



Government of Malawi
Department of Fisheries

Analysis of Catch and Effort Data for the Fisheries of Nkhata Bay, Lake Malawi, 1976-1999.

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Introduction

The fishery in Nkhata Bay covers a stretch of coastline from Mlowe to the Dwambazi River, a distance of approximately 200 km, Area H in Figure 1. The northern two thirds consist of steep rocky shoreline, which continues below the surface resulting in very deep water very close to shore. The fisheries are therefore concentrated into the very narrow coastal strip. The shoreline south of Nkhata Bay boma is wider with long stretches of sandy beaches separated by rocky headlands (Tweddle *et al* 1995).

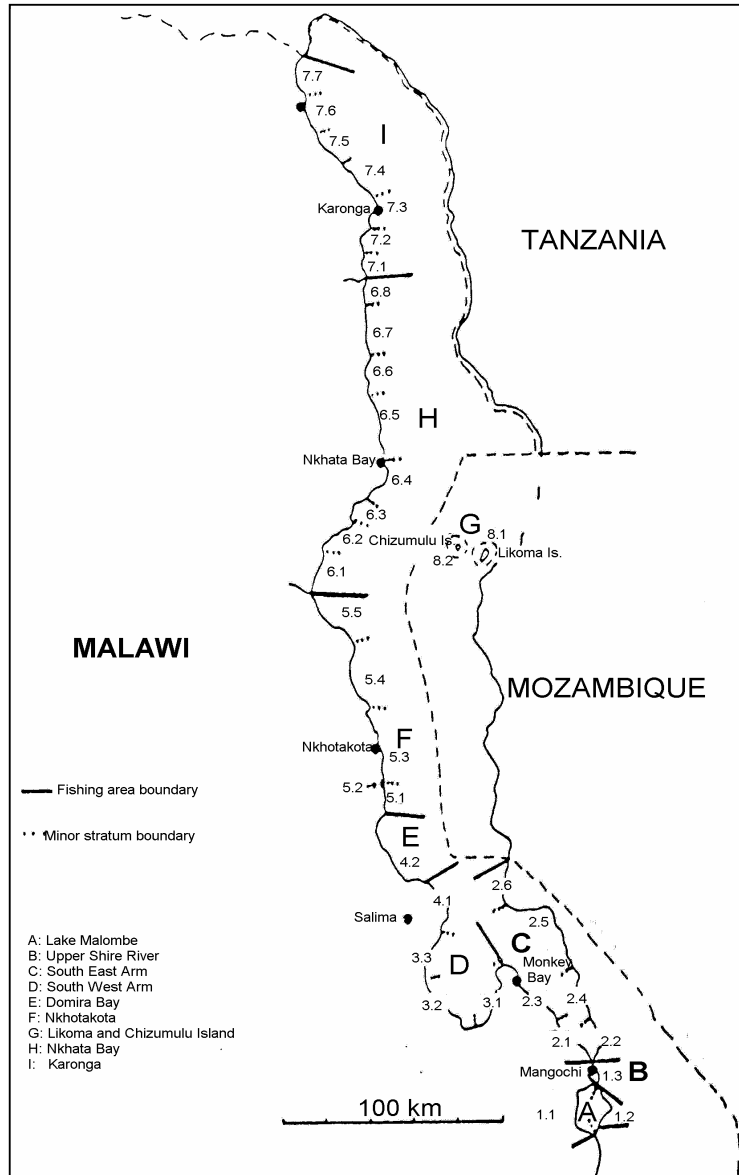


Figure 1: Map of statistical strata in Lake Malawi, the upper Shire river and Lake Malombe.

Data Collection

Statistical data on the traditional fisheries are collected and analysed using methods developed by Bazigos (1972) and implemented by Walker (1974;1976). For purposes of data collection, Nkhata Bay is divided into eight minor strata (Figure 1). Estimation of total catch and fishing effort in each minor stratum are estimated by combining data obtained in monthly catch assessment surveys (CAS) and in annual frame surveys. Estimates of Maximum Sustainable Yield (MSY) and Optimum level of fishing (F_{MSY}) were obtained by fitting the Schaefer (Graham 1935) and Fox (Fox 1970) models to the catch and effort data (Sparre and Venema, 1989) using Microsoft Excel's Solver least squares technique as described in Barrows and Burns (1997).

The purpose of this report is to update the catch and effort data available for Nkhata Bay district and to determine general trends in the fishery. However data for 1998 - 2000 is not yet available and has therefore not been used in this analysis.

Results

Total Catch and Effort

There were large fluctuations in the estimated catches over the 22-year period. Estimated catch ranged from 900 to 5,600 tons with a mean of 2,500 tons (Figure 2). Effort kept on increasing up to 1994 (Figure 2) but since then it has nose-dived. The decline in effort can be attributed to data collection problems in the Nkhata Bay District Fisheries Office since 1995.

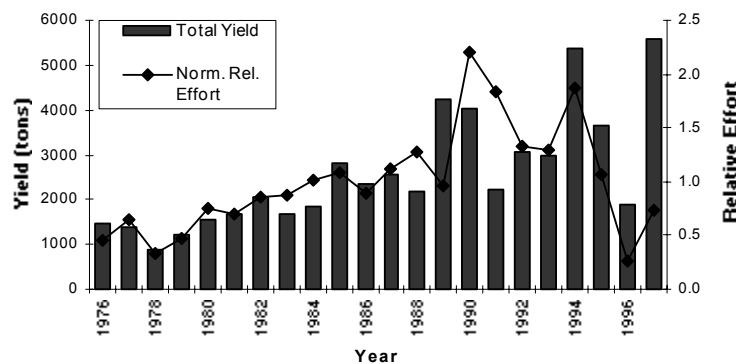


Figure 2: Trends in total yield and effort in Nkhata Bay district from 1976-1997.

