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Background Paper: SFA 02

Results of the Catch Assessment Survey (CAS) 2009 and Research Activities for Artisanal Fisheries

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1. Artisanal fisheries statistics 2009

1.1 Catch and effort

1.1.1 Catches

The total artisanal catch for 2009 is estimated at 3010.8 Mt, representing a decrease of 37% over the 4777.1 Mt estimated for the previous year (figure 1).

A decrease of 14% was recorded in catches landed on Praslin whereas the total catches on Mahe decreased by 42%.

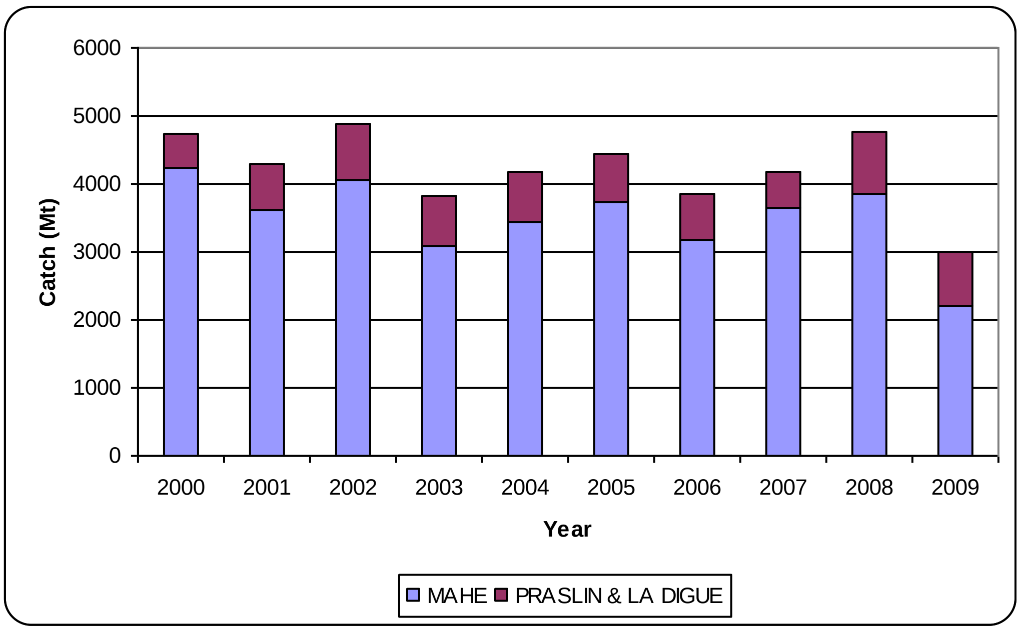
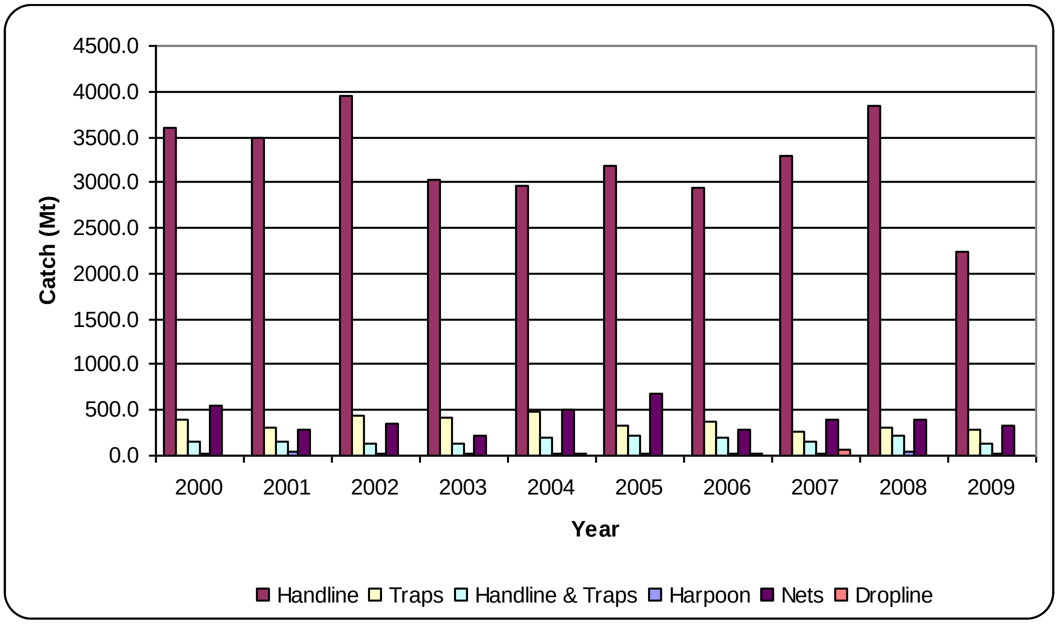


Figure 1. Artisanal catch (t) for Mahé and Praslin/La Digue: 2000 to 2009.

In terms of gear categories, all recorded a decrease in the catch compared to 2008. the handline fishery, the harpoon , dropline and the handline and trap fishery all recorded decrease of 42%, 61% , 100%and 38% respectively. A slightly low decrease of 2 % and 16 % was recorded for the trap and net fishery respectively(Figure 2: left).



