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Distribution and Abundance of Skipjack Larvae off the Coasts of Brazil

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From an examination of the literature, and of unpublished data collected during the International Skipjack Year Program, larval skipjack were found to be widely abundant in the Guiana Current off the northeast coast of Brazil, particularly in the first quarter of the year (Jan. to March), although they were present in lower abundance also at other times. Skipjack larvae were also present in waters of the Brazil Current off the southwest coast of that country, but their occurrence was more restricted to the austral summer, ie. the first and particularly the last quarter. Skipjack larvae were highly abundant over the shallow bank of Abrolhos. Larvae were never found at stations where water temperatures were below 24°C.

The observed distribution of larvae suggests that the north coast of Brasil and the area over the Abrolhos bank are potential areas for future fisheries.

L'étude des travaux publiés sur ce sujet, ainsi que de données inédites rassemblées dans le cadre du programme d'Année internationale du Listao, permet d'observer que les larves de listao abondent dans le courant de Guyane au large des côtes nord-est du Brésil, surtout pendant le premier trimestre (janvier–mars), mais aussi, bien qu'à un moindre degré, à d'autres époques. Les larves de listao sont également observées dans les eaux du courant du Brésil, au large des côtes sud-est du pays, où leur présence se limiterait à l'été austral, c'est-à-dire pendant le premier trimestre, et surtout le dernier. Les larves de listao sont très abondantes sur les hauts-fonds d'Abrolhos. Aucune larve n'a été observée aux endroits où la température de l'eau est inférieure à 24°C.

La répartition larvaire observée permet de penser que les côtes nord du Brésil et le secteur du banc d'Abrolhos sont des zones potentielles de pêche pour l'avenir.

Al consultar estudios anteriores y datos no publicados recogidos durante el Programa Año Internacional del Listao, se halló que las larvas de esta especie eran muy abundantes en la Corriente de Guyana frente a la costa Nordeste de Brasil, particularmente en el primer trimestre del año (Enero a Marzo) si bien aparecieron en menor abundancia en otras estaciones. Asimismo, se encontraron larvas de listado en aguas de la Corriente de Brasil, frente a la costa Sudoeste, pero su presencia dependía principalmente del verano austral, durante el primer y, sobre todo, el último trimestre. Las larvas de listado eran muy abundantes sobre el banco poco profundo de Abrolhos. No se encontró larvas en lugares donde la temperatura de las aguas era inferior a los 24°C.

La observación de la distribución de las larvas sugiere que la costa Norte de Brasil y la zona sobre el banco de Abrolhos son áreas potenciales para el desarrollo de futuras pesquerías.

1. Introduction

One of the objectives of the International Skipjack Year Program was to find new skipjack tuna stocks in areas where no commercial fishery is operating. One means of doing this is to look for larval skipjack in plankton tows, since the presence of larvae indicates the recent presence of adult skipjack in or near the area. This then was one of the goals of the larval surveys conducted for the Program. A second objective, was to determine the areas and season in and at which skipjack spawn in the Atlantic Ocean, since such information may be useful for defining subpopulations.

This paper concerns larval surveys conducted in the southwest Atlantic off the coast of Brazil. Pertinent literature is reviewed and the results of two original cruises are presented.

2. Materials and Methods

Larval skipjack are collected in plankton nets which may be towed through the water in a number of ways. Tows may be made horizontally at the surface, or at depth; they may be made vertically from deep waters to the surface while the vessel is stationary; or they may be made obliquely by stopping and lowering the net from the surface to a certain depth, then retrieving it while the vessel is moving; if the net is also lowered while the vessel is moving, the method is referred to as "a double oblique haul". Since numbers and species of plankton differ at different depths in the water column, the single depth horizontal tows are not comparable with oblique and vertical tows. Furthermore, workers may express the results of tows in different ways, some recording results per tow or haul over a given distance and time, others recording the numbers of plankton sampled per standard volume of water strained. Where comparisons are possible, I have tried in this work to standardize the presentation of results from different authors by expressing skipjack larval density as numbers of larvae under 10 m^2.

