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# DISTRIBUTION OF LARVAE OF YELLOWFIN TUNA AND SKIPJACK IN THE ATLANTIC OCEAN (PRELIMINARY)

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The occurrence of larval tunas in the Atlantic Ocean has been discussed by Richards (1969), Richards and Simons (1971) and Ueyanagi (1971). Recently, Nishikawa et al. (1978) reported the distribution atlas of larval tunas and billfishes collected by Japanese research vessels during 1956–1975. It covers most of longline grounds in the Pacific, Indian and Atlantic Oceans. In their atlas, larval abundance is depicted by the number of larvae per tow on time-area strata of three months and 5-degree squares. Using more refined data with additional information from other Japanese training vessels, this manuscript provides the occurrence and the pattern of distribution of larval yellowfin tuna and skipjack and their temperature preference on a preliminary basis.

## Data base and procedures

This manuscript is based on data from Dr. S. Ueyanagi's larval identification work made on 1,656 plankton samples collected in the Atlantic Ocean during the past nine years between 1959 and 1971. For individual collections, date, position, start and end time of tow, kinds of nets used, single tow or double tows, surface or sub-surface tow and sea surface temperatures were coded with the number of tuna larvae and computer-processed to provide data base. For each tow, the amount of water strained was obtained as a product of the effective area of the mouth of net and distance towed, without regard to the filtering rate which can not be determined. The number of larvae collected per unit amount (1000 $m^3$) of water strained was used as the abundance index.

## Method of collection

Ueyanagi (1969) describes in detail the construction of larval nets and method of towing employed in field investigations. These are briefly as follows: Two kinds of the conical net were used. The larger net, 2.0 m in diameter and 6 m long, has mesh sizes of 1.7 mm in the anterior two-thirds of the length of net and 0.5 mm in the posterior one-third of it. The smaller net, 1.4 m in diameter and 4 m long, has the same meshes. The double horizontal tows using smaller net for the surface and larger net for the subsurface and the single horizontal tow by smaller net only were conducted at the average speed of 2 knots for, as a general rule, 15 minutes. A depth of 20–30 m for the subsurface net was empirically determined. The depth was kept by adjusting the length of warp from the stern of a vessel. When drawing up, the vessel stopped and the net sometimes lowered to roughly 70 to 80 m, depending on the length of warp or other conditions. The underwater behavior of the net was recorded by the depth-distance recorder.

## Diurnal occurrence of larvae

As our plankton tows sample fish larvae at the surface and a roughly fixed subsurface layer, the time the collections were made is especially important to study occurrence of tuna larvae. Tables 1 – 2 show the occurrence of larvae of the yellowfin tuna, Thunnus albacares, and skipjack, Katsuwonus pelamis, for successful tows, arranged by the time of collection and by the surface and subsurface tows.

A total of 238 yellowfin tuna larvae were collected in the Atlantic Ocean during the past research cruises; 166 larvae from the surface and 122 larvae from the subsurface collections. However, the surface collections with the average catch rate (catch per 1000 $m^3$ of water strained) of 2.222 tend to catch by far more larvae than the subsurface collections with the average catch rate of 0.276. The successful tows for the yellowfin tuna larvae nearly cover the day and night. From the surface, 112 larvae were caught during the day with the average catch rate of 2.944 and 54 larvae at night with the average catch rate of 1.472. Thus, the surface collections tend to catch more larvae during the day than at night, as evidenced by Richards and Simons (1971) for the eastern Atlantic Ocean. In addition, fewer number of successful tows, it seems, tends to be achieved at night. From the subsurface, 20 larvae were collected during the day with the average catch rate of 0.193 and 102 larvae at night with the average catch rate of 0.302. The subsurface collections appear to catch more larvae at night. The above results suggested in this preliminary analysis, however, are not fully supported by previous evidences on the yellowfin tuna larvae, especially for the Pacific Ocean (Ueyanagi 1969, Nishikawa et al. 1978).

A total of 931 skipjack larvae were collected in the Atlantic Ocean, of which 198 larvae were from the surface and 736 larvae from the subsurface collections. The average catch rate (catch per 1000 $m^3$ of water strained) is, inversely, 1.776 for the surface and 0.687 for the subsurface. From this, however, more surface catch than subsurface catch could not be concluded, since only two successful tows are achieved at the surface during the day. Previous evidences indicated very few catch of skipjack larvae at the surface during the day due to their vertical migration to the surface at night (Wade 1951, Strasburg 1960, Ueyanagi 1969, Richards and Simons 1971, Nishikawa et al. 1978). The surface collections caught only three larvae during the day and 195 larvae at night. The comparison of these numbers seems to be more meaningful on this occasion than the comparison of the average catch rate. The subsurface collections caught 122 larvae during the day with the average catch rate of 0.426 and 614 larvae at night with the value of 0.783. Lower average catch rate during the day may suggest the vertical migration of the skipjack larvae, supported by the general evidence that they are scarce at the surface during the day. For the Pacific Ocean, this difference in the occurrence between the day and night at the subsurface is supported by Ueyanagi (1969) and Nishikawa et al. (1978).

