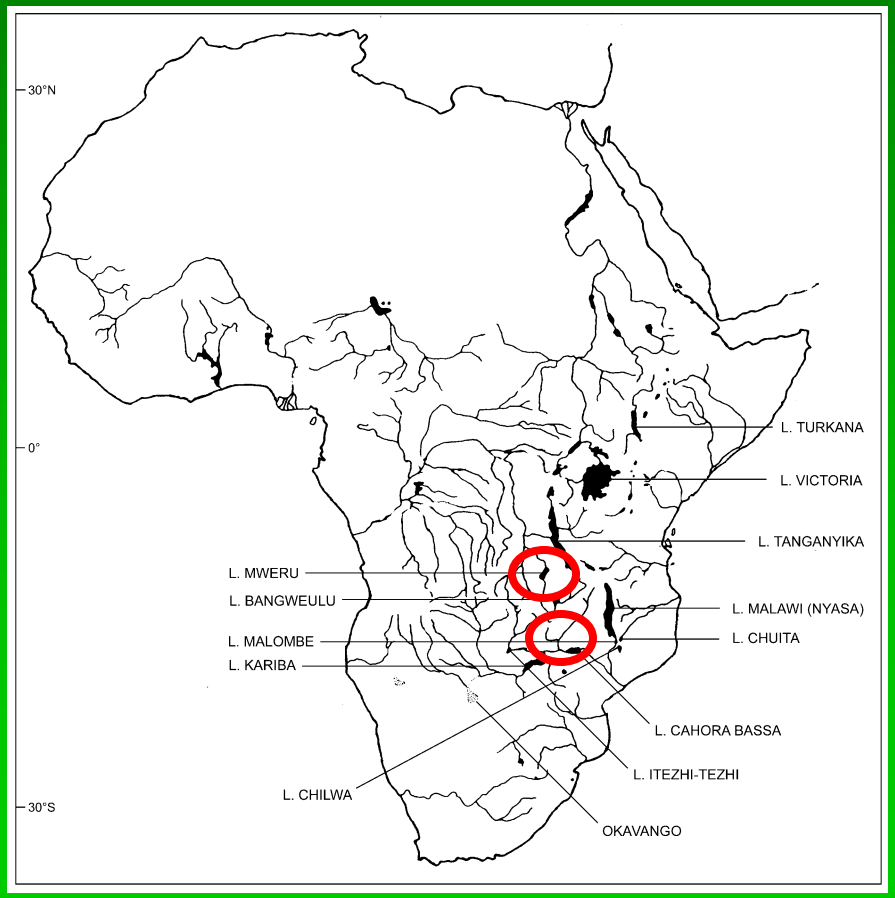
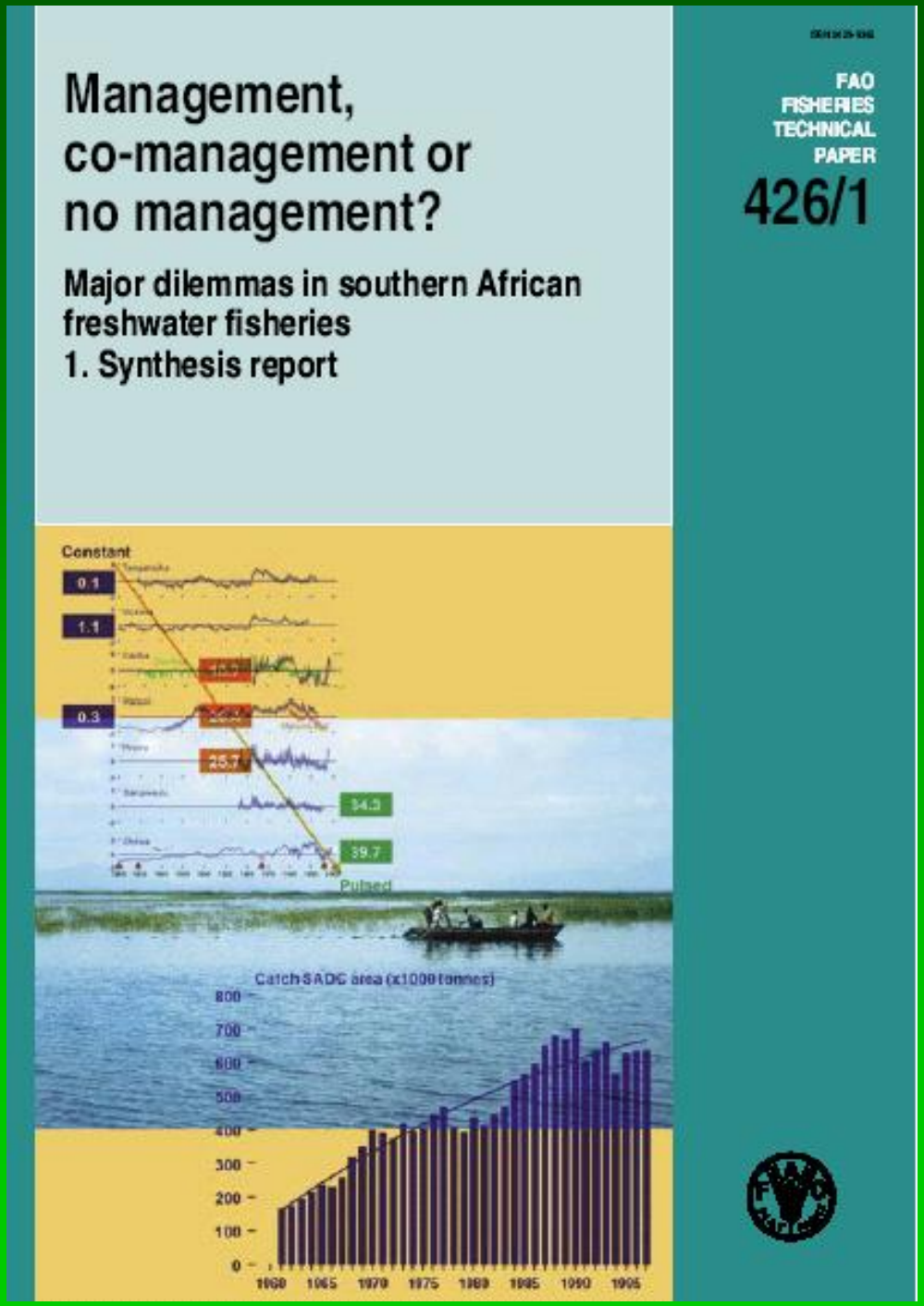
Bangweulu swamps and Lake Kariba

