

3 Univariate analyses of data from the fisheries monitoring programme

VANUATU

3.1 Fishing Sites and sub-areas

The selected study sites and sub-areas contained within them have been described in Volume 2. They are summarised below in Table 3.1. The sub-areas include 'managed' and un-managed areas. Fishing methods employed are indicated in Table 3.2. In the analyses of the data, the following notation has been used : subarea.fishing method, when data is sorted by sub-area, or fishing method.sub area when data is sorted by fishing method. E.g. 200.4 indicates that the analysis relates to data collected in Atchin, sub-area 200, using 'string', that is hand-lines only.

Table 3.1. Study sites, and a description of managed (Tabu = Y) and un-managed sub areas within them, indicating the sub area code employed in Vanuatu.

Site name	Location	Subarea	Tabu	Start_date	End_date
Atchin	Submerged Reef - to NE	200	N		
Atchin	NW quadrant	201	N		
Atchin	NE quadrant	202	N		
Atchin	SE quadrant	203	N		
Atchin	SW quadrant	204	N		
Atchin	Channel	205	N		
Atchin	Malekula Coast	206	N		
Emua	Saama	262	N		
Emua	Reef	263	N		
Emua	Tabu Area	264	Y	15/07/1997	
Emua	Open water	261	N		
Lelepa	North coast reef	248	N		
Lelepa	South coast reef	249	N		
Lelepa	East coast reef	247	N		
Lelepa	Moso Island	241	N		
Lelepa	Open-water (west)	242	N		
Lelepa	Eretoka Island	243	N		
Lelepa	Efate Island Reef	244	N		
Lelepa	Channel	250	N		
Lelepa	Open-water (east)	245	N		
Lelepa	Tabu Area	246	Y		
Pellonk	Tabu Area	233	Y	01/01/1996	01/01/1999
Pellonk	Sakau Island	231	N		
Pellonk	Pellonk CFRA	232	N		
Uripiv	Malisa Tabu (permanent)	222	Y	01/01/1990	01/01/1999
Uripiv	West/South Coast	223	N		
Uripiv	North coast Uri Island	224	N		
Uripiv	South Coast Uri Island	225	N		
Uripiv	North coast	221	N		
Wala	Malekula / Channel	217	N		
Wala	SE Tabu (permanent)	215	Y	01/08/1996	01/01/1999

Wala	SW quadrant	216	Y		
Wala	NE (Erepos Tabu)	213	Y	19/10/1996	31/01/1997
Wala	East (Petani Tabu)	214	Y	06/03/1997	01/08/1998
Wala	NE quadrant incl 213/214)	212	N		
Wala	NW quadrant	211	N		

Table 3.2 : Fishing methods employed in Vanuatu, and the fishing method code employed.

Fishing Method	Fishing Method Code
Hand net	1
Gill net	2
Hand-collecting	3
String (Hand-line)	4
Spear gun	5
Spear	6
Poison	7
Throw Net	8

Data collection procedures for the fisheries monitoring programme have been described elsewhere (Volume 1)

3.2 Abundance indices and fishing effort

Assuming constant catchability, catch rates are an index of the abundance of the resource. In order to compare catch rates at different sub-areas within sites and across sites, aggregate (all species) catch rate data was examined for both the case of all fishing gears combined and that of representative gear types. Representative gear employed commonly at all fishing locations was gill-nets, hand-lines and spears. For combined gear analyses, effort data was standardised for seasonal and gear variation. Where representative gear types were examined the data was unstandardised.

Mean aggregate (all) species catch rate data for representative gear types, and that for all gear standardised for seasonal and gear variation (see Volume1, Chapter 2) was generated for each study year (November 1996-October 1997, and November 1997-October 1998) by sub-area. This data was analysed using a GT2 test and Gabriel's approximation (Sokal and Rohlf, 1995) which enables multiple comparisons among pairs of means based on unequal sizes. All sub-area frequency distributions with less than a sample size of 5 were deleted. The results of these tests are illustrated by the example of catch rate data recorded in 1997/98 (Tables 3.3-3.5 And Fig. 3.1). The presentation of the data enables sub areas both across sites and within sites to be compared, but this analysis will principally be used for within site comparisons. Of interest is whether tabu (managed) areas have significantly different catch rates (abundance) to open access areas. Differences between open access areas are of interest, but need to be explained in relation to fishing intensity or environmental characteristics. As discussed previously, abundance (and catch rates) may be expected to decrease with increased fishing intensity, and thus across site comparisons are correlated with fishing effort (see below).

The results of both the GT2 test (Tables 3.3-3.5) and Gabrielle's approximation (Fig. 3.1), summarised in Table 3.6, indicate that within sites no significant sub area differences in catch rate occurred except at Lelepa. At Lelepa, sub-areas 241 (Moso Island) and 246 (a tabu area) had significantly higher catch rates than all other sub-areas at that site. Amongst the remainder, most were not significantly different, but lower catch rates occurred at 242, 245 and 250 which are open water and channel sites and do not have comparable

environmental characteristics to the reef sites in Lelepa - catch rates may be expected therefore to differ. Fig 3.1 clearly illustrates that the mean standardised catch rate varies between sub areas across sites, but there are few significant differences. Catch rates in Lelepa and Emua, tended to be higher than at other sites. Sites 241 and 246 (246 is a tabu area), however, have markedly higher catch rates than elsewhere, both across sites and within the site of Lelepa. This data also indicated that of the 3 tabu areas for which catch rate data exists for 1997/8 (sub areas 222, 246 and 264), only that for 246 is significantly different from open access areas both within and across sites (see also Fig 3.2). Sub area 264, had a significantly higher catch rate than some sub-areas in Atchin and Uripiv, all sub areas in Wala, but did not differ significantly from most sites at Lelepa (Table 3.5).

The results of GT2 and Gabrielle's test comparisons of mean catch rates for other years and gear are indicated in Annex V1, and summarised in Table 3.6. During 1996/7 few significant sub-area differences in catch rate within each site were observed. Of the tabu areas, a significantly higher catch rate was observed only for area 246 (Lelepa) with spears. During 1997/8 there were no significant differences in sub-area catch rates for any gear except within Lelepa and for spears at Atchin. At Lelepa, the tabu area 246 had significantly higher catch rates than some or all sites for all-gear data, and for gill-nets and spears. Handline catch rates for this tabu area did not differ from other areas within this site, except 241 which was higher.

Summary : Results of GT2 and Gabrielle's approximation tests to compare mean catch rates indicate that within sites few significant sub area differences occur. Of the 3 Tabu areas for which catch and effort data were available, only one (246 in Lelepa) had a significantly higher catch rate than other areas within that site. Across sites, the catch rate varied between sub areas, but there were few significant differences.

Table 3.3 : Mean aggregate (all species) standardised catch rate (kg/hour), sample size, standard deviation, variation and standard error, recorded in 1997/8 at sub-areas in Atchin (200-206), Wala (211-217), Uripiv (221-225), Lelepa (241-250) and Emua (261-264) for all fishing gears combined. Tabu (managed) areas are marked with a 'T'.

Sub area:	200	201	202	203	204	205	206	211	212	221	222T	223	224	225
Mean	2.37	1.08	2.37	1.93	1.06	0.76	2.84	1.16	1.26	0.19	0.39	0.64	0.23	0.25
n	9	117	7	23	60	11	11	181	563	83	13	195	55	24
SD	2.38	1.86	3.14	3.87	1.61	0.76	4.66	1.65	2.98	0.15	0.47	1.00	0.30	0.30
Var	5.68	3.45	9.86	14.97	2.60	0.58	21.72	2.72	8.85	0.02	0.22	0.99	0.09	0.09
n-1	8	116	6	22	59	10	10	180	562	82	12	194	54	23
SE	1.13	0.09	1.45	0.44	0.17	0.92	0.92	0.06	0.02	0.12	0.78	0.05	0.18	0.42

Sub area:	241	242	243	244	245	246T	247	248	249	250	262	263	264T
Mean	10.25	2.35	4.73	3.80	0.97	7.86	2.35	2.80	3.42	1.34	3.19	2.25	4.75
n	7	57	48	75	7	27	29	42	91	48	28	45	18
SD	15.00	3.84	5.73	4.97	0.48	10.63	2.00	3.01	4.20	1.80	4.16	1.61	6.09
Var	224.86	14.72	32.81	24.66	0.23	112.98	4.02	9.04	17.64	3.26	17.26	2.61	37.06
n-1	6	56	47	74	6	26	28	41	90	47	27	44	17
SE	1.45	0.18	0.21	0.14	1.45	0.38	0.35	0.24	0.11	0.21	0.36	0.23	0.57

Table 3.4 GT2 Test applied to mean aggregate (all species) standardised catch rate (kg/hour) recorded in 1997/8 at sub-areas in Atchin (200-206), Wala (211-217), Uripiv (221-225), Lelepa (241-250) and Emua (261-264) for all fishing gears combined. The critical value for K, $K^* = K(K-1)/2$ with 1847 degrees of freedom is 3.778 at 5% error level. Pairs of means are significantly different if their difference equals or exceeds the critical difference.

