The effects of river flooding on the fish populations of two eastern Cape estuaries

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The effect of river flooding during July and August 1979 on fish populations in two eastern Cape estuaries is compared. It is shown that floods of varying intensity occur regularly in these estuaries. Fish populations in the two estuaries, namely the Swartkops and the Sundays, were differently affected: members of the family Mugilidae increased in numbers in the Swartkops estuary after the floods but decreased to insignificant numbers in catches in the Sundays estuary for a number of months after the floods. It is postulated that mud and silt which are deposited in the Swartkops during the flood serve as a food source for the mullet whereas the rich surface benthos layer of a channel-like estuary like the Sundays is washed away by heavy floods.

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Die invloed van twee opeenvolgende vloede gedurende Julie en Augustus 1979 op die visbevolking van die Swartkops- en Sondags-getyrivier is ondersoek. Die visbevolking van die twee getyriviere is verskillend beïnvloed: spesies wat behoort aan die familie Mugilidae het geweldig toegeneem in die Swartkops-getyrivier na die vloede terwyl dit byna verdwyn het in die Sondags-getyrivier vir 'n aantal maande na die vloede. Dit word gepostuleer dat ryk slik- en modderlae wat in die Swartkops-getyriver gedeponeer is deur die vloedwaters as voedingsbron dien vir springers terwyl die vrugbare oppervlakte-laag in 'n kanaalagtige getyrivier soos die Sondags deur sterk vloedwater verwyder word.

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The Swartkops estuary is subjected to regular floods, which are unpredictable in duration and extent (Macnae 1957; McLachlan & Grindley 1974; Marais 1976). Macnae states that one-third to one-half of the annual rainfall occurs over a few days during which times the river comes down in 'heavy spate'. Such occasional heavy floods are characteristic of rivers in the Eastern Cape. However, largely because of their short duration, these floods appear to have very little effect on the animal life in the estuary (Macnae 1957). Day & Grindley (1981) are of the opinion that the effects of severe floods (especially the burial of aquatic macrophytes and macrobenthic fauna) 'impoverish' many of the large South African estuaries.

Palmer (1980) states that adaptation to fluctuating and reduced salinities is essential, for without this, the survival of any organism as a permanent member of the estuarine community is impossible. Adaptive mechanisms are varied. The bivalve, *Dosinia hepatica* closes its shells (Hill 1981); *Upogebia africana* and *Callianassa kraussi* rely on physiological capabilities to survive floods of short duration (Hill 1967, 1981); the crab *Cyclograpsus punctatus* uses behvioural mechanisms coupled with a modest osmoregulatory ability (Boltt & Heeg 1975); fish such as *Lichia amia, Argyrosomus hololepidotus, Lithognathus lithognathus, Monodactylys falciformis, Pomadasys commersonni* as well as the mullets *Liza richardsoni, Liza dumerilli, Liza tricuspidens* and *Mugil cephalus* are often caught in salinities < 1‰ and can be expected to osmoregulate. McLachlan & Erasmus (1974) suggested that *Solen corneus* and *Solen capensis* are able to withstand low salinity conditions to a certain extent because salinity fluctuations are greatly reduced within the substrate where they are to some extent insulated. Forbes (1973) found that the burrowing habit of *Callianassa kraussi* did not protect it from sudden changes in surface water salinity. Estuarine animals can also be flushed out to sea as in the case of plankton (Day & Grindley 1981) and fish (Grindley 1974) and some motile animals may actually migrate out to sea (Hill 1981).

There is general agreement that estuarine animals have a remarkable ability to resist fresh water during floods of short duration but a much longer-lasting effect is caused by deposition of silt (Macnae 1957; Palmer 1980; Day & Grindley 1981; Hill 1981). If low-salinity conditions prevail for an extended period, animals may be killed on a large scale. Hill (1979) showed that *Upogebia africana* can withstand salinities as low as 1,7‰ for not longer than eight days. McLachlan & Grindley (1974) gave an account of the decimation of *Solen corneus* and *Macoma litoralis* in the middle regions of the Swartkops estuary owing to a flood in 1971. Hanekom (pers. comm.) quantified the effect of prolonged floods on macrobenthic animals during September 1975 and found that the populations of *Solen corneus* and *Upogebia africana* in the middle reaches of the Swartkops estuary were reduced by approximately 85 and 25% respectively. According to Hanekom these animals were either killed by the low salinity or flushed out to the sea. An account of the disrupted distribution patterns of zooplankton in the Swartkops estuary is given by Wooldridge & Melville-Smith (1979).

