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Analysis of reef fisheries under co-management in Tanga

Jim Anderson

December 2004

Tanga Coastal Zone Conservation and Development Programme

Development Cooperation Ireland

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Executive Summary

The Tanga Coastal Zone Conservation and Development Programme (TCZCDP) started in 1994 with the aim of enhancing the well-being of the coastal communities in the Tanga Region by improving the health of the coastal/marine environment that they depend on.

The Programme is implemented by the three coastal districts of Tanga Region (Muheza and Pangani Districts and Tanga Municipality) in collaboration with the Regional Administrative Secretariat, The Ministry of Natural Resources and Tourism, and the Vice-Presidents Office (Environment). The Eastern African Regional Office of IUCN - The World Conservation Union, based in Nairobi, provided technical and managerial advice on behalf of the donor agency, Development Cooperation Ireland. The Programme has been implemented in four phases, Phase 1 (1994-1997), Phase 2 (1997-2000), Phase 3 (2001-2003), and Phase 4 (2004-2006).

One of the major activities of the Programme has been to implement Collaborative Management Areas (CMAs) through which community-led conservation plans are implemented and by 2001, six CMAs had been established covering the entire length of the Tanga Region coastline. An essential element in the development and monitoring of resource management plans is the information provided by fisheries data collected across the three districts. Fisheries monitoring has sought to provide data suitable to assess whether the key objective, improved fishery yields and hence increased income to CMA residents, has been achieved. This overall objective was to result from an increase in resource abundance due to Programme activities including reduced destructive fishing, the creation of closed areas and reduced numbers of 'visiting' fishers.

Data have been collected, using three different protocols, on fish-catch, species composition, price, and the use of marine space by fishers. The 1st data collection protocol was established in 1995 and continued through to 2000 and mainly collected data from Kigombe Village located in what is now Mtang'ata CMA. Additional monitoring was conducted at Ushongo and Kipumbwi Villages but data collection at these two sites was relatively short-lived. The 1st Protocol adopted by TCZCDP, using a modified version of the nationwide Fisheries Division protocol, collected data on fish catch (using the local Ki-Swahili taxonomy), fishing effort in terms of vessel and gear-type (although not including hours spent at sea), the location of fishing (using local names for fishing grounds) and price data. The 2nd protocol was introduced in 2000, and after a trial period was extended to 13 villages/landing sites across all six CMAs in existence. This protocol collected similar data but effort (in hours) was added to the data profile. The new protocol introduced a pre-defined species list and those species *not* on the list were recorded under a single category of 'others'. A third protocol was introduced in 2003 that sought to improve the statistical validity of the fisheries data by introducing proper stratification to the sampling regime. Data have been managed in an Access database developed by TCZCDP. In addition to the fisheries-dependent monitoring, a separate (fishery-independent) reef-health monitoring protocol was also established by TCZCDP.

The key fisheries indicator chosen by TCZCDP was catch per unit effort (CPUE) or catch rate. CPUE is taken as an index of resource abundance: as resources increase so the catch rate would be expected to increase. The analyses presented in this report are based on a set of data covering the longest possible time-series, where sample size was sufficient, and comprised data from three vessel/gear combinations: ngalawa/mishipi (handline); ngalawa/madema (traps); and ngalawa/jarife (sharknet) from Kigombe Village. Multiple comparisons between mean annual CPUE for these data were undertaken using the Tukey Test (with the Kramer Modification for unequal sample sizes). Overall there was no clear increase year-on-year for any of the three datasets analysed although the datasets did show different apparent patterns in CPUE. CPUE for ngawala/mishipi has remained fairly constant since the start of monitoring with a significant increase in 2003/04 data. It remains to be seen whether this is an outlier or whether subsequent years will continue to show an increase in CPUE, suggesting an increase in the resources targeted by this vessel/gear combination. Data for ngalawa/madema showed a decline in CPUE of approximately 30% between 1996 and 2000 but by 2003/04 CPUE had recovered to be statistically similar to the 1996 results. For ngalawa/jarife CPUE increased by some 70% to a peak in 2000/01, only to fall again to be at a statistically similar level in 2003/04 compared with data from 1996/97.

To determine whether fishery-related incomes had increased over the course of the Programme data on mean price per kilogramme, and mean revenues (obviously linked directly to CPUE) were analysed. Since the inception of TCZCDP the value of the Tanzanian Shilling has declined against the US Dollar, and mean price data was therefore indexed against the exchange-rate in 1996. The analysis for Kigombe village only indicated a decline in mean price per kilogramme of fish landed particularly from 1995 to 1998. The pattern observed suggests price may be partly determined by supply, with the decline in price in early years occurring when catch rates increased. It was not possible to determine any further fisheries-related income benefits to residents of the CMA.

To monitor the use of marine space by fishers (both residents and visiting fishers), and to inform stakeholders on potential approaches to resolve spatial-conflicts between users of different gears, the location of fishing was recorded for all sampled fishing trips. Analyses were restricted because the majority of the data available reported on fishers from Kigombe Village only, and therefore could not more fully describe fishing patterns in all six CMAs. However, analysis of data, covering all CMAs, did indicate that there was some level of (un-restricted) migration of fishers between CMAs and that some important fishing grounds were probably trans-boundary and thus shared by fishers from different CMAs. This has implications for estimating yields and revenues from individual CMAs and for potentially restrictive management activities on any of these shared grounds. More detailed analyses will require the Programme’s vessel registration system to be finalised.

A number of recommendations were offered to the Programme as the responsibility for management is transferred from the IUCN-supported phases to a District-managed future.