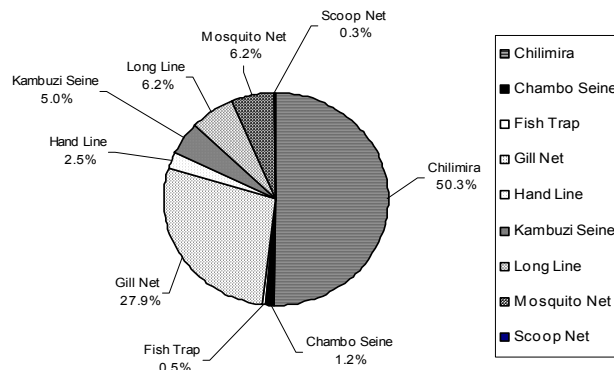


Figure 3: Contribution of each gear to the total catch over the period 1976-1997.

The main contributors to the total catch were Chilimira (CH) and Gill nets (GN) with 50.3% and 27.9% respectively while the least important are Scoop net (SC) and Fish traps (FT) with 0.3% and 0.5% respectively (Figure 3). The contribution of the various gears to the total catch has changed over

time. Gill nets and Chilimira are the mainstay of the fishery although Chilimira seem to have increased in importance in the 1990s (Figure 4).

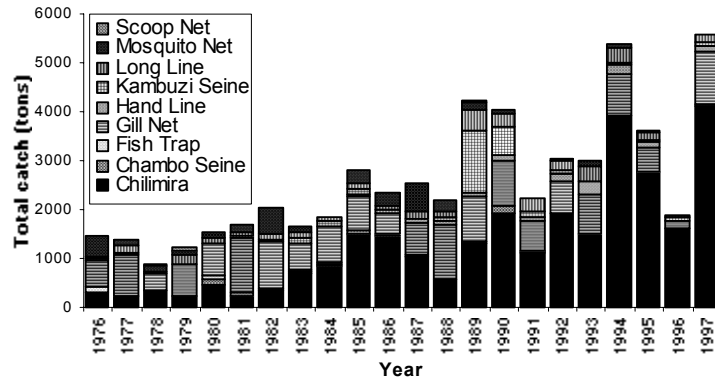


Figure 4: Annual catch by gear in Nkhata Bay District from 1976 to 1997.

The species composition of the catch has also changed over the same period. Utaka (*Copadichromis virginialis*) was the main catch until the early 1990s after which usipa (*Engraulicypris sardella*) became increasingly important (Figure 5). Their overall contribution to the total catch were 35% for utaka and 33% for usipa. The contribution of other species/groups were 3% for chambo (*Oreochromis* spp.), 7% for kampango (*Bagrus meridionalis*), 6% for mlamba (Clariid catfishes), 2% for chisawasawa (*Lethrinops* spp.) and 1% for kambuzi (small cichlids). Other tilapia, Ntchila (*Labeo mesops*) and other unidentified species contributed about 14% to the total catch (Figure 5).

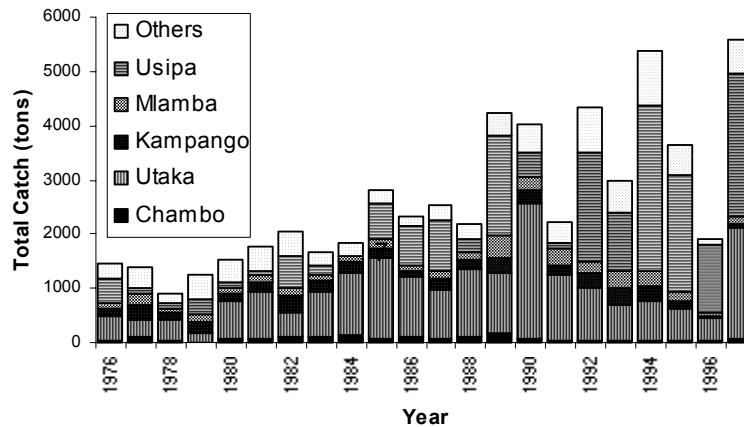


Figure 5: Annual catch by species or species' groups in Nkhata Bay district from 1976-1997.

Analysis by Gear

A number of fishing gears are used in Nkhata Bay district for harvesting the fishery resources found within the district. They include Gill nets, Chilimira, Mosquito nets, Kambuzi seines, Long lines, Handline, Fish traps, and Chambo seines. Details about each gear are presented in the sections that follow.

Chilimira Fishery

Temporal trends in effort, catch per unit effort and catch composition are shown in Figures 6 and 7. There has been a significant increase ($p < 0.05$) in the number of Chilimira nets from 147 in 1981 to 726 in 1999 as shown by the linear trendline in Figure 6. Effort increased steadily until 1991 when it reached a peak of about 250,000 pulls but has since decreased. CPUE was fluctuating around 10 kg/pull between 1976 and 1992 and thereafter it rapidly increased to over 50 kg/pull (Figure 7). This increase can be attributed to reduction in effort after 1992.

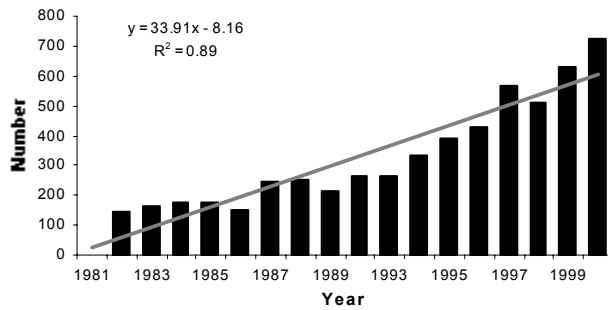


Figure 6: Number of Chilimira Nets in Nkhata Bay district (1981-1999).