The composition of the total artisanal catch by vessel category was dominated by whalers (47.6%), followed by outboard (37.6%), (Table 2).

Table 2. Percentage (%) of annual catch landed by major vessel types, including foot fishermen: 2000 – 2009.

Boat Type	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Pirogue	1.7	1.2	0.6	1.1	1.3	1.6	2.1	0.6	0.6	0.8
Outboard	32.5	25	25.4	27.4	34.3	36.2	28.3	25	25.4	37.6
Whalers	60.9	66.8	68.9	64.1	54.2	50.4	56.9	63.3	64.2	47.6
Schooners	4.1	6	4.5	6.8	9	11.1	11.5	9.3	8.9	13.3
Foot Fishers	0.9	1.1	0.6	0.6	0.9	0.7	0.6	0.4	0.8	0.5
Dropline vessels	0	0	0	0	0.3	0	0.6	1.4	0.1	0.2

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 increase from 294 vessels in 2008 to 324 vessels in 2009. The number of pirogue, whaler and schooner also increase by 11%,6% and 19% respectively. (Table 1).

In terms of fishing effort, the harpoon, handline and net fishery all recorded a decrease of 45%,32% and 10% respectively. An increase of 15% was recorded in trap fishery

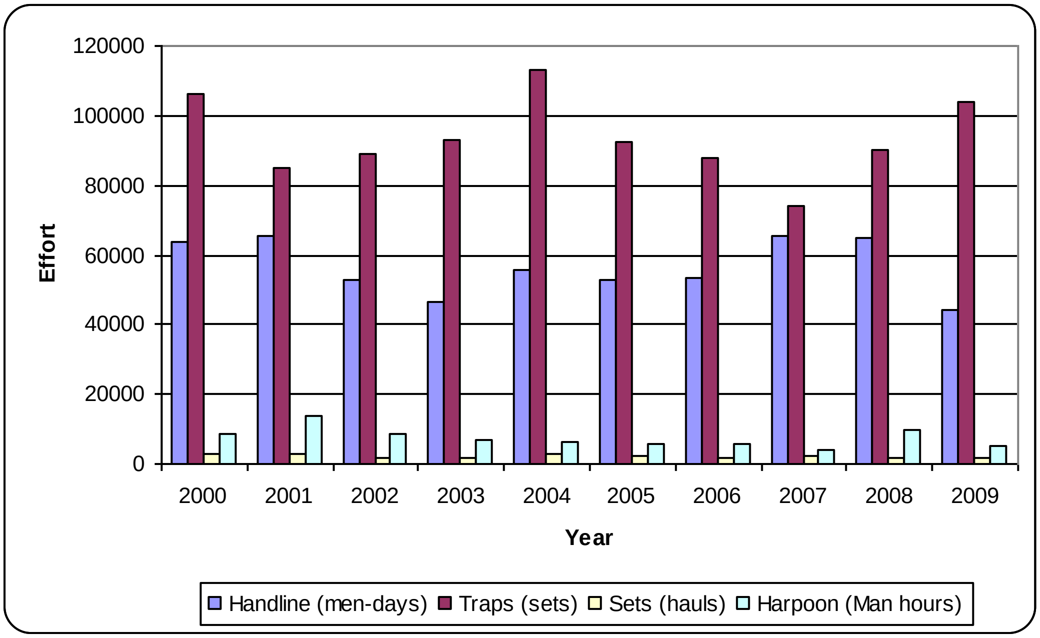


Figure 2. Total catches (left) and fishing effort (right) for the major gear types.

Table 1. Maximum monthly fishing vessels in operation: 2002 to 2009.

Vessel Type	2002	2003	2004	2005	2006	2007	2008	2009
Pirogue*	31	30	33	30	27	22	19	21
Outboard*	234	250	239	234	242	243	294	324
Whaler	96	109	93	83	94	105	107	113
Schooner	13	16	20	18	26	22	22	27
Sport	38	21	**	**	**	**	**	**
Dropline	1	0	4	2	4	5	2	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 slightly from 65 kg/man day in 2008 to 56.2 kg/man day in 2009 (Figure 3a). The whaler handline fishery continued to outperform other vessel types in terms of CPUE. Decrease was also observed all the fishery net fishery (figure 3c), from 200.3 kg/set in 2008 to 186.8 kg/set in 2009, trap (figure 3b), from 4.3 kg/trap to 3.5 kg/trap and the harpoon fishery from 16.9 kg/man hour in 2008 to 12.4 kg/man hour in 2009(figure 3d).