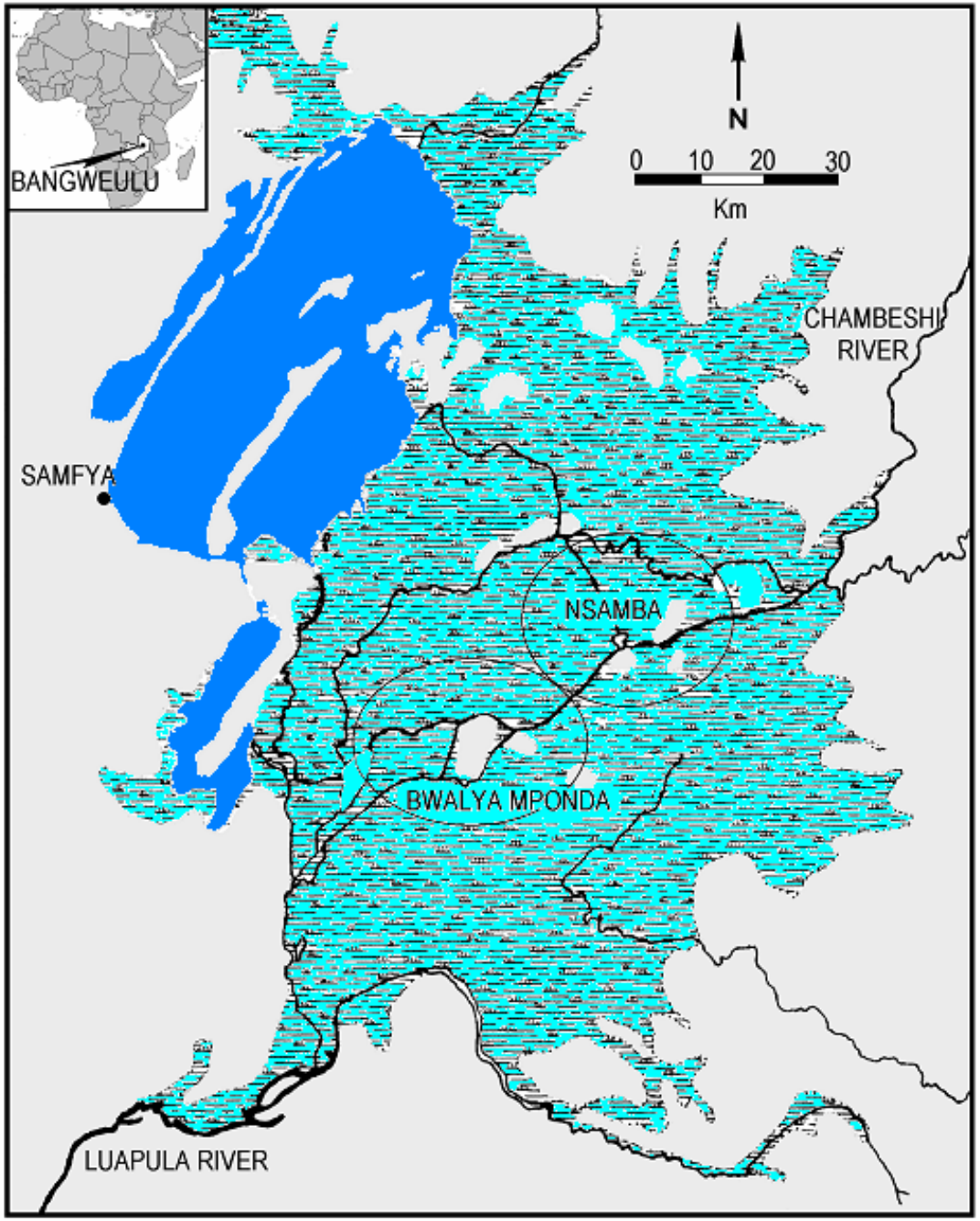




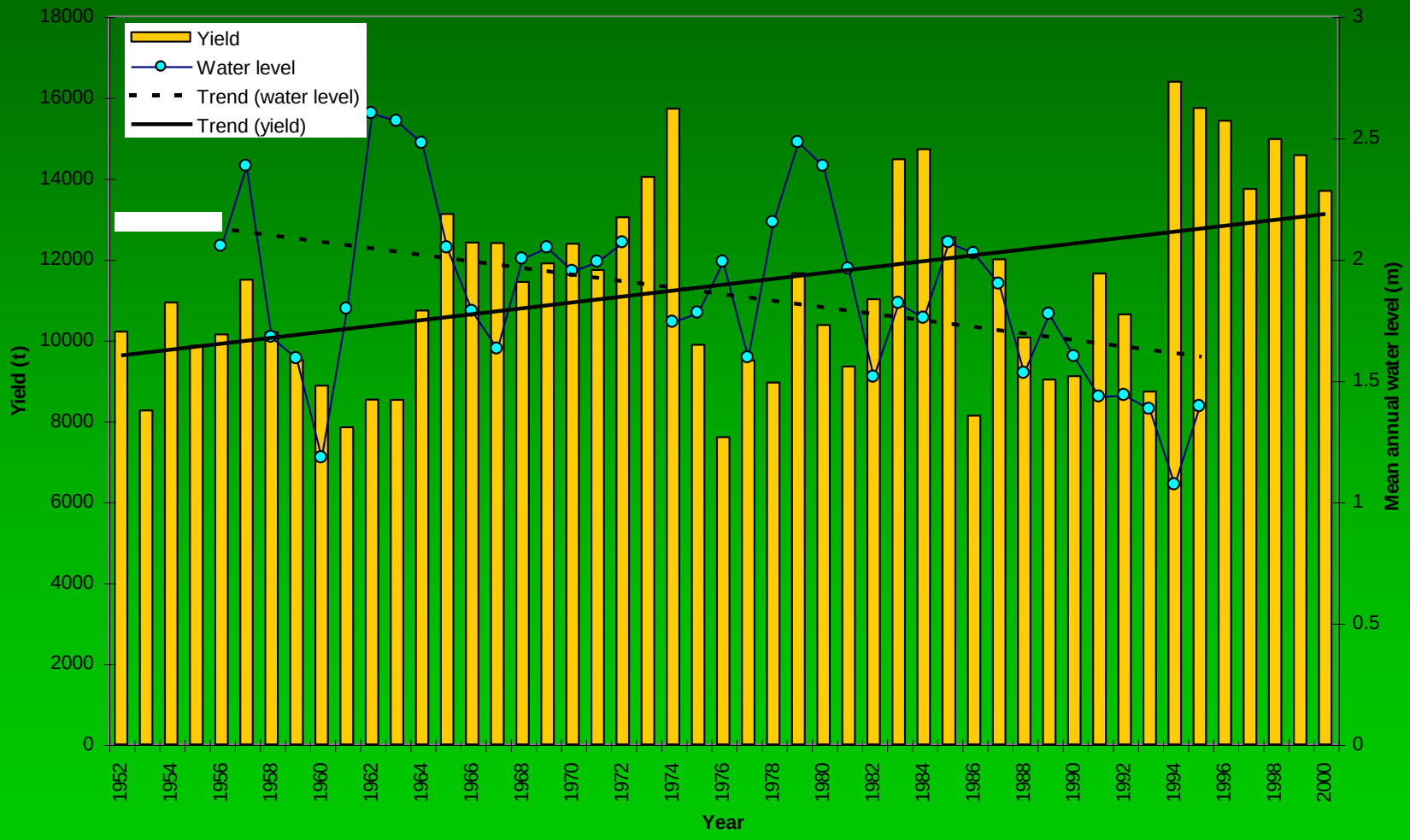
Bangweulu swamps

Where Dr. Livingstone died while crossing

What is the status in this unmanaged fishery..?



Bangweulu swamps



Bangweulu swamps

Fishery considered threatened due to increased fishing pressure and use of illegal fishing methods

TABLE 2. *Recorded effort in the Bangweulu fishery*.

year	#fishermen	# actively involved	#canoes	source
1965	5015		6437	Anon. 1965
1971	5193	13878	5475	Inoue 1971
1973			8739	Bazigos *et al*. 1975
1976		7696	4500	Evans 1978
1992	4800	10240	5900	Ticheler and Chanda 1993

Bangweulu swamps

Regulations currently in place are:

- Mesh size restrictions. In the Bangweulu fishery mesh sizes smaller than 51 mm (2”) stretched mesh are prohibited.
- A closed fishing season from the first of December to the first of March. It is not allowed to fish in this period and transport of fish is prohibited as well.
- Fishing gear and method restrictions. All forms of active fishing are prohibited, this includes the popular kutumpula fishing and seine netting. Although not explicitly mentioned in the fisheries act, fishing weirs are generally regarded as illegal gears as well.
- Industrial fishing is not allowed in the Bangweulu fishery.

Getting the data

Exercise books

Measuring board

Fishing gear

Materials and methods

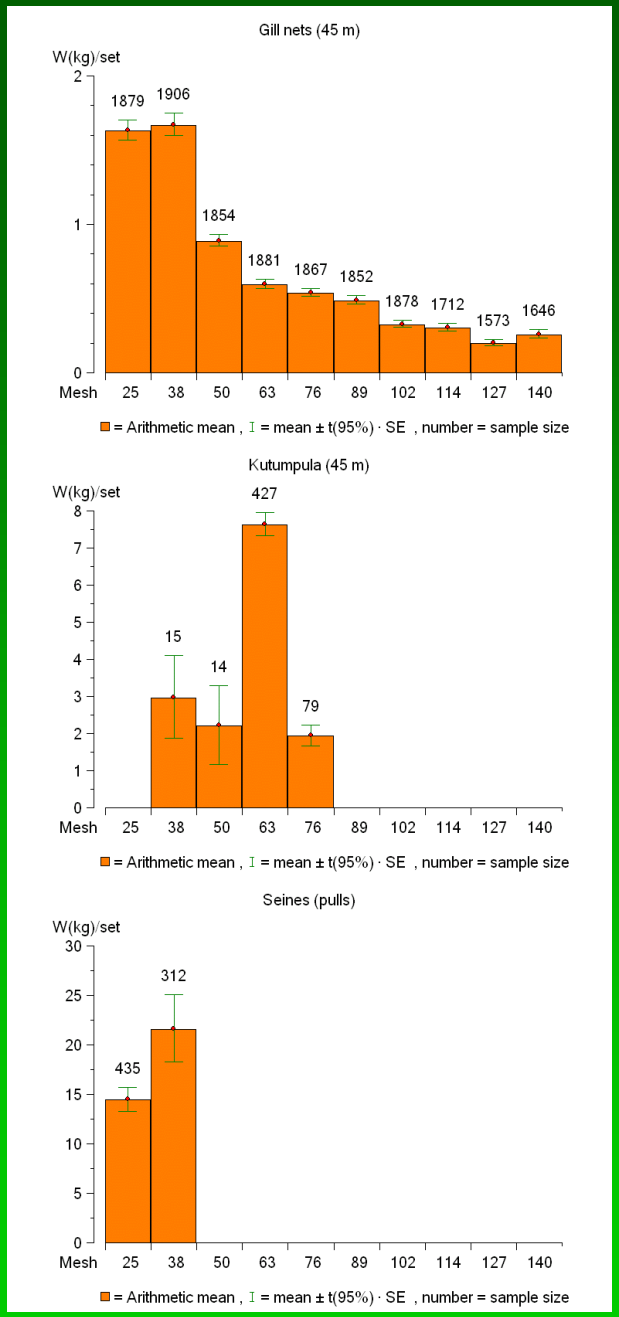
- Growth, mortality
- Length based VPA
- Long-term Thompson and Bell analysis

TABLE 3. *The number of individual fish records and fish species collected in different fishing gears between July 1994 and July 1996 (except the Lundgren nets, which covers the period June 1995 to July 1996). Local fishermen collected all data except DoF experimental gillnets.*

Gear/method	No. of records	No. of species
DoF experimental gillnets	16,528	37
Experimental gillnets	264,589	37
Lundgren nets	102,602	36
Artisanal gillnets	233,717	34
Seine fishery	290,736	34
Kutumpula fishery	37,810	21
	945,982	

Fishing gear by type and mesh size (from frame surveys)

Mesh size (mm)	Total number of gear by type			
	gillnets	kutumpula	seines	weir traps
3				3 869
4				8 358
6				2 322
8				387
10				
25	534	17	53	
38	6 719	68	178	
50	4 233	135	49	
63	1 260	643		
76	554	74		
89	136	-		
102	-	-		
114	-			
127	255			
140	-			
Total:	13 691	937	280	14 936
%	46	3	1	50
% legal	22			



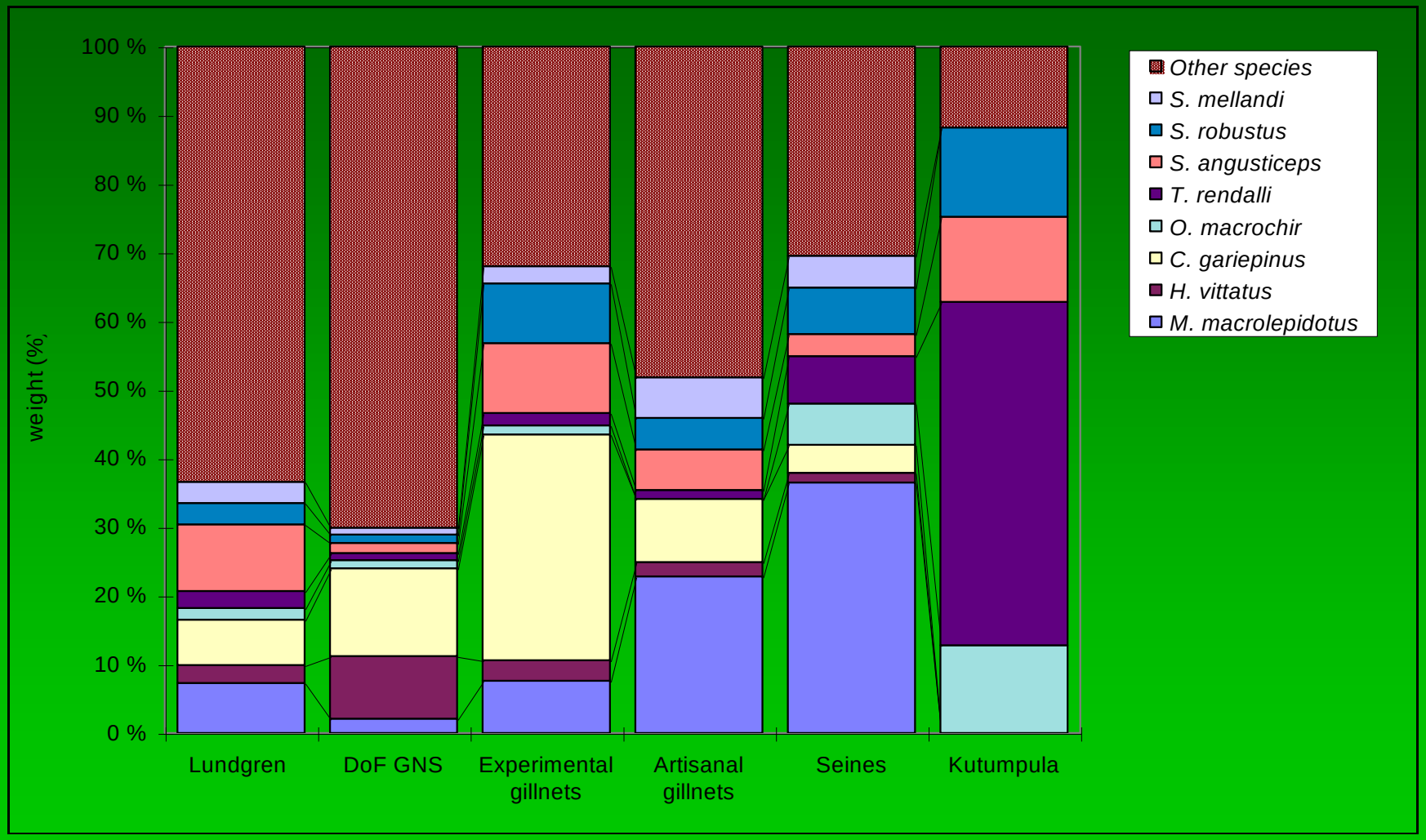
Catch rates and fishing pattern – effort tuned to CPUE !!