Longhurst (1957) studied the effects of floods on the natural food organisms and thus on the fish population of a West African estuary. The extent to which fish populations are affected by sudden drastic changes in salinity and substratum has not yet been investigated in South African estuaries. In this present study the effect of flooding on the abundance of fish in the Swartkops and Sundays estuaries is described.

Site description

The Swartkops estuary enters Algoa Bay approximately 10 km north-east of the Port Elizabeth harbour. The fresh waters of the Swartkops estuary are derived from the Elands and Swartkops Rivers which originate in the Grootwinterhoek mountains. They flow parallel to each other in steep narrow valleys and join shortly after entering the flood pain about 31 km from the estuarine mouth. The main stream, the Swartkops, is dammed about 40 km from the estuary mouth by the Groendal dam (Figure 1).

The Sundays estuary opens into Algoa Bay approximately 25 km to the north-east of the Swartkops estuary. The river originates in the Karoo near Nieu-Bethesda. It fills Lake Mentz near Jansenville from where a steady flow of fresh water is released (Figure 1). In contrast to the Swartkops River estuary, the Sundays River has no salt marshes or extensive intertidal mud- and sand-flats. It was described by Wooldridge & Melville-Smith (1979) as 'channel-like' along its entire length with only a narrow intertidal zone. Owing to this characteristic, flushing of the estuary during floods is virtually complete (Baird & Erasmus 1977).

Methods

Catch per unit effort (CPUE) of fish in the Swartkops and Sundays estuaries was obtained by means of gill-nets. Each gill-net consisted of five 10-m sections 3 m deep with stretched mesh sizes of 55; 70; 85; 110 and 145 mm, and each covered 150 m^2. They were laid for a 12-h period (from dark till dawn) across the estuary. The catch per unit effort is regarded as the number or mass of fish caught by the 150-m^2 net during a 12-h period.

Catches were made in the lower, middle and upper reaches of both estuaries shortly after the floods and were initially repeated bi-weekly and later at monthly intervals. The catch results are compared to the mean values obtained over extended periods: Swartkops estuary, September 1975 to January 1979; Sundays estuary, December 1976 to December 1979.