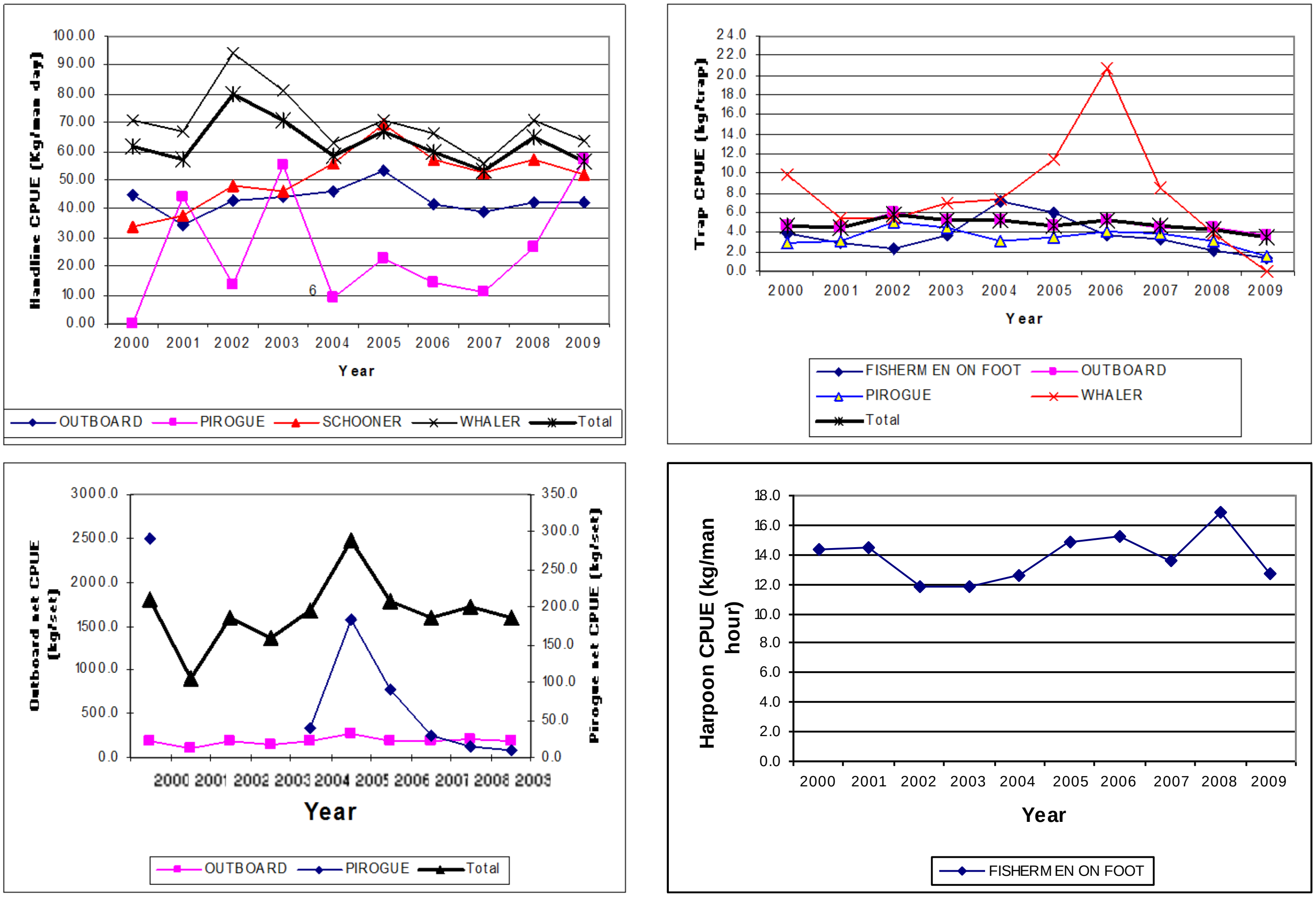


Figure 3. Trends in catch rates (CPUE) for the major vessel and gear combinations in the (a) handline fisheries, (b) trap fisheries, (c) gill net fishery and (d) the harpoon (octopus) fishery for the period 2000-2009.

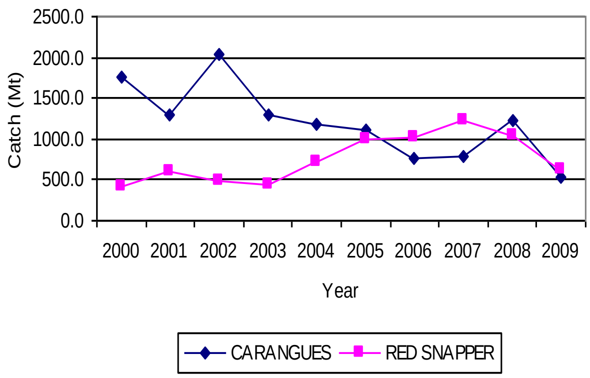
1.3 Species composition

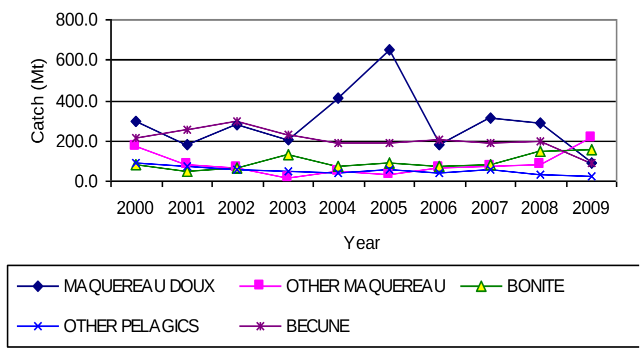
In 2009 increases was recorded only in the catch of Rabbitfish (*Siganus* spp.) (14%). Significant decreased were observed in the catches of Trevally (*Carangoides* spp.) (56%), Groupers (*Epinephelus* spp.)(47%), Red snapper (*Lutjanus* spp.) (41%) and Emperors (*Lethrinus* spp.) (36%) .Decrease were also recorded in Jobfish (*Aprion virescens*) (31%), Other Trap Fish (23%) and Mackerel (*Rastrelliger* sp.) (18%), (figure 4).

