

## SPATIAL DATA ANALYSES OF ATLANTIC BLUEFIN TUNA LARVAL SURVEYS IN THE 1994 ICCAT BYP

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### SUMMARY

Spatial data analyses are conducted to study "larval distribution patterns of bluefin, blackfin, yellowfin, albacore and skipjack" and "relationships between bluefin tuna larval distributions and environmental conditions" in the Gulf of Mexico and the Mediterranean Sea based on the information collected during the Bluefin Year Program in 1994. It is roughly observed that more frequent larvae occurred in the Gulf of Mexico than in the Mediterranean Sea for all species. It was also learned that particular physical environmental conditions affected distributions and occurrence (aggregation) of bluefin tuna larvae, although there were different ranges in two survey areas.

### RÉSUMÉ

Des analyses des données spatiales sont menées pour étudier les modes de distribution larvaire du thon rouge, du thon à nageoire noire, de l'albacore, du germon et du listao et les relations entre les distributions larvaires du thon rouge et les conditions environnementales dans le Golfe du Mexique et la Méditerranée, en se fondant sur les informations collectées pendant le Programme Année Thon rouge en 1994. On observe qu'il y a eu, pour toutes les espèces, une fréquence larvaire plus importante dans le Golfe du Mexique que dans la Méditerranée. On a également observé que les conditions environnementales physiques particulières ont affecté la distribution et la présence (regroupement) des larves de thon rouge, bien qu'il y ait différentes gammes dans deux zones de prospection.

### RESUMEN

Se llevan a cabo análisis de datos espaciales para estudiar 'esquemas de distribución larvaria de atún rojo, atún aleta negra, rabil, atún blanco y listado', y 'relaciones entre las distribuciones de larvas de atún rojo y las condiciones medioambientales' en el Golfo de México y el mar Mediterráneo, basándose en la información recogida durante el Programa Año del Atún Rojo en 1994. Se observa que la mayor frecuencia de larvas tuvo lugar en el Golfo de México, en relación al Mediterráneo, para todas las especies. También se observó qué condiciones físicas medioambientales particulares afectaron a las distribuciones y presencia (agregación) de larvas de atún rojo, si bien eran rangos muy diferentes en dos áreas de prospección.

### 1. Introduction

This paper describes the results of the spatial data analyses for the Atlantic bluefin tuna (*Thunnus thynnus*) larval surveys conducted during the 1994 ICCAT/BYP in two spawning grounds (Gulf of Mexico and Mediterranean Sea). Two aspects are highlighted in this paper, i.e., (a) larval distribution patterns of major tuna species (bluefin, yellowfin, albacore and blackfin tuna) and skipjack and (b) relationship between distribution of Atlantic bluefin tuna larvae and physical marine environmental conditions.

### 2. Data

Occurrence (number of larvae/100m<sup>2</sup>) and depth wise sea temperature and salinity are primary information used in the analyses, which were collected by *Shoyo-maru*, *Oregon II* and EU boats during the surveys. Details on these data are described in Tsuji *et al* (1996), Richards (1996) and Turner (1996). In addition, the base maps containing bottom contours available in the Geographical Information System (GIS) software, are also utilized. Table 1 summarizes these information.

### 3. Methods

#### 3.1 Data process

Occurrence of larvae (number/100m<sup>2</sup>) are represented by three levels of symbols (small, medium and large solid circles). Following method is used to assign larval occurrence data into three symbols. Larval occurrence data (all species combined) in two spawning areas are initially combined and ranked. Then, approximately, the first 1/3 of the data from the lowest rank, are assigned for small symbol, the second 1/3 for medium and the last 1/3 for large. This means that equal number of the data (frequencies) are assigned to each symbol. In this way, the different distribution maps for the larval occurrence are comparable. Table 2 shows the boundaries of these three levels and other relevant information.

Temperature and salinity collected by 1m depth interval by *Shoyo-maru*, were utilized as marine environmental information. Because tuna larvae are considered to be distributed within a seasonal mixing layer, the simple average temperature and salinity data from surface to 10m depth are computed and used as the representative of the marine environmental conditions in the analyses and mappings.

