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UPDATED INDICES OF LARVAL BLUEFIN TUNA (Thunnus thynnus) ABUNDANCE FROM ICHTHYOPLANKTON SURVEYS IN THE GULF OF MEXICO

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SUMMARY

Indices of larval abundance are updated using survey data through 1990. The methods described in SCRS/90/77 are applied in the present report. Methods for incorporating uncertainty in the estimates due to within station and between station variability are described. Variability in the estimates is high, potentially making the index more applicable for detecting large changes in spawning stock biomass rather than interannual variability in this population parameter.

RESUME

Les indices de l'abondance larvaire sont mis à jour en utilisant des données de prospection jusqu'en 1990. Les méthodes décrites dans le document SCRS/90/77 sont appliquées dans ce rapport. Les méthodes utilisées pour incorporer des incertitudes dans les estimations dues à la variabilité à l'intérieur d'une station et entre des stations sont décrites. La variabilité dans les estimations est élevée, faisant en sorte que l'indice soit plus apte à détecter de grands changements dans la biomasse du stock plutôt qu'une variabilité interannuelle dans le paramètre de population.

RESUMEN

Se actualizan los índices de abundancia de larvas utilizando datos de prospección de 1990. Los métodos descritos en el SCRS/90/77 se aplican en el presente informe. Se describen los métodos para incorporar incertidumbres en las estimaciones debidas a las estaciones y variabilidades entre éstas. La variabilidad en las estimaciones es alta, haciendo potencialmente más aplicable el índice para detectar grandes cambios en la biomasa reproductora del stock en vez de variabilidades interanuales en el parámetro de población.

Introduction

ICCAT assessment working groups have applied the larval 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.

Methods

Larval Survey Data

The data used for previous larval survey indices were reviewed and 1990 data were incorporated into the updated analysis. In the analysis presented by Scott *et.al.* (1991, SCRS/90/77), only data from the first tow at any station were used in analysis, which resulted in not incorporating some tows in the survey area in the analysis. For this analysis, all tows at a station were used in estimating larval densities. Again, after review, it was determined that some stations included in the previous analysis were from outside of the survey area defined in Scott *et.al.* (1991). Only stations from the defined survey area were included in the present analysis. The summary data table for the updated analysis is presented in Table 1.

Larval Index Estimates

Based on the methods of Scott *et.al.* (1991), estimates of larval abundance per $100m^2$ at first daily increment formation were used to index total abundance. Due to rounding effects, the probabilities of age given length in the classification matrix used for ageing the larvae by Scott *et.al.* (1991) were found to sum, in some cases, to values greater or less than 1. The classification matrix used in this update has been revised to eliminate the effects of rounding on the summation. The larval index values were estimated as:

$$I_{s,y} = \{{}^{n}\textstyle\sum_i R(exp(-Z(D_{s,y,i}-1))\}/A_{s,y},$$

where y indexes year, s indexes sampling station, i $(= 1,..., n)$ indexes individual larvae, A the surface area sampled, and the variables R, Z, and D, represent the gear efficiency estimate applied, the estimated daily loss rate for larvae, and the number of daily increments for the larvae, respectively, as described by Scott *et.al.* (1991). Estimates were constructed using the preferred method as described in Scott *et.al.* (1991), which adjusts the density estimates for estimated larval loss rates and gear efficiency. Variability in $I_{s,y}$ was estimated using the Delta method (Seber 1983), assuming independence between the product terms, as follows:

$$V(I_{s,y}) = {}^{n}\textstyle\sum_i[(V(R_i) + R_i^2(V(Z_i)(Z_i)^2 + V(D_{s,y,i})(1-D_{s,y,i})^2))exp(-Z(D_{s,y,i}-1))\,]A_{s,y}^{-2}$$

The variance estimates for the component parts of the estimated larval density are described in Scott *et.al.* (1991). Between station variability ($V(I_\Delta)$) was estimated based on the station sample mean and variance from the ln transformed I_s estimates by year using the Δ-distribution method described by Pennington (1983). This method was was used to estimate average annual levels (I_y), taken to be the annual index value. For the preferred method of indexing larval density, variance about this estimate was assumed equal to the sum of the between station variance, which incorporates the variable proportion of zero catch information into the estimate as well as inter-station variability for the positive catch stations and the within station variability contributed by the variance term defined above. Thus, overall variability in the estimate was taken as:

$$V(I_y) = {}^{n}\textstyle\sum_i V(I_{s,y}) + V(I_\Delta)$$

The within station variability terms were summed over all positive stations before summing to the between station variability estimated via Pennington's algorithm.

