	30319	46349	40998	15773	14292	419	2053	1569	2610	205	0	132	146	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	3992	1926	59657	9435	6492	21530	446	5021	1185	524	1695	118	0	26	13	0	0	0	0	0	0	0	0	0	0	0
1974	0	310	17907	2767	8354	8280	11688	3921	580	3378	1585	1546	679	125	75	32	13	7	11	15	39	49	26	11	3	0	0	0
1975	0	0	25899	5406	134796	8571	1475	3937	7821	6096	603	220	518	205	64	12	62	96	81	75	123	212	207	97	12	0	0	0
1976	54	0	3783	171	13333	4634	56984	7720	29	0	0	0	0	0	6	10	23	29	67	88	123	136	61	21	4	0	0	0
1977	0	12	401	355	9980	8008	420	2744	3556	17346	2781	1372	436	692	179	1	9	11	10	47	126	165	112	57	15	4	0	0
1978	0	0	381	3533	1717	4807	6047	10566	2214	1930	3767	3152	2437	339	17	55	60	35	13	7	12	18	33	25	0	1	1	0
1979	0	0	0	44	3186	3123	5054	8489	1930	10032	4324	97	217	193	56	2	0	18	12	6	44	253	450	233	91	12	6	0
1980	227	0	464	1584	1187	6897	6030	3769	3307	2863	2246	237	101	21	5	21	286	103	77	53	18	11	25	27	15	7	3	0
1981	0	17	601	2127	3022	3999	801	5761	1109	552	845	392	114	59	50	151	761	1212	584	236	115	60	4	4	11	3	0	0
1982	0	24	213	590	57	352	131	533	246	24	9	0	2	17	29	66	78	200	301	249	79	38	1	4	0	1	0	0
1983	0	0	1285	612	17	0	63	20	0	9	0	0	0	16	13	36	215	187	288	412	352	148	57	18	10	0	0	1
1984	0	0	10	62	120	87	0	0	0	0	0	0	9	2	8	29	106	228	401	329	368	153	61	30	5	0	0	0
1985	0	0	0	0	0	0	0	0	0	1	0	0	0	0	6	17	39	106	215	330	321	360	146	28	9	1	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	23	38	78	198	292	405	245	68	13	3	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	36	141	233	201	191	235	266	207	64	17	2	1	1
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	13	111	220	266	211	211	252	208	82	27	3	2	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	27	103	199	286	271	244	227	160	48	11	4	1	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	169	399	328	272	219	193	125	47	15	1	0	0
1991	0	0	1	2	3	0	0	0	0	0	0	1	1	5	25	281	462	295	122	36	37	15	12	1	4	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	142	139	239	293	202	157	85	62	24	2	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	279	736	437	118	79	36	13	5	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	422	397	384	295	111	52	20	13	3	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	279	588	241	137	67	35	9	7	2	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	48	94	216	384	218	116	62	27	12	2	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	235	174	181	247	230	123	42	17	1	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	333	447	225	161	182	69	16	7	1	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	36	240	515	396	164	67	36	12	1	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	288	269	342	300	163	63	14	6	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	53	129	253	271	199	66	19	0	1	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	107	125	46	122	251	255	142	43	11	3	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	527	525	334	157	105	104	48	25	13	2	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	69	65	70	29	6	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11	44	122	272	259	115	52	35	25	8	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	13	2	4	1	2	1	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	7	7	9	5	19	18	22	14	4	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	54	25	6	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	8	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	20	33	109	58	57	30	5	0	1	1	0	0	0	0	0

