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Background Paper: SFA 02

Results of the Catch Assessment Survey (CAS) 2010 and Research Activities for Artisanal Fisheries

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1. Artisanal fisheries statistics 2010

1.1 Catch and effort

1.1.1 Catches

The total artisanal catch for 2010 is estimated at 2595 Mt, representing a decrease of 14% over the 3010.8.1 Mt estimated for the previous year (figure 1).

A slight increase of 6% was recorded in catches landed on Mahe whereas the total catches on Praslin decreased by 70%. Given that there has not been any report of lack of fish on Praslin we can only conclude that this decrease in catches on Praslin/La Digue was due to 76% decrease in sampling coverage compared to 2009, which the software has failed to take into consideration. A total of 552 samples were taken on Praslin/La Digue in 2010 compared to 2282 in 2009.

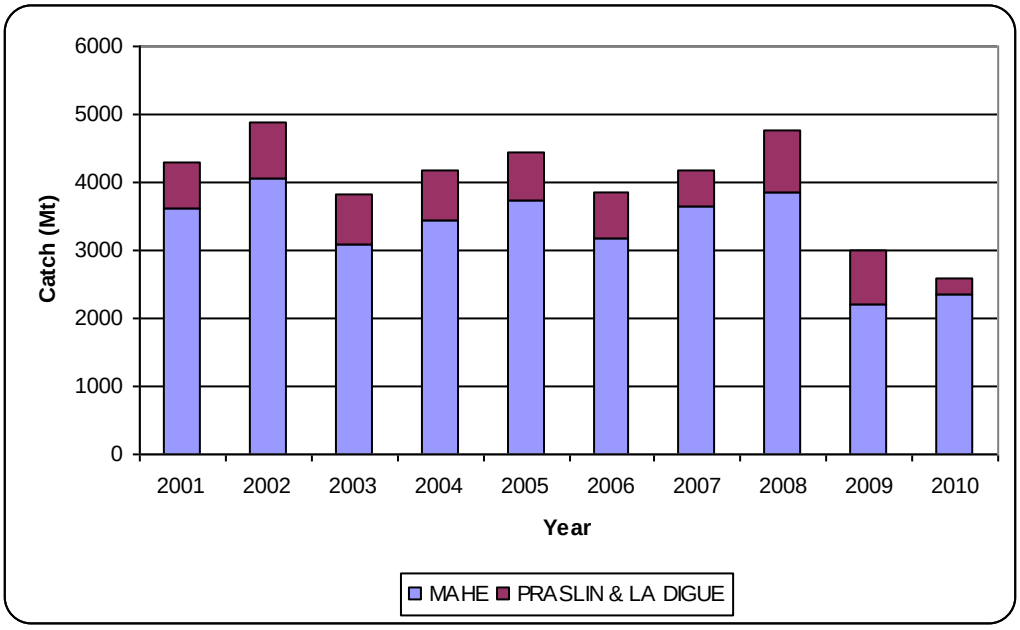

Figure 1. *Artisanal catch (t) for Mahé and Praslin/La Digue: 2001 to 2010.*

In terms of gear categories, the handline fishery, nets fishery and harpoon fishery all recorded decrease of 16%, 19% and 39% respectively. Both traps fishery and handline & traps fishery recorded a slight increase of 5% over the previous year (Figure 2)

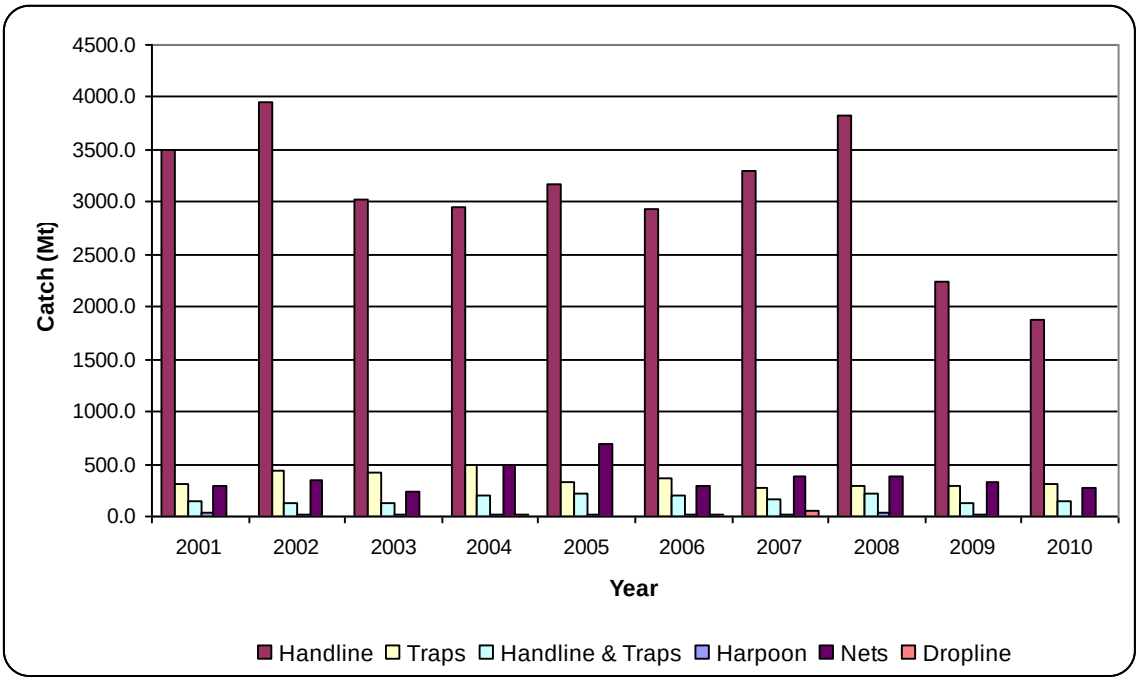

Figure 2. *Catch (MT) by gear category for 2001 to 2010*

The composition of the total artisanal catch by vessel category was dominated by whalers (47.8%), followed by outboard (33.9%). (Table 1).