Previous plankton tows in the southwest Atlantic which produced results useful to a survey of the distribution of larval skipjack (Table 1) were made using surface horizontal tows and Nishikawa et al. (1978), Kikawa and Nishikawa (1979) and Rudomiotkina (1983) used horizontal surface tows, but while the former workers expressed results as number of larvae per 1000 m^3, Rudomiotkina gave only number of larvae per haul.

Table 1. List of survey cruises from which the data analyzed in this report were taken.

Cruises	Period	Number of stations	Survey areas	Sources
Equalant I	Feb–Apr, 1963	77	Northern subarea	Richards 1969
Equalant II	Aug–Oct, 1963	24	Northern and eastern subareas	Richards 1969
FINEP I	Nov–Dec, 1975	140	Southeastern subarea	Matsuura & Sato 1981
FINEP II	Jan, 1976	140	idem	idem
FINEP III	May, 1976	140	idem	idem
FINEP IV	Sep–Oct, 1976	140	idem	idem
FINEP VIII	June, 1976	64	Eastern subarea	Matsuura 1982b
FINEP IX	Nov–Dec, 1978	64	idem	idem
FINEP F	Jun–Jul, 1981	48	Northern and eastern subareas	Original
Koyo-Maru	Dec, 1979	43	Northern subarea	Original
Total		880		

Richards (1969) summarized results from the Equalant I and II survey cruises which were made by a number of different countries. The recommended standard method was to make a thirty minute oblique haul from the top of the thermocline to the surface using a net of 0.280 nylon mesh, with a 100 cm diameter mouth, but some participating countries did not follow this recommended procedure. Richards (1969), who analyzed the data on scombrid larvae from these cruises, expressed larval density in number under 100 m^2 of sea surface.

Matsuura and Sato (1981) reported results of four FINEP cruises, and Matsuura (1982) reported results from two more cruises in this series. All plankton samples from FINEP cruises were taken with 61 cm Bongo nets, following the method described by Ahlstrom et al. (1973). At each station a double oblique haul was made from sea surface to 200 m depth in deep water stations and to 5 m depth above the sea floor in shallow water stations. Meshes of Bongo nets were 0.505 and 0.333 mm. The water volume strained was measured with a flow meter attached inside the mouth of the Bongo frame. Ship speed while towing was held at about two knots and a wire angle was adjusted to maintain 45°.

Original data reported in this paper derive from one further FINEP cruise, and from a cruise by the *Koyo-Maru* (Table 1). Samples from FINEP cruises collected with the coarse mesh net (0.505 mm) were first sorted for eggs and larvae, and the scombrid larvae were separated from this. Skipjack larvae were identified by morphological characteristics, such as chromatophore pattern and myomere counts, following the description by Matsumoto (1958) and Ueyanagi and Watanabe (1964).

Skipjack larvae taken by Bongo nets were expressed as the number of larvae under 10 m^2 of sea surface, using the equation:

$$Y = \frac{X \times d}{V} \times 10$$

where X = number of larvae taken at each station, d = depth of tow in (m), V = volume of water strained (m^3) and Y = number of larvae per 10 m^2 of sea surface.

During the oceanographic cruise of the R/V *Koyo Maru* to the northern Brazilian coast, zooplankton sampling was made with a larva-net, 130 cm mouth diameter and 450 cm in length (Shimonoseki Univ. 1981). This conical net consisted of two different meshes, the anterior ⅔ with 0.530 mm mesh, and posterior ⅓ with 0.328 mm mesh. Surface horizontal tows were made with ship speed of about two knots for 15 minutes. Plankton samples were sorted and skipjack larvae identified at the laboratory of the Instituto Oceanográfico da Universidade de São Paulo. Since the results from these surface tows were

