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Results of the Catch Assessment Survey (CAS) 2006 and Research Activities for Artisanal Fisheries

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[I] Seychelles Fishing Authority, P.O. Box 449, Victoria, Mahé, Seychelles

This paper presents information on the status of artisanal fisheries in Seychelles derived from monitoring programmes and stock assessments, and outlines research activities conducted since the 18th BSFC SSCM.

1. Artisanal fisheries statistics 2006

1.1. Catch and effort

The total artisanal catch during 2006 was 3,850 metric tonnes (t). Representing a decrease of 13% compared to 2005, the catch was the lowest since 2003 (Figure 1). The catch was 645 t lower than the long-term (22-years) average annual catch of 4,495 t. With respect to the previous year, there was a greater decrease in catches on Mahé (15%) compared to Praslin/La Digue (3%).

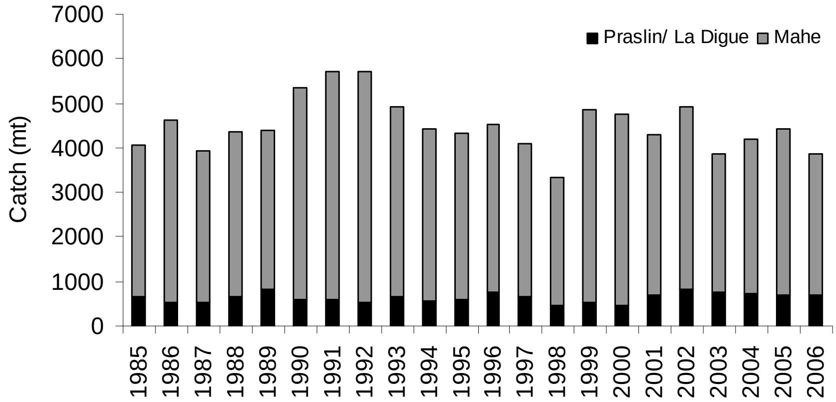

Figure 1. Artisanal catch (t) for Mahé and Praslin/La Digue: 1985 to 2006.

Catches for most gear categories declined in 2006. In terms of handline gear, catches decreased by 251 t (7.6%) compared to 2005, while catches by harpoon declined from 24 to 20 t (17.1%). Catches in the net fishery decreased by the largest amount (58.6%), from 690 to 286 t. In 2006 the trap fishery catch increased slightly (by 10.7%) over the previous year (Figure 2: left). Effort in all but the handline fisheries, which registered an increase in effort of 1%, showed a decrease in 2006 compared to 2005. By far the most significant decline was in net fishery, for which effort declined by 38% from 2,600 to 1,600 sets (Figure 2: right).

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 fishing activities of outboard, whaler and schooner vessels all increased in 2006 compared to the previous year. The increase in vessel activity party resulted from the completion of fleet rehabilitation programmes in 2005 following the December 2004 Tsunami (Table 1). The composition of the total artisanal catch by vessel category was typical of long-term trends, with whalers dominating catches, followed by outboards, schooners and pirogues (Table 2). Catches by whalers and schooners increased slightly over 2005, while those made by outboard vessels declined.

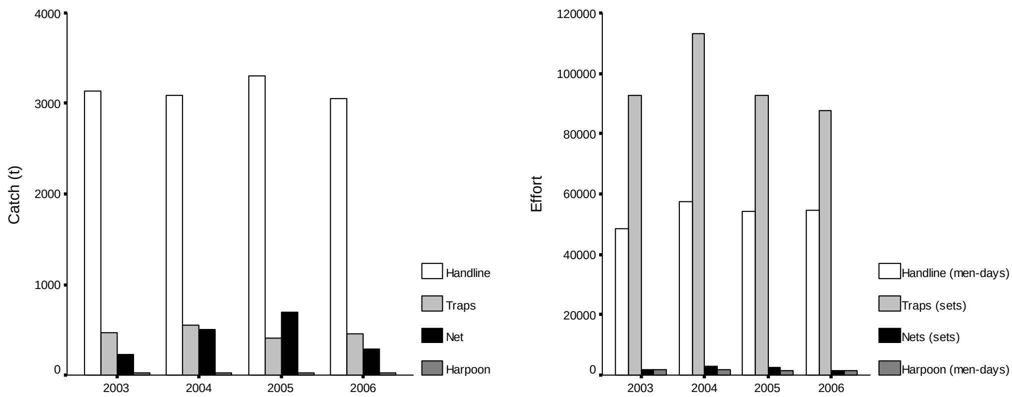

Figure 2. Total catches (left) and fishing effort (right) for the major gear types.

Table 1. Maximum monthly fishing vessels in operation: 2001 to 2006.

Vessel type	2001	2002	2003	2004	2005	2006
Pirogue*	32	31	30	33	30	27
Outboard*	236	234	250	239	234	242
Whaler	95	96	109	93	83	94
Schooner	14	13	16	20	18	26
Sport	40	38	21	**	**	**
Dropline	2	1	0	4	2	4

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

Table 2. Percentage (%) of annual catch landed by major vessel types, including foot fishermen: 2001 – 2006.

Vessel type	2001	2002	2003	2004	2005	2006
Pirogue	1.2	0.6	1.1	1.3	1.6	2.1
Outboard	24.9	25.2	27.2	34.3	36.2	28.2
Whalers	66.7	68.5	63.8	54.2	50.4	56.8
Schooners	6.1	4.5	6.8	9.0	11.1	11.5
Foot fishermen	1.1	0.6	0.6	0.9	0.7	0.6
Research vessel	1.7	0.2	0.1	0.1	0.1	0.1
Dropline vessels	0.1	0	0	0	0.1	0.6

1.2. Catch rates of the major fisheries

Catch rates (CPUE) for the handline fisheries declined slightly in 2006 compared to the previous year, with the exception of CPUE for the mixed gear outboard category (Figure 3a). The whaler handline fishery continued to outperform other vessel types in terms of CPUE, but estimates were still lower than the peak for this fishery recorded in 2002. The decline in CPUE since 2002 partly reflects the change in strategy as whalers have increasingly targeted demersal over semi-pelagic species. CPUE in the trap fishery has remained more or less stable at between 4 and 5 kg/trap over the last 6 years (Figure 3b). In terms of the encircling gill net fishery for mackerel, CPUE has declined in 2006 which, coincident with a low catch for the year, probably reflects a reduced seasonal abundance and distribution in coastal areas (Figure 3c). Resource abundances in this fishery are considered to forced by environmental factors. CPUE in the harpoon fishery for octopus was similar in 2006 to the previous year (Figure 3d).