## Tendency in temperature preference

Data on all collections available were grouped into the surface and subsurface tows and arranged by sea surface temperatures at 0.5 °C intervals with respect to the larvae of yellowfin tuna and skipajck. Our plankton collections were made on cruises for experimental longlining in the Atlantic Ocean. The plankton stations were wide-spread and covered roughly the expanded Japanese longline grounds between 50°N and 50°S. As shown in Tables 3 - 4, sea surface temperatures at these stations ranged from 12.6°C to 29.0°C in the North Atlantic and from 10.1°C to 28.5°C in the South Atlantic. Temperatures where the subsurface collections were made are not available. As the depth towed generally ranged from 20m to 30m, the "Subsurface" temperatures may be close to surface temperatures, except for areas where the upwelling or the thin mixed surface layer is developed.

In the North Atlantic, the yellowfin tuna larvae were collected in waters warmer than 25.1°C. The majority was caught at a temperature above 26.1°C. This agrees well with the previous results (Ueyanagi 1969, Richards 1969, Richards and Simons 1971). The lower limit of temperature set for the presence of the yellowfin tuna larvae is, according to Richards and Simons (1971), is 24°C in the Atlantic Ocean. In our data, one yellowfin tuna larva was caught at a temperature of 22.1-22.5°C in the South Atlantic. At this moment, whether this was true or mis-recorded in the field data can not be determined.

For the skipjack larvae, data used in Table 4 are all based on data from the night collections. The temperature range in which the skipjack larvae were collected was from 24,1°C to 28.5°C in the North Atlantic and from 22.6°C to 28.0°C in the South Atlantic. In the Pacific Ocean, they were collected in waters warmer than 24°C (Ueyanagi 1969). Their wider tolerance to lower temperatures would suggest their wider range in distribution, both horizontal and vertical. However, the majority of the skipjack larvae, like those of yellowfin tuna, were collected in waters warmer than 26°C.

## Pattern of distribution

Most of plankton collections were made from October to March. From April to September, their coverage is limited mainly in the North Atlantic. The amount of water strained, the number of larvae collected and the catch rate (larvae per 1000 $m^3$ of water strained) were given according to time-area strata of the quarter of the year and 5-degree areas. Figs. 1 - 3 present the distribution of these values on the annual basis.

Although the plankton stations were wide-spread, intensive sampling was conducted in the western part of the Atlantic roughly between 15°N and 30°S (Fig. 1). The yellowfin tuna larvae were collected from this latitudinal range (Fig. 2). The catch rate in each 5-degree area is a crude value, not standardized, and simply obtained from the amount of water strained and the number of larvae collected in that area, indifferent to the surface and subsurface or the day and night (Fig. 3).

On the annual basis (Fig. 3), the highest catch rate is marked in an area off Brazil. Other 5-degree areas indicating relatively high larval abundance are in the Caribbean Sea, the Gulf of Guinea and its adjacent seas west- to north-westward. The limited range of occurrence of yellowfin tuna larvae in the eastern Atlantic is in contrast with their extensive coverage in the western Atlantic, as already indicated by Ueyanagi (1971). In the Gulf of Guinea waters, no yellowfin tuna larvae were collected south of 5°S but they are known to occur also from 5°S to 10°S (Richards 1969).

To describe the distribution of the skipjack larvae, data from the night collections were used in this preliminary analysis. This is because of very small number of successful tows during the day, especially at the surface. The amount of water strained, the number of larvae caught and the catch rate by 5-degree areas are given in Tables 5 - 7. Intensive night sampling was carried out in the western Atlantic roughly from 20°N to 30°S (Fig. 5). The skipjack larvae occurred from 25°N to 25°S (Fig. 6). The overall range of larval occurrence, as already reported (Ueyanagi 1971), resembles that of yellowfin tuna larvae. However, a number of 5-degree areas indicating high larval abundance are from the Caribbean Sea to off Brazil along the north-eastern coast of the South American Continent (Fig. 7). The distribution of the catch rate on the quartery basis is given in Fig. 8. The peak spawning season from January to March is here apparently indicated, although the period from April to September lacks adequate information. The pattern of distribution as presented in Fig. 8 would suggest that the western Atlantic is more productive in the skipjack larvae than the eastern Atlantic with the Gulf of Guinea area as a center of spawning. In the Gulf of Guinea, the occurrence of the skipjack larvae to the vicinity of 10°S is also evidenced (Richards 1969).

The catch rate, larvae per 1000 $m^3$ of water strained, used in this manuscript bears many problems in the treatment of data in terms of the surface and subsurface or the day and night, and should be improved to describe the apparent relative abundance of the larvae more adequately.

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Table 1 Diurnal occurrence of yellowfin tuna larvae by surface and subsurface tows.