Surface water salinity was measured by a hand-held

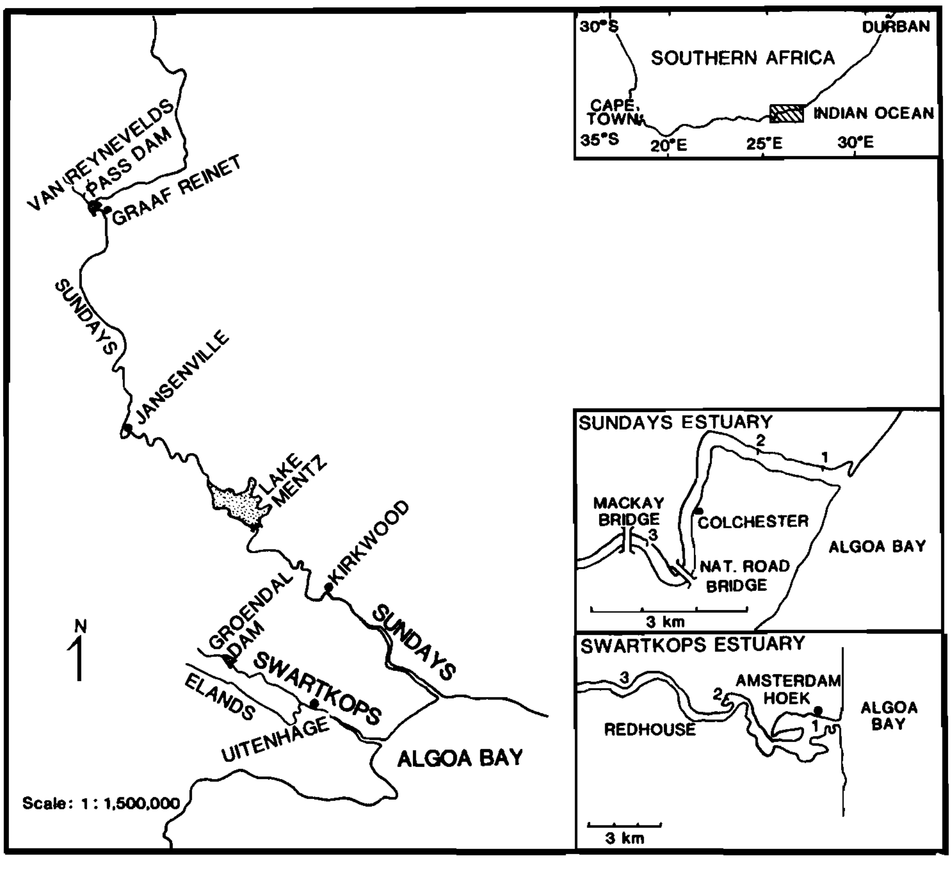

Figure 1 Geographical positions of Swartkops and Sundays estuaries and location of sampling sites.

refractometer in the morning prior to the lifting of the nets on each occasion when netting took place. On some occasions bottom salinity was measured.

The nature conservation officer stationed at the Swartkops estuary furnished data on dead animals, which accumulated in the grids of the inlet channel to the Swartkops Power Station, two days after the August 1979 flood.

Results

Mean catch composition (compiled from normal and post-flood data) is largely similar when the three stations sampled at Swartkops are compared with their counterparts in the Sundays estuary (Tables 1 – 3). However, the floods that occurred during July and August had a completely opposite effect on catch composition in the middle

Table 1 A comparison of CPUE from the mouth regions of the Swartkops and Sundays estuaries after two successive floods in 1979. Mean CPUE obtained over an extended period (26 catches in Swartkops and 17 in Sundays) is also given

Swartkops

Date	9/1975 – 1/1979			27/7/1979		7/8/1979			28/8/1979		4/9/1979		29/9/1979		24/1/1980	
Salinity: Surface (‰)	33,7		Flood	6,0		25,0		Flood	12,0		3,0		10		35	
Bottom															36	
Species	*n*	Mass (g)		*n*	Mass (g)	*n*	Mass (g)		*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)
L. richardsoni	3,0	1 030		4	1 229	1	256		4	1 048	10	2 299	2	306	2	382
M. cephalus	4,9	1 810		13	4 846	2	1 134		5	2 179	5	1 778	5	2 446		
L. tricuspidens	3,6	642		4	936	4	1 464						9	2 301		
L. dumerili	0,7	85		1	155	1	82		1	133	3	403	9	1 347		
V. buchanani											1	2 300				
L. macrolepis																
Mugilidae	12,2	3 567		22	7 166	8	2 936		10	3 360	19	6 780	25	6 400	2	382
P. commersonni	3,9	3 850		10	12 214	6	7 512		5	5 967			10	11 980		
R. holubi	2,9	273		13	1 381	1	103		3	292			6	478		
L. amia	1,0	434														
T. feliceps	1,0	539		26	15 206										12	5 895
E. machnata	1,0	1 844							6	16 000	3	6 800	6	12 360	1	2 250
A. hololepidotus	0,8	431		1	2 150	1	508				1	457	3	2 541	1	129
M. aquila	0,9	383													4	5 973
+ 7 other spp.	1,0	528		1	389				3	4 469	1	664	3	874	1	298
Total	24,7	11 849		73	38 506	16	11 059		27	30 088	24	14 701	53	34 633	22	14 927

Sundays

Date	12/76 – 12/79			3/8/1979			1/10/1979		16/10/1979		13/11/1979		6/12/1979	
Salinity: Surface (‰)	24,0		Flood	16,5		Flood	26,0		19,0		26,0		32,0	
Bottom				30,0					30,0		30,0		34,0	
Species	*n*	Mass (g)		*n*	Mass (g)		*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)
M. cephalus	2,0	860									4	1 620		
L. richardsoni	4,4	1 221					2	615	1	167	6	1 056	9	2 348
L. tricuspidens	0,7	691					4	2 418					2	1 283
L. dumerili	0,3	53												
V. buchanani	0,2	267					1	1 750			1	171		
M. capensis	0,1	39							1	402	1	262		
Mugilidae	7,7	3 131					7	4 783	2	569	12	3 109	11	3 631
T. feliceps	3,5	1 602		3	1 519		1	667	2	797	4	1 930	6	2 856
A. hololepidotus	1,7	3 584		2	14 310				3	4 770				
P. commersonni	2,1	3 506		3	5 798		5	8 830	13	30 960	1	950	3	4 860
M. aquila	2,8	803		1	285		1	253			3	795	1	198
L. amia	3,0	3 845					1	349	1	1 800	18	36 574		
E. machnata	1,1	2 157		2	5 000				4	9 350			1	2 200
+ 7 other spp.	1,7	838					1	327	2	1 380				
Total	23,6	19 466		11	26 912		16	15 209	27	49 626	38	43 358	22	13 745

and upper regions of the two estuaries. In the Swartkops estuary, mullet numbers increased markedly, whereas in the Sundays, minimal numbers were taken in the catches after the floods.