	Relative distribution of effort and catch rates					
Mesh (mm)	gillnets		kutumpula		seines	
	effort%	CPUE%	effort%	CPUE%	effort%	CPUE%
3						
4						
6						
8						
10						
25	4	24	2		19	40
38	49	24	7	20	64	60
50	31	13	14	15	18	-
63	9	9	69	52		
76	4	8	8	13		
89	1	7				
102		5				
114		4				
127	2	3				
140		4				
Total:	100	100	100	100	100	100
% of all	46	12	3	26	1	62
% legal	22	6				

Catch composition

	GNS	FDC			Lundgren
	Experimental	Artisanal	Kutumpula	Seines	
Number of settings	1694	18037	1473	527	739	12076
Alestes macrophthalmus G.	19.7					2.8
Schilbe mystus L.	14.6	12.1	10.9		1.3	21.4
Barbus aff. unitaeniatus G.	10.6	1.9			1.3	5.3
Barbus paludinosis P.	9.3	4.1	10.3			8.0
Petrocephalus catostoma D.	7.9	18.8	24.0		8.2	17.3
Tilapia sparrmanii S.	5.8	19.1	24.1	4.5	5.6	7.1
Marcusenius macrolepidotus P.	4.1	13.8	17.1		48.2	4.1
Hydrocynus vittatus C.	3.5					
Serranochromis mellandi B.	2.3	3.5	4.3	2.4	6.7	1.2
Tylochromis bangwelensis R.	1.9			7.2	1.1	
Hippopotamyrus discorhynchus P.	1.8	1.4	1.8		13.5	1.7
Auchenoglanis occidentalis V.	1.7					
Clarias gariepinus B.	1.2	4.5				
Barbus trimaculatus P.		5.5				12.9
Serranochromis angusticeps B.		4.9	2.3	12.6	1.9	1.4
Synodontis nigromaculatus B.		1.7				1.0
Serranochromis robustus B.		1.6		9.6		
Ctenopoma multispinis P.		1.3				1.0
Tilapia rendalli B.				48.4	3.0	
Oreochromis macrochir B.				10.8	2.1	
Serranochromis macrocephalus B.				3.2		
Marcusenius monteiri G.					2.9	
Other species	15.6	5.8	5.2	1.3	4.2	14.8
Number of species contributing >1%	13	14	8	8	12	13

Catch composition



Length-Based Thompson and Bell Analysis

Species (length interval)	L_∞ (cm)	W_∞(g)	K	φ'	R_n	Z	CI_{Z1}	M	F	E
M. macrolepidotus	25.5	179.4	1.11	6.58	0.148	3.73	1.95-1.66	1.86	1.87	0.51
H. vittatus (2cm)	58.0	3268.3	0.53	7.49	0.120	2.55	2.76-2.35	0.90	1.65	0.65
H. vittatus (2cm)*	78.0	8389.5	0.34	7.63	0.127	2.76	3.01-2.50	0.62	2.13	0.77
C. gariepinus (2cm)	67.5	2290.4	0.51	7.75	0.089	1.40	1.50-1.30	0.85	0.55	0.40
O. macrochir (2cm)	31.6	687.3	1.00	6.90	0.181	2.74	3.65-1.83	1.62	1.12	0.41
T. rendalli (2cm)	35.5	760.1	0.85	6.98	0.134	2.72	3.37-2.07	1.41	1.31	0.48
S. angusticeps	36.5	661.9	0.65	6.76	0.107	1.81	1.95-1.66	1.18	0.63	0.35
S. robustus (2cm)	57.0	2898.6	0.51	7.41	0.110	1.76	1.99-1.53	0.89	0.87	0.49
S. mellandi†	26.0	267.8	0.78	6.27	0.151	2.12‡		1.44	0.68	0.32
Parameter values below were estimated data obtained with experimental, monofilament Lundgren nets										
B. paludinosis	11.45	16.8	1.40	5.21	0.218	2.58	3.22-1.93	2.69	M>Z	
B. trimaculatus	10.53	13.5	1.40	5.04	0.306	2.37	5.89-1.16	2.57	M>Z	
M. macrolepidotus	21.9	114.2	0.85	6.01	0.125	2.53	2.86-2.20	1.62	0.91	0.36
P. catostoma	9.2	8.9	1.46	4.82	0.745	3.06	4.83-1.28	2.75	0.31	0.01
S. mystus	15.0	34.9	1.29	5.67	0.193	2.51	2.79-2.23	2.36	0.15	0.06
T. sparrmanii	13.95	47.4	1.35	5.57	0.179	2.97	3.88-2.04	2.48	0.49	0.16

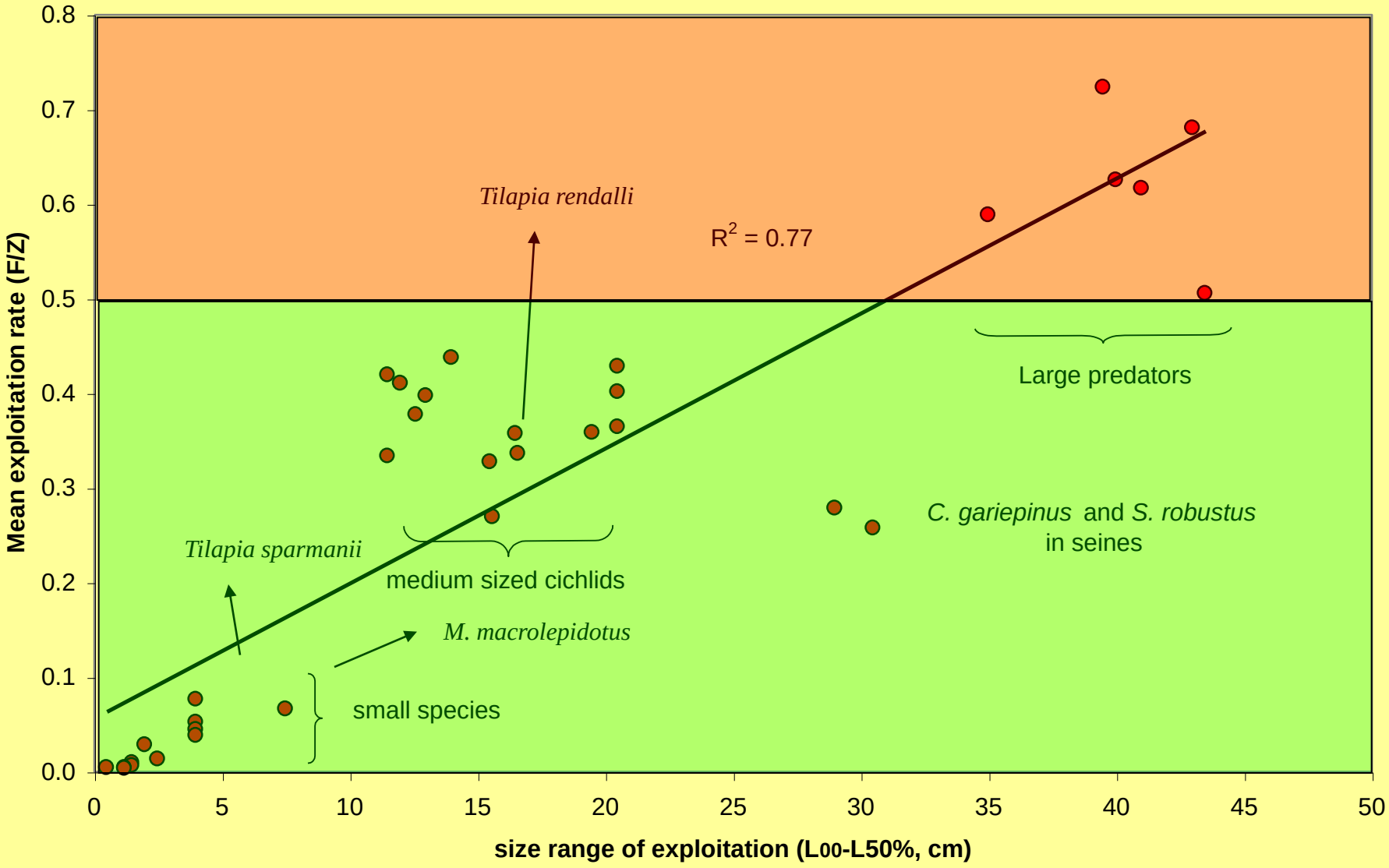
Long term T&B prediction

Species	Gear type	LM (cm)	L50% Catch	L∞-L50%	E mean	F mean	effort factor	Present Yield	MSY (tonnes)	MSY-Yield	Rank yield
C. gariepinus	seines	37	37	30.5	0.257	0.295	1.8	26.4	26.6	0.2	16
	gillnets	23	24	43.5	**0.505**	0.869	0.8	134.6	138.9	4.3	5
	kutumpula	27	28	39.5	**0.720**	2.189	0.6	6.9	7.4	0.5	
H. vittatus	gillnets	17	17	41.0	**0.616**	1.442	0.8	17.7	18.4	0.7	22
	seines	15	15	43.0	**0.680**	1.197	0.4	8.6	11.5	2.9	
S. robustus	seines	17	28	29.0	0.278	0.342	1.0	33.3	32.9	-0.4	14
	kutumpula	22	22	35.0	**0.588**	1.270	0.6	112.3	119.4	7.1	8
	gillnets	17	17	40.0	**0.625**	1.481	0.4	30.0	39.5	9.5	15
S. angusticeps	kutumpula	20	21	15.5	0.327	0.573	1.2	112.6	110.9	-1.7	7
	seines	17	17	19.5	0.358	0.659	1.6	23.9	24.7	0.8	19
	gillnets	16	16	20.5	0.364	0.675	1.0	112.7	112.2	-0.5	6
T. rendalli	**kutumpula**	18	19	16.5	0.357	0.784	1.2	423.1	429.2	6.1	**2**
	gillnets	15	15	20.5	0.401	0.942	1.0	8.0	8.0	0.0	
	seines	14	15	20.5	0.428	1.057	0.8	56.3	57.4	1.1	11
O. macrochir	seines	16	16	15.6	0.269	0.269	2.2	49.3	54.2	4.9	13
	gillnets	15	15	16.6	0.336	0.818	1.2	3.5	3.6	0.1	
	kutumpula	20	19	12.6	0.377	0.979	1.8	109.1	110.8	1.7	9
S. mellandi	gillnets	12	13	13.0	0.397	0.949	0.8	77.9	77.4	-0.5	10
	kutumpula	14	14	12.0	0.410	1.000	1.4	18.8	18.5	-0.3	21
	seines	12	12	14.0	0.437	1.117	0.6	26.2	26.6	0.4	17
M. macrolepidotus	kutumpula	18	18	7.5	0.066	0.131	>4	11.0	undef		24
	gillnets	14	14	11.5	0.333	0.931	1.6	259.0	272.1	13.1	4
	seines	14	14	11.5	0.419	1.344	1.0	456.5	450.7	-5.8	**1**
S. mystus	gillnets	14	13	2.0	0.028	0.067	>4	54.7	undef		12
	seines	11	11	4.0	0.076	0.195	>4	3.3	undef		
T. sparrmanii	**gillnets**	10	10	4.0	0.038	0.099	>4	263.1	undef		**3**
	seines	10	10	4.0	0.044	0.114	>4	23.0	undef		20
	kutumpula	10	10	4.0	0.052	0.135	>4	25.6	undef		18
B. paludinosis	seines	10	10	1.5	0.006	0.017	>4	0.8	undef		
	gillnets	9	9	2.5	0.013	0.036	>4	3.2	undef		
B. trimaculatus	seines	10	10	0.5	0.004	0.010	>4	0.9	undef		
	gillnets	9	9	1.5	0.009	0.023	>4	3.5	undef		
P. catastoma	seines	8	8	1.2	0.003	0.010	>4	15.4	undef		23
	gillnets	8	8	1.2	0.004	0.010	>4	9.4	undef		
							Total	2520.6		44.2	