	200	201	202	203	204	205	206	211	212	221	222T223	224	225	241	242	243	244	245	246T247	248	249	250	262	263	264T		
200	-	4.17	6.07	4.74	4.31	5.42	5.42	4.12	4.05	4.23	5.23	4.11	4.33	4.71	6.07	4.32	4.38	4.25	6.07	4.64	4.60	4.43	4.21	4.38	4.62	4.40	4.92
201	1.29	-	4.69	2.75	1.91	3.80	3.80	1.43	1.22	1.73	3.52	1.41	1.97	2.70	4.69	1.95	2.07	1.78	4.69	2.57	2.50	2.17	1.68	2.07	2.54	2.11	3.05
202	-0.00	-1.29	-	5.20	4.81	5.83	5.83	4.64	4.58	4.74	5.65	4.64	4.84	5.18	6.44	4.83	4.88	4.76	6.44	5.11	5.07	4.92	4.73	4.88	5.09	4.90	5.37
203	0.44	-0.85	0.44	-	2.96	4.42	4.42	2.67	2.56	2.84	4.18	2.66	2.99	3.52	5.20	2.98	3.06	2.87	5.20	3.42	3.36	3.13	2.81	3.06	3.39	3.09	3.79
204	1.31	0.02	1.31	0.87	-	3.95	3.95	1.80	1.64	2.04	3.69	1.78	2.25	2.91	4.81	2.23	2.33	2.09	4.81	2.79	2.73	2.42	2.00	2.33	2.76	2.38	3.24
205	1.60	0.31	1.61	1.16	0.30	-	5.14	3.74	3.67	3.87	4.94	3.73	3.98	4.39	5.83	3.97	4.03	3.89	5.83	4.31	4.27	4.08	3.85	4.03	4.29	4.05	4.61
206	-0.48	-1.77	-0.47	-0.92	-1.79	-2.08	-	3.74	3.67	3.87	4.94	3.73	3.98	4.39	5.83	3.97	4.03	3.89	5.83	4.31	4.27	4.08	3.85	4.03	4.29	4.05	4.61
211	1.20	-0.09	1.21	0.76	-0.10	-0.40	1.68	-	1.03	1.60	3.46	1.24	1.86	2.62	4.64	1.83	1.96	1.65	4.64	2.49	2.41	2.06	1.55	1.96	2.45	2.01	2.98
212	1.10	-0.19	1.11	0.66	-0.20	-0.50	1.58	-0.10	-	1.42	3.38	1.00	1.70	2.51	4.58	1.68	1.81	1.48	4.58	2.37	2.29	1.93	1.36	1.81	2.33	1.87	2.89
221	2.17	0.88	2.18	1.73	0.87	0.57	2.65	0.97	1.07	-	3.59	1.58	2.10	2.79	4.74	2.07	2.19	1.92	4.74	2.67	2.60	2.28	1.83	2.19	2.63	2.23	3.13
222T	1.98	0.69	1.98	1.54	0.67	0.37	2.45	0.77	0.87	-0.20	-	3.45	3.72	4.15	5.65	3.70	3.77	3.62	5.65	4.07	4.02	3.82	3.57	3.77	4.04	3.79	4.39
223	1.72	0.43	1.73	1.28	0.42	0.12	2.20	0.52	0.62	-0.45	-0.25	-	1.84	2.61	4.64	1.81	1.94	1.64	4.64	2.47	2.40	2.05	1.53	1.94	2.44	1.99	2.97
224	2.14	0.85	2.15	1.70	0.83	0.54	2.62	0.94	1.04	-0.03	0.17	0.42	-	2.95	4.84	2.28	2.38	2.14	4.84	2.83	2.77	2.47	2.06	2.38	2.80	2.42	3.27
225	2.11	0.82	2.12	1.67	0.81	0.51	2.59	0.91	1.01	-0.06	0.14	0.39	-0.03	-	5.18	2.93	3.01	2.83	5.18	3.38	3.33	3.08	2.77	3.01	3.35	3.05	3.76
241	-7.88	-9.17	-7.88	-8.32	-9.19	-9.49	-7.41	-9.09	-8.99	-10.06	-9.86	-9.61	-10.03	-10.00	-	4.83	4.88	4.76	6.44	5.11	5.07	4.92	4.73	4.88	5.09	4.90	5.37
242	0.02	-1.27	0.02	-0.42	-1.29	-1.59	0.49	-1.19	-1.09	-2.16	-1.96	-1.71	-2.13	-2.10	7.90	-	2.36	2.12	4.83	2.82	2.75	2.45	2.04	2.36	2.78	2.40	3.26
243	-2.36	-3.65	-2.36	-2.80	-3.67	-3.97	-1.88	-3.57	-3.47	-4.54	-4.34	-4.09	-4.50	-4.48	5.52	-2.38	-	2.23	4.88	2.90	2.83	2.55	2.15	2.46	2.87	2.50	3.33
244	-1.43	-2.72	-1.43	-1.87	-2.74	-3.04	-0.96	-2.64	-2.54	-3.61	-3.41	-3.16	-3.58	-3.55	6.45	-1.45	0.93	-	4.76	2.70	2.64	2.32	1.88	2.23	2.67	2.27	3.16
245	1.40	0.11	1.40	0.96	0.09	-0.21	1.88	0.19	0.30	-0.77	-0.58	-0.32	-0.74	-0.72	9.28	1.38	3.76	2.83	-	5.11	5.07	4.92	4.73	4.88	5.09	4.90	5.37
246T	-5.50	-6.79	-5.49	-5.94	-6.81	-7.10	-5.02	-6.70	-6.60	-7.67	-7.47	-7.22	-7.64	-7.61	2.39	-5.51	-3.14	-4.06	-6.90	-	3.22	2.97	2.64	2.90	3.25	2.93	3.67
247	0.01	-1.28	0.02	-0.43	-1.29	-1.59	0.49	-1.19	-1.09	-2.16	-1.96	-1.71	-2.13	-2.10	7.90	-0.00	2.38	1.45	-1.38	5.51	-	2.91	2.57	2.83	3.19	2.87	3.62
248	-0.43	-1.72	-0.43	-0.87	-1.74	-2.04	0.05	-1.64	-1.54	-2.61	-2.41	-2.16	-2.57	-2.55	7.45	-0.45	1.93	1.00	-1.83	5.07	-0.45	-	2.25	2.55	2.94	2.59	3.39
249	-1.05	-2.34	-1.05	-1.49	-2.36	-2.65	-0.57	-2.25	-2.15	-3.22	-3.03	-2.77	-3.19	-3.16	6.83	-1.07	1.31	0.38	-2.45	4.45	-1.06	-0.62	-	2.15	2.60	2.20	3.11
250	1.03	-0.26	1.03	0.59	-0.28	-0.58	1.51	-0.18	-0.07	-1.14	-0.95	-0.69	-1.11	-1.09	8.91	1.01	3.39	2.46	-0.37	6.53	1.01	1.46	2.08	-	2.87	2.50	3.33
262	-0.82	-2.11	-0.82	-1.26	-2.13	-2.43	-0.34	-2.03	-1.93	-2.99	-2.80	-2.54	-2.96	-2.94	7.06	-0.84	1.54	0.61	-2.22	4.68	-0.84	-0.39	0.23	-1.85	-	2.90	3.64
263	0.12	-1.17	0.12	-0.32	-1.19	-1.49	0.60	-1.09	-0.99	-2.05	-1.86	-1.61	-2.02	-2.00	8.00	0.10	2.48	1.55	-1.28	5.62	0.10	0.55	1.17	-0.91	0.94	-	3.36
264	-2.38	-3.67	-2.38	-2.82	-3.69	-3.99	-1.91	-3.59	-3.49	-4.56	-4.36	-4.11	-4.53	-4.50	5.50	-2.40	-0.02	-0.95	-3.78	3.11	-2.40	-1.95	-1.33	-3.41	-1.56	-2.50	-

Table 3.5 : Summary results of GT2 test applied to mean aggregate (all species) standardised catch rate (kg/hour) recorded in 1997/8 at sub-areas in Atchin (200-206), Wala (211-217), Uripiv (221-225), Lelepa (241-250) and Emua (261-264) for all fishing gears combined, indicating which pairs of mean catch rates are significantly different at the 5% level. 'T' and shading indicate comparisons with tabu areas.