Catches have over the past years increased from about 250 tonnes to about 4,000 tonnes in 1999. Usipa and utaka dominate the fishery however of late usipa seems to have become more important than utaka (Figure 7). The overall contribution to the total catch of usipa and utaka are 49% and 44% respectively with all other species groups contributing about 7%.

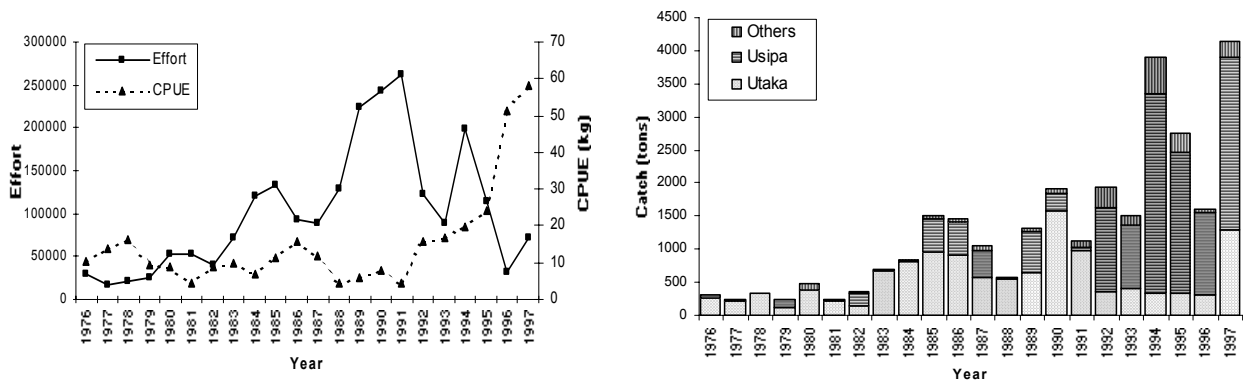


Figure 7: Trends in effort (no. of pulls), CPUE (kg/pull) and Catch in the Chilimira fishery from 1976-1997.

Gill net fishery

Temporal trends in effort, catch per unit effort and catch composition are shown in Figure 9. Catches have over the years fluctuated with no definite pattern with an average of about 600 tonnes. Utaka, with an overall contribution of about 38%, is the most important species harvested in this fishery. Other important species/groups are Kampango (21%), Chambo (7%), Chisawasawa (7%) and Mlamba (6%) with the rest contributing about 21%. However there is a marked decrease in catches of chambo, that is noticeable after 1989 (Figure 9). Effort has remained relatively stable at around 400,000 standard Gill nets (100 m stretches) while CPUE (kg/100 m) has fluctuated with no definite trend. There has been a significant increase ($p < 0.05$) in the number of Gill nets from 1,217 in 1981 to 4,600 in 1999 as indicated by the linear trendline in Figure 8.

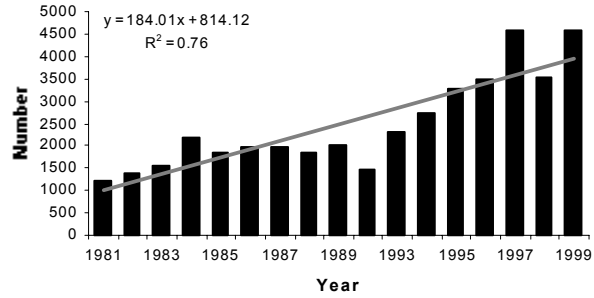


Figure 8: Number of Gill nets in Nkhata Bay district (1981-1999).

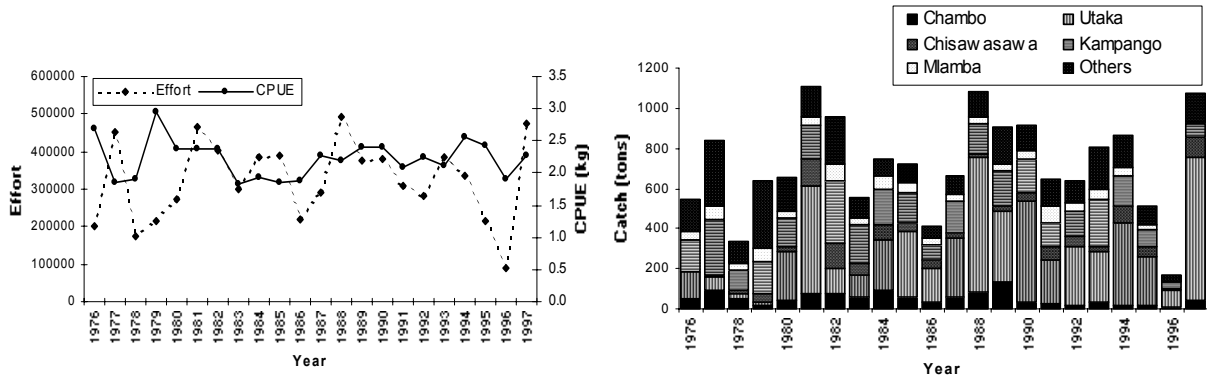


Figure 9: Trends in effort (no. of standard Gill nets), CPUE (kg/100 m) and Catch in the Gill net fishery from 1976-1997.