Table 1. *Percentage (%) of annual catch landed by major vessel types, including foot fishermen: 2001 – 2010.*

Boat Type	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Pirogue	1.2	0.6	1.1	1.3	1.6	2.1	0.6	0.6	0.8	0.6
Outboard	25.0	25.4	27.4	34.3	36.2	28.3	25.0	25.4	37.6	33.9
Whalers	66.8	68.9	64.1	54.2	50.4	56.9	63.3	64.2	47.6	47.8
Schooners	6.0	4.5	6.8	9.0	11.1	11.5	9.3	8.9	13.3	17.1
Foot Fishers	1.1	0.6	0.6	0.9	0.7	0.6	0.4	0.8	0.5	0.6
Dropline vessels	0.0	0.0	0.0	0.3	0.0	0.6	1.4	0.1	0.2	0.0

1.1.2 Effort

As determined from monthly mean estimates of the number of vessels in operation, whereby the maximum monthly value is used as an indicator of fleet activity for the year, the number of outboard decrease from 324 vessels in 2009 to 316 vessels in 2010. The number of pirogue and whaler also decrease by 24% and 7% respectively,whilst the number of schooner remained the same. (Table 2).

In terms of fishing effort, the harpoon, net and trap fishery all recorded a decrease of 30%,21% and 8% respectively. A slight increase of 4% was recorded in handline fishery. (Figure 3).

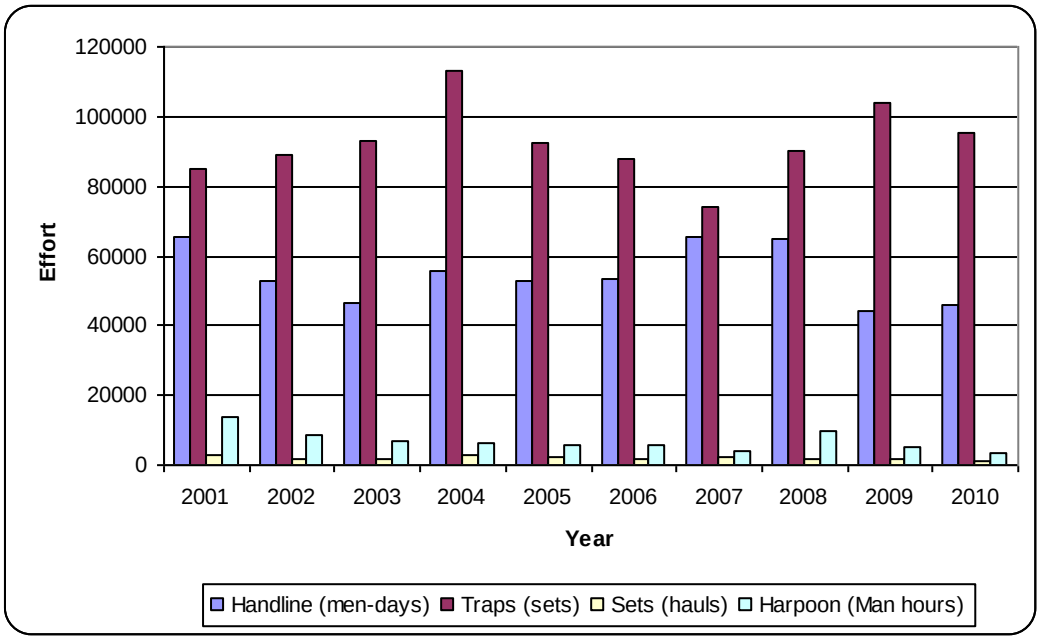

Figure 3. *Fishing effort for the major gear types for 2001-2010*

Table 2. *Maximum monthly fishing vessels in operation: 2002 to 2010.*

Vessel Type	2002	2003	2004	2005	2006	2007	2008	2009	2010
Pirogue*	31	30	33	30	27	22	19	21	16
Outboard*	234	250	239	234	242	243	294	324	316
Whaler	96	109	93	83	94	105	107	113	105
Schooner	13	16	20	18	26	22	22	27	27
Sport	38	21	**	**	**	**	**	**	**
Dropline	1	0	4	2	4	5	2	0	0

*Includes part time fishing vessels. **Data not available due to poor logbook returns.

1.2 Catch Rates

Catch rates (CPUE) for the handline fisheries decreased from 56.2 kg/man day in 2009 to 43.9 kg/man day in 2010 (Figure 3a). The schooner handline fishery recorded the highest CPUE compare to the other vessel types.An increase was observed in both handline and net fishery from 3.5 kg/trap in 2009 to 3.8kg/trap in 2010 (figure 3b) and 186.8 kg/set in 2009 to 191.3kg/set in 2010(figure 3c).The CPUE for harpoon fishery remained constant at 12.7 kg/man hour in 2010 (figure 3d).

