The Applicability of ELEFAN for Use in Analyzing Three Species of Deepwater Snappers in Tonga (*Etelis coruscans, Pristipomoides flavipinnis* and *P. filamentosus*, Fam. Lutjanidae)*

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Abstract

An attempt to fit the von Bertalanffy growth equation to three species of deep-sea snappers using the ELEFAN method was unsuccessful, mainly because the fish are slow-growing, long-lived species. Problems were also encountered in estimating asymptotic length and Z/K using a Wetherall plot. Possible approaches to resolving those difficulties are discussed.

Introduction

The bottomfishery of the kingdom of Tonga, with its target species of deep-sea snappers and groupers, is the largest commercial fishery in Tonga. An estimated 716 t were landed in 1987.

Pristipomoides filamentosus and *Etelis coruscans* are the two major export species. The next most important species are *Pristipomoides flavipinnis* and *Etelis carbunculus*, which are sold on the domestic market for T$2.50-2.80 per kg.

Fishing occurs throughout the Kingdom, both on the shelf of the Tonga Ridge (marked by a dotted line in Fig. 1), and on the sea mounts which run in a parallel line west of the Tonga Ridge, on a submerged ridge extending south of Pelorus Reef.

The size of the fishing grounds is 930 nm of 200 m isobath, approximately one-third of which comprises the seamounts.

Commercial development of the fishery began in 1980 as a consequence of the South Pacific Commission's Deep Water Fishing Projects of 1978 and 1979 and the UNCDF boatbuilding scheme.

Currently, 45 boats are engaged in bottomfishing, ranging in size from 6 to 11 m. All fishing boats use the FAO-designed Western Samoan wooden hand reel, with a multiple-hook terminal rig. Mead (1979) gives a detailed description of this fishing technique. The depth of fishing varies from 40 to 450 m.

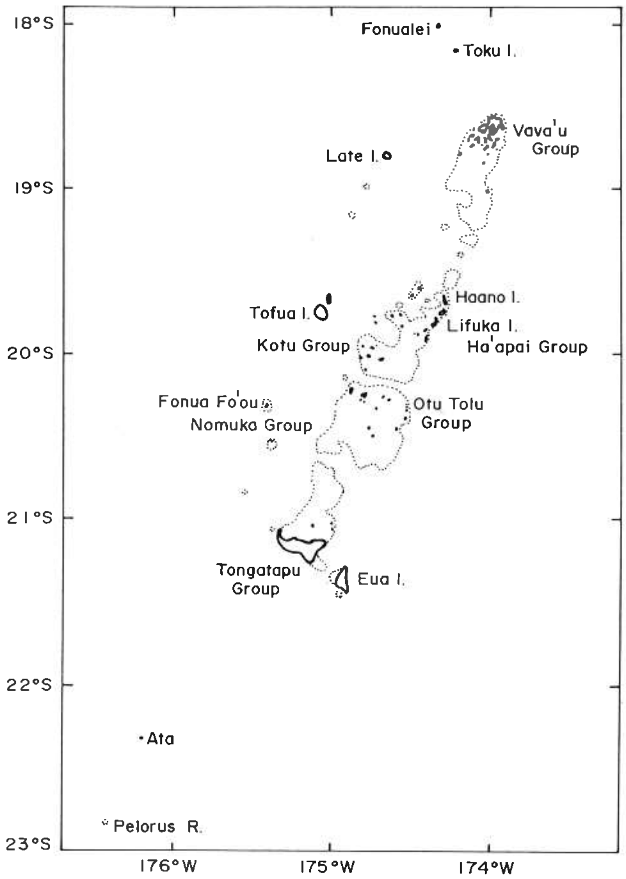

Fig. 1. Location, in Tonga, of sites mentioned in the text.

Analysis of catch data showed that although no overall depletion is apparent, a decline has occurred at some locations, along with a reduction in size of at least one species. With the establishment of export markets, fishing effort and landings increased dramatically from just over 300 t in 1986 to 716 t in 1987.

