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Analysis of annuli in otoliths, age distribution and growth rates of the Namibian hake (*Merluccius capensis)*

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RESUMO

Palavra-chaves:

ABSTRACT

Age and growth estimates of Cape hake (*Merluccius capensis*), in the waters off Namibia were described from 804 specimens collected during January and February 2003. Each specimen was aged twice using whole otoliths. Otolith growth measurements was taken and used in back-calculated length-at-age data of *M. capensis*. Direct average otolith growth measurements have shown that up to three false rings formed prior to the first annulus. Ogives demonstrated the differences in otolith diameter, location frequency between the annuli and false rings. A power fish length-otolith diameter relationship used for back-calculation is: ($L = 1.39 * OD^{1.1717}$). The average back-calculated lengths for the first four years of life were 19.3, 25.6, 31.8 and 38.2 cm total fish length. Age composition, estimated from an age length key, indicated that juveniles and young fish predominate in survey and commercial catches. The von Bertalanffy growth parameters was (growth coefficient, K = 0.07; asymptotic length, $L_\infty = 123.13$; $t_0 = -1.5$). Sexual maturity was reached at age 1.67 years. The high correlation between otolith weight and age permits the use of otolith weight as a substitute for future age assessments.

Key words: Age and growth, *Merluccius capensis*, Namibia, otolith growth, back-calculation, von Bertalanffy growth equation.

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1. Introduction

The Benguela is one of the major eastern current systems, characterised by upwelling of cold nutrient-rich water. This current system is an essential centre of plankton production which is able to maintain large-scale biodiversity and biomass of marine life (Shannon and O'Toole, 1998). The South Atlantic current uniquely supplies the equator with a net transport of heat. Consequently, the Benguela is at a critical location and potentially extremely vulnerable to any future climate change (Shannon and O'Toole, 1998).

Namibia's coastal line extends 1,300 km, situated in the central region of the Benguela system. Characteristically the water off the Namibian coast is naturally cold, hypoxic even anoxic, at depth. Seasonal south-easterly winds induce upwelling at the coast, making available an abundant supply of phyto- and zooplankton (Shannon and O'Toole, 1998).

The hakes, Cape hake *Merluccius capensis* (Castelnau) and Deep water hake *Merluccius paradoxus* (Franca), are Namibia's most important commercial species. Before independence in 1990 these resources had been overexploited because of unregulated fishing by many nations (Alheit and Pitcher, 1995). Unsustainable catches of up to 800 000 t were taken in the mid-1970s, while the resource was managed by the International Commission for South East Atlantic Fisheries (ICSEAF). Since 1990, the Namibian government has been managing the hake stock at a harvesting level of around 150 000 t per year (Fergus *et al*., 2005). The Namibian stock together with the South African stock is representative of over one-third of the world's hake biomass (Alheit and Pitcher, 1995).

The depth distribution of *M. capensis* covers the range from close inshore to 400 m. Generally smaller fish occur close inshore in shallow water. Larger fish inhabit the waters further offshore (Macpherson *et al.*, 1985; Botha, 1985). *M. paradoxus* can not be found close inshore at depth less than 150 m. Depth distribution for *M. paradoxus* ranges typically from 300 to 500 m with the possibility of inhabiting the deeper ocean at 1000 m (Mas-Riera, 1991). Stock separation is not well understood therefore these two species were not separately identified in historical commercial catches. *M. capensis*, the dominant species in the commercial catch, is the species selected for this study.

Studies from gonad examination indicated that hakes in the south-east Atlantic may spawn throughout the year (Botha, 1986; Payne, 1989). Spawning peaks have been observed in spring/summer (Pshenichnii and Assorov, 1969; Porebski, 1976) and in winter/spring (Roux, 2006). Spawning by *M. capensis* is continuous from August to March (O'Toole, 1978; Botha, 1986, Shannon, 1986; Olivar *et al.,* 1988; Gordoa *et al.,* 1995). No spawning grounds for deep-water hake have been located off Namibia (Gordoa *et al.,* 1995). *M. capensis* spawn inshore, not exceeding depths of 200m (O'Toole, 1978; Olivar et al., 1988; Olivar, 1990; Gordoa *et al.,* 1995) along the whole Namibian shelf, with the major concentrations located around Walvis Bay (23°S, O'Toole, 1978; Olivar *et al.*, 1988; Gordoa *et al.,* 1995). Larvae occurs at sea surface temperatures ranging from 14.8 to 16.5 °C and sea surface salinity values of 34.9 ‰ to 32.2 ‰ (O'Toole, 1978; Gordoa *et al.,* 1995). For the duration of periods of active upwelling (winter-spring), eggs and larvae group together in areas where the water column exhibit less stratification

(Gordoa *et al.,* 1995). Throughout inactive upwelling, eggs and larvae were found near the thermocline (Olivar, 1990; Gordoa *et al.,* 1995).

M. capensis feeding studies have indicated their food spectrum to be variable. Cannibalism increases with hake length and the preference for other species disappears (Roel and Macpherson, 1988). The importance of cannibalism in the diet of *M. capensis* was emphasized in observations of predominantly their own species found in the diet of individuals larger than 60 cm (Roel and Macpherson, 1988). *M. capensis* is preyed upon mainly at ages younger than 4 years by predator hakes that are usually older than 7 years (Lleonart *et al.*, 1985).

A fundamental requirement for management of any exploited resource, such as *M. capensis*, requires an accurate knowledge of its annual age composition and growth. Studies have shown that the Cape fur seal off Namibian waters feeds on a wide range of prey primarily targeting juvenile *M. capensis* in their pelagic phase (Shaughnessy, 1985; David, 1987, 1991, Roux, 2004). Roux (2004) had analysed length frequency distributions of Cape hake in the diet of Cape fur seal for over a decade, and discovered a pattern that suggested that fur seals prey on a single hake cohort at a time. According to the author, each hake cohort becomes available to the predator in summer and disappears from the diet the following summer. This pattern had allowed the author to estimate growth parameters and cohort strength of juvenile *M. capensis.* Thus, recruitment strength estimated during the decade of seal scat analysis had shown that the *M. capensis* cohort spawned during 2002 constituted the strongest cohort on record (Roux, 2004). During the survey 2003, a large amount of *M. capensis* was sampled and since it was the year after the highest recruitment. Therefore 2003 were chosen to investigate the age and growth determination in this study.

Age information forms the basis and is the most influential of biological parameters for calculations of growth rate, mortality rate and productivity (Campana, 2001). Traditionally otoliths were chosen most satisfactory to examine age in hake otoliths (Birtwistle and Lewis, 1925; Hickling, 1933). Otoliths of *M. capensis* and those of *M. paradoxus* are shaped differently (Botha, 1971). However, otolith ring structure is identical in the two species (ICSEAF, 1983). The ageing of *M. capensis* otoliths is normally done by counting concentric growth rings on otoliths via naked eye or light microscope. Botha (1971) had determined that generally one hyaline and one opaque ring are formed each year, and therefore age may be determined by counting rings. The determination of precise age method was an important goal of the study. ICSEAF (1983) and Wysokiński (1983) attempted to standardize interpretation of age reading in otoliths and have proposed theoretical schemes for interpretation. However the otoliths displayed in these theoretical schemes have clearly arranged increments, translucent rings and false rings as examples. Otoliths with such clarity are rarely found under normal circumstances. Naturally, it is therefore required of the reader to make random estimate of the age from otoliths. The clarity of position and width of false rings, annuli, nucleus and increments may contribute to systematic and bias error (Wysokiński, 1983). A lot of confusion exists on the position of the first annulus and that of the pelagic rings (Botha, 1971; Wysokiński, 1983; ICSEAF, 1983; Lleonart and Morales, 1985; Morales-Nin, 1987; Gordoa *et* al., 2001). This study aims to establish a relationship between annulus formation and otolith growth to aid in clarifying this concern. The identification of the first annulus is of great importance in this study.

There is a relationship between otolith weight and age of many different species (Pawson, 1990; Worthington et al., 1995a.b; Francis and Campana, 2004; Francis *et al*., 2005). This relationship has great potential for estimating age and age structure in fish populations (Worthington *et al*., 1995a). According to Boehlert (1985) the utilisation of otolith size could be better to understand fish age compared to fish length. This technique is a faster and less expensive method (Francis and Campana, 2004) and would be preferable when the ages of a great number of individuals are required. Given the large number of otoliths that need to be read every year, the lack thereof in Namibia and the backlog of otoliths not yet read in Namibia. This method is well worth investigating for Namibian hake.

Growth of Cape hake has been determined by length frequency analysis and age/length information (Morales-Nin, 1991). The recruitment of Cape hake has been predicted with the use of multinomial logistic regression incorporated with environmental factors (Voges *et al.,* 2001). The microstructure of otoliths from Cape hake has been examined (Morales-Nin, 1987, Gordoa *et al.,* 2001) and chemical composition analysed (Morales-Nin, 1986). According to Botha (1971), *M. capensis* reach a maximum length of 112 cm and *M. paradoxus* 92 cm. A variety of studies has approximate separate growth parameters for the two species, and separated by sex (Botha, 1971; Kolender, 1975; Prenski, 1978; Lleonart *et al*., 1981). Males mature earlier than females in both species, and females differ in their higher L_∞ (asymptotic length) and lower growth coefficient (Kolender, 1975). The growth between the two species was not considered predominantly detailed, and consequently the use of a single, shared set of growth/maturity parameter values was acceptable (Punt and Leslie, 1991). *M. capensis* matures at a length of 30 cm, and all fish over 40 cm are considered mature (Prenski, 1980). Earlier studies on age and growth of *M. capensis* have been carried out by various authors, otoliths have been widely used to study the growth of the species (Bas, 1969; Botha, 1971). Recent studies on the age and growth of *M. capensis* have been limited. European hake, which are closely related to *M. capensis* have extensive literature on age and growth estimates. Notwithstanding all the studies conducted on this species, there is yet to be developed a validated method for the ageing of its otoliths (Gordoa *et al.,* 2001). The reason for the large annual variation of growth parameters was due to incorrect interpretation of otoliths in European hake (Lleonart and Morales, 1985). The vagueness of ring pattern in European hake complicates interpretation of otoliths (Morales-Nin *et al.*, 1998). Reliable identification of the first growth zone can considerably improve the precision in individual age estimations for young fish (Campana, 2001). The difficulties in interpretation in otoliths of young *M. capensis* necessitate the development of reliable and consistent age determination. In order to fill in this gap in the research on annulus formation in otoliths of Namibian hake and investigate the current demographics of the population, I focused my research on five specific objectives:

1.1 Otolith Growth Pattern

The aim of the study was to investigate the age determination by means of otolith interpretation for *M. capensis*. In particular, to evaluate the link between otolith growth, otolith ring interpretation and fish length in 2003.

1.2 Age Determination

The objective was the development of a precise ageing method using data from 2003. To determine the time of annulus formation and birth date of *M. capensis* in 2003.

1.3 Age structure for 2003

The objective was the construction of an age length key (ALK) based on age information of *M. capensis* during 2003. Consequently, the determination and evaluation of the age structure during 2003.

1.4 Growth Rate Determination

To describe the growth pattern of *M. capensis* and to estimate the von Bertalanffy growth function by direct age estimation using sagittal otoliths for 2003.

1.5 Relationships between otolith weight, age and fish length

The objective is to look for alternative techniques of determining the proportions in each age class of Namibian hake for stock assessment purpose, in particular, to determine the relationship between otolith weight, fish length and age.

2. Materials and Methods

2.1 Sampling and Otolith Preparation

Swept-area biomass surveys for hake are conducted annually (during January and February) to obtain an index of abundance, to determine the geographical distribution and collect biological information from the stock (Figure 1). During the hake research survey in 2003, conducted on the commercial vessel (F/V "Blue Sea 1"), fish were measured to the nearest cm in total length (TL), sex, body mass and maturity stage were recorded. A sub-sample of otoliths (n=804) were extracted (approximately 10 per station), using stratified random sampling, cleaned and stored dry in paper envelopes and later prepared and read in the laboratory using the whole otolith method.

The whole otolith method: Otoliths were left in tubes with distilled water for at least a week, to increase the contrast between opaque and hyaline zones.

The size structure of the *M. capensis* population was determined by examination of the length-frequency distribution from January to February 2003. The size structure of the population during the study was generated by pooled and raised samples from the survey conducted during the two months (January and February) in 2003.

2.2 Otolith measurements and interpretation

In this study, the term "growth zone" refers to a section of the otolith which consists of an opaque and a translucent band. The opaque band is the wider zone, white when viewed against a black background under reflected light and the translucent, narrower band, also called hyaline ring, is dark when viewed against the same conditions. An annual growth zone (AGZ) represents one or more growth zones comprising one year of growth. The rings of the suspected annual growth zones (r1, r2, r3, r4) and their respective false rings (f1,f2,f3,f4) on the whole otoliths, were measured at 10 x magnification on the lateral face, using a ocular micrometer in the eyepiece of the Leica dissecting microscope. A false ring is a translucent (hyaline) band that may occur with the annual growth rings denoted as (f1, f2, f3, f4), respectively. Pelagic rings (P1, P2, P3) are false rings, which occur in the first year of life. An annulus is the translucent margin at the end of one year's growth, denoted as (r1, r2, r3, r4), respectively. The birth date for *M. capensis* on a calendar-year basis has been agreed upon by convention to be 1 January due to the convenience in data collection and stock assessment purposes (Gordoa *et al.,* 1995).

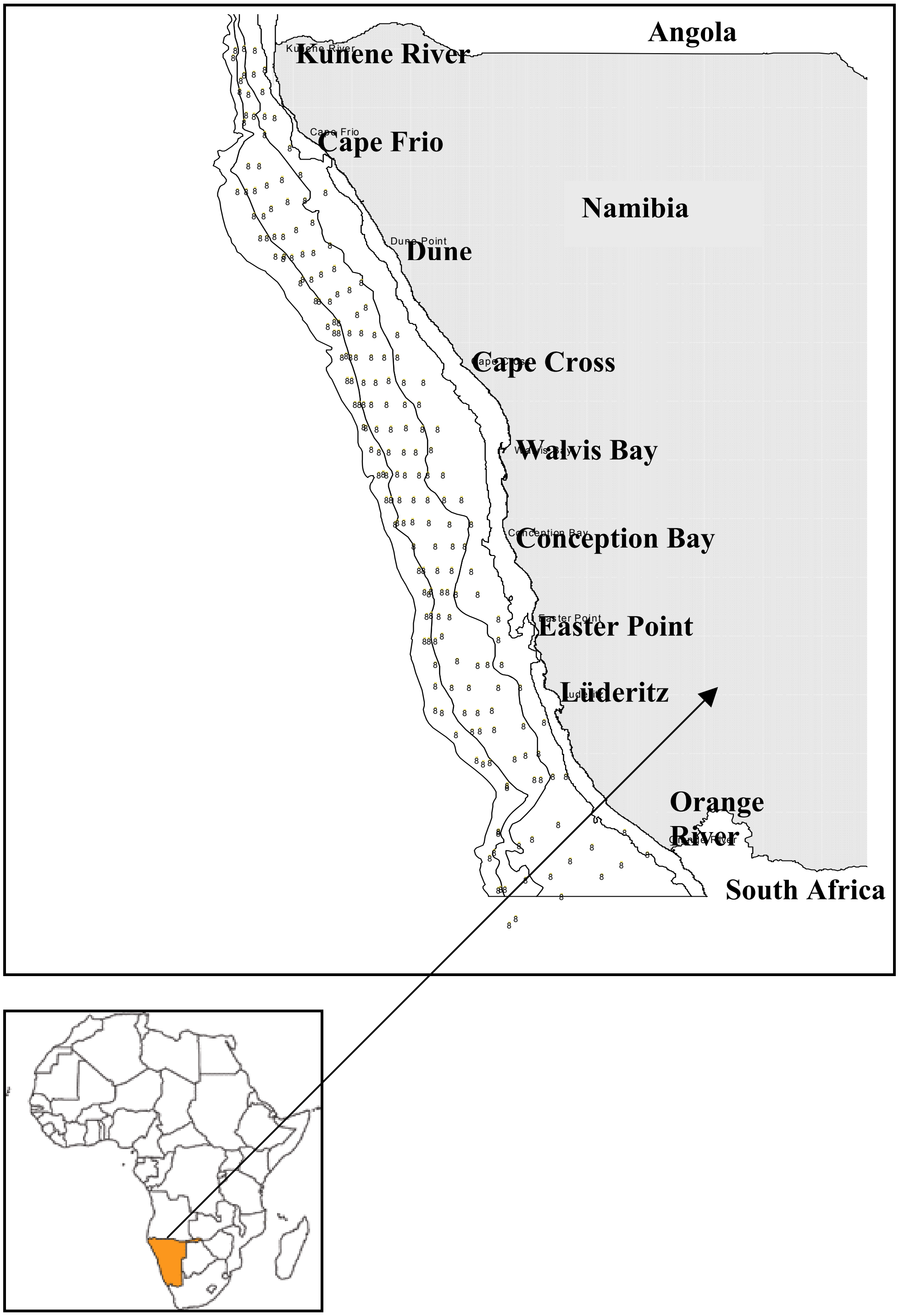

Figure 1. Stations layout of the entire region covered during the 2003 hake biomass survey (with depth contours of 100, 200, 500 and 1000 m).

2.3 Otolith Growth Patterns

The total length measurement between the anterior and the posterior tip was measured for each otolith (n=613) with a pair of electronic caliper and recorded as the Otolith Diameter (OD) in mm. The selected undamaged otoliths were examined under a light microscope (fitted with ocular micrometer) at 10 x magnifications against a dark background and the diameter of each translucent ring measured. It was observed that counting of the rings was much easier than determining the diameter measurements; rings were not essentially clear on the log axis of the otolith. Therefore readings were not obtained from all the otoliths examined. If most of the outline of the ring could not be clearly seen, yet it was a definite ring, it was counted for age determination but not measured. From these measurements the mean diameter, range, standard deviation and coefficients of variation for each translucent band were calculated. After which, the mean diameter, standard deviation and coefficients of variation for each translucent band separated by age were calculated. In this study, the mean was calculated as the sum of the observed values, divided by the number of them. The standard deviation was calculated as the sum of the squares of the differences (or deviations) from the mean, divided by the total number of observations minus one. The coefficient of variation was calculated as the standard deviation divided by the mean, expressed in percentage.

