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The demersal small-scale resources of the Republic of Cabo Verde, West Africa. II. Assessment

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1 Introduction

Between 1995 and 1997 the Icelandic International Development Agency (ICEIDA) and the Instituto Nacional de Desenvolvimento das Pescas (INDP) conducted three surveys of the demersal small-scale resources of the archipelago of the Republic of Cabo Verde. The general results of these surveys are introduced in an accompanying report "The demersal small-scale resources of Cabo Verde, West Africa. I. Three handline surveys, 1995-1997." In this report we present the results of assessment models that were constructed for seven commercially and/or biologically important species in the small-scale fisheries.

The models used in the assessment are the traditional steady state models most commonly used in stock assessment worldwide. These models make assumptions that in general are very hard to fulfill and make these models undesirable in many instances (Hilborn and Walters 1992). On the other hand these steady state models are a reasonable first approximation and can give valuable information if interpreted correctly (Sale 1991; Gallucci, Amjoun et al. 1996).

2 Methods

Most tropical fish do not lend themselves to easy age determination and age-based models are therefore inappropriate in most tropical fisheries (e.g. McManus, Nañola et al. 1996; Medley, Gaudian et al. 1993; Gallucci, Amjoun et al. 1996; Polunin, Roberts et al. 1996; Russ 1991; Sparre and Venema 1992; Gallucci, Amjoun et al. 1996). Unfortunately much of the development of assessment models has been in high latitude fisheries which have had the advantage of a longer history of fisheries science and funding (Pauly 1994). This has been changing in the last 15 years or so and the availability of length-based methods has increased dramatically (Gallucci, Amjoun et al. 1996). What is more, very sophisticated models have been constructed that in many ways are comparable to what the state of art is in age-based methods (e.g. Gallucci, Amjoun et al. 1996; Zheng, Murphy et al. 1995).

Some simple methods to estimate growth and mortality parameters include catch curves, geometric interpretations and estimations of Z/k. These methods are simple, and can be used in yield –per-recruit analysis, but they have assumptions that limit their applicability (Sullivan, Lai et al. 1990; Gallucci, Amjoun et al. 1996). Those assumptions are (1) populations as expressed in length distributions are in a steady state over time, (2) recruitment is knife-edged without size selection, (3) growth is deterministic with length-at-age well defined, (4) survival of recruits is a negative exponential function.

In this chapter we will first describe where we got the basic data for the assessment and what species we included in our analysis. Then we will describe the methods used to estimate the basic biological parameters, Z/K and L_∞. Subsequently we will describe the von Bertalanffy (LVB) growth model used to estimate the growth curve, and finally we describe the Yield Per Recruit (YPR) calculations and the estimate of the actual fishing mortality (F_{real}).

2.1 Data

The first and most important source of data were the three surveys treated in the accompanying report mentioned earlier and treated individually in three reports published by ICEIDA (Oddsson, Monteiro et al. 1996; Oddsson and Monteiro 1997; Oddsson and Monteiro 1998). Two other sources were used for auxiliary data, that is biological data for *Cephalopholis taeniops* from the INDP landing site sampling program of Salamança and catch and effort data for the years 1987 to 1996 from the statistical reports of INDP (e.g. Anon 1995; Anon 1996; Anon 1997).

2.2 Species analysed

Data for eight species (see Table 1) were used in the analysis of biological parameters. The data for esmoregal (*Seriola dumerili*) was insufficient for more analysis than for the Z/K ratio and it was therefore left it out of further modelling.

Table 1. The eight species analyzed in this study.

Species	Common name	
	Cabo Verde	English
Apsilus fuscus (Af)	Dobradão	African forktail
Cephalopholis taeniops (Ct)	Garoupa	African hind
Lutjanus agennes (La)	Goraz	African red snapper
Parapristipoma humile (Ph)	Papagaio	Guinean grunt
Priacanthus arenatus (Pa)	Façola	Atlantic bigeye
Seriola dumerili (Sd)	Esmoregal	Greater amberjack
Serranus cabrilla (Sec)	Manelinha	Comber
Spondyliosoma cantharus (Spc)	Ruta	Black seabream

2.3 Estimation of biological parameters

We used three different methods to calculate the basic biological parameters subsequently used in the assessment models.

