SEYCHELLES FISHERIES AUTHORITY

Stock Assessments of Three Key Demersal Species in the Artisanal Fishery

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1.1. Stock assessments

This report presents length-based stock assessments for three key indicator species of the demersal handline fishery; these are *Aprion virescens* (Green jobfsh, zob gri*), Epinephelus chlorostigma* (Brownspotted grouper, vyey makonde) and *Lutjanus sebae* (Emperor red snapper, bourzwa). Additionally Yield-per-Recruit (YPR) analyses was conducted for *Lutjanus sebae* only. Since 2022, sampling locations has expanded to include additional landing sites and fish markets such as Victoria, La Retraite, and Cascade fish markets. In previous years sampling activities were mainly focused on the Victoria and Providence artisanal fishing port.

1.1.1. *Aprion virescens*

In 2023, 2652 fork length samples were taken for this species, compared to 1919 samples collected in 2022 and only 418 in 2021 (Table 1). The age-based growth parameters used were derived by Mees (1992) where K = 0.26, L_{∞} = 104cm, however t_0 =-2.3 was derived from the FMSP Project R6465 (MRAG, 1999). This was used to provide estimates of total mortality (Z), fishing mortality (F) and length at first capture (L_{c50}). Two estimates of natural mortality (M) were used, the first (M1) from Pauly (1980) with a temperature of 22°C. Since this method tends to overestimate M for slow growing species, the derivation from Jensen was also used (1996; reviewed in Hoggarth et al., 2006), where M = 1.5K to estimate this parameter (M2).

Table 1. *Aprion virescens: Estimates of fishing mortality, and related parameters, for two different estimates of natural mortality (M1 and M2), and corresponding estimates of length at first capture (L_{c50}). Length at first maturity (L_{m50}) estimates and sample sizes (N) are also provided.*

Parameter	2018	2019	2020	2021	2022	2023
Z	1.77	1.08	1.17	1.18	1.01	1.19
CI of Z	-2.63-6.17	0.50-1.67	0.45-1.89	0.46-1.90	0.78-1.24	1.12 – 1.27
r^2	0.96	0.92	0.93	0.96	0.93	0.99
M1	0.26	0.26	0.26	0.26	0.26	0.26
F	1.51	0.82	0.91	0.92	0.75	0.93
E	0.85	0.76	0.78	0.78	0.74	0.78
L_{c50} (cm) – Logistic	73.59	74.67	59.84	86.19	45.35	38.20
L_{c50} (cm) – Running av.	68.45	57.76	67.06	72.66	43.22	38.48
F/M	5.81	3.15	3.50	3.54	2.88	3.58
M2	0.39	0.39	0.39	0.39	0.39	0.39
F	1.38	0.69	0.78	0.79	0.62	0.80
E	0.78	0.64	0.67	0.67	0.61	0.67

L_{c50} (cm) – Logistic	72.18	74.22	59.96	85.57	45.34	38.24
L_{c50} (cm) – Running av.	68.45	57.77	67.11	72.67	43.23	38.48
F/M	3.54	1.77	2.00	2.03	1.59	2.05

L_{m50} (Mees 1992; MRAG 1999)	62-64; 65 cm					
N	362	408	353	418	1919	2652

In both 2022 and 2023, based on both estimate of M, L_{c50} was less than $L_{m50,}$ unlike in previous years where L_{c50} was more than L_{m50} (Table 1). The change in sampling sites could be one reason why there is a notable change in $L_{c50.}$ The new sampling sites increase the possibility of obtaining catch from smaller outboard vessels and therefore the inclusion of catch from areas previously not covered by the sampling programme.
The F/M ratio was looked at as a possible indicator of over-exploitation, considering that F=M has been suggested as a proxy for F_{MSY}. The F/M ratio was 2.88 in 2022 and 3.58 in 2023 with M1 (0.26) and with M2 (0.39) it was 1.59 in 2022 and 2.05 in 2023. With both estimates of M, the ratio is indicating high fishing pressure (Table 1).

1.1.2. *Epinephelus chlorostigma*

The sample size for 2023 was 1077 which is a considerable increase from the 716 samples collected in 2022 and 209 in 2021. The same growth parameters were used as in previous years, based on average of three estimates from Grandcourt (2002), Mees (1992) and Sanders et al. (1988), where K=0.21 and L_{∞}=57.19. L_{c50} was assessed against a published maturity estimate for females (Moussac, 1986), rather than for males, since this species is suspected of protogynous hermaphroditism. Size at maturity was also calculated from $0.5L_{\infty}$. As was the case with *Aprion virescens*, two estimates of M were applied in the assessment, the first (M1) the standard Pauly (1980) method with a water temperature of 22°C, and the second (M2) calculated using M=1.5K.