Objective/Management Issue	Fishery-Related Recommendation
Monitoring Fisher Migrations	Complete the mapping of the fishing grounds with local fishers and enter into the GIS system available at TCZCDP HQ.
	Develop a registration system for fishing vessels and modify data collection form/database to allow recording of the registration number and therefore the home CMA/District of each vessel.
Monitoring Resource Abundance	Investigate alternative means of objectively verifying increases in fish abundance.
Data Collection	A programme of field supervision, regular training updates for field staff and unannounced site visits should be established.
	There is an urgent need for a sampling and information management post to be created within the TCZCDP administration.
	Review fishing gear definitions
Mainstreaming with Government Protocols	Initiate discussions with District Government/Fisheries Division on harmonising data collection activities within the Tanga Region

1. Background

The Tanga Coastal Zone Conservation and Development Programme started in 1994 and aims to enhance the well-being of the coastal communities in the Tanga Region by improving the health of the coastal/marine environment that they depend on, and by diversifying the options for the use of the coastal/marine resources. The Programme is working with the coastal fishing villages to improve management of the coral reefs and mangroves, and the coastal resources that the villagers depend upon for their livelihoods. Districts and village level institutions are being strengthened so that they can undertake integrated management in a sustainable way.

The Programme is implemented by the three coastal districts of Tanga Region (Muheza and Pangani Districts and Tanga Municipality) in collaboration with the Regional Administrative Secretariat, The Ministry of Natural Resources and Tourism, and the Vice-Presidents Office (Environment). The Eastern African Regional Office of IUCN – The World Conservation Union, based in Nairobi, provides technical advice and manages the Programme on behalf of the donor agency, DCI. The Programme has been implemented in four phases, Phase 1 (1994-1997), Phase 2 (1997-2000), Phase 3 (2001-2003), and Phase 4 (2004-2006).

The overall Goal of Phase 4 of the Programme is: "*Integrity of the Tanga coastal zone ecosystem improved, and its resources supporting sustainable development"*. The Purpose is: "*Improved coastal zone resources management by District Administration, resource users, and other stakeholders"*.

Three results were identified by which the Goal and Purpose would be achieved:

- Strengthening institutional support for long-term implementation of collaborative management area plans.
- Strengthening of knowledge base and supporting decision-making and adaptive management.
- Programme effectively managed, monitored, and evaluated.

An essential element in the development, and monitoring, of resource management plans is the information provided by fisheries data collected across the three districts. The data collection protocol has been adapted since the Programme's inception in 1994 and the most significant modification took place in January 2002.

A more detailed analysis of the fisheries data was required in order to better determine the effect of the management plans and their associated activities. This consultancy therefore undertook a thorough review of all historical protocols, an analysis of the available fisheries data, and provides some recommendations on future monitoring protocols. The Terms of Reference are presented in Appendix 3.

2. A Brief History of TCZCDP Collaborative Management Areas

The collaborative management areas of TCZCDP have undergone some modification in their boundaries, and been re-named since the inception of the Programme. The original profile of what were known as village management plans (Horril et al., 2001) and the current profile of what became known as Collaborative Management Areas (CMA) (TCZCDP, pers. comm.) are presented in Table 1. Note in Table 1 that there is usually a gap between the time the management areas/plans are developed and the time they are approved. In fact the area management plans have to be approved at three of the levels of governance under which TCZCDP operates following adoption by the respective village councils. These three authorities are:

- The local Central Coordinating Committee (CCC);
- The District Council(s) in which the management area in located; and,
- The Fisheries Division in Dar es Salaam.

There have also been three reviews of each management area plan (which have taken place at different times for each CMA), and again the three levels of approval are required (TCZCDP, pers. comm.).

Table 1 - History of Management Areas/CMAs Established under TCZCDP

Name of Village-based Management Plan	Date of Development (Approval)	Developed or Incorporated into	Name of Collaborative Management Area (CMA)	Date of Development (Approval)
Kigombe-Tongoni	July 1996 (1997)	→	Mtang'ata*	1999
Boza-Sange	September 1996 (1997)	→	Boza-Sange	1999 (2000)
Ushongo-Sange	July 1998 (1999)			
			Mwarongo-Sahare	July 1999 (2000)
			Mkwaja-Sange	September 2000 (2001)
			Deep Sea-Boma	September 2000 (2001)
			Boma-Mahandakini	2000 (2001)

* Mtang'ata is the only CMA that straddles two districts (Muheza and Tanga Municipality).

Under these various plans there have been a number of specific fisheries-related management activities principle amongst which is the reduction or elimination of the use of dynamite (which is in any case illegal in Tanzania), and the establishment, with full stakeholder participation, of closed areas. Table 2 presents a summary of the reefs that have been closed and identifies those that have subsequently re-opened to fishing.

Table 2 - Profile of Reef Closures by CMA

CMA	Reef Name	Date of Closure	Current Status	Date of Opening
Boma-Mahandakini	Bunju	2001	Closed	
Deep Sea-Boma	Chundo/Kiroba	2000	Closed	
Mwarongo-Sahare	Kipwani	2000	Closed	
Mtang'ata	Kitanga	1996	Open	1999
	Makome	2001	Closed	
	Shenguwe	2001	Closed	
	Upangu	1996	Open	1999
Boza-Sange	Dambwe	1998	Closed	
	Maziwe	1975	Closed	
Mkwaja-Sange	No Closures			

3. A summary of all available Frame Survey data for Tanga Region

A *frame survey* is defined as 'a complete description of the structure of any system to be sampled for collection of statistics. In fisheries, it may include the inventory of posts, landing places, number and type of fishing units (boats and gears), and a description of fishing and landing activity patterns, fish distribution routes, processing and marketing patterns, supply centres for goods and services, etc.' (Modified from Anon, 2002).