2.3.1 The Beverton and Holt method

The Beverton and Holt method:

$$\hat{\Theta}_{BH} = \frac{L_\infty - \bar{l}}{\bar{l} - l_c},$$

where $\hat{\Theta}_{BH}$ is an estimator of Z/k, l_c is the length at first capture, $\bar{l}$ is the mean length in the sample and L_∞ is the maximum asymptotic length of the species in question.

2.3.2 *The Ssentongo and Larkin method*

The unbiased Ssentongo and Larkin method (Ssentongo and Larkin 1973; Gallucci, Amjoun et al. 1996):

$$\hat{\Theta}_{USL} = \left(\frac{n-1}{n}\right)\frac{1}{\overline{Y} - Y_c},$$

where $\overline{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_i$, $Y_i = -\log(1 - l_i / L_\infty)$, and $Y_c = -\log(1 - l_c / L_\infty)$.

2.3.3 *The Wetherall, Polovina and Ralston method*

The Wetherall, Polovina and Ralston method (Wetherall, Polovina et al. 1987; Gallucci, Amjoun et al. 1996):

$$\hat{L}_\infty = \frac{\hat{\alpha}}{1-\hat{\beta}}$$

$$\hat{\Theta}_{WPR} = \frac{\hat{\beta}}{1-\hat{\beta}}$$

where $\hat{\alpha}$ and $\hat{\beta}$ are obtained by a simple linear regression of the form $l_i = \alpha + \beta l_i + \varepsilon_i$, where ε_i is a normally distributed error term.

2.4 The von Bertalanffy growth model

We used the traditional von Bertalanffy growth model (Beverton and Holt 1956; Sparre and Venema 1992; Appeldoorn 1996; Lai, Gallucci et al. 1996) for the estimation of growth parameters. The LVB is written as:

$l_t = L_\infty\left(1 - e^{-K(t-t_0)}\right)$ length based and

$w_t = W_\infty\left(1 - e^{-K(t-t_0)}\right)^b$ weight based,

where l_t is the mean length at age t, L_∞ is the mean asymptotic length, K is a parameter that describes the curvature of a growth curve and t_0 is the age at zero length and is an adjustment factor for the growth curve.

2.5 Yield per Recruit models

We used the size-based Beverton and Holt Yield per recruit model (Sparre and Venema 1992; Gallucci, Amjoun et al. 1996) for our calculations of yield.

$$Y' = \frac{Y}{RW_\infty} = E(1-c)^m \sum_{j=0}^{3} \frac{\Omega_j (1-c)^j}{1 + j\frac{K}{M}(1-E)}$$

Where $\frac{Y}{RW_\infty}$ is a dimensionless quantity describing yield, E is the part of a yearclass or cohort that that will die because of F that is $F = \frac{F}{F+M}$, c is the portion of the asymptotic length (or weight) at which the length of full recruitment (l_c) occurs that is $c = \left(\frac{l_c}{L_\infty}\right) = \left(\frac{w_c}{W_\infty}\right)^{1/3}$, K is a parameter that describes the curvature of a growth curve, M is the natural mortality and $\Omega_j = +1,-3,+3,-1$ for j = 0,1,2,3, respectively.

2.6 Estimating the actual fishing mortality

The actual fishing mortality experienced in a fishery is often very troublesome to estimate. For our estimation we used methods described in Sparre (1992).

3 Results

We first present the estimators of the biological parameters, then we present the results for the von Bertalanffy growth model and finally the results for the yield per recruit model. The results from each model are presented by species.

3.1 Estimators of biological parameters

The biological parameters we estimated were Z/K, K, L_∞ and t_0. Below are these parameters for each of the eight species analyzed (Table 2).

Table 2. This table shows the results of the estimation of biological parameters for eight species caught in the demersal small-scale fisheries. BH=Beverton and Holt method, WPR=Wetherall, Ralston and Polovina method, SsL=Ssentongo and Larkin method, var_{SsL} is the variation of the Ssentongo and Larkin Z/K.

Species	Z/K			
	BH	WPR	SsL	var_{SsL}
Apsilus fuscus	0,612	1,065	2,467	0,046
Cephalopholis taeniops	1,136	1,779	2,401	0,021
Lutjanus agennes	0,557	1,181	1,403	0,009
Parapristipoma humile	0,937	1,849	1,858	0,009
Priacanthus arenatus	0,475	0,987	0,968	0,013
Seriola dumerili	0,997	1,724	1,990	0,068
Serranus cabrilla	0,799	1,511	1,939	0,032
Spondyliosoma cantharus	0,363	0,807	1,350	0,015

The results from the models estimating the Z/K ratio vary quite a bit, two to three fold difference. This estimator is used in the yield per recruit model and therefore very much affects the yield calculations. We used the Ssentongo and Larkin method since that is thought to be the most appropriate estimator for this kind of data. It is a maximum likelihood method and is very tolerant towards the wrong model (see Gallucci et al. 1996). For the estimation of L_∞ we used the Wetherall, Polovina and Ralston method, which uses the whole length distribution for its regression estimate of maximum length.