*Preliminary results based on a paper written during a workshop on Length-Based Methods in Fish Analysis, 5-17 December 1988, Honiara, Solomon Islands (see Fishbyte 7(1): 11-12)

This contribution discusses an attempt to estimate the growth and mortality of the three most important species in this fishery.

Materials and Methods

A partial literature search was conducted to obtain an idea of the range of growth parameters that could be expected for each species. Unfortunately, the library facilities in Honiara are very limited.

In addition to weekly catch and effort data, length samples were obtained quarterly at the two main landing sites: Vava'u in the north and the Tongatapu in the south.

The sampling months were November, February, May and August; during these months, all fish from all accessible fishing boats were measured (fork length) to the nearest centimeter. Since Tonga has no research boat, the data stems from the commercial fishery only. Sampling began in November 1986.

The available length samples from the major species were pooled for all locations and arranged into size classes. Quarterly samples were assembled for *P. flavipinnis*, *E. coruscans* and *P. filamentosus*.

The length data for each species was plotted as a time series (Fig. 2) in order to visually assess the suitability of fitting the von Bertalanffy growth function (VBGF).

Analysis of the data was performed using the Compleat ELEFAN software package of Gayanilo et al. (1988).

Results

P. flavipinnis

The length samples available for this species (Fig. 2A) represent a classic case of when not to attempt to fit a growth curve using ELEFAN I or any other method. The samples are unimodal and no progression of modes appears over time.

Similarly, the Wetherall plot (Fig. 3B) led to a reasonable estimate of L_∞ (= 67.6 cm) only if a few of the points on the right side of Fig. 3A were included (see Table 1).

E. coruscans

The length data for this species are similar to those of *P. flavipinnis*, although more modes are apparent (see Fig. 2B).

The Wetherall plot (not shown) was successfully applied to the data, and the resulting estimates of L_∞ and Z/K are given in Table 1.

