SEYCHELLES FISHING AUTHORITY

Stock Assessments for Artisanal Fisheries

FISHERIES RESEARCH

2021

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1.1. Stock assessments

Assessments were undertaken for three key indicator species of the demersal handline fishery; these are *Aprion virescens*, *Epinephelus chlorostigma* and *Lutjanus sebae*. For all three species sampled, the number of size samples collected in 2019 increased compared to 2018. However, in 2020, a decrease in sample size was observed, due to reduction in sampling activities because of the country wide lockdown for several months.

1.1.1. *Aprion virescens*

In 2020, 353 fork length samples were taken for this species, compared to 408 samples collected in 2019. The same growth parameters were used as previous years: age-based growth parameters derived in FMSP Project R6465 were used in FiSAT II (K=0.1, L_∞=89.9, t0=-2.3) 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 Jenson 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	2014	2015	2017	2018	2019	2020
Z	0.27	0.4	0.34	0.36	0.33	0.35
CI of Z	0.14-0.39	-1.27-2.08	-0.64-1.32	-0.18-0.91	-0.16 - 0.82	-0.26 - 0.97
r^2	0.99	0.9	0.95	0.99	0.99	0.98

M1	0.26	0.26	0.26	0.26	0.26	0.26
F	0.01	0.14	0.08	0.1	0.07	0.09
E	0.04	0.35	0.24	0.28	0.21	0.26
L_{c50} (cm) – Logistic	66.18	79.28	68.68	73.63	71.49	75.52
L_{c50} (cm) – Running av.	67.47	69.16	68.42	68.45	65.9	68.81
F/M	0.04	0.54	0.31	0.38	0.27	0.35

M2	0.15	0.15	0.15	0.15	0.15	0.15
F	0.12	0.25	0.19	0.21	0.18	0.2
E	0.44	0.63	0.56	0.58	0.55	0.57
L_{c50} (cm) – Logistic	66.13	79.87	68.73	73.9	71.77	75.95
L_{c50} (cm) – Running av.	67.4	69.15	68.38	68.43	65.76	68.79

F/M	0.8	1.67	1.27	1.4	1.2	1.33
L_{m50} (Mees 1992; MRAG 1999)	62-64; 65 cm					
N	1036	235	634	362	408	353

In 2020, based on both estimate of M, L_{c50} was greater than $L_{m50,}$ as was the case in previous years. The ratio F/M was looked at as a possible indicator of over-exploitation, considering that F=M has been suggested as a proxy for F(MSY). The conclusions are contradictory depending on the value of M that is assumed. The F/M ratio was 0.27 in 2019 and 0.35 in 2020 with M1 = 0.26 indicating low fishing pressure, while with M2=0.15 it was 1.20 in 2019 and 1.33 in 2020 indicating relatively high fishing pressure. Similarly, to previous years, total mortality (Z) estimates were subject to large range in confidence interval (CI) leading to considerable uncertainties in estimates of F (Table 1).

Yield-per-Recruit (YPR) analyses were not conducted for this species.

1.1.2. *Epinephelus chlorostigma*

The sample size for 2020 was only 59 which was too low for analysis with FiSAT II therefore analysis was carried out on the 2019 data only. 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, 1996), rather than for males, since this species is suspected of protogynous hermaphroditism. 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, with K=0.21.

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	2014	2015	2017	2018	2019
Z	0.87	0.99	0.53	1.25	1.24
CI of Z	0.83-0.91	0.32-1.65	-3.34-4.4	0.18-2.31	-0.85 - 3.32
r^2	1	0.99	0.75	0.99	0.98
M1	0.48	0.48	0.48	0.48	0.48
F	0.39	0.51	0.05	0.77	0.76
E	0.45	0.52	0.09	0.62	0.61
L_{c50} (cm) – Logistic	33.56	35.79	30.04	34.9	
L_{c50} (cm) – Running av.	34.05	34.24	30.55	33.73	34.76
F/M	0.81	1.06	0.1	1.6	1.58
M2	0.315	0.315	0.315	0.315	0.315
F	0.56	0.68	0.22	0.94	0.93
E	0.64	0.68	0.41	0.75	0.75
L_{c50} (cm) – Logistic	33.55	35.8	29.93	34.91	
L_{c50} (cm) – Running av.	34.02	34.22	30.39	33.68	34.74
F/M	1.78	2.16	0.7	2.98	2.95
L_{m50} ($0.5L_\infty$; Moussac , 1986)	28.95 cm TL; 31 cm TL for females				
N	1437	161	601	216	540

Only the L_{c50} for running average was obtained in 2019 as the data did not run for L_{c50} logistic. For both estimates of M, the L_{c50} was greater than the L_{m50}. The F/M ratio varies depending on the estimate of M used. With M1, the F/M ratio is 1.58, whilst with M2, the ratio is 2.95 indicating a high fishing pressure. However, this result may be due to overestimation because of low sample number. The Z estimate were subject to large range in CI (-0.85 - 3.32) (Table 2). There is a need to improve the sample size to get a better representativeness of the size classes of fish caught.