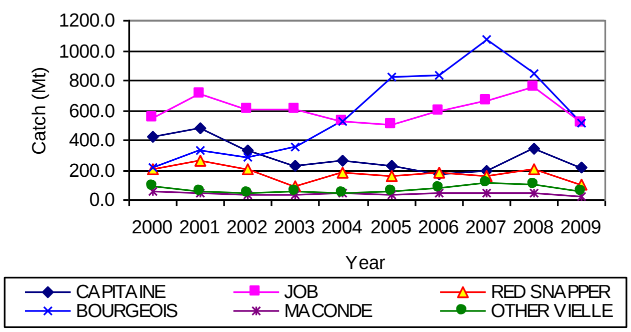
In 2009 Red snapper (*Lutjanus* spp.)was the dominant species caught accounting for 20.4% of the total catch followed by Trevally (*Carangoides* spp.) (17.8%) and Jobfish (*Aprion virescens*)(16.9%) (table 3).

Table 3. Percentage (%) species/species-group composition of artisanal catch for the period 2000-2009

Species Group	Percentage (%) of total annual catch									
English/Scientific	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Trevally (*Carangoides* spp.)	37.1	30.1	41.7	33.6	28.2	24.8	19.7	18.7	25.7	17.80
Red snapper (*Lutjanus* spp.)	8.7	13.9	10	11.6	17	22.3	26.7	29.6	22	20.48
Jobfish (*Aprion virescens*)	11.6	16.4	12.5	15.8	12.5	11.2	15.5	15.7	15.8	16.94
Emperors (*Lethrinus* spp.)	8.9	11.2	6.9	6.1	6.2	5.1	4.4	4.6	7.1	7.23
Groupers (*Epinephelus* spp.)	3.2	2.5	1.5	2.4	2.3	2.1	3.2	3.8	3.2	2.72
Rabbitfish (*Siganus* spp.)	3.7	2.1	4.2	6.6	7.6	5.4	7.3	5.1	4	7.25
Mackerel (*Rastrelliger* sp.)	9.9	6.2	7.1	5.8	11	15.4	6.6	9.2	7.9	10.24
Other Pelagics	8.1	8.9	8.8	10.8	7.4	7.5	8.6	7.7	8	8.83
Other Trap Fish	4.5	3.6	3.7	3.5	3.7	2.6	3.3	2.4	3.4	4.20
www	4.3	5.1	3.6	3.8	4.2	3.5	4.9	3.1	2.8	4.32
Total annual catch (MT)	**4748.4**	**4285**	**4889.1**	**3835.7**	**4174**	**4433.3**	**3845**	**4181.4**	**4777.1**	**3010.83**







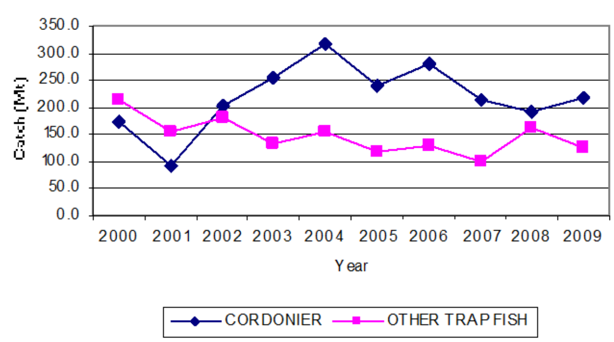


Figure 4. Trends in catches (Mt) for the major species and species groups for the periods 2000-2009, in terms of (a) comparison of the dominant species/groups in the artisanal catch, (b) semi-pelagic fisheries, (c) demersal, and (d) trap fisheries.

1.4. Wholesale and exports

Purchases by Oceana Fisheries Co. Ltd. and Sea Harvest were equivalent to 9% (268.5 MT) of total landings. Major species groups purchased were carangue (105.1 MT), bourgeois (88.1 MT), job (24.4 MT) ,other pelagic (21.9 MT), and other vielle (10.9 MT).Fish purchases from foreign longline and purse seine vessels by Oceana Fisheries Co. Ltd and Sea Harvest totaled 82.2 MT during 2009. Major species purchased were the common dolphin fish (60.3 MT) and wahoo(15.5 MT). Other species include marlin, sailfish groupers and jobfish.

In 2009, fish and fish product exports from the artisanal fishery amounted to 330.7 MT. The bulk (68%) 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 57.6 million (C.I.F). The main markets were the United kingdom (76.4 MT) Mauritius (66.5 MT)and Hong Kong (55.9 MT), The species bourgeois constituted 37% of the total export followed by the other species group (19%), and sea cucumber species pentard (11%).