The data on the number and type of fishing units generated by a frame survey is used in conjunction with sample fisheries data (catch/effort/value etc collected at landing sites/markets etc) to estimate the total catch/effort/value of that particular system. The sample data (average catch per gear-hour, for example) is *raised* by multiplying it by the frame survey data to give the total catch for that fleet/gear type. For example, in basic terms, if the average catch of a ring-net is 50kg per gear-hour (from sample data), the average trip length is 5 hours (from sample data), all the ring-nets in the fleet are used every day of the month (from sample data) and there are 100 ring-nets of this type in the fleet (from the frame survey data), then the total catch per month for that fleet will be estimated as 50kg*5hrs*30days*100nets = 750,000kg. A similar exercise could be undertaken for beach-seine nets, or fish traps, using sample data and frame survey data specific for those types of gears.

Marine frame surveys were undertaken by the Fisheries Division in 1995, 1998 and most recently in 2001 and the data from these are presented in Table 3 and Table 4.

Table 3 - Summary of Frame Survey Landing Site, Fisher Numbers and Vessel Data for Tanga Region

Year	No. of Landing Sites	Number of Fishers*	Number of Engines**		Vessel Categories				
			IB	OB	Ngalawa	Mashua	Mtumbwi	Dau	Boti
1995	48	4,202	2	96	394	150	261	50	41
1998	46	4,380	2	95	452	84	262	137	34
2001	52	4,361***	5	91	502	100	237	84	21

Source: Fisheries Division
* Includes those recorded as 'owners'.
** IB = Inboard Engine; OB = Outboard Engine
*** Numbers of fishers were adjusted to account for apparent anomalies in some landing site datasets between 1998 and 2001.

Table 4 - Summary of Frame Survey Fishing Gear Data for Tanga Region

Year	Gill-net	Shark Net	Hand-line	Long-line	Beach Seine	Fish Traps	Ring Nets	Scoop Nets
1995	1,182	814	2,898	38	57	1,294	79	66
1998	631	608	2,654	34	84	1,258	128	255
2001	953	404	1,883	56[a]	- [b]	2,161	102	106

Source: Fisheries Division
[a] The frame survey reports 788 longlines for 2001 but this is an error – data recording mixed number of hooks per line with number of lines (H. Kalombo pers. comm.). When recalculated from the raw data the actual figure is around 56 (33 in Muheza, 23 in Pangani and 0 in Tanga)
[b]Beach seines were banned in 2001.

4. Summary Description of Previous and Current Fisheries Sampling Protocols in TCZCDP

Why Sample? Sometimes, the entire population will be sufficiently small, and the researcher can include the entire population in the study. This type of research is called a census study because data is gathered on every member of the population. Usually, the population is too large for the researcher to attempt to survey all of its members. A small, but carefully chosen sample can be used to represent the population. The sample reflects the characteristics of the population from which it is drawn. (Source: Statpac Survey Software, Sampling Methods)

In order to know whether management activities are having the desired affect in terms of improving incomes of small-scale fishers or increasing the abundance of particular species (etc.), managers need to have information from the fishery itself. But obtaining information on every catch landed or price obtained etc from fishers is usually impractical because it is expensive and time-consuming, especially in small-scale fisheries where there are many small, isolated landing sites often with poor access. So *sampling* protocols are usually developed, which give a statistically accurate picture of the fishery but only require a certain number of fishing trips to be recorded. These *sample* data are then used in conjunction with the *frame survey* data (as described in Section 3) to estimate total catch/revenue.

There have been three distinct sampling protocols employed under the TCZCDP. At the time of inception of TCZCDP the Fisheries Division operated a sampling regime at six landing sites in Tanga Region (see Table 5).

Table 5 - Landing Sites Sampled by Fisheries Division (Tanga Region)

Landing Site	District
Moa	Muheza
Kwale	Muheza
Kigombe	Muheza
Tongoni	Tanga
Deep Sea	Tanga
Kipumbwi	Pangani

Source: Fisheries Division

A range of data were (and continue) to be collected and these are presented in Table 6. The sampling methodology was based on 16-days sampling per month at the six sites with an expected 100% coverage of the fishing activities on those days, i.e. all boats that land a catch on a given sampling day should be interviewed and the catch/effort recorded. Note that data were not collected according to scientific nomenclature but using local taxonomy, which tends to group a number of species and genera (and in some cases families) together under species groupings.

Table 6 - Profile of Fisheries Data collected by Fisheries Division

Effort Data	Catch Data
Date Vessel Registration Number Vessel Type Gear Type, Number and size Number of Crew Arrival Time Time Spent Fishing	Weight by species (groupings) Number by species (groupings) **Economic Data** Value of catch (beach price) by species (groupings)

Source: Fisheries Division

Although this profile is a useful one for fisheries data, there was typically a limited level of supervision of monitors, and, equally crucial, the data management was poor to the extent that these raw data, apart from summary profiles in Annual Reports, are no longer available to researchers. Although an ACCESS database had been developed in 2002 under the RFIS Project (SADC/DFID) to facilitate the entry, production analysis and reporting of data, the up-take of this system and hence the opportunities for improved data management were limited.

4.1. First TCZCDP Fisheries Sampling Protocol (1995-2001)

With the inception of the TCZCDP there was an attempt to improve on the Fisheries Division data collection system and to take some control over the data that was collected.