These otolith diameter measurements also provided calculations of observed and predicted ogives of otolith length against age. Ogives are graphs that represent the cumulative frequency as a fraction of each length class found at each age. The frequency distribution how many observations on a given variable have a particular attribute. A line plot of the cumulative frequency enables characteristics to be easily compared (Kenney and Keeping, 1962). The relationship between variable x and y is often ‘S’ shaped, the variable predicted is continuous, it can be assumed the errors are normally distributed. These ogives demonstrated visually the differences in location of the hyaline ring formed in the otolith, represented as otolith diameter, mm. An approximate estimate of mid-point was described as observed 50 % fraction complete ring formation.

Subsequently, otolith growth was analysed in relation to fish growth. The sizes of the fish during the formation of each ring were calculated using back-calculation formula for a power relationship for combined sexes. The conversion of the power relationship to a linear form, by taking the natural logarithm on both sides of the equality sign; yield the back-calculation formula (Folkvord and Mosegaard, 2002):

$$\boldsymbol{L_i} = (\boldsymbol{S_i} \ / \ \boldsymbol{S_c})^v . \boldsymbol{L_c} \quad \text{……………………..} \quad (1)$$

Where *Li* = the back-calculated length of fish when the ith increment was formed;

Lc = the length of fish at capture;

Si = the otolith length (diameter, longest part, tip to tip) at the ith increment; and

Sc = the otolith length (diameter) at capture;

The value of v (exponent in power equation) was inferred from the regression plot of fish length against otolith length diameter (Figure 8).

2.4 Age Determination

I read all undamaged readable samples (n=757) twice with a substantial time interval between readings (more than a year) by the author without prior knowledge of the fish length, previous age estimates. The first reading was performed in 2004 and used for the hake stock assessment for 2005 (Wilhelm and Brinkman, 2004). Otoliths were declared unreadable and rejected due to various reasons, listed below:

- Otoliths that showed signs of deposition of calcified material and physical deterioration;
- Broken or damaged otoliths; and
- The translucent rings were too vague to make out a decent pattern.

Otoliths were considered readable even though they had the following common sources of error and therefore could pose a significant obstacle in precise interpretation of annuli.

- "Crowding" of annuli near the edge of the otolith; and
- Inconsistent annulus widths.

The majority of Cape hake otoliths have these optical features within their structure. "Bands" which are spans of translucent rings with very narrow spaces between successive rings, was also a common feature within the structure of the Cape hake otolith. Translucent ring width was variable in most otoliths with a typical pattern of narrow multiple rings near the edges.

Age group assignment to an individual fish was done as described in (ICSEAF, 1983). On each sagittal otolith (n=757), firstly the number of translucent bands and false rings were counted and the results expressed in terms of age groups. Then, the edge of the each otolith was recorded as either hyaline (incomplete last annual growth zone) or opaque (forming new annual growth zone). Precision was assessed using four measurements of bias. Percent Agreement, Average Percent Error (APE, Beamish and Fournier, 1981) and the Coefficient of Variation (CV, Chang, 1982) and age bias plots

(Campana et al., 1995) to compare reproducibility of age determination between readings of the same reader.

The percent agreement was taken as the fraction of otoliths where either both readings agreed (100%) or both differed (0%) (Panfili and Morales, 2002). Bowker's test was done to determine if systematic difference exists between paired ages assignment and considers only the samples where the age was not agreed upon. The hypothesis that a table matrix, consisting of age estimations of a sample into categories (e.g. two age readings of the same reader), is symmetric about the main diagonal. The test statistic, a chi-square variable with m(m-1)/2 degrees of freedom for a table that has no empty cells (Bowker, 1948; Hoenig *et al.*, 1995).

$$X^2 = \sum_{i=1}^{m-1} . \sum_{j=i+1}^{m} \frac{(n_{ij} - n_{ji})^2}{n_{ij} + n_{ji}} \quad \ldots\ldots\ldots\ldots \quad (2)$$

where: n_{ij} = the observed frequency in the ith row and jth column

n_{ji} = the observed frequency in the jth row and ith column

The summation is over all the cells above the diagonal. These cells are paired with the corresponding cells below the diagonal (Bowker, 1948; Hoenig *et al.*, 1995).

The APE was calculated as:

$$APE = 100\,\% . \frac{1}{R} \sum_{i=1}^{R} \frac{/ X_{ij} - \overline{X}_j /}{\overline{X}_j} \quad \ldots\ldots.. \quad (3)$$

And CV was calculated as:

$$CV = 100\% \cdot \frac{\sqrt{\sum_{i=1}^{R} \frac{(X_{ij} - \overline{X_j})^2}{R-1}}}{\overline{X_j}} \quad \ldots\ldots\ldots \quad (4)$$

where X_{ij} is the ith age estimation of the jth fish, $\overline{X_j}$ is the mean age of the jth fish, and R is the number of times each fish is aged. Bias plots were plotted from the mean age of each reading at the age group of the reference age. The reference age was taken as the second age estimation (reading).

A marginal increment analysis (MIA) was conducted. This technique determines the time of annulus formation by measuring the increment of the opaque ring deposited after the last identifiable annulus of the otolith over time (Panfili and Morales, 2002). Marginal increment analysis uses the relative marginal distance (RMD) ratio (Panfili and Morales, 2002):

$$RMD = AMD / D_{i,i-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (5)$$

where the absolute marginal distance, AMD, is the width from the last annulus to the edge of the otolith and $D_{i,i-1}$ is the width separating the last two annuli. Without Cape hake otolith monthly sample data in Namibia during the last decade, had made it difficult to evaluate seasonal growth and annulus formation. The existence of a simple relationship between the otolith diameter (OD) and the fish Total Length made it possible to calculate the size of the fish when each of the translucent rings was laid down, which is mostly once a year throughout the life of the fish. Therefore, in this study, measurements of AMD and $D_{i,i-1}$ were used to calculate the growth curve of the precise age of Cape hake for the first four years.

2.5 Age structure in 2003

Age-length key (ALK), a table with estimations of proportions at age for each length class was used in this study. When the catch in numbers at length, from the length frequency of the large sample, is multiplied with the ALK, a matrix of catch-at-age is obtained (Mesnil, 2002).

$$CAA = \sum CAL \times p_i \;\ldots\ldots\ldots\ldots \text{ Equation (4)}$$

Where, $N_i = CAL =$ number of fish caught at each length

$p_i =$ proportion at age for a given length obtainable from ALK

2.6 Growth Rate Determination

A von Bertalanffy growth function (VBGF) was fitted to observed length-at-age data for 2003 (Beverton and Holt, 1957).

$$\boldsymbol{L_x} = \boldsymbol{L_\infty}\left\lfloor 1 - \boldsymbol{e}^{-\boldsymbol{K}(\boldsymbol{x} - \boldsymbol{t}_0)} \right\rfloor \;\ldots\ldots\ldots\,.\,\ldots.. \qquad (1)$$

Where, $L_x =$ length at age x

x = age in years

$L_\infty =$ the maximum theoretical length *M. capensis* can attain

K = growth coefficient

$t_0 =$ age of fish at length $L_x = 0$

Weight-at-age was calculated using VBG coefficients, together with weight-length relationships calculated from the biological information of each otolith (Wilhelm, 2006).

$$W_L = a \,.\, L^b \quad \text{………………….. Equation (2)}$$

Where, W_L = weight at length L; a and b = constants;

A description of the immature and mature stages for *M. capensis* has been determined such that Stages 0 (unknown/juvenile), 1 (male / female inactive), 2 (active), 3 (ripe), 4 (ripe-and-running) and 5 (spent) for *M. capensis* (Botha, 1986). Accordingly stage's 0 to 2 from biological samples of the survey were considered immature and stage's 3 to 6 was considered mature in this study. Proportion mature at each age was plotted against age and a logistic function fitted (Wilhelm, 2006):

$$Proportion\ mature = \frac{1}{(1 + e^{(-(age - a_{0.5})/\delta)})}$$

Where, $a_{0.5}$ = age at 50 % maturity and δ is a constant.

2.7 Relationships between otolith weight, age and fish length

The total otolith weight (g) were taken of the undamaged otoliths (n=596) using a 0.0001 g precision scale. The fragile nature of the otoliths made it difficult to use only a specific side (left or right) of the pair. Thus, otoliths of Cape hake were used interchangeably and with assumption that the difference between left and right side otoliths was negligible.

The relationship between otolith weight and total fish length was plotted for *M. capensis*. A power curve was fitted using least-squares linear regression was used to determine the relationship between otolith weight and age for *M. capensis*. The mean weight of otoliths for each age was also determined and compared with the observed otolith length measurements as well as with predicted measurements (Fletcher, 1991).

3. Results

The individual data for length-frequency distribution for each month was unavailable. The monthly survey data, January and February, in Namibia are not examined separately. The length frequency distribution of the biomass survey caught of *M. capensis* caught off Namibia during January and February 2003, ranged from 16 cm to 60 cm with a mode of 8.8 % of the population at 28 cm (Figure 2). The length frequency distribution of the commercial fleet of *M. capensis* caught during January to December in 2003, ranged from 20 cm to 74 cm with a mode of 6 % at 36 cm (Figure 2).

3.1 Otolith Growth Patterns

Up to three false ring termed P3, P2, P1 were visible before the first annual ring (Table 1), but the number of individuals with P3 was very low (n=4). The pattern of false rings continued with decreasing frequency after the first annulus had been formed. The frequency for the ages formed indicated that age 1 had the highest number of individuals (n=145), followed by age 2 (n=141) and age 4 (n=103), respectively (Table 1). The mean calculated otolith diameter (tip to tip) for each translucent ring of hake (Table 1) was similar to mean calculated otolith diameter (tip to tip) separated for fish aged 0 to 4 for *M. capensis* (Table 2).

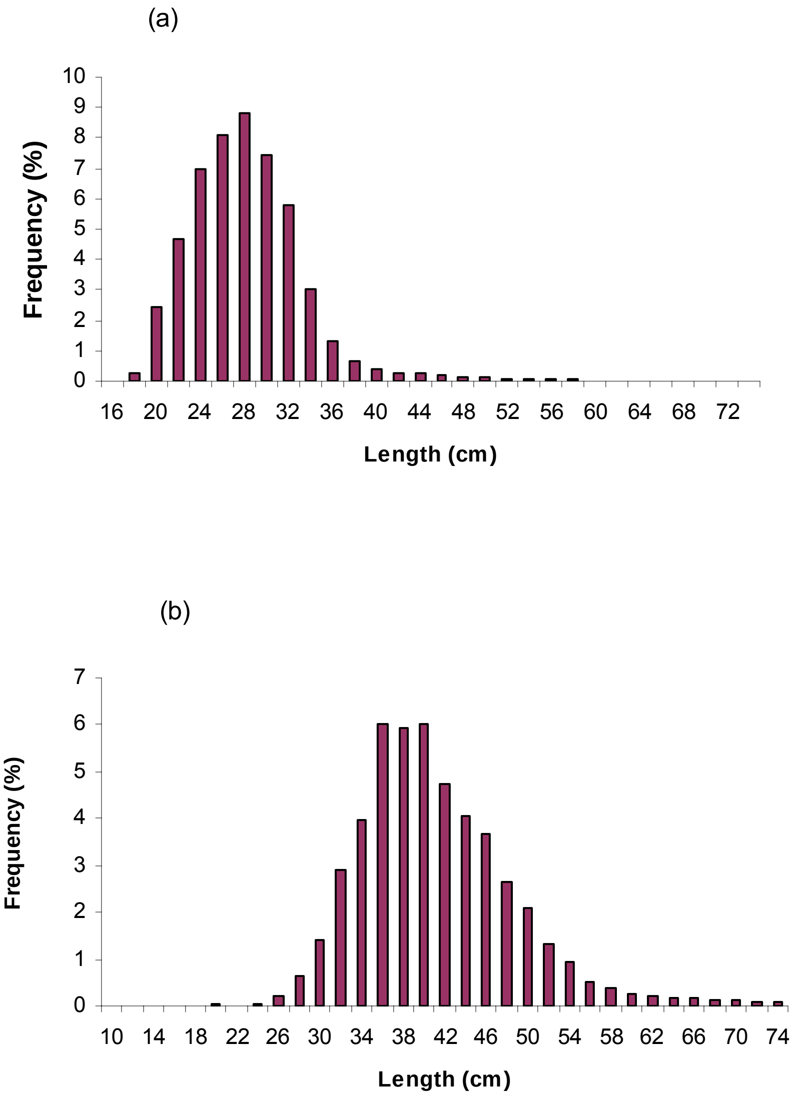

Figure 2. *(a)* Length frequency distribution of *M. capensis* caught during the biomass survey in January and February 2003 off Namibia. Frequencies are presented in percentage of total number in millions km^{-2} for January and February. *(b)* Length frequency distribution of *M. capensis* caught by the commercial fleet off Namibia in January to December 2003. Frequencies are presented in percentage of total number in million for the year.

The general pattern for the occurrence of rings formed on the otolith of *M. capensis* showed more scatter with increasing otolith growth, with f2 (n=27) and f3 (n=8) as the exception (Figure 3). Averages of otolith diameter (mm) and ages for 5 to 12, showed a greater overlap, similarities between mean and mode (Figure 4). The low frequency of older *M. capensis* caught during the biomass survey 2003, and the difficulty in interpreting the ring pattern and age estimation, had introduced discrepancies especially in the age 7 to 12 classes (Figure 4). Age 7 and 8 had produced very similar results; where as age 9 and 11 has larger mean, mode, and range compared to age 10 and 12, respectively.

Mean back-calculated lengths at each of the first four annuli (Table 3), indicated the reverse of Lee’s phenomenon, the trend for back-calculated lengths of older fish’s earlier age to be systematically underestimated than the young fish at the same age (Smith, 1983). Mean back-calculated lengths at each of the four annuli were derived from power regression between fish length and otolith diameter, which had a relatively high correlation coefficient, and explained by the following equation (Figure 8):

$$L = 1.39 \times OD^{1.1717}$$

Table 1: Mean calculated otolith ring diameters (mm) separated for fish aged 0 to 4, for *M. capensis* collected in Namibian waters. (P3 = 1st pelagic ring, P2 = 2nd pelagic ring, P3 = 3rd pelagic ring; f1; f2; f3; f4 = False rings; Mean = average calculated for translucent bands (tip to tip) at each age; S.D. = standard deviation; C.V. = coefficient of variation)

Age	**No. indiv**	**P3**	**P2**	**P1**	**f1**	**f2**	**f3**	**f4**	**1**	**2**	**3**	**4**
0	47	3.9	5.17	5.58								
1	145	5.17	6.32	7.43	10.51				10.04			
2	141		6.8	7.33	10.38	12.7			9.547	12.46		
3	80			7.94	10.11	12.5	14.9		9.26	11.85	14.02	
4	103			7.18	11.2		16.4	17.3	9.406	12.2	14.31	16.69
No rings		4	22	117	61	27	8	7	290	220	120	99
Mean		4.53	6.1	7.09	10.55	12.6	15.6	17.3	9.564	12.17	14.17	16.69
S.D		0.9	0.84	0.89	0.463	0.13	1		0.34	0.302	0.21	
CV		19.8	13.8	12.6	4.391	1	6.36		3.555	2.486	1.484	

Table 2: Mean calculated otolith diameter tip to tip at each translucent band for rings of *M. capensis* otoliths colleted off Namibian waters during 2003. (P3 = 1st pelagic ring, P2 = 2nd pelagic ring, P3 = 3rd pelagic ring; f1; f2; f3; f4 = False rings; Mean = average calculated for translucent bands (tip to tip) irrespective of age; S.D. = standard deviation; C.V. = coefficient of variation, q1; q3 = lower and upper quartile, I-range = inter-quartile range)

	P3	**P2**	**P1**	**f1**	**f2**	**f3**	**f4**	**r1**	**r2**	**r3**	**r4**
q1	3.83	5.50	5.80	10.00	12.05	14.35	17.70	8.90	11.50	13.40	16.05
Min	3.60	4.60	4.50	8.20	11.20	14.10	14.40	7.30	10.10	12.10	14.00
Median	4.75	6.35	7.20	10.50	12.50	14.85	17.90	9.50	12.25	14.00	16.70
Max	6.30	7.90	8.90	12.20	13.90	15.70	18.80	12.30	15.20	16.30	19.80
q3	5.78	6.70	7.90	10.90	13.10	15.43	18.25	10.30	12.90	14.80	17.20
Mean	4.85	6.19	6.74	10.44	12.54	14.88	17.57	9.65	12.22	14.11	16.65
I-Range	1.95	1.20	2.10	0.90	1.05	1.08	0.55	1.40	1.40	1.40	1.15
S.D	1.31	0.88	1.24	0.73	0.75	0.66	1.46	0.99	0.94	0.90	0.91
C.V.	26.96	14.29	18.35	7.01	5.98	4.43	8.28	10.24	7.71	6.35	5.45

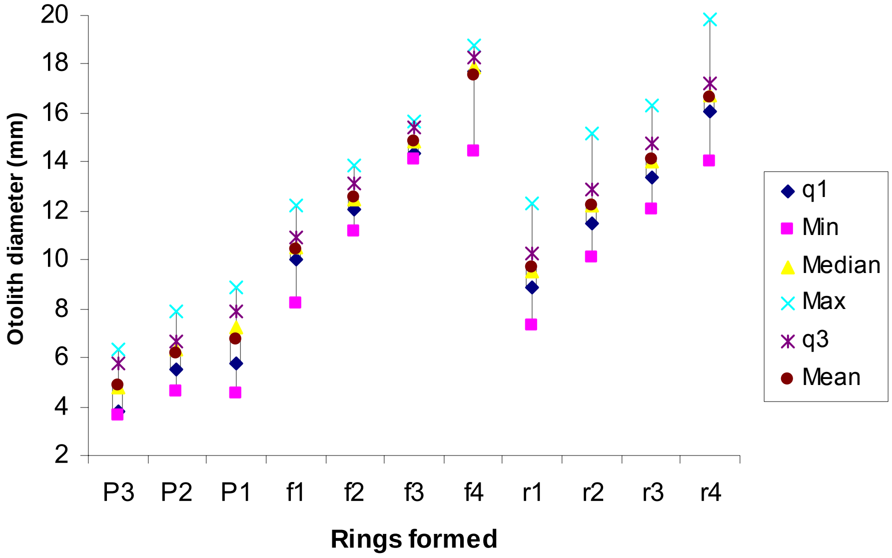

Figure 3. The proportion of translucent rings found at diameter formed on otoliths of *M. capensis* during the biomass survey 2003 off Namibian waters.