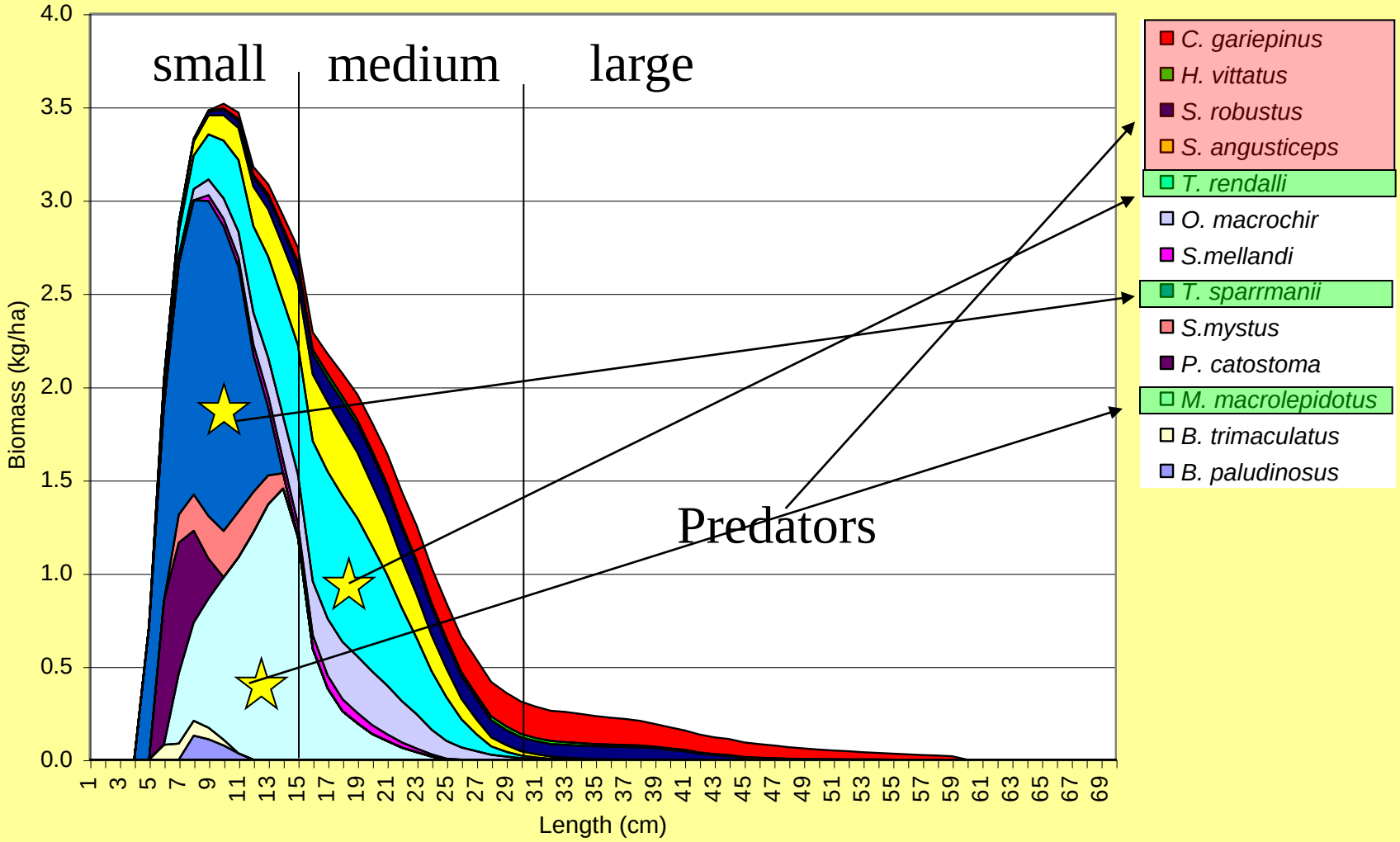
Present yield in the Bangweulu swamps is dominated by three species:

1. the small *Marcusenius macrolepidotus* (which is caught in the large quantity of some 700 tonnes per year in both seines and small meshed gillnets)
2. the medium sized *Tilapia rendalli* (420 tonnes in kutumpula), and
3. the small *Tilapia sparmanii* making up around 260 tonnes in the gillnets.

Exploitation rate and size



Biomass-size distribution



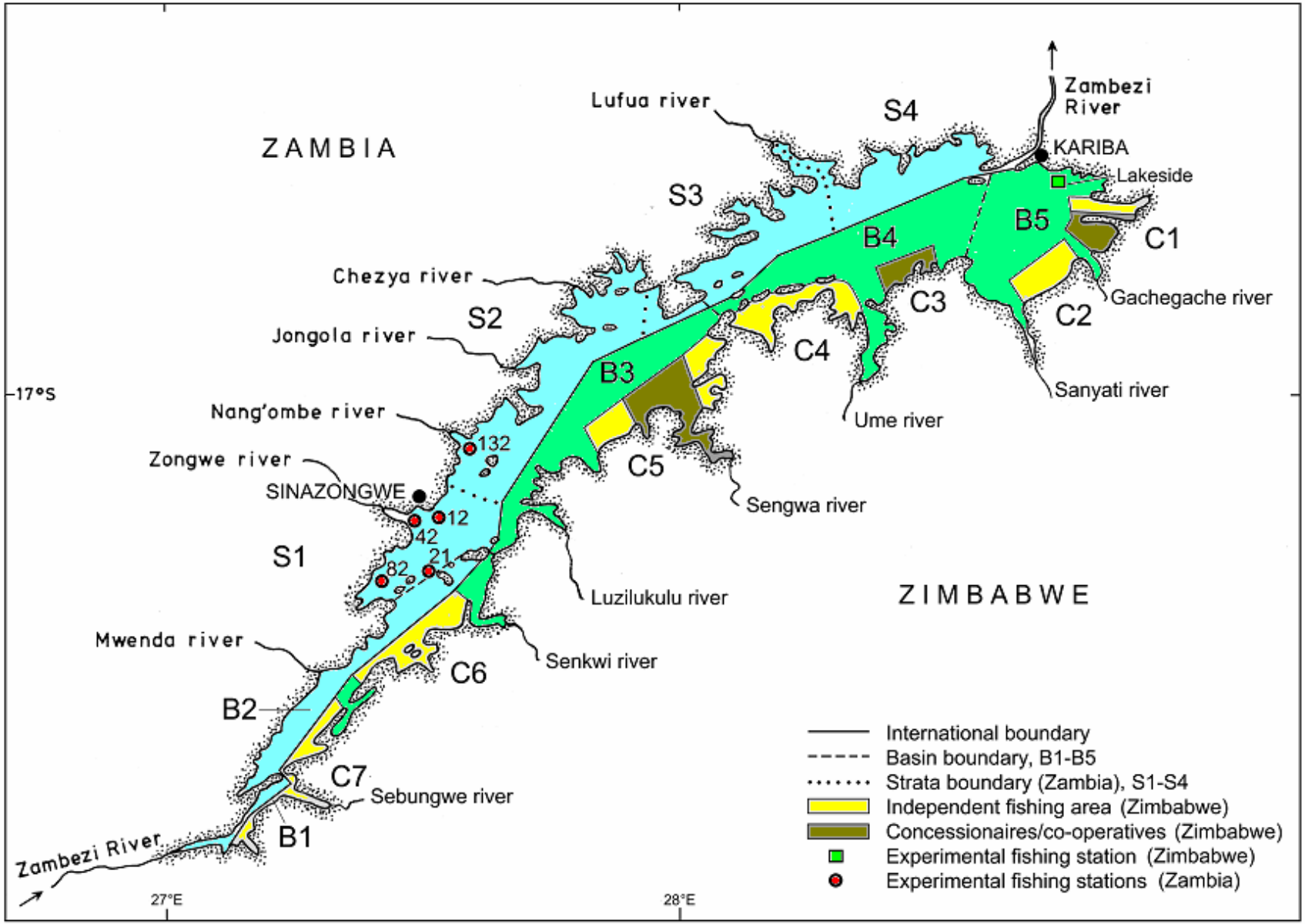
Multi-species multi gear analysis

Species/gear Combination	Yield (tonnes)	E-mean	F-mean	Z (F/E)	effort factor	MSY (tonnes)	Diff %
All gears by species							
M. macrolepidotus	726.5	0.355	1.021	2.876	1.6	743.7	2.4
T. rendalli	487.4	0.214	0.383	1.790	2.0	519.3	6.5
S. angusticeps	249.2	0.307	0.522	1.700	1.2	247.1	-0.8
S. robustus	175.6	0.484	0.834	1.723	0.4	198.3	12.0
C. gariepinus	167.9	0.480	0.786	1.638	0.8	171.7	2.3
O. macrochir	161.9	0.228	0.478	2.096	2.0	173.6	7.2
S. mellandi	122.9	0.163	0.483	2.960	>3.0	>165.8	>34.9
H. vittatus	26.3	0.633	1.553	2.453	0.6	30.1	15.3
All species by gear							
Kutumpula	793.8				1.0	796.1	0.3
Seines	680.5				>3.0	>754.8	>10.9
Gillnets	643.4				1.2	661.6	2.8
All species							
All gears	2117.7				1.3	2158.9	1.9

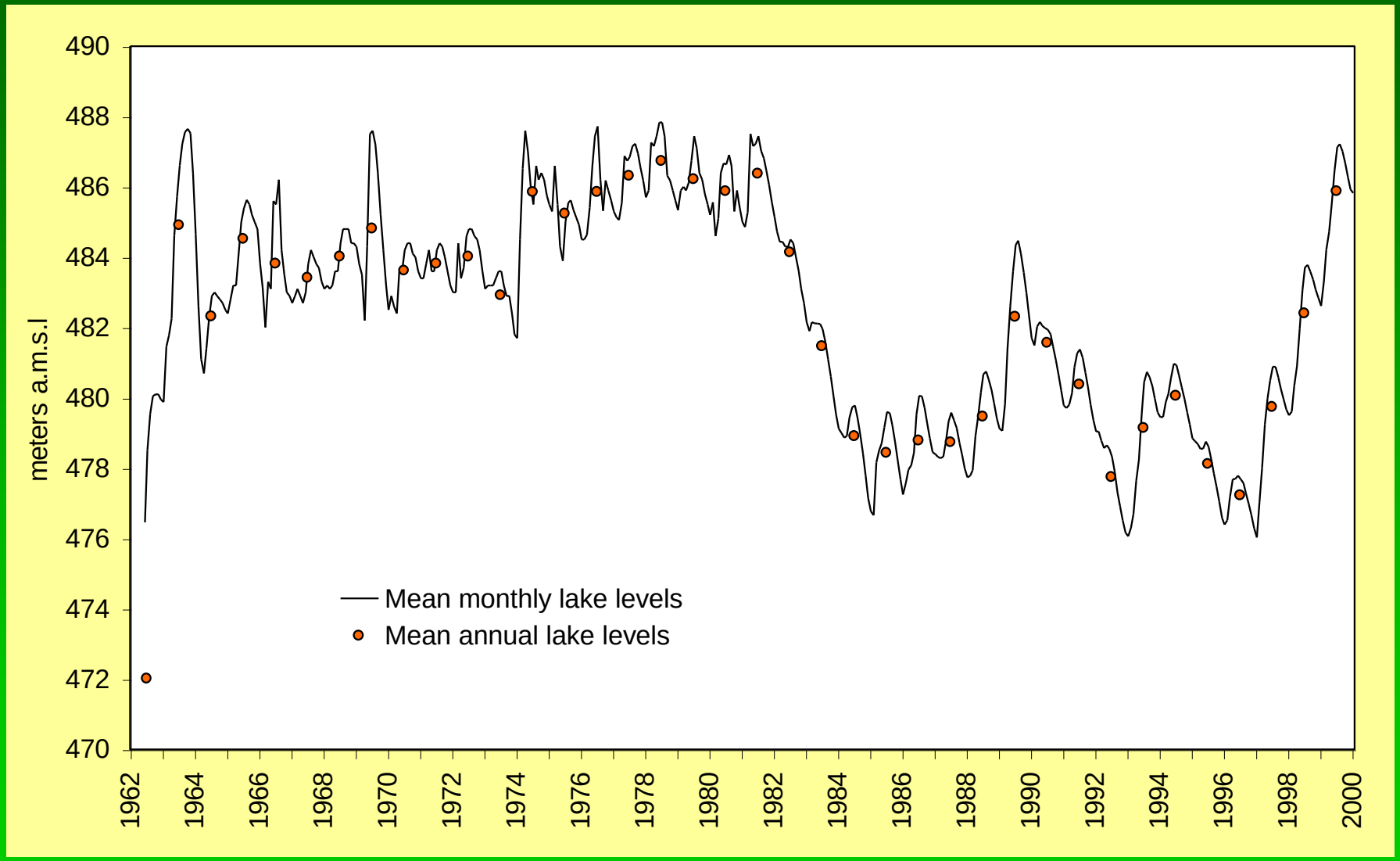
Conclusions

- Fishery optimized – present yield very close to long term MSY.
- No overfishing on most stocks except a few top predators which contribute marginally to yield.
- If present management regulations were enforced yield would decrease by 80%
- Enforcing present management regulations would also increase pressure on large predators.
- All management regulations are based on unverified assumptions.