The sensitivity of the estimates to timing of the survey was evaluated by calculating larval densities using data from different time periods. Specifically, estimates were calculated for the annual data from the entire time period of sampling (in some years sampling began as early as mid-April while in other years sampling was not concluded until late June, see Table 1). Estimates were constructed for 1) all station data for each year, 2) only for May and June stations, and 3) only for May stations.

Results

Results of the updated estimates of larval densities based on ichthyoplankton surveys from 1977-1990 are presented in Table 1 and Figure 1. Incorporating estimates of within station variability into the average density estimates can, in some cases, result in considerable added uncertainty in the mean index value (see Table 1). Figure 1 shows the results of the estimation applied to the station data in Table 1 for a) all of the stations available, b) stations in May and June, and c) stations in May only. Restricting analysis to the May and June station samples tends to increase the mean density estimates for some years in the mid-range of the sample. Restricting estimation to only May further affects only the 1990 value since this was the only survey year with samples that late in the season. However, even with the levels of uncertainty estimated in this paper, there are some patterns in the index than can be discriminated. The most notable feature of the larval index time trend are the relatively high values in 1977 and 1978 and relatively low values in 1983 - 1986.

Another notable feature of the available estimates is the high degree of variability in the estimates associated with those based on small numbers of larvae sampled (see Table 1 and Figure 1). Typically when the number of larvae sampled in the standard grid is less than 10, the ratio of the standard deviation to the mean (CV) is 70% or more (up to 136% in 1987). A consequence of this is that the statistical power of discriminating interannual differences in the index values is quite low and comparison of the mean values in isolation of their associated variances could easily lead to incorrect inference about changes in the biomass that spawned these larvae. Because variability in the estimates is high, especially for recent years where the numbers of larvae sampled is low and the proportion of positive stations is also low, this index, as it is currently formulated, may be more appropriate for use in detecting large increases (*i.e.* doubling or more) in spawning stock biomass, rather than interannual variation in spawning stock biomass that might be expected under current conditions.

References

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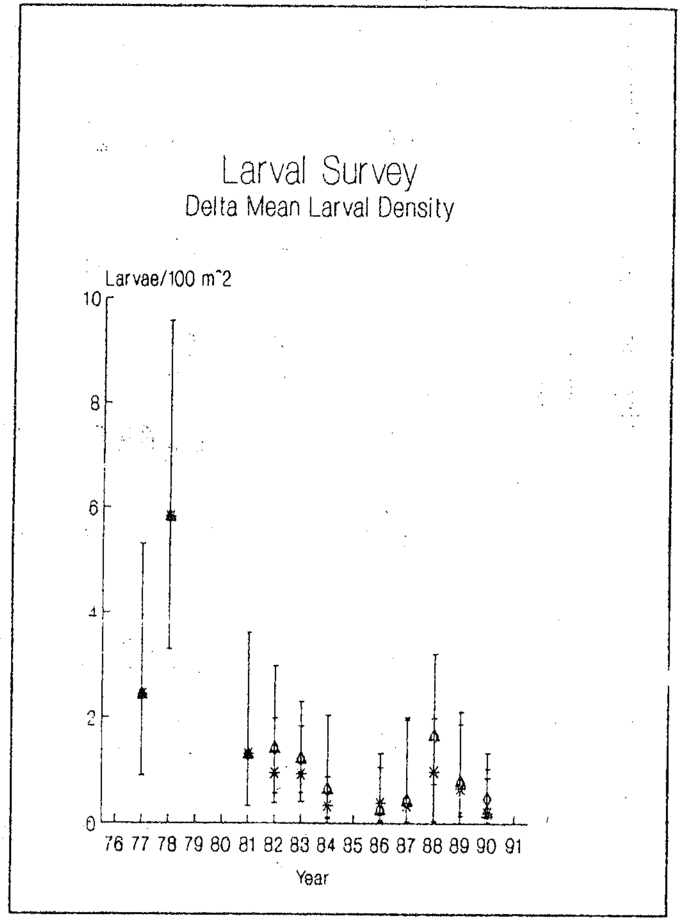

Figure 1. Annual larval density estimates (larvae/100m^2) with associated 95% confidence intervals (bars). Asterix represent all stations data; triangles, May and June stations; and diamonds, May only stations.