| Time of tows | Number of successful tows | Amount of water strained (x 1000 m³) | Number of larvae | Catch per 1000 m³ of water strained |
|---|---|---|---|---|
| SURFACE TOWS | | | | |
| 6 - 8 | - | - | | - |
| 8 - 10 | 7 | 12.09 | 13 | 1.075 |
| 10 - 12 | 11 | 10.98 | 28 | 2.550 |
| 12 - 14 | 11 | 10.98 | 56 | 5.100 |
| 14 - 16 | - | - | - | - |
| 16 - 18 | 3 | 3.99 | 15 | 3.759 |
| (Subtotal day) | (32) | (38.04) | (112) | (2.944) |
| 18 - 20 | 12 | 15.14 | 26 | 1.717 |
| 20 - 22 | 4 | 12.90 | 14 | 1.085 |
| 22 - 0 | - | - | - | - |
| 0 - 2 | 5 | 4.65 | 10 | 2.151 |
| 2 - 4 | - | - | - | - |
| 4 - 6 | 3 | 3.99 | 4 | 1.003 |
| (Subtotal night) | (24) | (36.68) | (54) | (1.472) |
| Total | 54 | 74.72 | 166 | 2.222 |
| SUBSURFACE TOWS | | | | |
| 6 - 8 | 1 | 3.88 | 1 | 0.258 |
| 8 - 10 | 11 | 76.03 | 14 | 0.184 |
| 10 - 12 | - | - | - | - |
| 12 - 14 | - | - | - | - |
| 14 - 16 | - | - | - | - |
| 16 - 18 | 3 | 23.85 | 5 | 0.210 |
| (Subtotal day) | (15) | (103.76) | (20) | (0.193) |
| 18 - 20 | 14 | 54.30 | 52 | 0.958 |
| 20 - 22 | 19 | 248.63 | 40 | 0.161 |
| 22 - 0 | 1 | 3.88 | 4 | 1.031 |
| 0 - 2 | 3 | 23.47 | 4 | 0.170 |
| 2 - 4 | - | - | - | - |
| 4 - 6 | 2 | 7.76 | 2 | 0.258 |
| (Subtotal night) | (39) | (338.04) | (102) | (0.302) |
| Total | 54 | 441.80 | 122 | 0.276 |

Table 2 Diurnal occurrence of skipjack larvae by surface and subsurface tows.

| Time of tows | Number of successful tows | Amount of water strained (x 1000 m³) | Number of larvae | Catch per 1000 m³ of water strained |
|---|---|---|---|---|
| SURFACE TOWS | | | | |
| 6 - 8 | - | - | - | - |
| 8 - 10 | 2 | 2.66 | 3 | 1.128 |
| 10 - 12 | - | - | - | - |
| 12 - 14 | - | - | - | - |
| 14 - 16 | - | - | - | - |
| 16 - 18 | - | - | - | - |
| (Subtotal day) | (2) | (2.66) | (3) | (1.128) |
| 18 - 20 | 18 | 23.07 | 75 | 3.251 |
| 20 - 22 | 26 | 57.89 | 79 | 1.365 |
| 22 - 0 | 2 | 2.06 | 2 | 0.971 |
| 0 - 2 | 10 | 16.83 | 25 | 1.485 |
| 2 - 4 | 1 | 1.00 | 1 | 1.000 |
| 4 - 6 | 6 | 7.98 | 13 | 1.629 |
| (Subtotal night) | (63) | (108.83) | (195) | (1.792) |
| Total | 65 | 111.49 | 198 | 1.776 |
| SUBSURFACE | | | | |
| 6 - 8 | 7 | 42.05 | 28 | 0.665 |
| 8 - 10 | 26 | 166.59 | 69 | 0.414 |
| 10 - 12 | - | - | - | - |
| 12 - 14 | 2 | 7.76 | 2 | 0.258 |
| 14 - 16 | - | - | - | - |
| 16 - 18 | 9 | 70.02 | 23 | 0.328 |
| (Subtotal day) | (44) | (286.45) | (122) | (0.426) |
| 18 - 20 | 21 | 81.46 | 191 | 2.345 |
| 20 - 22 | 48 | 590.54 | 296 | 0.501 |
| 22 - 0 | 1 | 3.88 | 5 | 1.289 |
| 0 - 2 | 8 | 64.58 | 56 | 0.867 |
| 2 - 4 | - | - | - | - |
| 4 - 6 | 11 | 43.25 | 43 | 0.994 |
| (Subtotal night) | (69) | (783.11) | (614) | (0.723) |
| Total | 133 | 1,070.56 | 736 | 0.687 |

Table 3 Occurrence of yellowfin tuna larvae by surface water temperatures in the North and South Atlantic Oceans.