	Atchin						Wala		Uripiv					Lelepa					Emua								
	200	201	202	203	204	205	206	211	212	221	222T	223	224	225	241	242	243	244	245	246T	247	248	249	250	262	263	264T
200	-																										
201	n	-																									
202	n	n	-																								
203	n	n	n	-																							
204	n	n	n	n	-																						
205	n	n	n	n	n	-																					
206	n	n	n	n	n	n	-																				
211	n	n	n	n	n	n	n	-																			
212	n	n	n	n	n	n	n	n	-																		
221	n	n	n	n	n	n	n	n	n	-																	
222T	n	n	n	n	n	n	n	n	n	n	-																
223	n	n	n	n	n	n	n	n	n	n	n	-															
224	n	n	n	n	n	n	n	n	n	n	n	n	-														
225	n	n	n	n	n	n	n	n	n	n	n	n	n	-													
241	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-												
242	n	n	n	n	n	n	n	n	n	Y	n	n	n	n	Y	-											
243	n	Y	n	n	Y	n	n	Y	Y	Y	Y	Y	Y	Y	Y	Y	-										
244	n	Y	n	n	Y	n	n	Y	Y	Y	n	Y	Y	Y	Y	n	n	-									
245	n	n	n	n	n	n	n	n	n	n	n	n	n	n	Y	n	n	n	-								
246T	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	n	Y	Y	Y	Y	-							
247	n	n	n	n	n	n	n	n	n	n	n	n	n	n	Y	n	n	n	n	Y	-						
248	n	n	n	n	n	n	n	n	n	Y	n	Y	Y	n	Y	n	n	n	n	Y	n	-					
249	n	Y	n	n	Y	n	n	Y	Y	Y	n	Y	Y	Y	Y	n	n	n	n	Y	n	n	-				
250	n	n	n	n	n	n	n	n	n	n	n	n	n	n	Y	n	Y	Y	n	Y	n	n	n	-			
262	n	n	n	n	n	n	n	n	n	Y	n	Y	Y	n	Y	n	n	n	n	Y	n	n	n	n	-		
263	n	n	n	n	n	n	n	n	n	n	n	n	n	n	Y	n	n	n	n	Y	n	n	n	n	n	-	
264T	n	Y	n	n	Y	n	n	Y	Y	Y	n	Y	Y	Y	Y	n	n	n	n	n	n	n	Y	n	n	-	

Fig 3.1. Gabriel's approximation to the GT2 test applied to mean aggregate (all species) standardised catch rate (kg/hour) recorded in 1997/8 at sub-areas in Atchin (200-206), Wala (211-217), Uripiv (221-225), Lelepa (241-250) and Emua (261-264) for all fishing gears combined. Pairs of means are significantly different when the upper and lower comparison limits do not overlap. Tabu areas are indicated with a 'T'

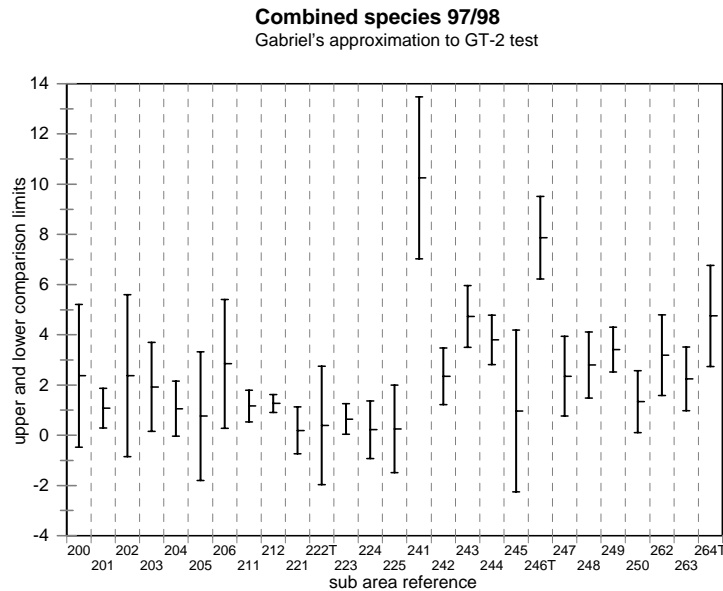


Fig. 3.2 The mean aggregate standardised catch rate (kg/hour) recorded in 1997/8 at Atchin, Wala, Uripiv, Lelepa and Emua for all species and all fishing gears combined for all open access sub-areas within sites (closed circles). The mean aggregate standardised catch rate (kg/hour) recorded in tabu sub areas (open squares) is also indicated.

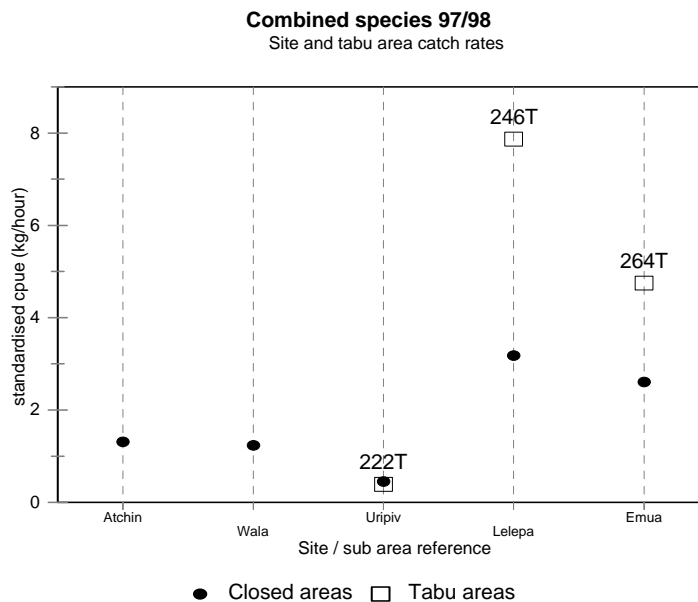


Table 3.6. A summary of the results of the GT2 test and Gabrielle's approximation to test for significant differences (at the 5% level) in mean catch rate observed between sub-areas within sites in Vanuatu for different years and different gear.

Species	Gear	Year	Site	Observations
All	All	1996/7	Atchin	No sub area differences
All	All	1996/7	Wala	No sub area differences
All	All	1996/7	Uripiv	No sub area differences
All	All	1996/7	Lelepa	No sub area differences
All	Gillnets	1996/7	Atchin	No sub area differences
All	Gillnets	1996/7	Wala	No sub area differences
All	Gillnets	1996/7	Uripiv	No sub area differences
All	Gillnets	1996/7	Lelepa	244>249, rest No difference
All	Handlines	1996/7	Atchin	203<200=201, rest =
All	Handlines	1996/7	Wala	No sub area differences
All	Handlines	1996/7	Uripiv	No sub area differences
All	Handlines	1996/7	Lelepa	No sub area differences
All	Spears	1996/7	Wala	No sub area differences
All	Spears	1996/7	Uripiv	224>223=221>225
All	Spears	1996/7	Lelepa	246(T)>247=249; All rest no difference
All	All	1997/8	Atchin	No sub area differences
All	All	1997/8	Wala	No sub area differences
All	All	1997/8	Uripiv	No sub area differences
All	All	1997/8	Lelepa	241=246(T) > all other sub areas (243>242; 250<243, 244)
All	All	1997/8	Emua	No sub area differences
All	Gillnets	1997/8	Atchin	No sub area differences
All	Gillnets	1997/8	Wala	No sub area differences
All	Gillnets	1997/8	Uripiv	No sub area differences
All	Gillnets	1997/8	Lelepa	246>244=249>247
All	Gillnets	1997/8	Emua	No sub area differences
All	Handlines	1997/8	Atchin	No sub area differences
All	Handlines	1997/8	Wala	No sub area differences
All	Handlines	1997/8	Uripiv	No sub area differences
All	Handlines	1997/8	Lelepa	241>243> rest no difference
All	Handlines	1997/8	Emua	No sub area differences
All	Spears	1997/8	Atchin	203>201=204
All	Spears	1997/8	Wala	No sub area differences
All	Spears	1997/8	Uripiv	No sub area differences
All	Spears	1997/8	Lelepa	246>>243> rest no difference
All	Spears	1997/8	Emua	No sub area differences

In order to examine differences in relative abundance between sub areas subject to different levels of fishing intensity, the natural logarithm of mean sub area catch rates were plotted against standardised total effort per annum (hours.km⁻².year⁻¹). Where environmental factors are assumed to be equal, this approach to spatial data is known as a Munro-Thompson plot (Munro and Thompson, 1983), and is equivalent to a Fox surplus production model. These plots were generated for representative gear types (gill nets, handlines and spears), and aggregated data for all gear types for each study year (Table 3.7 and Figs 3.3-3.4).