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
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
STATIONS SAMPLED	19	70	32	121	92	75	74	78	71	76	144
TOWS	19	91	32	121	92	97	74	78	71	76	144
STATIONS SAMPLED WITH LARVAE	8	35	6	21	16	9	7	5	13	10	10
TOWS SAMPLED WITH LARVAE	8	44	6	21	16	9	7	5	13	10	10
TOTAL CATCH	22.	281.	20.	74.	68.	16.	12.	10.	64.	36.	23.
MEAN LENGTH OF LARVAE	4.7	4.1	4.6	4.1	3.5	4.2	4.9	5.0	3.4	4.1	3.9
LENGTH RANGE OF LARVAE	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- 6.9	2.5- 8.0	2.6-7.5
ALL STATIONS											
MEAN LOG(I_s)	1.367	1.765	1.815	1.386	1.377	0.551	1.296	1.634	1.351	1.151	0.946
VARIANCE(LOG(I_s))	0.925	1.448	0.328	0.696	0.627	1.860	0.263	0.100	0.745	1.074	0.239
MEAN I (Larvae/100m^2)	2.435	5.824	1.317	0.963	0.939	0.336	0.386	0.342	0.989	0.662	0.199
BETWEEN STATION VARIANCE	1.113	2.518	0.323	0.072	0.087	0.040	0.024	0.024	0.122	0.086	0.005
WITHIN STATION VARIANCE	0.215	0.078	0.461	0.103	0.052	0.006	0.106	0.718	0.043	0.133	0.067
TOTAL VARIANCE	1.328	2.596	0.784	0.175	0.139	0.046	0.130	0.742	0.165	0.219	0.072
MAY AND JUNE STATIONS											
STATIONS SAMPLED	19	70	32	63	70	33	51	48	40	63	113
STATIONS WITH LARVAE	8	35	6	14	16	4	3	4	12	10	8
MEAN LOG(I_s)	1.367	1.765	1.815	1.594	1.377	0.623	1.414	1.620	1.350	1.151	1.105
VARIANCE(LOG(I_s))	0.925	1.448	0.328	0.588	0.672	3.439	0.231	0.132	0.812	1.074	0.088
MEAN I (Larvae/100m^2)	2.435	5.824	1.317	1.430	1.235	0.653	0.261	0.445	1.662	0.798	0.222
BETWEEN STATION VARIANCE	1.113	2.518	0.323	0.206	0.145	0.274	0.025	0.051	0.363	0.123	0.006
WITHIN STATION VARIANCE	0.215	0.078	0.461	0.188	0.052	0.006	0.074	0.315	0.046	0.133	0.108
TOTAL VARIANCE	1.328	2.596	0.784	0.394	0.197	0.280	0.099	0.366	0.409	0.256	0.114
MAY STATIONS											
STATIONS SAMPLED	19	70	32	63	70	33	51	48	40	63	53
STATIONS WITH LARVAE	8	35	6	14	16	4	3	4	12	10	8
MEAN LOG(I_s)	1.367	1.765	1.815	1.594	1.377	0.623	1.414	1.620	1.350	1.151	1.105
VARIANCE(LOG(I_s))	0.925	1.448	0.328	0.588	0.672	3.439	0.231	0.132	0.812	1.074	0.088
MEAN I (Larvae/100m^2)	2.435	5.824	1.317	1.430	1.235	0.653	0.261	0.445	1.662	0.798	0.474
BETWEEN STATION VARIANCE	1.113	2.518	0.323	0.206	0.145	0.274	0.025	0.051	0.363	0.123	0.003
WITHIN STATION VARIANCE	0.215	0.078	0.461	0.188	0.052	0.006	0.074	0.315	0.046	0.133	0.108
TOTAL VARIANCE	1.328	2.596	0.784	0.394	0.197	0.280	0.099	0.366	0.409	0.256	0.111