Separate consideration of Tables 1 – 3 gives clearer understanding of the effects of floods on the individual fish species in the different regions of the estuary. In the mouth region of the Swartkops estuary one week after the July flood in 1979, mullet numbers, especially *Mugil cephalus,* were more than double the mean value found over an extended period (Table 1). *Pomadasys commersonni* also increased after the first flood and was sporadically present when later catches were made. Despite the considerably reduced salinities after the floods (Table

Table 2 A comparison of CPUE from the middle regions (Station 2) of the Swartkops and Sundays estuaries after two successive floods in 1979. Mean CPUE obtained over an extended period (9 catches in Swartkops and 16 in Sundays) is also given

Swartkops

Date	9/1975 – 1/1979			27/7/1979		7/8/1979			28/8/1979		4/9/1979		29/9/1979		9/11/1979		11/12/1979		24/1/1980	
Salinity ($^0/_{00}$): Surface	27,9		Flood	0		5		Flood	0		0		0		24		28		30	
Bottom																				
Species	*n*	Mass (g)		*n*	Mass (g)	*n*	Mass (g)		*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)
L. richardsoni	1,6	511		36	6 862	7	2 565		41	12 503	21	5 633	29	8 936	2	1 554			2	469
M. cephalus	0,7	218		20	6 763	3	662		2	470	4	706	6	1 854	6	2 455				
L. tricuspidens	1,0	597		2	314				9	2 214			2	1 286	7	3 990				
L. dumerili	0,4	49		2	294	2	296		2	204	3	416	8	1 230	1	234			1	138
V. buchanani	0,2	351		1	881	1	1 570						1	1 430						
M. capensis									3	2 087										
Mugilidae	3,9	1 726		61	15 114	13	5 093		57	17 478	28	6 755	46	14 736	16	8 233			3	607
P. commersonni	8,6	5 323							15	7 475			6	9 475	7	4 811	5	2 186		
R. holubi	2,2	206							1	44									5	278
L. amia	1,7	774													3	4 899			1	43
T. feliceps	4,8	2 853																	16	16 049
E. machnata	1,2	1 579				1	2 650		1	612					3	6 800	1	2 580		
A. hololepidotus	0,6	1 303				5	7 083		9	4 155	1	433	3	1 075	1	407			2	337
P. indicus	1,1	635																		
S. mossambicus													8	7 885						
C. carpio																	1	692		
+ 7 other spp.	1,6	1 265				1	106		2	115	2	122					1	434	2	1 250
Total	25,7	15 664		61	15 114	20	14 932		85	29 879	31	7 310	63	33 171	30	25 150	8	5 892	29	18 564

Sundays

Date	12/1976 – 12/1979			3/8/1979			7/9/1979		1/10/1979		16/10/1979		13/11/1979		6/12/1979	
Salinity ($^0/_{00}$): Surface	26,5		Flood	6,5		Flood	15		16		16		26		22	
Bottom				30,0			20				30		30		23	
Species	*n*	Mass (g)		*n*	Mass (g)		*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)
M. cephalus	1,0	436													5	2 294
L. richardsoni	0,9	379									2	405	6	1 939	1	592
L. tricuspidens	0,2	146													1	693
L. dumerili	0,6	107											7	1 040	1	290
M. capensis	0,1	42											1	671	2	858
Mugilidae	2,8	1 110									2	405	14	3 650	10	4 727
T. feliceps	6,1	2 921		18	9 973								1	491	5	2 712
A. hololepidotus	2,0	4 614		2	22 441		2	6 770			2	5 939	7	16 570	2	1 238
P. commersonni	2,3	3 954		6	9 739				7	13 930	7	14 610			3	4 170
M. aquila	1,3	405							2	418			8	2 420	2	830
L. amia	0,4	498									1	3 340	1	424		
E. machnata	0,9	2 156							1	2 380	3	7 890	3	7 050		
M. cyprinoides				1	1 250											
+ 11 other spp.	2,4	552		1	24		2	438	1	246					6	867
Total	18,3	16 210		28	43 427		4	7 208	11	16 992	15	32 184	34	30 605	28	14 544

1), catch composition in general was not greatly affected in the mouth region of the Swartkops.