Lake Kariba


ZAMBIA
ZIMBABWE
Lufua river
S4
Zambezi River
KARIBA
Lakeside
S3
B5
B4
C1
Chezya river
C3
C2
Gachegache river
S2
Jongola river
C4
B3
17°S
Sanyati river
Ume river
Nang'ombe river
132
Zongwe river
C5
SINAZONGWE
Sengwa river
12
42
S1
82
21
Luzilukulu river
Mwenda river
Senkwi river
C6
B2
C7
Sebungwe river
B1
Zambezi River
27°E
28°E
International boundary
Basin boundary, B1-B5
Strata boundary (Zambia), S1-S4
Independent fishing area (Zimbabwe)
Concessionaires/co-operatives (Zimbabwe)
Experimental fishing station (Zimbabwe)
Experimental fishing stations (Zambia)

Lake Kariba: Man-made fluctuating environment



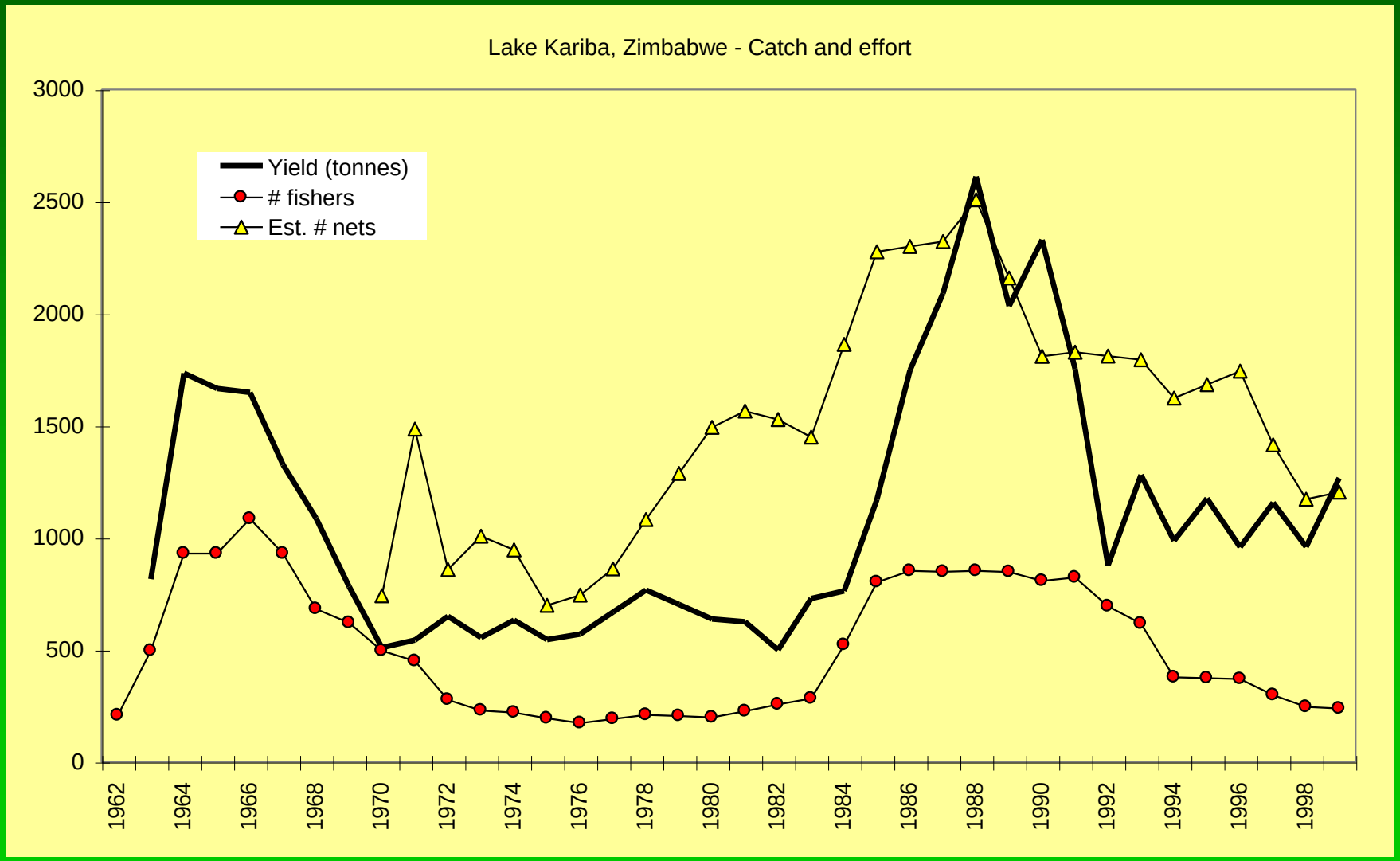
Objective:

Compare the results after 40 years of two very different management regimes in the same ecosystem

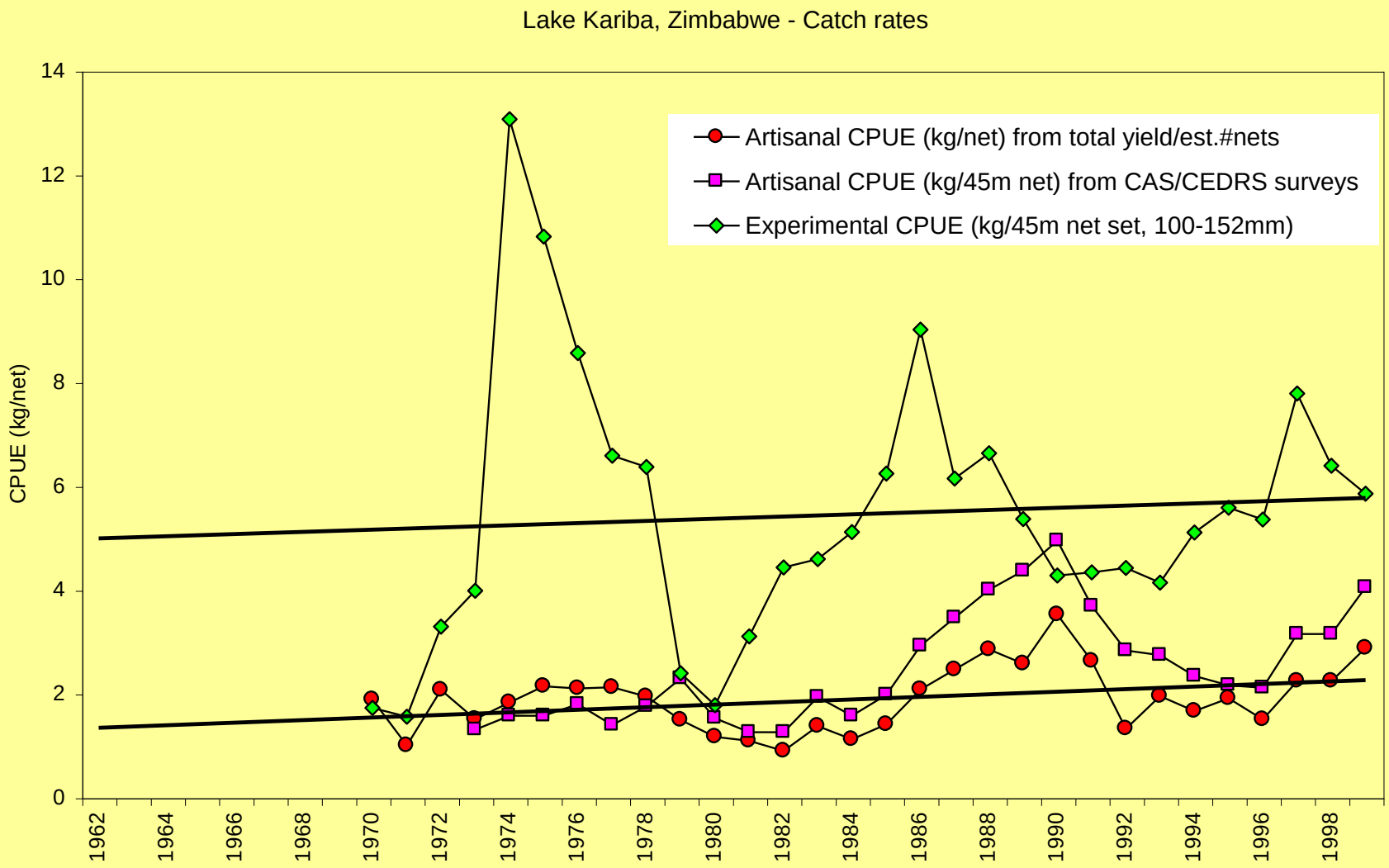
Zambian side = open access and regulations not enforced