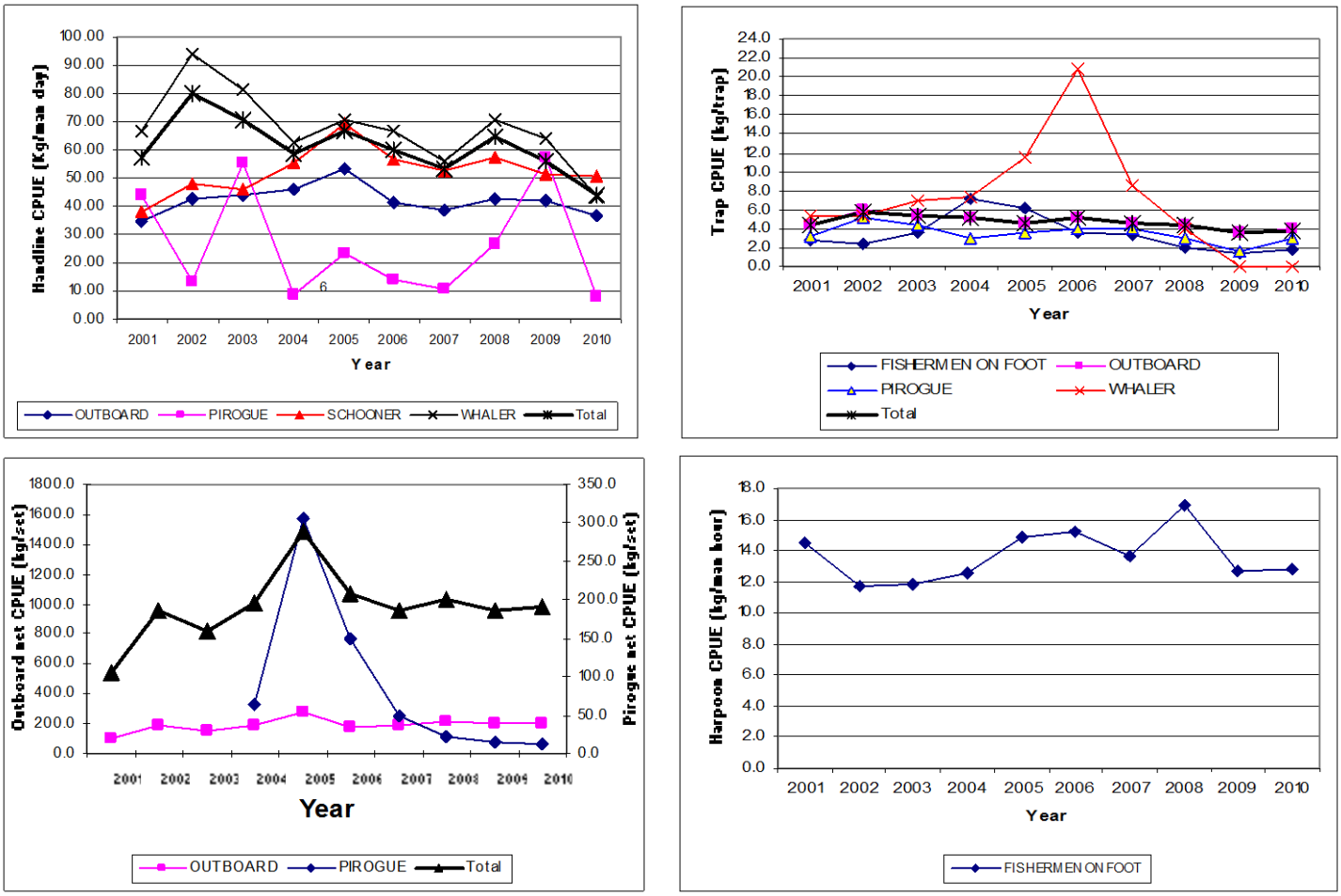

Figure 4*. Trends in catch rates (CPUE) for the major vessel and gear combinations in the (a) handline fisheries, (b) trap fisheries, (c) gill net fishery and (d) the harpoon (octopus) fishery for the period 2001-2010.*

1.3 Species composition

In 2010 an increase was recorded only in the catch of Rabbitfish (*Siganus* spp.) (17%) and Trevally (Carangoides spp.) (26%) .Significant decreased were observed in the catches of Emperors (*Lethrinus* spp.) (55%), other pelagics category (48%), Mackerel (*Rastrelliger* sp.) (34%) and Jobfish (*Aprion virescens*) (31%).Decrease were also recorded in Other Trap Fish (15%), Red snapper (Lutjanus spp) (9%) and Groupers (*Epinephelus spp)* (5%), (figure 5).

In 2010 Trevally (*Carangoides* spp.) was the dominant species caught accounting for 26% of the total catch followed by Red snapper (*Lutjanus* spp.) (21.6%) and Jobfish (*Aprion virescens*)(13.6%) (table 3).