The effect of the floods on the fish population was completely different in the Sundays estuary. No mullet were caught at Station 1 (Table 1) two weeks after the first flood but they appeared in more or less normal numbers in later catches. Abundance of other species was little affected except for a drastic increase in the number of *P. commersonni* in October 1979 and of *Lichia amia* in November 1979. This could not be ascribed to the flood conditions. *Lichia amia* increases in eastern Cape estuaries during November (unpubl. data) whereas *P. commersonni* can show considerable fluctuations from month to month (Table 1 and Marais 1981).

At Station 2 in the middle regions of the Swartkops estuary, numbers of fishes of the family Mugilidae, especially *Liza richardsoni*, showed a large increase after the two floods (Table 2). Their numbers remained high until five months after the first flood. Only mulllet were caught a week after the first flood but one and a half weeks later, *Monodactylus falciformis*, *Elops machnata* and *Argyrosomus hololepidotus* also appeared in the net. A large number (15) of *Pomadasys commersonni* were caught a week after the second flood (Table 2). The freshwater

Table 3 A comparison of CPUE from the upper regions (Station 3) of the Swartkops and Sundays estuaries after two successive floods in 1979. Mean CPUE obtained over an extended period (15 catches in Swartkops and 18 in Sundays) is also given.

Swartkops

Date	12/1975 – 1/1979			27/7/1979		7/8/1978			28/8/1979		4/9/1979		29/9/1979		9/11/1979		24/1/1980	
Salinity: Surface	24,0		Flood	0		0		Flood	0		0		0		10		15	
(⁰/₀₀) Bottom																		
Species	*n*	Mass (g)		*n*	Mass (g)	*n*	Mass (g)		*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)
L. richardsoni	7,0	2 010		8	1 406	26	7 516		53	13 158	42	8 230	60	12 967	63	16 404	9	1 815
M. cephalus	2,6	886				2	639		10	2 346	9	2 210	21	6 508	39	16 754		
L. tricuspidens	1,7	770											1	534	5	1 587		
L. dumerili	0,3	37																
M. capensis						2	884		3	1 242								
Mugilidae	11,6	3 703		8	1 406	30	9 039		66	16 746	51	10 440	82	20 009	107	34 745	9	1 815
P. commersonni	2,7	2 962				7	9 397		22	24 004			9	9 098	15	7 341	6	1 815
R. holubi	0,9	45																
L. amia	2,1	1 230													1	480	6	5 793
M. falciformis	3,7	217													1	24	4	339
E. machnata	1,5	2 479															1	773
A. hololepidotus	1,7	650											7	7 472	6	3 717	4	820
M. salmoides						1	693											
C. carpio									2	3 650								
+ 6 other spp.	1,5	2 383															5	2 226
Total	25,7	13 669		8	1 406	38	18 129		90	44 400	51	10 440	98	35 579	130	46 307	35	13 581

Sundays

Date	12/1979 – 12/1979			3/8/1979			7/9/1979		1/10/1979		16/10/1979		13/11/1979		6/12/1979	
Salinity: Surface	10,7		Flood	4,0		Flood	0		10		8,0		10		14	
(⁰/₀₀) Bottom				27,5			4,0				24,0		25		19	
Species	*n*	Mass (g)		*n*	Mass (g)		*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)	*n*	Mass (g)
M. cephalus	6,7	2 066													4	2 082
L. richardsoni	5,2	2 063							1	372						
L. tricuspidens	2,2	3 371												2 750	13	14 680
Mugilidae	14,1	7 500							1	372			2	2 750	17	16 762
T. feliceps	2,9	1 348		31	15 514				1	512						
A. hololepidotus	3,8	8 071		3	5 679		4	30 769	1	2 750	6	15 015	4	5 690	2	1 600
P. commersonni	2,8	2 318		12	8 717		4	6 500	5	7 200	1	2 100	3	2 750	1	1 840
E. machnata	0,8	1 715									1	2 300	3	6 200	1	2 100
+ 6 other spp.	0,9	240														
Total	25,3	21 192		46	29 910		8	37 269	8	10 834	8	19 415	12	17 390	21	22 302

Table 4 Number and mass of animals that accumulated in the grids of the water inlet channel to the Swartkops Power Station after the flood of 21/8/1979

