SCRS/1993/069

AN UPDATED INDEX OF WEST ATLANTIC BLUEFIN SPAWNING BIOMASS BASED ON LARVAL SURVEYS IN THE GULF OF MEXICO

Col.Vol.Sci.Pap. ICCAT, 42 (1) : 211-213 (1994)

Scott, G.P., S.C. Turner

Southeast Fisheries Science Center, National Marine, Fisheries Service,
75 Virginia Beach Drive, Miami, Florida 33149, USA

SUMMARY

An updated index of spawning biomass for west Atlantic bluefin tuna is presented. The index utilizes larval survey data through 1992.

RESUME

Un indice actualisé de la biomasse reproductrice du thon rouge de l'Atlantique ouest est présenté. L'indice utilise les données de prospection larvaire jusqu'à 1992.

RESUMEN

Se presenta un índice actualizado de la biomasa reproductora del atún rojo del Atlántico oeste. El índice utiliza datos de prospección de larvas hasta finales del año 1992.

Introduction

ICCAT assessment working groups have applied this index to infer information on abundance of large bluefin tuna in the west Atlantic Ocean. That the index is based on the results of spawning in the Gulf of Mexico is considered useful; other indices available for large bluefin in the west Atlantic are derived from fishery data which could conceivably include catches of fish which had migrated from the eastern Atlantic.

Larval Survey Data

The data used for previous larval survey indices were reviewed and 1991-1992 data were incorporated into the updated analysis. In this update, data from 6 stations sampled in 1982 and from 2 stations sampled in 1988, for which flow meter readings were missing, were included in analysis. The 1982 stations were assigned the average over all years, flow meter readings at stations sampled within 0.25° of the 1982 station positions. The 1988 stations with missing flow meter readings were assigned the average value from all stations sampled by the same vessel in 1988. The effect of these assumptions on larval density estimates are described below. The methods described in Scott and Turner (1992) were employed in this analysis. The preferred method of analysis involves only data collected during May. However, for completeness, data from all stations were also analyzed. The summary data table for the updated analysis is presented in Table 1.

Larval Index Estimates

Based on the methods of Scott and Turner (1992), estimates of larval abundance per $100m^2$ at first daily increment formation were used to index total abundance. The larval index values were estimated as:

$$I_{s,y} = \frac{\sum_{i=1}^{k} R_D e^{-z(D_{s,y,i}-1)}}{A_{s,y}} \qquad (3)$$

where y indexes year, s indexes sampling station, i ($= 1,\ldots, k$) indexes individual larvae, A the surface area sampled, D, the age of each larvae sampled (in days) and R_D, the gear efficiency estimate applied. Variability in $I_{s,y}$ was estimated using the delta method (Seber 1983), assuming independence between the product terms, as follows:

$$V(I_{s,y}) = \frac{1}{A_{s,y}^2}\left[\sum_{i=1}^{k} e^{-2(D_{s,y,i}-1)}\left(V(R_{D,i}) + \left(Z_i^2 V(Z_i) + (1-D_{s,y,i})^2 V(D_{s,y,i})\right) R_{D,i}^2\right)\right] \quad (4)$$

We estimated average annual larval density, I_y, taken to be the annual index value, and the variability in the index due to among station effects ($V(I_{\Delta,y})$) from the station sample mean and variance of the $\log_e$ transformed $I_{s,y}$ estimates using the Δ-distribution method (Pennington 1983). Thus,

$$I_y = \frac{m_y}{n_y} e^{T_y} G_{m_y}\left(\frac{s_y^2}{2}\right), \quad (5)$$

where m_y is the number of stations sampled with larvae, n_y the total number of stations, T_y and s_y^2 the sample mean and variance of the m_y $\log_e$ transformed $I_{s,y}$ values, and

$$G_{m_y}\left(\frac{s_y^2}{2}\right) = 1 + \frac{m_y - 1}{m_y}\left(\frac{s_y^2}{2}\right) + \sum_{j=2}^{\infty} \frac{(m_y-1)^{2j-1}}{m_y^j (m_y+1)(m_y+3)\ldots(m_y+2j-3)} \frac{\left(\frac{s_y^2}{2}\right)^j}{j!}. \quad (6)$$