***Table 3**. Percentage (%) species/species-group composition of artisanal catch for the period 2001-2010*

Species Group	Percentage (%) of total annual catch									
English/Scientific	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Trevally (*Carangoides* spp.)	30.1	41.7	33.6	28.2	24.8	19.7	18.7	25.7	17.8	26.0
Red snapper (*Lutjanus* spp.)	13.9	10	11.6	17	22.3	26.7	29.6	22	20.48	21.6
Jobfish (*Aprion virescens*)	16.4	12.5	15.8	12.5	11.2	15.5	15.7	15.8	16.94	13.6
Emperors (*Lethrinus* spp.)	11.2	6.9	6.1	6.2	5.1	4.4	4.6	7.1	7.23	3.7
Groupers (*Epinephelus* spp.)	2.5	1.5	2.4	2.3	2.1	3.2	3.8	3.2	2.72	3.0
Rabbitfish (*Siganus* spp.)	2.1	4.2	6.6	7.6	5.4	7.3	5.1	4	7.25	9.8
Mackerel (*Rastrelliger* sp.)	6.2	7.1	5.8	11	15.4	6.6	9.2	7.9	10.24	7.8
Other Pelagics	8.9	8.8	10.8	7.4	7.5	8.6	7.7	8	8.83	5.3
Other Trap Fish	3.6	3.7	3.5	3.7	2.6	3.3	2.4	3.4	4.2	4.2
Others	5.1	3.6	3.8	4.2	3.5	4.9	3.1	2.8	4.32	4.9
Total annual catch (MT)	**4285**	**4889.1**	**3835.7**	**4174**	**4433.3**	**3845**	**4181.4**	**4777.1**	**3010.83**	**2595.4**

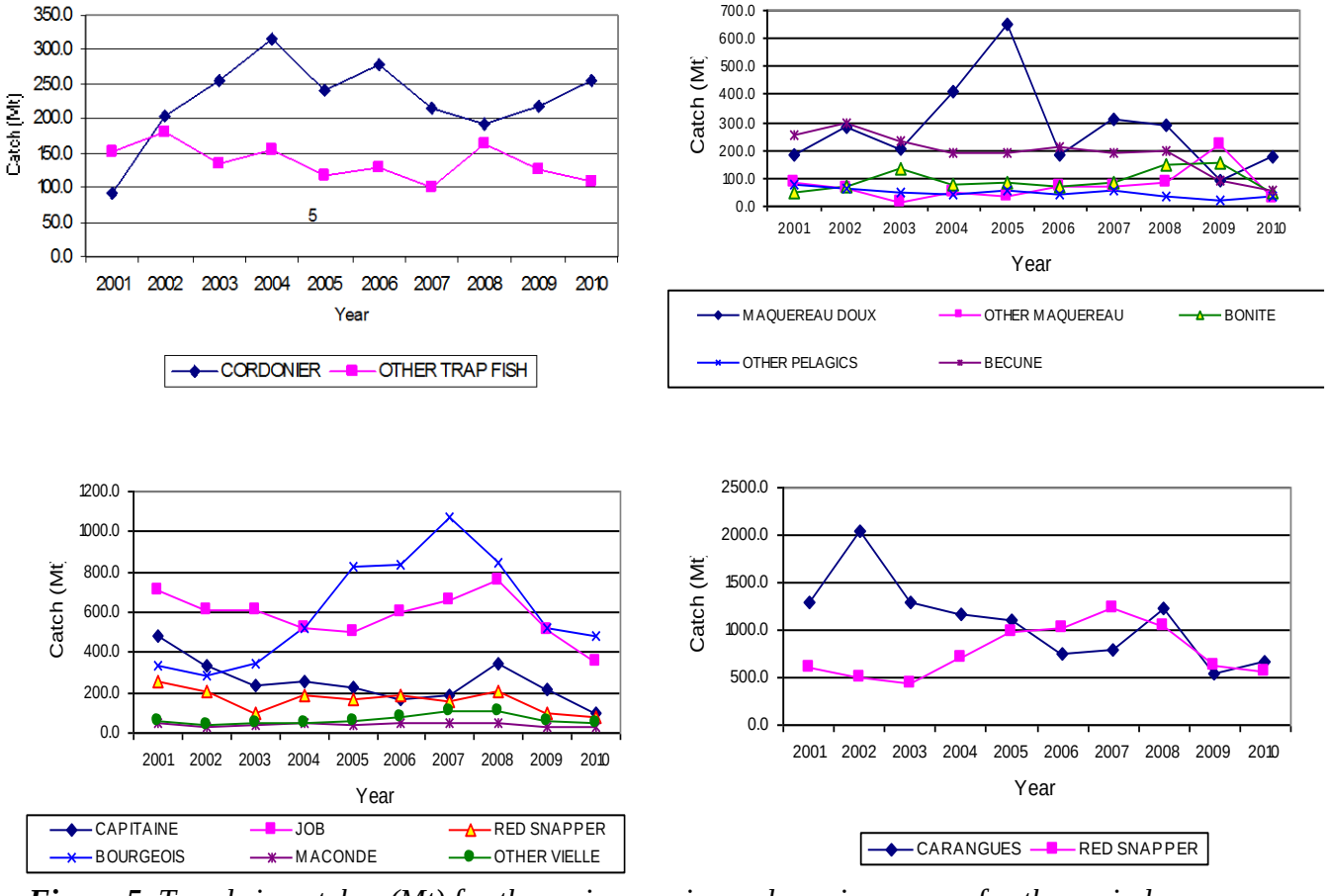

***Figure 5**. Trends in catches (Mt) for the major species and species groups for the periods 2001-2010, in terms of (a) comparison of the dominant species/groups in the artisanal catch, (b) semi-pelagic fisheries, (c) demersal, and (d) trap fisheries.*