Date:	22/8/1981		23/8/1981		24/8/1981	
Species	*n*	mass (kg)	*n*	mass (kg)	*n*	mass (kg)
Rhabdosargus holubi	126	7,0	188	9,5	9	0,5
Gilchristella aestuarius	900		1 550		200	
Monodactylus falciformis	15		26		2	
Argyrosomus hololepidotus	15	4,2	2	2,5		
Pomatomus saltatrix	5	2,2	7		0	
Solea	6		17		4	
Pomadasys commersonni	3	7,9	18		11	
Mugilidae	16	2,2	500		75	
Amblyrhynchotes honkenii	7		20		2	
Hyporhamphus knysnaensis			17		3	
Upogebia africana		23,0		20,6		1,7[a]
Scylla serrata	4		1		0	
Sesarma catenata	31		6		0	
Sepia australis	5	4,5	2	1,0	0	0
Xenopus laevis			13		7	

[a]Some removed earlier

species *Sarotherodon mossambicus* and *Cyprinus carpio,* were caught one and four months after the second flood respectively.

At Station 2 in the Sundays estuary, in contrast to the Swartkops, no mullet were caught until 2½ months after the first flood (Table 2). A larger-than-normal number of sea-catfish, *Tachysurus feliceps,* were caught two weeks after the first flood (3-8-1979) whereas larger-than-normal numbers of *Pomadasys commersonni* were sporadically caught.

As could be expected, the effect of the floods was more severe in the upper regions of the estuaries where the third net was set (Table 3). Abundance of two mullet species, *Liza richardsoni* and *Mugil cephalus,* and of spotted grunter, *P. commersonni* increased considerably from about two weeks after the first flood. Two freshwater species, *Micropterus salmoides* and *Cyprinus carpio,* also appeared in the catches. The catch composition at Station 3 was only more or less back to normal six months after the first flood (Table 3) in the Sundays estuary.

Only three mullet were caught in the five-month period after the first flood at Station 3 in the Sundays estuary (Table 3). Other species that normally dominate in the nets like kob, *Argyrosomus hololepidotus,* and spotted grunter were caught regularly but in low numbers. Sea-catfish were abundant in the net, as at Station 2 (Tables 2 & 3), two weeks after the flood in July and then just about disappeared from the catches.

Numbers, and in some instances mass, of animals trapped by the grids of the inlet channel to the Swartkops Power Station, are given in Table 4. This table suggests that large numbers of typical estuarine fish like *Rhabdosargus holubi, Pomadasys commersonni, Argyrosomus hololepidotus,* mullet and *Gilchristella aestuarius,* as well as other animals like the blue river crab, *Scylla serrata,* the mud prawn, *Upogebia africana* and the crab, *Sesarma catenata* appeared to be stunned by the flood conditions. According to Mr Gilmer, who is in charge of regular grid inspections, more animals accumulated on the grids after the July floods than in August (Table 4). They were, however, not quantified.

Discussion

The extremes of a number of factors may be responsible for changes in abundance of estuarine biota after floods. Day & Grindley (1981) stated that apart from raising the water level and increasing current velocities, floods may have other effects. The increased discharge of the river at first reduces the salinity of the surface waters and then as turbulence increases, the salinity of the bottom layers also decreases and in extreme cases the whole estuary may run fresh to the sea. Rivers in flood usually carry an increased load of silt and when the turbulent water reaches the estuary the water becomes increasingly turbid (Day & Grindley 1981). Day (1981) mentions that sediments that have been sorted and resorted during ten years of natural flow may be completely swept away during a single flood, thus changing the bottom topography of an estuary.

The first and probably major effect of a flood on the estuarine system is the physical removal of animals and plants. As stated by Grindley (1974), most of the estuarine plankton and fishes are swept out to sea during a major flood. This may be especially severe in a channel-like estuary with a narrow intertidal range such as the Sundays River estuary where flushing of the estuary is virtually complete according to Baird & Erasmus (1977). In an estuary such as the Swartkops with a wide food plain, mud flats and *Spartina capensis* beds, the physical effects of a flood will be reduced.