4.1.1. Description of the Sampling Method

The first protocol modified the Fisheries Division data collection form, and TCZCDP-seconded staff collected the data. These were collected at the market place rather than at the actual landing-site. A similar sampling protocol to that used by the Fisheries Division was employed (16-days per month, 100% coverage of fishing trips on those days) but the data profile was adjusted and effort was no longer recorded. The data profile is shown in Table 7.

Table 7 - TCZCDP first Fisheries Data Profile (1995-2001)

Effort Data	Catch Data
Date Name of Fisher Vessel Type Gear Type and Number Place of Fishing	Weight by species (species groupings) Number by species (species groupings)
	Economic Data
	Value of catch (beach price) by species (groupings)

Source: TCZCDP

The first village management plan was established under TCZCDP in Kigombe-Tongoni, off Muheza District (see Table 1) and the 1st sampling protocol was implemented at the Kigombe landing site on the 30th September, 1995. Further data collection activities were established at Kipumbwi village, for the adjacent Ushongo-Sange village management plan from August 1996 to September 1999 and at Ushongo village (Boza-Ushongo village management plan), from May to September 1999. Figure 1 presents a short-version of the data collection form used under the 1st Protocol.

Figure 1 - Fisheries Data Collection Form for TCZCDP (1995 TO 2001)

Date	Name of Fisher	Type of Boat	Gear (No.)	Name of Fishing Ground	Type of Fish	Number of Fish	Weight	Value

Source: TCZCDP

The database holding the 1995-2001 data has an additional category of fisheries-related data to those collected on the form shown in Figure 1, namely size category and number of fish within each category. There are three categories, A, B, and C (originally a fourth category was also used) which relate respectively to the length of a hand, the length from fingertip to mid-forearm and the length from fingertip to shoulder.

4.1.2. Observations on the 1st TCZCDP Sampling Protocol

There are many types of data that can be taken during sample surveys (mean catch, trip length, revenue per trip, the species composition, the fishing ground used, the weather, the time of fishing etc). These data can be used for a range of purposes. One of the most common uses of the catch and effort data is to calculate the *catch per unit effort*.

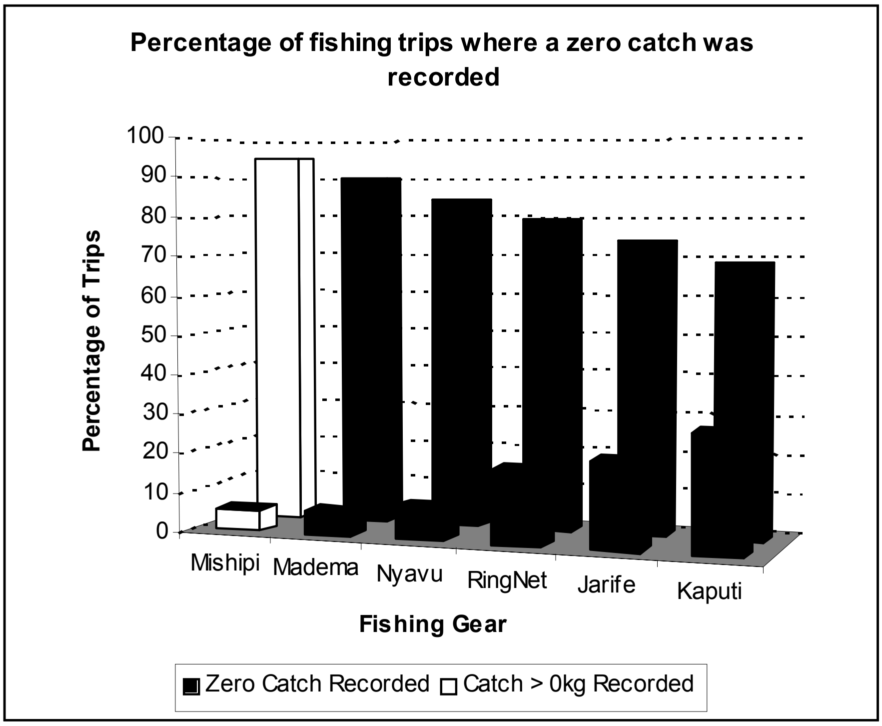
> Catch-Per-Unit-Effort (CPUE) - also called catch rate - is frequently the single most useful index for long-term monitoring of a fishery. Declines in CPUE may mean that the fish population cannot support the level of harvesting. Increases in CPUE may mean that a fish stock is recovering and more fishing effort can be applied.
>
> CPUE can therefore be used as an index of stock abundance, where some relationship is assumed between that index and the stock size. Catch rates by boat and gear categories, often combined with data on fish size at capture, permit a large number of analyses relating to gear selectivity, indices of exploitation and monitoring of economic efficiency. (Source: Anon, 2002).

There are three issues on the use of CPUE related to the 1st Sampling Protocol:

- No fishing effort, except 'fishing trip', was recorded: Managers/researchers would be looking to observe what happens to the CPUE over time, that might reflect an increasing, stable or decreasing abundance of fish. However, without details on the actual fishing effort (ideally numbers of hours) other than numbers of trips it is possible that a change in CPUE (catch per trip) will not accurately reflect the abundance of fish because trip length may have changed and so fishers may be spending more (or less) time at sea to catch a given amount of fish.

- Data were collected at the market place rather than at the landing site beaches: Recording catch data at the market place means that no zero-catches would be recorded (because fishers would not have anything to sell) and this would give a false-impression of the CPUE information. The impact of this omission depends somewhat on the gear one is talking about and a graphical display of the variation between gears is presented in Figure 2.