1.4. Wholesale and exports

Purchases by Oceana Fisheries Co. Ltd. and Sea Harvest from the artisanal vessel were equivalent to 36% (942.4 MT) of total landings. Major species groups purchased were carangue (317.2 MT), bourgeois (290.8 MT), other pelagic (116.1 MT) , job (93.3 MT), and other vielle (44.1 MT).Fish purchases from foreign longline and purse seine vessels by Oceana Fisheries Co. Ltd and Sea Harvest totaled 232.6 MT during 2010. Major species purchased were the common dolphin fish (136.8 MT) and wahoo(81.1 MT). Other species include marlin, sailfish groupers and jobfish.

In 2010, fish and fish product exports from the artisanal fishery amounted to 381.9 MT. The bulk (63%) were exported fresh on ice to the EU and countries of the region, while most dried product was destined for Asian markets. These exports were valued at SCR 57.8 million (C.I.F). The main markets were Mauritius (100.5 MT) Hong Kong (73.9 MT)and United kingdom (73.4 MT). The species bourgeois other pelagics constituted 28 % of the total export followed by the other pelagics species category (21%), and sea cucumber species pentard (11%).

Table 4. *Export of artisanal catches by preservation type for the year 2010*

Species	Chilled	Dried	Fresh On Ice	Frozen	Grand Total
Carangues	0.0	0.0	0.0	0.0	**0.0**
Becune	0.0	0.0	1.0	0.0	**1.0**
Tuna	1.4	0.0	18.0	0.0	**19.4**
Common dolphinfish	0.0	0.0	0.4	41.7	**42.1**
Other pelagic	6.0	0.0	74.0	0.5	**80.5**
Capitaine	0.0	0.0	5.0	0.0	**5.0**
Other Snapper	0.0	0.0	2.3	0.0	**2.3**
Bourgeois	1.4	0.0	105.4	0.3	**107.1**
Job	0.8	0.0	16.4	0.1	**17.4**
Maconde	0.0	0.0	4.0	0.0	**4.1**
Other Vielle	0.1	0.0	9.1	0.0	**9.2**
Cordonier	0.0	0.0	0.0	0.0	**0.0**
Other Trap fish	0.0	0.0	0.0	0.0	**0.0**
Shark Fin	0.0	5.2	0.0	0.0	**5.2**
Black teatfish	0.0	3.6	0.1	0.0	**3.7**
Prickly Redfish	0.0	6.4	0.1	0.0	**6.4**
Pentard	0.0	39.3	1.5	0.0	**40.7**
White teat	0.0	19.1	0.3	0.0	**19.4**
Other Sea Cuucmber	0.0	0.6	0.0	0.0	**0.6**
Crab	0.0	0.0	0.9	0.1	**1.0**
Others	0.0	0.0	1.0	15.8	**16.8**
Grand Total	**9.7**	**74.1**	**239.6**	**58.5**	**382.0**

2. Research Activities

2.1. Stock assessments

In 2010, size samples were collected only during the first quarter of the year (Jan-Mar), in contrast to previous years where size samples were collected throughout the year. Assessments were undertaken for three key indicator species of the demersal handline fishery.

2.1.1. *Aprion virescens*

In 2010, 579 samples were taken for this species. 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 mortality (Z, F, M) 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, we also used the derivation from Jenson (1996; reviewed in Hoggarth et al., 2006), where M = 1.5K to estimate this parameter (M2).

Table 7. *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) also provided.

Parameter	2005	2006	2007	2008	2009	2010
Z	0.34	0.28	0.32	0.33	0.34	0.43
CI of Z	-0.28-0.97	-0.30-0.86	0.28-0.35	-0.28-0.93	-0.30-0.98	-0.72-1.57
r^2	0.98	0.97	0.99	0.98	0.98	0.96
M1	0.26	0.26	0.26	0.26	0.26	0.26
F	0.08	0.02	0.06	0.07	0.08	0.17
E	0.23	0.07	0.18	0.21	0.23	0.39
L_{c50} (cm) – Logistic	71.28	70.30	70.70	69.70	72.08	75.45
L_{c50} (cm) – Running av.	68.25	67.67	68.48	68.54	68.51	69.09
F/M	0.31	0.077	0.23	0.27	0.30	0.65
M2	0.15	0.15	0.15	0.15	0.15	0.15
F	0.19	0.13	0.17	0.18	0.19	0.28
E	0.56	0.46	0.53	0.55	0.56	0.65
L_{c50} (cm) – Logistic	71.45	70.38	70.73	69.71	72.20	75.71
L_{c50} (cm) – Running av.	68.22	67.62	68.45	68.52	68.48	69.07

F/M	1.27	0.87	1.13	1.2	1.27	1.87
L_{m50} (Mees 1992; MRAG 1999)	62-64; 65 cm					
n	1142	169	88	410	530	579

In 2010 and based on both estimates of M, L_{c50} was greater than $L_{m50,}$ as was the case in previous years. Combined with an F/M ratio of 1.87, this suggests that overfishing is unlikely to be occurring. However, similar to previous years, total mortality (Z) estimates were subject to large range in CI leading to considerable uncertainty in estimates of F (Table 7). Based on these results, YPR analyses were not conducted for this species.