Zimbabwean side = strict control and enforcement

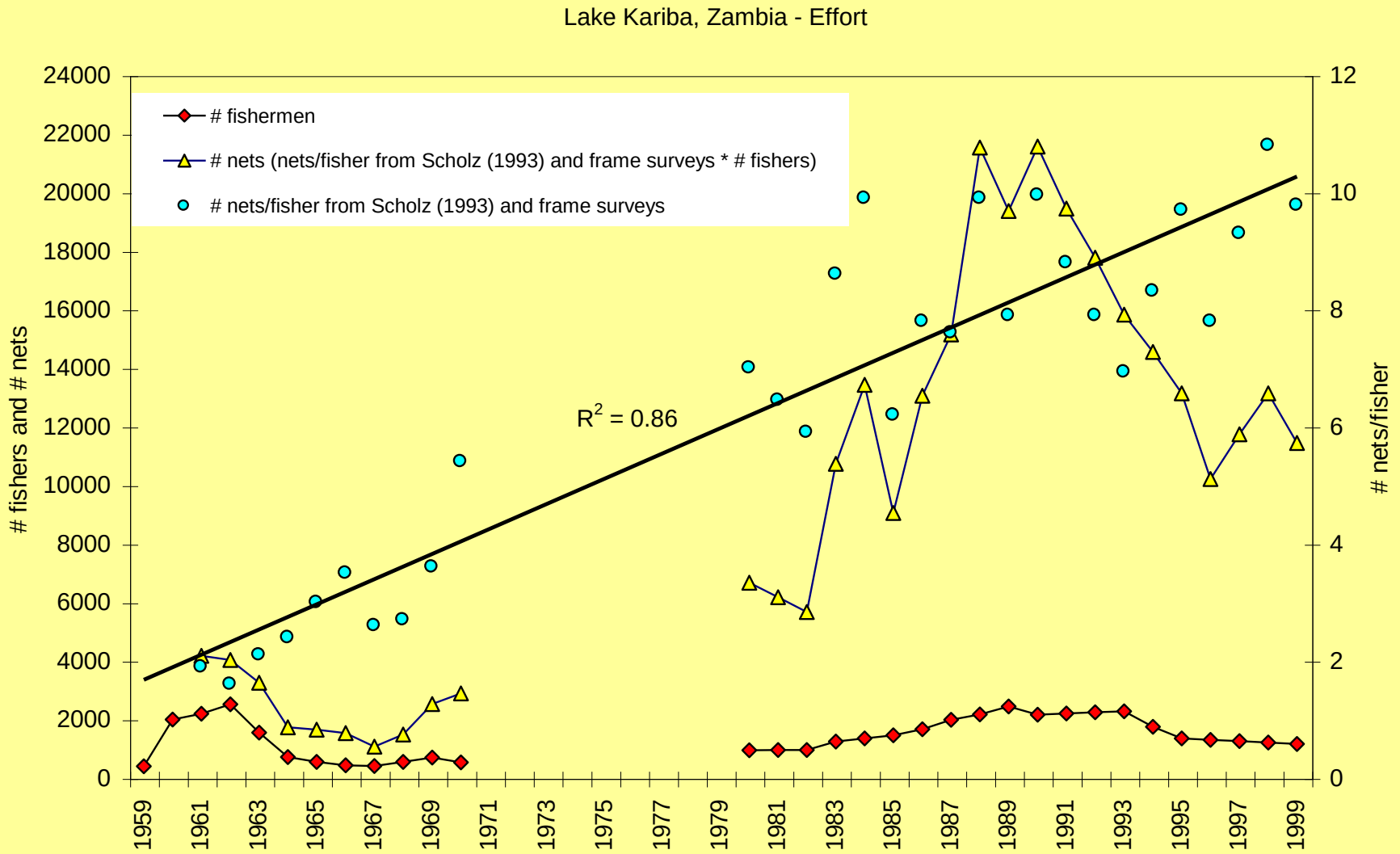
Catch and effort - Zimbabwe



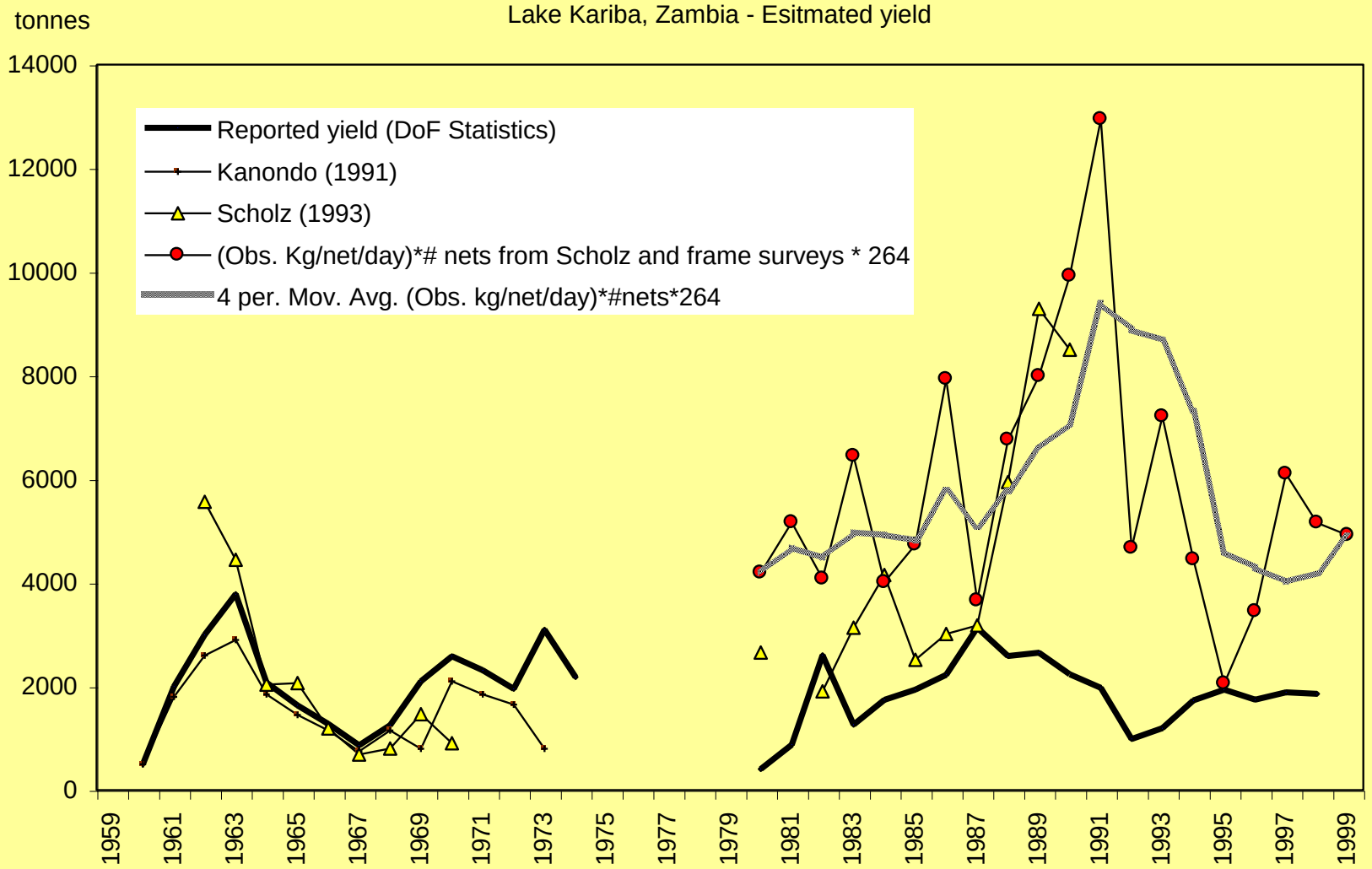
Catch rates - Zimbabwe



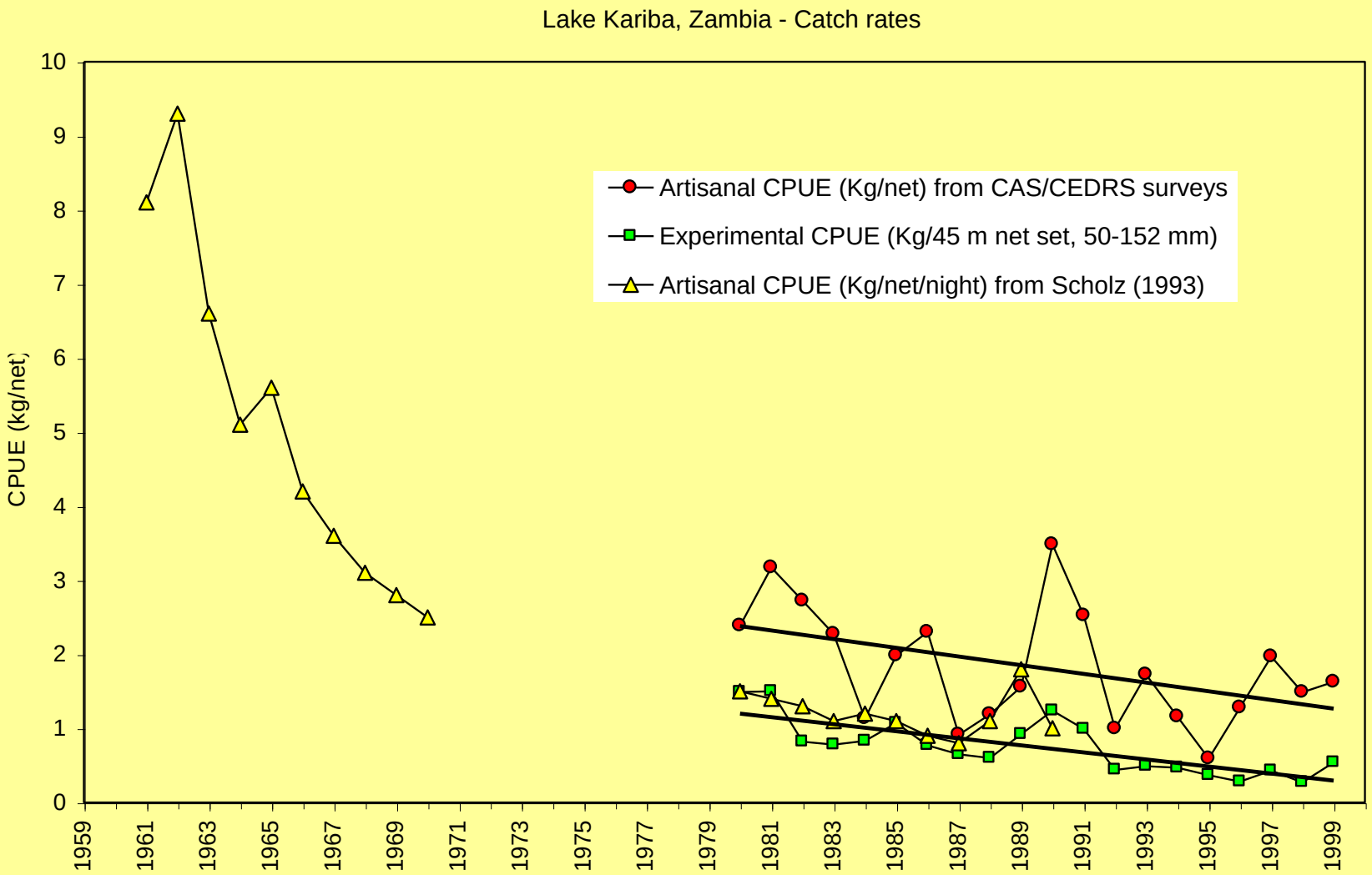
Effort - Zambia



Catch - Zambia

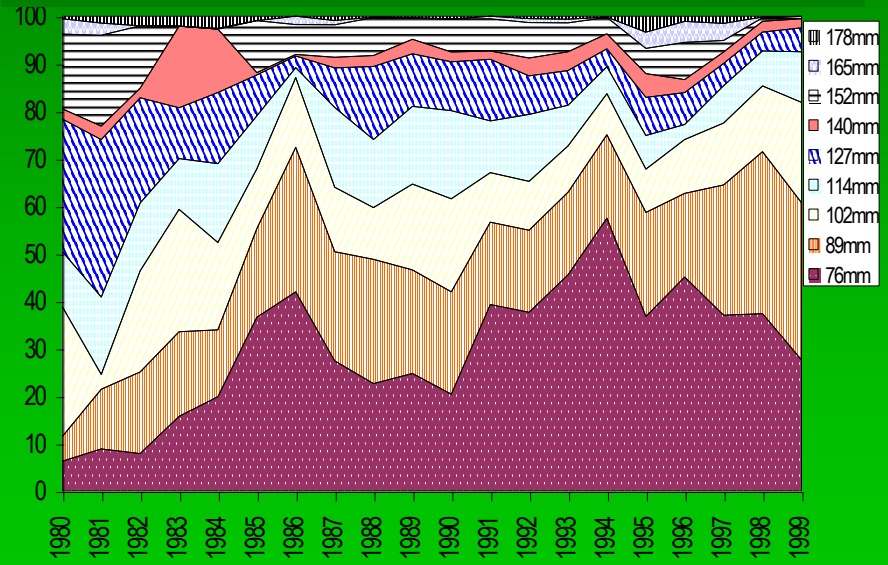


Catch rates - Zambia

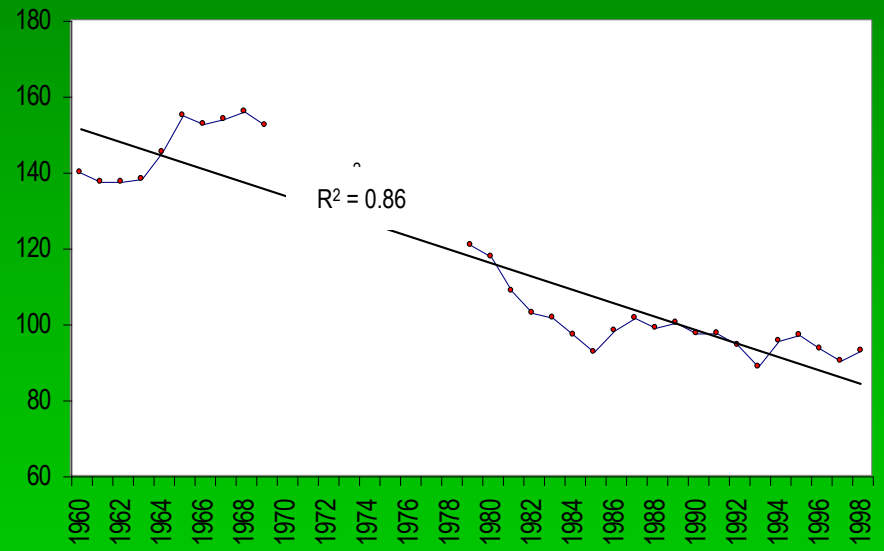


Changes in fishing pattern - Zambia