Table 3.7 indicates that no significant correlation between ln.catch rate and fishing intensity occurred in 1996/7 for any gear type. During 1997/8 catch rates were observed to decrease significantly with increasing fishing intensity for spear guns (P=0.06). Regression lines have been fitted to these data plots (Fig 3.4D). The fishing intensity in tabu areas is expected to be low. Catch rates in these areas would be expected to fall on or about the regression line for any given fishing intensity. Data exists for three areas (222, 246 and 264). In general, catch rates for areas 246 and 264 tended to be high relative to fishing intensity, and that for 222 was low, but this was not consistent across all gear types (Table 3.7). It will be recalled from the GT2 analyses, that in fact, only 246 stood out as being significantly different from other sub-areas, and especially for spears, catch rates at that site are higher than expected for the level of fishing effort (Fig 3.4D).

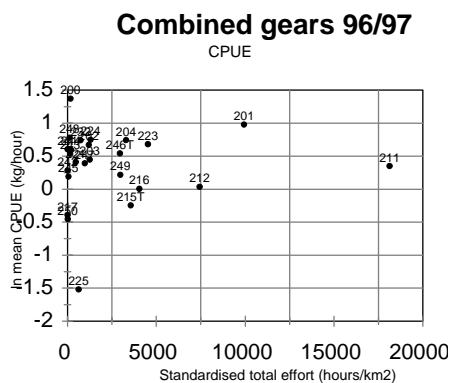
Summary : Observed catch rate data from fishing surveys are poorly correlated with fishing intensity. Limited data was available for tabu areas, and results were not consistent for the three areas studied. Area 222 had low / expected catch rates, those at 264 were as expected, whilst those at 246 tended to be higher than expected relative to fishing intensity.

Table 3.7: Results of the regression of Ln.catch rate by sub area against standardised total effort for representative gear types and all gears in 1996/7 and 1997/8. The column 'Tabu' highlights the status of tabu areas relative to others at similar levels of fishing intensity. Sig? indicates the level of significance of the regression. N is >0.1.

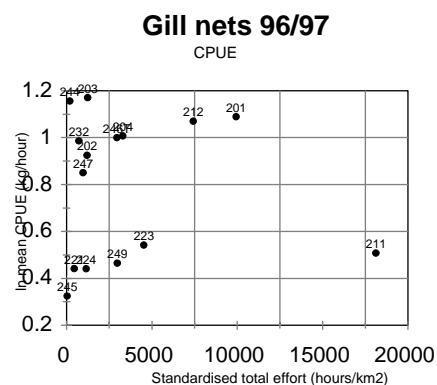
Gear	Year	Across sites	Ln cpue and standardised effort data			
			Trend	Tabu	R^2	Sig?
Gill net	1996/1997	Atchin, Wala, Lelepa, Uripiv	-	246 no difference	0.002	N
	1997/1998	Atchin, Wala, Lelepa, Uripiv, Emua	Decrease	246, 264 high	0.021	N
Handline	1996/1997	Atchin, Wala, Lelepa, Uripiv	Increase	246 no difference	0.057	N
	1997/1998	Atchin, Wala, Lelepa, Uripiv, Emua	Decrease	264, 246, 222 no difference	0.045	N
Spear gun	1996/1997	Wala, Lelepa, Uripiv	-	246 no diff	0.001	N
	1997/1998	Atchin, Wala, Lelepa, Uripiv, Emua	Decrease	246 well above line	0.162	0.06
All gears	1996/1997	Atchin, Wala, Lelepa, Uripiv	Increase	246, 215 no difference	0.005	N
	1997/1998	Atchin, Wala, Lelepa, Uripiv, Emua	Decrease	246, 264 high, 222 low	0.033	N

Figs. 3.3 A-D. Munro-Thompson plots of spatial catch rate data (kg/hour, by sub area, indicated) against standardised total effort (hours.km⁻²) in 1996/7 for all gears and representative gear types.

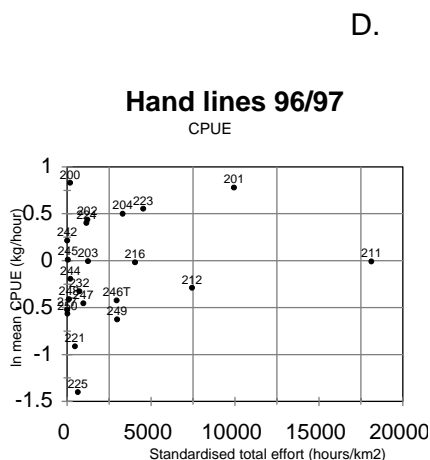
A.



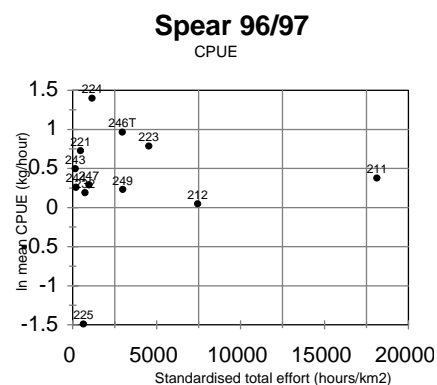
B.



C.

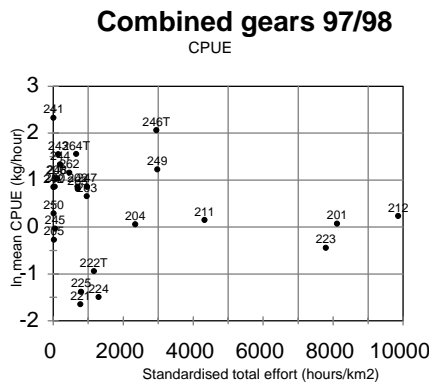


D.

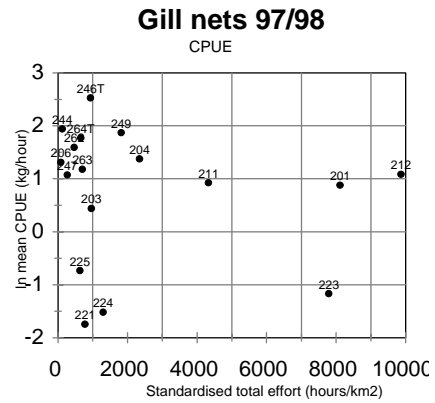


Figs. 3.4 A-D. Munro-Thompson plots of spatial catch rate data (kg/hour, by sub area, indicated) against standardised total effort (hours.km⁻²) in 1997/8 for all gears and representative gear types. Regression lines have been fitted where a significant (P<=0.5) correlation occurred.

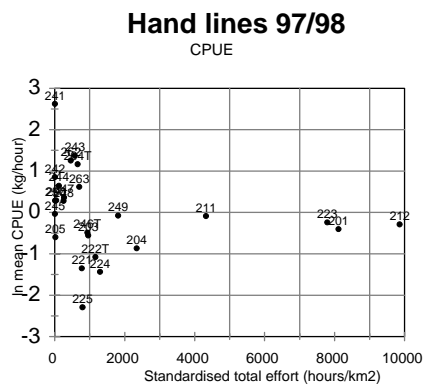
A.



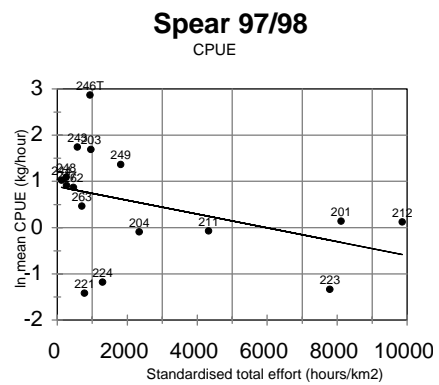
B.



C.



D.



3.3 Population demographic variables

Data collectors recorded the length of all fish landed from any sampled fishing trip, and did not target particular species. The number of fish sampled by species and site was computed. Species and sites where the sample size was 100-249, 249-499 and 500+ were highlighted in order to assist in the identification of suitable key species for further study. Based on sample size, the following species were considered suitable for comparisons either between sites, or for sub-areas within sites:

Species	Within site	Accross site
<i>Acanthurus lineatus</i>	Wala	Yes
<i>Acanthurus triostegus</i>	Wala	Yes
<i>Ctenochaetus striatus</i>	Lelepa	Yes
<i>Lethrinus harak</i>	Uripiv, Wala	Yes
<i>Siganus lineatus</i>	Wala	Yes
<i>Siganus argenteus</i>		Yes
<i>Acanthurus nigricauda</i>	Lelepa	No
<i>Lutjanus kasmira</i>	Atchin	No
<i>Naso lituratus</i>	Lelepa	No
<i>Monotaxis grandoculis</i>	Lelepa	No
<i>Parupeneus barberinus</i>	Lelepa	No
<i>Scarus shlegeli</i>	Lelepa, Pellonk	No
<i>Scarus flavipectoralis</i>	Uripiv	No
<i>Scarus niger</i>	Wala	No
<i>Variola louti</i>	Lelepa	No

Length frequency data from these 'key' species were employed to determine mean length, growth rate, and mortality rate by sub-area or site (see Methodology, Volume 1 Chapter 2). These variables were compared across sub-areas and sites to examine differences between tabu and open access areas in particular. Population demographic variables were also correlated with fishing intensity (standardised total effort) and abundance indices (catch rate).