Table 4. Export of artisanal catches by preservation type for the year 2009

Species	Fresh On Ice	Chilled	Frozen	Dried	Grand Total
Carangues	0.0	2.1	0.0	2.1	**4.2**
Other Carangues	0.0	0.0	0.0	0.0	**0.0**
Becune	0.2	0.0	0.0	0.0	**0.2**
Tuna	24.3	1.2	0.4	0.0	**25.9**
Other pelagic	41.9	0.6	19.6	0.0	**62.2**
Capitaine	7.2	0.8	0.0	0.0	**8.0**
Other Snapper	2.5	0.0	0.0	0.0	**2.5**
Bourgeois	118.0	3.7	1.0	0.0	**122.7**
Job	15.5	0.4	11.7	0.0	**27.7**
Maconde	2.5	0.0	0.0	0.0	**2.6**
Other Vielle	7.9	0.0	0.0	0.0	**7.9**
Cordonier	0.0	0.0	0.0	0.0	**0.0**
Other Trap fish	2.2	0.0	0.0	0.0	**2.2**
Shark & Rays	0.6	0.0	0.1	0.0	**0.7**
Shark Fin	0.0	0.0	0.0	4.5	**4.5**
Black teatfish	0.0	0.0	0.0	0.9	**0.9**
Prickly Redfish	0.1	0.0	0.0	4.9	**4.9**
Pentard	0.3	0.9	0.0	36.3	**37.5**
White teat	0.2	0.0	0.0	15.2	**15.5**
Other Sea Cuucmber	0.0	0.0	0.0	0.9	**0.9**
Crab	0.1	0.0	0.0	0.0	**0.1**
Others	0.0	0.0	0.3	1.6	**1.9**
Grand Total	**223.5**	**7.7**	**35.2**	**64.4**	**330.7**

1.5. Update on the sea cucumber fishery

During the year 2009, the total catch of sea cucumber reported stands at 490, 631 pieces, representing a significant increase of 110% from the 233,551 pieces recorded for the same period the previous year (table 5 and figure 5). Significant increase was observed in white teat, prickly red and Pentard whilst sandfish and the other category recorded a decrease of 83% and 40% respectively.

Table 5. Reported number of sea cucumbers caught between January to June 2001 to 2009.

	Black teat	Sandfish	White teat	Prickly red	Pentard	Others	Total
2001	4117	114	16758	2802	2784	3427	30002
2002	6411	708	40555	6302	9875	40173	104024
2003	8243	33	25510	15579	47810	69482	166657
2004	9380	622	41132	12221	59331	51341	174027
2005	9219	92	36822	13708	65660	84935	210436
2006	10370	2047	39316	15873	165002	106123	338731
2007	7883	433	57837	19693	181670	63499	331015
2008	5051	1778	50244	19632	133782	23064	233551
2009	6230	303	134978	44885	290285	13950	490631

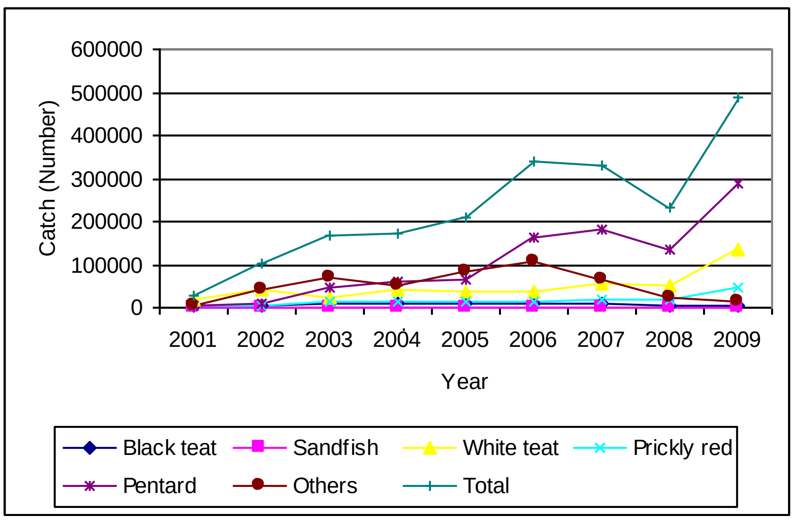


Figure 5. Trends in catches of sea cucumber during the first semester of the year, 2001 to 2009.

According to export statistics from the Department of Finance, a total of 59.7 MT or an equivalent of 169,370 pieces of sea cucumbers were exported in 2009 for a total value of SR 31.3 million. This represents a decrease of 22% in net weight of sea cucumber exported in 2009 compared to the previous year..

Table 6. Comparison of TAC (No.) against the estimated catch of 2009.

Common Name	Status	TAC (No.)	Estimated Catch 2008
Black teatfish	Under exploited. Some localised depletion	228,000	6,230
Sandfish	Over exploited	0	303
White teatfish	Under exploited	94,000	134,978
Prickly redfish	Under exploited	87,000	44,885
Pentard	Over-exploited	71,000	290,285

The data indicate that black teatfish, white teatfish and prickly redfish are all underexploited against the TAC (Table 6). As for sandfish, catches reflect the relatively small exploitable stock, which was used to justify a zero TAC for this species. Pentard has been overexploited against the TAC. The management plan for the sea cucumber fishery has been approved by the Cabinet. However, TACs are not operational as a management measure; this is highly due to the fact that TACs are highly disputed amongst fishermen. There are plans for a new stock assessment in 2010 which will be done in conjunction with the sea cucumber licensees and will lead to revised TACs.

1.6. Update on the lobster fishery (see background paper SFA04).

2. Research Activities

2.1. Stock assessments

The number of size frequency samples collected in 2008 was higher than 2007. Assessments were undertaken for three key indicator species of the demersal handline fishery.