3.2 The von Bertalanffy growth model

As stated above there was not sufficient data available for esmoregal (*Seriola dumerili*) to estimate its growth parameters. There are therefore seven species in all that have its growth parameters estimated.

Table 3. Results from the Von Bertalanffy growth model for the seven species with sufficient data. See Table 1 for the meaning of the acronyms.

Species	K	L_∞	t_0
Af	0,168	47,503	-4,274
Ct	0,129	51,977	-2,915
La	0,217	47,154	-4,044
Ph	0,108	39,687	-8,046
Pa	0,353	35,819	-2,672
Sec	0,361	36,985	-1,473
Spc	0,331	44,057	-1,678

We also compared the growth model to the actual data from the surveys (see Figure 1). The growth model seems to confirm well to the data in all cases.

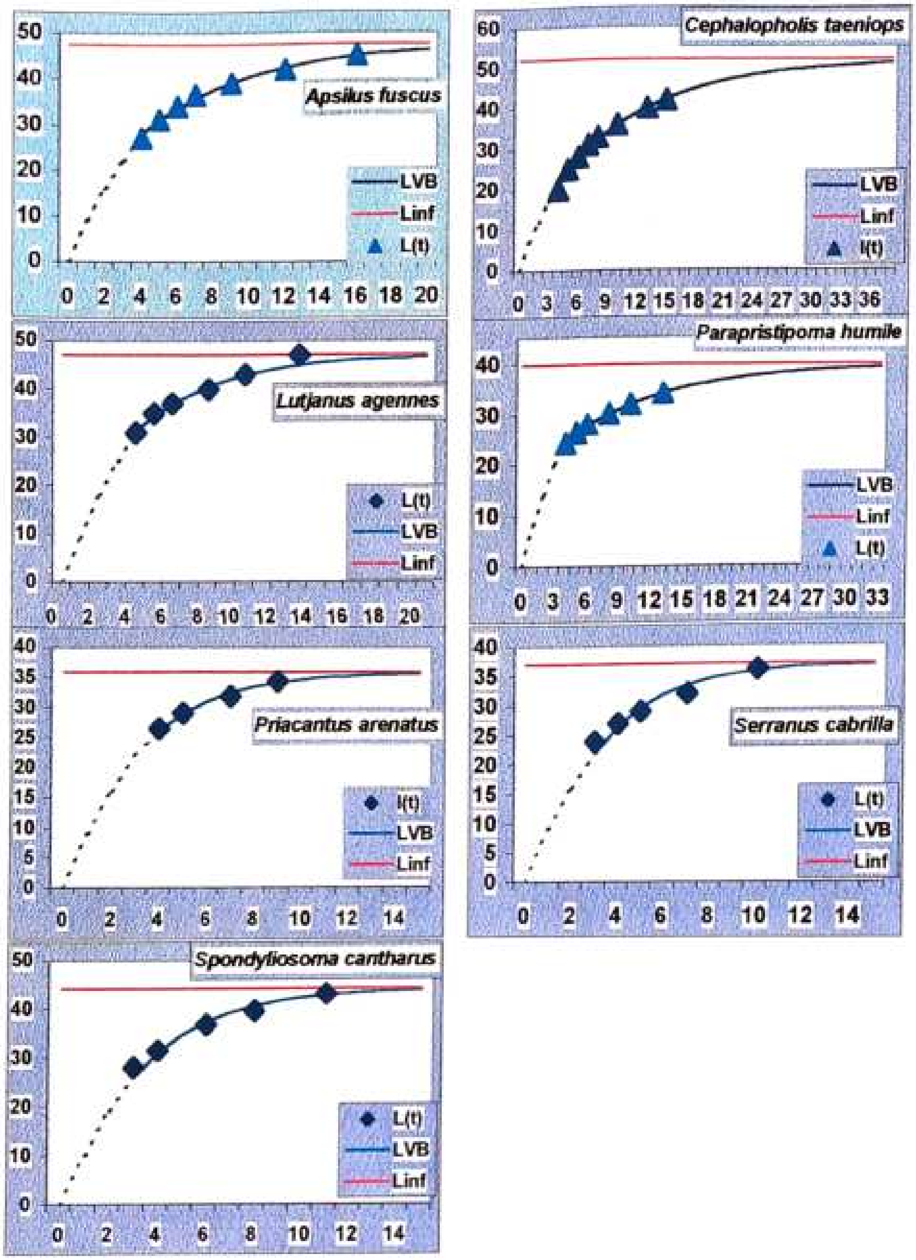

Figure 1. The von Bertalanffy model for seven species of demersal small-scale species caught in Caboverdean waters. The red line is the maximum length of each species (L_∞), the line is the model and the points are the real data. The x-axis represents age in relative "years" and the y-axis represents the length in centimeters.

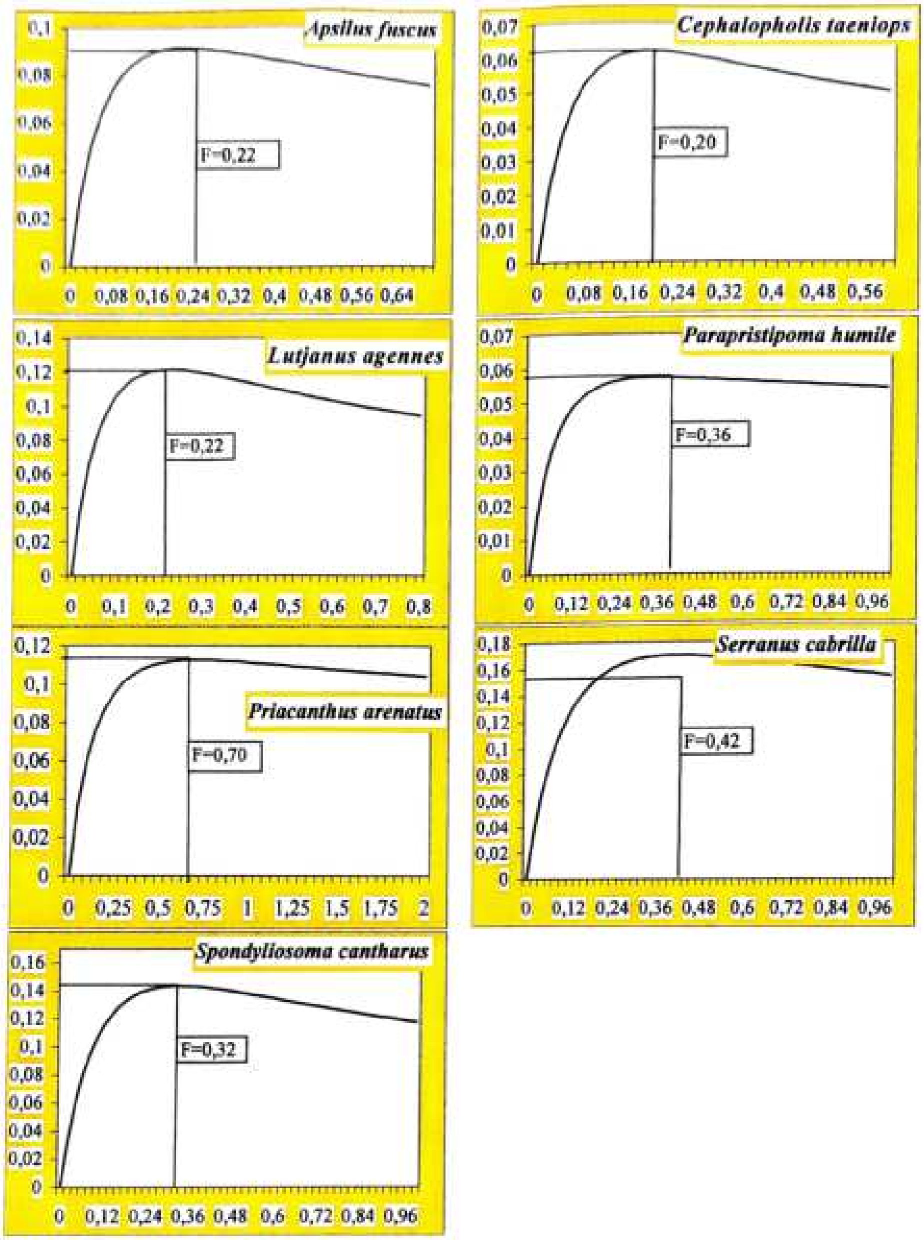

Figure 2. The results of the Yield per recruit model for seven commercially and ecologically important demersal small-scale species in Caboverdean waters. The x-axis shows the fishing effort and the vertical line shows the optimal fishing effort for each species. The y-axis shows relative yield.

