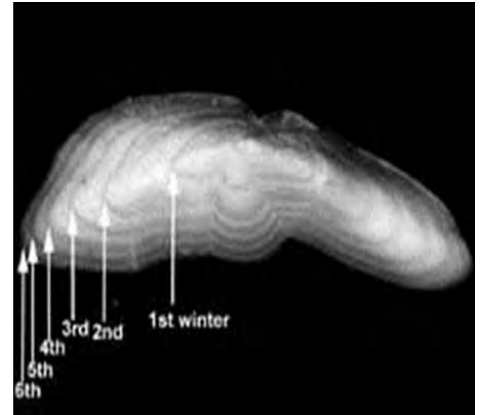


*Age Determination of the Black Sole, *Synaptura cadenati* and the Red Sole, *Cynoglossus senegalensis* in The Gambia using Otoliths*



**Gambia-Senegal Sustainable Fisheries Project
(BaNafaa)**

2011



This publication is available electronically on the Coastal Resources Center's website at <http://www.crc.uri.edu>. For more information contact: Coastal Resources Center, University of Rhode Island, Narragansett Bay Campus, South Ferry Road, Narragansett, Rhode Island 02882, USA. Tel: 401) 874-6224; Fax: 401) 789-4670; Email: info@crc.uri.edu

The BaNafaa project is implemented by the Coastal Resources Center of the University of Rhode Island and the World Wide Fund for Nature-West Africa Marine Ecoregion (WWF-WAMER) in partnership with the Department of Fisheries and the Ministry of Fisheries, Water Resources and National Assembly Matters.

Citation: Gibril Gabis, Lamin Sanyang, Ivan Mateo, John Burnett and Kathleen Castro, 2011. Age Determination of the Black Sole, *Synaptura cadenati* and the Red Sole, *Cynoglossus senegalensis* in The Gambia using Otoliths, Coastal Resources Center, University of Rhode Island, pp.11

Disclaimer: This report was made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government. Cooperative Agreement # 624-A-00-09-00033-00.

Cover Photo: Coastal Resources Center

Photo Credit: Coastal Resources Center

Acknowledgements

There is little doubt that involving all stakeholders as partners in developing management plans will assist in the progress towards improved management of the fishery resources. The industrial sector plays a very important role in data collection for fishery management purposes. The participation of processing plants in collecting basic biological information is critical, especially in data deficient situations. We wish to thank Atlantic Seafood Company for their participation in data collection about the sole resources. This information dramatically improved the data poor scenario and allowed very specific questions to be formulated and investigated.

Table of Contents

Introduction	5
Methods	6
Results	7
Validation	9
Discussion.....	11
References.....	12

List of Figures

Figure 1. (Left picture) Otoliths extracted from sole at beach landing site.(Right picture) Otoliths extracted at Atlantic Seafood.....	6
Figure 2. Detail Otolith extraction	6
Figure 3. Otolith samples from black and red sole by sex and size.	7
Figure 4. Von Bertalanffy age growth model for black sole fit using non-linear	9
Figure 5. Age and length predicted from published studies on <i>Cynoglossus canariensis</i> and otolith data from <i>Synaptura cadenati</i> (this study).....	10

Introduction

The use of otoliths (ear stones) to determine age in fish is a well-tested method frequently used in marine temperate water areas (AFS, 1983). Annual marks are easily distinguished because growth is seasonal. Fish are usually born in the same season and there are patterns of warm temperature and rapid growth and cooler temperature with reduced growth. The advantages of using otoliths for aging are that they are formed during the embryonic period and reflect all life history events. Growth bands correspond to daily, seasonal or annual patterns. The presence of distinguishable daily increments in otoliths provides an accurate and precise method for age estimation. The chemical properties of otoliths also provides a window to the past environmental conditions that might allow a fish to be biopositioned in space and time throughout its life (Campana and Thorrold, 2000).

There is a misconception that tropical fish cannot be aged using this method because of the aseasonal environment. Fowler (1995) showed that tropical fish do have seasonal otolith increments and a recent review (Morales-Nin and Panfili, 2005) demonstrated that two main forcing variables influence the seasonal variations in the tropics: temperature and hydrology. Sea surface temperatures reflect seasonal variations and upwelling events especially in the major coastal regions of the world (including West Africa). The different fish species in these environments generally have high specific growth rates with both K and r strategies leading to extremely variable longevities. All types of reproductive strategies exist in the tropics from pelagic egg spawning to small brood spawners. The most important variation in regards to aging fish is variable reproductive timing as the estimation of birth date may be difficult to calculate.