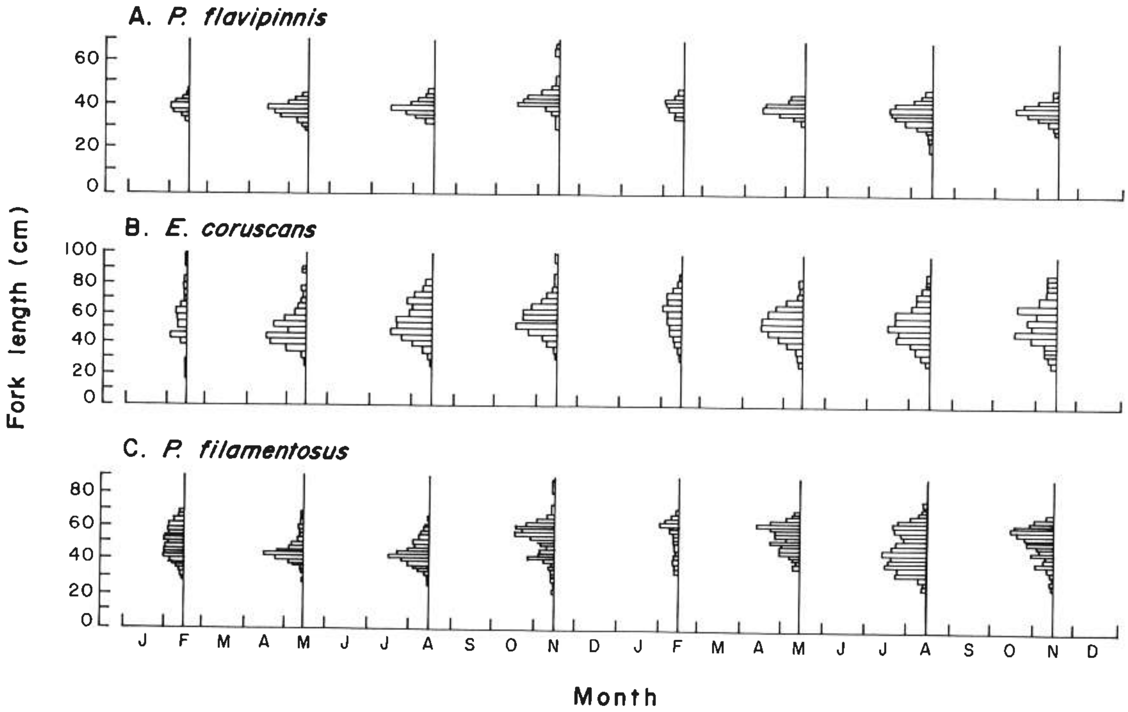

Fig. 2. Time series of length-frequency data for three important species of snappers caught in Tonga.

Table 1. Reported growth parameters of three snapper species important to Tongan fisheries

Species Method-Location	L_∞ (cm) year^{-1}	K (cm)	Z/K	L_{max} (cm)	Source
P. flavipinnis					
otoliths - Marianas	48.6	0.19	-	-	Ralston and Williams (1988)
L.F. data - Marianas	54.4	-	4.64	-	- do -
otoliths - Vanuatu	42.0	0.42	-	-	Brouard and Grandperrin (1984)
otoliths and L.F. data -Vanuatu	60.0	0.36	-	60.0	Brouard and Grandperrin (1984)
L.F. data - Tonga	57.5	-	11.5	57.0	Langi and Langi (1987)
L.F. data - Tonga	67.5	-	1.018	67.5	This study
E. coruscans					
otolith ages - Marianas	109.1	0.123	-	-	Ralston and Williams (1988)
L.F. data - Marianas	98.1	0.154	2.33	-	
otolith ages - Vanuatu	75.0	0.23	-	-	Brouard and Grandperrin (1984)
otolith and L.F. data - Vanuatu	82.0	0.128	-	82.0	Brouard and Grandperrin (1984)
Marianas	97.6	0.166	-	-	Polovina and Ralston (1986)
L.F. data - Tonga	99.3	-	3.33	96.0	Langi and Langi (1987)
L.F. data - Tonga	98.5	-	3.52	98.0	This study
P. filamentosus					
otolith ages - Marianas	58.4	0.29	-	-	Ralston and Williams (1988)
L.F. data - Marianas	67.0	0.20	2.54	-	- do -
otolith and L.F. data use - Vanuatu	58.0	0.29	-	76.0	Brouard and Grandperrin (1984)
Marianas	67.3	0.23	-	-	Polovina and Ralston (1986)
Wetherall - Tonga	77.2	-	4.10	75.0	Langi and Langi (1987)
L.F. data - Tonga	82.9	-	4.08	89.5	This study

P. filamentosus

The length-frequency data on this species appeared suitable for fitting of growth curve. Numerous modes are apparent and they shift their position over time. However, the cumulative length-frequency data showed two peaks (Fig. 4). Since a marked geographical size difference occurs in this species in Tonga (Langi et al., unpublished data), it was decided to delay analysis of this species to allow separation of locations.

Estimates of L_∞ = 82.9 cm and Z/K = 4.08 were obtained from the Wetherall plot (Fig. 3D).

Discussion

The key conclusion of the working group on "Methods of Analysis and Assessment" at a recently held conference on length-based method for stock assessment (Shepherd et al. 1987) were that the applicability of length-based methods is closely linked with the characteristics of the data.

Fig. 4 shows four extreme types of length-frequency data, while Table 2 presents methods appropriate for each type.

In the case of *P. flavipinnis* (Fig. 2A), the data are clearly of Type A, i.e., there is only one mode and this does not progress over time.

Several age classes may be included in this mode, if we consider the relative age at length calculated from otoliths by Ralston and Williams (1988) (Table 2).

Also, published values of K are low, i.e., this fish is slow-growing and long-lived (Table 1). Thus, the difficulties of a Type A situation are compounded by a Type D situation, i.e, there are multiple overlapping cohorts.