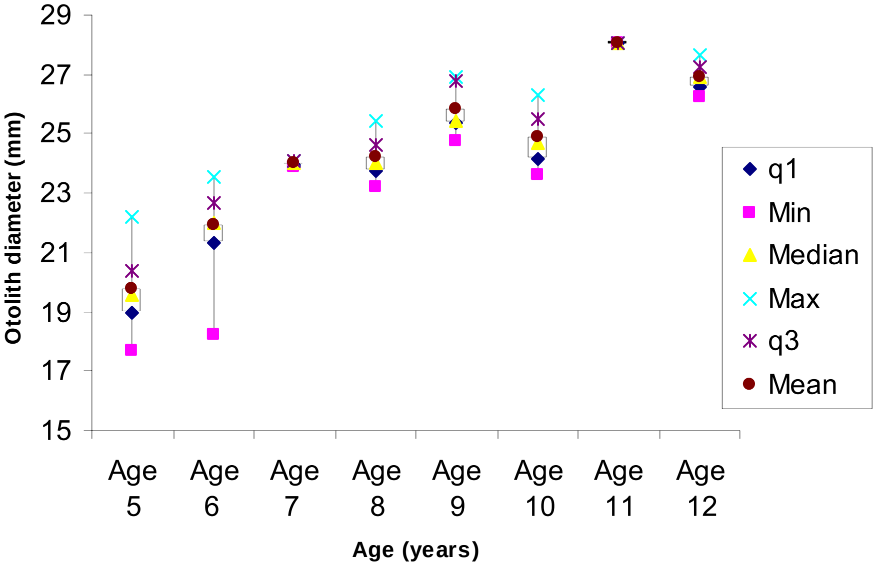

Figure 4. The proportion of ages found at diameter formed on otoliths of *M. capensis* during the biomass survey 2003 off Namibian waters.

Mean observed lengths-at-age were higher than mean back-calculated lengths for *M. capensis* and were probably due to the strong variation in size for each age class (Table 4). The relationship between observed lengths-at-age and predicted lengths-at-age was not significantly different ($x^2 = 0.8748$; d.f. = 5; $p < 0.05$) for the *M. capensis* population. There was no evidence in location overlap between ages 1 to 4 (annuli), when hyaline ring formation occurred (Figure 5). This trend was also observed in the annuli of the 1st and 2nd ages with their respective false rings, f1and f2 (Figure 6).

However, the pelagic rings had shown overlap in their location in *M. capensis* otoliths, especially during very earlier stages of growth in fish length < 12 cm (Figure 7). The 50 % observed location of hyaline ring formation on the otolith diameter for fish was calculated from the ogives and compared with the mean back-calculated fish length (Table 5).

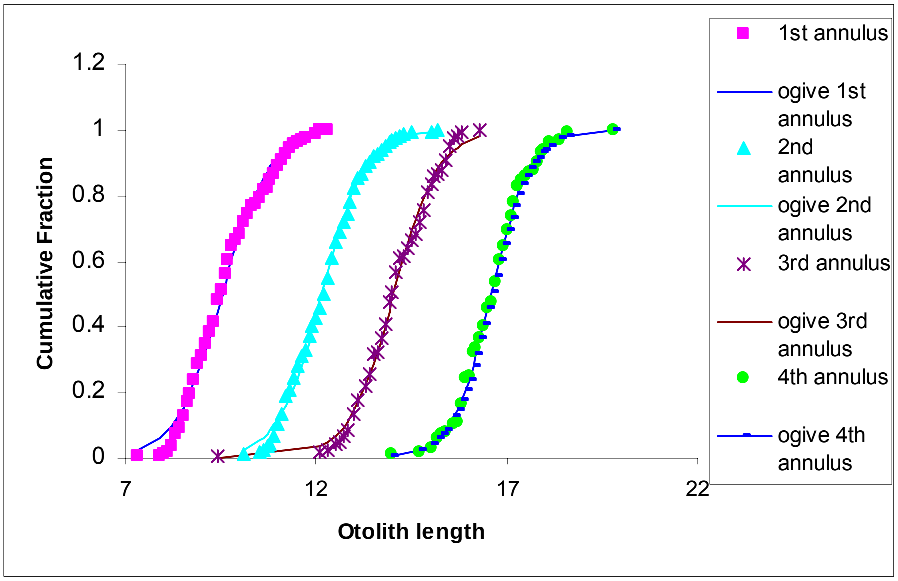

Figure 5. Performance: Cumulative distribution of annuli (ages 1 to 4) of *M. capensis*. These ogives demonstrate the differences in otolith diameter, location frequency between the four ages (annuli) and predicted ring location. An approximate estimate of mid-point or any comparative parameter is described as ‘observed location’ and can easily be made visually from such plots.

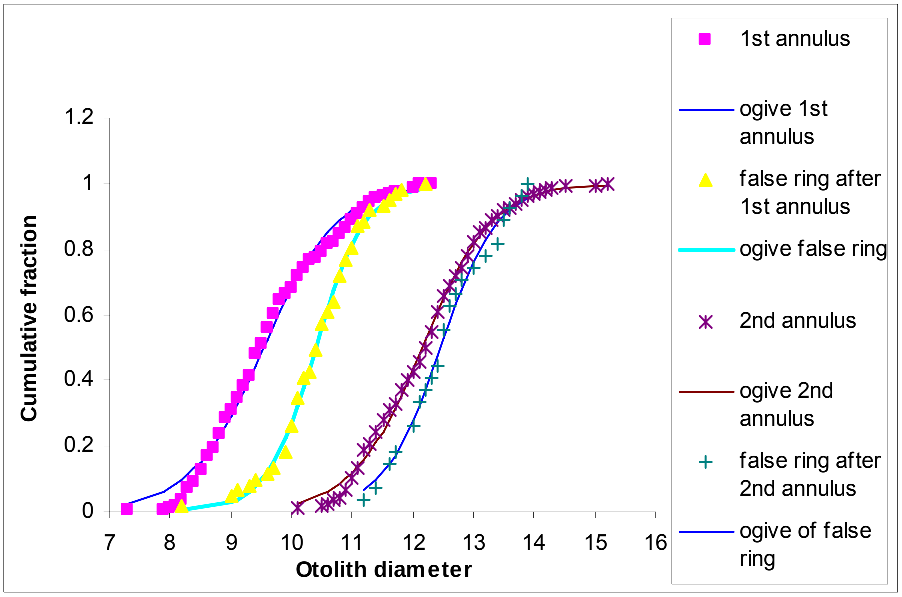

Figure 6. Performance: Cumulative distribution of 1st and 2nd annuli and their respective false rings of *M. capensis*. These ogives demonstrate the differences in otolith diameter, location frequency between the first two annuli and their respective annuli and predicted ring location. An approximate estimate of mid-point or any comparative parameter is described as ‘observed location’ and can easily be made visually from such plots.

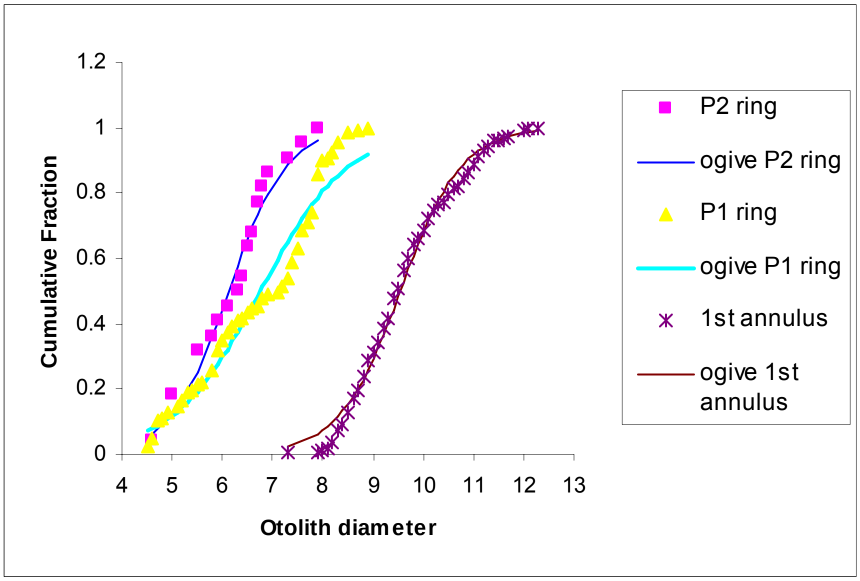

Figure 7. Performance: Cumulative distribution of pelagic rings and 1st annulus of *M. capensis*. These ogives demonstrate the differences in otolith diameter, location frequency between the pelagic rings and 1st annulus and predicted ring locations. An approximate estimate of mid-point or any comparative parameter is described as 'observed location' and can easily be made visually from such plot

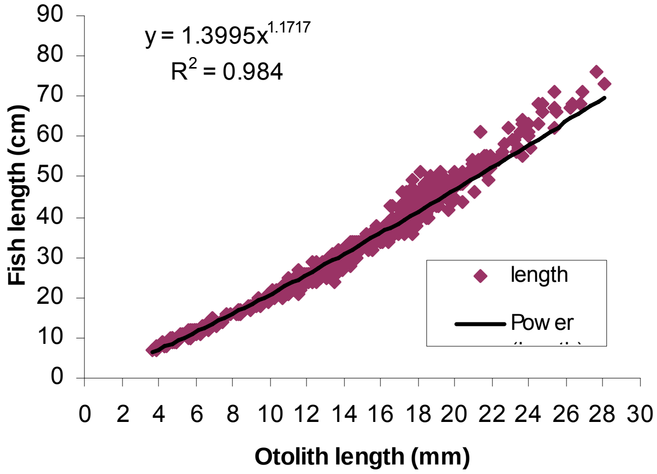

Figure 8. Power regression between fish length and otolith diameter (length) for *M. capensis* during biomass survey in 2003 in Namibia.

Table 3: The mean back-calculated fish lengths at ages for *M. capensis*.

Age	P3	P2	P1	r1	f1	r2	f2	r3	f3	r4	f4
0	6.34	9.152	10.76								
1	9.07	11.59	14.04	20.22	20.95						
2		11.94	13.67	19.05	19.88	25.99	26.08				
3			14.87	18.55	20.46	24.8	25.52	32.33	32.33		
4			13.55	19.2	22.18	26.04		31.22		38.18	39.15
mean	7.7	10.89	13.38	19.26	20.87	25.61	25.8	31.78	32.33	38.18	39.15

Table 4: Mean, minimum and maximum lengths-at-age (cm) and statistics for observed actual and back-calculated ages 0 to 4 years for *M. capensis* in 2003.

	0	1	2	3	4
Back-calculated					
Mean	10.66	19.26	25.6	31.78	38.18
Min	5.761	13.4	17.2	25.89	32.17
Max	16.65	26.14	33.8	35.75	46.08
S.D	1.994	2.303	2.45	2.034	3.201
n	141	284	215	52	98
Observed					
Mean	11.61	22.8	28.7	32.81	40.14
Min	7	16	23	27	33
Max	17	29	34	49	51
S.D	2.317	2.859	2.71	3.505	3.252
n	95	131	154	98	139

Table 5: Observed mean otolith diameter, mean back-calculated fish length, mean otolith diameter and fishlength calculated from ogives. (Mean OD = Mean observed diameter in mm; Mean B.F = Mean back-calculated fish length in cm; Mean OD from ogives = Mean otolith diameter calculated from Ogives; Mean F from Ogives = Mean fish length calculated from ogives).

	P3	P2	P1	f1	f2	f3	f4	r1	r2	r3	r4
Mean OD	4.9	6.2	6.7	10.4	12.5	14.9	17.6	9.7	12.2	14.1	16.7
Mean B.F	7.7	11	13	20.9	25.8	32.3	39.2	19	25.6	31.8	38.2
Mean OD from Ogives	3.9	6.3	7.2	10.5	12.5	14.4	17.9	9.5	12.2	14	16.7
Mean F from Ogives	6.9	12	14	22	27	31.9	41.1	20	26.2	30.8	37.9

3.2 Age Determination

Age estimates were produced from 757 otoliths after the rejection of unreadable or damaged otoliths (n=47). Thus 94 % of the whole sample was successfully analysed. The percent agreement calculated between two readings was 66.3 % in otoliths of Cape hake with ages ranging from 0 to 13 years. The repeated age estimates were relatively precise with 70 % of the otoliths assigned the same age for young individuals, in each round; 100 % of the estimates ± 0 year; 76 % ± 1 year; 73 % ± 2 years; 73 % ± 3 years. Typically precision decreased with increasing age. The greatest discrepancy encountered was age 7 which had a 0 % percentage agreement. No individuals were assigned the age 11 for each round of age estimations.

The measurement of average CV between the readings was 12 %. In Table 6, the measurements of CV between readings for ages 0 to 13 are shown. Visual examination of all age estimations was very precise for *M. capensis* estimated at 0 to 13 years of age; the 95 % confidence intervals associated with age class estimates overlapping the 1:1 ratio line (Figure 9). However, the age class 11 was slightly underestimated in comparison with the other age classes. Bowker's test result for individuals older than 2 years, (x^2 = 21.78; d.f. = 30; p = 0.86) was used to compare the two readings and had indicated that Cape hake individuals was assigned ages without systematic disagreement (bias); thus the hypothesis of symmetry is accepted and the disagreement between the readings was due to simple random error.

Table 6: CV for each age group of *M. Capensis* for 2003. CV is noted as a fraction of the age group.

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**Overall**
2003	0.28	0.12	0.08	0.1	0.1	0.11	0.16	0.12	0.1	0.04	0.12	0	0.1208

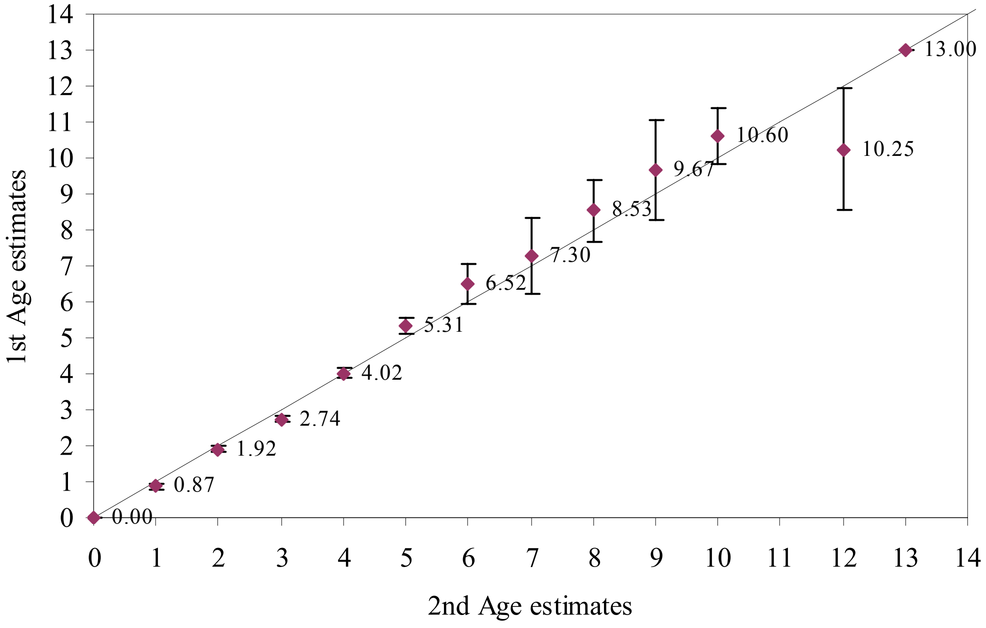

Figure 9. Age-Bias plot of otoliths (n=757) for *M. capensis* with the 1:1 ratio shown. Mean 1st Age estimates was plotted with a 95 % confidence interval.

The marginal increment analysis for data had indicated decreasing absolute marginal distance, AMD (the distance between edge and last annulus) with increasing age (Table 7). The relative marginal distance (RMD) for first four annuli (Table 8), had indicated the precise ages for Cape hake and was used to predict fish length from back-calculated data. The linear regression of fish length-at-precise age had produced a very high correlation coefficient, $R^2 = 0.9952$ and yielded the following formula (Figure 10):

$$L = 5.8927 \times \text{precise age} + 12.528$$

However, the observed fish length-at-precise age signifies an even higher correlation coefficient, $R^2 = 0.991$ with the formula (Figure 11):

$$L = 6.7046 \times \text{precise age} + 12.656$$

The assumption that most of the hyaline bands had formed up to age 4, implied that the mean relative marginal distance (RMD) values was formed a year ago prior to capture of Cape hake. Therefore, the month in which the hyaline ring had formed, since the capture date was from January to end of February, was:

r1 = 0.2 × 1 year = 0. 2 × 12 months = 2.4 months; less than two and half months prior to capture between October and November 2002;

r2 = 0.4 × 1 year = 0.4 × 12 months = 4.8 months; approximately 5 months prior to capture between August and September;

r3 = 0.3 × 1 year = 0.3 × 12 months = 3.6 months; three and half months prior to capture between September and October;

r4 = o.3 × 1 year = 0.3 × 12 months = 3.6 months; three and half months prior to capture between September and October.

3.3 Age Structure

The 2003 Age Length Key (ALK) calculated from data of biomass survey is given in Table 9, and applied to the biomass survey length-frequency distribution to calculate the age distribution, the catch-at-age for 2003, shown in Figure 12. The 2003 Age length key (ALK) calculated from data of biomass survey was applied to the commercial length-frequency distribution to calculate the age distribution, the catch-at-age for 2003, shown in Figure 13.

Table 7: Mean absolute marginal distance for annuli calculated during Cape hake survey in 2003.

Age	**r1**	**r2**	**r3**	**r4**
1	1.42			
2		1.01		
3			0.65	
4				0.91

Table 8: Relative marginal distance, RMD for annuli calculated during Cape hake survey in 2003.