2.1.2. *Epinephelus chlorostigma*

The sample size for *E. chlorostigma* was higher compared to previous years. The same growth parameters were used as in previous years, based on average of 3 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.

Based on the lower estimate of M (M2), the L_{c50} was greater than the L_{m50} . Combined with an F/M ratio of 0.89, this suggests that the stock is unlikely to be overfished. This is a stark contrast compared to the results of 2009 where the stock was considered to be overfished. Compared to previous years, this year we were able to get a better range of CI through the adjustments of the data points selected in the regression analysis to obtain Z (Table 8).

Table 8. *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) also provided.

Parameter	2005	2006	2007	2008	2009	2010
Z	0.98	0.85	0.78	0.47	1.82	0.68
CI of Z	-4.11-6.07	-5.69-7.39	-5.04-6.6	0.17-0.77	-3.44-7.07	0.02-1.35
r^2	0.86	0.73	0.75	0.99	0.95	0.84
M1	0.48	0.48	0.48	0.48	0.48	0.48
F	0.50	0.37	0.30	-0.01	1.34	0.20
E	0.51	0.43	0.38	-0.02	0.74	0.29
L_{c50} (cm) – Logistic	31.52	31.14	31.26	34.70		36.22
L_{c50} (cm) – Running av.	32.96	31.91	31.48	34.73	34.81	33.65
F/M	1.04	0.77	0.63	-0.02	2.80	0.42
M2	0.315	0.315	0.315	0.315	0.315	0.315
F	0.67	0.54	0.47	0.16	1.51	0.28
E	0.68	0.63	0.60	0.33	0.83	0.47
L_{c50} (cm) – Logistic	31.46	31.07	31.20	34.46		36.28
L_{c50} (cm) – Running av.	32.74	31.73	31.29	34.56	34.81	33.61
F/M	2.13	1.71	1.49	0.50	4.80	0.89
L_{m50} ($0.5L_{\infty}$; Moussac, 1986)	28.95 cm TL; 31 cm TL for females					
n	1161	348	78	178	250	437

2.1.3. *Lutjanus sebae*

In addition to analyses at the Plateau level, sample data were sufficient to perform analyses of the SE (sectors 5 and 6) area only.

Mortality and capture estimates

Due to problems in obtaining reliable performance of the YPR models in the Yield software using point estimates of growth parameters, we use an average of 2 age-based estimates (Grandcourt et al. 2008 and Newman 2000) and 2 length-based estimates (Mees 1996), where K = 0.163; L_∞ = 88.6; t0 = -0.95. We used 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.

The length at first capture (62.23 cm) was the same as the length at first maturity (62 cm) for all sectors combined in 2010. Moreover, the F/M ratio was 2.09, indicating that the stock is fully fished to slightly overfished (Table 9). Similarly, in the sectors 5 and 6 area, L_{c50} was equal to L_{m50} (Table 10). In addition, the F/M ratio was 2.14 indicating that at the sector level the stock is being slightly overfished and there is a cause for concern.

Table 9. *Lutjanus sebae*: Estimates of mortality and corresponding estimates of length at first capture (L_{c50}) from 2004 to 2010. Length at first maturity (L_{m50}) estimates, based on Mees (1992), and sample sizes (n) also provided.

Parameter	2004	2005	2006	2007	2008	2009	2010
Z	0.64	0.52	0.58	0.55	0.50	0.56	0.56
CI of Z	0.50-0.78	0.10-0.95	0.35-0.82	0.39-0.71	0.24-0.76	0.44-0.68	0.41-0.63
r^2	0.99	0.99	0.99	0.99	0.99	0.99	0.98
M	0.182	0.182	0.182	0.182	0.182	0.182	0.182
F	0.46	0.34	0.40	0.37	0.32	0.38	0.38
E	0.72	0.65	0.69	0.67	0.64	0.68	0.68
L_{c50} (cm) – Logistic	63.99	59.13	64.32	62.29	61.70	60.50	62.23
L_{c50} (cm) – Running av.	65.11	60.07	64.08	62.56	60.59	57.55	58.67
F/M	2.52	1.87	2.19	2.03	1.76	2.09	2.09
Maturity	62 cm FL						
n	1235	4797	4109	807	1430	2975	2243

Table 10. *Lutjanus sebae*: Estimates of mortality and corresponding estimates of length at first capture (L_{c50}) for 2009 and 2010. Length at first maturity (L_{m50}) estimates, based on Mees (1992), and sample sizes (n) also provided.

Parameter	All sectors (2009)	W-NW (Sectors 8 9, 10) (2009)	All sectors (2010)	SE (Sectors 5&6) (2010)
Z	0.56	0.61	0.56	0.57
CI of Z	0.44-0.68	0.38-0.85	0.41-0.63	0.36-0.77
r^2	0.99	0.96	0.98	0.96
M	0.182	0.182	0.182	0.182
F	0.38	0.43	0.38	0.39
E	0.68	0.70	0.68	0.68
L_{c50} (cm) – Logistic	60.50	61.08	62.23	61.92
L_{c50} (cm) – Running av.	57.55	58.29	58.67	59.03
F/M	2.09	2.35	2.09	2.14
Maturity	62 cm FL			
N	2975	853	2243	539