Table 2. *Epinephelus chlorostigma: Estimates of fishing mortality, and related parameters, for two different estimates of natural mortality (M1 and M2), and corresponding estimates of length at first capture (L_{c50}). Length at first maturity (L_{m50}) estimates, based on $0.5L_{\infty}$ and Moussac (1986), and sample sizes (N) is also provided.*

Parameter	2018	2019	2021	2022	2023
Z	1.25	1.24	1.5	0.82	1.21
CI of Z	0.18-2.31	-0.85 - 3.32	0.21 - 2.80	0.16-1.49	0.75 – 1.67
r^2	0.99	0.98	0.99	0.99	0.99

M1	0.48	0.48	0.48	0.48	0.48

F	0.77	0.76	1.02	0.34	0.73
E	0.62	0.61	0.68	0.41	0.60
L_{c50} (cm) – Logistic	34.9		37.82	34.16	34.45
L_{c50} (cm) – Running av.	33.73	34.76	34.51	33.38	33.76
F/M	1.6	1.58	2.13	0.71	1.52
M2	0.315	0.315	0.315	0.315	0.315
F	0.94	0.93	1.19	0.51	0.90
E	0.75	0.75	0.79	0.62	0.74
L_{c50} (cm) – Logistic	34.91		37.93	34.12	34.45
L_{c50} (cm) – Running av.	33.68	34.74	34.5	33.34	33.72
F/M	2.98	2.95	3.78	1.62	2.86
L_{m50} ($0.5L_{\infty}$; Moussac , 1986)	28.59 cm TL; 31 cm TL for females				
N	216	540	209	716	1077

For both estimates of M in 2022 and 2023, the L_{c50} was greater than the $L_{m50.}$ For 2023, the F/M ratio for both M1 and M2 were indicating high fishing pressure, 1.52 and 2.86 respectively. This is a change from 2022 where the ratio with M1 was indicating low fishing pressure with 0.71 (Table 2).

1.1.3. *Lutjanus sebae*

Mortality and capture estimates

An average of 2 age-based estimates was used (Grandcourt et al. 2008 and Newman 2000) and 2 length-based estimates (Mees 1996), where K = 0.163; L_{∞} = 88.6; t0 = -0.95 were used as growth parameters for the analysis. Additionally, an estimate of natural mortality based on an average derived from two methods; M = 1.5K and an age-based estimate derived by Grandcourt et al. (2008) using the Hoenig (1983) empirical equation was used.

The estimate of total mortality (Z) was 0.40 in 2023 which was slightly higher compared to estimates in 2022 but still lower than the estimation in 2021. Both the running and logistic estimate of L_{c50} was lower than the L_{m50} (Table 3). The F/M ratio (1.21) is still indicating high fishing pressure, however, in 2023 it has increased slightly compared to 2022, though, it remained lower than previous years (Table 3).

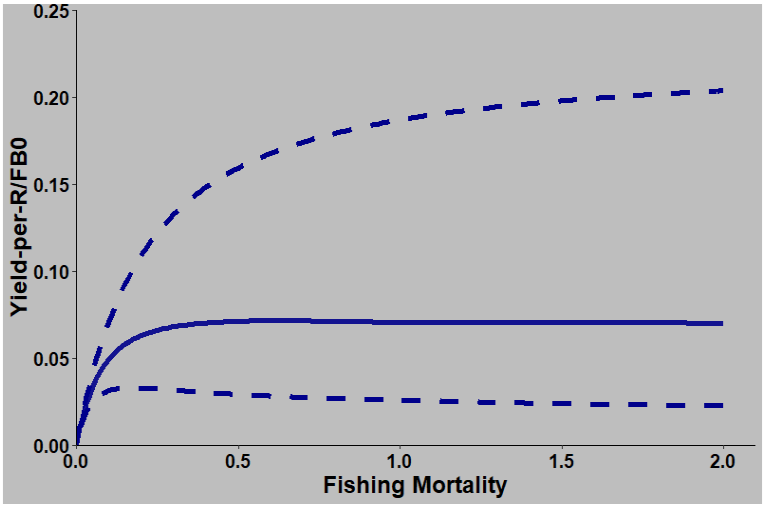
***Table 3**. Lutjanus sebae: Estimates of mortality and corresponding estimates of length at first capture (L_{c50}) from 2018 to 2023. Length at first maturity (L_{m50}) estimates, based on Mees (1992), and sample sizes (N) also provided.*