2.1.1. *Aprion virescens*

In 2008, 409 samples were taken for this species. However, almost three quarters of the samples could not be traced to their respecting fishing vessel, preventing robust analyses at a fine spatial scale. The same growth parameters were used as in 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	2004	2005	2006	2007	2008
Z	0.49	0.32	0.23	0.32	0.33
CI of Z	0.43-0.55	0.14-0.49	0.1-0.35	0.28-0.35	-0.28-0.93
r^2	0.99	0.99	0.98	0.99	0.98
M1	0.26	0.26	0.26	0.26	0.26
F	0.23	0.06	-0.02	0.06	0.07
E	0.47	0.18	-0.09	0.18	0.21
L_{c50} (cm) – Logistic	73.47	69.98	71.17	70.70	69.70
L_{c50} (cm) – Running av.	68.37	67.67	67.97	68.48	68.54
F/M	0.88	0.23	-0.08	0.23	0.27
M2	0.15	0.15	0.15	0.15	0.15
F	0.34	0.17	0.08	0.17	0.18
E	0.69	0.53	0.35	0.53	0.55
L_{c50} (cm) – Logistic	73.82	70.09	68.53	70.73	69.71
L_{c50} (cm) – Running av.	69.34	67.62	66.69	68.45	68.52
F/M	2.27	1.13	0.53	1.13	1.2

L_{m50} (Mees 1992; MRAG 1999)	62-64; 65 cm				
n	377	1142	169	88	409

In 2008 and based on the lower estimate of M (M2), L_{c50} was greater than L_{m50}, as was the case in previous years. Combined with an F/M ratio of 1.2, this suggests that overfishing is unlikely. However, 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. Larger sample sizes that are traceable to their respective fishing vessels are being obtained in 2009, which may permit analyses at the level of sector and highlight any concerns at a finer spatial scale.

2.1.2. *Epinephelus chlorostigma*

In contrast to *Aprion virescens*, the sample size for this species was small in 2008. The same growth parameter 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 $0.5L_\infty$. Estimates of M using the Pauly method led to implausible results for F (negative values), and we present only the results using an estimate of M derived from M=1.5K, with K=0.21.

Table 8. *Epinephelus chlorostigma*: Estimates of fishing mortality, and related parameters, for 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	2004	2005	2006	2007	2008
Z	1.04	0.97	0.85	0.78	0.47
CI of Z	-2.77-4.85	-4.00-5.94	-5.69-7.39	-5.04-6.6	0.17-0.77
r^2	0.92	0.86	0.73	0.75	0.99
M	0.315	0.315	0.315	0.315	0.315
F	0.73	0.66	0.54	0.47	0.16
E	0.70	0.68	0.63	0.60	0.33
L_{c50} (cm) – Logistic	30.67	31.41	31.07	31.20	34.46
L_{c50} (cm) – Running av.	32.83	32.35	31.73	31.29	34.56
F/M	2.32	2.10	1.71	1.49	0.50
L_{m50} ($0.5L_{\infty}$; Moussac , 1986)	28.95 cm TL; 31 cm TL for females				
n	991	1161	348	78	178

Compared to previous years, total mortality (Z) was much lower (0.47). Also, levels of uncertainty around Z were smaller than previous year (Table 8). Length at first capture has also increased and is above length at first maturity. It is not certain whether this has resulted from a change in hook size or changes in depth or area fished, but this should be explored. Mortality rates have declined since 2004. Measured against the indicators (L_{c50}; F/M), the status for this species was not a cause for concern in 2008.

2.1.3. *Lutjanus sebae*

In addition to analyses at the Plateau level, sample data were sufficient to perform analyses of the W-NW (sectors 9 and 10) 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, similar to last year, we have used 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.

Length at first capture (61.70 cm) was equivalent to length at first maturity (62 cm) for all sectors combined in 2008, while F/M < 2, highlighting little cause for concern. Similarly, in the sector 9 and 10 area, L_{c50} was higher than L_{m50}, and showed a large increase over 2007, which will require further research to explain, especially since length at first capture declined slightly at the plateau level compared to the previous year (Table 9).

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

Parameter	All sectors (2007)	W-NW (Sectors 9, 10) (2007)	All sectors (2008)	W-NW (Sectors 9, 10) (2008)
Z	0.55	0.47	0.50	0.49
CI of Z	0.39-0.71	-0.37-1.31	0.24-0.76	0.20-0.78
r^2	0.99	0.98	0.99	0.99
M	0.182	0.182	0.182	0.182
F	0.37	0.29	0.32	0.31
E	0.67	0.61	0.64	0.63
L_{c50} (cm) – Logistic	62.29	55.32	61.70	64.86
L_{c50} (cm) – Running av.	62.56	59.37	60.59	64.19
F/M	2.03	1.59	1.76	1.70
Maturity	62 cm FL			
N	807	376	1430	387

Yield per recruit

<u>All sectors</u>

YPR indicated that MSY per recruit occurs when F is around 1.2, compared to 0.9-1.1 in 2007. The SSB is reduced to less than 20% when F = 0.45, similar to the estimate in 2007 (Figure 6). From the histograms, MSY per recruit is achieved when F is around 0.6-1.4 (Figure 7). To maintain SSB per recruit at 20% of unexploited biomass, F should be in the range of 0.36-0.48 (Figure 8). While most of the range estimates of current F (0.32; range = 0.058-0.578) are below $F_{SSB20\ per\ recruit}$., the upper range of current F exceeds the upper limit of $F_{SSB20\ per\ recruit}$.

