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SUMMARY OF SKIPJACK SURVEY AND ASSESSMENT PROGRAMME PRELIMINARY GROWTH DATA

(Paper Prepared by the Skipjack Programme)

1.0 INTRODUCTION

Analysis of growth is an essential component in any assessment of fishery resources for a variety of reasons. The most common usage is in connection with yield forecasting, where information on growth, recruitment, and mortality are combined to predict the return for a given level of fishing effort. Growth characteristics can also be used as an indicator of population structure. Significant differences in growth patterns consistently observed between fish from different temporal or spatial areas offer evidence that they are behaviourally, if not genetically, isolated. Growth information can also be used to determine the time the fish are vulnerable to each of the different gear types that may be competing for the resource. Each gear exploits a particular size range. From the average growth pattern the time spent in each size range can be estimated, and thereby the duration of vulnerability to the various gears. This is especially important when studying the impact of competing gear types on one another.

Over the past three years, the Skipjack Survey and Assessment Programme has received 5,750 tag recaptures from approximately 150,000 releases of skipjack and yellowfin tuna. These and future tag recoveries provide the information needed for a comprehensive analysis of growth. This information will aid in answering the immediate questions of population structure, production, and gear interactions, and will contribute to a greater understanding of the life-history and ecology of skipjack.

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2.0 THE GROWTH DATA

In analyzing growth from tagging data, four pieces of information for each recaptured fish are of primary importance: (1) the length at release; (2) the length at recapture; (3) the date of release; and (4) the date of recapture. The release length, the growth increment (the difference between length at release and length at recapture), and the time at large (the number of days elapsed between date of release and date of recapture) are the raw data from which growth patterns can be determined. Not all the tags returned to the Skipjack Programme are accompanied with recapture length and date information, so the amount of usable data is somewhat less than the total number of returns.

In addition to the above primary data, other information relevant to skipjack growth has also been assembled, including: (1) release and recapture location, since positions at time of release and recapture, as well as distance travelled, may play an important role in explaining variation in growth patterns; (2) lengths and weights from as many as twenty fish per school, caught during the tagging operations but not released, so that the length/weight relationship can be determined; and, (3) for each recaptured fish, the identity of the tagger and the category of the source of recapture (such as joint local venture or long-range Japanese pole-and-line vessels, etc.) to aid in an analysis of errors in length measurements.

In the following section, the methods of analysis are briefly outlined, and, as an example, preliminary results are presented for skipjack tagged in the waters of Solomon Islands.

3.0 ANALYTICAL PROCEDURES

Joseph and Calkins (1969) found that, on average, skipjack in the eastern Pacific grow about 30cm in their first year, 20cm in their second, and 10cm in their third, declining thereafter as a size of 88cm is approached, beyond which little growth occurs. In our analyses, the aims will be to accurately define growth over the whole of our survey area, to compare published growth patterns with those derived from Skipjack Survey and Assessment Programme data, and to consider the management implications.

To derive an accurate mathematical description of skipjack growth, we have followed the procedures outlined below.

3.1 Data Preparation

Normally, only a subset of all recaptures will be suitable for an analysis of growth in a particular region. Those tag returns which satisfy criteria of originating within the area of interest and of having the required primary data associated with them must be identified and isolated. The results of this procedure applied to data for Solomon Islands is presented in Table 1. From the total data set, 298 recaptures are of fish tagged in waters of Solomon Islands, of which 46 must be excluded for the reasons listed (e.g., not skipjack, missing data, unreliable data), leaving 252 usable data points. The computer program compiles various summary information; for instance, the numbers of tuna from each of the recapture sources and the numbers associated with each of the taggers. It also prepares a scattergram showing the distribution of the data with respect to length at release and time at large, an example of which is given in Figure 1. For Papua New Guinea we have 893 usable data points, 743 for New Zealand, and 1,452 for Fiji, though only 72 east of 160°W.

3.2 The Weight/Length Relationship

The weight/length relationship is a key element in the study of fish growth. The results of the analysis of growth pattern will be in terms of fish length. With the weight/length curve these results can be "translated" into fish weight. The weight/length curve for skipjack collected around Solomon Islands is shown in Figure 2. As expected, length and weight are highly correlated and the exponent in the weight/length relationship is about 3.0. These results are typical of other regions in the SPC area: the correlation coefficient is always greater than 95 percent and the weight/length exponent ranges from 3.0 to 3.2.