Fish trap fishery

Temporal trends in effort, catch per unit effort and catch composition are shown in Figure 11. As observed from the effort trend in Figure 8, Fish traps are no longer an important gear in Nkhata Bay. There has been a general decline though not significant ($p > 0.05$) in the number of Fish traps from 29 in 1981 to 2 in 1999 as indicated by the trendline in Figure 10.

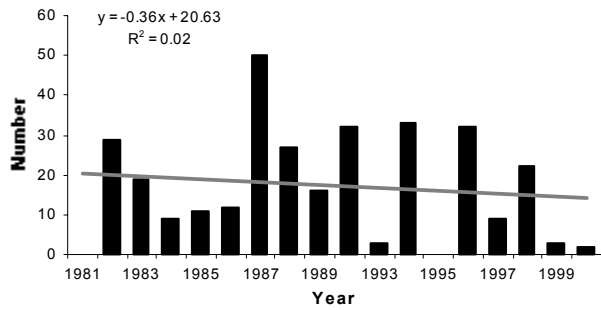


Figure 10: Number of Fish traps in Nkhata Bay district (1981-1999).

The gear was quite important from 1976 up to around 1987. Catches used to be mostly composed of a large number of unidentified species which are grouped in to the 'other' category (Figure 11).

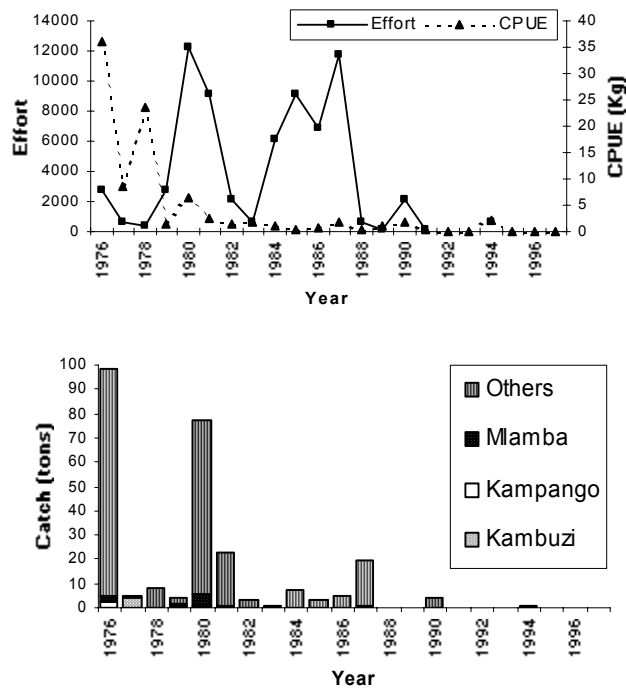


Figure 11: Trends in effort (no. of traps), CPUE (kg/trap) and Catch in the Fish Trap fishery from 1976-1997.

This category which also includes species with an overall contribution of less than 1% used to make up over 91% of the total catch. Other important species in terms of overall contribution to the total catch included mlamba (3%), kambuzi (2%) and kampango (1%). Catches used to fluctuate with no definite trend.

Kambuzi seine fishery

Temporal trends in effort, catch per unit effort and catch composition are shown in Figure 13. Catches in this fishery suddenly shot up between 1989 and 1990 reaching a peak of over 1,200 tonnes from an average of about 50 tonnes. Utaka and usipa, which contributed 45% and 28% respectively, are the most important species harvested in this fishery.

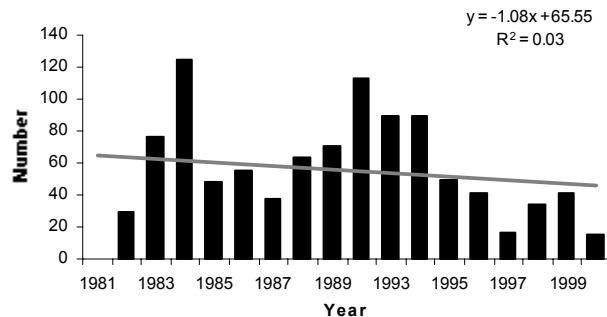


Figure 12: Number of Kambuzi seines in Nkhata Bay district (1981-1999).

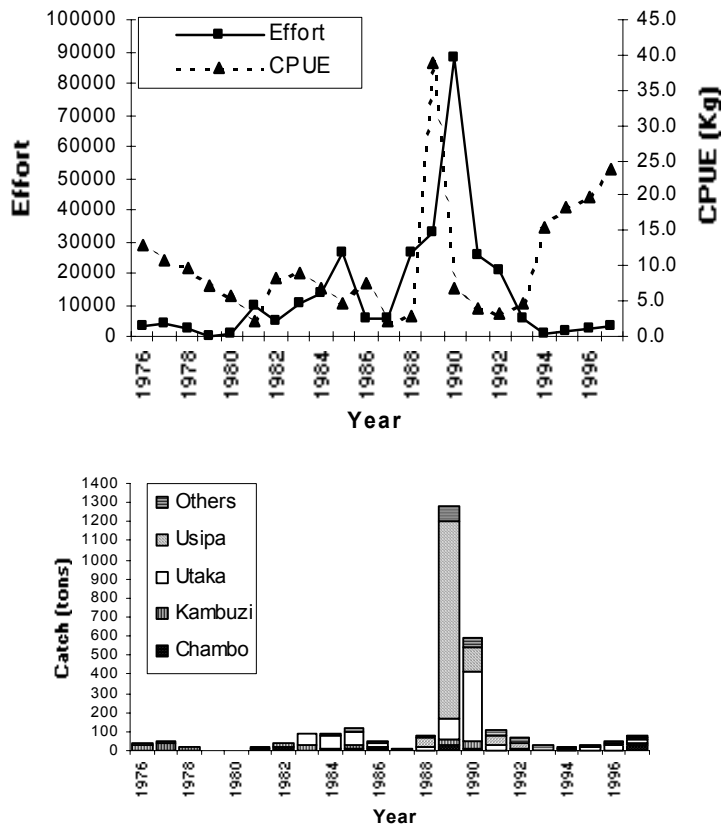


Figure 13: Trends in effort (no. of pulls), CPUE (kg/pull) and Catch in the Kambuzi seine fishery from 1976-1997.