3.3 The yield per recruit model

Finally we represent the results of a yield per recruit model (Figure 2). The intention of this model at this stage is to give an indication of where the fishing effort is in relation to the optimal effort. Because of the lack of information on the recruitment of all the species analyzed the results of the growth model do not give an indication of the absolute yield from the stocks but only an idea of the relative location of the fishing effort. Which in it self is a very important result.

4 Discussion

In this chapter we will discuss the individual species separately and then try to draw conclusions for the fishery as a whole.

The assessment models explored in this report have certain limitations that are necessary to take into account when interpreting the results. What is ultimately more important is the indication the models give of the state of the individual stocks and the fishery as a whole. The models are all so-called steady state models, that is, they do not take into account the inherent stochasticity of natural systems. This is a good first approach but considerably more work is needed before any accurate predictions can be made about the long-term absolute yield of the stocks.

As stated earlier eight species were originally chosen for analysis because of their commercial and/or ecological importance. Together these eight species make up more than 70% of the commercial catches in the Caboverdean small-scale demersal fisheries. Of the seven species only *Priacanthus arenatus* (Façola, Atlantic bigeye) is not highly sought after, fetches low price at the market and is therefore often discarded by the fishermen. We had reasonably good data for all the species except *Seriola dumerili*

(Esmoregal, Greater amberjack) and therefore had to exclude it from any analysis beyond the basic biological parameters.

4.1 *Apsilus fuscus* (Dobradão, African forktail)

Apsilus fuscus is of the snapper family (Lutjanidae), inhabits corraline and rocky bottom from 15 to 100 m depth and feeds on small fishes, squids and crustaceans (Allen 1985).

A. fuscus had the largest estimated value of Z/K, 2,467 with a variation of 0,046 or less than 2%. Simulation models that calculate the Z/K for a given length distribution are a great tool to see how well estimation model results confirm with the values expected when looking at the observed length distribution. The estimated Z/K value for *A. fuscus* confirms well with the expected value that gives confidence in the results.

The estimated maximum length of *A. fuscus* is 47,5 cm and fits well with the observed maximum length in the survey catches (Oddsson, Monteiro et al. 1996; Oddsson and Monteiro 1997; Oddsson and Monteiro 1998).

The von Bertalanffy growth model seems to give reasonably good results for all the species, including *A. fuscus*. The model indicates a slow growing, long-lived species, which fits with what is expected of a Lutjanidae.

The Yield Per Recruit model for *A. fuscus* is shown in Figure 2. The estimated optimum yield according to this model is achieved at a fishing mortality of 0,22. The yield curve indicates that a fishing mortality between about 0,18 and 0,25 is very close to the optimum yield. The only information we have of the real fishing mortality is for *Cephalopholis taeniops* and indicates that the real fishing mortality is around 0,25. There is no reason to expect the fishing mortality for *A. fuscus* to be much different so the real fishing mortality seems to be a little bit to the left, but very close to the optimum yield. This seems to indicate that A. fuscus is being exploited close to its ideal level, in the areas covered by the survey. It is important to note that the models analyzed in this study do not give an indication of the stock size only the level of the exploitation.

4.2 *Cephalopholis taeniops* (Garoupa, African hind)

Cephalopholis taeniops is a member of the grouper family (Ephinephelidae). It inhabits sandy and rocky bottoms between 20 and 200 meters depth (Smith 1990). Nothing has been published on its biology, but like other groupers it seems to be slow growing and long lived (unpublished data by the authors).

C. taeniops had a Z/K value of 2,401 with a variation of 0,021 or 0,8% that is a very small error term. This Z/K value is second only to *A. fuscus* and similar to the value for *A. fuscus*, confirms with the expected value based on the size distribution of the samples from the surveys (Oddsson, Monteiro et al. 1996; Oddsson and Monteiro 1997; Oddsson and Monteiro 1998).

