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AGE, AND GROWTH OF YELLOWFIN IN THE CENTRAL AND WESTERN PACIFIC
List of Relevant Data

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"*... there is still a lot of unclear things for this subject.*"

—Suzuki quoting Wild on age, growth (and sex) in yellowfin.

1. Introduction

This paper is basically a list of the data sets relevant to studying age and growth in yellowfin in the central and western Pacific. The list was prepared for reference by the Western Pacific Yellowfin Research Group in planning research priorities and feasabilities. The work already conducted in this area has been recently reviewed by Suzuki (1991).

Under the rubric, "Age and Growth", we expect to deal with two basic issues: 1) determination of age of fishes, leading it is hoped to determination of age distribution in the catch, 2) investigation of growth, which usually boils down to estimation of parameters of a growth model (often the von Bertalanffy model). It could be argued that these items should really be lumped with other topics to which they are more closely related than to each other. The primary reason to determine the age distribution of the catch is to enable powerful stock reconstruction analyses, such as VPA, to be conducted. Such analyses need not consider the sizes of fish. Age distribution is what is needed. The primary reason to investigate growth, on the other hand, is that growth is a component of biomass production, but growth may have little to do with age (see below). True, the results of stock reconstruction analyses might be combined with size and growth information to calculate cohort biomass which then can lead to presentation of management advisories such as yield per recruit. But results of investigations in other topics (mortality, stock structure, CPUE, etc.) also go into preparation of management advisories. So why are age and growth considered closer to each other than to these other topics?

2. Caveat

The main reason age and growth are lumped together is because fish size is usually thought of as being related to age, and because fish size, which is easy to measure, is very often used to estimate fish age, which is hard to measure. However, growth (the rate of change in size) may be more fundamentally related to size rather than age. This is certainly implied in the von Bertalanffy relationship, whose differential equation form gives growth as a function of size:

$$growth = \frac{d\ell}{dt} = -K(\ell_\infty - \ell)$$

where ℓ_∞ is the asymtotic length and K is the growth parameter. Jones (1981) suggests that growth increments of fish of a given size are bound to be more tightly distributed (have a smaller variance) than increments for fish of a given age. As to the use of length to determine age ... for anyone contemplating such practice, a required reading should be Chapter 13, ***Analysis of Size and Growth Data***, in a new book by Hilborn and Walters (1992). The problems are more fundamental than simply the difficulties of getting representative fish samples (which are difficult enough!).

As an example of the pitfalls for the unwary, consider Figure 1 wherein the *expected* length of fish as a function of age is given by the solid line (determined by the integral form of the von Bertalanffy model). However, in this example the actual lengths of fish at a given age are normally distributed about the expected length with a coefficient of variation, CV, of 0.1 . For constant recruitment, the probabilities of fish being in the various age-length categories are indicated by the shading. The probabilities decrease with distance from the solid line, but they also decrease with age because fish are dying exponentially. If the population is sampled the shading gives the expected distribution of sampled fish by age and length. The average lengths for the various age classes, plotted against age, gives a curve that is indistinguishable from the underlying von Bertalanffy growth curve. On the other hand, the average ages plotted against length (dotted line) is very different from the underlying growth curve. It is the dotted line, not the growth curve, that should be used to estimate age from length. Matrix methods exist (eg. Bartoo and Parker 1983) for translating length distributions to age distributions if a reliable age×length distribution is known. In a real situation, with variable recruitment, the expected age at length may be more bizzare than shown in Figure 1, but worse than that, it and the age×length distribution will be variable. It is therefore necessary to frequently re-determine the age×length distribution from independent (ie., not length-based) ageing of new fish samples. In other words, the age-from-length procedure must be constantly re-calibrated. It is to be hoped that improvements in the techniques of automatic hardpart preparation and counting will obviate the necessity and temptation of using length as a surrogate for age.

3. Relevant Data Sets

The above caveats and grumblings notwithstanding, we will now proceed to a list of data sets relevant to age and growth of yellowfin in the central and western Pacific (CWP). Probably the most comprehensive data holdings, relevant here, are held by the South Pacific Commission (SPC). Much of the information below comes from the latest SPC data catalogue (SPC 1992). The list below is necessarily incomplete for there is certain to be relevant data that I do not know about yet. I have therefore included an "other" heading in all cases as a place to add additional information that I hope will be contributed by other participants in the meeting.