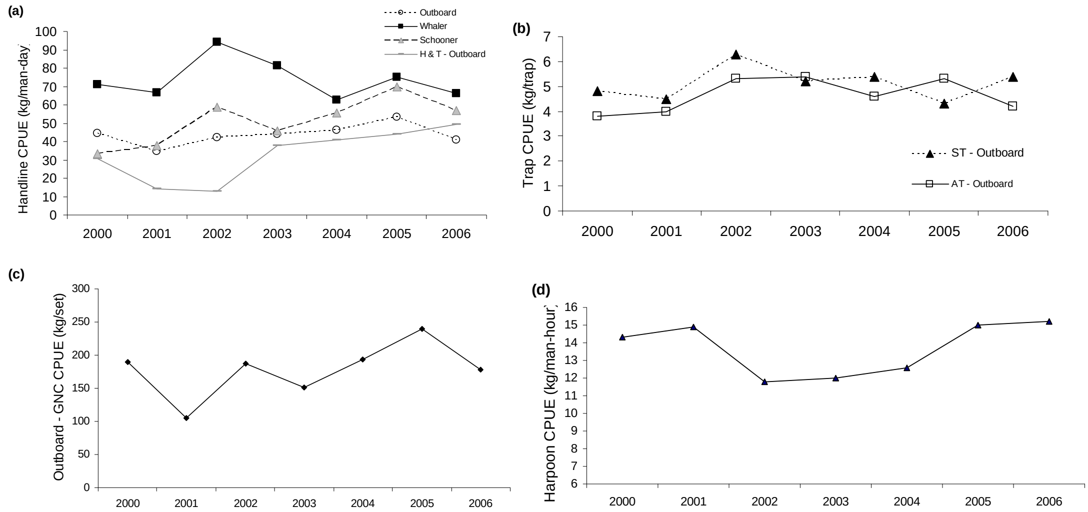

Figure 3. Trends in catch rates (CPUE) for the major vessel and gear combinations in the (a) handline fisheries, (b) trap fisheries, (c) gill net fishery and (d) the harpoon (octopus) fishery for the period 2000-2006.

1.3. Species composition and catch

A significant change in the species composition of the catch occurred in 2006, with catches of lutjanids surpassing those of carangids for the first time (Table 3; Figure 4a). The catch of bourgeois (*Lutjanus sebae*) alone amounted to 840 t. Carangids have declined in relative importance to the total artisanal catch, from a high of 41.6% (2,042 t) in 2002 to a low of 19.9% (766 t) in 2006. As catches of these semi-pelagic species have decreased, those of lutjanids have increased each year since 2002, reaching 1,028 t in 2006. Catches of job (*Aprion virescens*) have also increased, from 499 t in 2005 to 597 t in 2006, as reflected by their importance to the catch (Table 3; Figure 4c). The grouper catch also improved over the previous year, increasing from 93 to 123 t. These trends are related and are due to greater targeting of demersal species by whaler vessels in particular. This has important implications for demersal stocks, as discussed later in this report.

Table 3. Percentage (%) species/species-group composition of the artisanal catch for the period 2001-2006.

Species group		Percentage % of annual catch					
English / scientific	**Creole**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Trevally (*Carangoides* spp.)	Karang	30.0	41.6	33.6	28.2	24.9	19.9
Red snapper (*Lutjanus* spp.)	Bourzwa, etc	14.1	10.0	11.5	17.0	22.2	26.7
Jobfish (*Aprion virescens*)	Zob	16.4	12.4	15.8	12.5	11.2	15.5
Emperors (*Lethrinus* spp.)	Kapten	11.3	6.9	6.1	6.2	5.1	4.4
Bonito (*Euthynnus* spp.)	Bonit	1.2	1.5	3.5	1.9	2.0	1.9
Groupers (*Epinephelus* spp.)	Vyey	2.5	1.5	2.4	2.3	2.1	3.2
Rabbitfish (*Siganus* spp.)	Kordonnyen	2.1	4.1	6.6	7.6	5.4	7.2
Mackerel (*Rastrelliger* spp.)	Makro dou	6.1	7.0	5.7	11.0	15.4	4.8
Others		16.3	15.1	14.8	13.3	12.0	16.4
Total catch (t)		**4290**	**4915**	**3852**	**4177**	**4439**	**3850**

In contrast to most demersal groups, catches of emperor continued to decline (Figure 4c). The importance of bonito to the catch remained stable compared to the previous year (Figure 4b). The mackerel fishery is known to be highly variable and the recent trend of increasing catches was reversed in 2006, with a decline of 499 t compared to the previous year (Figure 4b). Constituting one of the main target groups of the trap fishery, catches of rabbitfish increased from 241 to 277 t, raising their importance in the catch composition (Table 3; Figure 4d).

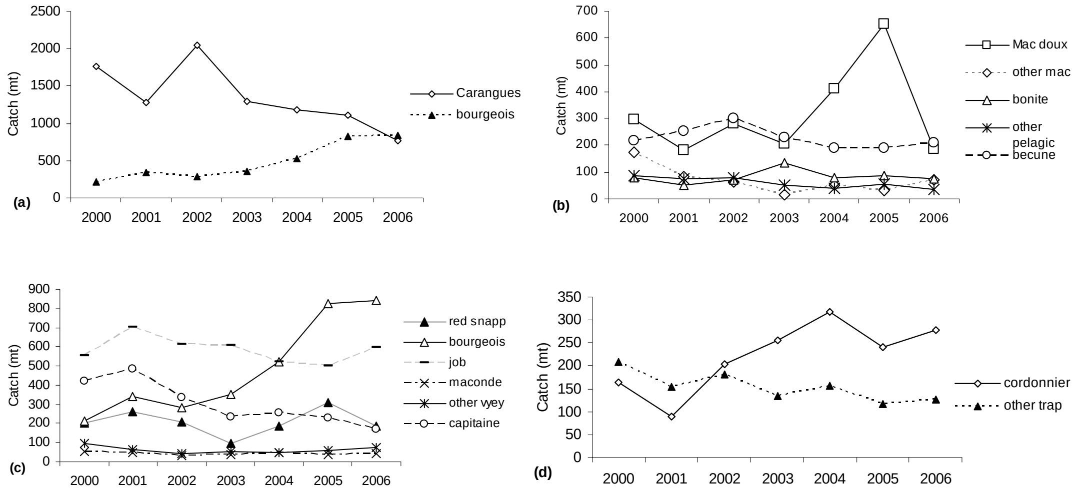

Figure 4. Trends in catches (mt) for the major species and species groups for the period 2000-2006, in terms of (a) comparison of the dominant species/groups in the artisanal catch, (b) semi-pelagic fisheries, (c) demersal, and (d) trap fisheries.