The estimated maximum length of *C. taeniops* is 52 cm, which fits well with the observed maximum length in the survey catches and in the biological sampling at the Salamança landing site, which was 51 and 55 cm respectively. Incidentally that is well above the maximum length of 40 cm for *C. taeniops* reported in the FAO species catalogue on groupers (Heemstra and Randall 1993).

The von Bertalanffy growth model calculated for *C. taeniops* fits the observed data extremely well.

The Yield Per Recruit model for *C. taeniops* is very similar to the one for *A. fuscus* and for *Lutjanus agennes*, with an optimum fishing mortality of 0,20. As mentioned earlier *C. taeniops* was the only species analysed here that had sufficient auxilary data to estimate its real fishing mortality, which turned out to be 0,25. The difference between the optimum fishing effort and the real fishing effort is 20% which is much more than is recommandable. On the other hand this difference in fishing effort between what is optimal and what is observed in the fisheries, is not reflected in the yield of the stock according to the YPR model. When considering these results we have to keep in mind two things, first that this is the first attempt to estimate the yield of the *C. taeniops* stock and that the scarceness of data limits not only the accuracy of the model, but also the . Second that there is an inherent variation in estimation models of this kind. At this point we cannot ascertain what is the reason that we cannot detect a statistically significant difference between the yield for the observed fishing mortality and the optimal fishing mortality. We therefore conclude that there is negligent difference between the optimum yield from the *C. taeniops* fishery and current yield. Again we would like to point out that the fishing grounds of Cabo Verde vary very much in their size and species richness and this statement only reflects the overall condition of the stock not the exploitation pattern on individual fishing grounds, which is potentially very different (as seen in the great variation in the survey catch rates on different grounds; (Oddsson, Monteiro et al. 1996; Oddsson and Monteiro 1997; Oddsson and Monteiro 1998).

4.3 *Lutjanus agennes* (Goraz, African red snapper)

Lutjanus agennes is a snapper or Lutjanidae, like *A. fuscus*, with similar live history characteristics. It lives on rocky bottoms and coral reefs. The juveniles are common in brackish lagoons and found in rivers (Allen 1985).

The Z/K estimated for *L. agennes* was 1,403 with a variation of 0,009 or 0,6%. This is considerably lower than for the two previous species, but still confirms with the observed length distribution.

The maximum length of 47 cm fits with the observed maximum length from the surveys. The K (0,217) is almost twice as high as the K for *A. fuscus* and *C. taeniops*

(0,168 and 0,129 respectively), which probably is sufficient to explain the difference in Z/K and indicates that *L. agennes* is faster growing than either of the previously mentioned species. The K-value or the curvature parameter is an indicator of how quickly the species reaches L_∞ or how quickly it grows. The higher the K-value the quicker L_∞ is reached.

The von Bertalanffy growth model calculated for *L. agennes* fits the observed data fairly well, except for the last data point which is considerably above the calculated value. It is not unusual that the ends of the growth curve deviate from the observed. This results from the small amount of data, and therefore larger variation, that lies behind the smallest and largest fish, or the youngest and oldest fish. Aside from that the model seems to predict the growth of the species very well.

The Yield Per Recruit model is, as stated before, very similar to the ones for *A. fuscus* and *C. taeniops*. The optimum F or fishing mortality is 0,22 or about 12% less than the observed fishing mortality in the *C. taeniops* fishery. This difference is considerable but perhaps not more than expected considering the variation in the calculations.

4.4 *Parapristipoma humile* (Papagaio, Guinean grunt)

Parapristipoma humile is of the grunt family (Haemulidae) and lives on sandy and rocky substrate from the littoral down to 100 meters depth (Roux 1990).

The Z/K estimate for *P.humile* is 1,858 with a variation of 0,009 or 0,5%. The maximum length estimated from the Wetherall, Polovina and Ralston model is 40 cm, which fits with the maximum observed length from the surveys of 41 cm. The K value is the lowest one estimated four the seven species analyzed, 0,108, and *P. humile* should therefore be the slowest growing species analyzed here.

The von Bertalanffy growth model fits the observation very well, but the t_0 indicates some problems with the age of first capture and the age axis should therefore not be taken literally. As in fact is the case for all the growth models presented here.

The YPR model shows a very flat curve and an F value of 0,36, which is considerably higher than the ones for the other slow growing species. This F value is very much in league with the ones for *Serranus cabrilla* and *Spondyliosoma cantharus* (see below).