3.3.1 Mean Length

Length frequency data was generated by species for each gear-type and sub-area aggregated over the sampling period (November 1996 - June 1998). This data was analysed using a GT2 test and Gabriel's approximation (Sokal and Rohlf, 1995) which enables multiple comparisons among pairs of means based on unequal sizes. All sub-area/gear frequency distributions with less than a sample size of 5 were deleted. The results of these tests are illustrated by the example of *Lutjanus kasmira* caught by handlines in Atchin (Tables 3.8-3.10 And Fig. 3.5). The results of both the GT2 test and Gabrielle's approximation indicate that the mean length of fish caught at sub area 200 is significantly greater than that of fish caught in sub area 202. There are no other significant differences between sub-areas. The results for other species, gears and sub-area comparisons are indicated in Annex V3, and summarised in Table 3.11 for within site comparisons, and Table 3.12 for across site comparisons.

Table 3.8 : Mean fork length (cm), sample size, standard deviation, variation and standard error, for *Lutjanus kasmira*, at sub areas in Atchin, caught with handlines

Details	Sub area and gear					
	200.4	201.4	202.4	203.4	204.4	205.4
Mean	19.82	18.22	16.60	17.29	17.19	20.30
n	33	181	98	118	104	10
SD	4.48	5.24	4.71	5.18	4.58	3.77
Var	20.09	27.48	22.20	26.84	20.93	14.23
n-1	32	180	97	117	103	9
SE	0.74	0.14	0.25	0.21	0.24	2.45

Table 3.9 GT2 Test applied to length frequency data for *Lutjanus kasmira* from Atchin, caught by handlines. The critical value for K, K* (6, 15) where 6= the number of data sets being compared and $K^* = K(K-1)/2$ with 538 degrees of freedom is 2.742 at 5% error level. Pairs of means are significantly different if their difference equals or exceeds the critical difference.

Meani-Meanj	MSDij					
	200.4	201.4	202.4	203.4	204.4	205.4
200.4	-	2.742	2.915	2.852	2.894	5.229
201.4	1.603	-	1.817	1.714	1.782	4.706
202.4	3.216	1.613	-	1.980	2.039	4.809
203.4	2.530	0.927	-0.686	-	1.948	4.771
204.4	2.626	1.023	-0.590	0.096	-	4.796
205.4	-0.482	-2.085	-3.698	-3.012	-3.108	-

Table 3.10 : Summary results of GT2 test applied to length frequency data for *Lutjanus kasmira* from Atchin, caught by handlines indicating which pairs of mean lengths are significantly different at the 5% level.

	200.4	201.4	202.4	203.4	204.4
200.4	-				
201.4	n	-			
202.4	Y	n	-		
203.4	n	n	n	-	
204.4	n	n	n	n	-
205.4	n	n	n	n	n

Fig 3.5. Gabriel's approximation to the GT2 test applied to length frequency data for *Lutjanus kasmira* from Atchin, caught by handlines. Pairs of means are significantly different when the upper and lower comparison limits do not overlap.

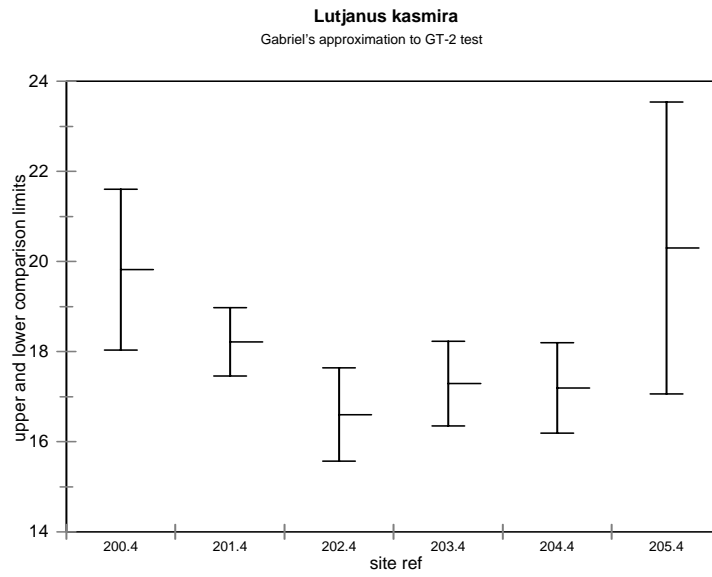


Table 3.11 : A summary of the results of the GT2 test and Gabrielle's approximation to test for significant differences (at the 5% level) in mean length of fish between sub-areas within sites, by species and fishing method (Refer to Annex? For full details).

Species	Gear	Site	Observations
<i>Lutjanus kasmira</i>	String	Atchin	202<200, rest=
<i>Acanthurus nigricauda</i>	Gill net	Lelepa	no sub area differences
<i>Lethrinus harak</i>	Gill net	Lelepa	no sub area differences
<i>Monotaxis grandocculis</i>	Gill net	Lelepa	no sub area differences
<i>Naso Lituratus</i>	Gill net	Lelepa	no sub area differences
<i>Parupeneus barberinus</i>	Gill net	Lelepa	no sub area differences
<i>Scarus schegeli</i>	Gill net	Lelepa	no sub area differences
<i>Variola louti</i>	Gill net	Lelepa	no sub area differences
<i>Acanthurus nigricauda</i>	Spear	Lelepa	no sub area differences
<i>Acanthurus nigricauda</i>	Spear gun	Lelepa	243>other sub areas
<i>Monotaxis grandocculis</i>	Spear gun	Lelepa	243>other sub areas
<i>Naso Lituratus</i>	Spear gun	Lelepa	no sub area differences
<i>Parupeneus barberinus</i>	Spear gun	Lelepa	no sub area differences
<i>Scarus schegeli</i>	Spear gun	Lelepa	no sub area differences
<i>Variola louti</i>	Spear gun	Lelepa	no sub area differences
<i>Acanthurus nigricauda</i>	Handline	Lelepa	no sub area differences
<i>Lethrinus harak</i>	Handline	Lelepa	no sub area differences
<i>Monotaxis grandocculis</i>	Handline	Lelepa	243>other subareas, 242> some
<i>Parupeneus barberinus</i>	Handline	Lelepa	243,245> rest(inc 246T)
<i>Variola louti</i>	Handline	Lelepa	243>other sub areas>249
<i>Lethrinus harak</i>	Gill net	Uripiv	no sub area differences
<i>Lethrinus harak</i>	Handline	Uripiv	222= all areas, 223>221,224,225
<i>Scaus flavipectoralis</i>	Gill net	Uripiv	no sub area differences
<i>Scaus flavipectoralis</i>	Spear gun	Uripiv	no sub area differences
<i>Acanthurus lineatus</i>	Spear gun	Wala	no sub area differences
<i>Acanthurus triostegus</i>	Gill net	Wala	no sub area differences
<i>Acanthurus triostegus</i>	Spear gun	Wala	no sub area differences
<i>Acanthurus triostegus</i>	Parachute	Wala	no sub area differences
<i>Lethrinus harak</i>	Gill net	Wala	215<212(both=211)
<i>Siganus spinus</i>	Gill net	Wala	211=212
<i>Siganus spinus</i>	Parachute	Wala	211=212
<i>Siganus spinus</i>	Spear gun	Wala	211=212
<i>Naso Lituratus</i>	Spear gun	Wala	211>215T (rest=)
<i>Lethrinus harak</i>	Handline	Wala	214T<211,212,216; 215T =all
<i>Naso Lituratus</i>	Handline	Wala	no sub area differences
<i>Siganus spinus</i>	Handline	Wala	211>212
<i>Scarus niger</i>	Gillnet	Wala	212>211; 214T=all
<i>Scarus niger</i>	Handlines	Wala	211>215T only
<i>Scarus niger</i>	Spear gun	Wala	no sub area differences
<i>Siganus lineatus</i>	Spear gun	Wala	no sub area differences

Table 3.12 : A summary of the results of the GT2 test and Gabrielle's approximation to test for significant differences (at the 5% level) in mean length of fish between sub-areas across sites, by species and fishing method (Refer to Annex? For full details).