1.1.3. *Lutjanus sebae*

Mortality and capture estimates

In 2020, the sample size was only sufficient to carry out analyses at the plateau level.

Due to problems in obtaining reliable performance of the YPR models in the Yield software using point estimates of growth parameters, 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. 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.

At the plateau level, the estimate of total mortality (Z) was 0.42 in 2020 which was relatively lower compared to estimates in 2019 and 2018. The running estimate of L_{c50} was lower than the L_{m50}, while the logistic estimate of L_{c50} was similar to the L_{m50} (Table 3). The F/M ratio was lower in 2020 (1.32) compared to the previous two years, however, it still indicates a relatively high fishing pressure.

Table 3. *Lutjanus sebae*: Estimates of mortality and corresponding estimates of length at first capture (L_{c50}) from 2014 to 2020. Length at first maturity (L_{m50}) estimates, based on Mees (1992), and sample sizes (N) also provided.

Parameter	2014	2015	2017	2018	2019	2020
Z	0.40	0.54	0.55	0.46	0.48	0.42
CI of Z	0.31-0.50	0.45-0.63	0.45-0.66	0.43-0.49	0.42-0.53	0.28 - 0.56
r^2	0.98	0.99	0.99	0.99	0.99	0.97
M	0.182	0.182	0.182	0.182	0.182	0.182
F	0.22	0.36	0.37	0.28	0.30	0.24
E	0.55	0.66	0.67	0.60	0.62	0.57
L_{c50} (cm) – Logistic	60.35	62.21	60.77	58.54	57.49	62.02
L_{c50} (cm) – Running av.	57.73	57.84	59.71	58.68	56.24	57.81
F/M	1.18	1.98	2.03	1.54	1.65	1.32
Maturity	62 cm FL					
N	2268	889	861	413	1210	768

Due to the low number of samples in the different sectors, estimates of mortality were not estimates for different sectors. A YPR analysis was carried out for all sectors combined for 2020.

Application of Yield software

Yield per recruit

<u>All sectors</u>

The yield-per-recruit analysis indicated that MSY would occur when F is around 0.81. However, the Spawning Stock Biomass (SSB) would be reduced to less than 20% (a usual limit reference point) when F = 0.32 (CI= 0.17-0.57) (Fig. 1). From the histograms, maximum yield-per-recruit is achieved when F is around 0.3 – 0.7 (median= 0.53, CI=0.17-2.93) (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 in the range of 0.24 – 0.32 (median= 0.30, CI= 0.14 – 1.29) (Fig. 3). The estimate of current F for 2020 (0.24; range = 0.10 - 0.38) is within the range of $F_{SSB20\ per\ recruit}$, however, the upper range of F exceeds the upper limit.