3.3 Error Analysis

From the information on tagger and recapture source, errors in measurement of length can be examined. The object here is to use data for skipjack at large for less than ten days to determine the bias and reliability of measurement for each tagger and recapture source. In ten days, we expect the growth increment will be near zero: any deviations from zero we can then interpret as measurement error. In addition, we also have a number of recaptures caught on board the SPC research vessel, whose length measurements are as accurate as possible and thus very useful in determining errors at release. These results will subsequently be used to correct the data used in the next analysis, that of quantifying the growth curve.

Preliminary results show that errors in growth increment are, on average, unbiased, but with a range of plus or minus 6cm. Some of the returned tags are accompanied with weight as well as length data. Those lengths verified by comparison with length predicted by the weight/length curve show a significantly smaller range in errors, and thus increased reliability, than those not verified.

3.4 Growth Model Analyses

Fisheries scientists have used a variety of mathematical expressions to describe the pattern of growth a fish follows throughout its lifetime. The most commonly used is the von Bertalanffy equation; others include the logistic, the monomolecular, and the Gompertz curves, all of which are special cases of the Richards function. Each of these equations, or growth models, describes a particular pattern, ranging from S-shaped to a straight line. Some of these growth models will provide a better mathematical description of skipjack than others, and this will be assessed during the coming months.

In virtually all previous studies on skipjack growth, the von Bertalanffy model has been used. This equation, which has a shape ressembling the top half of a C, is a mathematical way of saying that the size of the average fish increases rapidly from the time of its birth, afterwards slowing the rate at which it grows, until the fish eventually reaches a maximum size beyond which no growth occurs. The maximum size and rate of growth at birth are parameters in the equation. Our problem is to estimate the values of these parameters using the available data, and to assess the degree to which growth of individuals varies about the average growth pattern.

Some results are illustrated in Figure 3, where a von Bertalanffy curve fitted to data from Solomon Islands is compared to that of skipjack from the eastern Pacific fishery. The mean length at age for younger fish from Solomon Islands appears substantially higher than that for eastern Pacific skipjack, although the maximum size is lower, 60cm compared to 88cm. These results are, however, not corrected for errors in the data so that the curve shown in Figure 3 ought to be regarded as tentative and pending further study. If it is ultimately concluded that the growth rate is indeed much faster than previously thought (50cm in the first year of life, falling to 10cm in the second year with little growth afterwards, instead of 30cm in the first year), there are some very interesting and practical implications concerning interactions between different gear types that harvest skipjack.

The growth curve for Solomon Islands appears to be typical for the western Pacific. Growth curves for Papua New Guinea and Fiji are illustrated in Figures 4 and 5.

In summary, management questions of immediate relevance to the development of skipjack fishing in the SPC area and to relations between fisheries in the SPC area and distant-water fishing nations will continue to be the focus of future, more refined analyses of growth.

4.0 LITERATURE CITED

JOSEPH, J., and T.P. CALKINS (1969). Population dynamics of the skipjack tuna (*Katsuwonus pelamis*) of the eastern Pacific Ocean. Inter-American Tropical Tuna Commission, Bulletin 13(1):273 p.

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*  GREETINGS FROM GROW1, THE GROWTH DATA SNIFFER *
*                                                *
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SEARCH CRITERIA FOR SOLOMON ISLANDS:
STARTING DATES:    771101.    800525.
STOPPING DATES:    771204.    800628.

SPECIES IS SJ


SUMMARY INFORMATION:

RECAPTURES SATISFYING CRITERIA =  298

DATA EXCLUSION TOTALS, IN DESCENDING PRIORITY:
                 WRONG SPECIES       5
MISSING RELEASE DATE OR LENGTH       4
MISSING CAPTURE DATE OR LENGTH      33
      ILLEGAL RECAPTURE SOURCE       4
        NEGATIVE DAYS-AT-LARGE       0

NUMBER OF DATA POINTS ACCEPTED =  252

MISSING RELEASE OR RECAPTURE LOCATIONS      4

TAGGER TOTALS:
   AWA    58
   JPH    66
   JNI    58
   JOM    18
   GAR     4
   RDG     2
   YAO    12
   ADL    34

  RECAPTURE SOURCE TOTALS:
       CODE "A"   12
       CODE "B"   67
       CODE "C"    0
       CODE "D"    0
       CODE "W"  173
       CODE "X"    0