Other important species/groups include Kambuzi (10%) and chambo (4%) with the rest of the species including those contributing less than 1% adding up to just around 13%. Examination of the trend in effort indicates that effort increased up to about 90,000 pulls in 1992 after which it fell sharply to about 10,000 pulls (Figure 13). There has been a general decline though not significant ($p > 0.05$) in the number of Kambuzi seines from 29 in 1981 to 15 in 1999 as indicated by the trendline in Figure 12. CPUE has fluctuated with no definite trend up to 1993 after which it rapidly rose to over 200 kg/pull. This rapid increase can be attributed to reduction in effort which is evident after 1992 (Figure 13).

Handline Fishery

Temporal trends in effort, catch per unit effort and catch composition are shown in Figure 15. Catches in this fishery gradually increased from less than 10 tonnes in 1978 to over 250 tonnes in 1993 after which a slight decline is registered. Catches are mostly composed of the 'other species' category which together with less important species (less than 1% overall contribution) make up over 93% of the total catch. Other important species/groups include kampango (4%) and bombe (3%). Examination of the trend in both effort and CPUE indicates that CPUE was considerably higher between 1976 and 1990 fluctuating around 15 kg/haul than after 1990 when it dropped to below 1 kg/haul. Effort shows a generally increasing trend especially after 1990 reaching a peak of about 3,000,000 hauls in 1995. This explains the sudden drop in CPUE after 1990 (Figure 15). The number of handlines shows a significant increasing trend ($p < 0.05$) with a total of 44 handlines being recorded in 1981 and 848 handlines in 1999 (Figure 14).

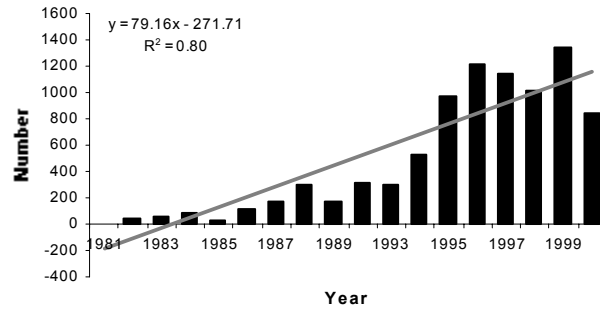


Figure 14: Number of Hand lines in Nkhata Bay district (1981-1999).

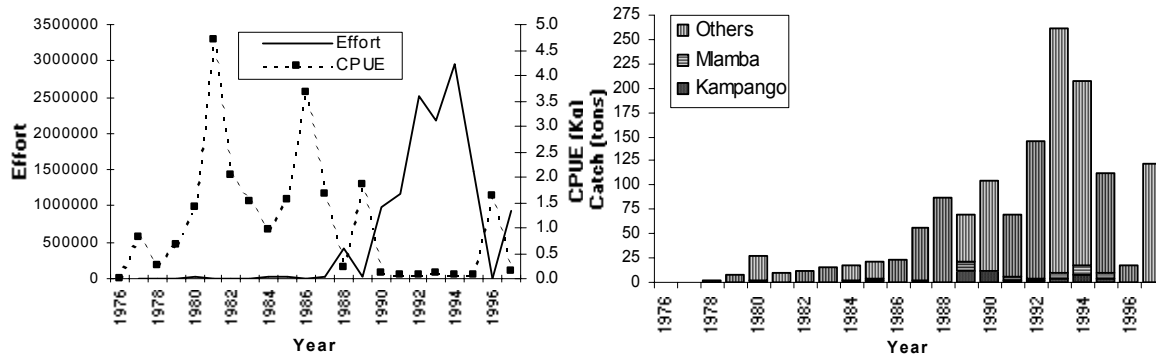


Figure 15: Trends in effort (no. of hauls), CPUE (kg/haul) and Catch in the Handline fishery from 1976-1997.

Chambo Seine Fishery

Temporal trends in effort, catch per unit effort and catch composition are shown in Figure 17. Catches in this fishery fluctuated without a definite trend between 1980 and 1991 after which a gradual decline in catches becomes evident. In terms of overall contribution to the total catch, Chambo (38%) and utaka (40%) dominate the catches although substantial quantities of kambuzi (12%) and kampango (1%) are also caught. Unidentified species including other less important ones make up about 9% of the total catch. Both effort and CPUE have fluctuated with no definite trend (Figure 17). The number of Chambo seines shows a general decline though not significant ($p > 0.05$) with 27 seines being recorded in 1981 and only 8 in 1999 (Figure 16).

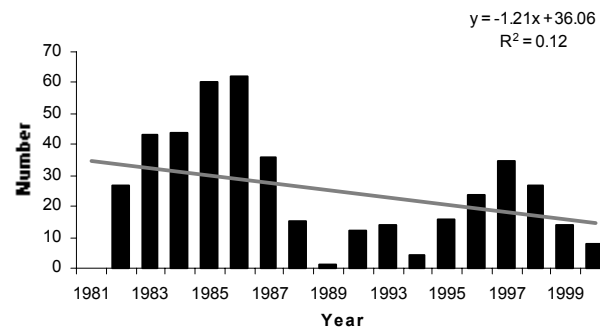


Figure 16: Number of Chambo seines in Nkhata Bay district (1981-1999).