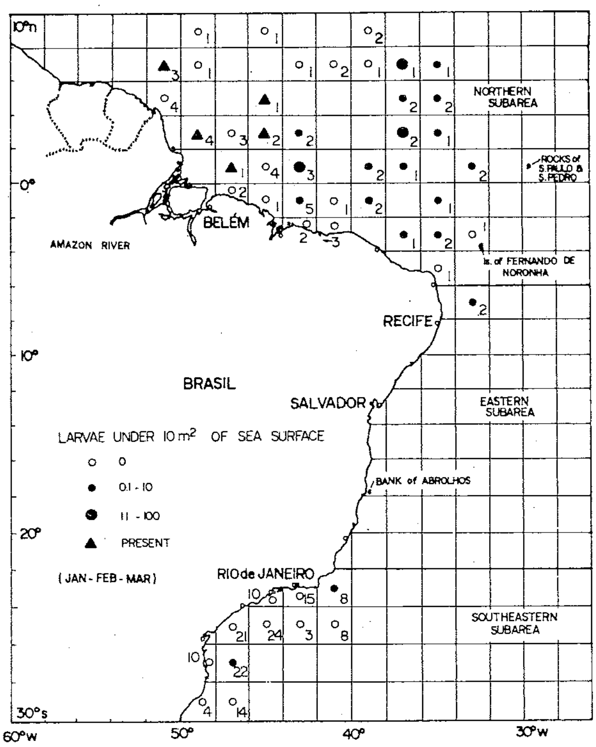

Figure 1. Distribution and number of stations in 2° squares, indicating the abundance (circles small open, closed small or large) of skipjack larvae collected under 10 m^2 of sea surface during the first quarter of the year (Jan.–March). Triangles indicate capture of skipjack larvae at stations where flow meter malfunctioned, or where only surface hauls were made.

not comparable with those from oblique tows, they have been reported as indicating presence or absence of larvae with no attempt to indicate density.

In this paper the southwest Atlantic was divided into three subareas (Figs. 1–4) on the basis of oceanic currents (Defant 1961): a northern equatorial subarea represented by the Guiana Current System (lat. 10°N–6°S); an eastern subarea represented by the Brazil Current System (lat. 6°S–22°S); and a southeastern subarea of shelf water and adjacent ocean (lat. 22°S–30°S). The last subarea was separated from the Brazil Current System, because the ichthyofauna encountered there was different from that in the eastern subarea.

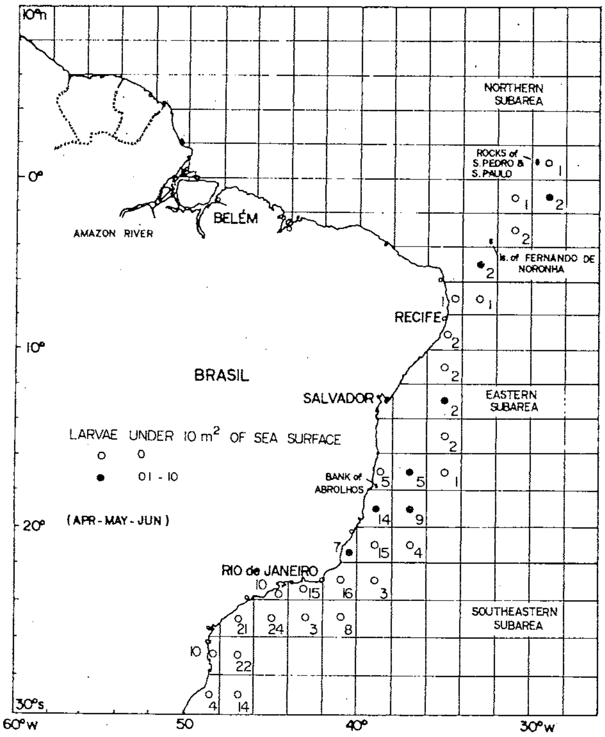

Figure 2. Distribution and number of stations in 2° squares, indicating the abundance (circles open or closed) of skipjack larvae collected under 10 m² of sea surface during the second quarter of the year (April–June).