Seasonal growth variations are now recorded and validated in a wide range of tropical species. Annual increment interpretability varies between tropical species and between regions with the trend towards more difficulties with decreased temperature fluctuations (Caldow and Wellington, 2003). Care needs to be taken when examining the otoliths from tropical species especially in regards to the first growth area, birth date and reproductive cycle. Daily growth marks have been documented on several tropical species to date. Being able to age fish provides stock assessment scientists with an accurate tool to estimate growth and mortality. Recruitment, growth and mortality rates are three of the most important life history characteristics controlling the productivity of fish populations.

The objective of this study was to determine if red (*Cynoglossus senegalensis*) and black sole (*Synaptura cadenati*) otoliths can be used for accurate age determination of sole in the coastal waters of the Gambia.

Methods

Otoliths were collected from sole captured by the artisanal fishery in Brufut and processed at the Atlantic Seafood facility and from directly from sole landed in Sanyang. An attempt was made to sample fish from a wide range of sizes in order to collect fish from as many different age classes as possible. Fish were measured, then both otoliths were removed, and the fish sex and maturity were recorded.



Figure 1. (Left picture) Otoliths extracted from sole at beach landing site. (Right picture) Otoliths extracted at Atlantic Seafood

Cuts were made just above the cranium in order to open up the cranial cavity. Tweezers were then used to locate and remove the two otoliths. Once removed, the otoliths were cleaned, dried and placed directly into labeled envelopes. All otoliths were stored in manila coin envelopes and labeled with date, species, landing site, length and sex. Males were identified by the presence of the testis; presence of ovary or eggs for the females. Immature fish were generally unclassified.



Figure 2. Detail Otolith extraction

Otoliths were sent to the Woods Hole Oceanographic Institution, Age and Growth Lab. The otoliths were embedded in paraffin/graphite wax and cut with a low speed double diamond bladed saw to produce thin slices of 200-400 microns, and read with 40x low magnification/transmitted light by two readers. Annual growth rings were counted. The mean length at each age was calculated.

Growth is described by the Von Bertalanffy growth model (1938), a simple asymptotic function that is calculated as:

$$L_t = L_\infty \left(1 - e^{-K(t-t_0)}\right)$$

Where L_∞ is asymptotic length (the value of L for which growth is zero), t is age, K is the growth coefficient.

Parameters for the model were calculated in three ways. A Ford Walford plot was used to calculate L_∞ and K where a plot of L_t versus L_t+T forms a straight line regression that intersects the 45 degree line of no growth. K is $-(\ln(a)/T)$. The intersection between the two lines is L_∞ . A Gulland-Holt method was also used to obtain L_∞ and K and also t_0 . Data for the Gulland-Holt method are fit by a linear model using a regression of the annual growth increment versus mean length. The value of K comes from the slope, and the y intercept gives an estimate of L_∞ .

An estimate of t_0 is obtained by taking the mean of t_0 obtained for the ages and lengths of the youngest fish when substituted into the rearranged von Bertalanffy function with calculated parameters for K and L_∞ . A non-linear iterative procedure minimizing the sum of squares (Solver in Excel 2010) was also explored to generate these parameters.

Results

In total, 36 red sole otoliths, with a size range of 31-53 cm, and 22 black sole otoliths, with a size range of 29-41 cm were collected. The red sole otoliths were not readable as thin slices and further work will involve polishing and burning techniques. Black sole otoliths were clear and age was determined for 19 of the 22 samples. Initial readings indicate an age range of 1 to 5 years old for the black sole that were sampled (Figure 1).