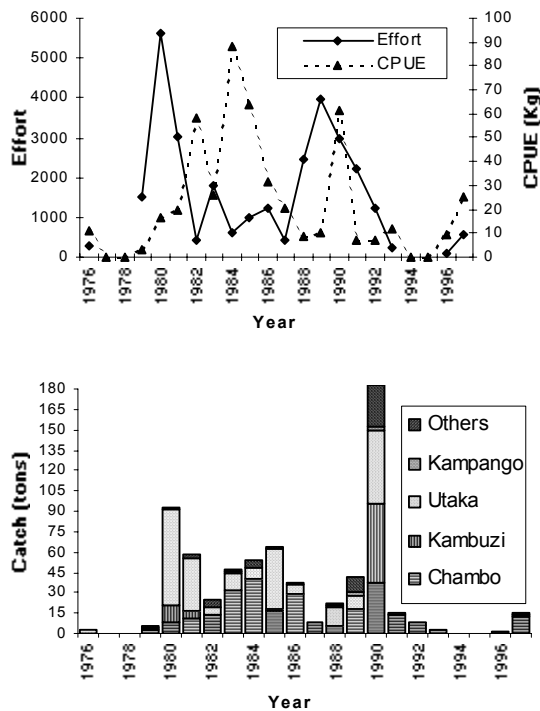


Figure 17: Trends in effort (no. of pulls), CPUE (kg/pull) and Catch in the Chambo Seine fishery from 1976-1997.

Long line fishery

Temporal trends in effort, catch per unit effort and catch composition are shown in Figure 21. Catches in this Fishery have generally increased from less than 50 tonnes in 1976 to over 500 tonnes in 1993 although a slight decline is noticeable especially after 1994. Mlamba and kampango with overall contributions to the total catch of 74% and 19% respectively are the most important species/group harvested in this fishery. The rest of the species including unidentified ones only make up 7% of the total catch. Effort in this fishery shows a general increasing trend reaching a peak of about 200,000 standard Long lines (100 hooks) in 1995 after which it declined to below 50,000 standard longlines.

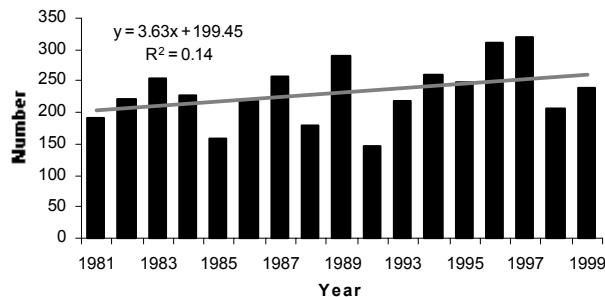


Figure 20: Number of Long lines in Nkhata Bay district (1995-1999).

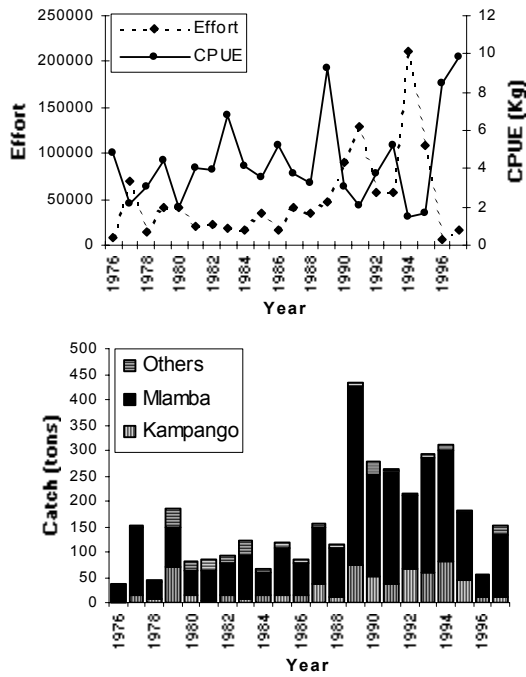


Figure 21: Trends in effort (no. of standard Long lines), CPUE (kg/100 hooks) and Catch in the Long line fishery from 1976-1997.

There is a general increasing trend though not significant ($p > 0.05$) in the number of longlines. About 191 Long lines were recorded in 1981 while about 238 were recorded in 1999 (Figure 20). On the other hand CPUE has remained rather stable fluctuating around 4 kg/100 hooks in 1990 (Figure 21).

Mosquito Net Fishery

Temporal trends in effort, catch per unit effort and catch composition are shown in Figure 19. Catches in this fishery show a gradual decline especially during the late 1990s probably because of a reduction in effort as observed from Figure 19.

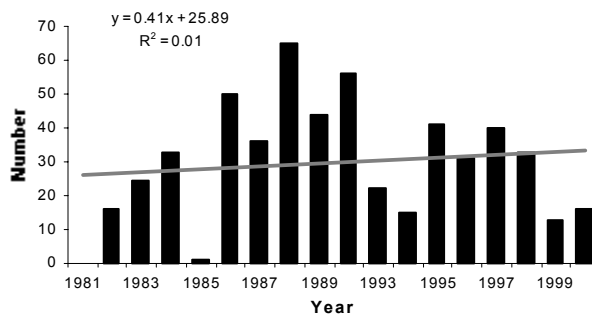


Figure 18: Number of Hand lines in Nkhata Bay district (1981-1999).