#### 3.2 GIS

The PC based marine GIS software, '*Marine explorer*' is used for the mapping and the spatial data analyses, for which first version was recently completed by the Environmental Simulation Laboratory (Kawagoe, Saitama, Japan). It has the base maps covering the global waters with 14 bathymetry (contour) lines from 0 (coastal line), 200 m, 500, 1,000, 1,500, 2,000, 2,500, 3,000, 3,500, 4,000, 4,500, 5,000, 5,500 and 6,000m or deeper.

#### 3.3 Thematic maps

To effectively learn 'larval distribution patterns' and 'relationships between bluefin tuna larval distributions and environmental conditions', six thematic maps are designed and created by combining different factors from available information listed in Table 3.

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#### 4. Results

Six resultant thematic maps are presented in Maps 1-6, where Maps 1-3 are for the Gulf of Mexico and Maps 4-6 for the Mediterranean Sea.

#### 5. Discussion

##### 5.1 Gulf of Mexico (Maps 1-3)

Larvae of four species groups (blackfin/yellowfin, yellowfin, skipjack and bluefin tuna) are observed in the survey waters. Larvae are more frequently found in the waters which depth ranges from 200-3,000m. Blackfin/yellowfin means that species is either blackfin tuna or yellowfin tuna because they could not be sorted into the respective species names. Number of yellowfin and skipjack larvae collected by the tow, are higher than those of blackfin/yellowfin and northern bluefin tuna. No significant difference was observed in the distribution patterns of bluefin tuna between samplings by *Shoyo-maru* and *Oregon II*.

##### 5.2 Mediterranean Sea (Maps 4-6)

Distribution patterns and occurrence levels of larvae are different by species and survey vessels, i.e., albacore and bluefin tuna larvae are primarily sampled in the eastern part of the Mediterranean Sea by *Shoyo-maru*, while the EU boats sampled larvae in the entire region. Different distribution patterns and levels of larvae between survey boats are considered to be caused by different survey periods, i.e., different marine environmental conditions between these two survey periods are considered to alter the distribution patterns and occurrence levels of larvae. *Shoyo-maru* found high aggregation of northern bluefin tuna larvae in the central Mediterranean Sea (south of Italy). In that water, the particular ranges of physical environmental conditions were observed, i.e., bathymetry range from 1,000-3,000 m in depth, temperature range from 23.5-25.0°C, and salinity from 37.8-38.2.

##### 5.3 General discussion

It is roughly observed that more frequent larvae occurrence are observed in the Gulf of Mexico than in the Mediterranean Sea for all species. This is likely due to the higher sea temperature range in the Gulf of Mexico (25-27°C), which is considered to provide productive and rich marine environments to enhance spawning activities.

It was learned that particular physical environmental conditions affected distributions and occurrence of Atlantic bluefin tuna larvae, although they were different levels between in the Gulf of Mexico and in the Mediterranean Sea. This implies that spawning activities of Atlantic bluefin tuna will be enhanced when such particular marine environment conditions are formed.

In this study, two environmental factors (temperature and salinity) were preliminary used, but other (possibly) available marine environmental information such as winds, chlorophyll, dissolved oxygen and nutrient are suggested to include and re-analyze the data in similar way in the future, in order to learn more specific mechanisms, dynamics and behaviors of distributions and aggregations of Atlantic bluefin tuna larvae.

#### 6. References

- TSUJI, S., Y. Nishikawa, K. Segawa and Y. Hiroe. 1996. *Distribution and abundance of Thunnus larvae and their relation to the oceanographic condition in the Gulf of Mexico and the Mediterranean Sea during May through August of 1994 (Draft)*. ICCAT Collective Volume of Scientific Papers; 46(2); 161 - 176.
- RICHARDS, W.J. 1996. *Report on US collections from the Gulf of Mexico, 1994*. ICCAT Collective Volume of Scientific Papers; 46(2); 186 - 188.
- TURNER, S. C. 1996. (Rev.) *Observations on the larval catches made by the "Oregon II" with Japanese and Bongo nets in the Gulf of Mexico in 1994*. ICCAT Collective Volume of Scientific Papers; 46(2); 203 - 26.

**Table 1. Information used in this paper.**

	Gulf of Mexico			Mediterranean Sea		
	Species	Temperature and salinity	Track lines of the boats	Species	Temperature and salinity	Track lines of the boats
<i>Shoyo-maru</i> (Japan)	Blackfin/yellowfin (*) Yellowfin Skipjack Bluefin tuna	Data by 1 m depth interval	ADCP data Set	Albacore Bluefin tuna	Data by 1m depth Interval	ADCP data set
<i>Oregon II</i> (USA)	Bluefin tuna	(na)	(na)			
EU boats				Albacore Bluefin tuna	(na)	EU larval data set

Note (\*): These two species could not be sorted into the respective species names.