Yield per recruit

<u>All sectors</u>

YPR indicated that MSY occurs when F is around 1.2. However, SSB is reduced to less than 20% when F = 0.38 (CI=0.28-0.86) (Figure 6). From the histograms, MSY per recruit is achieved when F is around 0.65-1.15 (median= 0.88, CI=0.67-1.09) (Figure 7). To maintain SSB per recruit at 20% of unexploited biomass, F should be in the range of 0.35-0.39 (Figure 8). The estimate of current F (0.38; range = 0.23-0.45) is within the range of $F_{SSB20 \text{ per recruit.}}$ However, the upper range of current F exceeds the upper limit of $F_{SSB20 \text{ per recruit.}}$

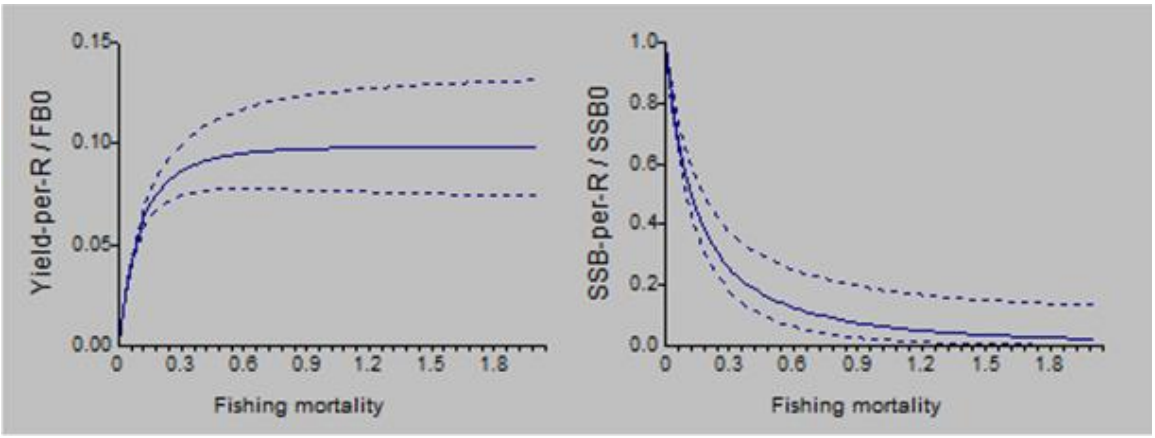

Figure 6. Yield per recruit and Spawning Stock Biomass per recruit against levels of fishing mortality for all sectors combined

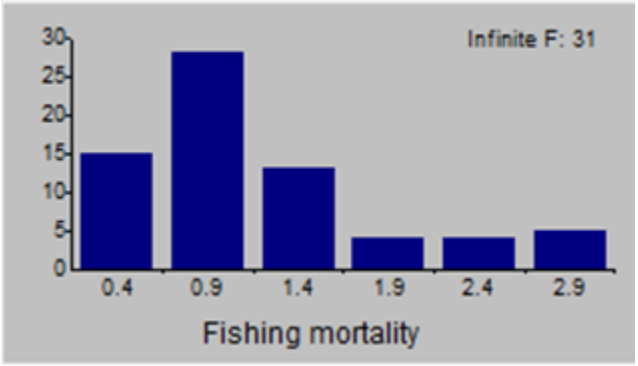

Figure 7. Frequency distribution of fishing mortality that produces maximum yield-per-recruit for all sectors combined

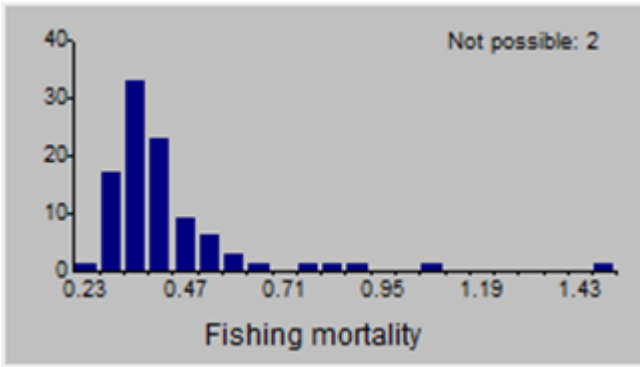

Figure 8. Frequency distribution of fishing mortality that maintains Spawning Stock Biomass at 20% of its unexploited value for all sectors combined

Sectors 5 and 6 (SE area)

YPR indicated that MSY per recruit occurs when F is around 1.65. SSB is reduced to less than 20% when F = 0.38 (CI=0.30-0.74) (Figure 9). From the histograms, MSY per recruit is achieved when F is around 0.2-1.4 (median=1.02, CI=0.86-1.19), however there

was a high number of infinite F (Figure 10). To maintain SSB at 20%, F should be in the range of 0.35-0.42 (median=0.39, CI=0.37-0.41) (Figure 11). The estimate of current F (0.39; range = 0.18-0.59) is within the range of $F_{SSB20\ per\ recruit.}$ However, the upper range of current F exceeds the upper limit of $F_{SSB20\ per\ recruit.}$