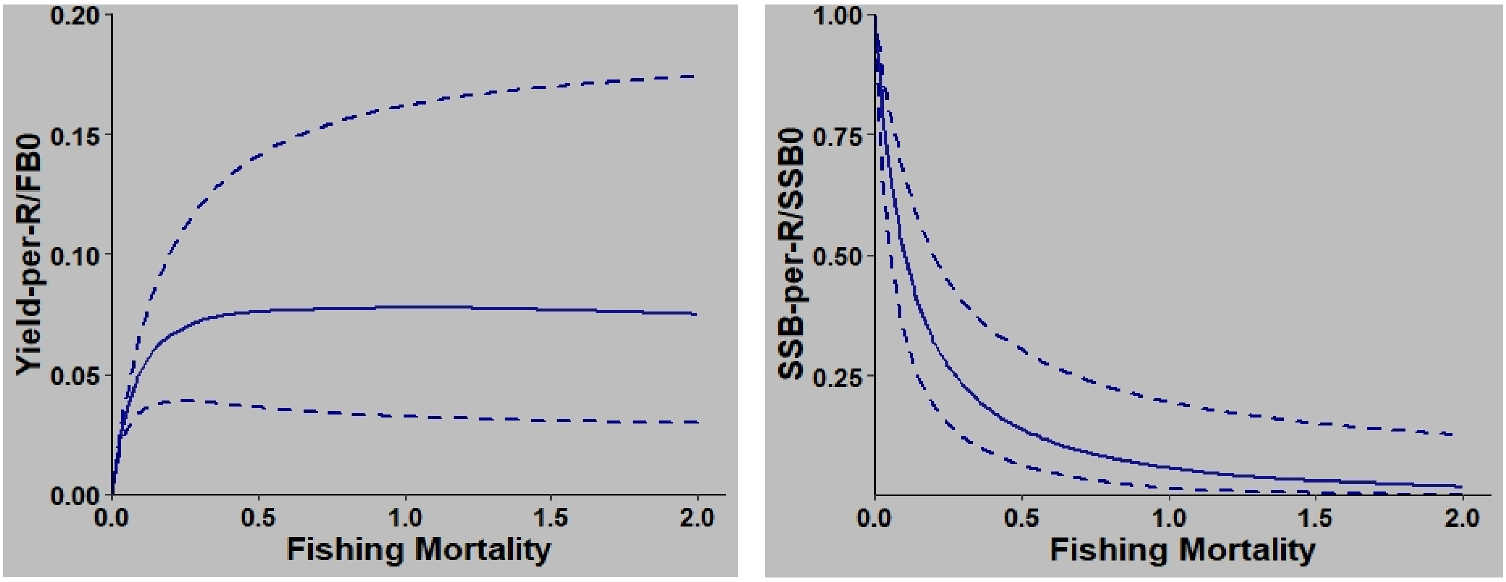

Figure 1. Yield-per-recruit and Spawning Stock Biomass per recruit against levels of fishing mortality for all sectors combined

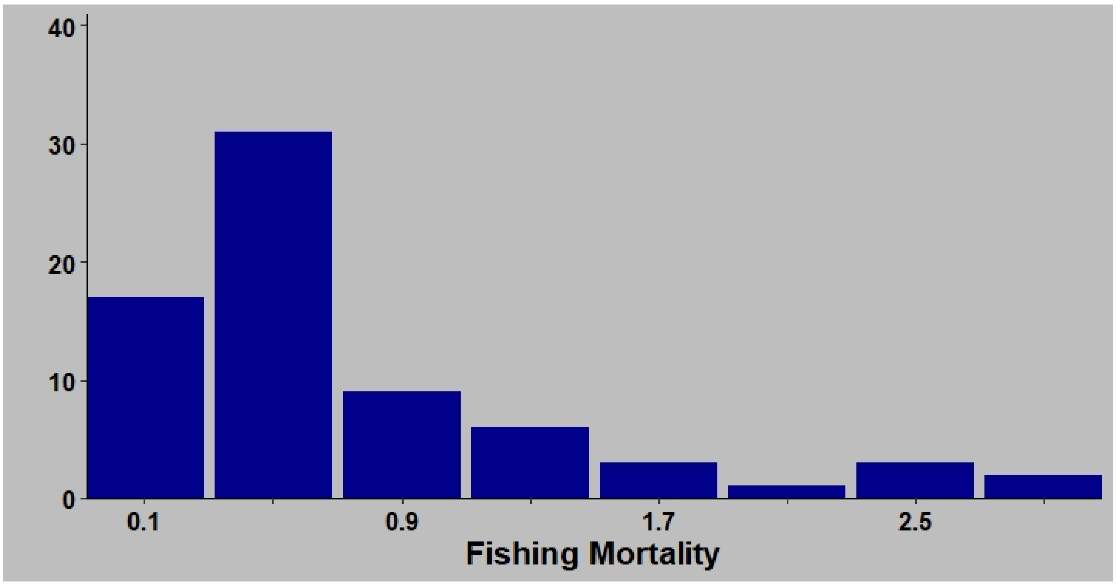

Figure 2. Frequency distribution of fishing mortality that produces maximum yield-per-recruit for all sectors combined