**Table 2 Definition of symbols representing magnitudes of larval occurrence in the thematic maps.**

Size of the symbol (solid circle) representing magnitudes of larval occurrence	Range of larval occurrence (number/100m <sup>2</sup> ) (< - □)	Number of the data (frequency)	Percent of frequency (%)
Small	0 - 50(*)	242	37.0
Medium	50 - 100	192	29.4
Large	100 - 13,000	193	33.6
(total)		654	100.0

Note: 44 was the exact boundary of the 1/3 of the frequency, but 50 is used for convenience.

**Table 3 List of thematic maps and their specifications**

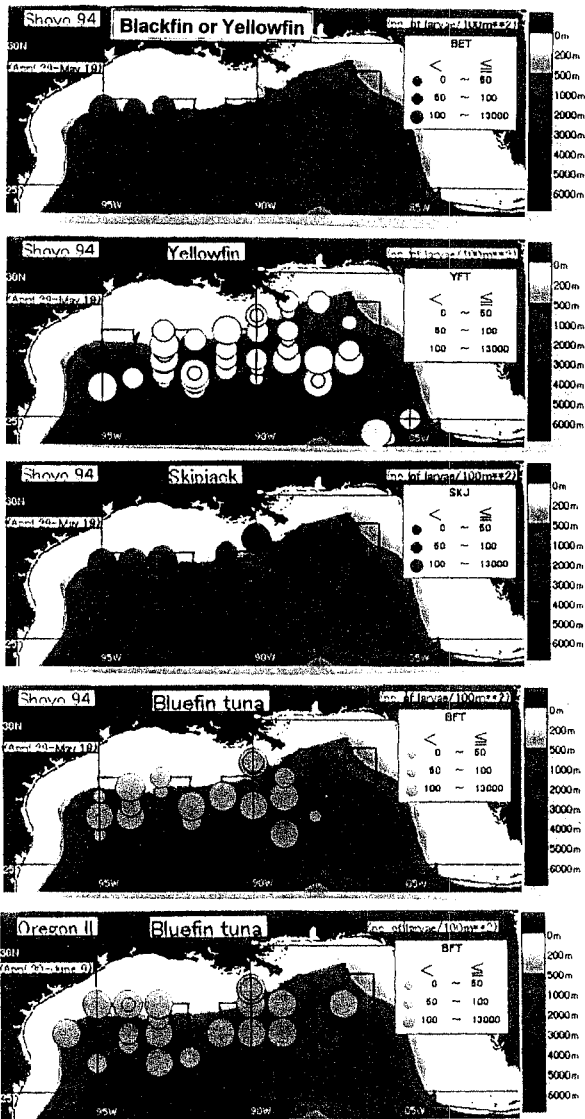
##### Gulf of Mexico (*Shoyo-maru* and *Oregon II*)

Thematic Map	Theme	Species	Track line	Bathymetry	Temperature	Salinity
1	Relationship between larval distribution and bathymetry.	Blackfin/yellowfin Yellowfin Skipjack Bluefin tuna				
2 (a) <i>Shoyo-maru</i> (b) <i>Oregon II</i>	Relationships among larval distribution, bathymetry and temperature by boat.	Bluefin tuna				
3 (a) <i>Shoyo-maru</i> (b) <i>Oregon II</i>	Relationships among larval distribution, bathymetry and salinity by boat.	Bluefin tuna				

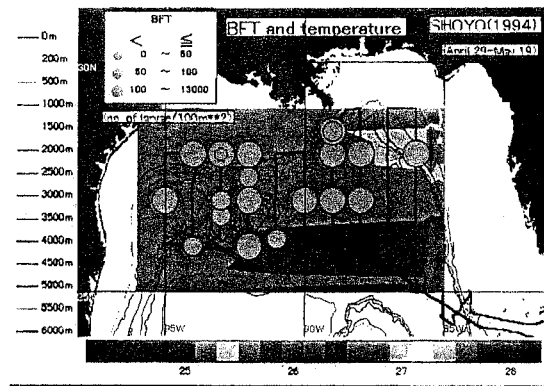
##### Mediterranean Sea (*Shoyo-maru* and EU boats)