1.4. Wholesale and exports

Purchases of pelagic fish by Oceana Fisheries Co. declined by a large amount in 2006 compared to the previous year, while purchases of demersal species by the company increased, with the exception of capitaine (emperors) (Table 4). By contrast, purchases of a few pelagic groups by Sea Harvest Fisheries have increased over 2005. Bourgeois and red snapper purchases by Sea Harvest Fisheries declined slightly, while those of maconde and other vielle increased. The total purchase of bourgeois by both companied amounted to 391 t in 2006, approximately 47% of the total catch of this species. Nevertheless, Sea Harvest continues to rely on demersal products for exports due to shortages in availability in fresh tuna, their traditional product.

Exports of the major categories of demersal and pelagic species landed by artisanal fisheries have declined slightly (-0.8%) compared to 2005 (Figure 5). The largest decline in exports was for red snapper (-62.8%), but there were also declines in the export of pelagic fish (-28.5%), job (-35.1%), capitaine (-17.7%) and the ‘others’ category (-62.8%), which includes crabs and sharks. However, exports of bourgeois (*Lutjanus sebae*) continued to increase, from 143 t in 2005 to 203 t in 2006. This indicates that around 24% of the bourgeois catch was exported. Exports of bourgeois were 52% of the total purchase of this species by the two companies, highlighting the importance of local marketing with Oceana in particular developing new bourgeois products. Exports of vielle also increased (50%) in 2006 compared to the previous year.

Table 4. Purchases by Oceana and Sea Harvest from local vessels in 2005 and 2006 with percentage (%) change.

	Oceana			**Sea Harvest**		
	2005	**2006**	**% change**	**2005**	**2006**	**% change**
Carangue	103.7	35.5	-65.8	3.6	3.9	8.3
Bonito	3.6	0.2	-94.4	0.01	2.5	>24000
Becune	1.9	1.3	-31.6	1.1	2.0	81.8
Other pelagic	45.3	5.5	-87.9	20.0	15.8	-21.0
Red snapper	20.8	21.9	5.3	22.0	18.9	-14.1
Bourgeois	240.1	297.7	23.9	92.9	92.8	-0.1
Job	69.3	74.7	7.8	27.7	35.2	27.1
Maconde	8.9	12.1	35.9	3.5	4.6	31.4
Other vielle	13.5	20.2	49.6	10.8	10.7	-0.9
Capitaine	27.5	21.3	-22.6	10.4	8.4	-19.2

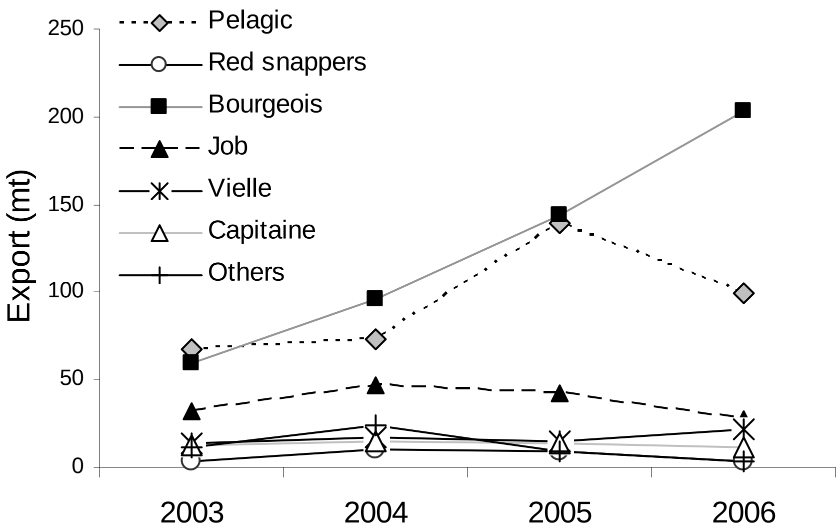

Figure 5. Exports of (fresh and frozen) species/species-groups for the period 2003 to 2006

Interviews were conducted with the managers of Oceana Fisheries Co. and Sea Harvest to request information on their role in the changing patterns observed for the artisanal fisheries. Both noted that increases in the catches of high valued demersal species are being driven by the fishers, possibly in response to higher operational costs, and not by markets. Oceana stated that they have increased exports and production of value added products (e.g. fillets) for local markets in response to the higher availability of these species, and have not directed fishers towards these resources to meet demand or a change in marketing strategy. The socio-economic status of this fishery needs to be assessed as part of management the process.

1.5. Update on the sea cucumber fishery

The number of sea cucumbers harvested as continued to increase in 2006 (Table 5). As expected, the most significant increase was for the 'pentard' species, of which around 160,190 units were harvested in 2006 compared to 83,822 in 2005, an increase of over 90%. For all species, the catch in 2006 was 28.6% greater than the previous year.

Table 5. Reported number of sea cucumbers caught for the period 2002 to 2006.

Year	Black teat	Sandfish	White teat	Prickly red	Pentard	Others	Total
2002	6,926	903	41,212	6,561	9,912	46,026	111,541
2003	8,543	33	26,374	15,779	48,506	69,482	168,717
2004	9,417	622	41,221	12,254	59,488	52,181	175,183
2005	11,602	100	45,928	17,194	83,822	98,055	256,701
2006	10,050	1,852	38,148	16,189	160,190	103,844	330,273

Data given as presented in the 2006 Annual Report: - some catch and effort forms not submitted

According to export statistics from the Department of Finance, in 2006 a total of 43.7 t and an additional 74,000 pieces of dried sea cucumbers were exported with a value of SR 1,947 million. In 2006, SFA initiated procedures to inspect all sea cucumber exports to allow validation against landed volume.

Table 6. Comparison of TAC (No.) against the estimated catch of 2006.

Common Name	Status	TAC (No.)	Estimated Catch 2006
Black teatfish	Under exploited. Some local depletion	228,000	10,050
Sandfish	Over exploited	0	1,852
White teatfish	Under exploited	94,000	38,148
Prickly redfish	Under exploited	87,000	16,189
Pentard	Over-exploited	71,000	160,190

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 yet to be approved by Cabinet so the TAC is not yet operational as a management measure. Once approved, a ban on the harvesting of pentard has been recommended due to the overexploitation in recent years. .

1.6. Update on the lobster fishery

The lobster fishing season has been changed from November-January to December-February and was reopened in 2006/2007. The total catch for the season was estimated at 6.1 t (4.1 t from Mahe, 2 t from other strata), compared to 3.9 t the previous season. As per usual, most catches were made with snorkelling gear. Based on logbook submissions, a total of 222 trips were undertaken in the season, comprising 583 man-trips. The estimated CPUE was 27.7 kg/trip which was considerably higher than the previous season. Typical of previous seasons, the catch composition of lobsters was dominated by pronghorn spiny lobster (*Panulirus penicillatus*), which accounted for 68.7% of the catch, followed by the long-legged spiny lobster (*Panulirus longipes*) with 28.5%.