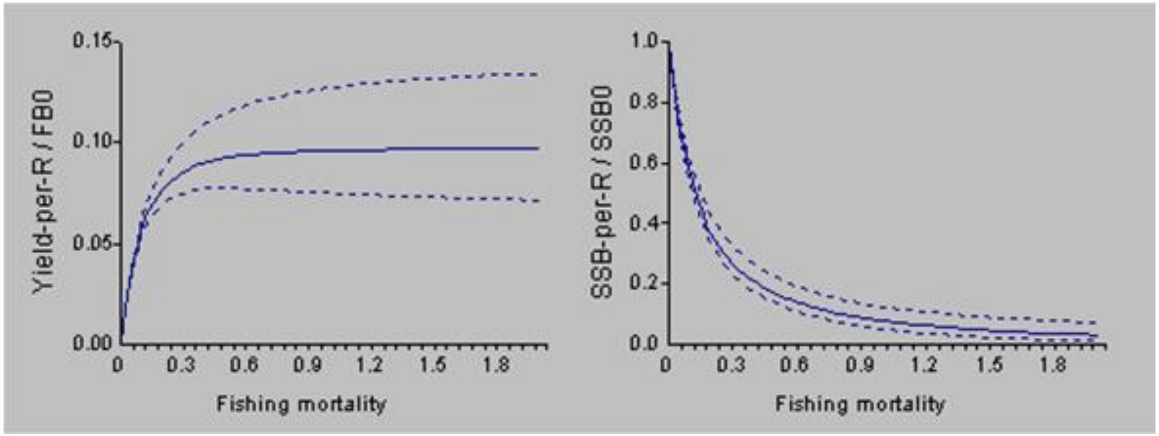


Figure 6. Yield per recruit and Spawning Stock Biomass per recruit against levels of fishing mortality for all sectors combined

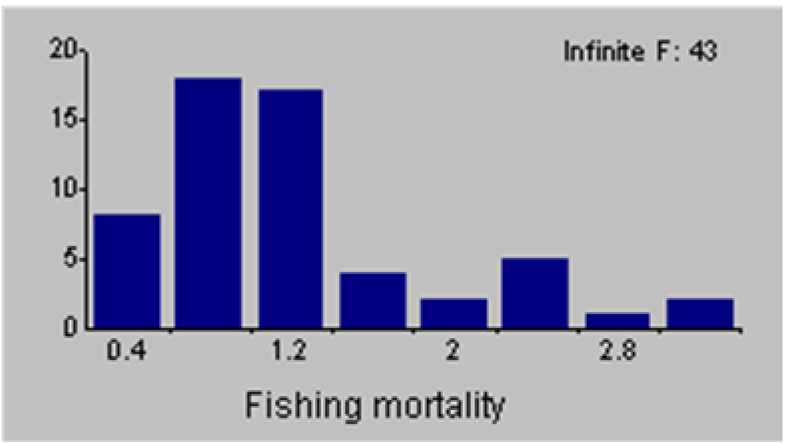


Figure 7. Frequency distribution of fishing mortality that produces maximum yield-per-recruit for all sectors combined

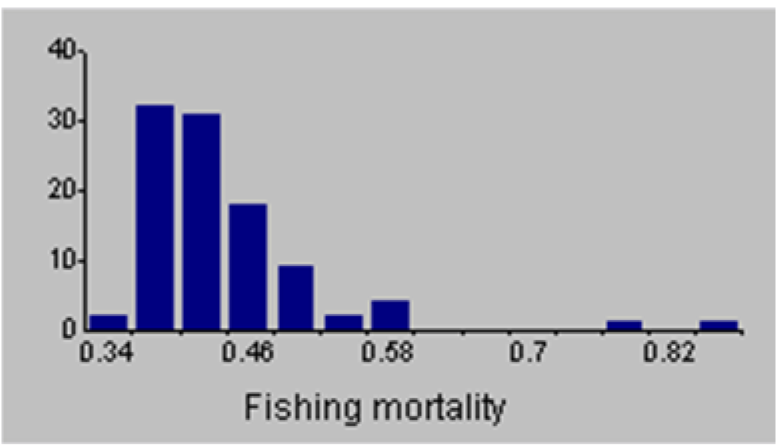


Figure 8. Frequency distribution of fishing mortality that maintains Spawning Stock Biomass at 20% of its unexploited value for all sectors combined

Sectors 9 and 10 (W-NW area)

YPR indicated that MSY per recruit occurs when F is around 1.2,but an asymptote is still not entirely reached when F is greater than 1.8. SSB is reduced to less than 20% when F = 0.7, however, the upper confidence interval is quite wide (Figure 9). From the histograms, MSY per recruit is achieved when F is around 0.25-1.65 (Figure 10). To maintain SSB at 20%, F should be in the range of 0.36-0.99 (Figure 11). The range of current F (0.31; range = 0.018-0.598) overlaps the lower boundary of $F_{SSB20 \text{ per recruit}}$.