Parameter	2018	2019	2020	2021	2022	2023
Z	0.46	0.48	0.42	0.50	0.39	0.40
CI of Z	0.43-0.49	0.42 - 0.53	0.28 - 0.56	0.23-0.77	0.33-0.45	0.24–0.56
r^2	0.99	0.99	0.97	0.97	0.99	0.98
M	0.182	0.182	0.182	0.182	0.182	0.182
F	0.28	0.3	0.24	0.32	0.21	0.22
E	0.6	0.62	0.57	0.64	0.53	0.55
L_{c50} (cm) – Logistic	58.54	57.49	62.02	61.94	54.91	58.71
L_{c50} (cm) – Running av.	58.68	56.24	57.81	56.90	55.02	57.10
F/M	1.54	1.65	1.32	1.76	1.15	1.21
Maturity	62 cm FL					
N	413	1210	768	1177	1608	1255

Yield per recruit

A yield-per-recruit analysis was undertaken at the Mahe Plateau level including all fishing sector using the Yield Version 1.0 Software (MRAG, 2001). The results from the Yield software were imported into R Statistical software (R core team, 2024) for further processing.

The analysis indicated that MSY would occur when F is around 0.63. However, the Spawning Stock Biomass (SSB) would be reduced to less than 20% (a usual limit reference point) when F = 0.27 (CI= 0.15-0.47) (Fig. 1). For both MSY and SSB the estimates of current F (0.22) are not indicating overfishing (Table 4). From the histograms, maximum yield-per-recruit is achieved when F is around 0.16 – 0.40 (median= 0.47, CI=0.17-2.11) (Fig. 2), but at the expense of reducing the spawning stock biomass to unacceptable levels. To maintain SSB per recruit at 20% of unexploited biomass, F should be below the range of 0.25 – 0.32 (median= 0.26, CI= 0.14 – 0.50) (Fig. 3). The estimate of current F for 2022 (0.22; range = 0.058-0.38) is within the range of $F_{SSB20\ per\ recruit}$, though the upper range of F (0.38) exceeds the upper limit (0.32).



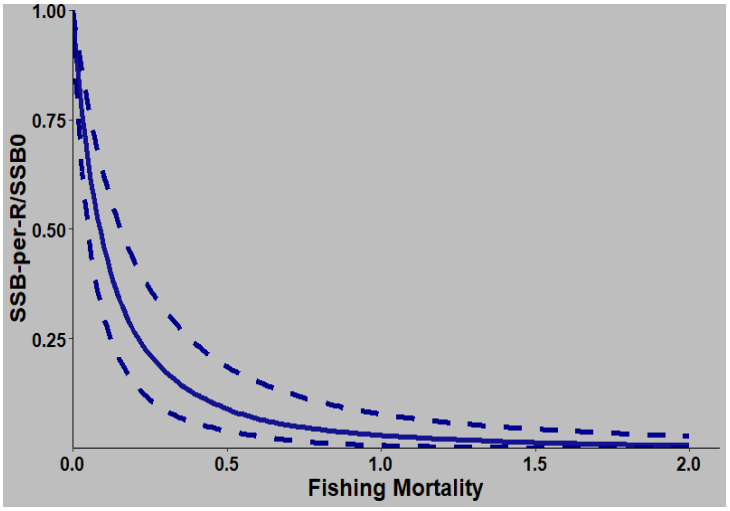


Figure 1. *Yield-per-recruit and Spawning Stock Biomass per recruit against levels of fishing mortality for all sectors combined*