In the case of Tonga's data set on *P. flavipinnis* then, length-based methods are not appropriate for estimating growth and mortality.

E. coruscans

In the case of *E. coruscans* (Fig. 2b), the situation is less extreme, since more than one mode appears in some samples. However, there is little, if any, progression of these models over time, and a Type D situation should occur, given the low values of K reported for this species (Table 1).

P. filamentosus

Fig. 2C shows several modes for this species, and these modes appear to shift over time (Type B situation). Thus, it will be worthwhile analyzing these data once samples from various geographical

Table 2. Appropriate methods for analysing different types of length-frequency data[a] (modified from Shepherd et al. 1987).

Data type[a]	Priorities for data collection: Length	Priorities for data collection: Other types	Most appropriate length-based method for estimating: Growth	Most appropriate length-based method for estimating: Mortality
A	Low	High - Selection, life history, growth, mortality	None	None
B	High	Low - Growth, mortality, recruitment period data	ELEFAN I, and similar methods	Several, see Pauly and Morgan (1987)
C	High, intensive for one year	Low - Growth data for confirmation	Modal progression analysis	Length-converted catch curve, mean length methods, Pope[b], Sparre[b], etc.
D	High, extensive over many years	High - Growth information	Approaches combining age and length data (see Pauly and Morgan 1987)	Length-converted catch curve, Pope[b] and Sparre.[b]

[a]As illustrated in Fig. 4
[b]pertains to methods described in Pauly and Morgan (1987).

locations have been separated, although again the large number of overlapping age classes might even then still present a problem.

The Wetherall plot

This length-based method assumes the investigated population to be in a steady state and does not have time as a dimension (Wetherall et al. 1987). However, this method (which assumes a trawl-type selection curve, where P = 1 for large fish) is not appropriate in the case of *P. flavipinnis* where heavy selection occurs at the right hand side of the frequency distribution (Fig. 3A). The assumption of P = 1 for large fish is violated in the case of a hook fishery where selection against very large fish also occurs.

Some estimates of L_∞ and Z/K for the three species presented above are given in Table 1.

It is difficult to compare Z/K values as they combine two processes. It is also difficult to compare values of L_∞ found in Tonga with those from other areas. However, in the case of *E. coruscans*, a very consistent picture appears, with Z/K ranging from 2.3 to 3.5 and with L_∞ estimates being close to L_{max}.

Conclusion

In the case of Tonga's data on *P. flavipinnis* and *E. coruscans*, both long lived species, slow growing fish, the use of the ELEFAN I for estimation of

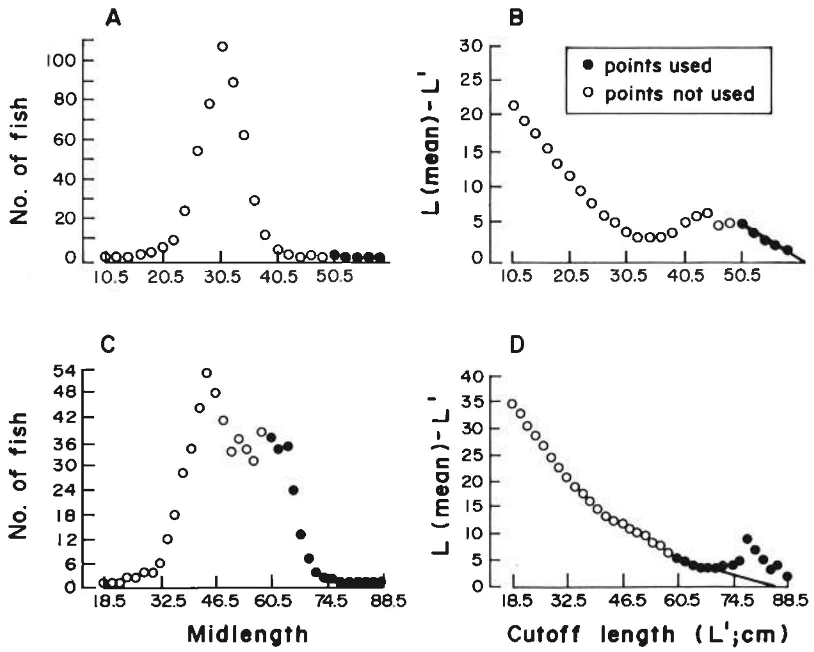

Fig. 3. Plots of cummulative frequency and (A, C) of Wetherall plots (B, D) for *P. flavipinnis* (A, B) and *P. filamentosus* (C, D); see text and Table 1.