4.5 *Priacanthus arenatus* (Façola, Atlantic bigeye)

Priacanthus arenatus is of the bigeye or catalufa (Priacanthidae) family. It inhabits coral reefs and rocky bottoms (Randall 1978) and often forms small schools near the bottom (Hureau 1990). It is a nocturnal feeder (Böhlke and Chaplin 1993) that feeds mainly on small fishes, crustaceans and polychaetes (Randall 1978) and most of its prey are larvae.

The estimation of Z/K for *P. arenatus* is 0,968 with a variation of 0,013 or 1,3%. This is by far the lowest estimated value of Z/K.

The maximum length estimated for *P. arenatus* is 36 cm compared with a maximum observed length of 37 cm. The estimated K-value was 0,353, that is more than two times higher than for the previous mentioned species. That is the long-lived relatively slow growing species. The relatively low t_0 value points to the same conclusion.

The von Bertalanffy growth model also shows the same, i.e. that *P. arenatus* is much faster growing and lives shorter than the snappers and groupers mentioned before.

The YPR model shows a very flat topped yield curve, with an extremely high F-value, 0,70. This is obviously much higher than the observed F for the fishery. We therefore draw the conclusion that *P. arenatus* is not being fished close to its optimum level, and that the exploitation rate can be increased considerably without any adverse effects.

4.6 *Seriola dumerili* (Esmoregal, Greater amberjack)

Seriola dumerili is of the Carangidae (jacks and pompanos) family. The greater amberjack inhabits deep seaward reefs; occasionally entering coastal bays. It feeds primarily on fishes such as the bigeye scad, and horse mackerel but also feeds on invertebrates (Smith-Vaniz 1986). Small juveniles associate with floating plants or debris in oceanic and offshore waters. Juveniles usually form small schools (Fischer, Sousa et al. 1990). *S. dumerili* occurs between the littoral down to 360 meters depth (Cervigón 1993).

S. dumerili has a wide length distribution and therefore needs a large sample size to show trends in the size distribution that can be used to estimate its age distribution. The number of *S. dumerili* caught in the three surveys was not sufficient for that, but it sufficed to estimate the Z/K, which was estimated at 1,990 with a variation of 0,068 or 3,5%. The error term is about twice as high as for the other species analyzed, but the Z/K is comparable to the one estimated for *Serranus cabrilla* (see below).

4.7 *Serranus cabrilla* (Manelinha, Comber)

Serranus cabrilla is of the family Serranidae (sea basses). It is usually found on the shelf and upper slope on rocks, sandy and muddy bottoms It generally feeds on fishes and invertebrates. It inhabits waters from the littoral down to 450 meters depth (Smith 1990).

The estimated Z/K value for *S. cabrilla* is 1,939, with variation of 0,032 or 1.6%. The K-value is 0,361 which is the highest one estimated for all the species, and indicates as previously mentioned that *S. cabrilla* is the fasted growing of the seven species reported here. The estimated maximum length is 37 cm, compared to an observed maximum length of 38 cm in the survey catches. The t0 is also relatively low and indicates that *S. cabrilla* comes into the fishery at a young age.

We see the same trends in the von Bertalanffy growth model, which does not quite capture the size of the youngest observed year class.

The F that is estimated in the YPR model is 0,42, that is in-between the slow growing groupers and snappers and the fast growing bigeye.

4.8 *Spondyliosoma cantharus* (Ruta, Black seabream)

Spondyliosoma cantharus is of the Sparidae (porgies) family. The species inhabits inshore waters on rocky or sandy bottoms and *Posidonia* beds to 50 m (young) and 300 m (adults). The depth range of *S. cantharus* is from 50-300 meters depth (Bauchot and Hureau 1990). It prefers to live in schools, sometimes in large schools. It is omnivorous, feeding on seaweed and small invertebrates, especially crustaceans. It is a protogynic hermaphrodite (Bauchot and Hureau 1986).

S. cantharus had an estimated Z/K of 1,350 with variation of 0,015 or 1%. The estimated maximum length was 44 cm, compared to 46 cm in the survey catches, so that fits well with each other. The estimated K was high, 0,331, indicating a relatively fast growing species and the t_0 was also relatively low indicating the same.

The von Bertalanffy growth model had a similar fit to the one for *S. cabrilla*, that is it had a good fit in the mid range but did not fit well in the outer ranges, especially the low range.

The YPR model shows a similar shape as the groupers and snappers, with an estimated optimal F of 0,32. This indicates that *S. cantharus* is being exploited relatively close to its optimum exploitation level.