Relative mesh size distribution

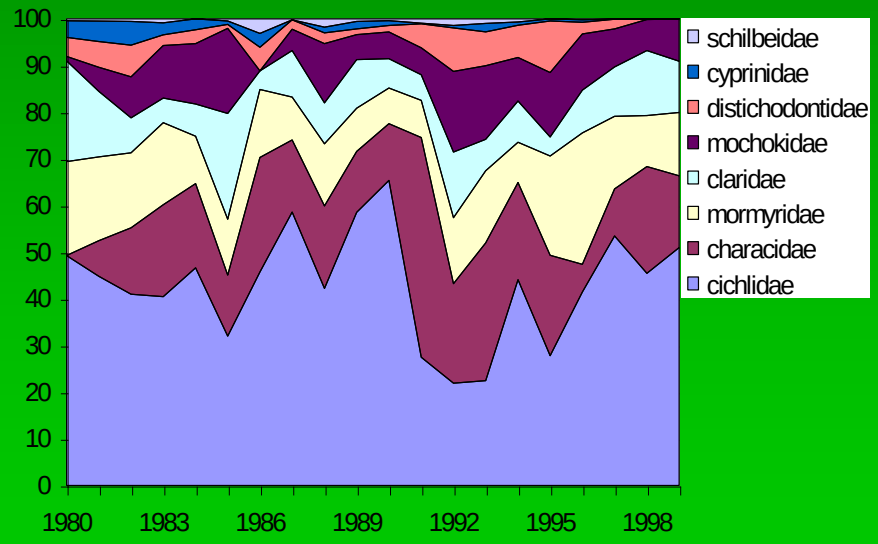


Average mesh size

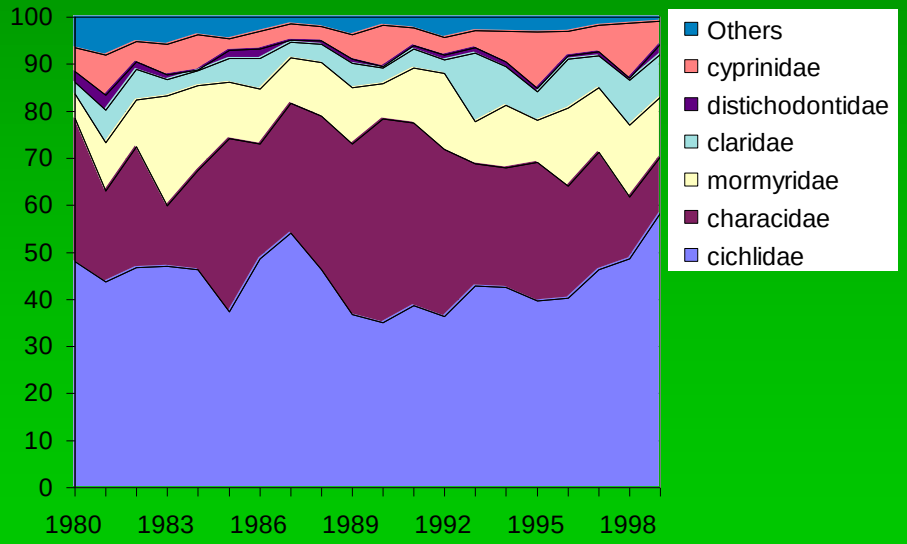


Catch composition

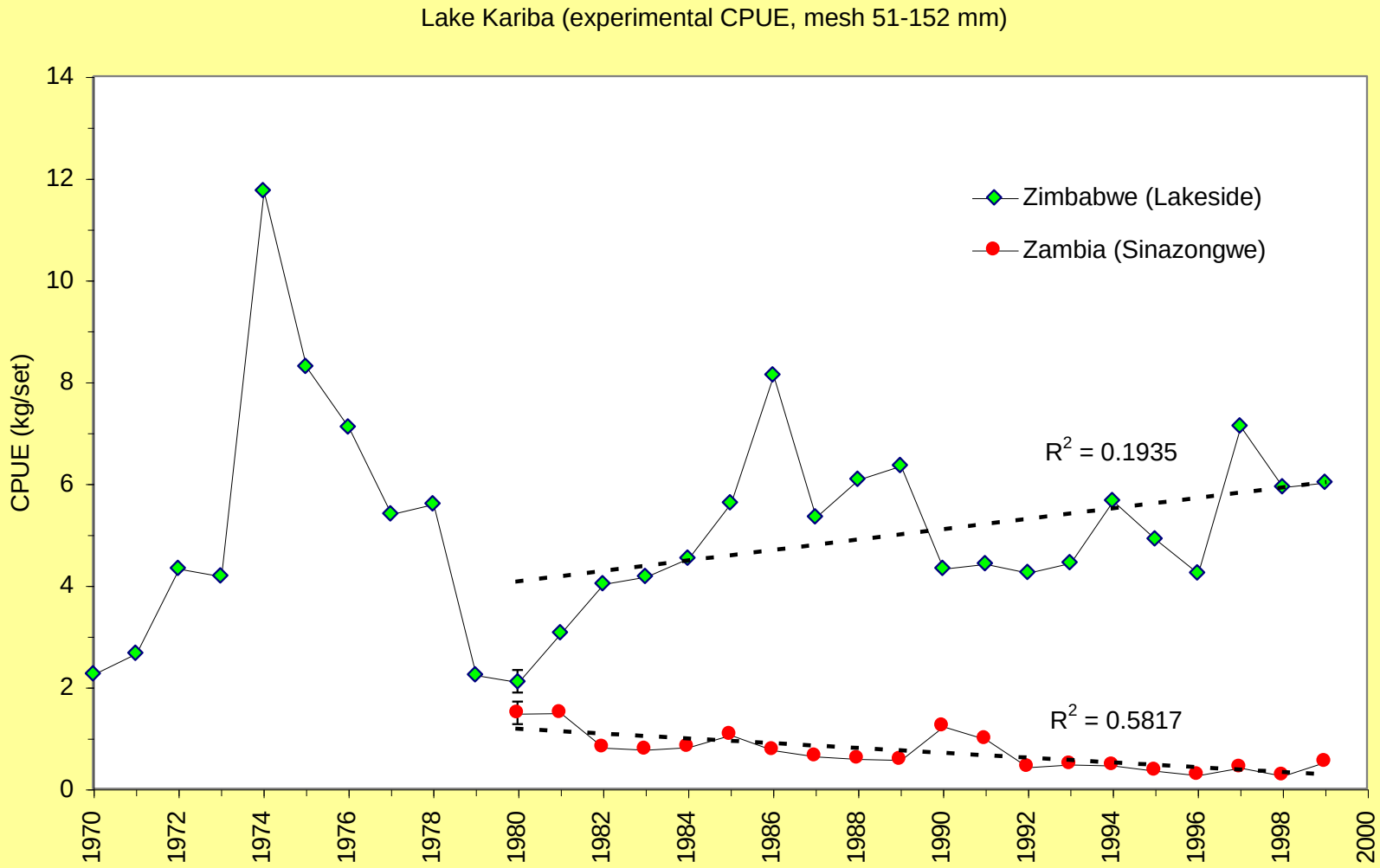
Zambia



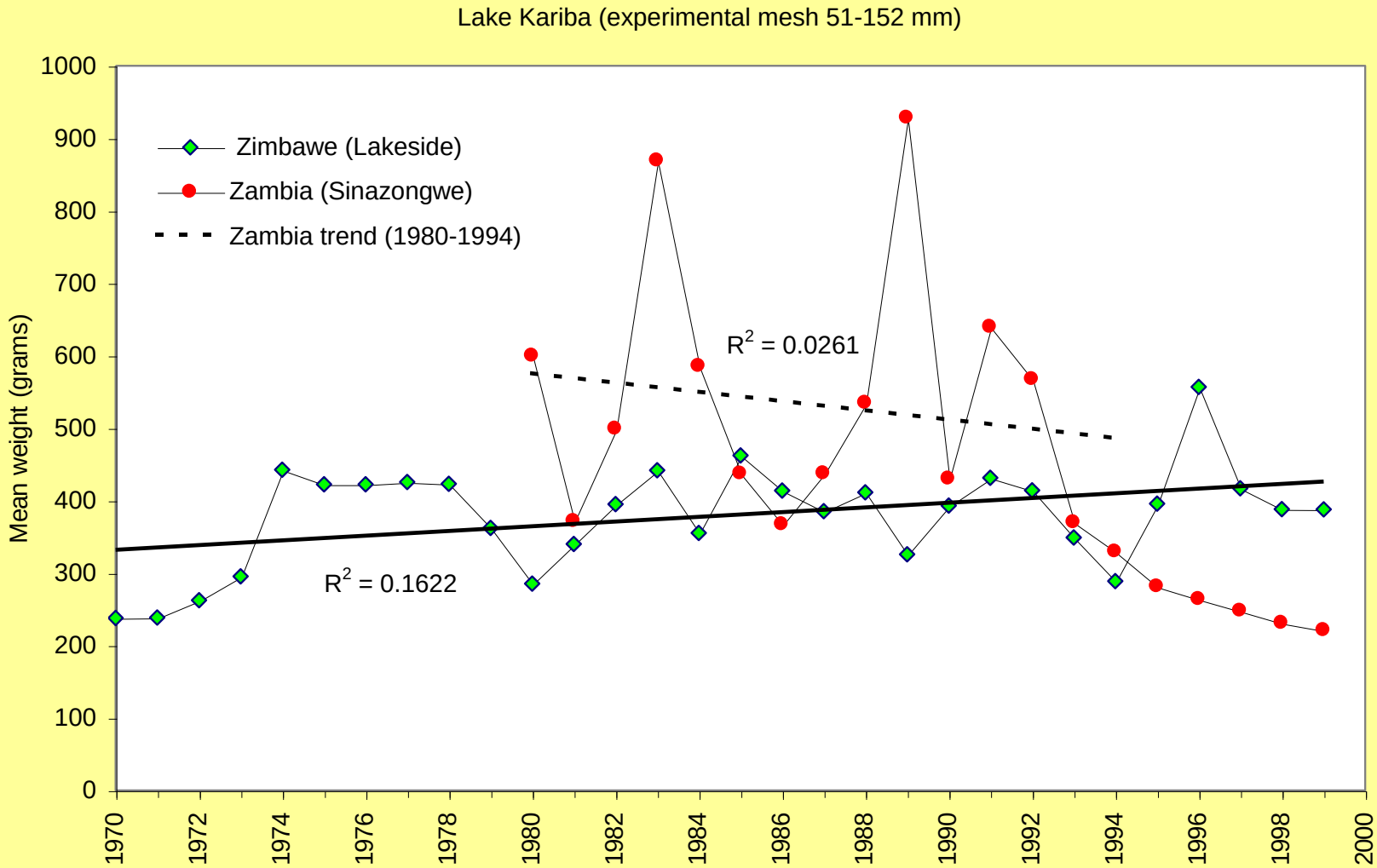
Zimbabwe



Experimental catch rates - Zambia and Zimbabwe



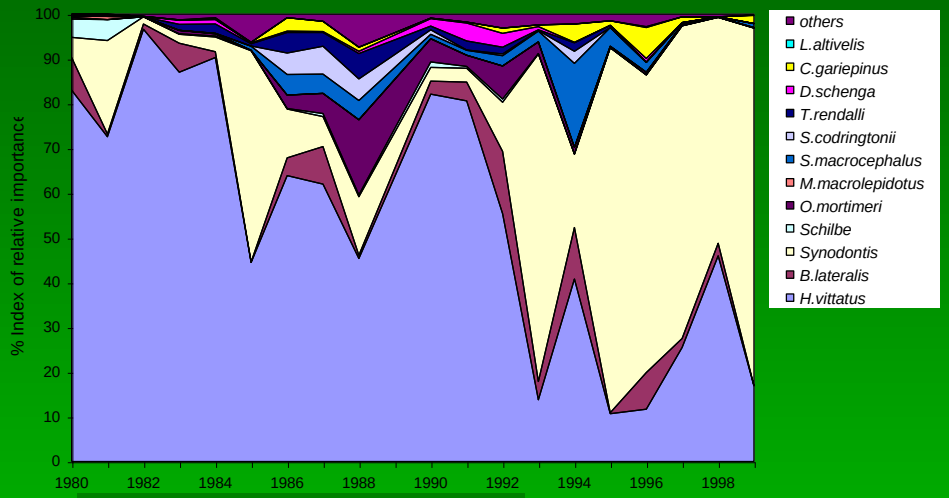
Experimental catches: mean weight - Zambia and Zimbabwe