Figure 2 - Percentage of fishing trips with zero catch by fishing gear



Data source: TCZCDP

- An issue related to the market-based sampling is that smaller catches, both in size of fish and weight, would not tend to be auctioned at market (where a levy is charged) but would have been sold on the landing beach. If small catch/zero-catches are not recorded this will give a misleading figure for the CPUE: it will have the effect of increasing the mean CPUE because only larger (auctioned at market) catches will be recorded. The amount and quality of data collected in market-based sampling may be reduced because of the speed at which catches are sold-off, and the fact that potential buyers, or the vendors themselves, do not usually want researchers handling their catch. This creates a challenge for data collectors, who generally rely on the good-will of fishers/vendors, to satisfactorily complete their work. This is by no means a simple problem to solve and beach sampling also faces similar challenges because fishers are usually keen to get their catch processed and sold quickly with minimal interference from data collectors or other researchers.

A further important feature of this 1st Protocol was that there appeared to be no stratification designed into the sampling.

> **Stratified sampling** is commonly used probability method that is superior to random sampling because it reduces sampling error. A stratum is a subset of the population that share at least one common characteristic. Examples of stratums might be dhows and ngalawas, or mishipi and nyavu. The researcher first identifies the relevant stratums and their actual representation in the population. Random sampling is then used to select a *sufficient* number of subjects from each stratum. "*Sufficient*" refers to a sample size large enough for us to be reasonably confident that the stratum represents the population. Stratified sampling is often used when one or more of the stratums in the population have a low incidence relative to the other stratums. (Modified from Statpac Survey Software, Sampling Methods)

A somewhat unusual feature of the data generated under this first protocol, given that small-scale reef fisheries tend to be multi-species in profile, is that relatively few trips appear to have caught more than one species (or group). In fact only 9% of all the fishing trips recorded having more than one species/species group, compared to 24% in the more recent data collected by TCZCDP. The reason for this is not specifically understood but it may originate in the design of the data collection form itself.

Ideally a data form should represent the relational nature of the information required from a fishing trip; that is to say that one fishing trip (the *effort*, including date, time, area fished, type of boat etc) will relate to more than one record of catch (i.e. there are usually more than one species caught in a single trip). But the original design nominally allows for only one row of information per trip. If more than one species is actually recorded then more than one row will have to be entered, although this can result in duplicate date, time, and area fished etc being entered, or just empty cells. This can lead data collectors to just write a single record for each trip, rather than fill in the entire catch. Neither does such a form design facilitate the data entry process (because of the empty cells or duplicate data).

4.2. Second TCZCDP Fisheries Sampling Protocol (2001-2003)

The second data collection protocol employed by TCZCDP was initiated by the newly appointed Technical Advisor (TA) in June 2000. In addition to issues related to statistical design, the TCZCDP had also moved from what was a village-based pilot programme to an area-based management approach. This change in design necessitated a larger-scale monitoring programme to be developed (Hassan Kalombo, TCZCDP, pers. comm.).

4.2.1. Description of the Sampling Method

This protocol was first piloted in August 2001. The villages that were sampled are presented in Table 8. The design was based on sampling in three-four villages per district, with each village sampled once every three-months. The protocol attempted to sample at least 20% of each category of vessel present at the landing site on any sampling day (TCZCDP, pers. comm.).

The improved data entry form (translated into English) is presented in

Figure 3.

Table 8 - Landing Sites Sampled for Fisheries Data under the 2nd TCZCDP Protocol

Management Area	Village/Landing site (period sampled)
Boma-Mahandakini	Moa; Moa/Kijiru (2002-present)
Boza-Sange	Kipumbwi (2002-present)
	Pangani (2002 only)
	Stahabu (2003-present
	Ushongo (2002 only)
DeepSea-Boma	Deep-sea (2002-present)
	Kichalikani (2002-present)
	Mwandusi (2002 only)
Mkwaja-Sange	Mkwaja (2002-present)
Mtang'ata	Kigombe (2001-present)
Mwarongo-Sahare	Machui (2002-present)
	Mwarongo (2002-present)
	Sahare (2002-present)

Source: TCZCDP

4.2.2. Observations on the 2nd TCZCDP Sampling Protocol

This 2nd Protocol included a number useful changes compared with the 1st Protocol:

- Sampling took place in a larger number of villages covering all the so-called Collaborative Management Areas (CMAs) that were then in place;
- An attempt was made at incorporating some degree of stratification by recording 20% of the catches from each vessel-type although this does put an unnecessary onus on the data collectors to make decisions about their sampling activity;
- Effort (in hours) was recorded;
- Sampling was conducted on the beach (rather than in the market);
- The data form targets pre-determined species for the detailed sampling of weight and numbers. The rationale for this is not clear;
- The design of the data collection form conforms to the requirement that the relational (one-to-many) nature of data generated from a single fishing trip is effectively captured on the data collection form;
- There was no option to record price data for individual species unlike under the 1st Protocol.