Species	Gear	Observations
Acanthurus lineatus	Gill net	Atchin, Wala (212) and Lelepa > Uripiv, Wala (211)
Acanthurus triostegus	Gill net	a number of sub area differences mostly between sites but some within ((atchin, Uripiv), Generally, Atchin, Pellonk>Lelepa, wala>Uripiv
Ctenochaetus striatus	Gill net	Some within site differences (Atchin, 200>others; Wala , 212>211, Llelepa, 246T>249), but major differences between sites Atchin, Pellonk, Lelepa>Wala, Uripiv
Lethrinus harak	Gill net	Lelepa, Wala(XPT 215),Pellonk>Uripiv
Siganus argenteus	Gill net	Pellonk, Atchin, Wala,Lelepa(xpt 245)>Uripiv
Siganus lineatus	Gill net	Pellonk, Atchin>Wala, Uripiv, Lelepa
Siganus argenteus	other gears	few data
Acanthurus triostegus	Parachute	No sub area or site differences
Acanthurus triostegus	Spear	No sub area or site differences
Ctenochaetus striatus	Spear	Lelepa>Wala=Uripiv
Acanthurus lineatus	Spear	Atchin, Lelepa, Uripiv (223) > Uripiv 221
Acanthurus lineatus	Spear gun	Atchin, Wala (214-6) and Lelepa > Uripiv, (Wala (211and 212 slightly lower))
Acanthurus triostegus	Spear gun	No sub area or site differences
Ctenochaetus striatus	Spear gun	Atchin (200,202,204)> Atchin (201, Lelepa, Uripiv, Wala (211,212)>Wala (215)
Lethrinus harak	Spear gun	Lelepa, Wala>Uripiv(XPT 222T)
Siganus lineatus	Spear gun	No sub area or site differences, but few data
Acanthurus lineatus	string	No sub area or site differences
Acanthurus triostegus	String	Lelepa> Atchin, Wala
Ctenochaetus striatus	String	No sub area or site differences
Lethrinus harak	String	Lelepa, Wala,Pellonk, Atchin>Uripiv(XPT 222T)
Siganus lineatus	String	210 (Atchin)> Atchin, Wala, Uripiv

Within site comparisons were made to explore any differences in mean length of fish, particularly between tabu and open access areas. Data were compared for representative gear types, but not between different gear types. Gear selectivity affects the size of fish caught, but it was not the aim of the present study to examine this. Table 3.11 (see Annex V3 for details) indicates that few sub-area differences occurred within sites for any species or any gear type. Data for tabu areas was not available for every site, species and gear. That available for species with a sufficient sample size to enable within site comparisons is indicated in Table 3.13 which summarises the observations of mean length in tabu areas compared to those observed in open access areas. Fish caught in Tabu areas in Lelepa, Uripiv and Wala areas did not differ in mean length from fish caught in open access areas (e.g. see *L. harak*, *P. barberinus* in Annex V3). In some cases certain open access areas had larger fish than were observed in tabu areas (and in other open access areas). These areas were Eretoka Island (243) at Lelepa, and an open water area (245) at that site, and the NW quadrant (211) of Wala. Such differences were considered to relate to particular features of those sub-areas, rather than any effect of management or otherwise. The effects of fishing

intensity are explored below. Inconsistent differences between sites and gears were found for tabu areas 214 and 215 at Wala for *Lethrinus harak*.

Table 3.12 indicates comparison of mean lengths of fish across sites. For each gear type site differences in mean length of fish were observed. Although these were not consistent, the general picture was that fish were larger at sub areas within Atchin, Pellonk, Wala, Lelepa, and Uripiv in descending order. Such differences may relate to either environmental characteristics or fishing intensity. The latter is examined below.

Summary: Few differences in mean length between sub areas within fishing sites were observed for any species or gear type. No significant differences in mean length occurred for fish caught in tabu areas compared to open access areas.

Significant differences in mean length occurred between sites, although not consistent, the trend was Atchin, Pellonk, Wala, Lelepa, and Uripiv in descending order.

Table 3.13 A summary of observations relating to mean length of fish caught in tabu areas compared to those caught in open access areas.

Species	Site	Gear	Tabu	Observations
<i>Acanthurus nigricauda</i>	Lelepa	Handlines, spear guns	246	Fish from tabu area had no significant difference in mean length to those from any other area, except 243 (Eretoka Island) with spear guns.
<i>Monotaxis grandoculis</i>	Lelepa	Gill net, handlines, spear gun	246	Fish from tabu area had no significant difference in mean length to those from any other area, except 243 (Eretoka Island) with spear guns, and with handlines
<i>Naso lituratus</i>	Lelepa	Spear, gill net	246	No difference between tabu and open access areas
<i>Parupeneus barberinus</i>	Lelepa	Gill net, handlines, spear	246	No difference between tabu and open access areas for gill net and spear, Areas 243 and 245 > tabu area (246) with handlines
<i>Scarus shlegeli</i>	Lelepa	Gill net, spear gun	246	No difference between tabu and open access areas
<i>Variola louti</i>	Lelepa	Gill net, handlines	246	No difference with gill nets. Area 243 > tabu area with handlines
<i>Lethrinus harak</i>	Uripiv	Handlines	222	No difference between tabu and open access areas
<i>Acanthurus lineatus</i>	Wala	Spear gun	214, 215	No difference between tabu and open access areas
<i>Acanthurus triostegus</i>	Wala	Gill net, Spear gun, parachute	214, 215, 215 respectively	No difference between tabu and open access areas
<i>Lethrinus harak</i>	Wala	Gill nets, handlines	215, 214+215 respectively	Fish at 215 greater than 212 only for gill nets, but no sub area differences for handlines. By contrast with handlines 214 > 3 areas, but not the other tabu area (215)
<i>Scarus niger</i>	Wala	Gill net, handlines, spear gun	214, 215, 215 respectively	No difference with spear guns or gill nets. with handlines area 211 > tabu area 215.
<i>Siganus lineatus</i>	Wala	Spear gun	215	No difference between tabu and open access areas

In order to examine potential effects of fishing on fish size, the mean length of fish sampled by key-species and sub area was correlated for representative gears against standardised total fishing effort, and standardised catch rate. Annex V4 indicates the details of these analyses which are summarised in Tables 3.14 and 3.15.

In most cases there was no correlation between mean length and fishing intensity (Table 3.14), but in six cases a significant correlation occurred. Four related to spear guns (*Ctenochaetus striatus*, *Siganus lineatus*, *Siganus argenteus*, and *Naso lituratus*), and two to gill nets (*Naso lituratus* and *Monotaxis grandoculis*). The results for gill nets were inconsistent, one indicating a decrease in mean length with increased fishing pressure, and the other an increase. The spear gun data consistently showed a significant decrease in mean length with increasing fishing intensity, as would be predicted. The mean length of fish in tabu areas was generally consistent with that predicted for the given level of fishing intensity (e.g. sub area 215 at Wala, *Siganus lineatus*, Fig 3.6; sub area 246 at Lelepa, *Ctenochaetus striatus*, Fig 3.7) although for certain species and gear types fish in the Lelepa tabu area (246) tended to be larger than would be predicted, and fish in the Wala tabu area (215) tended to be smaller. Figure 3.7 illustrates this for area 215 and *C. striatus* (see also Annex V4).

Fig. 3.6 Regression of mean fork length (cm) of *Siganus lineatus* caught by spear guns at sub areas in Vanuatu during the period November 1996-October 1998, against total standardised fishing effort.

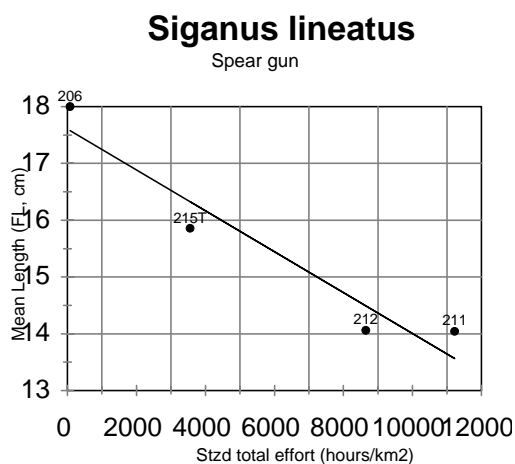
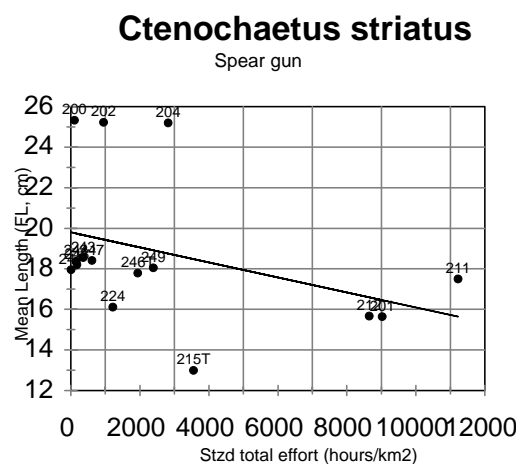


Fig. 3.7 Regression of mean FL (cm) of *Ctenochaetus striatus* caught by spear guns at sub areas in Vanuatu during the period Nov 1996-October 1998, against total standardised fishing effort .