2. Research Activities

2.1. Stock assessments

The status of three key indicator species for the demersal line fishery has been assessed based on the FMSP guidelines used in BIOT. In addition, an assessment of a key trap fishery species, *S. sutor*, is also presented.

2.1.1. *Aprion virescens*

This assessment is based on length frequency (L_F) data collected over the last 3 years on a broad spatial scale, since the process to incorporate VMS data for assessments at the sector level has not yet been completed for this species. 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). The results were used to assess the status of stocks and in terms of the need for YPR analyses.

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
Z	0.49	0.32	0.23
CI of Z	0.43-0.55	0.14-0.49	0.1-0.35
r^2	0.99	0.99	0.98
M1	0.26	0.26	0.26
F	0.23	0.06	-0.02
E	0.47	0.18	-0.09
L_{c50} (cm) – Logistic	73.47	69.98	71.17
L_{c50} (cm) – Running av.	68.37	67.67	67.97
F/M	0.88	0.23	-0.08
M2	0.15	0.15	0.15
F	0.34	0.17	0.08
E	0.69	0.53	0.35
L_{c50} (cm) – Logistic	73.82	70.09	68.53
L_{c50} (cm) – Running av.	69.34	67.62	66.69
F/M	2.27	1.13	0.53
L_{m50} (Mees 1992; MRAG 1999)	62-64; 65 cm		
n	377	1142	169

As an indicator of status, L_{c50} was greater than L_{m50} in all years against both estimates of maturity and using both methods for estimating capture (Table 7). This suggests that the stock is not overfished. Estimates of F/M indicate that fishing mortality was highest in 2004 and has declined since. However, the sample size was small in 2006 which leads to greater uncertainty in this estimates. In 2004, F>2 using M2, but combined with L_{c50} relative to L_{m50}, overfishing is considered unlikely. Based on these results, YPR analyses were not conducted for this species. Analyses at the level of sector may indicate the need for YPR and effort controls.

2.1.2. *Epinephelus chlorostigma*

Similar to *Aprion virescens*, the assessment for this species was based on a temporal analysis as VMS data have not been incorporated to date. Three sets of growth parameter estimates from Grandcourt (2002), Mees (1992) and Sanders et al. (1988) were averaged to provide inputs for the analyses, 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 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	2004	2005	2006
Z	1.04	0.97	0.85
CI of Z	-2.77-4.85	-4.00-5.94	-5.69-7.39
r^2	0.92	0.86	0.73
M1	0.48	0.48	0.48
F	0.56	0.49	0.37
E	0.54	0.50	0.43
L_{c50} (cm) – Logistic	30.76	31.47	31.14
L_{c50} (cm) – Running av.	33.04	32.53	31.91
F/M	1.17	1.02	0.77
M2	0.315	0.315	0.315
F	0.73	0.66	0.54
E	0.70	0.68	0.63
L_{c50} (cm) – Logistic	30.67	31.41	31.07
L_{c50} (cm) – Running av.	32.83	32.35	31.73
F/M	2.32	2.10	1.71
L_{m50} ($0.5L_\infty$; Moussac, 1986)	28.95 cm TL; 31 cm TL for females		
n	991	1161	348

Total mortality (Z) estimates were subject to large range in CI leading to considerable uncertainty in estimates of F (Table 8). Mortality rates have declined since 2004. All estimates of L_{c50} were greater than the lower estimate of maturity (28.9 cm), while the upper estimate of maturity (which corresponds to females) was slightly above that of L_{c50} in 2004 and it is possible that overfishing occurred in that year. As with *Aprion virescens*, it is recommended to proceed with analysis at a finer spatial scale when the VMS data have been incorporated and to undertake YPR analyses depending on the indicators (L_{c50}; F/M) produced.

2.1.3. *Lutjanus sebae*

For *L. sebae*, biological data (L_F) were analysed at a spatial level, similar to the last report, since a temporal analysis has recently been completed (Grandcourt *et al*. in press). Data were not available in sufficient quantities for the analyses of more than 4 sector areas. In addition to analysis of data pooled for the Mahe Plateau, we have chosen to analyze data from sector areas from which 3 or more vessel trips monitored by VMS have been sampled. By far the largest sample was from the W-NW (sectors 9 and 10) area of the Mahe Plateau, from which catches pertaining to 11 trips monitored by VMS were sampled. Only 3 trips monitored by VMS to the N-NE area (sectors 2 and 3) of the Mahe Plateau were sampled, while 4 trips from the E-SE area were sampled. Owing to the small sample sizes from the latter 2 areas, the results should be viewed with caution.

Mortality and capture estimates

Instead of the length-based growth parameters used in the last assessment, we adopted the parameters recently derived from age-based methods (K = 0.14; L_∞ = 78.7; t0 = -1.9; Grandcourt *et al*. in press), which compare well to validated estimates for this species from elsewhere. Given the improvement in growth parameter estimates, estimates of natural mortality (M) rates were considered the greatest source of uncertainty in this. Therefore, we estimated fishing mortality (F) and length at first capture (L_{c50}) against a range of estimates of M for this species. These included the Pauly (1980) method (M1), which is known to overestimate this parameter in slow growing species, estimates from M = 1.5K (M2) and an age-based estimate (M3) derived by Grandcourt et al. (in press) using the Hoenig (1983) empirical equation were also employed. A different length-weight relationship to that used in the last BSFC report was adopted for the YPR analyses, again from (Grandcourt et al. in press). Otherwise, the parameters used in Yield remained the same.

Total mortality (Z) estimates were highest for the W-NW (sectors 9 and 10) area, followed by the Mahe Plateau, the E-SE (sectors 4 and 5) area and the N-NE (sectors 2 and 3) area (Table 9). The high estimate of natural mortality derived using the Pauly (1980) empirical equation (M1) led to negative fishing mortality rates, which often occurs when using this method for slow growing species. Fishing mortality rates were obviously highest using the lowest estimate of M (M3) derived from the Hoenig (1983) method. However, since Grandcourt et al. (in press) note that this method may have slightly underestimated M an estimate (M4) was derived from the mean of M2 and M3 (M=0.165) and used in YPR analyses.