Figure 3 - Fisheries Data Collection Form for TCZCDP (2001 to 2003)

<table>
<tr><th colspan="3">Fish Catch Recording Data Sheet</th></tr>
<tr><td>O Boza-Sange
O DeepSea-Boma

Village:…………………</td><td>O Mtang'ata
O Boma-Mahandakini

Recorder:…………………..</td><td>O Mwarongo-Sahare
O Mkwaja-Sange

Date: / / Time: ………</td></tr>
<tr><td colspan="3">Name of Skipper/Fisher: ………………………………..Number of Fishers:……………………………

Type of Boat: O Ngalawa O Canoe O Dau O Mashua

Type of Gear: …………….. …………………………Number of Gears:………………………………</td></tr>
<tr><td colspan="3">Name of Fishing Ground:………………………… Time spent fishing:…………………..Hrs

Total Weight of Fish: ………Kg O Estimated O Weighed
Total Number of Fish: …… O Estimated O Counted Value (Tshs):………</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Changu (Snappers & Emperors)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Changu Doa (L.harak)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Changu Njana (L.lentjan)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mkundaji (Goatfish)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mkundaji 1 (P.cinnabarinus)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mkundaji 2 (P.indicus)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Chafi (Rabbitfish)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Chafi (S.luridus)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Chafi (S.sutor)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Kangu</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Kangu 1 (S.ghobban)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Kangu 2 (H.harid)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mlea (Sweetlips)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mlea (P.gaterinus)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Kohe (D.pictum)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mbono (Fusiliers)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mbono 1 (C.xanthonotus)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mbono 2 (C.diagramma)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Chewa (Groupers)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Chewa (E.fasciatus)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mjombo (E.punctatus)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Taa (Rays)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Taa (D.jenkinsii)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Pungu (S.narinari)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Jodari (Tuna)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Kibua/Bangra (R.kanagurta)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Jodari (T.albacarus)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mizia (Barracudas)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Mizia (S.barracuda)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Msusa (P.fosteri)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Kolekole (Jacks)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Kolekole manjano (C.sem)</td><td>Pcs</td><td>Kg</td></tr>
<tr><td>Kolekole ubwi (C.sexfasciatus)</td><td>Pcs</td><td>Kg</td></tr>
</table>

Note that Changu were listed as comprising only snappers (Lutjanidae) although the species listed on the form are emporers (Lethrinidae). Although the TCZCDP had developed their own various data collection protocols, the Fisheries Division of Tanzania continued to collect their own data independently of TCZCDP. A quick comparison of data for three months in 2002, collected in Muheza District, against the TCZCDP data reveals the extent of the differences between estimates of CPUE (kg per gear-hour) derived from the two sources (seeTable 9) and see Appendix 1 for definition of gear types and of boat types.

Table 9 - Comparison of CPUE data from TCZCDP and Fisheries Division, Muheza District, 2002

Year (2002) Month	Type of Boat	Type of Fishing Gear	TCZCDP Mean Catch (kg/gr-hr)	Fisheries Division Mean Catch (kg/gr-hr)	FD Data >10% Higher or Lower than TCZCDP?	FD Data as % of TCZCDP Data
2	DC	Mi	0.64	0.66	-	**102.5%**
2	DH	Ny	0.20	0.12	**L**	**62.2%**
2	DH	Ja	0.92	0.58	**L**	**62.8%**
2	DH	Ma	0.79	0.20	**L**	**25.2%**
2	NG	Mi	0.38	0.40	-	**106.7%**
3	NG	Mi	0.27	0.35	**H**	**129.8%**
4	DC	Ny	0.32	0.07	**L**	**21.9%**
4	DH	Ny	0.22	0.07	**L**	**32.4%**
4	DH	Ja	0.62	0.28	**L**	**45.6%**
4	NG	Ny	0.32	0.07	**L**	**21.3%**
4	NG	Mi	0.30	0.18	**L**	**59.9%**
4	NG	Ja	0.81	1.04	**H**	**127.6%**
5	DC	Ny	3.22	0.08	**L**	**2.4%**
5	DH	Ny	0.54	0.08	**L**	**14.2%**
5	DH	Mi	0.53	0.36	**L**	**67.2%**
5	DH	Ja	0.59	0.52	**L**	**88.1%**
5	NG	Mi	0.50	0.29	**L**	**58.7%**

4.3. Third TCZCDP Fisheries Sampling Protocol (2003-present)

The third fisheries data collection protocol employed by TCZCDP was developed in collaboration with the SADC/RFIS Project and established in March 2003.

4.3.1. Description of the Sampling Method

This 3rd protocol was specifically designed to report on monthly catches/revenues by district and vessel/gear combination, in preparation for a district-based fisheries permit system and therefore *district* and *month* is the major stratum, and *vessel/gear combination* the minor stratum against which the sampling was planned. The FAO publication 'Sample-Based Fishery Surveys – A Technical Handbook' (Anon, 2002) was employed to develop the survey protocol, based on the approach of sampling in space and in time. The sampling was marginally constrained by the fact that it had to take place at the same landing sites as presented in Table 8. The required sample size for each stratum was defined as the target for each vessel/gear combination to achieve 90% accuracy in the data (Anon, 2002) and therefore depended on the estimated population size (maximum number of trips likely per month within a district, by vessel/gear combination) but typically ranged between 30-32 samples per month. The selected villages were then apportioned sampling effort in order that the required sample sizes for each vessel/gear combination were achieved. Because this 3rd Protocol was developed according to the FAO Guidelines, it is possible to utilize the full equation to calculate an estimate of total catch for a stratum. The modified version of the data collection form is presented in Figure 4. Note that a space was provided on the new form for the collection of length-frequency data, although at the time of writing a sampling protocol for length-frequency data had not yet been implemented.