Apart from floods sweeping nekton and plankton out to sea, benthic fauna may also be transported away as the topography of the bottom and banks changes during the flood. Simultaneously, benthic macro- and micro-fauna may be permanently covered by a layer of silt and mud of varying thickness, which could in some instances have a more drastic and longer-lasting effect than flushing, a phenomenon referred to as 'blanketing' by Stephenson, Cook & Raphael (1977). Macnae (1957) mentions an instance in January 1951 when a layer of mud deposited by a flood was probably responsible for the extermination of *Ochaetostoma capense* in the Swartkops estuary. A combination of 'blanketing' and prolonged reduced salinity decimated the bivalves *Macoma litoralis* and *Solen corneus* in the middle reaches of the Swartkops in 1971 (McLachlan & Grindley 1974). Perkins (1974) reports an instance where floods in Scotland swept bivalves away or buried them too deep for survival. The same floods described in this paper caused smothering of *Zostera capensis* beds together with their *Nassarius kraussianus* populations in the Bushmans estuary (Palmer 1980). Recolonization coincided with habitat recovery and regeneration of *Z. capensis* cover.

A further adverse effect of silt-laden flood waters is interference with oxygen uptake in euryhaline animals well adapted to low-salinity conditions. Animals caught in the grids of the inlet channel to the Swartkops Power Station were either dead or immobilized to such an extent that they were unable to avoid being caught in the grids after the floods in 1979 (Table 4).

Stenohaline animals with limited or no locomotory ability are the first to die after a flood. Day & Grindley (1981) mention that *Parechinus angulosus*, which normally colonizes the rocks near the mouth of the Kowie estuary, died in thousands when floods reduced salinity to below 5‰ for a week. There are many records of typical estuarine animals being killed by low-salinity conditions after floods. Floods of September 1975 in the middle regions of Swartkops estuary reduced the population size of *Solen corneus* by 85% and of *Upogebia africana* by 25% (Hanekom, pers. comm.). An account of the effect of seasonal floods of long duration on the fauna and the flora of the Blackwood estuary in Western Australia is given by Hodgkin (1978). The fish population in the estuary was less affected than the benthic fauna. A study of the effect of floods on the ecology of Blackwood estuary, together with evidence from other estuaries, convinced Day & Grindley (1981) that it was not so much the absolute value of minimum salinity which impoverishes the fauna as the duration of the oligohaline conditions.

It is often impossible to distinguish whether floods affect fish populations directly or indirectly through a reduction in their natural prey organisms as shown by Longhurst (1957). Tables 1 – 3 clearly show that the fish populations, sampled by gill-net, were definitely affected by the July and August floods of 1979 which occurred in both estuaries at the same time. Unfortunately nets could not be set shortly after the floods because of possible damage to the nets by the flood waters and drifting debris.

Catches from the mouth regions of both estuaries after floods (Table 1) differed little from long-term mean values. From Station 2 upwards, flood effects are more evident. The two estuaries also seem to be affected in different ways. Mullet increased considerably after the floods in the middle (Table 2) and upper reaches (Table 3) of the Swartkops estuary after a slight initial decrease in number at Station 3 one week after the first flood. In contrast, not a single mullet was caught at any of the regular sampling sites in the Sundays estuary when nets were first put out after the July flood (Tables 1 – 3). It took a number of months before their numbers returned to normal. Fish other than mullet, were caught in larger numbers after the floods except at Station 1 (where only a larger mass was caught).

Consideration of the flood effects on the normal grazing grounds and natural food organisms of the major fish species will contribute to an understanding of these apparently conflicting data. Gill-netting (Marais & Baird 1980a) has shown that the family Mugilidae dominated catches numerically in both the Swartkops and Sundays estuaries. The second most abundant species in the Swartkops estuary (numbers and mass) was the spotted grunter, *Pomadasys commersonni,* followed by the ten-pounder, *Elops machnata* in terms of mass. In the Sundays River estuary, sea-catfish, *Tachysurus feliceps,* was second in abundance numerically, followed by the kob, *Argyrosomus hololepidotus* and *P. commersonni* (Marais 1981). In terms of mass, kob dominated the catches in the Sundays estuary (Marais 1981).

Heavy floods, as experienced in 1979, deposited a layer of silt and clay of varying thickness on the sand- and mudbanks of the Swartkops estuary.