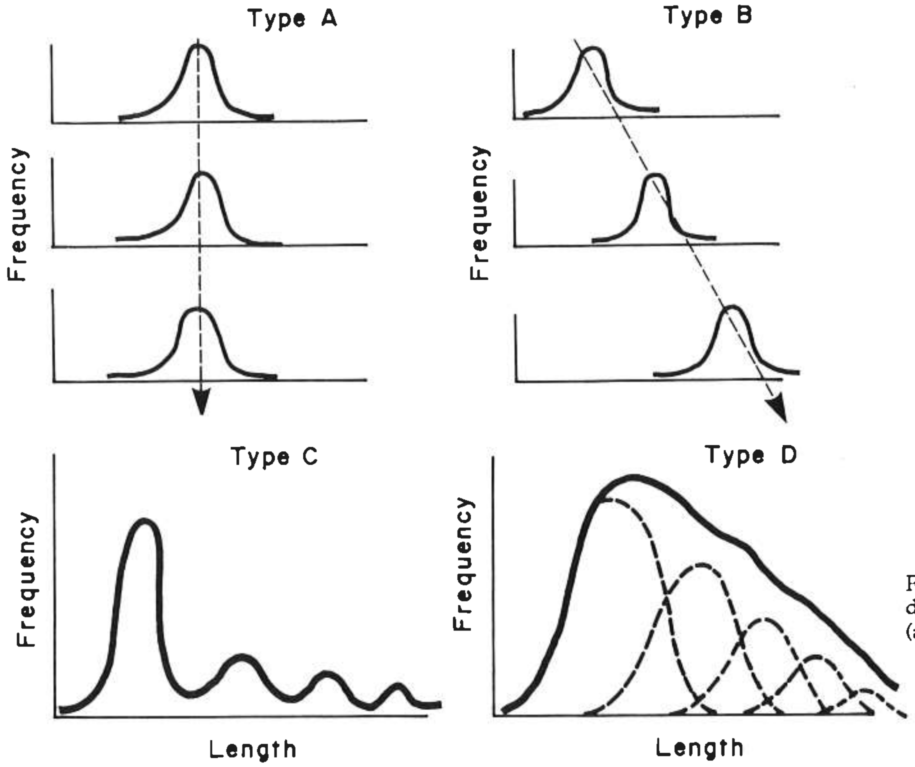

Fig. 4. Schematic representation of four different types of length-frequency data (adapted from Shepherd et al. 1987).

growth parameters is not appropriate. The Wetherall plot can be used to estimate L_∞ and Z/K, but the assumptions of this method may not be fully met.

Many authors have discussed the difficulties of using otoliths for ageing tropical fish, e.g., Morales-Nin (1988). These problems are compounded in the case of long-lived, deepwater fish, for which validation of the assumed otolith-derived ages is difficult.

A fairly reliable method of ageing these fish would be to tag them using break-off hooks and bait injected with tetracycline. The otolith readings could then be validated using the marked otoliths upon recapture. Unfortunately, this kind of tagging program would be too costly for a small island fisheries division, both in terms of manpower and budget.

An approach that has so far proved useful in Tonga is to use catch and effort data from individual seamounts to monitor exploitation levels. Where depletion has occurred, the model of Allen (1966) was used to estimate catchability and recruitment. From this, surplus production and annual yields can be estimated. Length data can be useful, however, both for detecting size reduction due to fishing pressure and in checking whether the fish are being caught before they reach maturity.

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