A convergence criterion of 0.001 was used in calculating this series. The estimate of among station variance ($V(I_{\Delta,y})$) from the Δ-distribution method (Pennington 1983) takes the form:

$$V(I_{\Delta,y}) = \frac{m_y}{n_y} e^{2T_y}\left[\frac{m_y}{n_y} G_{m_y}^2\left(\frac{s_y^2}{2}\right) - \left(\frac{m_y - 1}{n_y - 1}\right) G_{m_y}\left(\frac{m-2}{m-1} s_y^2\right)\right]. \quad (7)$$

Since sampling was conducted in a two-stage fashion, the overall variance about I_y was calculated as the weighted sum of the Δ-distribution variance, which incorporates the variable proportion of zero catch information into the estimate as well as inter-station variability for the positive catch stations from equation (7), and the variability contributed by uncertainty within a station due to ageing and gear effects as estimated from equation (4). Thus, overall variability in the estimate was taken as:

$$V(I_y) = \left(\frac{n_y}{N}\right) \frac{\sum_{s=1}^{n_y} V(I_{s,y})}{n_y^2} + \left(1 - \frac{n_y}{N}\right) V(I_{\Delta,y}), \quad (8)$$

where N represents the total possible number of stations in the study area (approximated by the study surface area). Since the number of possible stations in the study area is very large compared to the number sampled, the weight given to the within station term ($V(I_{s,y})$) is negligable and the overall variance is approximated by the among station term ($V(I_{\Delta,y})$).

Table 1 provides the updated results through 1992. Figure 1 shows the resulting pattern in the larval density estimates over the available time series. Inclusion of the additional station data in 1982 and 1988 resulted in increased estimates of larval density for those years. In 1982, 1 of the 6 additional stations had larvae (2 additional fish), whereas in 1988, both of the additional stations had larvae (7 additional fish). Inclusion of these stations in the analysis of May data resulted in a 6% increase in the estimated mean larval density for 1982 and a 17% increase in the estimated mean larval density for 1988.

References Cited

Pennington, M. 1983. Efficient estimators of abundance for fish and plankton surveys. Biometrics. 39:281-286.

Seber, G.A.F. 1983. The estimation of animal abundance and related parameters. 2nd Ed. MacMillan Publ. Co. Inc., New York, 654 pp.

Scott, G.P. and S.C. Turner. 1992. Updated indices of larval bluefin tuna (*Thunnus thynnus*) abundance from ichthyoplankton surveys in the Gulf of Mexico. ICCAT Coll Vol Sci Pap. XXXIX(3):789-792.

Table 1. Summary of the updated larval survey data used in estimating the annual larval index values and associated variances.