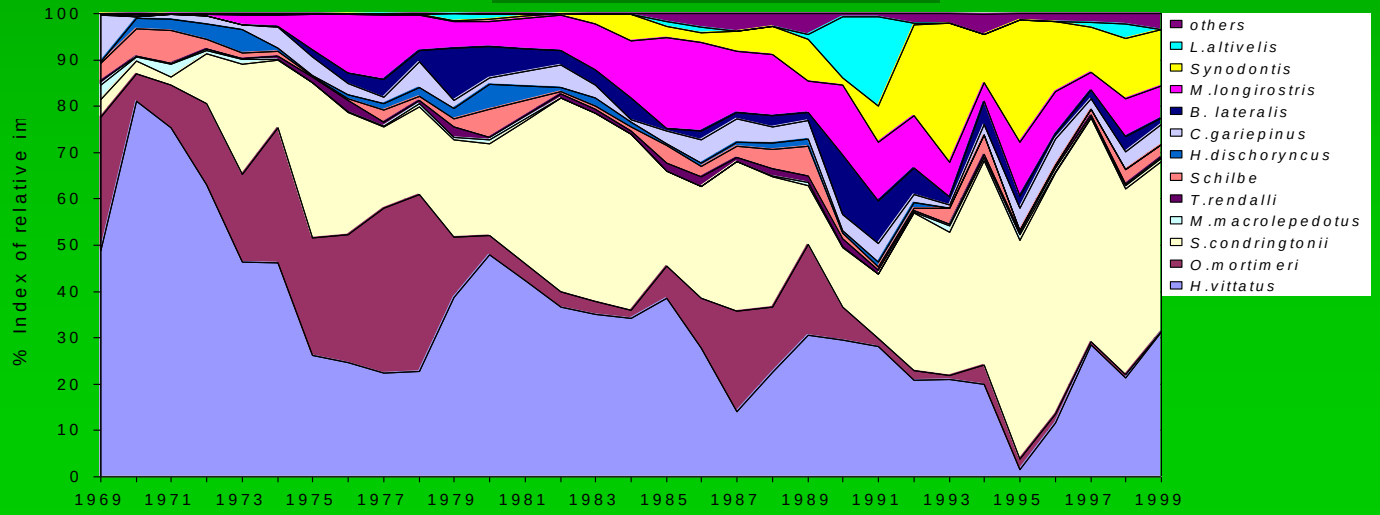
Species changes:

Natural Succession: Index of relative importance (%IRI)

Zambia

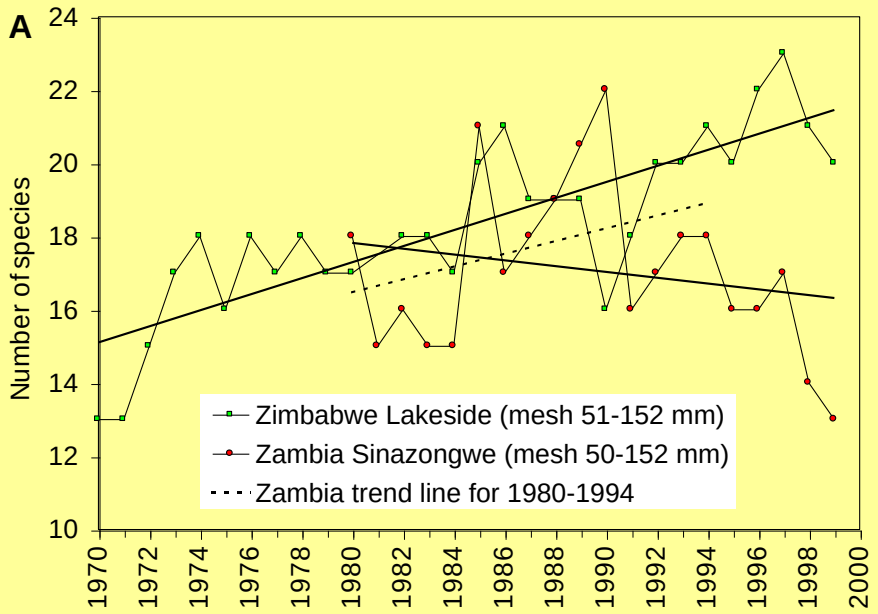


Zimbabwe

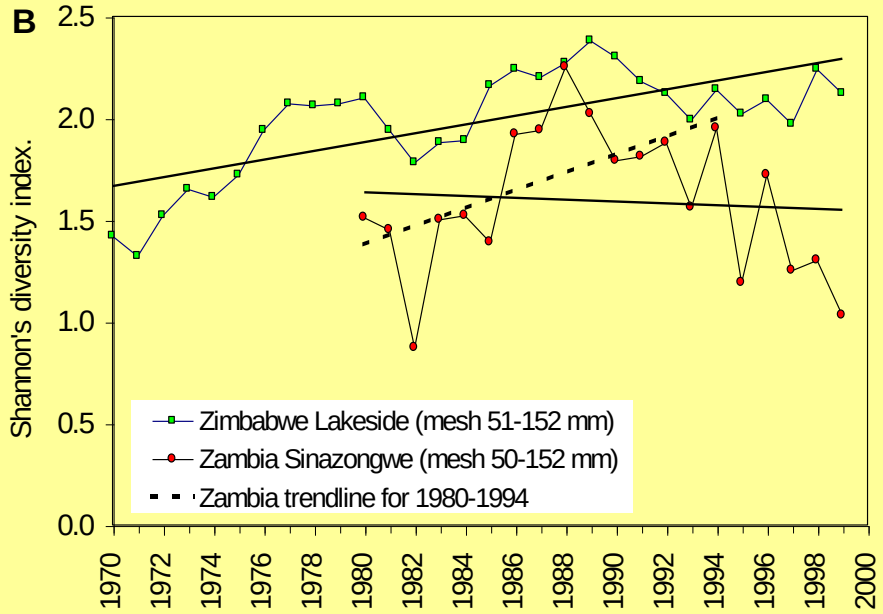


Diversity development

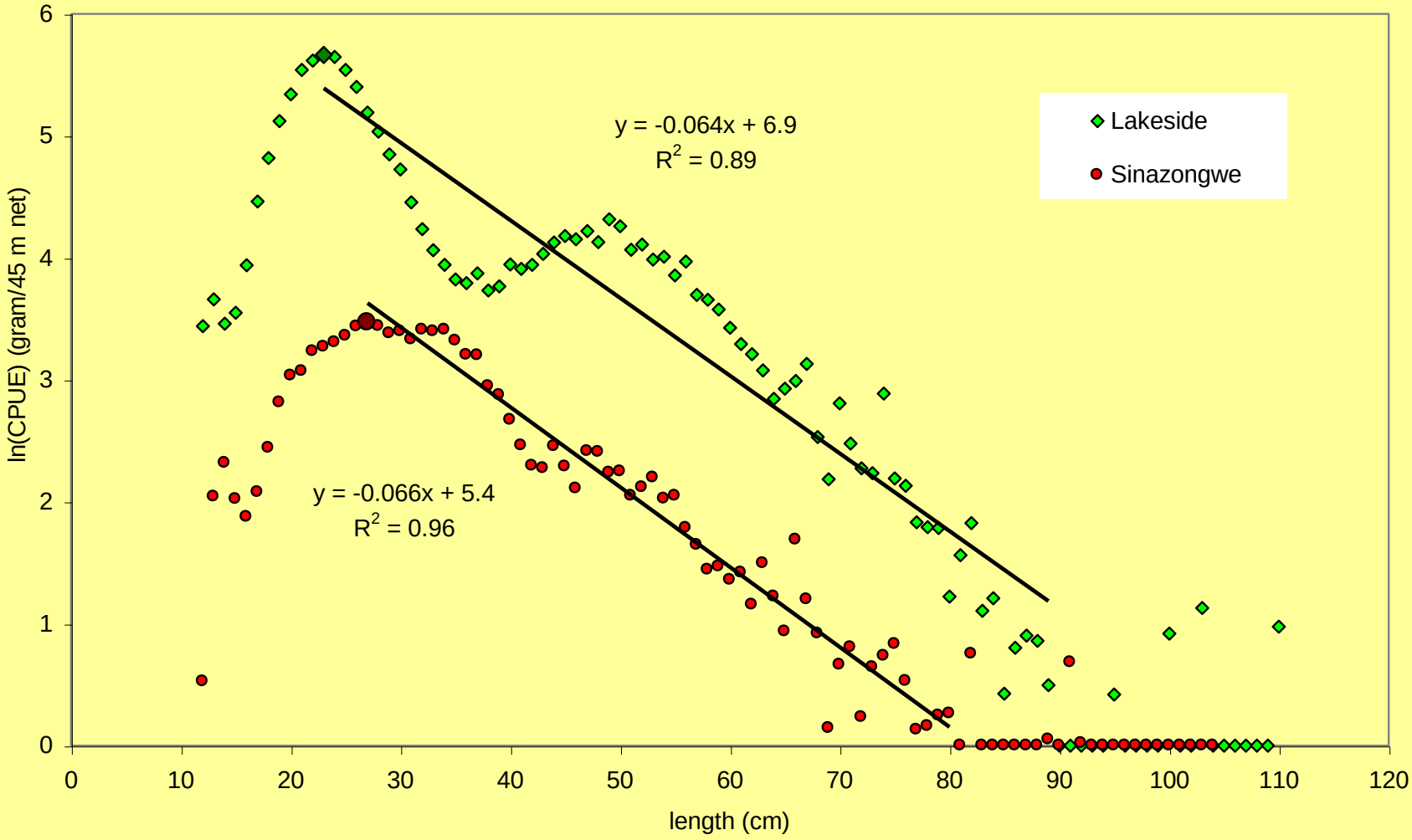
Number of species



Shannon's index



Biomass-Size distributions



Causes for changes: environment and/or effort

Dependent variable		Independent variables								
Annual mean catch rate		Hydrology				Effort			Interaction	
System Variable	N	Lag	Variable	Sign	%	Variable	Sign	%	Sign	%
Zimbabwe										
Artisanal CPUE (Kg/net)	27	0+1	Lake levels	+ (**)	29	# Fishers	- (**)	44	Ns	
Artisanal CPUE (Kg/net)	27	0	Lake levels	+ (**)	19	# Nets	- (**)	26	Ns	
Exp. CPUE (kg/net)	29	0	Amplitude	+ (**)	39	# Fishers	Ns		Ns	
Exp. CPUE (kg/net)	29	0	Amplitude	+ (**)	39	# Nets	Ns		Ns	
Kapenta CPUE(t/night)	26	0	Lake levels	Confounded		Boats	Confounded		- (**)	56
Zambia										
Artisanal CPUE (Kg/net)	20	0	Lake levels	+ (**)	32	# Fishers	Ns		Ns	
Artisanal CPUE (Kg/net)	20	0	Lake levels	+ (**)	32	# Nets	- (*)	9	- (*)	8
Exp. CPUE (kg/net)	20	0	Lake levels	+ (**)	31	# Fishers	Ns		Ns	
Exp. CPUE (kg/net)	20	0	Lake levels	+ (**)	34	# Nets	- (**)	23	- (*)	11
Kapenta CPUE(t/night)	18	0	Lake levels	Confounded		Boats	Confounded		- (**)	60

Inshore Fisheries in Lake Kariba

	Zimbabwe	*Zambia*
Management	Strict enforcement	No enforcement
Fishing pattern	No changes	Increasingly unselective
Catch rates	Increasing	Decreasing
Daily returns	2.8 kg/net	1.8 kg/net
Yields	Low - constant	High - fluctuating
# fishers (effort)	Low	High (fluctuating)
Catch composition	Stable	Stable
Diversity	Increasing	Increasing
Community structure	No changes (large fish)	No changes (small fish)
Sign of overfishing	No	No
Status ?	Under-utilised?	Optimized ?