Age	**r1**	**r2**	**r3**	**r4**
1	0.23			
2		0.41		
3			0.356	
4				0.30629

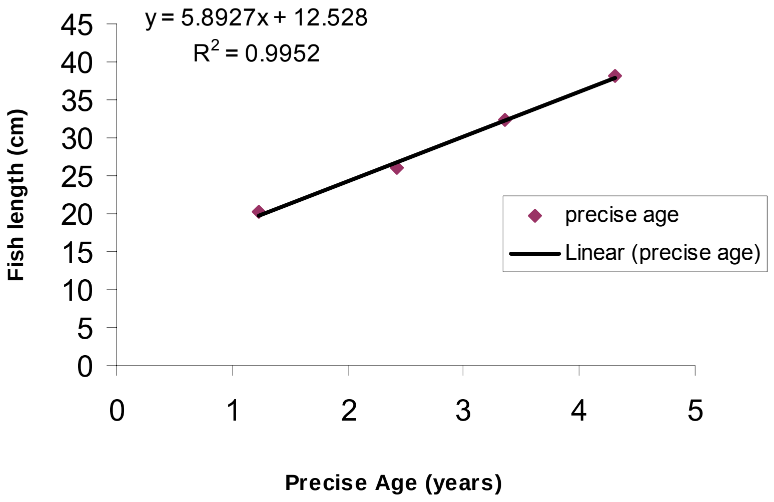

Figure 10. The linear regression plot of back-calculated total fish length against precise age. The marginal increment analysis estimation was used to acquire the precise age estimations and for the 2003 hake survey.

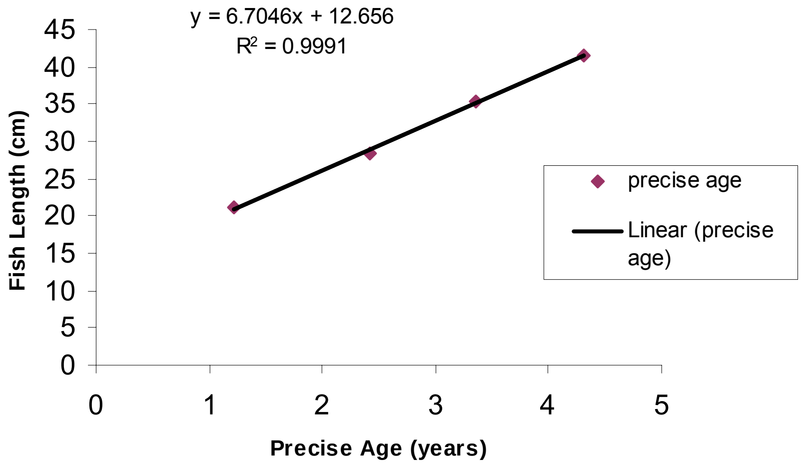

Figure 11. The linear regression plot of observed total fish length against precise age. The marginal increment analysis estimation was used to acquire the precise age estimations for the 2003 hake survey.

Table 9: 2003 Age length key (ALK) for *M. capensis*

	AGE GROUP (year)														
Length class (cm)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Grand Total**
<8	2														2
8	5														5
10	26														26
12	31														31
14	19														19
16	9	1													10
18	2	11													13
20		13													13
22		33													33
24		38	8												46
26		24	26												50
28		8	44	11											63
30		3	39	13											55
32			20	23											43
34			17	21	2										40
36				21	16										37
38				7	34										41
40				1	27										28
42				2	24	1									27
44					25	5									30
46					8	16	1								25
48					1	21	2								24
50				1	1	21	4								27
52					1	15	2								18
54						10	4								14
56						5	9	1	1						16
58						2	5	2							9
60						1	2	3	4						10
62							3	2	4						9
64								1	3		1				5
66								1	3	1					5
68									1	2	2		1		6
70										1	1				2
72										2	1	1	1	1	6
74											1				1
76												1	1	1	3
78									1				1		2
80													1		1
Grand Total	94	131	154	100	139	97	32	10	17	6	6	2	5	2	795
Mean Length	13	23	29	39	43	50	54	61	62	69	69	74	74	74	

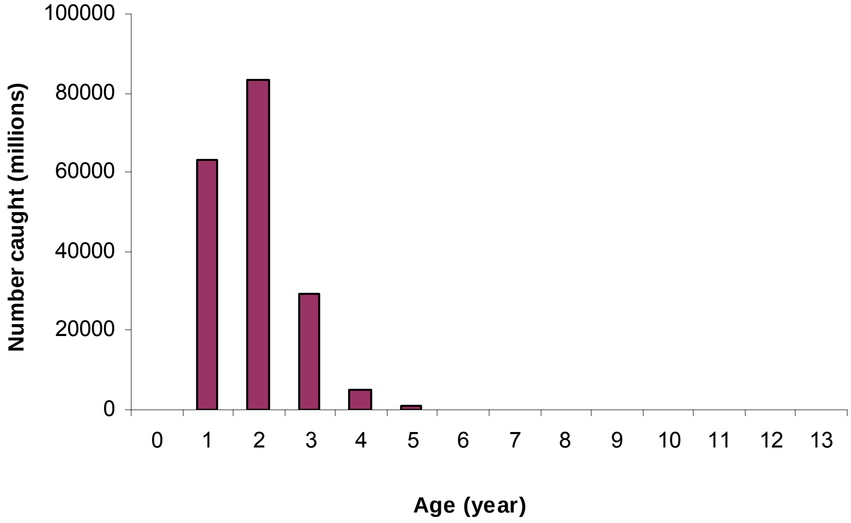

Figure 12. The catch-at-age for 2003 calculated from the biomass survey length frequency distribution and the ALK.

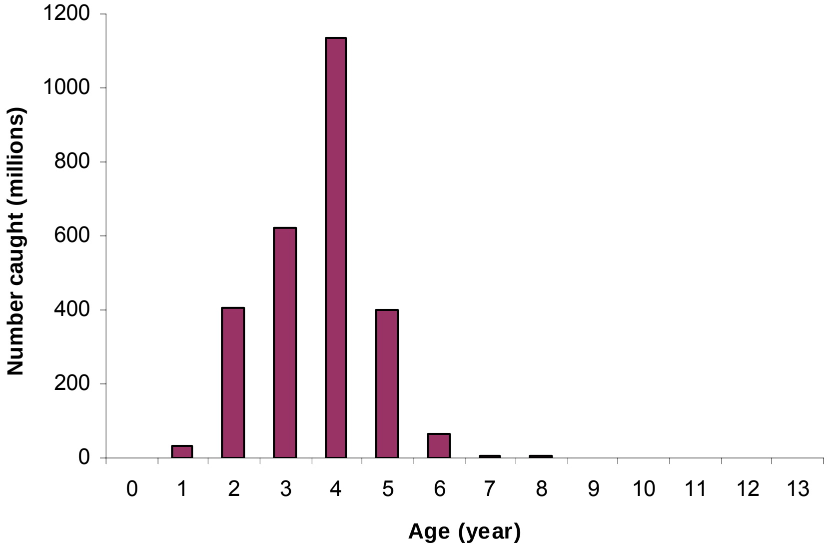

Figure 13. The catch-at-age for 2003 calculated from the commercial fleet length frequency distribution and the ALK.

3.4 Growth Rate Determination

The von Bertalanffy growth parameters were estimated for *M. capensis* by non-linear regression analysis fitting the von Bertalanffy growth function and the following parameters and Residual sum of squares (RSS) was determined:

L_{∞} = 123.13; K = 0.07; t_0 = -1.5; RSS = 9963

The resultant growth function was:

$$L_t = 123.13\left[1 - e^{-0.07(t+1.5)}\right]$$

The growth curve for *M. capensis* are presented in Figure 14. The weight-length relationship was presented by the following parameters:

a = 0.0076; b = 2.9739

The resultant non-linear power regression weight-length relationship function resulted with a very high correlation coefficient, $R^2 = 0.99$, illustrated in Figure 15, was:

$$W_t = 0.0076L^{2.9739}$$

The resultant non-linear power regression weight-at-age relationship functions based on the von Bertalanffy growth function parameters and *M. capensis* biological information from the biomass survey, indicated in Figure 16.

Figure 17, has shown that the age at 50 % maturation, $a_{0.5}$ for *M. capensis* was 1.67 years during 2003 assessment.

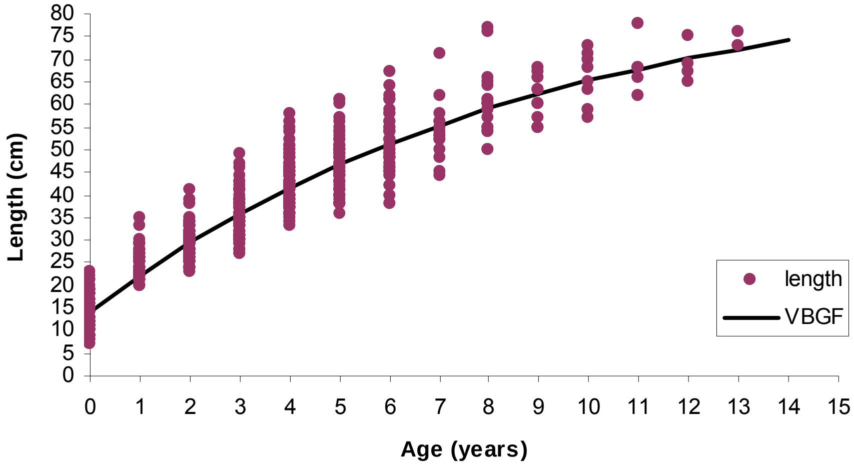

Figure 14. Estimates of mean length-at-age for *M. capensis*, based on the von Bertalanffy growth function parameters.

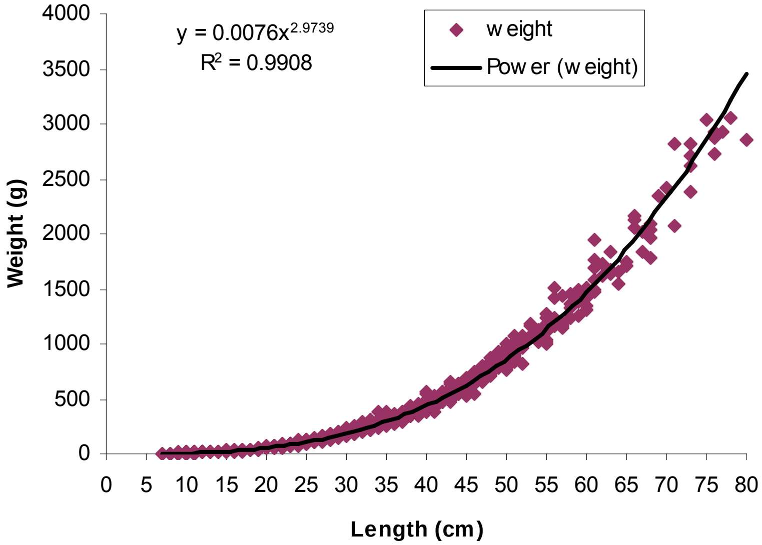

Figure 15. The non-linear power regression relationship between fish weight and fish length for *M. capensis* off Namibia in 2003.

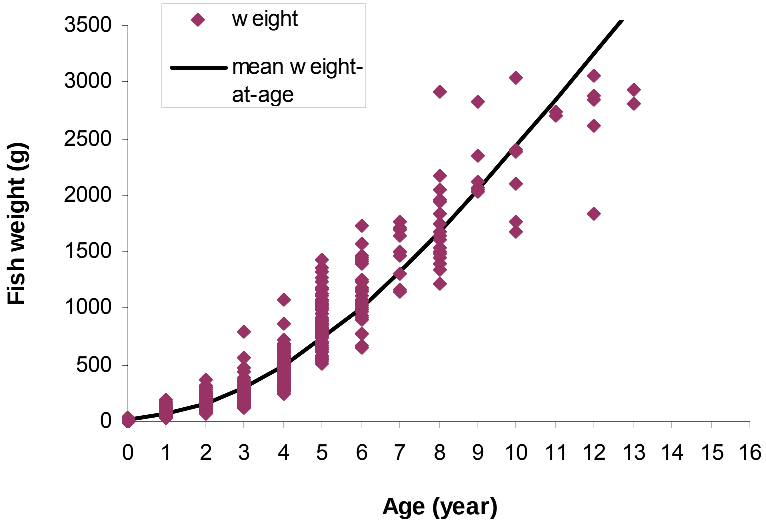

Figure 16. Fish weight against age for *M. capensis* obtained from the 2003 biomass survey fitted with a power curve.

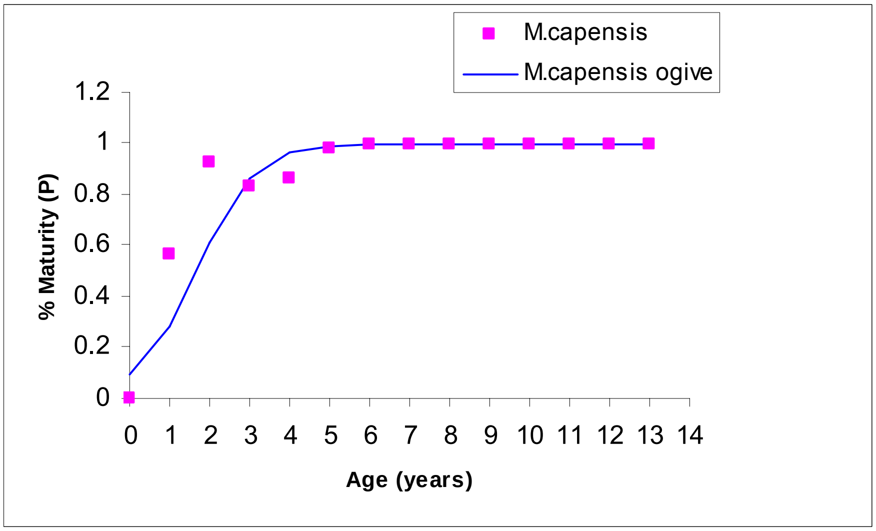

Figure 17. Percentage maturity against age of *M. capensis* off Namibia in 2003.

3.5 Relationships between otolith weight, age and fish length

The regression analysis of the relationship between otolith weight (OW) and age indicated linearity;

$$\mathrm{OW} = 0.0384 \times \mathrm{age} + 0.0074$$

And provided the best fit, with a correlation coefficient, $R^2 = 0.939$ (Figure 18). A regression analysis of fish length-at-age yielded;

$$L = -0.2372 \times (\mathrm{age})^2 + 8.1386 \times \mathrm{age} + 12.887$$

Explaining 94 % of variability in length, shown in Figure 19. The linear regression analysis of otolith diameter-at-age yielded;

$$L = -0.1348 \times (\mathrm{age})^2 + 3.2312 \times \mathrm{age} + 6.9531$$

And with a correlation coefficient, $R^2 = 0.9332$, Figure 20. The relationship between otolith weight and age (Figure 16) had a similar correlation coefficient than that otolith length and age. The fish length-age relationship yielded a similar correlation coefficient than that between fish length and age. Therefore, for *M. capensis* it is precise to use otolith weight to estimate age.

The relationship between otolith weight and fish length shown, in Figure 21, indicated a non-linear polynomial function:

$$OW = 5\exists - 05x^2 + 0.0025\,x - 0.027$$

And a relatively high correlation coefficient, $R^2 = 0.9768$. The relationship between otolith weight and otolith length shown in Figure 22, yielded a non-linear power function:

$$OW = 0.0001\,(OL)^{2.5498}$$

With a high correlation coefficient, $R^2 = 0.9935$. Therefore, both fish length and otolith length can be used to efficiently predict otolith weight.

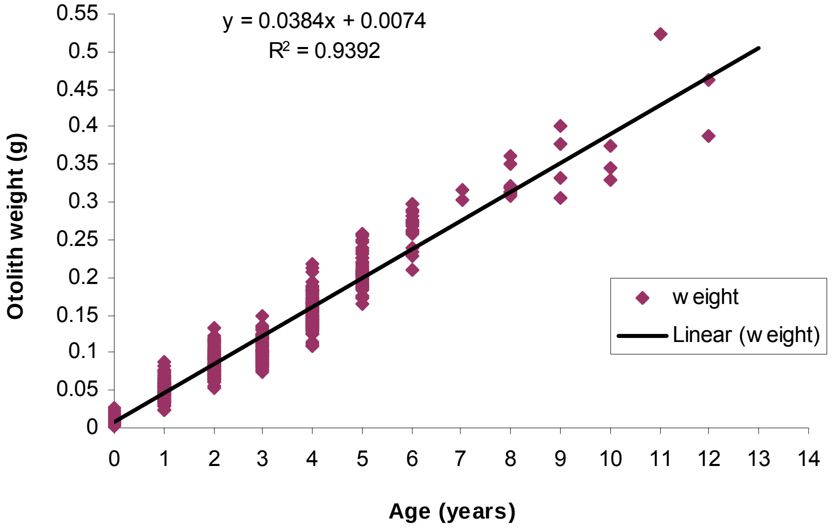

Figure 18. Linear regression relationship for otolith weight against age of *M. capensis* in 2003.

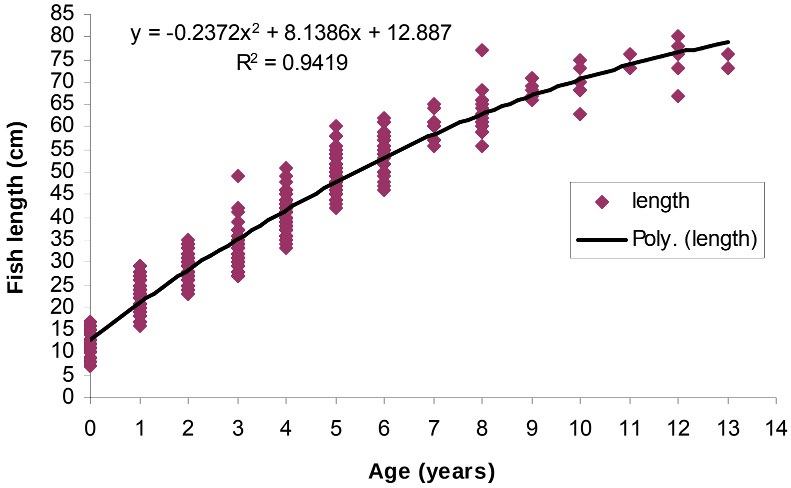

Figure 19. Linear regression relationship for fish length-at-age of *M. capensis* in 2003.