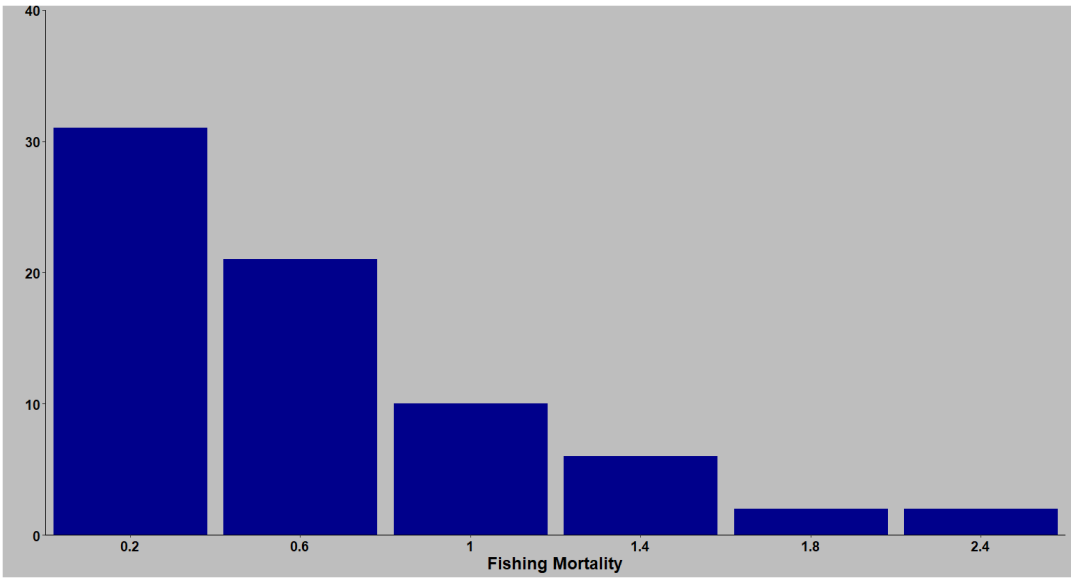


Figure 2. *Frequency distribution of fishing mortality that produces maximum yield-per-recruit for all sectors combined*

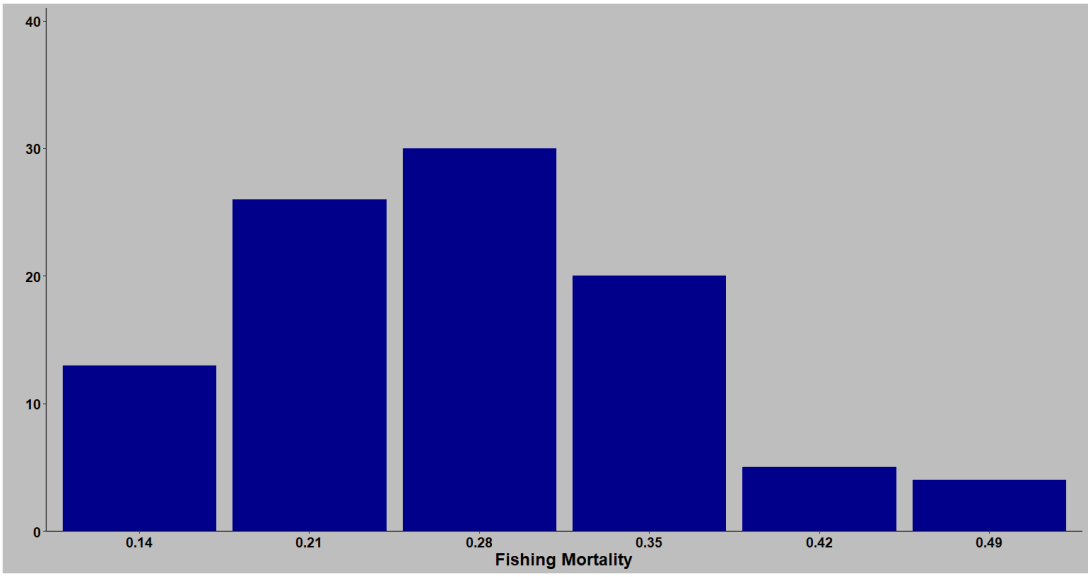


Figure 3. *Frequency distribution of fishing mortality that maintains Spawning Stock Biomass at 20% of its unexploited value for all sectors combined*

In summary, $F_{current}$ is within the range of estimates of the limit reference point F_{SSB20}, however, the upper limit of F exceeds the range of estimates of F_{SSB20} (Table 4). In addition, considering the mortality estimates derived, it can be concluded that despite a reduction in fishing pressure there is a possibility that this species remains overexploited.

Table 4. *Summary results of the YPR for Lutjanus sebae. Estimates of F required to achieve maximum yield per recruit (F_{MSYPR}) and F to maintain spawning stock biomass at 20% of unexploited biomass (F_{SSB20}).*

	All sectors 2023
F_{MSYPR}	0.63
F_{SSB20}	0.25 – 0.32
$F_{current}$ (CI)	0.22 (0.058-0.38)

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