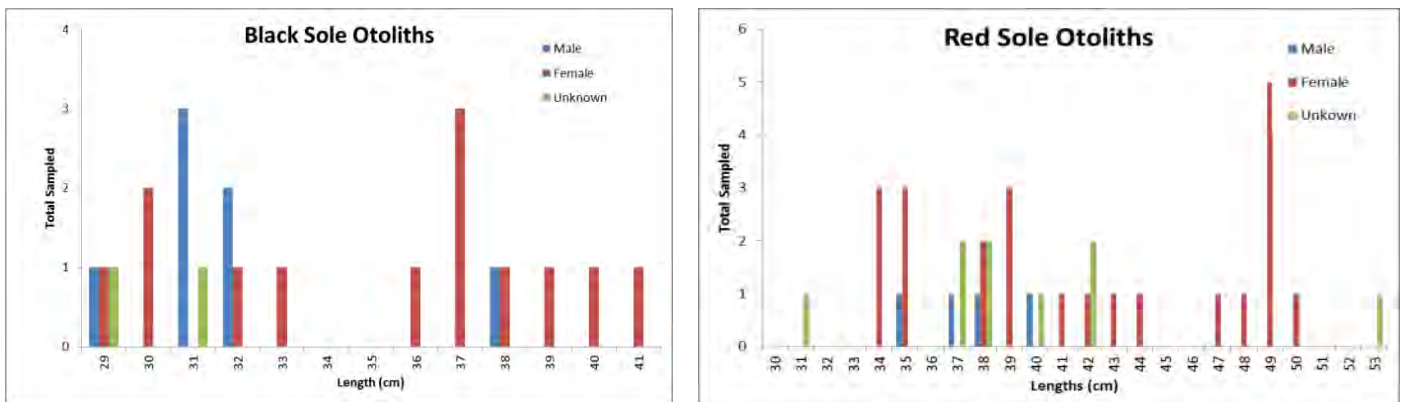
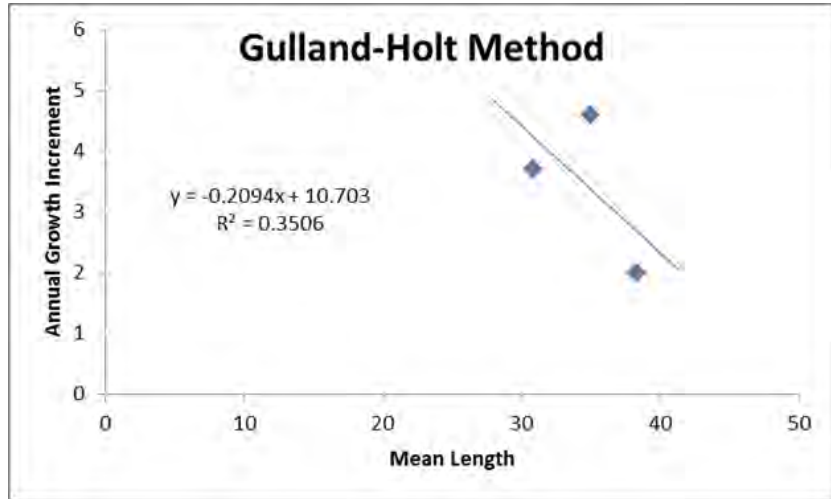


Figure 3. Otolith samples from black and red sole by sex and size.

The observed ages of the black sole were used to calculate out the growth parameters for the von Bertalanffy model.

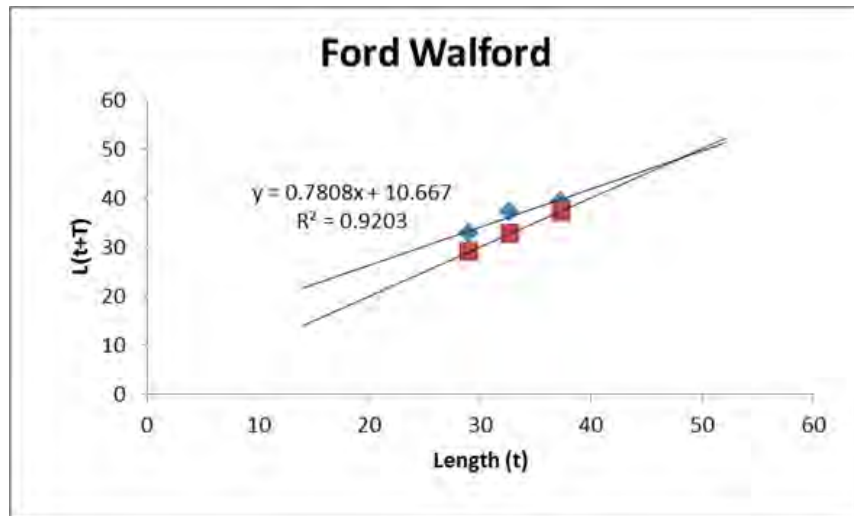


The Gulland Holt method produced estimates of:

$K=0.21$

$L_{\infty} = 51.34$

$T_0=-2.91$



The Ford-Walford Method produced estimates of:

K=0.247
 $L_{\infty} = 48.66$

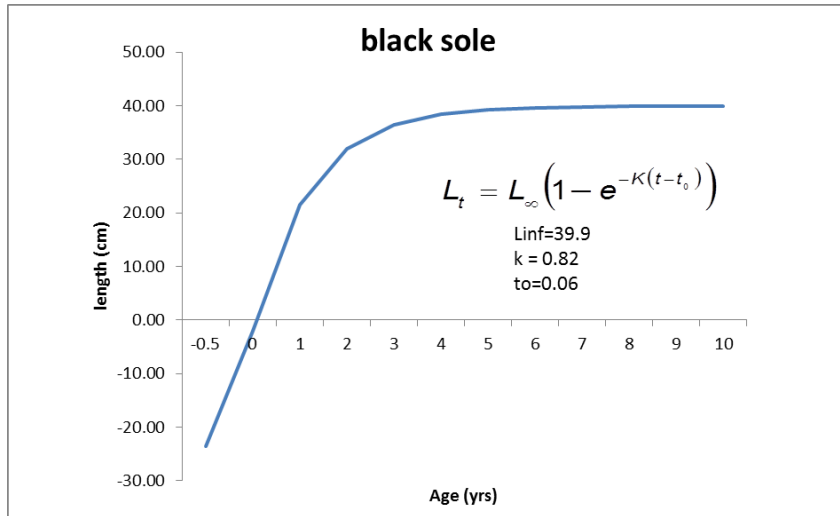


Figure 4. Von Bertalanffy age growth model for black sole fit using non-linear methods.

Validation

In order to validate the results obtained for the black sole, we compared our results with those published life history characteristics for L_{∞} , k and t_0 for a similar species, *Cynoglossus canariensis*. Mean length per age group was calculated (Ajayi, no date, Chauvet, 1972).

Table 1. Comparison of predicted age and length for sole (length in cm)

Source	Age				
	1	2	3	4	5
Male(Ajayi)	15.6	23.74	32.7	35.46	
Male (Chauvet)	27	34	34	39	
Female (Ajayi)	16	25.7	34.3	39.1	43.1
Female (Chauvet)	27	35	41	45	49
Observed this study	29	31.9	37.3	39.3	

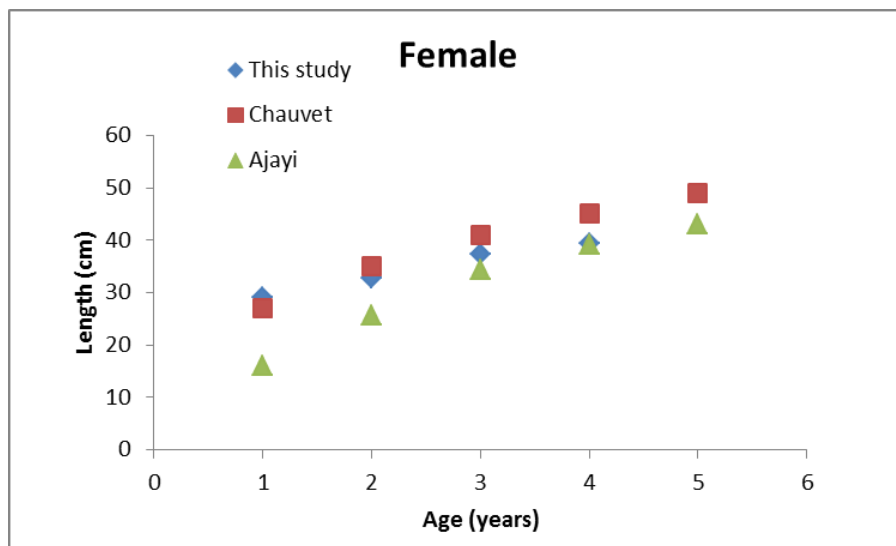
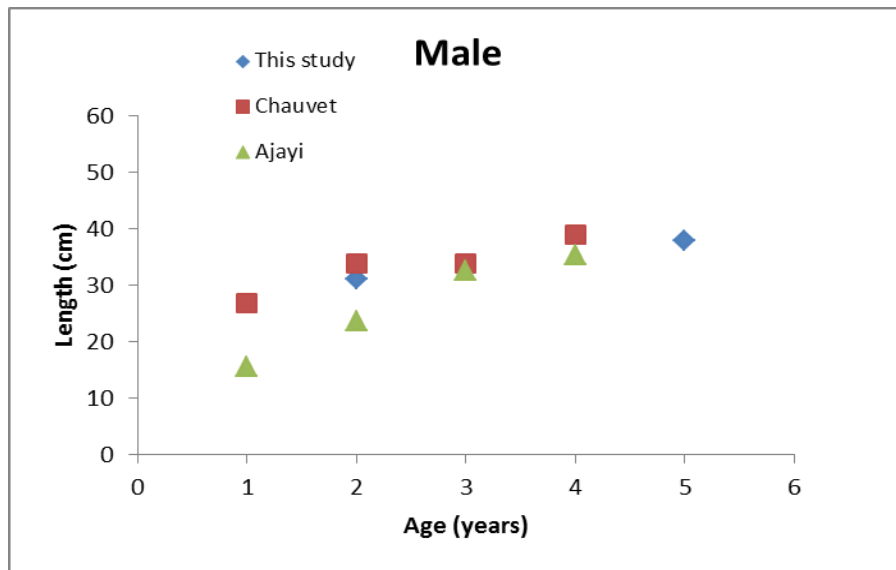