In order to obtain the necessary data for raising catch/effort *samples* to estimate the *total catch* for the stratum the 3rd Protocol form design also included *Boat Activity Coefficient* (BAC) data. One can't necessarily assume that every fisher goes fishing everyday and BAC data reports on the individual choices made by fishers about whether to fish or not on any particular day. They may have other things to do, such as farming activities. Following the FAO Guidelines the approach taken was of asking sampled fishers whether they had fished the three-days prior to the date of that particular interview. This is a cost-effective and efficient way of obtaining the necessary sample size (according to FAO this is three-times the sample size required for the fisheries catch/effort). A further requirement for raising catch/effort samples is a record of a fleet's Active Days, i.e. how many days an entire fleet is active during the month, perhaps fishing is prevented due to a storm, or a religious holiday. This data is reporting an influence that tends to affect the whole fleet. This data can be generated through a few interviews with key informants at the end of each month of sampling and a separate form was provided to TCZCDP to record this data. TCZCDP were previously assuming, based on their own knowledge of the fisheries, that approximately 21-days were fished each month (TCZCDP, pers. comm.).

4.3.2. Observations on the 3rd TCZCDP Sampling Protocol

- Building on the 2nd Protocol, but with improved stratification of sampling;
- Sampling protocols (number of samples required from each sample site by vessel-type and gear) were produced and issued to data collectors to rationalize sampling effort;
- The introduction of Boat Activity Coefficient (BAC) and Vessel Activity Survey (VAS) offers data managers a more robust means of estimating total catch/revenues by sampling stratum. However, data management activities within TCZCDP should include adequate support to data collectors to ensure that sampling requirements are met at each site;
- The introduction of options for collecting Length-frequency data on the same form (rather than having a separate form) is useful because it ensures LF samples will be attributable to a particular fishing trip/vessel/gear/fishing ground etc;
- The 3rd Protocol doesn't allow for species/species group price data to be collected unless the catch is entirely single species;
- The selection of the species list printed on the data sheet could be re-visited in light of the dominant species in the catch and the inclusion of species that are relatively uncommon in the catch.

Figure 4 - Fisheries Data Collection Form for TCZCDP (March 2003 to present)

Fish Catch Recording Data Sheet		
Village:…………………	Recorder:…………………..	Date: / / Time: ………

Name of Fisher: ……..…………………………………… Number of Crew:……………………………

Type of Boat: O Ngalawa O Canoe O Dau O Mashua

Type of Gear: …………….. …………………………Number of Gears:……………………………

Fishing Ground:……………………………… Time Spent Fishing:…………………..Hrs

Weight of Fish:…………………KG O Estimated O Weighed Value:………

Number of Fish:………………… O Estimated O Actual Value

BAC Survey	Day -3: y / n	Day -2: y / n	Day -1: y / n

Type of Fish	Length (cm)		Type of Fish	PCS	KG
			Changu (Snappers & Emperors)		
			Changu Doa (*L.harak*)		
			Changu Njana (*L.lentjan*)		
			Mkundaji (Goatfish)		
			Mkundaji 1 (*P.cinnabarinus*)		
			Mkundaji 2 (*P.indicus*)		
			Chafi (Rabbitfish)		
			Chafi (*S.luridus*)		
			Chafi (*S.sutor*)		
			Kangu		
			Kangu 1 (*S.ghobban*)		
			Kangu 2 (*H.harid*)		
			Mlea (Sweetlips)		
			Mlea (*P.gaterinus*)		
			Kohe (*D.pictum*)		
			Mbono (Fusiliers)		
			Mbono 1 (*C.xanthonotus*)		
			Mbono 2 (*C.diagramma*)		
			Chewa (groupers)		
			Chewa (*E.fasciatus*)		
			Mjombo (*E.punctatus*)		
			Taa (Rays)		
			Taa (*D.jenkinsii*)		
			Pungu (*S.narinari*)		
			Jodari (tuna)		
			Kibua/Bangra (*R.kanagurta*)		
			Jodari (*T.albacarus*)		
			Mizia (Barracudas)		
			Mizia (*S.barracuda*)		
			Msusa (*P.fosteri*)		
			Kolekole (Jacks)		
			Kolekole manjano (*C.sem*)		
			Kolekole ubwi (*C.sexfasciatus*)		

4.4. Summary Comparison of the Three TCZCDP Sampling Protocols

Table 10 presents a summary comparison of the three TCZCDP sampling protocols according to a number of criteria related to statistical robustness and utility for fisheries management analysis.

Table 10 - Summary Comparison of TCZCDP Sampling Protocols

Sampling Protocol	Species-specific Price Data?	Compatibility with FAO Guidelines	Stratified?	Detailed Effort Sampled?	Zero-Catches?	Sampling at Beach Landing Site
1st (1995-2000)	Y	N	N	N	N	N
2nd (2001-2003)	N	N	Y/N	Y	Y	Y
3rd (2003-present)	N	Y	Y	Y	Y	Y

Taking the observations in Table 10, it is possible to provide a summary profile of the types of analysis that are possible with the data generated under each data collection protocol and this is presented in Table 11.