	Year												
	77	78	81	82	83	84	86	87	88	89	90	91	92
SAMPLING DATE RANGE	502-512	502-530	501-526	415-525	422-523	421-512	423-522	418-521	420-525	426-519	421-630	417-521	422-521
STATIONS SAMPLED	19	70	32	127	92	75	74	78	73	76	144	79	83
TOWS	19	91	32	127	92	97	74	78	73	76	144	79	83
STAT SAMPLED W LARVAE	8	35	6	22	16	9	7	5	15	10	10	4	13
TOWS SAMPLED W LARVAE	8	44	6	22	16	9	7	5	15	10	10	4	13
TOTAL CATCH	22	281	20	76	68	16	12	10	71	36	23	7	36
MEAN LENGTH OF LARVAE	4.7	4.1	4.6	4.1	3.5	4.2	4.9	5.0	3.5	4.1	3.9	3.8	3.5
LARVAE LENGTH RANGE	3.4- 8.1	2.4- 9.5	2.7- 7.0	2.0-10.7	2.0- 6.8	2.9- 6.0	3.5- 6.0	2.3- 9.2	2.3- 7.0	2.5- 8.0	2.6- 7.5	2.4- 6.0	2.5- 9.0
ALL STATIONS													
MEAN LOG(I_s)	1.367	1.765	1.815	1.441	1.377	0.551	1.296	1.634	1.422	1.151	0.946	1.272	0.755
VARIANCE(LOG(I_s))	0.925	1.448	0.328	0.729	0.627	1.860	0.263	0.100	0.690	1.074	0.239	0.691	0.915
MEAN I (Larvae/100m^2)	2.435	5.824	1.317	0.961	0.939	0.336	0.386	0.342	1.115	0.662	0.199	0.231	0.502
AMONG STATION VAR	1.113	2.518	0.323	0.067	0.087	0.040	0.024	0.024	0.134	0.086	0.005	0.019	0.036
WITHIN STATION VAR	0.215	0.078	0.461	0.104	0.052	0.006	0.106	0.718	0.056	0.133	0.067	0.144	0.059
MAY STATIONS													
STATIONS SAMPLED	19	70	32	69	70	33	51	48	42	63	53	50	57
STATIONS WITH LARVAE	8	35	6	15	16	4	3	4	14	10	8	4	12
MEAN LOG(I_s)	1.367	1.765	1.815	1.660	1.377	0.623	1.414	1.620	1.426	1.151	1.105	1.272	0.671
VARIANCE(LOG(I_s))	0.925	1.448	0.328	0.612	0.672	3.439	0.231	0.132	0.743	1.074	0.088	0.690	0.897
MEAN I (Larvae/100m^2)	2.435	5.824	1.317	1.514	1.235	0.653	0.261	0.445	1.946	0.798	0.474	0.365	0.614
AMONG STATION VAR	1.113	2.518	0.323	0.222	0.145	0.274	0.025	0.051	0.403	0.123	0.003	0.047	0.055
WITHIN STATION VAR	0.215	0.078	0.461	0.188	0.052	0.006	0.074	0.315	0.060	0.133	0.108	0.144	0.068

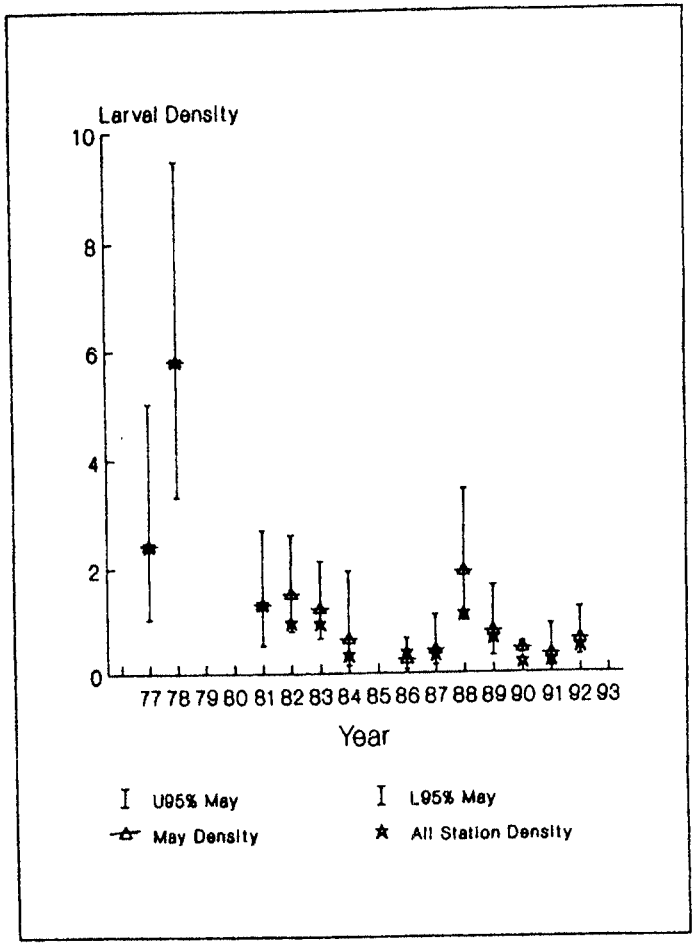

Figure 1. Annual larval density estimates (larvae/100m^2) with associated 95% confidence intervals. Diamonds represent May stations data; Stars, All stations.