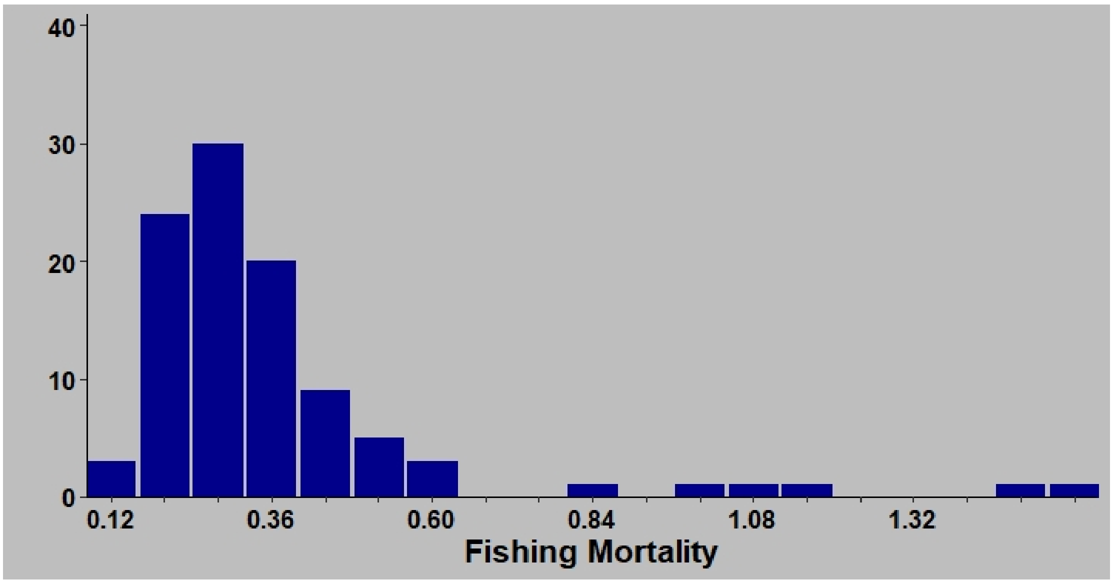

Figure 3. Frequency distribution of fishing mortality that maintains Spawning Stock Biomass at 20% of its unexploited value for all sectors combined

In summary, at the Mahe plateau level, $F_{current}$ 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 5). In addition, considering the mortality estimates derived, it can be concluded that there is a possibility that this species is overexploited. Caution should be taken in interpreting the stock status given the sample size was lower compared to previous years except for 2018.

Table 5. 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 2020
F_{MSYPR}	0.81
F_{SSB20}	0.24–0.32
$F_{current}$ (CI)	0.24 (0.10-0.38)

2. Weight of Evidence Approach

The Seychelles Fishing Authority (SFA) adopted the Weight of Evidence (WoE) method to determine the stock status of key species for different fisheries in 2015. This follows the recommendation made at the Commission meeting of the South West Indian Ocean Fisheries Commission (SWIOFC) in 2014, whereby member countries were encouraged to adopt this approach as a standard tool for the assessment of the status of fish stocks. Subsequently, in 2014, a workshop was held to train scientist from the member countries on how to apply this approach.

The WoE framework is a structured and scientific process for assembly and review of indicators of biomass status and levels of fishing mortality. A range of indicators are used in order to reliably determine the stock status. The process involves documenting key evidence and the rationale for the decisions based on the evidence. Expert judgement plays a key role in interpreting the documented evidence in order to derive the stock status.

The steps of the WoE approach are summarized below:

1. Describe the attributes of the species and fishery
2. Compile lines of evidence for status
3. Status determination (weighing of evidence)

The information is compiled in Excel templates.

The WoE framework was used to determine the stock status for thirteen different species and one species group for six different fisheries. The fisheries assessed are as follows:

- Demersal handline fishery
- Semi-pelagic handline fishery
- Trap fishery
- Semi-industrial longline fishery
- Lobster fishery
- Sea cucumber fishery

In future, the WoE approach will also be applied to the encircling gillnet fishery and other key species in the fisheries mentioned above.

The biomass and fishing mortality status of the different species classified under each fishery are summarised in the tables below:

Fishing mortality	Not subject to overfishing	Subject to overfishing	Uncertain
Biomass	Not overfished	Overfished	Uncertain

<u>Demersal hand-line fishery</u>

Fishery status	**2018**		**2019**		**Comments**
Biological status	Fishing mortality	Biomass	Fishing mortality	Biomass	
Emperor red snapper (*Lutjanus sebae*)					Slight increase in catch from 2017 while effort has been high but declining. Decline in Nominal CPUE since 2017 while slight increase in 2018 and 2019.
Green Jobfish (*Aprion virescens*)					Declines in standardised CPUE observed from 2008 to 2013. Catches have been fluctuating around MSY level. declines in catch and nominal CPUE from 2009 to 2015. Nominal CPUE for 2017 - 2019 could not be determined due to data being recorded by family instead of by species
Brown marbled grouper (*Epiniphelus chlorostigma*)					Catch has been increasing since 2017. Decline in nominal CPUE since 2014. In 2018 -2019 nominal CPUE has been low but stable