DAYS-AT-LARGE TOTALS:
0-15  15-30  30-90    90+
  79     40     83     50

GROW1 ALL DONE. NUMBER OF RECORDS READ = 156560. NO FATAL ERRORS.
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TABLE 1 - Growth data preparation for skipjack tagged in the waters of Solomon Islands. The data is first isolated on the basis of dates that the SPC research vessel was operating within the region of interest, here November 1 to December 4, 1977 and May 25 to June 28, 1980. Recapture source code "A" refers to fish caught on board the SPC research vessel, "B" to joint Japanese and local pole-and-line vessels, "C" to long range Japanese pole-and-line, longliners, and other longliners and purse-seiners, "D" to other reliable sources, and "W" to weight verified recaptures. Tagger codes refer to individual taggers.

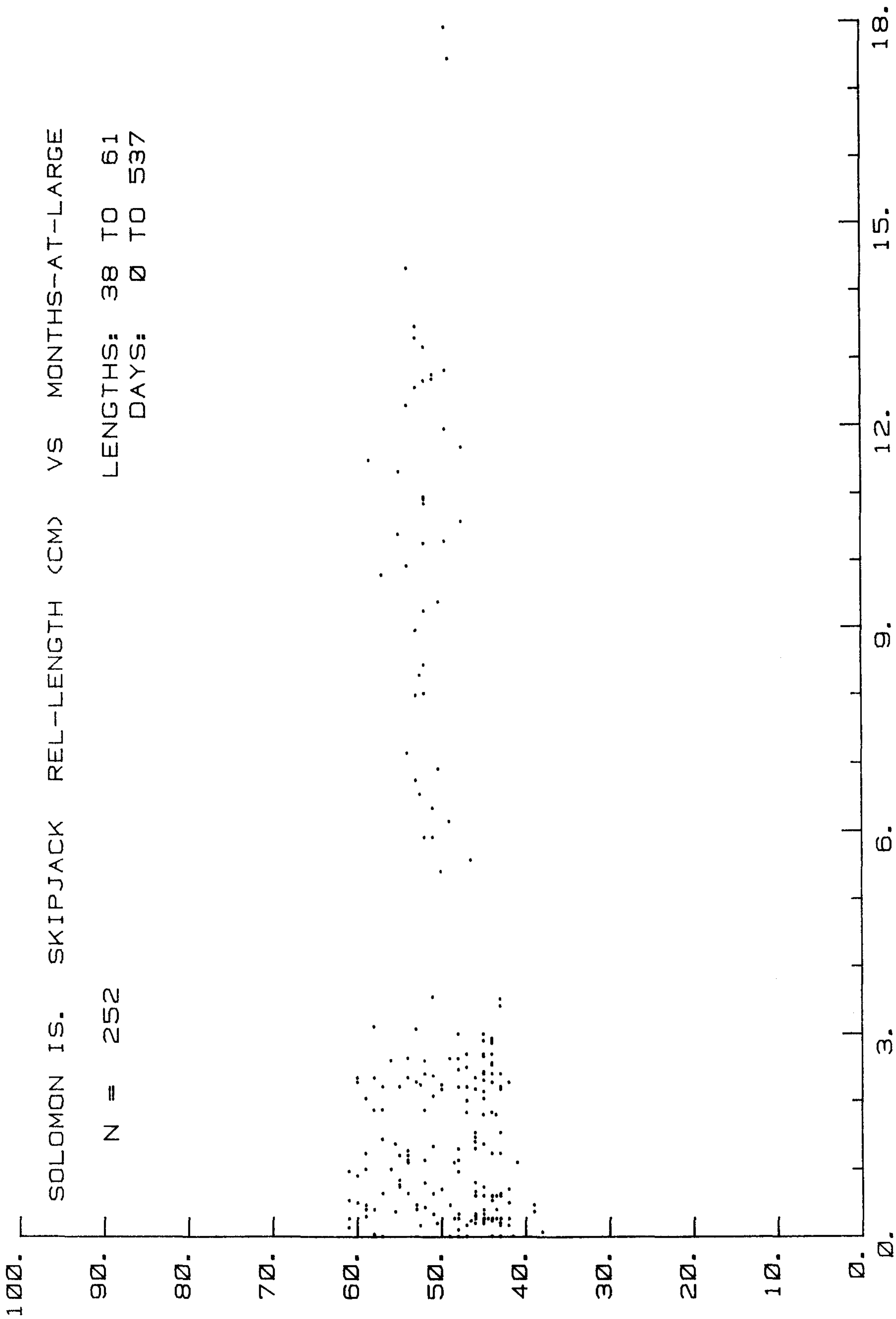

FIGURE 1 - Plot of length at release and time at large for Solomon Islands skipjack. Most fish were between 40cm-60cm at time of tagging and were out for less than three months.