Figure 5. Age and length predicted from published studies on *Cynoglossus canariensis* and otolith data from *Synaptura cadenati* (this study).

Discussion

The results with the existing data yielded unreliable parameters for the growth model. Although the predicted L_{∞} from the Ford Walford and Gulland-Holt method were reasonable, the t_0 is not. The non-linear method produced a more reasonable t_0 but the L_{∞} was below the observed fish size.

The results show promise for setting up an age based growth model for the black sole in The Gambia, however, a larger size range needs to be sampled for both sexes. There was only 1 readable otolith at year 1 for a female fish, and considerable variation for year 2 fish that was confirmed by both readers. The lack of larger fish restrained the prediction of a realistic L_{∞} . In general female fish displayed a larger length at age 1 than the male fish for *S. cadenati* and the *C. canariensis*. The flattening out of the growth curve is expected, especially for females since maturity is predicted to occur at age 2 and 3.

The reference for this growth data (Chauvet, 1972) has never been located or confirmed. It is not known how similar these species are in terms of longevity and growth.

Future work with expanded data collection will hopefully clarify the scatter at year 2 and provide older fish to further clarify the L_{max} and L_{∞} . Work on the red sole will continue to see if other methods can be used to determine the age. The initial data collection is an important step in collecting important management information on the sole species of The Gambia.

References

- Ajayi, T.O. (no date). The age and growth of the tongue sole *Cynoglossus canariensis* (Steind, 1882). Report from the Nigerian Institute for Oceanography and Marine Research, Lagos, Nigeria. Pgs 228-235.
- American Fisheries Society. 1983. Fisheries Techniques. Edited by Nielsen, L.A. and D.L Johnson. 468 pps.
- Caldow C. and G. M. Wellington. 2003. Patterns of annual increment formation in otoliths of pomacentrids in the tropical western Atlantic: implications for population age structure examination, *Marine Ecology Progress Series* 265: 185-195.
- Campana, S.E., and S.R. Thorrold. 2000. Otoliths, increments and elements: keys to a comprehensive understanding of fish populations? *Canadian Journal of Fisheries and Aquatic Sciences* 58:30-38.
- Chauvet, C. 1972. Croissance et determination de l'age par lecture d'ecailles d'un poisson plat de Cote d'Ivoire *Cynoglossus canariensis* (Steind. 1882). *Doc Scient. Cent/Rech. Oceanogr. Abidjan* 3:1-18.
- Favler, A.J. 1995. Annulus formation in otoliths of coral reef fish: a review. In 'Recent Development in Fish Otolith Research'. Editors: DH Secor, JM Dean, and SE Campana. Pp 45-63. University of South Carolina Press, Columbia, SC.
- Morales-Nin, B., and J. Panfili. 2005. Seasonality in the deep sea and tropics revisited: what can otoliths tell us? *Marine and Freshwater Research* 56:585-598.