Sport	30-	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300+
1970	0	270	4852	644	3549	329	449	0	15	15	0	0	0	23	23	3	141	121	269	557	409	394	131	53	54	0	0	3
1971	0	0	6803	6803	4082	777	0	0	0	0	0	8	120	45	68	83	15	53	153	403	899	1001	659	297	69	8	8	8
1972	0	2	1427	3319	3813	4189	1713	1216	16	230	176	294	23	15	16	89	44	15	161	474	1034	1120	867	528	197	23	1	0
1973	0	0	192	80	2490	356	238	874	18	233	47	37	125	18	10	35	95	60	62	157	358	603	686	467	117	20	0	0
1974	0	0	34107	784	588	980	1176	0	0	0	0	0	0	0	1	6	401	18	38	1688	1284	3510	1492	766	31	4	1	
1975	9	153	12321	1364	1002	1508	9	68	149	145	30	0	9	26	12	9	33	18	43	83	277	652	812	590	331	88	8	9
1976	0	0	1020	298	463	397	210	7	10	46	30	12	6	0	7	12	28	40	95	138	255	427	498	414	119	16	0	
1977	17	16	306	221	3368	465	115	325	64	49	21	0	4	4	5	0	6	1	6	23	76	193	488	672	557	156	13	1
1978	46	4	301	1185	2157	1335	119	131	25	15	11	6	2	8	0	0	21	30	12	12	30	209	444	742	583	250	40	3
1979	7	0	564	2113	925	3015	242	345	30	23	13	3	7	30	103	75	18	25	39	69	166	284	397	568	520	279	42	5
1980	5	0	228	695	905	4058	369	206	116	129	56	40	5	27	13	16	88	50	38	70	86	123	295	564	548	316	78	4
1981	0	13	238	2005	963	1134	297	231	92	13	13	20	26	0	0	8	73	177	228	157	92	92	191	340	494	372	132	13
1982	0	42	2282	443	1304	1613	393	326	101	59	42	34	68	40	23	28	82	108	253	236	67	82	128	153	137	47	37	25
1983	0	180	773	643	1865	534	419	424	195	35	21	25	20	67	60	50	159	89	136	193	330	366	402	404	277	69	36	30
1984	23	11	381	550	4040	1392	485	714	149	201	134	67	66	103	64	70	105	142	215	285	422	445	259	150	69	11	16	4
1985	0	58	3																									

Table C2: Continued.

Traps	30-	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300+	
1970	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	1	2	10	36	79	133	182	100	64	29	9	0	1	
1971	0	0	0	0	0	0	0	4	5	13	1	8	6	13	3	2	1	3	19	37	88	89	80	35	13	0	0	0	
1972	0	0	0	0	0	1	0	0	0	4	5	6	26	21	5	0	11	35	35	25	27	22	25	28	10	1	0	0	
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	52	181	155	164	27	8	3	0	0	0	
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3	11	30	166	267	278	149	40	3	0	0	
1975	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	3	0	0	3	10	41	80	123	95	56	17	5	2	
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	50	131	172	90	12	0	0	
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	3	30	133	313	655	682	277	18	0	0	0	0	0	0	0	
1978	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	2	2	0	1	0	2	12	18	67	122	128	110	36	
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	15	17	30	8	1	0	
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	6	3	7	1	4	6	6	22	30	21	13	4	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	6	7	29	33	13	1	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	4	25	49	50	19	2	0	
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	6	3	0	0	0	
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	1	0	0	
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	9	14	16	5	0	0	
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	3	3	0	2	5	6	8	5	9	5	0	
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	3	3	0	2	4	5	7	4	7	4	0	
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	0	0	
1992	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	
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	10	20	27	12	4	0	0	
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	4	6	21	41	62	49	25	0	0	
1995	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	1	0	1	8	9	19	30	56	35	22	5	4	
1996	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	2	1	12	29	35	36	64	44	33	15	1	0	
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	2	15	30	46	46	17	0	0	
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	10	17	23	46	43	36	22	7	6	3	
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	14	29	34	35	7	7	2	0	
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	6	11	9	9	3	3	0	
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	8	15	10	8	2	2	0	0	
2002	0	0	0	0	0	0	0	0	0	0	0	0	2	16	51	27	10	14	16	17	8	2	0	1	0	0	0	0	
2003	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13	110	131	78	10	28	53	27	13	13	0	0	0	0	
2004	0	0	0	0	0	0	0	0	0	5	0	1	2	3	1	8	6	14	23	51	30	10	1	0	0	0	0	0	
2005	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	1	5	10	7	1	4	1	2	0	0	0	
2006	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	2	3	0	0	0	2	1	2	1	0	0	0	
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	6	0	1	0	0	
2008	0	0	0	0	0	0	0	0	0	0	0	0	8	11	42	54	44	27	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	9	17	2	3	10	7	2	16	6	8	8	9	13	5	0	0	0	
2010	0	0	0	0	0	0	0	0	0	0	0	1	1	2	4	1	9	7	9	18	27	19	21	14	5	0	0	0	
2011	0	0	0	0	0	0	0	0	0	0	3	0	5	0	2	0	1	3	5	3	11	15	16	22	6	3	0	0	
2012	0	0	0	0	0	0	0	0	0	0	1	0	5	5	6	7	4	5	9	7	7	6	5	6	2	0	0	0	
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	5	6	4	1	8	7	7	2	0	1	0	

Table C3: CPUE (relative abundance) series used.