3. Occurrence and Density of Skipjack Larvae by Area and Season

3.1 Northern Operational Subarea

During the first quarter of the year (Jan. to March) skipjack larvae were abundant (11–100 under 10 m² of sea surface) particularly in areas east of 40°W and north of the equator, although they were present almost everywhere (Fig. 1). Sampling in this area during the second quarter of the year was limited to eight stations in the region around São Pedro and São Paulo Rocks and the islands of Fernando de Noronha where larvae were low in abundance (0.1–10 under 10 m²) or absent (Fig. 2). In the third quarter

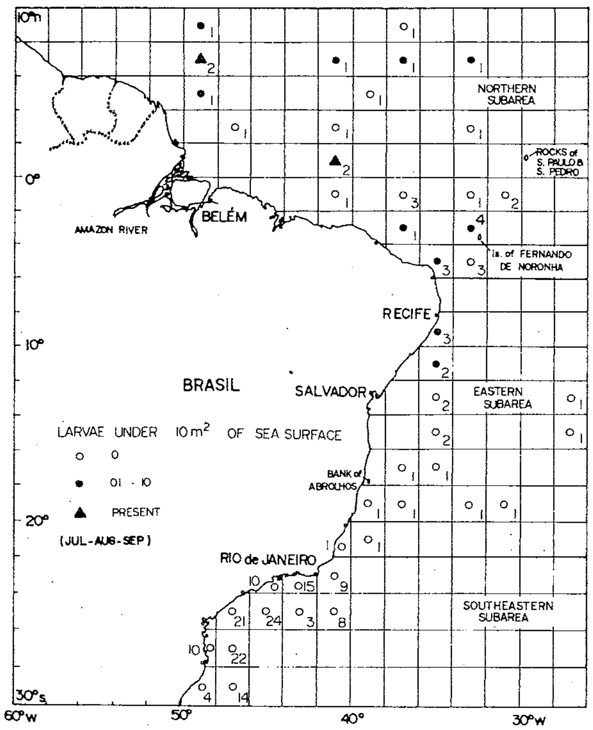

Figure 3. Distribution and number of stations in 2° squares, indicating the abundance (circles open or small) of skipjack larvae collected under 10 m² of sea surface during the third quarter of the year (July–Sept.). Triangles indicate capture of skipjack larvae at stations where flow meter malfunctioned, or where only surface hauls were made.

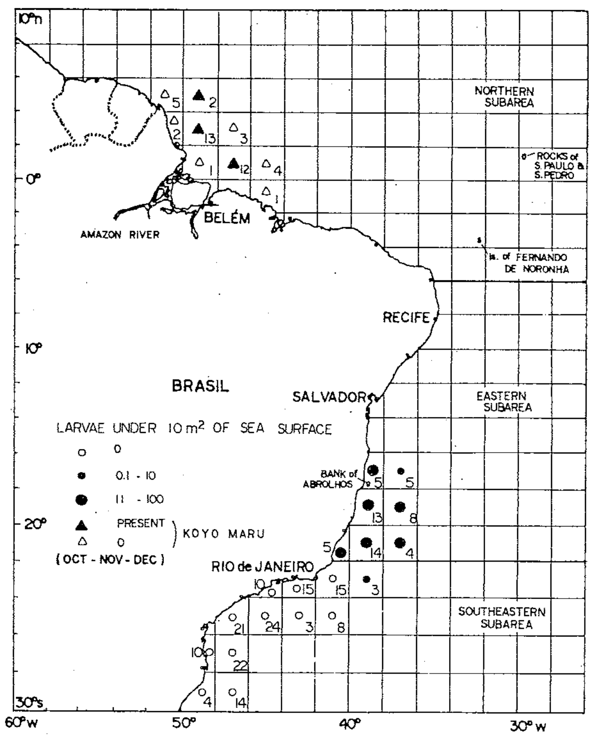

Figure 4. Distribution and number of stations in 2° squares, indicating the abundance (circles, small open, closed small or large) of skipjack larvae collected under 10 m² of sea surface during the fourth quarter of the year (Oct.–Dec.). The triangles indicate stations where no information was available on the volume of water strained.