Table 9. *Lutjanus sebae*: Estimates of fishing mortality, and related parameters, for different estimates of natural mortality (M1, M2, M3 and M4), 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	W-NW (Sectors 9, 10)	N-NE (Sectors 2, 3)	E-SE (Sectors 4, 5)
Z	0.27	0.31	0.19	0.24
CI of Z	-0.07-0.61	-0.02-0.63	-0.49-0.87	0.03-0.46
r^2	0.99	0.99	0.93	0.99
M1	0.34	0.34	0.34	0.34
F	-0.07	-0.03	-0.15	-0.10
E	-0.25	-0.09	-0.77	-0.40
L_{c50} (cm) – Logistic	60.18	57.52	65.58	65.66
L_{c50} (cm) – Running av.	57.97	56.70	58.52	59.22
F/M	-0.21	-0.09	-0.44	-0.29
M2	0.21	0.21	0.21	0.21
F	0.06	0.10	-0.02	0.03
E	0.22	0.32	-0.11	0.13
L_{c50} (cm) – Logistic	60.29	57.48	66.14	65.86
L_{c50} (cm) – Running av.	57.93	56.63	58.47	59.20
F/M	0.29	0.48	-0.10	0.14
M3	0.12	0.12	0.12	0.12
F	0.15	0.19	0.07	0.12
E	0.56	0.61	0.37	0.50
L_{c50} (cm) – Logistic	60.37	57.45	66.69	66.01
L_{c50} (cm) – Running av.	57.89	56.57	58.43	59.19
F/M	1.25	1.58	0.58	1.0
M4	0.165	0.165	0.165	0.165
F	0.11	0.15	0.02	0.07
E	0.39	0.47	0.13	0.31
L_{c50} (cm) – Logistic	60.33	57.46	66.36	65.94
L_{c50} (cm) – Running av.	57.91	56.60	58.45	59.20
F/M	0.67	0.91	0.12	0.43
Maturity	62 cm FL			
n	4020	1120	320	330

Length at first capture (L_{c50}) was lower than the length at first maturity (L_{m50}) for both estimates of this parameter at the Mahe Plateau and W-NW sectors (Table 9). For the N-NE and E-SE sector areas, the estimate of L_{c50} was below L_{m50} using the running averages function, but greater than L_{m50} using the logistic function. As a conservative approach, the lowest estimate of L_{c50} was used in the YRP analyses. There was considerable difference in L_{c50} compared to 2005 for the Mahe Plateau (all samples pooled) area; L_{c50} was 40.09 cm in 2005, at least 17 cm lower than the estimate for the 2006 dataset. For sector 9 in 2005, L_{c50} was slightly lower (c. 3 cm) than the current estimate. This has important implications for the status of the fishery. Sufficient hook size information has only been collected since late 2006, with most fishers reporting use of hooks in the 12-14 size range, and it is not possible to determine if the difference in the size structure of the sampled catches was caused by a change in hook size. The other possible explanation in the change between years could be a sampling artefact, caused by changes in size related marketing preferences by either Oceana Fisheries or the fishermen.

Yield per recruit

Variation in the input parameters was confined to the natural mortality estimate (M) as noted above. The Yield software was unable to provide reliable estimates of F_{MSYPR}, with MSYPR tending to increase with F and no clear maximum obtained. This was presumably due to the high values of length at first capture for the input parameters used. $F_{current}$ equalled or exceeded the lower estimate of F_{SSB20} for the pooled sample and at the W-NW sector areas, approaching the maximum in the latter location. The range in F_{SSB20} was not exceeded for the N-NE and E-SE sector areas. However, there was considerable uncertainty in $F_{current}$ when the CI's of Z are taken into account, and it possible that F_{SSB20} may have been exceeded in all areas.

Table 10. Results of the YPR for *Lutjanus sebae*. Estimates of F required to achieve maximum yield per recruit (F_{MSYPR}) and F resulting in depletion of the spawning stock biomass to 20% of unexploited biomass (F_{SSB20}).

	All sectors	**W-NW (Sectors 9, 10)**	**N-NE (Sectors 2, 3)**	**E-SE (Sectors 4, 5)**
F_{MSYPR}	No maximum	No maximum	No maximum	No maximum
F_{SSB20}	0.11-0.17	0.12-0.16	0.12-0.17	0.12-0.16
$F_{current}$ (CI)	0.11 (-0.24-0.45)	0.15 (-0.19-0.47)	0.02 (-0.66-0.71)	0.07 (-0.14-0.30)

Management implications

Meetings held with stakeholders in July 2007 to discuss the overfishing of *Lutjanus sebae* were inhibited by a low turnout. However, those present by and large recognised that current practices were unsustainable in the long-term. Stakeholders supported the introduction of precautionary management measures (closed areas and seasons were proposed by fishers) until a management plan for the demersal line fishery is prepared and implemented. A proposal for FAO TCP assistance has been written and presented to the national node and the sub-regional office but no feedback has been given at the time of writing this report. The main reasons that FAO support has been requested is for expertise to help navigate the complex issues of resource access and rights and to develop educational and awareness programmes that address these issues.

2.1.4. *Siganus sutor*

A recent assessment of stocks of *S. sutor* was undertaken as part of paper on the sustainability of the aggregation fishery for this species presented at the 5th WIOMSA Scientific Symposium. The manuscript is still being prepared and here we summarise some of the results. Since sufficient time-series fishery-independent data on aggregation abundances are not available, and fisheries-dependent data is difficult to disaggregate into non-aggregation and aggregation components, the sustainability of aggregation fishing was assessed by looking at indicators of stock status and other evidence based on the history of the fishery and fisher perceptions.

Reproductive biology
A total of 138 biological samples were sampled from catches made directly on aggregations at Praslin in November 2003 and 2004. Between April 2003 and February 2006, a total of 729 *S. sutor* were sampled from commercial catches landed on Mahé and sexed and staged macroscopically. Males slightly outnumbered females in sampled catches (M: F = 1.1: 1). In terms of samples taken directly from aggregation catches in November 2004, the sex ratio was male biased (M: F = 1.4: 1). The length frequency distribution of males and females overlapped to give a single mode in distribution and there was no significant difference between sexes in terms of size (Mann-Whitney U: Z = -1.20, p > 0.05). A total of 281 females were sub-sampled for histology. *S. sutor* spawns over a protracted period from September to May as evidenced by trends in GSI (Figure 6) and patterns in sexual maturation (Figure 7).

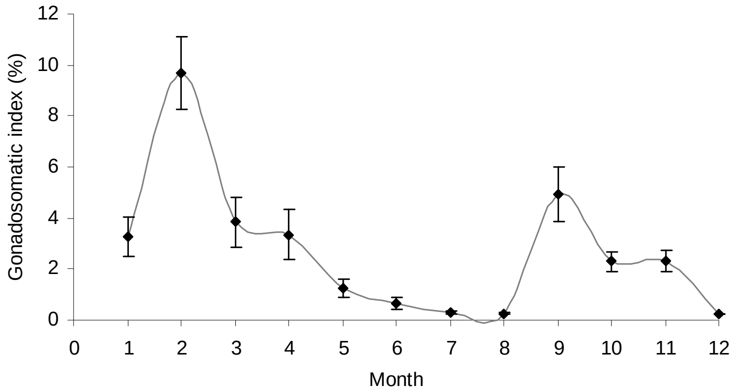

Figure 6. Trends in female GSI for data pooled over two years (N = 340). Samples obtained directly from aggregations not included in graph.