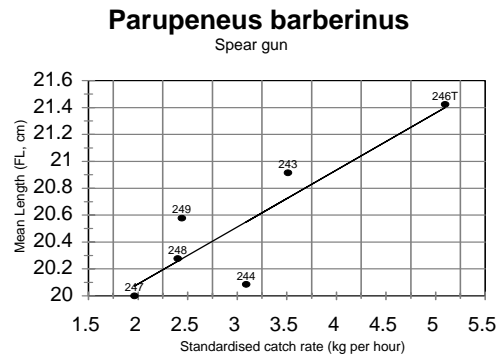
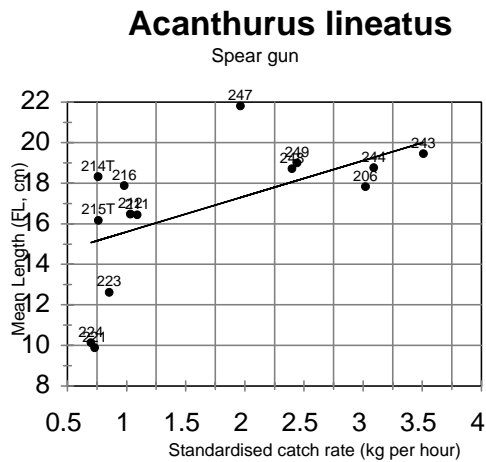


Mean length was significantly correlated to abundance for 14 (of 35) species/gear combinations studied ($P < 0.1$, of which 10 data sets, $P \leq 0.05$), 10 of which related to spears or spear guns, 3 related to gill nets and one to handlines (Table 3.15). Data for spears and spear guns is more likely to reflect the population size structure than hand-lines or gill nets which may be subject to mesh and hook size selectivity at different sites. Information on mesh and hook size was not available. A significant increase in mean length was indicated with increasing abundance (as would be predicted) for all species/gear except *Naso lituratus* with gill nets and spear guns (*Ctenochaetus striatus*, *Lethrinus harak*, *Siganus lineatus*, *Acanthurus lineatus*, *Parupeneus barberinus*, *Scarus schlegeli*, *Scarus flavipectoralis* and *Scarus niger*). As was the case with fishing intensity, tabu areas showed some variation about the predicted mean length for any given level of abundance, but were generally

consistent with expectation (e.g. 214,215 at Wala, *Acanthurus lineatus* Fig. 3.8; 246 at Lelepa, *Parupeneus barberinus*, Fig 3.9. See also Annex V4).

Fig. 3.8 Regression of mean fork length (cm) of *Acanthurus lineatus* caught by spear guns at sub areas in Vanuatu during the period November 1996-October 1998, against standardised catch rate.

Fig. 3.9 Regression of mean FL (cm) of *Parupeneus barberinus* caught by spear guns at sub areas in Vanuatu during the period Nov 1996-October 1998, against standardised catch rate.



Summary : Although not consistent for all species and gear, a significant correlation existed between mean length of fish caught and both fishing intensity and abundance. This was most apparent for spears and spear guns and the species : *Acanthurus lineatus*, *Ctenochaetus striatus*, *Lethrinus harak*, *Siganus lineatus*, *Siganus argenteus*, *Naso lituratus*, *Monotaxis grandoculis*, *Parupeneus barberinus*, *Scarus schlegeli*, *Scarus flavipectoralis* and *Scarus niger*. The mean length of fish caught in tabu areas showed some variation, but tended to be consistent with that predicted for the level of fishing intensity occurring within them.

Table 3.14. Summary results of regression analyses to investigate correlation between mean length of key species landed at sub areas across sites for representative gear types and standardised effort as an index of fishing intensity. The column 'Tabu' highlights the status of tabu areas relative to others at similar levels of fishing intensity. Sig? indicates the level of significance of the regression. N is >0.1.

Species	Within site	Across site	Gear	Standardised effort		R ²	Sig?
				Trend	Tabu		
Ctenochaetus striatus	Lelepa	Yes	Gill net	Decrease	246, No difference	0.094	N
			Handline	Decrease	n/a	0.109	N
			Spear gun	Decrease	246 on, 215 below predicted line	0.138	0.09
Lethrinus harak	Uripiv, Wala	Yes	Spear	Decrease	n/a	0.074	N
			Gill net	Increase	215 below, 246 on predicted line	0.078	N
			Hand lines	Increase	214, 215, 222 no difference	0.037	N
Siganus lineatus	Wala	Yes	Spear gun	Increase	246 above predicted line	0.136	N
			Gill net	Increase	246 no difference	0.017	N
			Hand lines	Increase	n/a	0.139	N
Acanthurus triostegus	Wala	Yes	Spear gun	Decrease	215 on predicted line	0.923	0.02
			Gill net	Decrease	214, 246 no difference	0.004	N
			Hand lines	Decrease	n/a	0.255	N
Acanthurus lineatus	Wala	Yes	Spear gun	Decrease	215 below predicted line	0.178	N
			Gill net	Decrease	246 on predicted line	0.143	N
			Spear gun	Decrease	214, 215 on predicted line	0.030	N
Siganus argenteus			Spear				
			Gill net		246 no difference		
			Spear gun	Decrease	n/a	0.804	0.05
Lutjanus kasmira	Atchin	Data = Atchin only	Hand lines		n/a		
Naso lituratus	Lelepa	Wala and Lelepa	Gill net	Decrease	246 above predicted line	0.803	0.003
			Spear gun	Decrease	246 above, 215 below predicted line	0.287	0.04
			Gill net	Increase	246 above predicted line	0.899	0.03
Monotaxis grandoculis	Lelepa	Lelepa only	Hand lines	Decrease	246 no difference	0.013	N
			Spear gun	Decrease	246 low	0.102	N
			Hand lines	Decrease	246 no difference	0.064	N
Variola louti	Lelepa	Lelepa only	Hand lines	Decrease	246 no difference	0.064	N
Acanthurus nigricauda	Lelepa	Lelepa, and 232 Pellonk Lelepa only	Gill net		n/a, 232 higher than Lelepa		
			Spear Gun	Decrease	246 no difference	0.023	N
			Gill net		246 no difference		
Parupeneus barberinus	Lelepa	Uripiv, Pellonk, mostly Lelepa	Hand lines	Decrease	246 on predicted line	0.294	N
			Spear gun	Increase	246 high	0.298	N
			Gill net	Increase	246 no difference	0.056	N
Scarus shlegeli	Lelepa, Pellonk	Lelepa and 232, pellonk	Spear gun	Increase	246 high	0.271	N
			Gill net	Decrease	n/a	0.027	N
Scarus flavipectoralis	Uripiv	Uripiv and Lelepa	Spear gun	Decrease	246 above predicted line	0.064	N
			Gill net	Decrease	215 below predicted line	0.323	N
Scarus niger	Wala	Wala and 206, Atchin	Spear gun	Decrease	215 below predicted line	0.323	N

Table 3.15. Summary results of regression analyses to investigate correlation between mean length of key species landed at sub areas across sites for representative gear types and standardised catch rate as an index of abundance. The column 'Tabu' highlights the status of tabu areas relative to others at similar levels of abundance. Sig? indicates the level of significance of the regression. N is >0.1.