4.9 The demersal small-scale fishery overall

The seven species we were able to do the full analysis on seem to fall into three categories regarding the estimators coming out of the models. The snappers and groupers, *A. fuscus*, *C. taeniops* and *L. agennes*, have a relatively high Z/K value, a relatively low K value, a relatively high L_∞ and a relatively low optimal F value, between 0,20 to 0,22. The second group is the seabream, the porgie and the grunt, *P. humile*, *S. cabrilla* and *S. cantharus*. They have a medium Z/K value but a high K-value (except for *P. humile*), lower L_∞ than the snappers and groupers and an F value between 0,32 and 0,42. Finally we have the bigeye, *P. arenatus*, with a low Z/K value, a high K-value, a low L_∞ value, and a very high F-value, 0,70.

These results reflect the varying life histories of these species. The slow growing and long-lived snappers and groupers that tolerate a low rate of exploitation. The fast growing species in group two that come early into the fishery and are short lived (except for *P. humile* which is anomalous) and finally the schooling fast growing, short lived Atlantic bigeye, which seems to tolerate a very high rate of exploitation. Unfortunately it is not a very marketable species in Cabo Verde, although it is on other markets.

The good news we get from this exercise is that overall most of the species and stocks analyzed are in a relatively good shape, although all kinds of precautions have to be drawn for these conclusions. These conclusions have to be supported by further data analysis and more modelling before we acquire confidence in them. The most important point we can take from this work is that lays the groundwork for further modelling of the demersal marine resources of Cabo Verde.

5 Conclusion

In this document we have reported on the results of the first assessment models that have been constructed for the demersal small-scale resources of Cabo Verde. It is of utmost importance that this work be continued in the near future, especially since there is considerable uncertainty involved in the models presented here. This uncertainty makes the results less reliable.

It has been stated that the calculation of optimum effort and maximum sustainable yield are the wrong questions to ask when doing fisheries assessment (Hilborn and Walters, 1992). That is probably correct but all the same it is very important to calculate the basic assessment parameters as we have done in this paper. Without those parameters you cannot begin to know anything about the state of the exploited stocks. We hope to introduce more complete and more reliable assessment models at a later date.

6 Recommendations

Our recommendations are aimed at increasing the reliability and relevance of the assessment models reported in here and are also meant to give an indication of the direction management of the small-scale resources should take in the near future.

First the increased reliability if the assessment. The models reported in this paper suffer from the lack of available data. It is not unusual to run into minimal data situations in low latitude small-scale fisheries and acquiring more complete information on the general biology, growth and recruitment of the most important capture species in a fishery is a common goal everywhere where natural resources are exploited. With more and better data it is possible to build better assessment models and to make more reliable predictions on the current and future state of the exploited stocks. This should be a main goal of any future work on the fisheries of Cabo Verde. The landing site sampling program in Salamança, which collects biological data from the small-scale fisheries, is an excellent example of what further work should emphasized. It is necessary to expand that work to other landing sites on other islands and to include all the most important species of the small-scale fishery in the sampling.

The management of small-scale fisheries is not simple. There are numerous issues that have to be confronted. It is necessary to confront the lack of data regarding the catch and effort of the small-scale fleet. Reliable *catch statistics* are invaluable in a fisheries management system. Good strides have been made in constructing a good catch-reporting program in Cabo Verde. But there is still much work to be done regarding the fishing effort exerted in the small-scale fisheries and it is of great importance to continue that work. The more reliable the catch statistics the easier it is to assess the current and predict the future biological and economic state of the sector.

There is in effect a *licensing* system in the fisheries sector of Cabo Verde. It is important to make certain that the licensing scheme takes into account not only the economic realities of the sector but also the biological capabilities of the resource. Of course it is important to build up the technological capabilities of the small-scale fleet not only for reasons of economic efficiency but also to increase the safety of the fleet. It is important to realize what effects technological change will have on the workforce and movement between sectors. The potential of demersal stocks on soft and sandy bottom has not been explored to the full and should be kept in mind in the future planning of the fisheries sector.

An increased importance has been put on the role of *marine protected areas* in the conservation of marine living resources and biological diversity. Marine protected areas have been shown to have the potential of being a source of commercially important species and to increase the resilience of neighboring areas. Already some work has been done on marine protected areas within the Cabo Verde coastal zone and it is very important to extend that work to the most important demersal fishing grounds.

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