| Surface temperature (C°) | North Atlantic | | | | | | | | South Atlantic | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Surface | | | | Sub-surface | | | | Surface | | | | Sub-surface | | | |
| | N | W | C | R | N | W | C | R | N | W | C | R | N | W | C | R |
| 10.1-10.5 | - | - | - | - | - | - | - | - | 3 | 10.49 | 0 | 0 | 1 | 14.74 | 0 | 0 |
| 10.6-11.0 | - | - | - | - | - | - | - | - | 1 | 4.52 | 0 | 0 | 1 | 13.19 | 0 | 0 |
| 11.1-11.5 | - | - | - | - | - | - | - | - | 4 | 8.76 | 0 | 0 | 2 | 9.70 | 0 | 0 |
| 11.6-12.0 | - | - | - | - | - | - | - | - | 1 | 1.33 | 0 | 0 | - | - | - | - |
| 12.1-12.5 | - | - | - | - | - | - | - | - | 4 | 17.88 | 0 | 0 | 3 | 44.22 | 0 | 0 |
| 12.6-13.0 | 1 | 1.00 | 0 | 0 | - | - | - | - | 3 | 10.62 | 0 | 0 | 1 | 15.13 | 0 | 0 |
| 13.1-13.5 | - | - | - | - | - | - | - | - | 2 | 5.32 | 0 | 0 | 2 | 15.52 | 0 | 0 |
| 13.6-14.0 | - | - | - | - | - | - | - | - | 4 | 13.33 | 0 | 0 | 1 | 15.13 | 0 | 0 |
| 14.1-14.5 | - | - | - | - | - | - | - | - | 3 | 6.76 | 0 | 0 | - | - | - | - |
| 14.6-15.0 | 3 | 3.99 | 0 | 0 | 3 | 9.70 | 0 | 0 | 3 | 10.49 | 0 | 0 | 1 | 14.74 | 0 | 0 |
| 15.1-15.5 | 6 | 11.04 | 0 | 0 | 5 | 29.09 | 0 | 0 | 3 | 7.01 | 0 | 0 | 1 | 6.59 | 0 | 0 |
| 15.6-16.0 | 1 | 1.33 | 0 | 0 | 1 | 3.88 | 0 | 0 | 2 | 4.05 | 0 | 0 | - | - | - | - |
| 16.1-16.5 | 3 | 3.99 | 0 | 0 | 2 | 7.76 | 0 | 0 | 3 | 7.65 | 0 | 0 | 2 | 18.42 | 0 | 0 |
| 16.6-17.0 | - | - | - | - | - | - | - | - | 3 | 7.65 | 0 | 0 | 2 | 19.39 | 0 | 0 |
| 17.1-17.5 | 1 | 1.33 | 0 | 0 | - | - | - | - | 5 | 16.76 | 0 | 0 | 5 | 48.87 | 0 | 0 |
| 17.6-18.0 | 2 | 2.66 | 0 | 0 | 2 | 7.76 | 0 | 0 | 2 | 9.05 | 0 | 0 | 2 | 26.38 | 0 | 0 |
| 18.1-18.5 | 1 | 1.33 | 0 | 0 | - | - | - | - | 10 | 37.97 | 0 | 0 | 8 | 98.91 | 0 | 0 |
| 18.6-19.0 | 1 | 1.33 | 0 | 0 | 1 | 3.88 | 0 | 0 | 6 | 11.48 | 0 | 0 | 1 | 3.88 | 0 | 0 |
| 19.1-19.5 | - | - | - | - | - | - | - | - | 5 | 10.48 | 0 | 0 | - | - | - | - |
| 19.6-20.0 | 3 | 3.99 | 0 | 0 | 1 | 3.88 | 0 | 0 | 7 | 16.05 | 0 | 0 | 2 | 16.29 | 0 | 0 |
| 20.1-20.5 | 2 | 2.66 | 0 | 0 | 1 | 4.27 | 0 | 0 | 2 | 3.72 | 0 | 0 | - | - | - | - |
| 20.6-21.0 | 2 | 2.33 | 0 | 0 | 1 | 7.56 | 0 | 0 | 5 | 11.17 | 0 | 0 | 2 | 17.84 | 0 | 0 |
| 21.1-21.5 | 5 | 5.66 | 0 | 0 | 2 | 7.76 | 0 | 0 | 7 | 17.03 | 0 | 0 | 6 | 45.77 | 0 | 0 |
| 21.6-22.0 | 4 | 4.33 | 0 | 0 | 1 | 3.88 | 0 | 0 | 6 | 20.93 | 0 | 0 | 4 | 54.30 | 0 | 0 |
| 22.1-22.5 | 1 | 1.00 | 0 | 0 | - | - | - | - | 15 | 42.06 | 0 | 0 | 9 | 95.19 | 1 | 0.010 |
| 22.6-23.0 | 4 | 4.33 | 0 | 0 | 2 | 7.76 | 0 | 0 | 12 | 28.15 | 0 | 0 | 6 | 58.57 | 0 | 0 |
| 23.1-23.5 | 13 | 54.61 | 0 | 0 | 10 | 150.50 | 0 | 0 | 4 | 10.76 | 0 | 0 | 3 | 23.47 | 0 | 0 |
| 23.6-24.0 | 12 | 38.85 | 0 | 0 | 9 | 104.53 | 0 | 0 | 15 | 28.24 | 0 | 0 | 9 | 64.78 | 0 | 0 |
| 24.1-24.5 | 14 | 39.51 | 0 | 0 | 9 | 100.66 | 0 | 0 | 10 | 25.64 | 0 | 0 | 8 | 67.83 | 0 | 0 |
| 24.6-25.0 | 14 | 27.60 | 0 | 0 | 10 | 68.85 | 0 | 0 | 23 | 50.68 | 0 | 0 | 9 | 102.01 | 0 | 0 |
| 25.1-25.5 | 22 | 52.92 | 1 | 0.019 | 11 | 103.76 | 4 | 0.039 | 16 | 32.63 | 0 | 0 | 13 | 85.33 | 2 | 0.023 |
| 25.5-26.0 | 21 | 46.25 | 0 | 0 | 13 | 105.50 | 1 | 0.009 | 19 | 41.43 | 1 | 0.024 | 13 | 98.33 | 2 | 0.020 |
| 26.1-26.5 | 63 | 132.16 | 14 | 0.106 | 48 | 420.03 | 39 | 0.093 | 27 | 75.90 | 0 | 0 | 23 | 470.50 | 4 | 0.009 |
| 26.6-27.0 | 71 | 147.35 | 6 | 0.041 | 57 | 488.72 | 19 | 0.037 | 26 | 44.03 | 5 | 0.114 | 20 | 111.30 | 0 | 0 |
| 27.1-27.5 | 64 | 115.26 | 19 | 0.165 | 40 | 408.24 | 20 | 0.049 | 24 | 28.07 | 0 | 0 | 18 | 63.81 | 0 | 0 |
| 27.6-28.0 | 74 | 90.96 | 20 | 0.220 | 28 | 129.36 | 19 | 0.147 | 46 | 60.49 | 5 | 0.083 | 23 | 89.21 | 3 | 0.034 |
| 28.1-28.5 | 58 | 62.64 | 26 | 0.415 | 9 | 34.91 | 9 | 0.258 | 4 | 4.66 | 0 | 0 | 2 | 7.76 | 0 | 0 |
| 28.6-29.0 | 19 | 19.32 | 39 | 2.019 | - | - | - | - | - | - | - | - | - | - | - | - |
| 29.1-29.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 29.6-30.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