Species	Within site	Across site	Gear	Standardised catch rate			
				Trend	Tabu	R ²	Sig?
Ctenochaetus striatus	Lelepa	Yes	Gill net	Increase	246 on predicted line	0.042	N
			Handline	Increase	n/a	0.454	N
			Spear gun		215 low		
Lethrinus harak	Uripiv, Wala	Yes	Spear	Increase	n/a	0.514	0.05
			Gill net	Increase	215, 246 on predicted line	0.049	N
			Hand lines	Increase	214 on, 215 above predicted line	0.343	0.01
Siganus lineatus	Wala	Yes	Spear gun	Increase	246 on predicted line	0.283	0.05
			Gill net	Decrease		0.091	N
			Hand lines	Decrease	n/a	0.034	N
Acanthurus triostegus	Wala	Yes	Spear gun	Increase	215 above line	0.674	0.09
			Gill net	Increase	214, 246 no difference/low	0.002	N
			Hand lines	Increase	n/a	0.287	N
Acanthurus lineatus	Wala	Yes	Spear gun		215 no difference	0.002	N
			Gill net	Increase	246 below predicted line	0.331	0.03
			Spear gun	Increase	214 above, 215 on predicted line	0.305	0.02
Siganus argenteus			Spear	Increase	215 above predicted line	0.532	0.08
			Gill net	Increase	246 below predicted line	0.178	0.09
			Spear gun	Increase	n/a	0.562	N
Lutjanus kasmira	Atchin	Data = Atchin only	Hand lines		n/a, 205 chanel> reef areas		N
Naso lituratus	Lelepa	Wala and Lelepa	Gill net	Decrease	246 above predicted, all Lelepa similar	0.803	0.003
			Spear gun	Decrease	215 below, 246 above predicted line	0.288	0.04
Monotaxis grandoculis	Lelepa	Lelepa only	Gill net	Increase	246 high	0.310	N
			Hand lines	Decrease	246 no different	0.034	N
			Spear gun		246 low	0.007	N
Variola louti	Lelepa	Lelepa only	Hand lines		246 no difference	0.002	N
Acanthurus nigricauda	Lelepa	Lelepa, and 232 Pellonk Lelepa only	Gill net	Decrease	n/a, 232 higher than Lelepa	0.342	N
			Spear gun	Increase	246 low	0.121	N
Parupeneus barberinus	Lelepa	Uripiv, Pellonk, mostly Lelepa	Gill net	Increase	246 below predicted line	0.055	N
			Hand lines		246 low		
			Spear gun	Increase	246 on predicted line	0.767	0.01
Scarus shlegeli	Lelepa, Pellonk	Lelepa and 232, pellonk	Gill net	Decrease	246 high	0.026	N
			Spear gun	Increase	246 on predicted line	0.674	0.09
Scarus flavipectoralis	Uripiv	Uripiv and Lelepa	Gill net	Increase	n/a	0.172	N
			Spear gun	Increase	246 on predicted line	0.729	0.01
Scarus niger	Wala	Wala and 206, Atchin	Spear gun	Increase	215 on predicted line	0.865	0.0

3.3.2 Growth parameter estimates

Length frequency data were aggregated for all gear types and all sub-areas within sites in order to generate sufficiently large monthly data sets for estimation of growth parameters using length based methods of assessment. Only a limited number of species had sufficiently large sample size and time series of information. Growth parameter estimates are indicated in Table 3.16. No attempt was made to determine growth by sub-area or to correlate these data with fishing intensity.

Table 3.16: Growth Parameter estimates

Species	Parameter	Site				
		Atchin	Lelepa	Pellonk	Uripiv	Wala
<i>A. lineatus</i>	Linf		39.52		39.88	
	K		0.145		0.148	
	to		-0.3		-0.53	
<i>A. triostegus</i>	Linf	23.88				31.54
	K	0.113				0.5
	to	-0.75				-0.31
<i>L. harak</i>	Linf		38.25	45.11	30.58	45.01
	K		0.156	0.214	0.313	0.201
	to		-0.54	-0.16	-0.15	-0.1
<i>C. striatus</i>	Linf	32.14				34.65
	K	0.104				0.102
	to	-0.98				-0.26

3.3.3 Fishing mortality

Total (Z) and fishing mortality (F) are positively correlated with fishing intensity, and negatively correlated with abundance. To test whether the expected correlation existed for key study species total mortality estimates were derived, and correlated against total standardised fishing effort for the study period, and against standardised catch rate, as an index of abundance. As was the case for growth parameter estimation, only a limited number of species had sufficiently large sample size and time series of information. Mortality estimates were calculated using both growth parameter estimates derived from the present study, and those reported in the literature. Full details of mortality estimates derived by species and sub area are given in Annex V5.

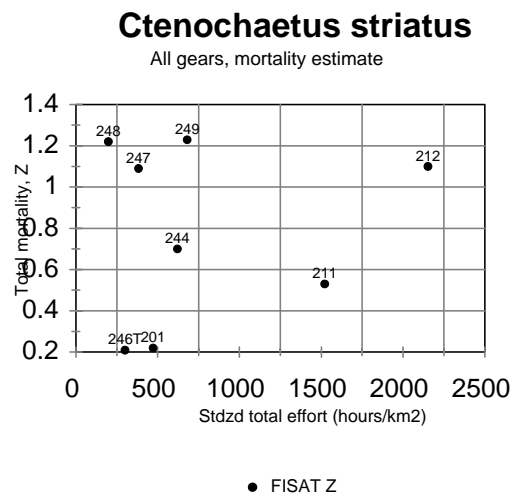
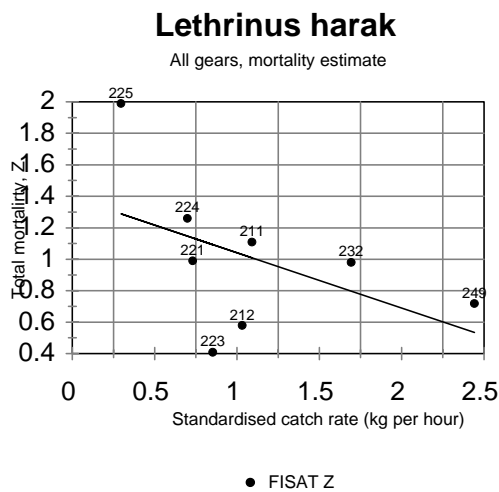
Tables 3.17 and 3.18 summarise the results of regression of mortality estimates against standardised catch rate and effort. No significant correlation was observed between total mortality by sub-area and fishing intensity (effort) for any species studied. Total mortality by sub area was negatively correlated with total abundance (catch rate) for *Lethrinus harak* (Fig 3.10), but no other species indicated any significant correlation. Insufficient data were available to determine mortality estimates in tabu areas except for *Ctenochateus striatus* in area 246, Lelepa. Total mortality was low for that species at that area (Fig 3.11).

Length based methods of assessment of growth and mortality are subject to uncertainty. Mortality estimates are sensitive to the growth parameter estimates employed to derive them.

This has been explored in other Fisheries Management science Programme Projects, to which the reader is referred : R5484, Analysis of Multispecies Tropical Fisheries; R6465 : Growth parameter estimation and the effect of fishing on size composition and growth of snappers and groupers: implications for management - Phase I and II. Given the level of uncertainty of mortality estimates derived from length based methods of assessment, the lack of significant correlations is unsurprising.

Fig. 3.10. To illustrate correlation between total mortality, (Z) and abundance (catch rate) for *Lethrinus harak* caught at sub areas within Vanuatu November 1996- October 1998.

Fig 3.11 To illustrate lack of correlation between total mortality (Z) and fishing intensity (effort) for *C. striatus* at sub areas in Vanuatu, Nov. 96 - Oct. 98. Note the low mortality observed in Tabu area 246T.



Summary : Total mortality was not significantly correlated to fishing intensity or abundance for any species studied, except *Lethrinus harak*. This reflects inaccuracies in mortality estimation using length based methods of assessment. Insufficient data were available to determine mortality estimates in tabu areas except for *Ctenochateus striatus* in area 246, Lelepa, where total mortality was low.

Table 3.17. Summary of regression analyses, for total mortality estimates against standardised catch rate and standardised effort using growth parameter estimates from published data. The column 'Tabu' highlights the status of tabu areas relative to others at similar levels of fishing intensity. Sig? indicates the level of significance of the regression. N is >0.1.

Species	Within site	Across site	Gear	Standardised catch rate				Standardised effort			
				Trend	Tabu	R ²	Sig?	Trend	Tabu	R ²	Sig?
Ctenochaetus striatus	Lelepa	Yes	All	Increase	n/a	0.231	N	Decrease	n/a	0.284	0.09
Lethrinus harak	Uripiv, Wala	Yes	All	Decrease	n/a	0.397	0.05	Decrease	n/a	0.047	N
Acanthurus lineatus	Wala	Yes	All	Increase	n/a	0.031	N	Increase	n/a	0.044	N
Lutjanus kasmira	Atchin	No	All	Decrease	n/a	0.046	N	Decrease	n/a	0.358	N
Scarus schlegeli	Lelepa	Yes	All	Increase	n/a	0.598	N	Decrease	n/a	0.007	N
Scarus flavipectoralis	Uripiv	No	All	Decrease	n/a	0.574	N	Decrease	n/a	0.300	N

Table 3.18. Summary of regression analyses, for total mortality estimates against standardised catch rate and standardised effort using growth parameter estimates calculated from the data. The column 'Tabu' highlights the status of tabu areas relative to others at similar levels of fishing intensity. Sig? indicates the level of significance of the regression. N is >0.1.

Species	Within site	Across site	Gear	Standardised catch rate				Standardised effort			
				Trend	Tabu	R ²	Sig?	Trend	Tabu	R ²	Sig?
Ctenochaetus striatus	Lelepa	Yes	All	Increase	246 low	0.003	N	Increase	246 low	0.019	N
Lethrinus harak	Uripiv, Wala	Yes	All	Decrease	n/a	0.235	N	Decrease	n/a	0.169	N
Acanthurus triostegus	Wala	Yes	All	Decrease	n/a	0.868			N		
Acanthurus lineatus	Wala	Yes	All	Increase	n/a	0.024	N	Increase	n/a	0.122	N