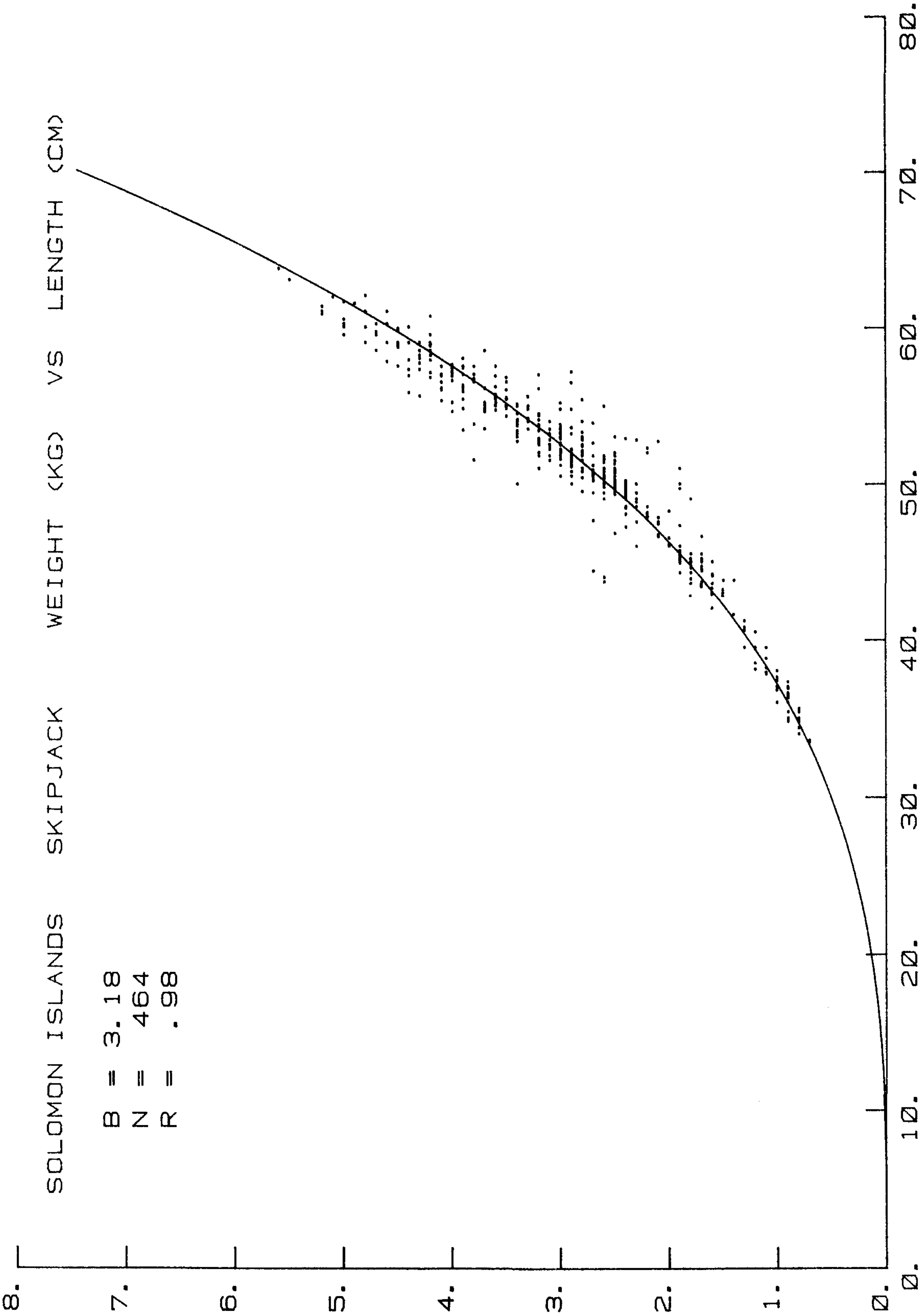

FIGURE 2 - Graph of weight versus length for Solomon Islands skipjack. B is the exponent in the weight/length equation, N is the number of data points, and R is the correlation coefficient between log-weight and log-length.