(July–Sept.) sampling was scattered throughout the area and revealed sporadic occurrence of skipjack larvae (Fig. 3). In the fourth quarter sampling by the R/V *Koyo Maru* was limited to an area around the mouth of the Amazon River where abudance was low (Fig. 4): in a total of forty three stations, only five yielded a total of six skipjack larvae.

From these results I conclude that spawning populations of skipjack occur off the northern coast of Brazil, probably throughout most of the year, but the majority of spawning occurs during the first quarter from January to March.

3.2 Eastern Subarea

In the first quarter, only two stations were sampled, near the northern limit of this area, where larvae were present in low abundance (10 under 10 m^2 of sea surface) (Fig. 1). The results obtained by Nishikawa et al. (1978) and Rudomiotkina (1983) showed high density of skipjack larvae in this subarea. In the second quarter, seventy stations were sampled in a band less than 5° longitude wide extending from northern to southern extremes of the area, and larvae were found in low abundance in some areas, particularly over the shallow bank of Abrolhos (depth 50 m) (Fig. 2). In the third quarter sampling was fairly extensive, but larvae were found only in the northwest corner of the subarea, and there in low abundance (Fig. 3). In the fourth quarter, skipjack larvae occurred at high density (11–100 larvae under 10 m^2 of sea surface) over the bank of Abrolhos (Fig. 4). Results from Nishikawa et al. (1978) indicated larvae were present also to the north of this region.

From the results I conclude that spawning populations of skipjack occur at least through the early austral summer (Oct. to Dec.) over the Abrolhos banks. Spawning may continue through the latter part of the summer and fall (Jan. to March) since some larvae still occurred in the period from April to June, but more sampling is needed to confirm this.

3.3 Southeastern Subarea

There were few skipjack larvae found in the southeastern subarea in any season, despite a fairly extensive and constant series of samples (Figs. 1–4). Larvae occurred at one station in the fourth quarter and at two in the first quarter, these two quarters containing the austral summer months. I conclude that at these high latitudes, spawning only occurs in the summer, and then rarely.

4. Temperature and Salinity

As previously reported by several authors (Far Seas Fish. Res. Lab. 1974; Richards and Simmons 1971) skipjack larvae have never been found at stations with a surface temperature lower than 24°C (Fig. 5). The mean temperature recorded at stations where larvae were found was 26.77°C with 95% confidence limit from 26.54 to 27.00°C. The mean salinity was 36.41‰ with 95% confidence limit from 36.23 to 36.58 ‰. The water temperature ranged from 24.9 to 28.7°C and salinity from 35.4 to 37.4 ‰ (Fig. 5).