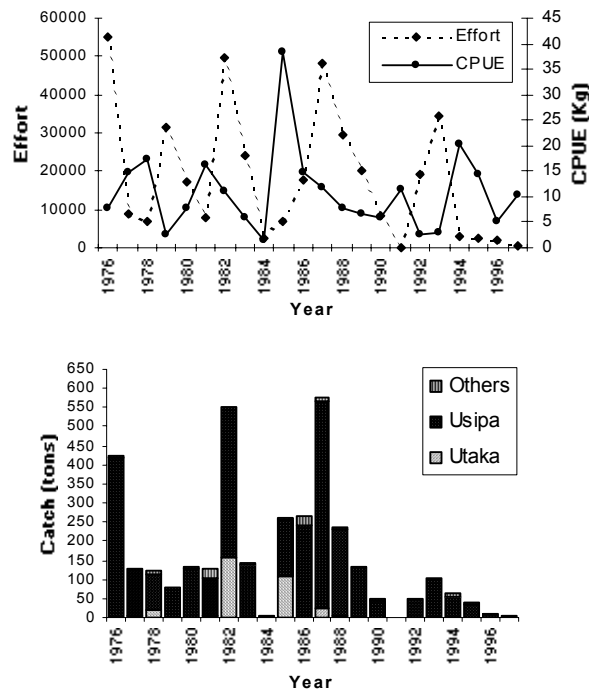


Figure 19: Trends in effort (no. of pulls), CPUE (kg/pull) and Catch in the Mosquito Net fishery from 1976-1997.

Catches are mostly composed of usipa (88%) although utaka (9%) was also harvested especially in the 1980s. All other species/groups contributed about 3% to the total catch. Effort and CPUE have fluctuated around 30,000 pulls and 10 kg/pull respectively although a substantial decline in effort is evident in the late 1990s (Figure 19). The number of Mosquito nets shows a general increasing trend though not significant ($P > 0.05$). About 31 nets were recorded in 1995 while only 16 were recorded in 1999 (Figure 18).

Estimation of Maximum Sustainable Yield (MSY)

To estimate MSY for the whole fishery relative CPUE, relative effort and total catch were used. There was significant correlation ($P < 0.05$) between CPUE and relative effort (Figure 22) and MSY was calculated using Fox and Schaefer forms of the surplus production model (Figure 23). MSY was calculated as 3,621 tons based on the Schaefer model and 2,881 tons based on the Fox model. The level of fishing effort required for MSY (F_{MSY}) was calculated as 4255 and 5,000 effort units for the Schaefer and Fox models respectively.

Of the two models, Fox gave a slightly smaller residual sum of squares (15,631,219) than Schaefer (16,831,533). Examination of Figure 23 indicates that both MSY and F_{MSY} were exceeded in the early 1990s particularly between 1990 and 1992. Not much can be said about the present status of the fishery because no data is available after 1997. The unavailability of data after 1997 is due to shortage of staff in the statistics section of the Nkhata Bay district fisheries office who are responsible for recording data in the field. However the existing data (Figure 23) indicates that the fishery is still in a relatively stable condition probably because it is dominated by pelagic species such as usipa and the semi-pelagic utaka. However the increasing trend of gears like Gill nets, Chilimira and handlines needs to be checked to avoid overcapitalisation and over-exploitation since the fishery is already past its MSY.

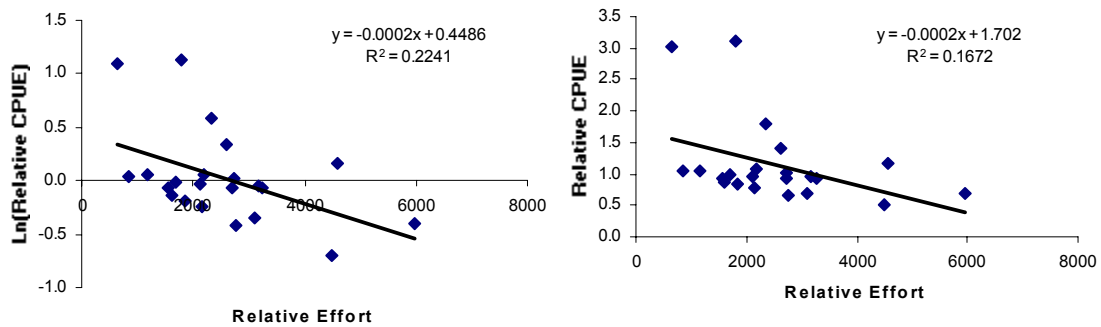


Figure 22: Regressions of Ln(Relative CPUE) and Relative CPUE against effort in the Nkhata Bay Fishery.

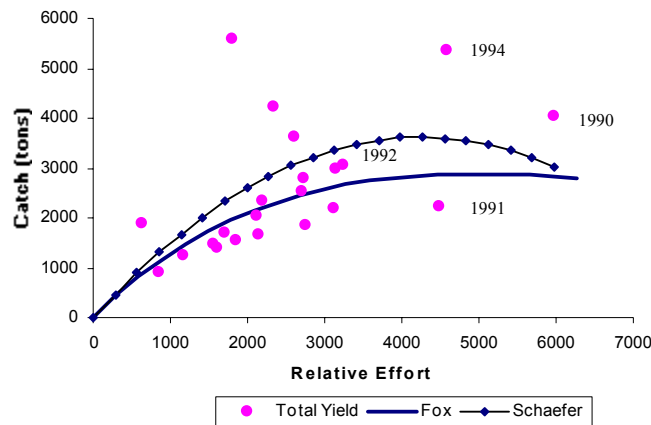


Figure 23: Fox and Schaefer model fits to total catch and relative effort data for the Nkhata Bay fishery (1976-1996).