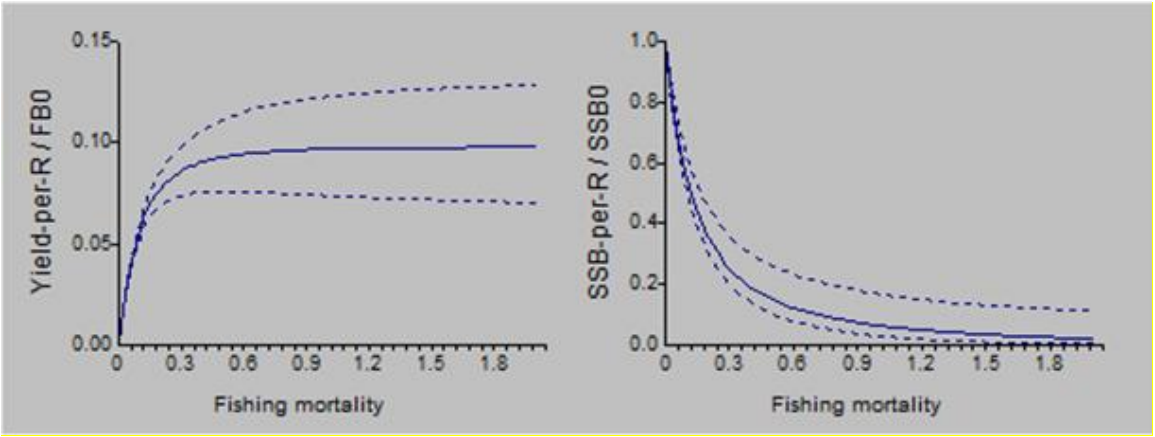

Figure 9. Yield per recruit and Spawning Stock Biomass per recruit against levels of fishing mortality for sectors 8, 9 and 10

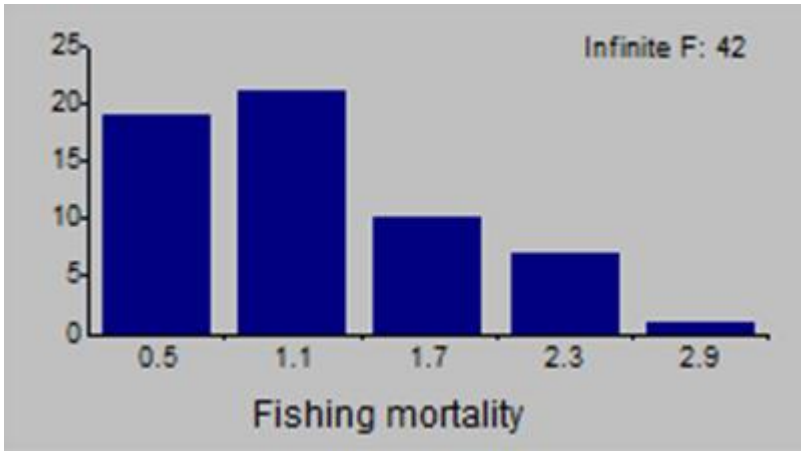

Figure 10. Frequency distribution of fishing mortality that produces maximum yield-per-recruit for sectors 5 and 6

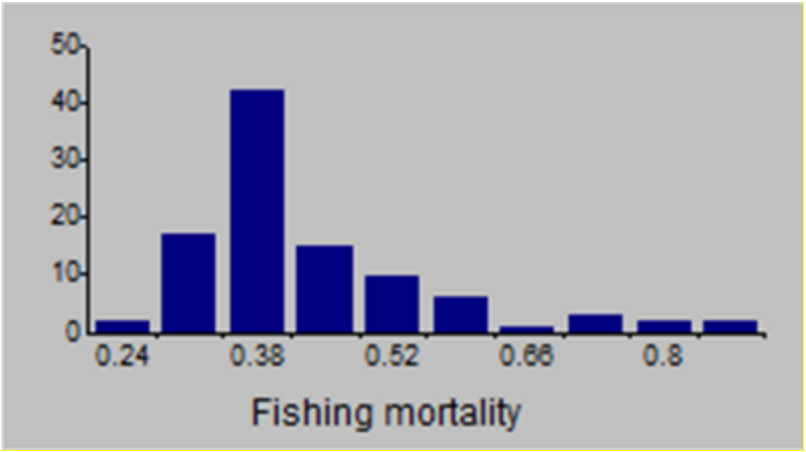

Figure 11. Frequency distribution of fishing mortality that maintains Spawning Stock Biomass at 20% of its unexploited value for sectors 5 and 6

At both the Mahe plateau and sector level, $F_{current}$ is within the range of estimates of F_{SSB20}, however the upper range of $F_{current}$ is above the upper boundary limit of F_{SSB20} (Table 11). Therefore, there is a possibility that this species is overexploited. In this year's assessments we were able to get much narrower confidence intervals for estimates of Z, which has improved our estimates of the range of current F. In summary, the stock status of *L.sebae* can be described as fully exploited to slightly overexploited. The exploitation rate of the stock has shown little changes over the past five yeas. However, caution should be taken in interpreting the stock status considering that samples were only collected during the first quarter of the year.

Table 11. Summary results of the YPR for *Lutjanus sebae*. Estimates of F required toachieve maximum yield per recruit (F_{MSYPR}) and F to maintain spawning stock biomass at 20% of unexploited biomass (F_{SSB20}).

	All sectors	**SE (Sectors 5 and 6)**
F_{MSYPR}	1.2	1.65
F_{SSB20}	0.35-0.39	0.35-0.42
$F_{current}$ (CI)	0.38 (0.23-0.45)	0.39 (0.18-0.59)

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