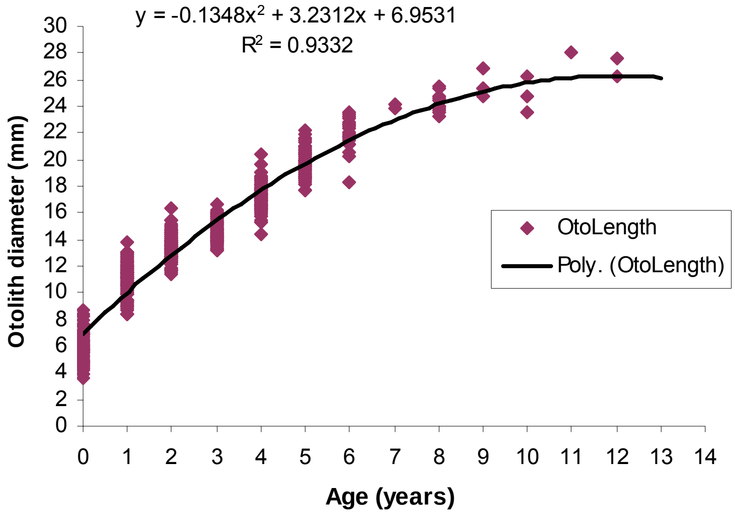

Figure 20. Linear regression relationship of otolith diameter-at-age for *M. capensis* in 2003.

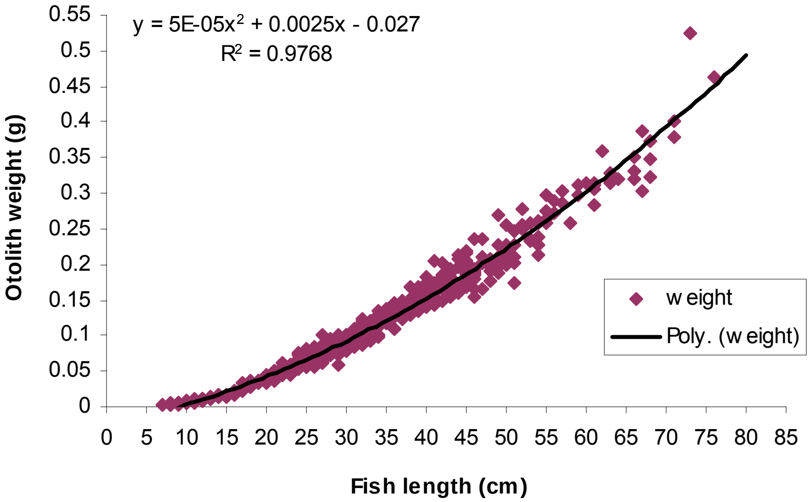

Figure 21. Relationship between otolith weight and fish length for *M. capensis* in 2003.

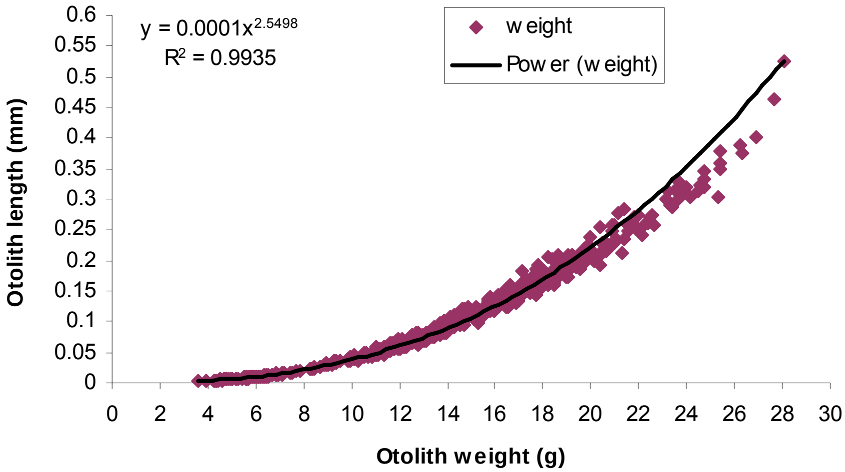

Figure 22. Relationship between otolith weight and otolith length for *M. capensis* in 2003.

4. Discussion

The modal size in the biomass survey for 2003 (mode = 28 cm) differed significantly with the commercial fleet's modal size (mode = 36 cm). The biomass survey's range had not included a significant part of the older age classes. Whilst the commercial fleet targets larger fish, the data shows that they are catching smaller fish. The larger individuals (<50 cm) were less represented in the recent years of sampling. The differences in survey and commercial size of *M. capensis* had suggested that it was impractical to determine a true modal size and hence precise estimates of fishing mortality can not be made with survey results.

4.1 Otolith Growth Patterns

M. capensis otoliths showed that the first annual translucent ring is preceded by three pelagic rings. The first pelagic ring laid down at 8 cm fish mean length was rarely visible. The second pelagic ring had a higher occurrence at 11 cm fish mean length. Whilst the 3rd pelagic ring, which was laid down just before the first annual translucent ring, had an even higher occurrence at 13 cm mean fish length. These findings agree well with studies of Gordoa *et al*. (2001), which observed *M. capensis* forming translucent rings throughout their first year of growth and depending on the month, the translucent ring would be of shorter or longer duration. They had observed 140 day old fish between 6-11cm; 160 day old fish between 14-18 cm; and 1 year old fish between 18 and 22 cm. The formation of translucent rings in the South Atlantic had been associated with hatching during spring (Botha, 1971; Piñeiro and Hunt, 1989).

The observed first annual hyaline ring was laid down at 22 cm mean fish length. The observed size range of fish when the first annual translucent ring had been laid down was very broad (16-29 cm) that is probably due to error in otolith interpretation. The mean back-calculated length at ages corresponding to translucent ring formation had shown similar results compared to the actual observed length at ages ($x^2 = 0.8748$; d.f. = 5; $p<0.05$). However, the overall mean observed length at age was slightly higher than the mean back-calculated length at age, likely due to the strong variation in size for each year class.

The back-calculated size range of fish when the first annual translucent ring was laid down was 13-26 cm with a mean of 19 cm. In this study, several false rings had been observed after the first four annuli, at a mean back-calculated fish length of 21 cm, 26 cm; 32 cm, 39 cm, respectively. This had represented a break in biological and or environmental significance after the first, second, third and fourth annuli had been laid down. *M. capensis* daily migratory pattern, variations in water temperature, feeding pattern (Morales-Nin, 1987, Pannella, 1980) might offer an explanation for the occurrence of these false rings.

The mean back-calculated length at age 1 (19 cm) confirms studies of Gordoa *et al*. (2001), who had estimated a mean length of 20 cm. Morales-Nin 1(986), had estimated a mean length of 22 cm at age 1 for *M. capensis*. Slight differences in back-calculated and actual observed length at age 1 can be attributed to different otolith interpretation. Growth of *M. capensis* seems to be greater than growth of the European hake. Gordoa *et al*. (2001), had shown that length at age 1 for Cape hake was higher than that of European hake and this study confirms this trend.

The average calculated otolith diameter (tip to tip) for all translucent bands from the sample of *M. capensis* otoliths (Table 2), provided similar results as that of the average calculated otolith diameter (tip to tip) for translucent bands separated by age 0 to 4 (Table 1). Therefore, otolith diameter (tip to tip) for all translucent bands need not be separated by age group. This implies that overall measurements of translucent bands can be used to indicate where to count annuli. Although effects of natural mortality and fishing mortality have to be evaluated for *M. capensis*, the absence of Lee's phenomenon from back-calculated data implies that size-selective mortality was not present in this population (Boehlert *et al*., 1989). Since the commercial fleet targets larger individuals, indicative of the low numbers of larger individuals (Figure 2), and with the absence of Lee's phenomenon the data is more suggestive towards evidence of cannibalism within the Cape hake population. This confirms well with previous studies emphasizing the importance of cannibalism in this species (Macpherson, 1980; Prenski, 1980; Roel and Macpherson, 1988; Roux 2006).

The cumulative distribution is a sigmoid curve. The performance of this method was illustrated by translucent ring location of different zones and compares the predicted location. The cumulative distribution of translucent ring formation illustrated the location and formation differences in the *M. capensis* otolith. Any given 'observed location' parameters can be estimated easily from the cumulative distribution. The cumulative distribution, an ogive, for all ages (1 to 4) calculated from the frequency distribution had shown that increment growth in the first year was the highest (Figure 5). Thereafter, the increment growth slows down and the increment width was smaller (Figure 5). These ogives (Figure 5 to Figure 7) had illustrated the differences in location between the first and second annulus and its subsequent false rings. The 1st and 2nd annuli and their respective false rings had the highest number of individual *M. capensis* otoliths (Table 1). This signifies the existence of the false rings after the 1st and 2nd annulus, respectively. The existence of false rings effectively increases the difficulty of age estimations. However, this result had shown that otolith diameter can effectively predict the annulus and false ring growth of the *M. capensis* otolith. Given that no overlap in ogives for these rings was visible, thus the first and second annuli and its subsequent false rings have not been identified interchangeable. Slight overlap, however had been observed in the two pelagic rings especially at smaller otolith size. This had illustrated that the pelagic rings, especially smaller than 6 mm otolith diameter length has a greater probability of interchangeable otolith term interpretation. Mean observed, back-calculated and cumulative distributions (Table 4 and Table 5) length at age 1 values was relatively similar compared to seal scat analysis studies done by Roux (2004). According to this author, the 2002 cohort had first appeared in the diet of the Cape fur seal at 8 cm fish length. By the end of December 2003, after completion of its first year of growth, the Cape hake had reached a mean length of 21 cm. Therefore, in careful consideration of results, this current study has successfully determined distinct growth rings on the whole sagittal otolith.

4.2 Age Determination

Precision describes the degree to which data generated from repetitive measurements of age differ from one another (Campana, 2001). Statistically this concept is referred to as dispersion. Accuracy refers to the correctness of the data; unless the true age is known and method validated, accuracy cannot be evaluated (Campana, 2001). High precision does not imply high accuracy and vice versa (Campana, 2001). Ageing errors can be either random or biased, reflecting some combination of process and interpretation error. Although bias can be avoided through validation studies and quality control, random error is virtually inevitable (Campana, 2001). Age estimates of *M. capensis* based upon actual observed annuli were relatively precise, with the precision values comparing favourably to studies of *M. capensis*. Generally, the CV values was higher in younger age classes and lower in older age classes (Table 10), in which CV values was compared and findings agreed well with studies done by Wilhelm (2006), whereby the author had pooled survey data over a five year period from 2000 to 2005. These findings, however are in contrast to comments by Campana *et al*., (1995), who had illustrated that at older ages, CV and APE values are expected to rise due to increased difficulty in interpretation of narrow annuli associated with decreased growth rates as the fish approaches asymptotic size. In this study, difficulty in reading and interpreting the older *M. capensis* ages was a certainty; therefore increment width had been measured for the first four ages only, beyond age 4 increment widths was extremely doubtful. The high CV values for age 1 can be ascribed to the difficulty in interpretation of *M. capensis* otoliths; thus necessitates the establishment of more precise ageing estimation methods to clearly distinguish between pelagic rings and the first and second annuli within the *M. capensis* population.

Several studies had pointed out the importance of ageing precision without systematic disagreement among readers or readings (Campana and Jones, 1992). Hoening *et al*., (1995) had described the test of symmetry developed by Bowker (1948), which determines if systematic difference exists between paired ages assignment and considers only the samples where the age was not agreed upon. Comparisons are made on the diagonal, i.e. fish with ages (1, 2) are compared with fish having ages (2, 1). Bowker's test was used to determine the type of error, systematic (bias) or random error was indicated within results. The lack of an age bias in CV values, Bowker's test (x^2 = 21.78; d.f. = 30; p = 0.86), had indicated that otoliths can provide precise ages for individuals older than 2 years.

Marginal increment analysis had indicated that annuli were laid down during spring (August to November) which agrees favourably with previous studies (Botha, 1971; Piñeiro and Hunt, 1989) which had indicated that there is a seasonal pattern for the opaque and translucent ring formation corresponding to fast growth in autumn and slow growth in spring. Although the hyaline zone can be formed throughout the year, studies have shown that in respect to seasonal zone formation, hyaline formation occurs in periods of maximum reproductive activity (Grinols and Tillman, 1970; Botha, 1971). Spawning in Namibia for Cape hake has been estimated to be around August to November (Gordoa et al. 2001). Therefore, this result for the approximate time of annulus formation, during peaks of spawning agrees with the above findings.

Ideally, annulus formation should be verified with monthly samples across a longer time series and across many age classes (Campana, 2001). The lack of monthly sampling in Namibia prior to this study had however restricted conventional marginal analysis technique and had made it impractical to compare monthly differences across ages. The results can however be of great important application in future marginal increment analysis.

The linear regression analysis of observed and back-calculated length at precise age estimates had illustrated a very high correlation coefficient, which had highlighted the importance for monthly samples across a broad range of ages for marginal increment analysis.

4.3 Age Structure

The use of stock assessment models in providing advice for the management of fish stocks requires information on the age structure of stocks (Campana and Thorrold, 2001). Generally, two methods are used to obtain estimates of catch-at-age (Mesnil, 2002). When fish is sampled randomly and age estimations made of all fish sampled. The proportions at age in the sample are taken as the estimates of those in the population being sampled (simple random sampling). An alternative method utilized, is when a large sample of fish is randomly sampled and the fish's length recorded, a sub-sample of the large sample is randomly selected (typically stratified by size classes, i.e. a fixed number is taken at each age) and its age estimated (Mesnil, 2002).

From visual evaluation of the catch-at-age data from the survey, it's clear that the survey had caught millions more smaller fish than the commercial fleet (Figure 12 and Figure 13). The restriction of older age classes in the survey and the commercial fleet targeting older fish indicated that the survey results was not representative of the whole population's age classes. And since the ALK was calculated from the survey data, it will not be representative of the older classes of *M. capensis* for 2003. The dominant presence of younger year classes in the population of Cape hake for both survey (mode at 2 years) and commercial, mode at 4 years (Figure 12 and Figure 13) during this study, has suggested that the exploitation rate in the Namibian fishery has been sufficiently high enough to have removed representative older year classes at the present level of fishing mortality. The presence of age classes older than 6 years are substantially low in both commercial and survey catches; whilst survey catch estimates detects only the young year classes.

Table 10: CV values for each group of Cape hake for the different years. CV is noted as a fraction of the age group. For age 0 it was not possible to calculate a fraction. Overall is the mean CV of all otoliths in all age groups.

Study/Author	Year	1	2	3	4	5	6	7	8	9	10	12	13	Overall
Wilhelm (2005)	**2000**	0.34	0.42	0.38	0.21	0.19	0.127	0.115	0.12	0.26				0.449
	2001	0.7	0.43	0.38	0.3	0.14	0.239	0.093	0.26	0.18				0.524
	2002	0.97	0.24	0.21	0.35	0.18	0.172	0.201	0.28	0.17				0.369
	2003	1.24	0.39	0.24	0.14	0.19	0.122	0.139	0.1	0.15				0.325
	2004	0.69	0.34	0.34	0.22	0.16	0.199	0.176	0.22	0.15				0.421
	2005	0.7	0.43	0.38	0.3	0.14	0.239	0.093	0.26	0.18				0.524
This study	**2003**	0.28	0.12	0.08	0.1	0.1	0.112	0.155	0.12	0.1	0.04	0.12	0	0.1208

Table 11: Von Bertalanffy growth parameters and maturity parameter for Cape hake reported in the Namibia during this decade.

Study/Author	Year	L_∞	K	t_0	RSS	$a_{0.5}$
Wilhelm (2003)	1999	98	0.13	-1.06	12799	5
	2000	98	0.15	-0.41	27055	4
Wilhelm (2006)	2000-2005	143.67	0.066	-1.14		1.72
This study	2003	123.13	0.07	-1.5	9963	1.67

4.4 Growth Rate Determination

The von Bertalanffy growth parameters calculated in this study are broadly consistent with values derived from studies in the Namibian region. The growth coefficient (*K*) of 0.07 is lower than the 1993, 1999 and 2000 VBG parameters (Table 11) which generally had an increasing pattern from 0.08 to 0.15 per year (Wilhelm, 2003). The growth coefficient (*K*) in the current study appeared to be consistent with pooled length at age data from 2000 to 2005 (Wilhelm, 2006), which had the 0.06 value (Table 11). The growth coefficient (*K*) in this study had also been consistent with early growth rate estimation done by Sanchez and Martin, (1985) for *M. capensis* in Namibia (Table 12).

Annual differences between VBG parameters had been examined and has been attributed to differences in otolith interpretation (Lleonart *et al.*, 1981), age length key (Morales-Nin and Payne, 1985), feeding conditions (Pshenichnii, 1979), environmental conditions (Macpherson *et al.*, 1985; Macpherson *et al.*, 1987). The result in the present study suggested the growth rate had decreased during 2003 (Table 11).

The asymptotic length $\left(L_{\infty}\right)$ of 123.13 has increased after 1999 and 2000 (Table 11). It is however much lower than pooled length at age data of 2000 to 2005 (Table 12), which could be a response of the Cape hake population to the high exploitation rate and low abundance of larger individuals. The Cape hake males mature at 36 cm and females at 48 cm (Botha, 1986). Males are reported to reach maturity faster at smaller size because of their slower growth rate (Botha 1971). Maturity is reached at an age of 4 years for males and 5 years in females (Botha, 1986). This is consistent with findings of Wilhelm (2003), when the author had calculated maturity levels for 1999 and 2000.

During 1999, Cape hake reached 50 % maturity at 5 years and in 2000 Cape hake reached 50 % maturity at 4 years (Table 11). However, in this study 50 % maturity of Cape hake was reached at 1.7 years, which is much less than previous studies. This result are however consistent with Wilhelm (2006), pooled maturity data for 2000 to 2005, where the author had illustrated 50 % maturity at 1.7 years (Table 11). The present study's result indicated that *M. capensis* low maturity levels are a response of the populations to overexploitation.

Table 12: Von Bertalanffy growth parameters of Cape hake reported in literature.