Acknowledgements

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Appendix 1: Annual summary of catch and effort data for Nkhata Bay district from 1976-1997.

Table 1: Annual catch by gear

Year	CH	CS	FT	GN	HL	KS	LL	MN	SCN
1976	311	3	98	543		40	36	421	
1977	232		5	839	0	45	150	129	
1978	333		8	333	2	20	43	122	35
1979	240	5	4	635	8	1	183	80	74
1980	472	93	77	652	27	5	81	133	
1981	242	59	23	1111	10	21	86	128	
1982	353	25	3	958	11	44	92	551	5
1983	702	48	1	551	15	89	121	142	
1984	844	54	7	744	17	93	68	4	
1985	1498	63	3	721	22	119	120	259	
1986	1460	38	5	410	24	45	84	267	
1987	1051	8	19	662	56	11	155	577	
1988	571	22	0	1081	86	79	115	235	
1989	1319	42	0	908	69	1277	432	133	39
1990	1905	183	4	918	105	589	276	48	
1991	1125	15	0	646	70	106	264	2	
1992	1932	9		636	144	67	215	47	
1993	1498	3		807	262	25	294	102	
1994	3907		1	861	206	18	310	64	0
1995	2752			516	112	33	183	38	
1996	1597	1		170	18	49	55	11	
1997	4133	15		1084	123	79	154	4	

Table 2: Annual Effort by gear

Year	CH	CS	FT	GN	HL	KS	LL	MN	SCN
1976	29853	304	2718	201932		3100	7480	55249	
1977	16529		573	452318	108	4091	69184	8731	
1978	20168		360	174952	5464	2035	13914	7025	4780
1979	25306	1535	2745	214084	12411	172	41489	31232	9165
1980	53651	5635	12301	274145	19341	865	41470.5	17202	
1981	52490	3031	9145	466797	2028	9416	21085	7915	
1982	39230	427	2184	404726	5562	5175	23353	49582	436
1983	72255	1811	638	301639	10140	10053	17905	24257	
1984	121332	618	6128	384858	17348	13591	16457	2581	
1985	132584	989	9147.5	391359	13842	26156	33915.5	6743.5	
1986	92508	1207	6912	218562	6512	5916	16062	17920	
1987	88443	413	11781	290518	33636	5272	41313	48381	
1988	129731	2478	611	494729	403048	26188	35618	29752	
1989	224859	3960	117	376695	37182	32872	46583	20374	2090
1990	242187	2980	2119	381636	983368	87736	90427	8149	
1991	261857	2200	138	307626	1154597	25948	128988	144	
1992	123013	1211		283975	2519726	20416	57081	19357	
1993	89217	222		383565	2177208	5311	56376	34251	
1994	198253		574	336423	2944487	1161	212081	3176	714
1995	114756			212931	1477791	1822.5	109315	2599.5	
1996	31259	115		89438	11095	2484	6549	2023	
1997	71314	582		475853	920750	3327	15601	350	

Table 3: Annual Catch (tons) by species

Year	Chambo	Other Tilapia	Kambuzi	Utaka	Chisawasawa	Kampango	Mlamba	Usipa	Ntchila	Other
1976	50.48	4.65	24.66	424.90	3.07	158.21	82.71	451.83	8.50	244.33
1977	97.57	25.00	42.24	301.98	4.20	298.17	200.81	122.26	15.35	291.27
1978	51.61	24.99	27.04	377.38	15.48	111.86	86.39	105.48	3.50	92.27
1979	16.49	2.19	6.37	147.87	50.03	229.12	139.61	255.86	2.94	380.82
1980	54.43	5.71	19.71	696.34	31.27	149.73	95.36	130.18	5.10	352.72
1981	79.56	2.36	43.13	764.39	149.91	172.86	105.68	101.21	6.71	195.31
1982	112.99	0.39	24.44	432.83	124.91	324.61	150.47	587.56	11.65	271.68
1983	96.29	0.19	33.78	839.62	59.79	208.98	120.01	157.17	5.81	147.27
1984	139.45	0.56	12.19	1143.68	76.34	204.53	112.04	2.08	2.34	138.64
1985	80.48	0.03	51.79	1495.40	46.60	172.46	149.59	654.85	8.61	144.60
1986	92.16	1.44	5.98	1114.57	47.49	94.00	104.74	744.73	16.46	111.58
1987	71.05	20.10	47.78	887.60	24.41	205.96	146.03	953.13	6.09	178.53
1988	93.09	0.25	11.63	1260.81	19.60	169.50	127.20	268.91	4.91	233.25
1989	181.02	0.00	60.98	1113.47	23.05	277.79	402.98	1833.01	2.35	324.67
1990	84.65	0.44	132.60	2488.97	44.85	243.20	250.43	438.06	11.57	333.02
1991	49.69	6.10	3.88	1215.84	76.20	161.72	314.76	106.43	6.73	286.04
1992	17.77	0.38	3.95	655.93	52.79	210.94	191.96	1352.66	17.05	538.73
1993	34.97	1.19	1.10	657.27	39.88	322.90	292.73	1068.29	8.28	562.60
1994	24.55	63.58	0.45	755.28	83.05	255.48	270.41	3072.58	21.39	822.16
1996	18.13	0.00	0.00	432.51	7.62	42.47	47.11	1255.13	0.00	97.92
1997	83.36	5.54	11.58	2016.06	97.59	93.22	125.81	2652.37	0.48	504.46