Thematic Map	Theme	Species	Track line	Bathymetry	Temperature	Salinity
4 (a) <i>Shoyo-maru</i> (b) EU-boats	Relationship between larval distributions and bathymetry by boat.	Albacore				
5 (a) <i>Shoyo-maru</i> (b) EU-boats	Relationships among larval distributions and bathymetry by boat.	Bluefin tuna				
6 (a) Temperature (b) Salinity	Relationships among larval distributions, bathymetry and environmental conditions.	Bluefin tuna			(a)	(b)

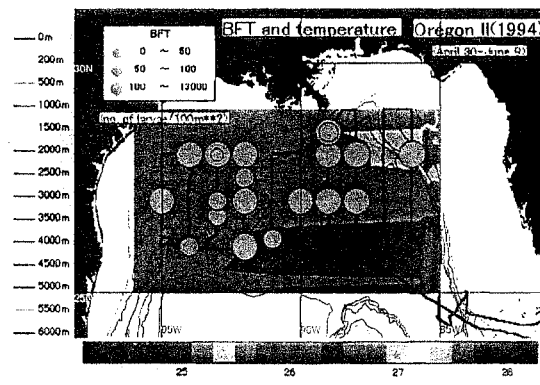
Note: Highlighted information are included in the thematic maps.



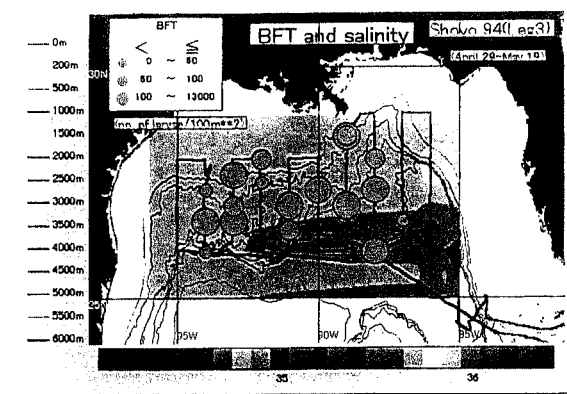
Map 1. Distribution of larvae by species in the Gulf of Mexico, overlaid with bathymetry and track lines. (Shoyo-maru: first four maps and Oregon II: bottom map)



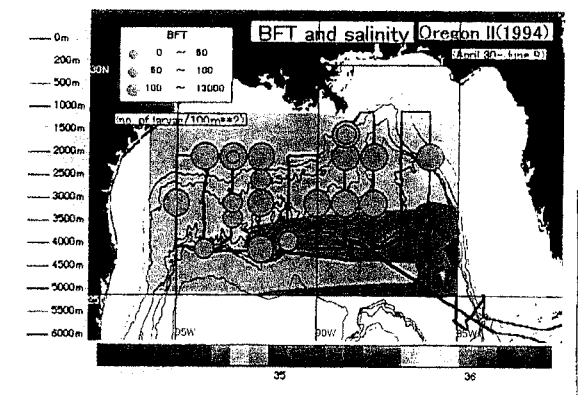
Map 2(a) Distribution of Atlantic bluefin tuna larvae in the Gulf of Mexico, overlaid with bathymetry, track lines and temperature. (Shoyo-maru)



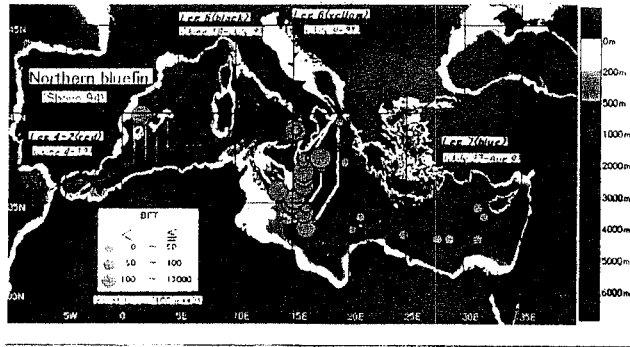
Map 2(b) (map for Oregon II)