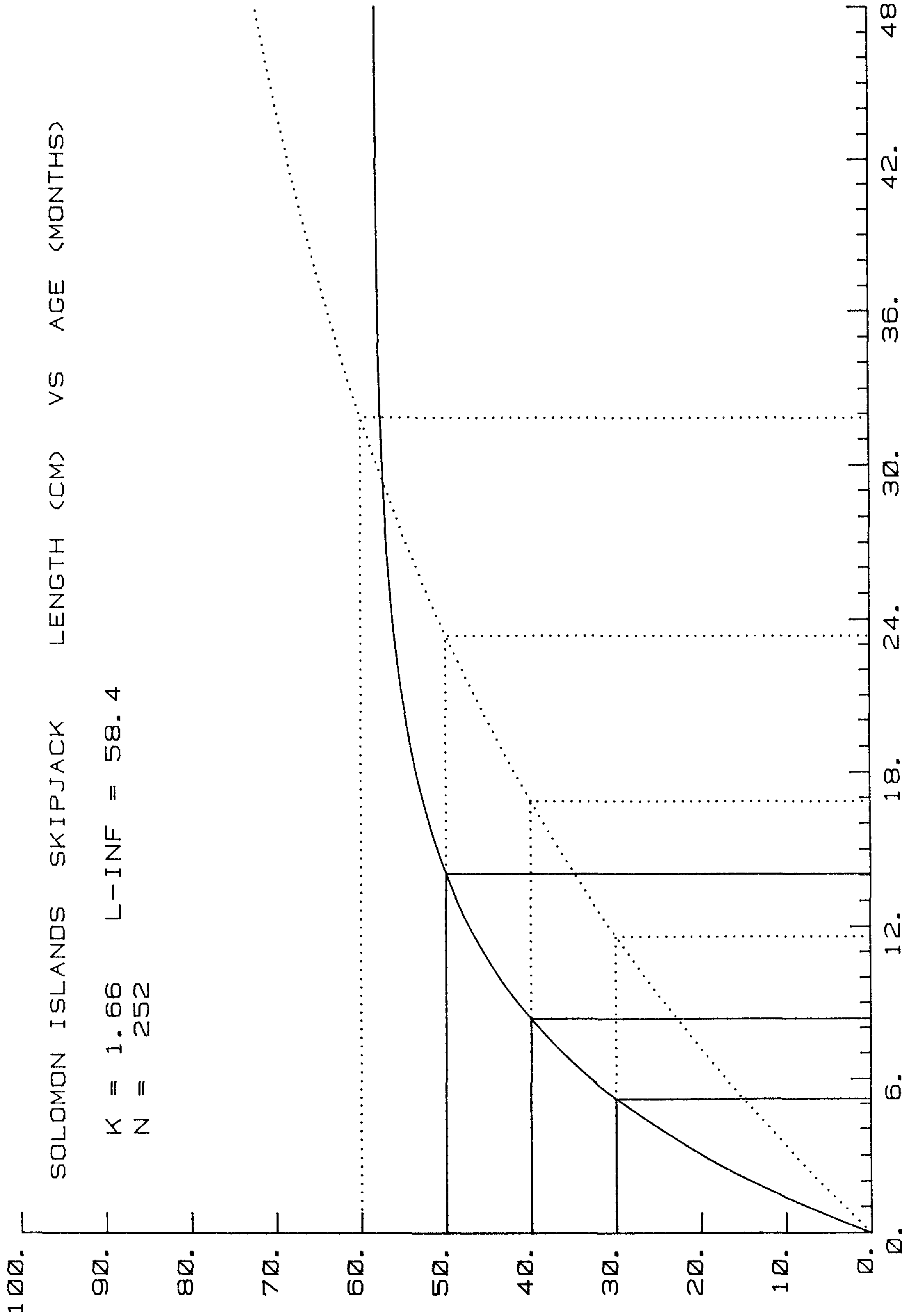

FIGURE 3 - The growth curve for Solomon Islands skipjack.
The solid line represents the Solomon Islands growth curve; the dotted line represents the eastern Pacific growth curve of Joseph and Calkins (1969). For the Solomon Islands, the von Bertalanffy parameters K and L-infinity are 1.66 years^{-1} and 58.4cm. The number of data points is 252. For the eastern Pacific, K and L-infinity are 0.43 years^{-1} and 88.1cm, and were determined from 67 points averaged from 438.