	CAN GLS	CAN SWNS	US RR<145	US RR 66-114	US RR 115-144	US RR>195	US RR>177	JLL WEST (area 2)	Larval zero inflated	US PLL GOM 1-6	JLL GOM	Tagging
Units	Numbers	Numbers	Numbers	Numbers	Numbers	Numbers	Numbers	Numbers	Biomass	Numbers	Numbers	Numbers
1970	-	-	-	-	-	-	-	-	-	-	-	1065132
1971	-	-	-	-	-	-	-	-	-	-	-	1001624
1972	-	-	-	-	-	-	-	-	-	-	-	431955
1973	-	-	-	-	-	-	-	-	-	-	-	183616
1974	-	-	-	-	-	-	-	-	-	-	0.968	341589
1975	-	-	-	-	-	-	-	-	-	-	0.534	554596
1976	-	-	-	-	-	-	-	2.250	-	-	0.666	253265
1977	-	-	-	-	-	-	-	4.390	2.250	-	0.913	257385
1978	-	-	-	-	-	-	-	-	4.390	-	0.876	121110
1979	-	-	-	-	-	-	-	-	-	-	1.287	98815
1980	-	-	0.799	-	-	-	-	0.810	-	-	1.158	192541
1981	1.320	-	0.399	-	-	-	-	1.180	0.810	-	0.553	337995
1982	0.600	-	2.102	-	-	-	-	0.840	1.180	-	-	-
1983	1.540	-	1.114	-	-	2.805	-	0.310	0.840	-	-	-
1984	0.850	-	-	-	-	1.246	-	-	0.310	-	-	-
1985	0.210	-	0.630	-	-	0.857	-	0.350	-	-	-	-
1986	0.240	-	0.778	-	-	0.503	-	0.310	0.350	-	-	-
1987	0.320	-	1.219	-	-	0.529	-	1.110	0.310	-	-	-
1988	0.530	13.860	0.988	-	-	0.941	-	0.620	1.110	-	-	-
1989	0.650	13.030	0.988	-	-	0.763	-	0.330	0.620	-	-	-
1990	0.190	12.320	0.904	-	-	0.626	-	0.300	0.330	-	-	-
1991	0.650	9.510	1.261	-	-	0.820	-	0.420	0.300	-	-	-
1992	1.450	9.410	0.820	-	-	0.910	-	0.440	0.420	0.80	-	-
1993	0.900	6.090	-	1.100	0.990	-	0.690	0.540	0.440	0.45	-	-
1994	0.250	7.280	-	0.260	0.260	-	0.940	0.220	0.540	0.33	-	-
1995	0.720	7.040	-	1.110	0.630	-	1.130	0.790	0.220	0.31	-	-
1996	0.080	5.560	-	1.630	0.730	-	3.330	0.330	0.790	0.18	-	-
1997	0.130	4.480	-	2.370	0.240	-	1.500	0.110	0.330	0.33	-	-
1998	0.240	7.950	-	1.390	0.900	-	1.620	0.460	0.110	0.36	-	-
1999	0.420	10.820	-	1.330	0.770	-	1.880	0.250	0.460	0.61	-	-
2000	0.320	4.660	-	0.950	1.270	-	0.630	0.460	0.250	0.89	-	-
2001	0.290	9.370	-	0.460	1.360	-	1.380	0.240	0.460	0.51	-	-
2002	0.450	11.490	-	1.480	2.600	-	1.940	0.790	0.240	0.48	-	-
2003	0.830	15.900	-	0.410	0.590	-	0.450	0.550	0.790	0.86	-	-
2004	1.080	9.150	-	2.230	0.670	-	0.740	0.180	0.550	0.78	-	-
2005	1.040	10.550	-	2.180	0.630	-	0.650	0.470	0.180	0.59	-	-
2006	1.140	11.660	-	0.580	1.460	-	0.430	0.390	0.470	0.41	-	-
2007	2.280	9.480	-	0.450	1.480	-	0.330	0.310	0.390	0.55	-	-
2008	1.740	13.650	-	0.350	1.380	-	0.400	0.580	0.310	1.26	-	-
2009	2.560	10.570	-	0.350	0.390	-	0.290	0.390	0.580	1.05	-	-
2010	-	9.180	-	0.610	1.240	-	0.940	1.020	0.390	0.89	-	-
2011	3.700	10.430	-	0.800	1.270	-	0.590	0.300	1.020	0.73	-	-
2012	5.620	9.660	-	0.400	1.110	-	0.650	0.980	0.300	1.34	-	-
2013	4.810	5.340	-	0.550	1.040	-	0.500	2.620	0.980	0.43	-	-

Table C4: Catches-at-length associated with the CPUE series used in the SCAL.

In the interests of keeping this document shorter, these data have not been listed below, but can be provided by the authors if required.