3.1 Tagging Data

Tagging data are a source of information on growth if reliable size measurements are made at time of release and at time of recapture. Analyses of growth from tagging have been conducted in the eastern Pacific (Bayliff 1988) and in the eastern Atlantic (Fonteneau ____). Yellowfin tagging data available for the CWP are:

o SPC

Certainly the great majority of tag data for yellowfin in the CWP is held by the SPC as a result of two large tagging programs. The Skipjack Survey and Assessment Programme (SSAP) released 9,181 yellowfin during the years 1977-1982, and 189 of these have been returned with reliable length measurements. The Regional Tuna Tagging Programme (RTTP) started in 1989, and is still underway. Combined with seperate in-country tagging projects in Kiribati, Solomon Islands, Federated States of Micronesia, and Fiji, a total of 43,662 yellowfin have been released so far of which 1,998 have been returned with reliable length measurements to date.

o Other

Tagging of tropical tunas has been conducted in the region by other agencies than the SPC — Japan, Indonesia, and perhaps others. I do not know how many yellowfin with good size measurements, if any, are available in these data.

3.2 Hardpart Data

As has been recognized elsewhere, including for Pacific yellowfin (Suzuki 1971), the most reliable method of determining age of fish is by counting circlui on hardparts. The Inter-American Tropical Tuna Commission has studied growth in yellowfin using otoliths (reviewed by Wild 1991), but no comparable work has been conducted in the central and western Pacific. ,What has been or is being done that I have been able to discover is:

o Japan

Japanese scientists (eg. Suzuki et al. 1989) have been making use of an age-length relationship determined from scale data more than 30 years ago (Yabuta et al. 1960). The hardpart data behing this relationship may still exist, but in any case, contemporary data are much more reliable for ageing contemporary catch.

o SPC

In the course of the RTTP, otoliths have been collected as part of the associated biological sampling. To date, 619 yellowfin otolith samples from throughout the CWP hav been accumulated. These samples have yet to be processed. However, otoliths from 11 recaptured yellowfin that were injected with tetracycline, tagged, and released in the Solomon Islands have been sent to the National Marine Fisheries Service (NMFS) for processing.

o Other CSIRO.

3.3 Size Data

Size data, particularly length data, is relatively easy to collect. Thus it is not surprising that a relatively large amnount of length data exists for yellowfin in the CWP. That which I know about follows:

o Length Frequency — SPC

The SPC has CWP yellowfin length frequency data from a variety of sources dating from 1977. Some of these data were directly taken in the course of the SSAP and RTTP. In addition. on the basis of various agreements and treaties, SPC has been receiving length frequency data from several other countries and agencies. Those data sources that include yellowfin are the Inter-American Tropical Tuna Commission (IATTC), Japan, Solomon Islands, Papua New Guinea, and the United States. The number of sampled yellowfin has grown from 1,260 in 1977 to more than 38,000 in 1991.

o Weight Frequency — NMFS

Some weight frequency data for yellowfin caught in Hawaii has been collected by NMFS from from the Honolulu fish auction. These include data from the 1950-s as well as later data from 1989-1991 (C. Boggs, pers. comm.).

o Length-Weight Relationship

The length-weight relationship is classically one of the first and most basic things that a fishery scientist will try to determine when dealing with a new fishery. Indeed, several such relationships have been determined for yellowfin in the CWP and have been reviewed by Suzuki (1991). Suzuki points out that such a relationship for purse-seine caught yellowfin in the CWP has not been determined and is urgently needed. There seems to be no lack of length data from yellowfin caught by purse-seine in the CWP (see above), but I have not ascertained to what extent weight measurements are simultaneously taken. I would hope that at least some of the port sampling data would include weight. The analytical work is routine. Hilborn and Walters (1992) suggest that length-weight analysis is a good exercise for teenage children to help them learn about correlation and regression. Therefore if the data exist, there should be no impediment to quickly addressing this problem.

o Other (Size Data cont.)

It is likely that most agencies that contribute to the SPC length frequency data base have additional data that have not been sent to SPC yet. It is also likely that other countries that do not contribute to that data base also have their own data. It is certain, for example, that Korea holds length frequency data for long-line and purse-seine caught yellowfin (Park et al. 1991). I do not have documentation or personal knowledge about any of the others.

3.4 Catch at Age

It is the age freguency of the catch that we should be aiming for if we wish to conduct stock reconstruction analyses or develop other kinds of age structured models. Estimation of age frequency is routinely conducted for yellowfin catch in the eastern Pacific and in the Atlantic. The examples that I know of for the CWP are:

o Japan

Suzuki et al. (1989) and Suzuki (1986) estimated age frequencies for CWP yellowfin catch in the lonline fishery, the purse-seine fishery and the Philippine fishery. The years covered are 1976-1986. The estimation was based on the age-length relationship of Yabuta et al. (1960).

o Other

4. Conclusion

If we aim to get age distributions leading up to stock reconstruction analyses and the like, there is a need for a great deal more work with sampling and counting of hardparts. We can hope for and encourage development of otolith counting technology improve the efficiency of the technique. If we wish to make use of the voluminous length distribution information, then we must be fully cognisant of issues raised in the caveat above. We should also consider analyses that may be just as informative in a management sense as VPA and the like (eg. delay-difference models) and which do not depend so heavily on accurate age determination.