N: Number of larval net tows  C: Number of larvae caught

W: Amount of water strained (x1000 m³)  R: C/W

Table 4 Occurrence of skipajck larvae by surface water temperatures in the North and South Atlantic Oceans.

| Surface temperature (C°) | North Atlantic | | | | | | | | South Atlantic | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Surface | | | | Sub-surface | | | | Surface | | | | Sub-surface | | | |
| | N | W | C | R | N | W | C | R | N | W | C | R | N | W | C | R |
| 10.1-10.5 | - | - | - | - | - | - | - | - | 1 | 2.72 | 0 | 0 | - | - | - | - |
| 10.6-11.0 | - | - | - | - | - | - | - | - | 1 | 4.52 | 0 | 0 | 1 | 13.19 | 0 | 0 |
| 11.1-11.5 | - | - | - | - | - | - | - | - | 2 | 3.33 | 0 | 0 | 2 | 9.70 | 0 | 0 |
| 11.6-12.0 | - | - | - | - | - | - | - | - | 1 | 1.33 | 0 | 0 | - | - | - | - |
| 12.1-12.5 | - | - | - | - | - | - | - | - | 1 | 2.72 | 0 | 0 | - | - | - | - |
| 12.6-13.0 | 1 | 1.00 | 0 | 0 | - | - | - | - | 1 | 2.72 | 0 | 0 | - | - | - | - |
| 13.1-13.5 | - | - | - | - | - | - | - | - | 2 | 5.32 | 0 | 0 | 2 | 15.52 | 0 | 0 |
| 13.6-14.0 | - | - | - | - | - | - | - | - | 2 | 7.90 | 0 | 0 | 1 | 15.13 | 0 | 0 |
| 14.1-14.5 | - | - | - | - | - | - | - | - | 2 | 4.05 | 0 | 0 | - | - | - | - |
| 14.6-15.0 | 1 | 1.33 | 0 | 0 | 1 | 3.88 | 0 | 0 | 7 | 5.43 | 0 | 0 | - | - | - | - |
| 15.1-15.5 | 4 | 8.38 | 0 | 0 | 4 | 25.21 | 0 | 0 | 3 | 7.01 | 0 | 0 | 1 | 6.59 | 0 | 0 |
| 15.6-16.0 | - | - | - | - | - | - | - | - | 1 | 1.33 | 0 | 0 | - | - | - | - |
| 16.1-16.5 | 2 | 2.66 | 0 | 0 | 1 | 3.88 | 0 | 0 | 2 | 2.66 | 0 | 0 | 1 | 3.88 | 0 | 0 |
| 16.6-17.0 | - | - | - | - | - | - | - | - | 2 | 6.32 | 0 | 0 | 1 | 15.52 | 0 | 0 |
| 17.1-17.5 | 1 | 1.33 | 0 | 0 | - | - | - | - | 3 | 10.44 | 0 | 0 | 1 | 30.45 | 0 | 0 |
| 17.6-18.0 | 1 | 1.33 | 0 | 0 | 1 | 3.88 | 0 | 0 | 1 | 2.00 | 0 | 0 | 1 | 5.82 | 0 | 0 |
| 18.1-18.5 | 1 | 1.33 | 0 | 0 | - | - | - | - | 5 | 19.08 | 0 | 0 | 3 | 43.83 | 0 | 0 |
| 18.6-19.0 | 1 | 1.33 | 0 | 0 | 1 | 3.88 | 0 | 0 | 5 | 8.76 | 0 | 0 | 1 | 3.88 | 0 | 0 |
| 19.1-19.5 | - | - | - | - | - | - | - | - | 3 | 5.05 | 0 | 0 | - | - | - | - |
| 19.6-20.0 | 2 | 2.66 | 0 | 0 | - | - | - | - | 6 | 14.73 | 0 | 0 | 1 | 12.41 | 0 | 0 |
| 20.1-20.5 | 2 | 2.66 | 0 | 0 | 1 | 4.27 | 0 | 0 | 2 | 3.72 | 0 | 0 | - | - | - | - |
| 20.6-21.0 | 1 | 1.00 | 0 | 0 | - | - | - | - | 3 | 3.66 | 0 | 0 | 1 | 3.88 | 0 | 0 |
| 21.1-21.5 | 4 | 4.33 | 0 | 0 | 1 | 3.88 | 0 | 0 | 5 | 13.04 | 0 | 0 | 4 | 34.13 | 0 | 0 |
| 21.6-22.0 | 3 | 3.33 | 0 | 0 | 1 | 3.88 | 0 | 0 | 3 | 8.34 | 0 | 0 | 1 | 17.45 | 0 | 0 |
| 22.1-22.5 | 1 | 1.00 | 0 | 0 | - | - | - | - | 9 | 21.04 | 0 | 0 | 4 | 38.79 | 0 | 0 |
| 22.6-23.0 | 2 | 1.67 | 0 | 0 | - | - | - | - | 8 | 15.53 | 1 | 0.063 | 2 | 23.08 | 0 | 0 |
| 23.1-23.5 | 8 | 42.51 | 0 | 0 | 7 | 121.02 | 0 | 0 | 3 | 9.43 | 0 | 0 | 2 | 19.59 | 0 | 0 |
| 23.6-24.0 | 6 | 13.84 | 0 | 0 | 3 | 31.61 | 0 | 0 | 7 | 10.34 | 0 | 0 | 1 | 14.35 | 0 | 0 |
| 24.1-24.5 | 11 | 28.20 | 0 | 0 | 5 | 67.69 | 1 | 0.015 | 7 | 13.19 | 2 | 0.104 | 5 | 49.07 | 0 | 0 |
| 24.6-25.0 | 8 | 12.93 | 0 | 0 | 4 | 25.93 | 0 | 0 | 18 | 17.33 | 0 | 0 | 5 | 56.44 | 1 | 0.018 |
| 25.1-25.5 | 15 | 27.65 | 2 | 0.072 | 6 | 50.42 | 12 | 0.238 | 11 | 17.66 | 0 | 0 | 8 | 41.70 | 1 | 0.024 |
| 25.6-26.0 | 14 | 30.55 | 0 | 0 | 7 | 63.61 | 2 | 0.031 | 15 | 21.95 | 0 | 0 | 10 | 49.45 | 7 | 0.142 |
| 26.1-26.5 | 38 | 71.57 | 65 | 0.908 | 30 | 154.38 | 193 | 1.233 | 17 | 44.70 | 0 | 0 | 13 | 365.58 | 19 | 0.052 |
| 26.6-27.0 | 44 | 87.29 | 47 | 0.538 | 35 | 334.93 | 187 | 0.558 | 19 | 30.99 | 0 | 0 | 13 | 73.89 | 13 | 0.176 |
| 27.1-27.5 | 35 | 63.65 | 20 | 0.291 | 21 | 310.89 | 47 | 0.151 | 15 | 16.10 | 6 | 0.373 | 9 | 28.90 | 3 | 0.104 |
| 27.6-28.0 | 45 | 49.26 | 4 | 0.081 | 15 | 55.03 | 18 | 0.327 | 30 | 36.43 | 20 | 0.549 | 9 | 34.91 | 69 | 1.977 |
| 28.1-28.5 | 40 | 43.68 | 0 | 0 | 7 | 27.15 | 13 | 0.479 | 4 | 4.65 | 0 | 0 | 2 | 7.76 | 0 | 0 |
| 28.6-29.0 | 9 | 9.34 | 0 | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| 29.1-29.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 29.6-30.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