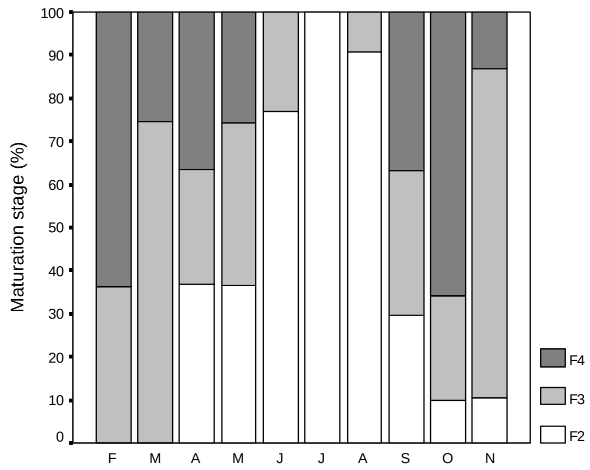

Figure 7. Patterns in sexual maturation determined histologically and expressed as monthly percentages (%) of mature inactive (F2), mature active (F3) and mature ripe (F4) individuals (n = 131).

Two methods were used to estimate female size at 50% sexual maturity (L_{m50}). Firstly, we calculated the effective maturity, defined as proportion of females (by 1 cm size groups) that were sexually active (F3, F4 and F5) during the spawning season (September to May, inclusive). Secondly, we used an empirical relationship to estimate the size at 50% sexual maturity from asymptotic length (L_∞) (Froese & Binohlan 1999 (L_∞ from Grandcourt, 1982). Using the first method (effective maturity), L_{m50} was 25.4 cm FL for females (n = 86) (Figure 8), which was equal to L_{m50} estimated by the second method.

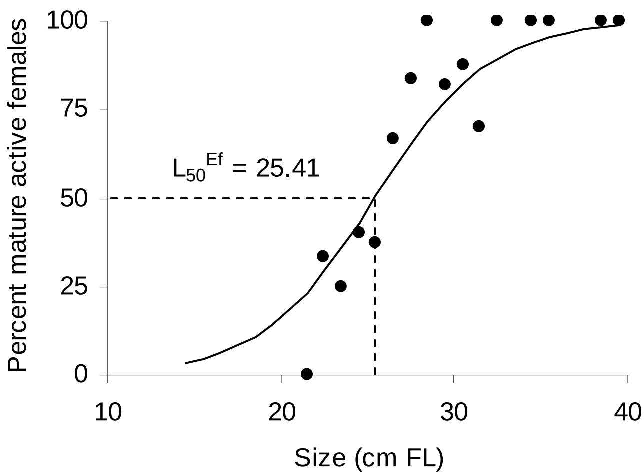

Figure 8. Estimate of female size at 50% maturity (dashed line) based on the effective maturity (L_{50}^{Ef}) method.

Resource status: CPUE

Although observations of fishing on aggregations at 2 sites on Praslin indicate that these are fished exclusively by active traps, analyses of CAS data indicate that active traps are not exclusive to aggregations, particularly on Praslin, and that static traps may also be used. Since problems of CPUE hyperstability may common in fisheries with a large spawning aggregation component, trends in CPUE were analysed by disaggregating CPUE by gear and season.

CPUE was significantly higher in the NW monsoon than during the SE Trades for both active (Mann-Whitney U; $Z = -7.86$, $p < 0.01$) and static trap (Mann-Whitney U; $Z = -18.20$, $p < 0.01$) gears. For all seasons and gears, there was a significant linear correlation between CPUE and time; all of which showed an increasing relationship in CPUE with the exception of static trap CPUE during the season of the SE Trades (Table 11). The strength of the relationships was strongest for an increase in active trap CPUE during the SE Trades. However, in general, the strength of the relationships was too weak to infer trends other than a relative stability in the siganid resource over the time-frame evaluated here. In terms of long-term monitoring of relative stock status, static trap CPUE in the SE Trades may be the most reliable indicator since the passive nature of the gear and the lack of reproductive activity combine to reduce the potential impacts of hyperstability on CPUE caused by dynamics in fisher and fish behaviour.

Table 11. Relationships between siganid CPUE and time (1991-2006) for static traps (kg/trap) and active traps (kg/set) during the NW Monsoon (September-April) and SE Trades (May-August) seasons.

Gear	Season	Relationship	Coefficient	*P*	Sample size
Active traps	NW Monsoon	Increasing	0.124	<0.01	1929
	SE Trades	Increasing	0.235	<0.01	672
Static traps	NW Monsoon	Increasing	0.089	<0.01	7844
	SE Trades	Decreasing	-0.064	<0.01	3663

Resource status: yield

Mean monthly yield (kg/km^2) varied substantially from a high of 8.6 kg/km^2 in 1992 to a low of 1.7 kg/km^2 in 2001 (Figure 9). There was a significant linear correlation, with yield declining over time, but the relationship was weak (Pearson coefficient = -0.195; $p < 0.01$). A declining trend in yield was observed between 1991 and 2001, followed by a period of recovery. Again, given the weak strength of the relationship, this measure shows no clear trend over time.

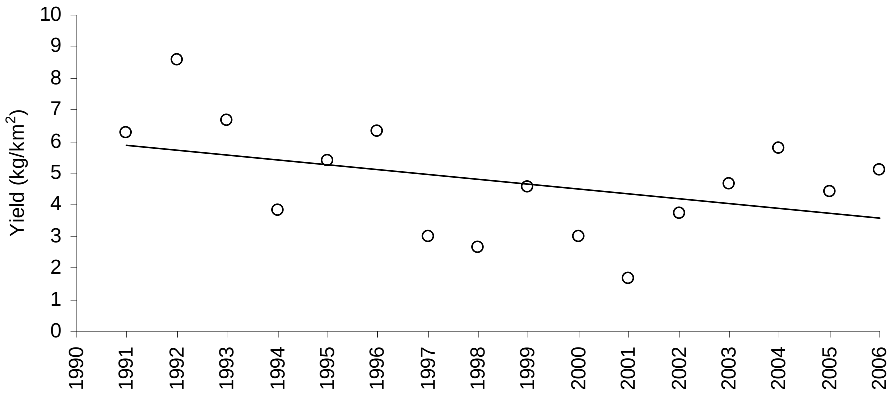

Figure 9. Yield (kg/km2) of siganids by the trap fishery between 1990 and 2006.