Study/Author	**Year**	L_∞	**K**
Botha (1971)	1971	141.3	0.091
Kolender (1975)	1975	174.8	0.063
Lleonart *et al.*(1981)	1981	111.1	0.12
Sanchez and Martin (1985)	1985	123	0.07
Morales-Nin (1991)	1991	81.5	0.103

4.5 Otolith Weight Relationships

The fact that otolith weight had been highly correlated with age can be of considerable practical use, as an analysis of the age structure of the *M. capensis* population off Namibia in future studies. This result had illustrated a successful first step towards establishing fish age estimation from otolith weight. The next step would be the determination of a cost-benefit analysis. This would involve a comparative study of the cost/time effectiveness and precision between fish length, otolith length and otolith weight techniques for predicting *M. capensis* age. Depending on the success of the outcome of the cost-benefit analysis, an age-frequency distribution can then be constructed from these otolith weight data, only after direct age estimation has established a growth curve. This technique then would not require the preparation and interpretation of otoliths for microscopic age examination. This approach assumes that the otolith weight-age relationship do not change significantly over a number of generations.

5. Conclusions

Young *M. capensis* tend to show rapid growth in the first few years of life and a slower growth rate once maturity is reached. This aspect of their growth complicates age estimation by otolith increments because translucent rings laid down recently prior to capture, in older age classes are so closely spaced that accurate counting and measurements become doubtful. The overlapping of increments in these older age classes or the lack of identifiable increment formation altogether due to asymptotic growth may lead to underestimation of ages in older fish. Although the maximum age demonstrated in this study was 13 years, the actual age might be older. The high CV values for age 1, therefore demands further studies to distinguish between pelagic rings and false rings. Reliable precision of the first annulus can considerably improve the precision in individual age estimations for young fish (Campana, 2001). Consequently, age validation is of great importance for *M. capensis* age estimations. Age validation refers to an accurate age determination method in other words validation of an age estimation procedure indicates that the method is sound and based on fact, which is difficult because in many species its impossible to acquire known-age specimens (Campana, 2001). According to Panfili and Morales-Nin (2002), the methodologies available for validating the frequency of formation of increments can be grouped into the following four main categories:

a) Direct validation: takes into consideration a well defined temporal reference mark on a calcified structure relative to the other growth marks. This technique is based on marking and/or rearing individuals.

b) Semi-direct validation: involves the observation of the development growth marks over time on a large number of individuals. This technique is based on populations of fish.

c) Indirect validation: involves the comparison of the observed age estimate with statistical back-calculated age estimate from age data. This technique is based on populations of fish.

d) Corroboration: entails multiple readings of one or more calcified structures.

The life history parameter estimates that have been presented in this study, was based upon one of the largest short-term samples collected for the study of *M. capensis* off Namibia during the last decade. The most significant aspect of this study is the differences in age at maturation of *M. capensis* in this century in comparison with previous studies. A difference in age of maturity of one year in a fish with a relatively short life span, such as Cape hake, can have a dramatic effect on the outcome of population models.

M. capensis is showing signs of overexploitation although the younger population (non-fishable) segment displays high abundance in recent years. Apart from the difficulties in the interpretation of translucent rings and growth increments observed in *M. capensis* otoliths, a major problem is the validation and verification methods for age estimation. Indeed, all authors concur to consider growth increments as annual rings but very few validation and verification technique studies had been conducted because they are especially difficult on deep-sea fish. Cautious use of the ages estimated for *M. capensis*, in this study is relevant, and while the continuation of otolith collection is important, validation and verification techniques is even more crucial and should be the main objective for future *M. capensis* age estimations.

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Appendix

M. capensis data collected off Namibian waters during 2003 (January and February). All data entries refer to *M. capensis.* (No. = Otolith number; L = Fish length in cm; Wt = Fish weight in g; Mat = Maturity stage; AR1 = First age reading; R2 = Second age reading; OD = Otolith diameter in mm; OW = Otolith weight in g; E = Otolith edge was denoted as either o = opaque or h = hyaline/translucent ring; P3 = 1st pelagic ring; P2 = 2nd pelagic ring; P1 = 3rd pelagic ring; f1, f2, f3, f4 = False rings; and r1, r2, r3, r4 = 1st , 2nd , 3rd, 4th respective annuli.

No.	L	Wt	Mat	AR1	AR2	OW	OD	E	P3	P2	P1	r1	f1	r2	f2	r3	f3	r4	f4
2	27	135	2		2	0.08	13.00	o			6.6	10.2		11.8					
6	34	275	3		2	0.11	15.00	o				8.3		12.4					
19	32	290	2	2	2			o											
42	51	1070	3	5	4			o											
53	23	85	3	1	1		10.80	o				9.8							
54	25	130	2	2	1	0.07	12.00	o			6.5	10.1							
55	26	115	3	1	1	0.07	12.26	o				11.4							
56	24	105	3	2	1	0.06	11.78	h				11.2							
57	11	20	0	0	0	0.01	5.60												
58	26	135	3	1	1		12.00	o				11.4							
59	26	130	3	2	2		12.16	o				9.1		11.2					
60	25	120	2	1	1	0.06	11.00	o				9.4							
61	25	110	2	1	2	0.07	11.72	h				9.8		11.1					
62	24	85	2	1	1	0.06	11.48	h				10.9							
63	14		0	0	0		6.94												
64	13	10	0	0	0	0.01	6.48												
65	14	25	0	0	0	0.02	6.88												
66	14	25	0	0	0	0.02	7.10												
67	27	140	3	1	2	0.07	13.00	h				9.2		11.3					
69	29	165	2	3	3	0.08	13.54	h				8.6		11.2		12.5			
70	29	195	3	1	1	0.09	13.80	o				12							
71	**29**	155	2	2	2	0.06	12.26	o				10.3		11.4					
72	30	220	2	2	2	0.09	14.54	h											
73	31	205	2	2	2	0.10	14.30	h						12.4					
74	26	140	2	2	1	0.07	12.10	o				10.5							
75	30	230	2	2	2	0.10	14.52	o											
76	28	140	3	2	2	0.08	13.00	o				10.6		12.2					
82	36	285	2		3	0.14	15.90	o											
85	28	160	2	2	2	0.08	13.82	h						13.3					
87	32	260	2	2	2	0.11	14.72	h											
88	33	315	2	2	2			h											
89	33	280	2	2	2	0.11	15.00	h						13.6					
97	31	260	2	2	2			h											
138	37	350	1	3	3			h											
158	56	1505	5	4	7			h											
162	61	1770	5	5	7			o											
163	43	630	2	3	4			o											
164	41	480	2	3	3			o											
165	55	1020	5	6	6			o											

166	49	910	4	5	6	0.27	21.80	h											
173	48	740	2		5	0.20	19.60	h											
219	48	825	5	4	5	0.21	18.65	h											
221	39	455	4	3	4	0.14	16.41	h										15.9	
222	44	610	4	3	4			h											
223	48	880	3	6	5			o											
224	45	645	2	5	5	0.17	18.64	h											
225	50	880	3	5	5	0.20	19.94	o											
234	44	615	2	5	4			h											
235	54	1025	4	4	5			o											
236	41	520	4	5	4			o											
262	27	140	4	2	2	0.08	13.41	h						12.4					
263	28	150	3	2	2	0.08	13.13	h				10.9		12.5					
264	30	205	4	3	3	0.09	13.93	o				9.7		11.9		13.1			
265	48	755	3	6	5	0.20	19.50	h											
266	26	120	3	1	2	0.07	11.84	h				9.7		11.2					
267	22	85	3	1	1	0.05	10.41	o				8.9							
268	32	210	4	3	3	0.10	14.26	h				9.4		11.2		13.3			
269	30	175	3	2	2	0.08	13.27	h						11.1	13				
270	30	175	2	3	3	0.08	13.13	h				9.7		11.2		12.7			
272	32	235	3	2	2	0.11	14.76	o						13.8					
274	29	175	3	1	2			h											
275	30	200	3	2	2	0.09	13.61	h											
279	30	185	3	2	2	0.09	13.90	h						12.9					
280	26	135	2	1	1			h				10.1							
281	24	115	3	1	1	0.06	11.35	o				10.3	11.3						
282	26	120	3	1	1	0.06	12.04	o											
283	25	100	2	1	2	0.06	11.64	h											
284	28	160	3	2	2			h											
285	28	175	3	1	1	0.07	12.58	o				11.4							
286	23	95	2	1	1			o											
287	27	150	3	1	1	0.07	12.44	o				12.1							
288	26	120	2	1	1	0.06	11.53	o				11.2							
289	30	200	4	2	2		13.65	h			5.8	9.2		12.3	13				
290	28	160	3	2	2	0.08	13.24	h				10.8		12.8					
291	24	110	1	1	1	0.06	11.82	o											
292	33	255	3	1	2	0.10	14.14	h						11.8	14				
293	24	100	1	1	1			o											
294	32	225	3	2	2	0.09	14.52	o											
295	28	170	3	1	2	0.08	13.26	h											
296	29	170	3	1	2	0.08	13.55	h											
297	25	120	1	1	1	0.06	11.64	o				11.1							
298	12	15	0	0	0	0.01	6.10												
299	11	10	0	0	0	0.01	5.71	h			5.5								
300	27	135	1	1	1	0.06	11.58	h				11.1							
301	14	20	0	0	0	0.01	6.70												
302	12	15	0	0	0	0.01	6.06	h			5.8								
303	11	15	0	0	0	0.01	5.87												
304	12	15	0	0	0	0.01	6.05												
305	33	310	2	2	2	0.12	15.50	h						12.9	14				
306	31	220	2	2	2			h											

307	30	200	3	2	2	0.08	13.16	h				9.4		12.6					
308	26	125	2	1	1	0.06	11.88	o				10.8							
309	28	165	2	2	2	0.07	13.04	o				10.4		12.3					
310	29	185	2	1	1	0.07	12.86	o				11.4							
311	11	5	0	0	0	0.01	5.55												
312	12	15	0	0	0	0.01	6.20												
313	12	10	0	0	0	0.01	5.76												
314	12	20	0	0	0	0.01	5.84												
315	11	5	0	0	0	0.01	5.40												
316	26	110	2	1	2	0.07	11.76	h				10.3		11.5					
317	29	205	3	2	2	0.08	12.91	h						12.5					
318	45	695	3	4	4	0.18	17.81	o										17.3	
319	29	195	1	2	2	0.07	12.57	h						12.2					
320	31	225	3	2	2	0.09	13.34	h				9.8		12.2					
321	28	165	2	1	1	0.07	12.93	o				10.5							
322	29	190	3	2	2	0.09	13.62	h				10.3		12.3					
323	30	205	2	2	2	0.10	13.87	o				11		12.7	13				
324	34	270	4	2	2	0.12	15.10	o						14.1					
325	32	245	2	2	2			h											
326	30	215	3	2	2	0.09	13.67	o				9.6		11.9					
327	43	575	2	4	4			h											
329	42	560	3		3			h											
330	37	350	3	3	3			h											
331	49	795	2	3	3			o											
360	23	85	2	1	1	0.05	10.64	h				10.2							
361	25	95	2	1	1	0.06	11.76	h				11							
362	29	170	3	2	2			o											
363	29	175	2	1	1			h											
364	31	185	2	3	2	0.10	13.87	o				9.4		12.9					
365	31	200	2	3	3	0.11	14.14	o				10.8		12.8		13.5			
366	33	275	3	3	3	0.11	14.36	o				11.3		12.4		14.1			
367	33	245	2	3	2			o											
368	34	375	2	3	2	0.10	14.39	o				8.2		13.1					
369	46	695	2	4	4	0.15	17.35	o										16.6	
398	61	1940	3	8	8	0.31	23.55	h											
481	50	955	5	5	5	0.22	20.70	o											
482	60	1510	4	8	7			o											
483	61	1685	5	6	8	0.31	23.93	h											
487	68	1970	5	11	8	0.32	24.55	o											
490	76	2735	5		11			o											
496	42	515	2	4	4	0.15	17.45	o										17.1	
497	46	630	2	4	4	0.18	17.79	o										17.2	
511	9	5	0	0	0	0.01	4.77												
512	9	5	0	0	0	0.00	4.26												
513	9	5	0	0	0	0.00	4.56												
514	9	5	0	0	0	0.01	4.75												
515	10	10	0	0	0	0.01	5.00												
516	27	160	2	1	1	0.08	12.81	h				12.1							
517	28	140	2	2	2			o											
518	28	180	3	1	2	0.08	12.54	o				9.8		11.4					
519	31	225	5	2	2	0.11	14.66	o						12.3					

520	32	265	2	2	2	0.10	13.75	o						12.3					
521	33	240	2	2	2			o						12.9					
522	34	295	2	2	2	0.12	15.07	o						15					
523	36	300	4	3	4	0.11	15.43	h										14.7	
536	24	85	3	1	2	0.07	11.91	h				9.8		11.4					
537	24	105	1	1	1	0.06	11.60	h				11.1							
538	27	140	4	2	2	0.08	12.82	h						12.3					
539	27	125	2	2	2			h											
540	28	160	3	2	3	0.08	13.25	h				8.8		11.2		12.5			
541	33	280	3	2	2	0.11	15.47	h						15.2					
542	34	310	3	2	2	0.13	16.38	h						14.1					
543	34	250	5	2	2	0.12	14.74	h						14.3					
544	35	295	5	1	2	0.12	15.50	h						12.6					
546	12	10	0	0	0	0.01	5.74												
547	11	15	0	0	0	0.01	5.68												
548	12	10	0	0	0	0.01	5.61												
549	13	15	0	0	0	0.01	6.36												
550	15	25	0	0	0														
551	15	25	0	0	0														
552	14	15	0	0	0	0.01	6.87												
553	12	15	0	0	0	0.01	5.91												
554	13	20	0	0	0	0.01	6.46												
556	41	445	2	3	4			o											
558	43	555	2	4	4	0.16	16.59	h										16.4	
560	46	685	2	3	4	0.18	17.12	o										16.9	
561	47	650	2	4	5	0.20	18.95	h											
562	47	715	2	5	5	0.16	17.68	h											
564	50	765	2	5	5		18.64	h											
565	51	835	2	6	5			h											
580	7	2	0	0	0	0.00	3.62												
581	15	30	0	0	0	0.01	6.95												
582	12	15	0	0	0	0.01	6.20	h			5.9								
583	13	15	0	0	0			o											
584	14	25	0	0	0	0.01	6.82	o											
585	9	10	0	0	0	0.00	4.24												
586	8	5	0	0	0	0.00	4.40												
587	8	5	0		0	0.00	4.37												
588	8	5	0	0	0	0.00	3.93												
589	8	5	0	0	0	0.00	4.35												
590	48	770	4	7	5			h											
591	32	220	3	2	2	0.10	14.16	o						13.5					
592	32	215	3	2	2	0.11	14.35	h						13.7					
593	29	165	3	2	2	0.10	13.73	h				9.2		13.3					
594	37	385	3	4	4	0.14	16.43	h				9.6		13.1		14.8		16	
595	30	195	2	2	2	0.10	13.96	o				12		13					
596	28	160	2	1	1	0.08	13.05	o											
597	29	155	4	2	2	0.09	13.43	h				12		13.3					
598	25	115	2	1	2	0.08	12.68	h				11.1		12.1					
599	26	125	2	1	1			o											
600	12	20	0	0	0	0.01	6.38												
601	10	10	0	0	0														

602	9	5	0	0	0	0.01	4.94												
603	12	10	0	0	0	0.01	5.90	o			5.6								
604	11	10	0	0	0	0.01	5.62	h			5.4								
605	10	10	0	0	0	0.01	4.76												
606	13	15	0	0	0	0.01	6.41	h			6.2								
607	49	805	5	4	5	0.19	17.74	h											
608	61	1495	5	6	8	0.31	23.84	h											
619	36	280	2	3	4	0.13	16.15	h										15.2	
620	66	2125	4	11	9	0.33	24.76	h											
644	**45**	615	5		4	0.22	19.72	h										16.1	18.8
645	47	750	2		5	0.21	19.08	h											
646	45	620	2	5	5	0.19	18.69	h											
656	66	2170	3	8	8	0.35	25.43	h											
658	48	705	2	4	5	0.20	18.39	h											
659	47	695	2	3	5			h											
660	73	2610	5	10	12			o											
672	58	1355	5	7/8	5			o											
673	51	875	5		5	0.25	20.90	o											
674	34	265	5	3	2	0.12	14.60	o											
675	29	155	2	2	2	0.08	13.48	h						12.5					
676	50	785	4	5	5	0.20	20.10	o											
677	61	1575	4		6			h											
678	44	590	2	4	4	0.17	17.29	o										16.7	
679	10	5	0	0	0	0.01	4.71	h			5.9								
680	9	5	0	0	0	0.01	4.55	h			4.7								
681	9	5	0	0	0			h											
682	10	10	0	0	0	0.01	4.72	h			4.7								
683	13	15	0	0	0	0.01	6.36	o			6.0								
684	10	5	0	0	0	0.01	4.69	h			4.6								
685	13	15	0	0	0			o											
686	10	10	0	0	0	0.01	4.80	o			4.7								
687	9	5	0	0	0	0.01	4.54	h			4.5								
688	54	1035	5	5	5	0.23	20.95	h											
690	10	10	0	0	0	0.01	4.74	h			4.7								
691	**73**	2710	3		11	0.52	28.07	h											
692	24	105	1	1	1	0.06	11.11	h				10.6							
693	27	135	1	2	2			o											
694	26	115	1	1	2	0.06	12.87	h			6.2	10.6		11.6					
695	28	150	3	2	2	0.08	13.72	o				11		12.7					
696	27	110	3	2	2	0.08	13.20	o				10.6		12.4					
697	28	150	3	3	2	0.08	13.42	h			7.4	10		12.7					
698	30	175	3	2	2	0.08	13.94	h				10.9		13.5					
699	28	140	2	2	2	0.09	13.78	h				8.3	10.9	13.4					
700	28	160	3	2	2	0.09	13.46	h				8.6		13.1					
716	63	1675	3	10	10	0.33	23.61	h											
717	52	990	3	7	5			h											
718	77	2920	5	8	8			h											
719	75	3040	5	12	10			h											
720	68	2095	4	10	10	0.37	26.30	h											
721	60	1340	4	9	8			h											
722	63	1830	4	9	8	0.32	23.99	h											