Semi-pelagic hand-line fishery

Fishery status	**2016**		**2017**		**Comments**
Biological status	Fishing mortality	Biomass	Fishing mortality	Biomass	
Yellowspotted trevally (*Carangoides fulvoguttatus*)					Standardised CPUE increased from 1999 to 2004. Declines in CPUE observed from 2004 to 2013. Nominal CPUE shows a decline from 2013 to 2016. CPUE for 2017 - 2019 could not be determined due to data being recorded by family instead of by species
Bludger (*Carangoides gymnostethus*)					From 1998 to 2005 standardised CPUE showed an increasing trend. From 2005 to 2013 CPUE shows a declining trend. Nominal CPUE shows a declining trend from 2011 to 2015. A peak in CPUE can be observed in 2016. Species specific CPUE for 2017 - 2019 could not be determined due to data being recorded by family instead of by species
Kawakawa (*Euthynnus affinis*)					Assessment of stock carried out by IOTC. The local CPUE has been declined in 2017. In 2018 and 2019 CPUE has been low but stable

Trap fishery

Fishery status	**2016**		**2017**		**Comments**
Biological status	Fishing mortality	Biomass	Fishing mortality	Biomass	
Siganidae (*Siganus sutor*, *Siganus argenteus*, *Siganus corallinus*)					Catch high and fluctuating since 2017. Nominal CPUE decline in 2016. From 2017 - 2019 nominal CPUE has been stable

Semi-industrial long-line fishery

Fishery status					**Comments**
Biological status	Fishing mortality	Biomass	Fishing mortality	Biomass	
Yellowfin tuna (*Thunnus albacares*)	2016	2016	2018	2018	New stock assessment carried out by IOTC in 2018, indicating overexploitation. On the local level the CPUE peaked CPUE has been increasing since 2018, with 2019 reaching an all-time high for the past 15 years
Bigeye tuna (*Thunnus obesus*)	2016	2016	2019	2019	The last stock assessment by IOTC was in 2019, the stock was determined to be not overfished but is subject to overfishing. On the local level, CPUE has been declining since 2015. From 2017 to 2019 it has been low but stable
Swordfish (Xiphias gladius)	2020	2020			Stock assessment carried out by IOTC in 2020 and the stock was determined to not be overfished and not subject to overfishing. The local CPUE shows decline since 2014 to 2017. From 2017 to 2019 CPUE has been low but stable

Lobster fishery

Fishery status	2019		2020		Comments
Biological status	Fishing mortality	Biomass	Fishing mortality	Biomass	
Pronghorn spiny lobster (*Panulirus penicillatus*)					The fishery was opened for the 2019/2020 season, with increase in catch but decrease in effort. The catch for the 2019/2020 fishing was the highest observed over the past 10 opened seasons. Nominal CPUE for all legal-size lobsters increase for the 2019/2020 season. Fisheries independent surveys indicate a decrease in number of lobsters sampled. CPUE increase in 2019 and 2020 indicating an increase in biomass and abundance. Based on these results the fishery was allowed to be opened for 2020/2021 season
Long-legged spiny lobster (*Panulirus longipes*)					The fishery was opened for the 2019/2020 season, with stable catch but decrease in effort. Nominal CPUE for all legal-size lobsters increase for the 2019/2020 season. Fisheries independent surveys indicate a decrease in number of lobsters sampled. CPUE increase in 2019 and 2020 indicating an increase in biomass and abundance. Based on these results the fishery was allowed to be opened for 2020/2021 season

Sea cucumber fishery

Fishery status	**2016**		**2017**		**Comments**
Biological status	Fishing mortality	Biomass	Fishing mortality	Biomass	
White teatfish (*Holothuria fuscogilva*)					Declines in catches and CPUE observed. Assessment of references cases shows evidence of population declines with significant declines in stock size from their pre exploited state
Flower teatfish (*Holoturia sp. (Pentard)*)					Declines in catches and CPUE observed. Assessment of references cases shows evidence of population declines with significant declines in stock size from their pre exploited state

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