Resource status: stock assessment

A total of 627 S. sutor were sampled from commercial catches for L_F data between April and June 2007. Fishing mortality (F) was calculated using length-converted catch curves, based on two estimates of natural mortality (M), and estimates of F were compared against reference points; F_{opt} (= 0.5M) and F_{limit} (= 2/3 M) (based on Patterson, 1992, and used for *Siganus canaliculatus* by Grandcourt et al. 2006).

Total mortality (Z) was estimated at 4.25 year^{-1} (95% CI 3.87-4.63) (Table?). Natural mortality (M) estimates derived from the equation M=1.5K and the Pauly (1980) method were 0.97 and 0.63 year^{-1}, respectively. The length (L_{c50}) at which 50% of fish were captured by the fishery was considerably smaller than the estimated length (25.4 cm FL) at which 50% of the female population reached first maturity (L_{m50}) (Table 12). For both estimates of natural mortality rate, the current rates of fishing mortality (F) exceed target (F_{opt}) and limit (F_{limit}) biological reference points. This indicates that the stock is overexploited. The timing of the sampling coincides with the end of the spawning season, over which time fishing pressure on the stocks is expected to have been high. Sampling should be maintained over the year to allow changes in F to be monitored.

Table 12. Estimates of mortality (M, Z, F), length at first capture (Lc50; cm FL) and exploitation rate (E) compared to target (F_{opt}) and limit (F_{limit}) reference points for two estimates of natural mortality (M). All mortality rates are year^{-1}.

	M	F_{opt}	F_{limit}	L_{c50}	Z (95% CI)	F (95% CI)	E
M1	0.63	0.32	0.42	16.15	4.25 (3.87-4.63)	3.62 (3.24-3.99)	0.85
M2	0.97	0.49	0.65			3.28 (2.89-3.66)	0.77

Summary

While trends in CPUE and yield indicated a degree of stability over the long-term, data are aggregated at the family level and may mask declines for individual species. Periodic declines in CPUE and yield (largely consistent) within the 17 year period examined here may indicate a cycle of stock decline and recovery. The size structure of the stock clearly indicates an overfished stock against BRPs, but more frequent sampling within the year will help assess whether or not any stock recovery occurs within the SE Trades. Studies of the *S. sutor* aggregations indicate that these have been an important commercial resource for over 100 years and have not collapsed despite consistently high levels of fishing pressure. Strong social institutions relating to the targeting of aggregations have developed, particularly on Praslin, which may have contributed to the sustainability of the fishery. The apparent resilience of this species and its aggregations may be explained by several factors, including the life history strategy of the species. A meta-population structure is also suspected with concentration of effort on only the nearshore populations, which coupled with the fact that only 3-4 of the 10 or so known aggregation sites are consistently fished, may combine to offer a significant refugia and sources of recruits or adults from outside the fishing areas. Management efforts are now focusing on strengthening the social institutions relating to the trap fishery, with funds secured under the GEF/UNDP Mainstreaming Biodiversity programme to develop co-management structures for the fishery over the next 3 years.

2.1.5. SWIOFC fishery assessments

In addition to the assessments carried out above, Seychelles now submits annual assessments on the status of fisheries to the Scientific Committee of SWIOFC. These tables, with explanatory notes, will be attached to this and future BSFC reports as a summary of resource assessment activities.

SWIOFC: Indication of Fish Stock Status Country: Seychelles Region: Western Indian Ocean

Species/ Species Group/ Species Complex	Stock / management Unit	Trans-boundary /Straddling/ within EEZ	Current catch (t) 2006[2]	% change from preceeding year	Measure of Abundance[3] Indicate trend	Stock status[4]	Annual Management plan?[5] (Yes/No)	Management Measure(s)[6]
1. Multi-species	Demersal line fish stocks	Within EEZ	1,794	1.6	CPUE stable	F-O	No	None
2. *Pristipomoides filamentosus*	Mahe Plateau	Within EEZ	34.6	80.2	-	R	No	None
3. *Lutjanus bohar*	Mahe Plateau	Within EEZ	102	45.7	-	D	No	None
4. *Lutjanus sebae*	Mahe Plateau	Within EEZ	840	2.1	-	O	No	None
5. Multi-species	Semi-pelagic line fish stocks	Within EEZ	1,089	-24.1	CPUE variable, no clear trend	M	No	None
6. Multi-species	Semi-pelagic gillnet stocks	Within EEZ	254	-63.2	CPUE variable, no clear trend	M	No	Gear/fishing time/area restrictions
7. Multi-species	Inshore trap fish stocks	Within EEZ	410	-25.7	CPUE weak declining trend	F-O	No	Minimum mesh size
8. *Siganus sutor*	Inshore trap fish stock	Within EEZ	-	-	-	O	No	Minimum mesh size
9. *Ranina ranina*	Mahe Plateau	Within EEZ	48	165.2	-	U	No	None
10. Spiny lobster	Mahe	Within EEZ	6.1	56.4	CPUE increased between 2005 and 2006 seasons	O	No	Limited entry, seasonal closure minimum size, berried females prohibited
11. Sea cucumber	Mahe & Amirantes stocks	Within EEZ	421	11.4	CPUE trends vary by species*	F, O	Yes	Limited entry, gear restrictions, TACs
12. Inshore sharks	Mahe Plateau, Amirantes, Outer islands	Within EEZ	15.3	-32	-	D	No	Shark nets prohibited, NPOA produced

[2] Or relevant annual fishing season ei. 2006/2007
[3] Survey index, CPUE, absolute biomass estimate
[4] If possible, cite assessment document or relevant source of information
[5] If possible cite document describing the Management Plan
[6] E.g. output controls such as total allowable catch (TAC), input controls such as limits on fishing effort, amount of gear that can be used (G), gear types.

13. Offshore (pelagic) sharks	-	Trans-boundary	-	-	-	O	No	None, NPOA produced
14. Octopus	Granitic islands	Within EEZ	28.7	-15.8	-	-	No	None