723	38	350	2	4	4			o											
724	36	305	3	3	3	0.13	15.75	o								14.7			
725	39	385	2	3	4	0.14	16.69	o										15.9	
732	52	810	2	4	5			h											
733	76	2935	2	13	13			h											
734	76	2880	2	8	12	0.46	27.63	h											
735	56	1185	2	7	6			h											
736	73	2380	2		10			o											
740	78	3060	3	11	12			h											
748	69	2350	3	12	9			h											
765	20	50	2	0	1	0.03	9.40	h				9.3							
766	22	70	2	1	1	0.04	10.10	h				9.7							
767	22	75	2	1	1	0.04	10.53	h				9.1	10.1						
768	23	95	2	1	1	0.06	11.17	h		5.8	7.9	9.6	10.8						
769	23	80	2	1	1	0.06	11.36	h		6.5	8.3	9.8	10.8						
770	23	80	3	1	1	0.06	11.50	h			6.3	9.3	10.7						
771	24	105	3	1	1			o											
772	25	105	2	1	1			h											
773	25	120	2	1	1			o											
774	26	130	2	1	2	0.07	12.58	h			5.8	8.8	10.6	11.9					
775	27	120	2	1	1	0.06	12.36	h				11.7							
776	8	5	0	0	0	0.00	4.34												
777	16	15	0	0	0	0.02	8.35	h			7.9								
778	17	35	0	0	0	0.03	8.65	h			8.2								
779	33	225	2	3	3	0.11	14.60	h											
780	35	265	3	3	3	0.12	15.30	o						12.5		14.8			
781	36	335	4	3	3			h											
782	37	305	4		3	0.12	16.05	o						12.9		15.6			
783	39	395	4	3	4	0.15	17.43	o								14.6		16.8	
785	55	995	5	7	6	0.27	22.60	h											
786	55	1270	3	4	5			o											
787	58	1245	5		6			o											
788	19	40	1	0	1	0.03	9.40	h				9							
790	21	50	1	0	1	0.04	10.10	h				9.7							
791	21	80	1	0	1			h											
799	28	135	2	2	2	0.09	13.36	h				8.3	10.8	12.8					
802	31	195	2	2	3		14.27	h						11.4		13.9			
803	33	225	2	3	3	0.12	15.32	o								14.9			
804	36	325	2	4	4	0.14	16.51	h								14.5		16.1	
807	48	830	3	6	5			h											
808	50	865	2	5	5			h											
820	46	700	5	4	5	0.19	18.72	h											
821	52	1010	4	7	6	0.28	21.11	h											
823	54	1085	4	8	6	0.24	22.12	h											
824	55	1045	4	9	6	0.27	21.94	h											
825	57	1145	3	9	7			h											
826	59	1400	5	10	8	0.31	23.20	h											
827	60	1450	5	8	8			h											
828	68	1775	2	11	10	0.35	24.72	o											
829	71	2820	3	10	9	0.40	26.90	o											
837	20	55	3	1	1	0.04	9.90	h				8.2	9						

838	21	65	3	0	1			h											
839	21	55	1	1	1	0.04	10.14	h				9.5							
840	22	80	3	1	1	0.05	11.30	h				9.8	10.8						
841	23	75	1	1	1	0.05	11.35	h				10.9							
842	23	90	3	1	1	0.05	11.01	h		4.6	7.5	9.4	10.2						
843	24	110	3	1	1			o											
844	26	115	1	1	1	0.06	12.04	h				11.7							
845	57	1180	3	10	6	0.29	23.39	o											
846	60	1310	3	9	7	0.32	23.91	h											
847	62	1610	3	11	8	0.36	25.38	h											
848	63	1640	3	9	8	0.31	24.48	h											
849	65	1750	3	12	8			o											
850	67	1835	3	12	12	0.39	26.22	h											
852	68	2045	3	9	9		26.78	h											
854	70	2410	3	10	10			h											
855	71	2065	4	7	9	0.38	25.40	h											
856	35	265	2	3	3	0.12	15.20	o						10.9	13	14.6			
857	36	340	2		4	0.14	16.55	o										15.9	
858	37	290	2	4	4	0.12	16.57	h				10.1		12.2		14.4		16.1	
859	38	340	2	4	4	0.13	16.32	h										16.1	
860	38	345	2	3	4	0.14	17.03	h						12.8		14.2		16.5	
861	38	345	2	4	4			h											
862	42	475	3	5	4	0.18	18.56	o			7.2	9.2				14.1		15.9	18.2
864	43	505	2	4	4	0.15	16.50	h										15.8	
865	43	505	2	4	4	0.17	17.97	o										17.6	
866	45	625	3	5	5	0.19	19.14	h											
867	46	680	2	5	4	0.17	17.70	o										17	
881	18	45	0	0	1	0.03	8.96	h				8.5							
882	18	35	0	0	1	0.03	9.22	h				8.7							
883	19	45	0	0	1			h											
884	20	60	3	1	1	0.05	10.72	o				9.6	10						
885	20	60	2	1	1	0.04	10.20	h			6.7	9.5							
886	21	65	2	1	1	0.04	10.28	h				9.6							
887	22	70	2	1	1	0.05	11.08	h	5.6	6.6	7.2	9.3	10.4						
888	22	75	2	1	1	0.05	11.20	h				11							
889	23	80	2	1	1			h											
890	23	85	3	2	2	0.06	11.54	h			7.1	8.7	9.7	10.8					
891	24	75	2	2	2	0.05	11.42	h						10.9					
892	16	30	0	0	1	0.02	8.45	h			7.9								
893	17	40	0	0	1	0.02	8.36	h			7.9								
894	17	35	0	0	1	0.02	8.44	h			7.9								
895	19	45	0	0	1	0.03	9.27	h				8.7							
896	18	40	0	0	1			h											
897	65	1710	2	8	7			o											
899	73	2815	3	13	13			o											
900	80	2850	3		12			h											
915	**15**	15	0	0	0	0.01	6.90	o			5.9								
916	15	30	0	0	0	0.02	7.50												
917	16	30	0	0	0	0.02	7.67	o			5.9								
918	16	25	0	0	0	0.02	7.88	o			6.3								
919	18	45	0	0	1	0.03	9.05	h				8.4							

920	21	70	2	1	1	0.04	9.88	h				9.2							
921	22	60	2	1	1	0.05	10.62	h				10							
922	22	75	2	1	1	0.05	11.13	h				10.5							
923	22	75	3	1	1	0.05	11.32	h		7.9	8.9	10.2	10.8						
925	47	715	5	6	5	0.20	19.65	h											
926	50	835	5	8	5	0.21	20.67	h											
927	55	1150	3	8	6	0.26	21.72	h											
943	9		0	0	0	0.01	4.85	h			4.5								
944	10	5	0	0	0	0.01	5.57	h			5.3								
945	11	10	0	0	0			h											
946	13		0	0	0			o											
947	15	25	0	0	0			o											
948	23	90	1	1	1	0.06	11.58	h			6.0	10	11						
949	24	90	2	1	1	0.06	11.34	h		5.5	8.3	9.8	10.5						
950	25	115	4	2	2	0.07	12.76	h			8.2	8.8	10	12					
951	25	115	5	2	2	0.07	12.44	h				9.2	10.1	10.7	12				
952	26	130	5	2	2	0.08	13.61	o			8.0	9.7	11.3	12.3	13				
953	26	115	2	2	1	0.07	12.39	o			7.4	10.6							
954	27	125	3	2	1			o											
955	27	140	2	2	2	0.07	12.81	h			6.8	11.6		12.6					
956	28	135	4	3	3	0.09	13.99	h						12		13.4			
957	31	190	3	3	3	0.10	14.27	h								13.5			
958	21	65	1	1	1	0.05	10.64	h		6.4	7.4	9.1	10						
959	23	80	1	1	1	0.05	11.28	h		5.5	7.3	10.7							
960	25	90	2	1	1	0.07	12.31	h		7.6	8.1	10.1	11.8						
961	25	110	3	2	2	0.07	12.56	h			8.5	9.9		12.1					
962	25	105	2	2	2	0.07	12.77	h		6.8	8	8.8	9.9	10.8	12				
963	25	115	3	2	2	0.07	12.29	h				9.4		11.2					
964	25	115	3	2	2	0.07	12.44	h				8.5		10.1	11				
965	26	115	2	2	2	0.07	12.48	h						11.2					
966	26	115	3	2	2	0.06	12.36	o			5.8			11.9					
967	28	150	2	2	2			o											
968	27	120	2	2	2	0.07	12.75	o				8.3		11.4	12				
969	27	140	3	2	2	0.08	12.83	o						12.4					
970	27	145	3	2	2	0.08	12.86	o				8.3	9.3	11.3	12				
971	28	160	2	2	2	0.07	13.20	h				9.5		11.2	13				
972	29	170	4	2	2	0.09	13.62	h				9.1		13					
973	31	210	3	3	3			o											
975	39	385	2	4	4	0.13	16.93	h										16.3	
976	46	645	4	5	5			h											
977	52	1040	4	6	5			o											
978	7	5	0	0	0	0.00	3.91												
979	11	10	0	0	0	0.01	6.30	o			5.9								
980	11	5	0	0	0	0.01	5.25	o			4.9								
981	12	10	0	0	0	0.01	6.06	o			5.5								
982	12	10	0	0	0			h											
983	19	50	0	0	1	0.04	9.88	h				9.3							
984	26	120	2	2	2	0.07	12.68	o				8.6	9.6	11.1	12				
985	28	160	2	2	3	0.10	13.88	h						11	12	13.5			
986	33	240	4	3	3			o											
987	34	280	2	3	3			o											

989	39	410	3	4	4	0.14	16.64	h				10.3		12.4		14.2		16.1	
991	46	680	3	4	4			o											
992	48	760	3	6	5			h											
993	53	1160	3	7	6			o											
998	37	360	3	4	4			o											
1000	41	450	2	4	4			h											
1001	42	545	2	4	4	0.17	17.45	h										17.1	
1002	44	625	4	5	5			h											
1004	54	1025	3	7	5			o											
1005	56	1160	5	6	6	0.29	23.28	h											
1006	59	1390	5	6	6	0.30	23.11	h											
1007	59	1485	4	8	8			h											
1008	67	2025	3	9	9	0.30	25.35	h											
1019	28	150	3	2	3	0.08	13.93	h				8.7				13.7			
1025	26	130	2	2	2	0.07	12.66	h			7.5	9.5		11.1					
1026	32	200	2	3	3	0.10	14.37	o						12.4		13.8			
1027	33	220	2	3	3	0.10	14.37	o								14.1			
1028	34	270	2	3	3	0.12	14.85	o								14.7			
1029	34	230	2	3	3	0.13	15.95	o				8.7		11.4		14.4	16		
1030	34	240	2	3	3	0.11	15.32	o								15.1			
1031	35	285	3	3	3			o											
1032	40	380	3	5	4	0.18	18.52	o			7.9	9.9	11.2	13		15.1		16.8	18.3
1033	41	380	3		4	0.21	18.22	o										16.9	
1034	44	550	2	4	4			o											
1045	25	115	3	1	2		13.05	o						12.1					
1046	25	110	4	1	2	0.06	12.70	h				8.6		11.7					
1047	27	150	4	1	2	0.08	13.49	o						12.5					
1048	28	155	3	1	2	0.07	13.14	o			7.9			12.2					
1049	29	180	2	1	2	0.09	13.92	o			8.0			12.3	14				
1050	30	200	3	1	2	0.08	13.87	o				9.4		13.3					
1051	32	205	3	2	3	0.12	14.78	o				9.7		11.8		14.7			
1052	44	550	3	5	4			o											
1053	45	560	4		5	0.20	19.50	o											
1054	50	800	4	8	5	0.25	20.38	h											
1055	11	10	0	0	0	0.01	6.01	o			5.1								
1056	13	15	0	0	0	0.01	6.87	o			6.1								
1057	12	10	0	0	0	0.01	6.65	o			6.0								
1058	14	20	0	0	0	0.01	7.11	o			6.4								
1059	19	45	0	0	1	0.04	9.25	h		6.1	8	8.8							
1060	25	110	3	1	1	0.06	11.97	o		7.3	8.3	11.2							
1061	26	110	3	1	1	0.07	13.12	o				12.3							
1062	26	120	2	1	1	0.07	13.07	o			7.3	11.2	12.2						
1063	26	125	1	1	1	0.08	12.84	o				12							
1064	26	105	3	1	1	0.06	12.20	o		6.5	7.9	11.3							
1065	26	130	2	1	1	0.06	12.78	o			7.9	11.1	11.7						
1066	28	140	3	2	2	0.08	13.50	o						13					
1067	29	170	3	2	2			o											
1068	29	170	2	2	2	0.08	13.50	o				8.6		11.5	13				
1069	44	565	3	5	5	0.20	19.74	h				8.9		11.9		13.3		16.9	
1070	11	6	0	0	0	0.01	5.63	o			5.2								
1071	17	40	0	0	1	0.02	8.67	o				8.2							

1072	18	30	0	0	1	0.04	9.28	o			6.1	9							
1073	18	30	0	0	1	0.04	9.51	o			6.0	8.2	9						
1074	19	40	0	0	1	0.04	9.49	o		6.3	7.8	9.5	10.5						
1075	21	80	1	1	1	0.05	11.06	o				9.6	10.6						
1076	22	75	1	0	1	0.05	11.17	o				11							
1077	23	85	2	0	2	0.06	11.74	o			7.9	8.6	10.2	11.5					
1078	25	110	2	1	2	0.06	12.21	o			7.3	11.1		12.1					
1079	26	125	2	1	2	0.07	12.85	o			7.4	11		12					
1080	26	115	2	1	2		12.70	o				10.9		12.3					
1081	27	140	3	2	2	0.08	13.10	o						12.4					
1082	28	160	3	2	2	0.10	14.03	o				8.3	10.5	12.7	14				
1083	28	140	1	2	2	0.08	13.56	o				8.6		13.1					
1084	32	220	3	2	3	0.09	14.06	o				8.4	10.5	12.5		14			
1085	9	5	0	0	0	0.01	4.99	o			4.6								
1086	9	5	0	0	0	0.01	4.99	o			4.7								
1087	11	5	0	0	0	0.01	5.85	o			5.2								
1088	23	75	3	1	1	0.05	11.17	o				8	10.1						
1089	24	90	3	1	1	0.05	12.06	o				11.5							
1090	24	95	3	1	1	0.06	12.31	o				10.4	11.6						
1091	24	90	3	1	1	0.06	11.77	o			7.9	9.6	11.1						
1092	24	95	2	1	1	0.07	12.54	o				11.7							
1093	27	145	3	1	2	0.07	12.81	o						12.2					
1094	27	135	2	1	2	0.08	12.55	h				10		11.8	12				
1095	27	145	3	1	3	0.09	13.61	h				9.8		11.8		13.1			
1096	30	185	3	2	3	0.09	14.30	h								13.9			
1097	23	85	1	1	1	0.06	11.05	o			7.7	8.9	10.4						
1098	24	100	3	1	1	0.06	12.05	o				11.4							
1099	27	135	2	2	2	0.08	13.28	o						12.7					
1100	27	135	4	2	3		13.18	o				8.3	9.4	11.6		13			
1101	**27**	140	1	2	3	0.10	13.87	h				8.3		11.6		13.5			
1102	28	175	3	2	2	0.08	13.15	h				9.4		12.7					
1103	28	155	2	2	2			o											
1104	28	160	1	2	2			o											
1105	29	165	3	2	3	0.09	13.91	o						13.3					
1106	45	525	4	6	5	0.20	19.50	h											
1107	28	160	3	3	3	0.09	14.32	h								13.9			
1108	30	200	2	3	3	0.10	14.05	o						14					
1109	30	190	1	2	3	0.10	14.27	o				8.1	9.9	11.6		13.8			
1110	31	190	2	2	3	0.09	13.73	o				10.5				13.1			
1111	32	215	1	3	3	0.12	15.52	o				10.2		13		14.9			
1112	33	245	1	3	3	0.11	15.04	o						11.5		14.7			
1113	33	225	3	3	3	0.11	14.87	o				10.8		11.7		14.3			
1114	35	280	2	3	3	0.12	15.80	o				9.2		12.5		15.1			
1115	39	445	2	3	4	0.16	17.45	o						12.7				16.8	
1116	44	540	3	6	5	0.21	19.84	h											
1134	29	190	2	2	2			o											
1135	33	270	1	2	2			o											
1136	32	210	3	2	3	0.10	14.45	h				8.5		11.2		13.9			
1137	32	210	1	2	3	0.11	14.51	o				8.9		12.5		13.8			
1138	35	320	2	3	3	0.12	15.74	o				8.1	9.1	11.9		13.4	14		
1139	36	300	3		4	0.13	16.99	h				8.8		11.6		14.9		16.8	