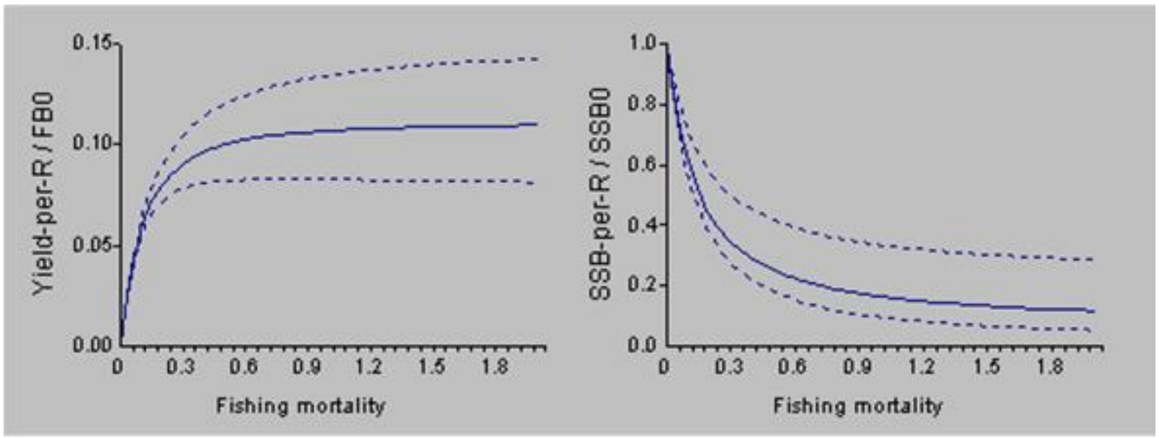


Figure 9. Yield per recruit and Spawning Stock Biomass per recruit against levels of fishing mortality for sectors 9 and 10

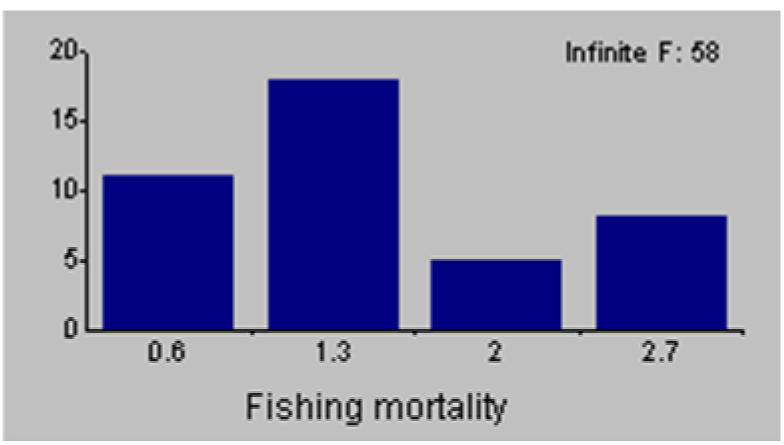


Figure 10. Frequency distribution of fishing mortality that produces maximum yield-per-recruit for sectors 9 and 10

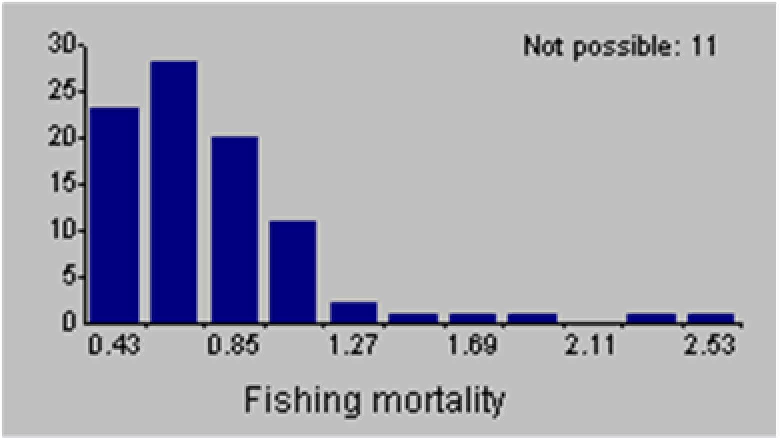


Figure 11. Frequency distribution of fishing mortality that maintains Spawning Stock Biomass at 20% of its unexploited value for sectors 9 and 10

$F_{current}$ is tending towards the lower estimates of F_{SSB20}, except for the pooled sample where there is a slight overlap of the upper $F_{current}$ above the upper boundary limit of F_{SSB20}.. Therefore, there is a possibility that this species is overexploited. However, based on the high level of uncertainty (large CI for W-NW sector $F_{MSY\ per\ recruit}$ and $F_{SSB20\ per\ recruit}$) caution should be taken in interpreting the results. In summary, the L. sebae stock status on the Mahe Plateau has shown some changes in this assessment, with declining exploitation rates and increasing length at first capture in some strata, which requires closer scrutiny. The situation with this stock may appears to be improving using these indicators, but it is still grossly overfished against other reference points (i.e. MSY, Grandcourt et al. 2008).

Table 10. 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	**W-NW (Sectors 9, 10)**
F_{MSYPR}	0.6-1.4	0.25-1.65
F_{SSB20}	0.36-0.48	0.325-0.995
$F_{current}$ (CI)	0.32 (0.058-0.578)	0.31 (0.018-0.598)

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