If our aim is to investigate growth, then there are some tagging data and hardpart data for the CWP waiting to be processed. Such investigations of yellowfin growth in other parts of the world's oceans have encountered complexities having to do with discontinuitites in growth rates, gender differences and difficulties in reconsiling results from different techniques — hence the quote at the biginning of this paper. We should not be surprised to find similar complexities in the CWP, and, given the cussedness of nature, new a different complexities as well.

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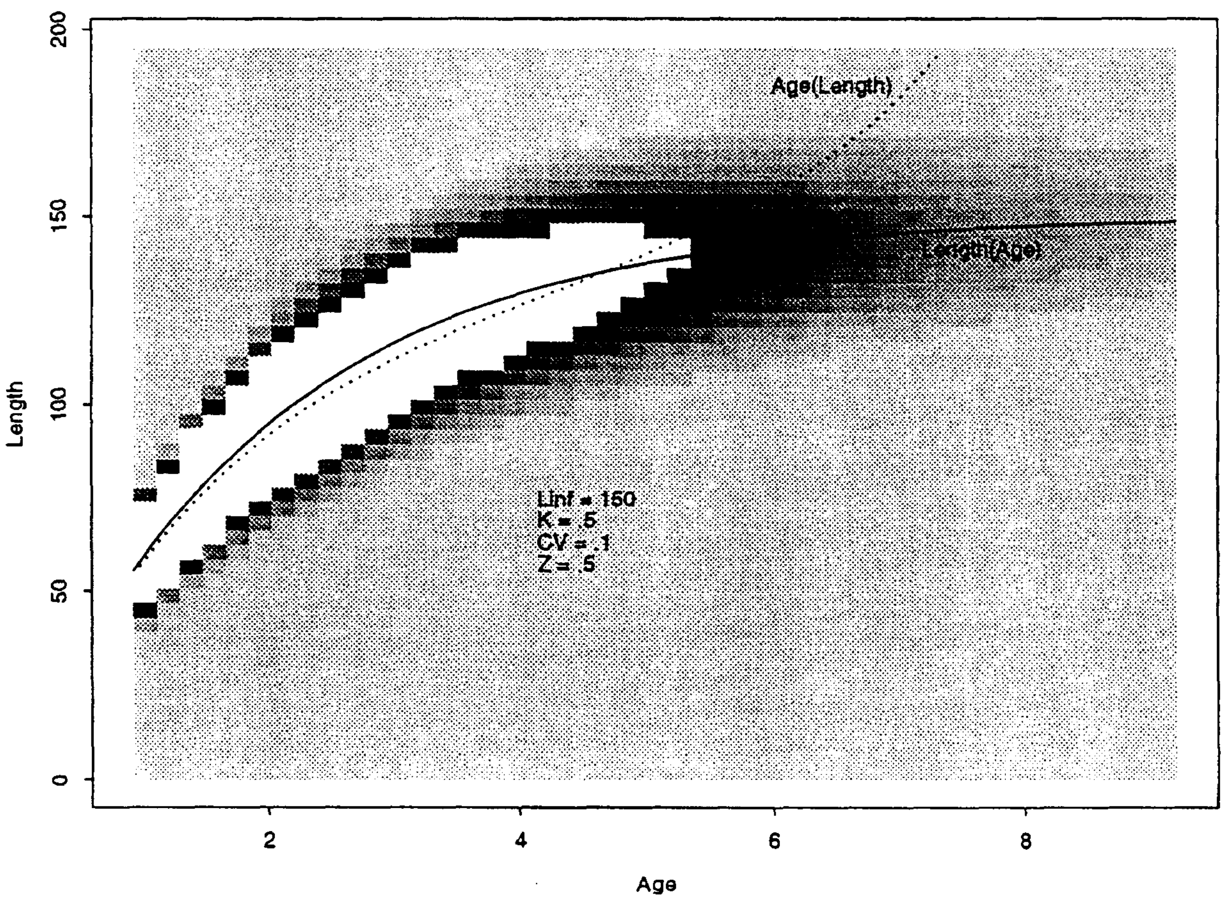

Figure 1. Grey scale shades indicate probability density of existence of fish as function of age and length under following conditions: constant recruitment, expected size at age given by von Bertalanffy model with indicated ℓ_∞ and K, normal distribution of size at age with given coefficient of variation, exponential death rate at indicated Z. To show the low probability levels at older ages, probability density is indicated up to a cut-off level, and the white area has probabilities above that cut-off. Length(Age) curve is mean length along vertical slices of the probability distribution. Age(Length) is mean age along horizontal slices of the probability distribution.