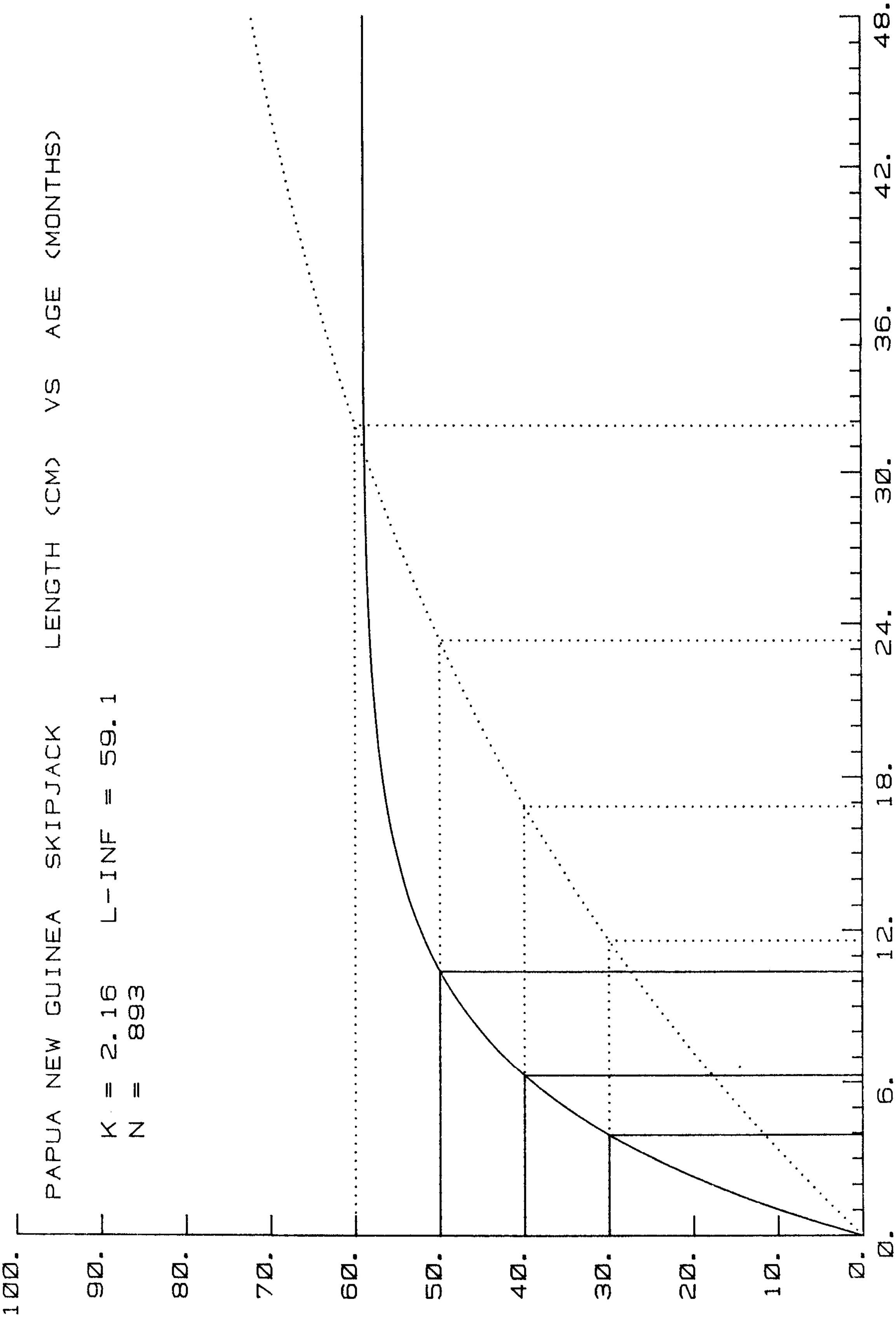

FIGURE 4 - The growth curve for Papua New Guinea skipjack.
The solid line represents the Papua New Guinea growth curve; the dotted line represents the eastern Pacific growth curve. Details analagous to Figure 3.