N: Number of larval net tows  C: Number of larvae caught

W: Amount of water strained (x1000 m³)  R: C/W

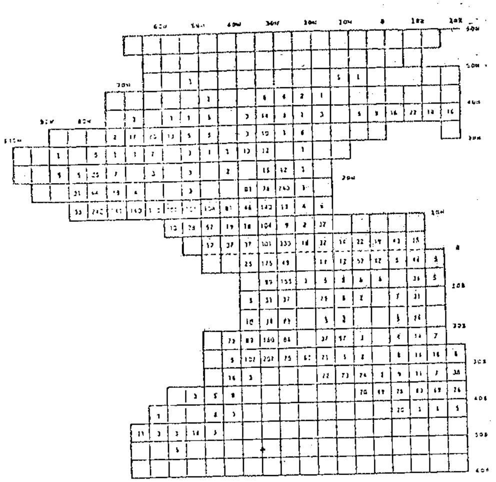

Fig. 1 Distribution of the amount of water strained by day time and night time larval net tows (Annual).

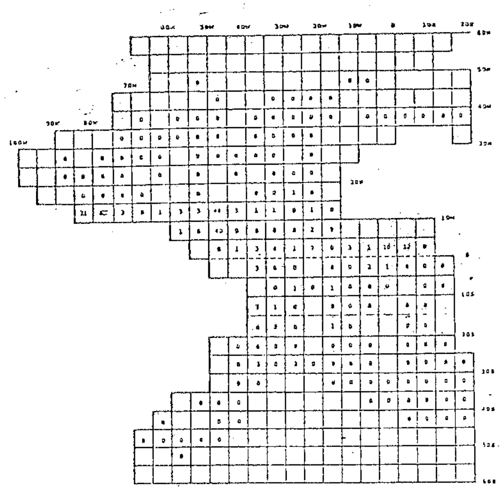

Fig. 2 Distribution of the number of yellowfin tuna larvae collected by larval net tows (Annual).