1140	40	450	2	6	4	0.17	18.10	o				8.8		12		15		17.3	
1141	40	465	2	4	4	0.16	18.43	o				9.9				13.9		17.7	
1142	56	1172	2		5			o											
1143	58	1325	3	4	5			o											
1144	23	100	4	1	1	0.06	11.48	o				10.8							
1145	24	105	1	2	1	0.05	11.62	o				9.4	10.9						
1146	29	150	2	2	2			o											
1147	29	175	2	2	3	0.09	13.80	o			7.8	8.6				13.3			
1148	29	175	3	2	2	0.08	13.20	o			7.5	8.5		12.4					
1149	30	190	1	2	3	0.09	13.98	h								13.5			
1150	30	180	1	2	3	0.08	14.06	h								14			
1151	31	175	4	3	3	0.11	14.59	o				9.4		12		13.7			
1152	31	225	1	2	3	0.10	14.61	h				8.9				14.1			
1153	33	245	1	3	3	0.10	15.14	o						12.4		14			
1154	31	220	1	3	2	0.09	14.00	o			7.4	9.1	10.2	13					
1155	32	220	2	2	2	0.10	14.80	o						13.8					
1156	34	270	1	2	3	0.12	15.59	o				9.5				14.5			
1157	35	280	3	2	3	0.13	16.20	h						12.2		15.5			
1158	36	290	2	4	4	0.14	16.72	o										16.2	
1159	38	350	2	4	4	0.14	16.22	h										15.6	
1160	38	340	3	4	4	0.15	17.65	h				11		12.9		14.9		17.1	
1161	39	443	4		3			h											
1162	39	350	3	3	4			h											
1163	53	1080	3		5	0.26	21.56	o				9.2		11	12	15.3			
1164	56	1215	3	5	8			h											
1165	57	1160	3	8	7	0.30	24.11	h											
1166	41	435	2	5	4	0.14	17.04	h						11				16.7	
1167	42	510	2	3	4			h											
1168	45	590	3	7	5	0.20	19.36	h											
1169	49	795	3	5	5	0.21	20.34	h											
1170	31	190	2	3	3	0.10	14.11	o				8.9		11.4		13.4			
1172	34	250	3	3	3	0.13	16.09	h				9.1	10.4	13		15.5			
1173	35	250	3	4	4	0.14	16.20	o				9.6		11.6		13.4		15.7	
1184	55	1115	3	9	6	0.30	23.58	h											
1188	66	2050	3	9	8	0.32	24.73	o											
1199	10	5	0	0	0	0.01	5.21	o			4.8								
1200	10	5	0	0	0	0.01	5.69	o			4.9								
1201	10	5	0	0	0	0.01	5.15	o			4.7								
1202	11	5	0	0	0	0.01	5.19	o			4.5								
1203	12	10	0	0	0	0.01	5.93	o			5.3								
1204	21	60	1	1	1	0.04	10.70	o			7.4	10.1							
1205	22	70	2	1	1	0.05	10.56	o			6.8	9.8							
1206	23	80	2	1	1	0.05	11.32	o			7.6	9.4	11						
1207	23	75	2	1	1	0.05	11.07	o				10.1							
1208	23	80	2	1	1	0.05	11.32	o				8.4	10.5						
1209	23	80	2	1	1	0.05	11.42	o				10.1							
1210	24	90	2	2	2	0.06	11.64	o						12.1					
1211	24	100	2	2	2	0.07	12.28	h				8.5	10	11	11				
1212	24	95	3	2	2			h											
1213	31	200	3	3	3	0.10	14.02	h				8.3		11.5		13.8			
1214	20	65	1	1	1	0.04	9.96	o		6.7	8.5	9.1	9.9						

1215	23	85	1	1	1			o											
1216	24	120	1	2	2	0.07	13.44	h				8.9		10.1	12				
1217	25	125	3	2	2	0.07	13.09	h			7.6	9.7	11.1	11.8					
1218	25	125	2	2	2	0.07	12.65	h				8.6	10.3	11.3					
1219	27	120	3	3	3	0.08	13.60	h			8.7	9.7	11.1	12.4		12.8			
1220	27	130	4	3	3	0.08	13.42	h			7.6	9.3		11		12.1			
1221	28	140	3	2	2	0.08	13.49	o			7.9	9.6		12.2	13				
1222	28	150	3	2	3	0.08	13.41	h			8.0	11.2		12.2					
1223	34	245	2	4	4	0.11	14.45	h				9.4		10.9		12.3		14	14.4
1224	25	105	3	2	1	0.06		h		6.9	7.8	9.8	10.7						
1225	36	310	2	4	4	0.14	17.73	o				8.2		11.7		14.4		16.5	
1226	29	170	3	3	3	0.10	13.84	h			7.6	10.2		11.6		13.5			
1227	31	230	2	3	3	0.10	14.37	h				8.9				13	14		
1228	31	210	3	3	3	0.10	14.29	h				9.3		11		13			
1229	35	300	3	3	3	0.12	15.97	o				9				15.6			
1230	35	290	4	3	3	0.12	15.25	o				8.9		11.2		14.8			
1231	37	340	1	4	4			h											
1232	39	415	2	4	4	0.14	16.91	h						11.5				16.4	
1233	40	435	1	4	4	0.16	17.27	h										16.9	
1234	36	275	1	4	4	0.14	16.34	h				8.4		11		13.4		15.8	
1235	36	290	3	4	4	0.13	16.50	h				8.8		10.6		12.6		15.9	
1236	36	330	1	4	4	0.15	17.22	h								13		16.8	
1237	37	305	1	4	4			h											
1238	39	430	1	4	4	0.17	17.76	o										17.3	
1239	41	475	5	5	4			o											
1240	43	495	1		4	0.16	17.66	o											
1241	44	640	4	4	4			o											
1242	46	550	1		5	0.19	19.35	o											
1243	51	905	2		5	0.25	21.54	o											
1290	35	285	1	3	3			o											
1291	35	280	3	3	3	0.13	16.10	o				10		12		15.5			
1292	36	305	5	5	4	0.13	16.31	h				8.7				13		15.9	
1294	39	360	1	3	4	0.13	16.94	h										16.5	
1295	40	385	4	5	4			o											
1296	40	540	3	5	4			o											
1297	41	470	3	5	4	0.15	17.91	o										17.8	
1298	41	415	1	2	4	0.16	17.43	h										17	
1299	43	560	4	5	5	0.17	18.97	h											
1300	46	650	3	6	6	0.23	21.09	h											
1301	40	450	1		4	0.16	17.35	h				8.6		13.1		15.5		17	
1302	44	575	1	4	4			o											
1303	34	305	2	3	3			o											
1304	45	660	3		5	0.19	18.92	h											
1305	47	705	2	5	5	0.24	19.95	o											
1306	48	815	5	6	5			o											
1307	49	780	5		5	0.21	19.46	o											
1308	51	900	1	4	5			o											
1309	52	985	5	5	5	0.25	21.91	o											
1310	53	1055	3	7	5	0.23	21.41	o											
1311	44	550	3	7	4			o											
1312	48	780	3		6			o											

1313	50	850	3		5			o											
1314	50	875	3	7	5			h											
1315	52	1070	3	5	5			h											
1316	52	970	3	6	6			o											
1317	54	1070	4		6			h											
1318	62	1735	3	7	6		22.86	h											
1327	30	190	3	3	2			o											
1328	30	175	2	3	2	0.08	13.35	o				9.3		11.3	13				
1329	30	175	2	3	2	0.10	14.44	o				9.2		10.7	14				
1330	30	180	3	3	2	0.08	13.72	o				9.4		13.7					
1331	30	195	3	3	2	0.09	13.92	o			7.7	9.6		13.1					
1332	33	240	2	3	2	0.09	14.11	o				9		13.8					
1333	34	260	2	3	2	0.10	14.44	o						14.2					
1334	35	280	2	3	3	0.12	15.94	o				9.6				13.6	16		
1335	35	290	2	3	3	0.12	15.59	o				8.5		11		13.7	15		
1336	38	395	3	5	4			h											
1337	21	55	1	1	1	0.04	10.85	o	3.6	5.0	7.8	10.3							
1338	21	55	1	1	1	0.04	10.64	o				10.1							
1339	24	100	1	1	1	0.06	11.83	o				11.3							
1340	24	100	1	1	1	0.06	11.96	o			7.6	9.4	11.5						
1341	24	80	1	1	1	0.06	11.68	o				10.2							
1342	29	150	1	2	2		13.48	o						13					
1343	33	255	3	2	3			o											
1344	35	300	3	3	3	0.12	15.18	o								14.8			
1345	35	385	1	3	3	0.12	15.78	o								15.4			
1346	36	285	1	4	4	0.11	15.23	h								15			
1347	37	325	2	3	4	0.13	16.62	o				9.5		11.5		13.5		16.1	
1348	38	390	1	6	4	0.17	17.88	h				8.8		13				15.8	17.5
1349	38	370	3	3	4	0.15	17.19	h								13.7		16.8	
1350	38	355	3	5	4	0.14	16.62	h				8.3		10.6				16.4	
1351	38	375	3	3	4			h											
1352	42	485	4	4	4	0.16	17.79	o				9		11.8		15.2		17.2	
1353	32	225	2		3	0.12	14.86	o				8.5		10.5	12	13.3	14		
1354	33	225	2		3	0.10	14.63	o				9.5		11.5		13.1	14		
1356	37	315	2	3	3			h											
1357	37	320	2	3	3			h											
1359	38	380	2	5	4	0.15	17.47	h											
1360	38	360	2	5	4	0.15	17.62	h			7.5	10.5				15.5		17.4	
1361	39	360	2	2	4			o											
1362	50	840	2	5	5			h											
1388	33	280	3	4	4	0.11	15.33	h				8.7		10.1		12.7		15	
1389	35	330	4	3	3			o											
1390	37	355	2	4	4	0.15	16.88	h				8.6		11.4		15.6		16.4	
1391	38	370	4	4	4	0.14	17.02	h				9.6						16.7	
1392	40	470	2	4	4	0.16	17.35	h										17	
1393	40	475	3	3	4	0.15	17.41	h				8.9				14.2		17.2	
1394	**42**	510	4	6	5	0.20	19.67	h											
1395	42	470	2	4	4	0.18	17.67	o				9.7		12.8		15.4		17.3	
1396	44	580	3	5	5			h											
1397	44	635	2	5	4	0.16	18.20	o										18	
1398	28	170	2	2	2	0.09	13.47	o				8.7		11.1	13				

1399	29	190	3	3	2	0.08	13.24	o				8.5		12.6					
1400	29	170	3	2	2	0.08	12.99	o				8.5		12.4					
1401	30	160	2	3	2	0.09	14.25	o						13.9					
1402	30	210	3	3	3	0.10	14.68	h								14.1			
1403	30	170	3	3	3	0.08	13.14	h								12.8			
1404	31	200	2	3	3	0.09	14.24	h				8.9				13.9			
1405	32	270	3	3	3	0.10	15.28	h				9				14.8			
1406	37	350	4	4	4	0.15	17.34	h				9.1						17	
1407	34	260	3	3	3	0.13	15.96	o				9.6		13		14.5	15		
1408	12	15	0	0	0	0.01	6.50	o			5.9								
1409	13	15	0	0	0			o											
1410	14	20	0	0	0	0.02	7.47	o											
1411	17	35	0	0	1	0.03	8.94	h		5.9	6.8	7.3	8.2						
1412	21	75	1	1	1	0.04	11.06	h				10.5							
1413	21	60	1	1	1	0.04	10.68	h				10.1							
1414	21	65	1	1	1	0.04	10.49	h	6.3	6.7	8.3	9.1	10						
1415	22	60	1	1	1	0.05	10.51	o				8.3	10.1						
1416	22	85	3	1	1	0.06	11.60	o			8.5	9.5	11.1						
1417	22	70	1	1	1	0.06	11.62	o				8.8	10.9						
1418	22	75	1	1	1	0.05	11.05	o				10.7							
1419	22	65	1	1	1	0.05	10.85	o			5.9	8.9	10.2						
1420	22	75	1	1	1	0.05	11.06	o			6.9	10.8							
1422	37	355	4	4	4	0.13	16.77	o				9.9						16.5	
1423	38	430	4	2	4	0.13	16.84	o										16.5	
1424	39	410	2	5	4			o											
1425	44	640	3	4	4	0.21	20.38	o										19.8	
1426	34	285	2	3	3	0.12	14.69	o				8.4	10.4	12.1		14.1			
1427	36	350	2	3	4			h											
1428	37	390	5		4	0.14	16.11	o										15.9	
1429	37	340	2	4	4			o											
1430	37	370	2	4	4	0.12	16.03	o				9.4		12.5				15.8	
1431	38	350	2		4	0.14	16.55	o				10.6		13.4		14.9		15.4	
1432	40	425	5	4	4		17.79	o				10						17.3	
1433	41	470	3	4	4			o											
1434	41	480	2	3	4			h											
1435	41	455	2	3	4	0.17	17.20	o				9.8						16.7	
1446	49	900	3	6	5			h											
1447	**51**	1000	3	4	5	0.17	18.10	h											
1448	52	1050	2	6	5	0.26	21.00	h											
1450	54	1040	5	5	5			o											
1451	56	1230	2	7	5			o											
1452	57	1440	5		6			o											
1453	58	1450	3	6	6	0.26	22.65	o											
1455	64	1650	5	6	7			h											
1491	36	355	1	3	3			o											
1492	38	350	2	3	4			o											
1493	41	450	2	3	4	0.16	18.49	h				9.9		13.5				17.9	
1494	43	545	2	3	4	0.18	18.02	h										17.5	
1495	52	1010	3	5	5	0.26	20.93	h											
1522	42	490	2	4	4			o											
1523	49	920	2	5	5	0.20	19.49	h											

1524	50	790	2	4	5			h											
1525	10	10	0	0	0		5.75	o	3.9	5.0	5.1								
1526	10	5	0	0	0	0.01	5.75	o		5.0	5.3								
1527	13	10	0	0	0	0.01	7.17	o			6.5								
1528	21	70	1	1	1	0.05	11.50	o				11							
1529	21	60	1	1	1	0.05	10.85	o			4.6	8.8	10.1						
1530	28	135	2	2	2	0.08	13.77	h				10.1		13.3					
1531	31	185	2	2	2	0.09	14.13	o						13.6					
1532	31	200	3	2	2			o											
1533	31	190	2	2	2	0.09	13.71	o				8.9		13.2					
1534	32	215	2	2	3	0.10	14.71	h				10.1				14.1			
1535	35	270	3	3	4	0.14	15.75	o				9.2		11.8		14		15.2	
1536	37	335	3	3	3	0.15	16.71	o				9.4		11.8		16.3			
1537	41	500	3	4	4	0.17	18.35	o				8.6				13.3		16.3	17.9
1538	42	500	3	4	4	0.17	17.62	o				9.4		11.3		13.9		17.2	
1539	28	160	1	2	2	0.07	13.05	o			7.5			12.5					
1540	30	160	2	2	2	0.10	14.68	o				10.2		14.5					
1541	31	200	2	2	2	0.09	14.30	o						13.9					
1542	31	205	1	3	3	0.10	14.18	o				8.8		10.9		13.9			
1543	33	255	1	3	3	0.11	14.31	o				9		10.9		13.1			
1544	35	295	2	3	3			o											
1545	35	295	2	3	4	0.13	15.87	h				9.2		12.1		13.8		15.2	
1546	38	345	4	3	4	0.15	16.89	o				9.8		13.2		14.9		16.6	
1547	40	385	2		4		17.04	o				9.4		13.9		14.2		16.1	
1548	60	1425	5	5	5			o											
1549	42	560	4	4	4	0.15	17.00	h										16.7	
1550	43	540	2	5	4	0.19	19.09	o				9.7		12.8		15		18.6	
1551	44	640	2	5	4			o											
1552	45	620	2	4	5	0.18	18.67	h											
1553	47	675	2	4	6		18.25	h											
1554	50	920	2	4	6	0.21	20.18	h											
1555	50	775	2	6	6	0.23	20.49	h											
1556	54	1065	2	6	6	0.26	22.37	o											
1558	58	1230	2	6	6			h											
1567	49	810	2	5	5	0.21	19.20	h											
1571	54	1085	2	8	5	0.26	22.20	o											
1572	59	1255	2	8	6			h											
1595	38	380	2	3	4	0.13	16.20	h				11.3		12.6				15.9	
1596	38	405	1	5	4	0.14	16.33	o				8.9		11.8		13.3		15.6	
1597	42	480	2	4	4	0.19	18.54	o				10.8		12.9				15.8	17.9
1598	43	535	4	4	4	0.19	17.78	o										17.4	
1599	43	525	1	5	4	0.18	18.72	h										18.4	
1600	43	475	1	5	4	0.17	18.12	o										17.8	
1601	45	625	2	6	5	0.22	19.97	h											
1602	45	650	2	4	5	0.17	18.27	h											
1603	49	820	2	6	5	0.21	19.90	h											
1604	50	935	2	6	6			h											
1605	55	1240	2	5	6	0.26	21.54	h											
1608	43	605	2	5	4	0.19	18.54	o				9.3		12.6		15.4		18.1	
1609	37	360	1	4	4			h											
1610	43	600	2		4	0.17	19.08	o				8.2		12.3		15.4		18.6	

1611	46	680	2	4	5	0.18	19.54	h											
1612	46	680	2	5	5	0.19	19.59	h											
1613	46	750	2	5	5	0.19	18.74	h											
1614	48	730	2	5	4	0.18	18.74	o				9.3						18.1	
1615	48	780	2	4	5			h											
1616	49	875	2	5	5	0.23	20.61	h											
1617	49	870	2	4	4			o											
1618	50	960	2	5	5			h											
1619	16	15	0	0	0	0.02	8.25	o			7.7								
1620	17	25	0	0	0	0.02	8.31	o		5.5	7.6								
1621	18	40	0	0	1	0.03	8.82	o			7.9								
1622	19	50	0	0	1			h											
1623	20	60	0	1	1	0.04	9.97	o				8.5							
1624	37	375	2	4	3			o											
1625	40	560	2	4	4	0.14	16.59	o				9.3		12.3		14.2		16.3	
1626	43	660	1	4	4	0.16	17.00	h										16.7	
1627	47	800	2	5	5			h											
1628	48	815	2	5	5			h											
1629	50	995	5	5	5	0.22	20.55	o											
1630	51	1010	2	5	5	0.20	19.25	h											
1631	53	1180	5	5	5	0.23	20.94	o											
1632	55	1185	3	6	5			o											
1633	61	1690	5	8	7			h											
1639	48	775	2	4	5		20.26	h											
1640	48	820	2	5	5	0.21	19.24	h											
1641	48	835	2	5	5	0.19	20.36	h											
1642	54	1125	2	6	5	0.21	21.30	o											
1643	54	1110	2	6	5	0.24		o											
1644	55	1190	2	8	5			o											
1648	45	590	2	5	4	0.17	18.17	o										17.9	
1650	51	990	2	5	5	0.21	20.36	o											
1651	61	1475	2	5	6	0.28	21.42	o											
1652	27	160	1	2	2	0.07	13.07	o						12.5					
1653	34	290	1	3	3		14.80	o				7.9		11.1		13.7			
1654	38	360	1	5	4	0.14	15.80	h				9.1		11.2		13		15.3	
1655	39	415	2	4	4	0.16	17.05	h			6.1	9.6		13.5		15.7		16.8	
1656	40	460	2	5	4	0.17	17.74	h				9.6		13.2		15.8		17.1	
1657	40	495	3	4	4			o											
1658	42	540	2	4	4	0.18	18.41	o										17.9	
1659	51	920	5	5	5	0.23	19.92	h											
1660	56	1410	5	6	6	0.27	22.50	o											
1661	60	1460	2	8	7			h											
1662	64	1540	5	8	8	0.32	23.68	h											