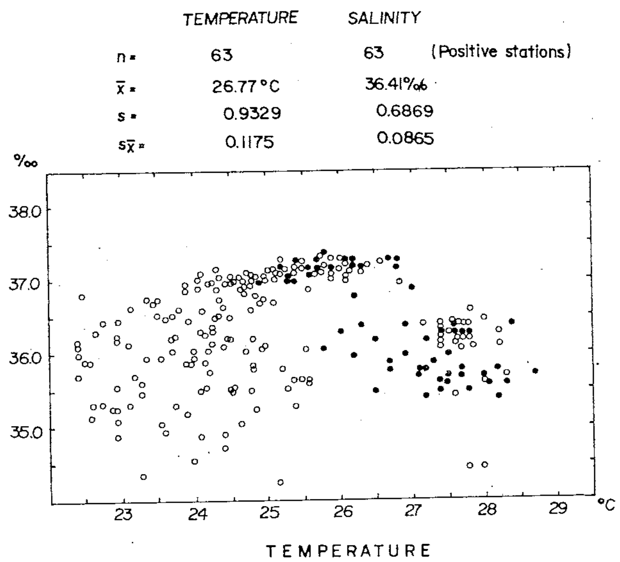

Figure 5. Temperature and salinity relations of skipjack larvae observed during ten survey cruises made in the western-central Atlantic ocean. Closed circles, skipjack larvae present (positive stations); open circles, no skipjack larvae found.

5. Discussion

As shown in this study and others, skipjack spawn at almost any season in equatorial waters and spawning becomes steadily more restricted to summer months (December to February in the southern hemisphere) the further south it occurs. Larvae have never been found at surface temperatures below 24°C, and the surface oceanic temperatures in the southeastern subarea usually are below this except during the austral summer season.

Based on a histological study of skipjack gonads, Cayré and Farrugio (this volume) concluded that skipjack are opportunistic spawners, since they can spawn wherever hydrological conditions are adequate. Despite their opportunistic spawning behaviour, skipjack survive in some remarkably unproductive oceanic environments during their larval stages. As pointed out by Sharp (1980b), "these conditions are probably not uniformly distributed in the tropical ocean as both location and season of tuna spawning are diverse, but they must occur frequently and in sufficient localities to provide for the observed continuous availabilities of these higher predators throughout the warm areas and contingent seas".

The population structure of skipjack has been well studied through the use of biochemical techniques in the Pacific Ocean (Fujino 1969; Fujino et al. 1981; Richardson 1978; Sharp 1978). Working with blood, Fujino and Kang (1968) were the first to demonstrate the existence of two genetically distinct subpopulations, one in western and another in central-eastern Pacific. Later, Richardson (1978) suggested the presence of a third subpopulation in the New Zealand waters. Recently, Sharp (1978) concluded that there are at least five genetically distinct subpopulations in the Pacific Ocean.

Based on the longline catch data of Japanese boats and considering the oceanic current, Matsumoto (1974, 1975) hypothesized that there are several semi-independent stocks of skipjack which are clearly associated with the oceanic gyre. Skipjack seem to move within oceanic current systems, and the seasonal feeding and spawning migrations are associated with particular oceanic gyres.

Despite these findings, attempts to associate proposed subpopulations with observed seasonal and regional spawning of skipjack have been unsuccessful. This is probably due to their opportunistic spawning behaviour, and to geographically overlapping distributions of different subpopulations. Furthermore, the low larval density of skipjack occurring in a vast tropical ocean create further difficulties for segregating spawning activities of each group.

From tagging data and genetic studies, Sharp (MS) demonstrated that most yellowfin tuna (95%) do not disperse beyond 660 nautical miles from a release point in the eastern Pacific, whereas a few nomadic individuals may range over a region with a diameter of about 1200 nautical miles. This suggests that despite their world-wide distribution, the distributional range of individual yellowfin tuna is relatively limited. A similar general restriction on the extent of habitat utilized by most individual skipjack might be supposed. The possible linkage of the entire life cycle of subpopulations to oceanic gyres (Matsumoto 1974) and the limitation of individual range may restrict or prevent inter-breeding between different subpopulations. However, at the present sampling level, it is difficult to separate the spawning activities of each subpopulation.

Since adult skipjack tolerate temperatures below 24°C, which is the lower limit for larvae, the use of larval surveys for identifying possible new fishing grounds is also restricted to areas above 24°C. Within this limitation, however, the data presented in this paper suggest that areas over the Abrolhos bank and off the north coast of Brazil have skipjack present at least during some seasons of the year. These are therefore potential areas for future fisheries and to confirm this supposition, one bait-boat has successfully caught more than twenty tonnes per day near the southern edge of the Abrolhos bank in August, 1983.

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