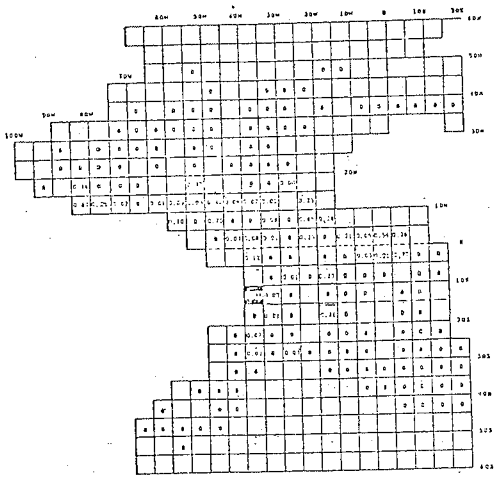

Fig. 3 Distribution of the number of yellowfin tuna larvae per 1000$^3$ of water strained (Annual).

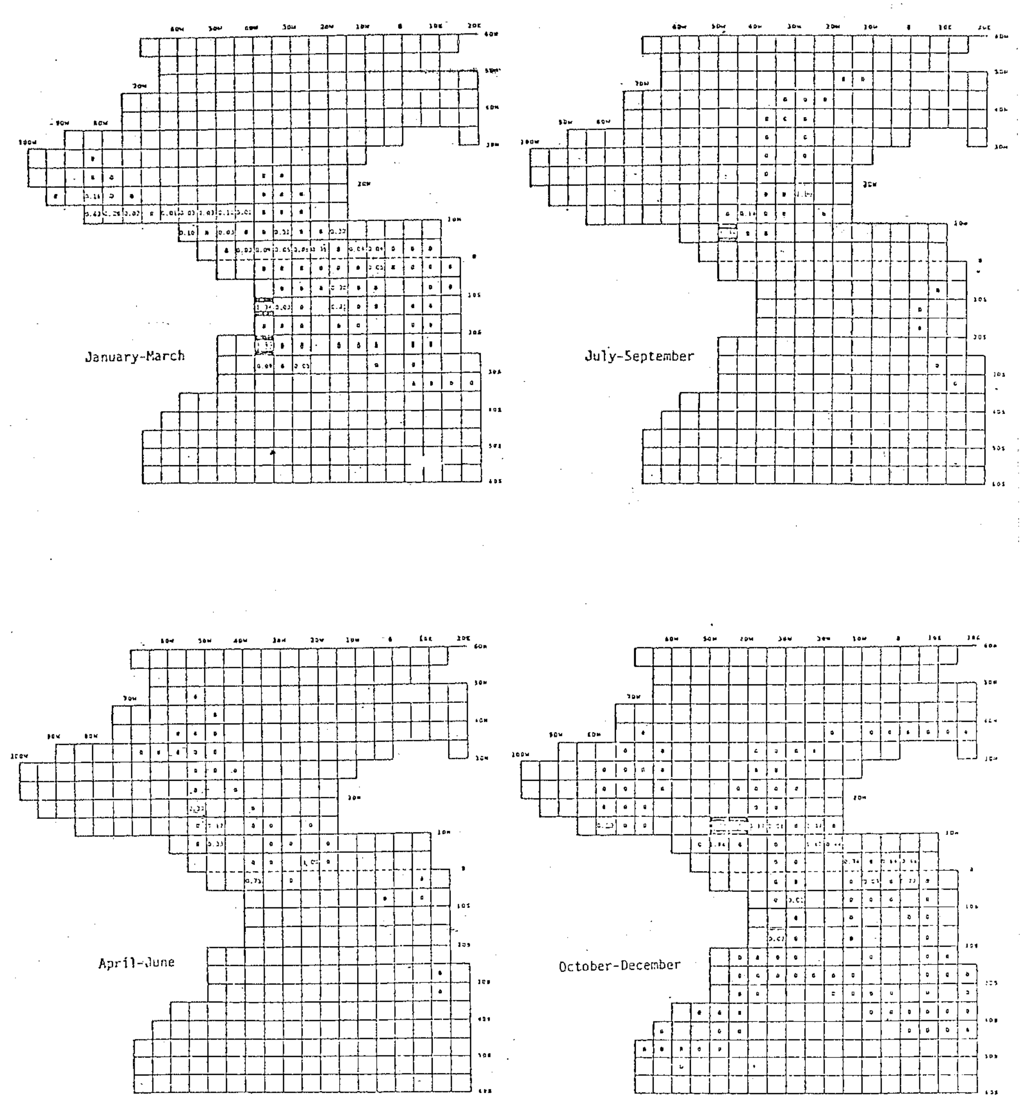


Fig. 4 Quartery distribution of the number of yellowfin tuna larvae per 1000$^3$ of water strained.

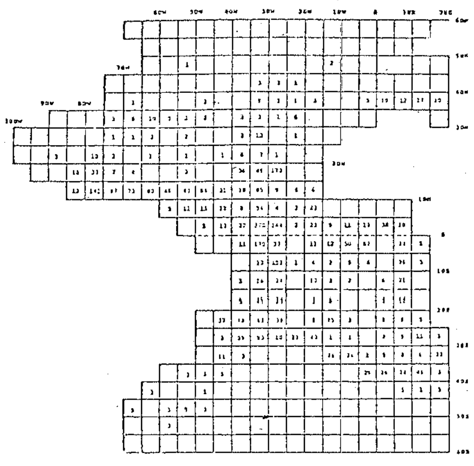

Fig. 5 Distribution of the amount of water strained by night time larval net tows (Annual).