It was noticeable in most areas as a thin yellowish layer. Macnae (1957) states that heavy floods tend to clear silt from the Gamtoos estuary while small floods tend to deposit it. The Gamtoos estuary is also channel-like, similar to the Sundays estuary. The increase in abundance of mullet in the Swartkops estuary after a heavy flood is possibly due to the presence of rich silt deposits. On the other hand, their disappearance from the Sundays estuary can probably be ascribed to the removal of silt, clay and colloidal humus with the bottom sediment during severe floods. Reddering (pers. comm.) found that severe floods remove the sediment down to the erosion base, which stretches from Station 3 to the mouth, in the Sundays estuary. The nutritious upper layer of the benthos accumulates in an estuary when fresh water, carrying suspended silt, clay and colloidal humus, mixes with salt water under more normal conditions over a long period of time (Day 1981). Motile benthic diatoms and diatoms attached to sediment particles of varying but specific size ranges, together with detritus, form the bulk of food items consumed by *Liza richardsoni, Liza dumerili* and *Mugil cephalus* (Macnae 1957; Masson & Marais 1975). *Liza tricuspidens,* more dominant in the upper reaches of the Sundays estuary (Marais 1981), feeds mainly on filamentous algae, fibrous matter and bits of larger aquatic plants (Masson & Marais 1975). Plants growing alongside the estuary in the upper reaches were considerably damaged by the flood waters in 1979.

The considerable increase in sea-barbels and spotted grunter one week after the July 1979 flood (Table 1), could probably be accounted for by the presence of large numbers of *Upogebia africana* in the water column. Mud-prawns may be seen swimming around in water of reduced salinity after floods. Many dead animals are also found on the high water mark during such conditions. Table 4 also substantiates the fact that mud-prawns may be present in the water column after floods. Unfortunately no counts were made of animals that accumulated in the inlet channel grids after the July flood. Specimens of *Pomadasys commersonni* caught at Station 1 in the Swartkops estuary had up to 14 mud-prawns in their stomachs. Some sea-catfish consumed up to 40, comprising 9% of their body mass. Van der Westhuizen & Marais (1977) showed that *Upogebia africana* is the most important food item of spotted grunters in Swartkops estuary and Marais (1981) mentions that sea-catfish take mud-prawns regularly, but they have never been found to consume more than 2 – 3 at a time.

Tachysurus feliceps also fed opportunistically on *U. africana* at Stations 2 and 3 in the Sundays estuary after the first flood which probably explains the large numbers caught at Stations 2 (18, Table 2) and 3 (31, Table 3). They consumed mud-prawns comprising up to 10% of their body mass at these stations. *Pomadasys commersonni* did not consume similar numbers of mud-prawns in the Sundays estuary as in the Swartkops estuary.

A similar increase in the number of food items in fish stomachs was not found after the second flood. Only at Station 3 in the Swartkops estuary, where the gill-net was set opposite a sandy beach where *Callianassa kraussi* dominates the macro-benthos, were up to 41 *C. kraussi* (33 g) found in *Pomadasys commersonni* stomachs. The large number of spotted grunters (22) caught there at the time suggests that sand-prawns too were probably more available than normally (Table 3, 28 – 8 – 1979). An analysis of anglers' catch data from the Swartkops estuary by Marais & Baird (1980b) revealed that *P. commersonni* catches showed seasonal peaks during the times of high rainfall whereas lowest numbers were caught during the dryer months. It is suggested that spotted grunters are attracted by increased food availability (most likely during and just after floods) and become available for line catching when the effect of the floods on their prey organisms declines.

The abundance of *Argyrosomus hololepidotus* changed little in the Sundays estuary after the floods, probably because of the absence of mullet, one of its main prey items (Whitfield & Blaber 1978; Marais 1981). On the other hand their numbers increased at Stations 2 and 3 in the Swartkops estuary (Tables 2 & 3) where most mullet were caught, especially after the second flood. Contrary to expectations, no mullet were found in kob stomachs, although some stomachs contained unidentifiable remains of larger fish which could have been mullet. *Gilchristella aestuarius* turned up regularly in kob stomachs in both estuaries, being especially common in kob caught in the Swartkops estuary (Stations 2 and 3) where up to 28 were found in one stomach.

Major floods have a considerable effect on the fish population depending on the severity of the flood, the configuration of the estuary and the extent to which the normal sources of food organisms of the inhabitant fish species are affected. Palmer (1980) found that it took 5½ months before the benthic gastropod *Nassarius kraussianus* recolonized a mud-bank after severe floods in July and August 1979 had annihilated most of the population in the Bushmans estuary. Recolonization depended on environmental recovery, notably *Zostera capensis* regeneration. In the middle and upper regions of the Swartkops and Sundays estuaries it took approximately 5 – 6 months before fish populations returned to 'normal' pre-flood composition (July and August 1979).

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