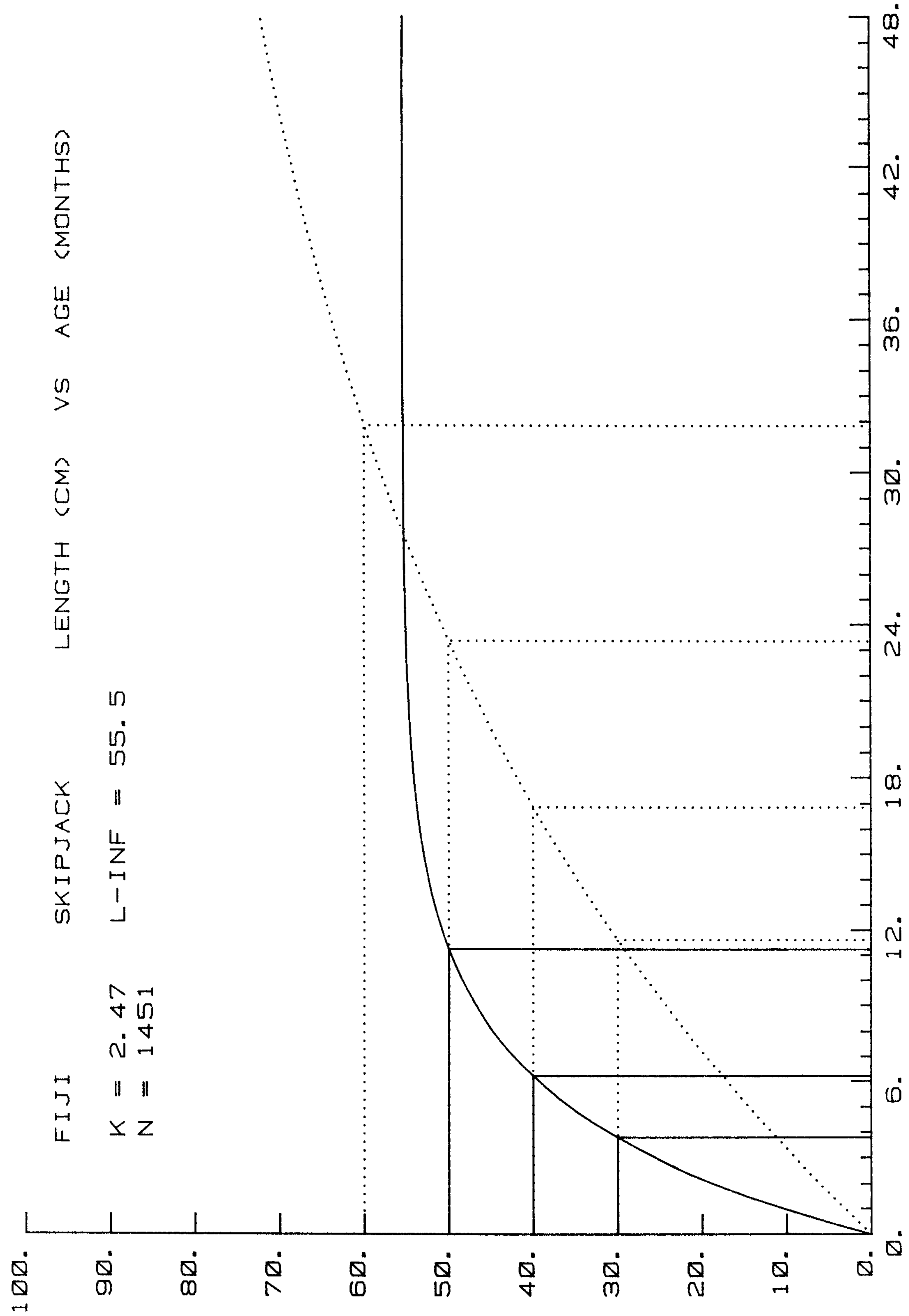

FIGURE 5 - The growth curve for Fiji skipjack.
The solid line represents the Fiji growth curve; the dotted line represents the eastern Pacific growth curve. Details analagous to Figure 3.