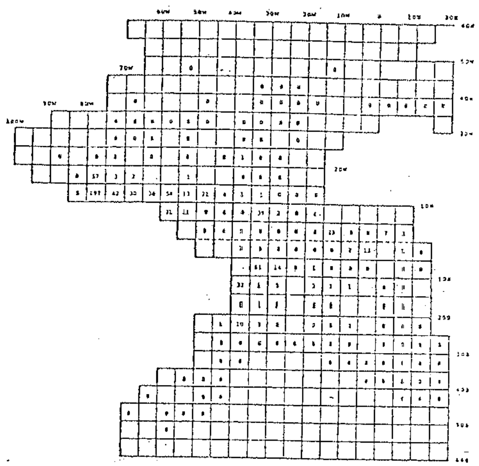

Fig. 6 Distribution of the number of skipjack larvae collected by larval net tows (Annual).

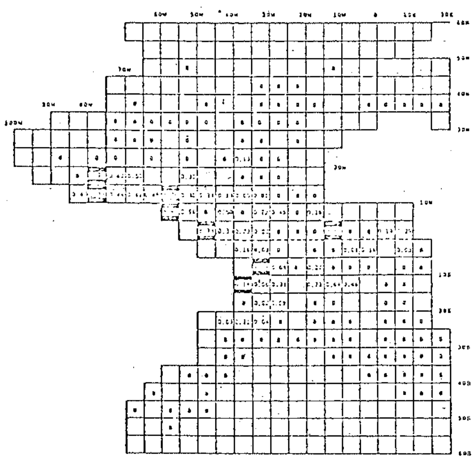

Fig. 7 Distribution of the number of skipjack larvae per 1000$^3$ of water strained (Annual)

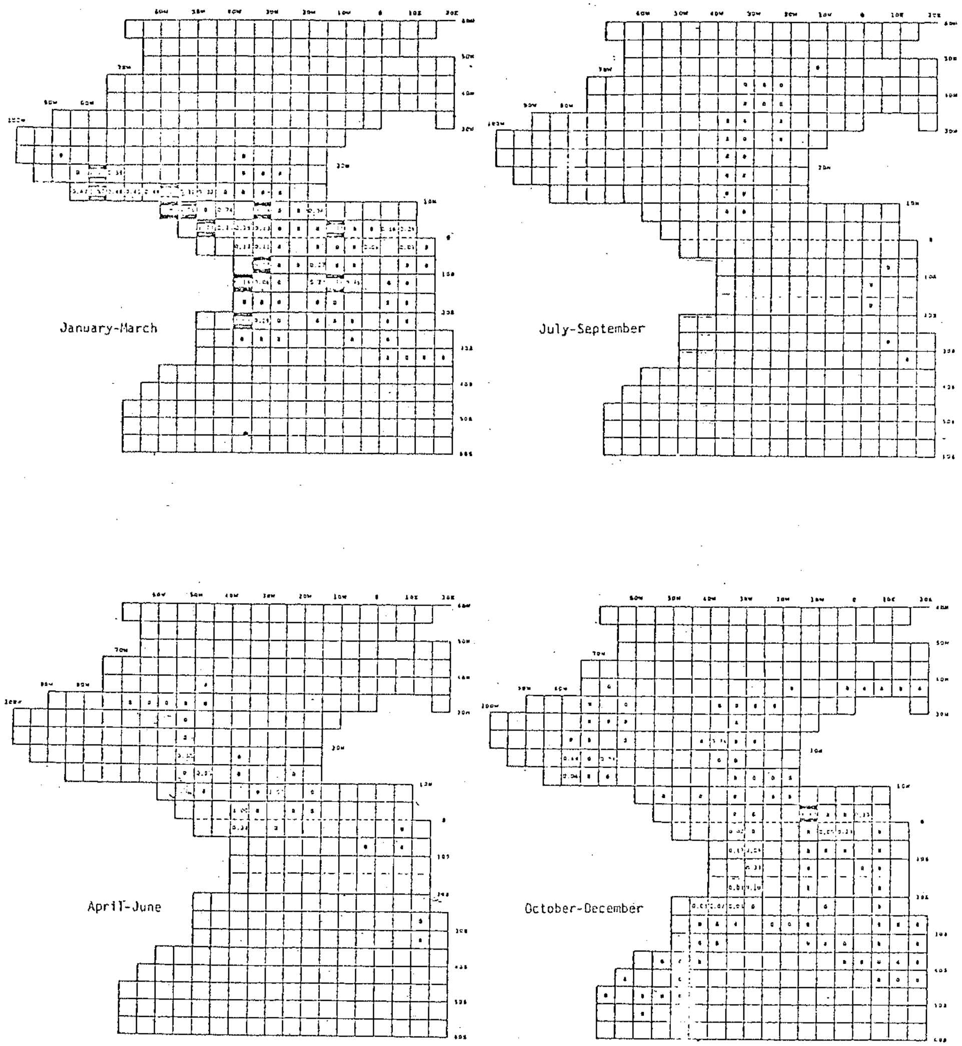


Fig. 8 Quartery distribution of the number of skipjack larvae per 1000$^3$ of water strained.