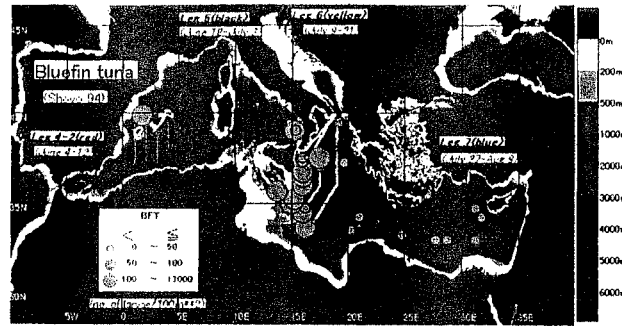
Map 3(a) Distribution of Atlantic bluefin tuna larvae in the Gulf of Mexico, overlaid with bathymetry, track line and salinity. (Shoyo-maru)



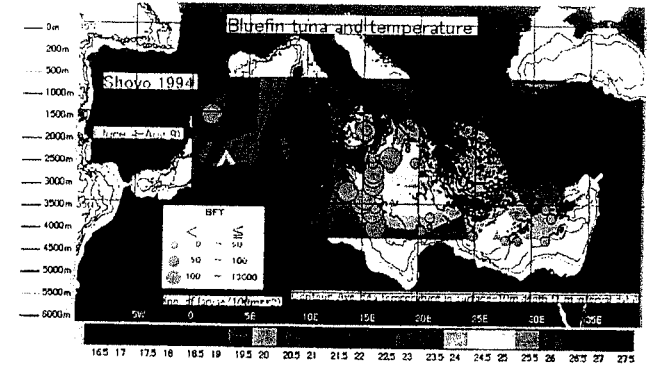
Map 3(b) (map for Oregon II)



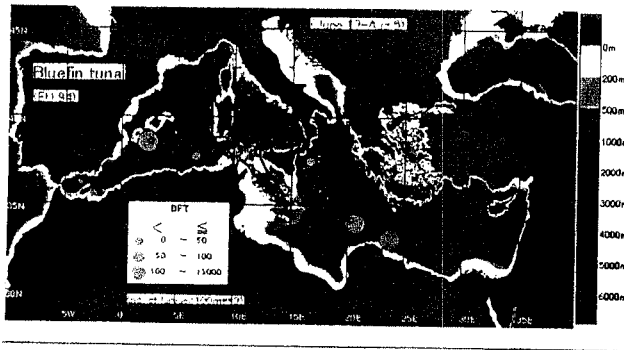
Map 4(a) Distribution of albacore tuna larvae in the Mediterranean Sea, overlaid with bathymetry and track lines. (Shoyo-maru)



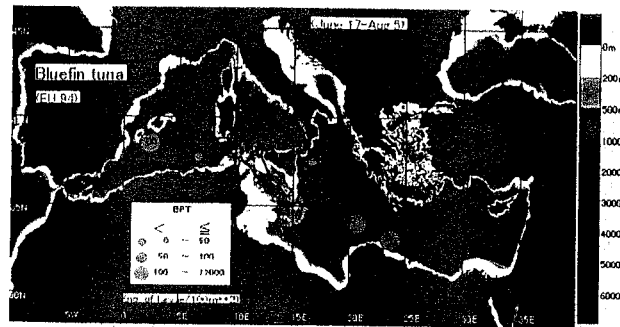
Map 5(a) Distribution of Atlantic bluefin tuna larvae in the Mediterranean Sea, overlaid with bathymetry and track lines. (Shoyo-maru)



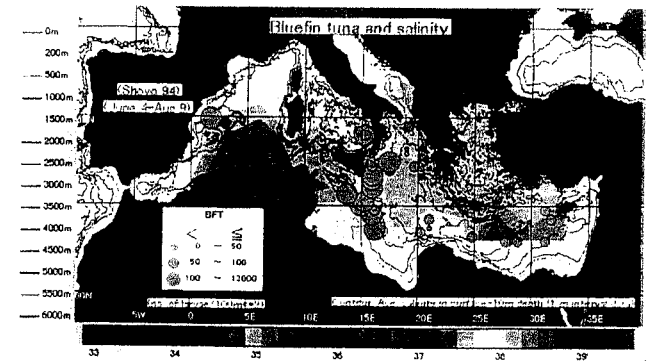
Map 6(a) Distribution of Atlantic bluefin tuna larvae in the Mediterranean Sea, overlaid with bathymetry and temperature. (Shoyo-maru)



Map 4(b) (map for EU boats)



Map 5(b) (map for EU boats)



Map 6(b) (map for salinity)