Table Notes:
1: Estimates of virgin biomass (1.4 t/km^2 = 17,500 t) and MSY (0.168 t/km^2 = 2100 t) for Mahe Plateau inshore & offshore line (< 75m) grounds (12,500 km2) from Mees (1992). Yield of demersal guild (0.144 t/km2) below MSY in 2006. However, several demersal stocks are fully or overexploited (see below).
2: Estimates of virgin biomass and MSY (268 t) for Mahe Plateau from Mees (1993). Yield in the last 10 years significantly below MSY - stocks were overfished in the early 1990s, but surveys by SFA in 2006 indicate stock are recovering in some areas.
3: A recent stock assessment of *Lutjanus bohar* stocks (Marriott 2005) using CAGEAN models predicted stock depletion on the Mahe Plateau to be between 20-30% of virgin biomass. Estimates of spawning potential ratio (SPR) ranged from 12 to 18.7%, predicting severe depletion of the stock.
4: Recent per recruit assessments (SFA, unpublished data; Grandcourt et al. in prep) indicate over-exploitation in recent years. High juvenile retention rate in the fishery. Sustainable harvest rates over-estimated by Lablache & Carrara (1988) - now improved using age-based methods. Stock requires urgent management.
5: Decline in catches due to vessels switching from this lower value resource to higher value demersal species. Main target species, *Carangoides* spp., *Sphyraena* spp. and *Euthynnus affinis* have not been assessed, but fishery is concentrated inshore and is considered to be only moderately exploited (Mees et al. 1998).
6: Highly variable fishery; large seasonal/inter-annual variability in catch and effort. Stocks of the main target species (e.g. *Rastrelliger kanagurta*) have not been assessed, but the fishery has been considered as under-exploited as only inshore portion of stock is targeted. Management plan being prepared.
7: MSY (445-471 t) derived from Schaefer models indicate fishery is fully exploited. However, the stock of *Siganus sutor* (a primary target species) are known to be over-exploited (SFA, unpublished data; Wakeford 2000).
8: Assessment in 2007 (SFA, unpublished data) indicated that fishing mortality is considerably greater than target and limit biological reference points, using the methods of Patterson (1992). Note: catch and virgin biomass difficult to estimate as siganid species are aggregated to family in the catch assessment survey.
9: The spanner crab (Ranina ranina) fishery is underexploited with yield far lower than MSY (381 t for the Mahe Plateau; Boullé 1995) and effort declining. Market constraints are the primary reason for underdevelopment of fishery.
10: The spiny lobster fishery is a seasonal fishery. Catches for the 2006/2007 season (6.1 t) were greater than MSY (4.7 t; Bautil 1992), with most overfishing occurring in the Mahe fishing stratum.
11: *CPUE increasing and decreasing for high value species; effort estimates are not partitioned between species, and the trends are considered an artefact of changes in targeting. Yields for several high value species exceeded TACs in 2006, including 'Pentard' (*Holothuria* sp.), one of the highest value species in the catch. MSY (all species) = 5265 t. Low value species under-exploited, but considering emphasis on high and medium value species, fishery considered fully to over-exploited. Management plan not yet implemented so TACs not actively enforced.
12, 13: Catch data includes rays. NPOA indicates that shark fisheries are substantially data deficient. Significant historical, anecdotal and fisheries-independent information suggests inshore populations are severely depleted. Offshore stocks subject to increasing, industrial fishing effort and the offshore fishery is considered overexploited. Current catch is considerably underestimated.
14: Octopus (*Octopus vulgaris*) is fished inshore by skin divers. Resource potential and status is not known.

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2.2. Other Research Activities

2.2.1. Reef fish spawning aggregations
Work on spawning aggregations has continued in late 2006 and 2007 but with less of an emphasis on field work since the WIOMSA MASMA funded programme has been completed. The final project report has now been published by WIOMSA (Robinson et al. 2007). The management measures for the outer island grouper aggregation sites have been prepared as a Cabinet memorandum but still await approval. As noted above, management of the siganid aggregations is being addressed under a separate initiative. Two papers have been submitted for publication, one of which is in review and the other 'in press'. Copies of both these can be made available upon publication. WIOMSA and SIDA have also expressed their willingness to support a regional programme on spawning aggregation research and management, with SFA leading a collaboration of regional institutions. The proposal is being developed and is expected to be submitted for funding at the end of the year, through the new phase of the MASMA programme (this time with a maximum of US$ 400,000 per project).

2.2.2. Fisheries sector climate change projects
SFA are implementing 2 projects as part of the enabling activities for Seychelles Second National Communication (SNC) to the UNFCCC. The first project is to establish a national network for gathering and sharing ocean temperature data obtained *in situ* or remotely, both current and historical. A series of monitoring sites for in-situ observations has been established and work on the database has progressed. The MOU is in its second draft and will be finalised in early 2007. The main product from the project will be an online application for members to share data and for non-members to access metadata, to view trends in ocean temperature, and to request raw data. The outline of the online database is progressing.

The second major project in the fisheries and marine environmental sector is to conduct a desk-top study on the socio-economic impacts of ENSO on the industrial fisheries. There have been considerable delays in the analysis of data from the industrial fisheries due to sorting and cleaning of the vessel expenditure database. Other data requests from industry, which include employment, costs and revenue data, have been slow in coming.

2.2.3. Oceanographic research
At the beginning of 2007, SFA recruited a Seychellois graduate (Calvin Gerry) in physical oceanography to help develop applications in this field for fisheries. A number of initiatives have been started.

With assistance from IRD, assessments using the Indian Oscillation Index (standardized sea level pressure anomaly between Seychelles and Darwin) are being conducted to examine the influence of anomalies in climate variability on industrial fisheries. The work is still at an exploratory stage but the sensitivity of IOI to ENSO and non-ENSO anomalies have been confirmed. The results of these analyses will be presented at the next BSFC meeting. It is also planned to look at the interaction of oceanographic-climate variables and the semi-pelagic fisheries.

SFA is now collaborating on a regional project, African Monitoring of the Environment for Sustainable Development (AMESD). The AMESD project objective is to improve the management of the natural resources of African countries by providing them with state-of-the-art earth observation, information and communication technologies. For the Western Indian Ocean, the theme being addressed is 'Coastal and Marine Management'. Seychelles, as a beneficiary country to this project, has identified needs in terms of type of data, software and hardware, and infrastructure. Feedback is still awaited. For SFA, as only one of several local partners in the project, the main aim is develop advanced monitoring capability for oceanographic parameters important to fisheries research, monitoring and management. There has been progress towards incorporating oceanographic variables into GIS (Arc Map) to promote the use of this tool for fisheries analysis. The aim is to maintain an oceanographic database for data relevant to understanding fisheries resources in relation to environment.

2.2.4. Regional sea cucumber project

This project involves 5 countries (Kenya, Tanzania, Madagascar, Réunion and Seychelles) and has a number of components. For the first component, ecology of sea cucumbers – stock assessments, Seychelles is not participating as stock assessments were undertaken during the FAO TCP project in 2004. The other countries are assessing mainly the reef areas. In terms of the second component, each country is working on the reproductive biology of one or two species. In Seychelles, the reproductive biology work started in May 2007 with sampling of *Holothuria atra* at Anse Royale. This work is expected to be completed in April next year. The size at first maturity will also be calculated from sampling planned for December 2007. The project also contains a socioeconomic component. A set of questionnaires were designed for the region and, in May 2007, a survey was conducted in Seychelles. A number of divers, boat-owners, processors and managers were interviewed. The results from this study will be incorporated with the socio-economic data from other participating countries to provide a regional perspective. A few publications have resulted from this project in 2007 (Aumeeruddy & Conand, 2007; Aumeeruddy, 2007).

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