Table 11 - Summary Profile of possible analyses under each TCZCDP Protocol

Sampling Protocol	Species-specific Price Analysis	Analysis of Catch by Vessel/Gear	Analysis of use of Fishing Grounds	Detailed CPUE Analysis	Accurate estimate of catch/effort by stratum	Length-Frequency Distribution Analysis
1st (1995-2000)	Y	Y	Y	N	N	N
2nd (2001-2003)	N	Y	Y	Y	N	N
3rd (2003-present)	N	Y	Y	Y	Y (with improved data collection)	Y (when a protocol is introduced)

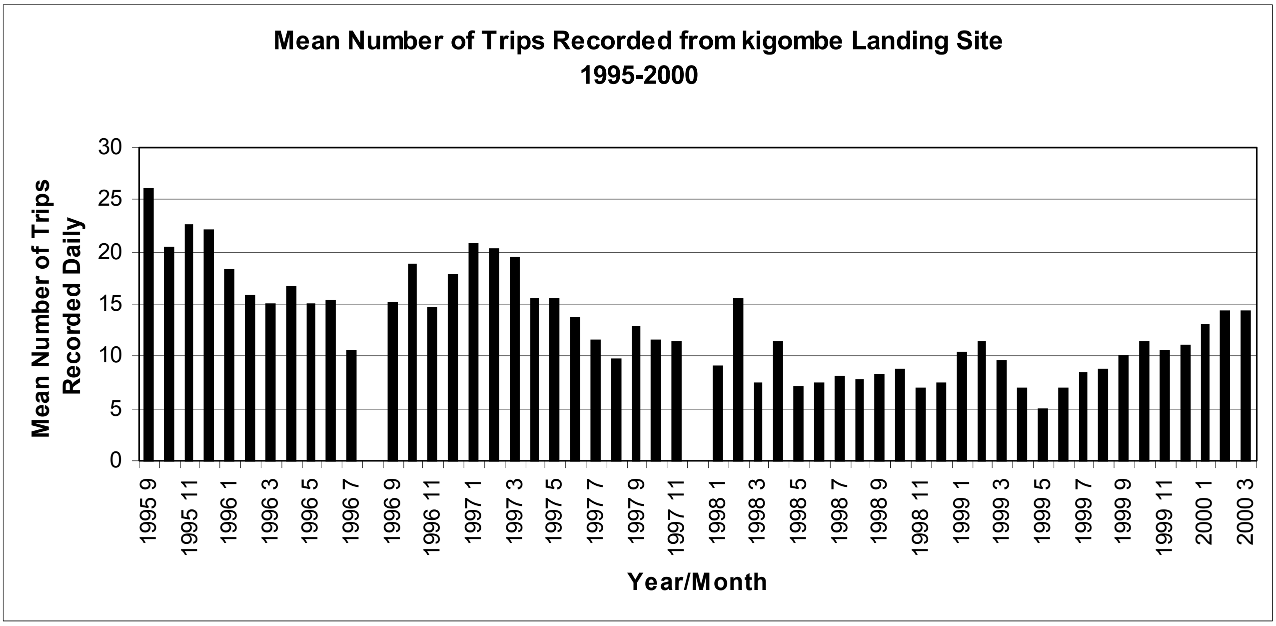
5. Previous data analysis activities and their major findings

One of the principle reports of analyses of data on TCZCDP marine resources was prepared by Horrill et al. (2001), which covered data from 1995 to 2000. As far as it relates to fisheries there were a number of issues covered, including observations on controls of fishing effort at Kigombe, which was the main sample site during the early years of the programme.

5.1. Sampling Effort 1995-2000

Figure 5 presents data on the mean daily number of trips recorded from Kigombe Village, 1995-2000. These data indicate a decline in the coverage of the sampling and Horrill et al. (2001) suggested that this might be the result of reduced numbers of fishing trips by all fishers (because coverage was designed as 100% of fishing trips on each sampling day), reduced numbers of visiting fishers from outside the management area, or that it might be an attempt by fishers to avoid the fish levy at the market place. The former would suggest some considerable success in reducing numbers of visitors but would also have required that permission was not being granted to visiting fishers, while the latter has to be put into the context of the taxation system, and the question asked why has the change occurred from around mid-1997? Unfortunately data are unavailable to determine which, if in fact either of these is responsible.

Figure 5 - Mean No. of Trips Recorded Daily from Kigombe Village 1995-2000. 1995 9 = September, 1995; 1995 11 = November 1995 etc



5.2. Analysis of Catch per Unit Effort (Catch-Rate)

There are various analyses of catch rate data presented in the Horrill et al. report, including:

- Catch per gear for pull-seine nets (before they were banned in 2000) showed 'the greatest increase' (Horrill et al., 2001, page 17);
- Handlines showed a smaller increase in catch per gear relative to pull-seine nets (p17);
- Entanglement nets (shark nets or *jarife*) showed a smaller increase in catch per gear relative to handlines (p17);
- Catch per gear for gill-nets was reported as 'stable' (p17);
- Catch per gear for fish-traps indicated a 'steady decline' (p17).

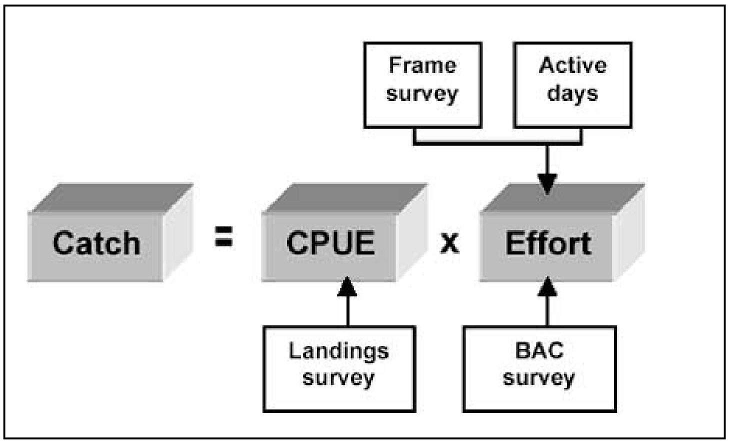
However, these interpretations are complicated by a number of issues. No statistical analyses are given that might determine whether the increases in catch per gear was in fact significantly different. Without detail on the *time* spent fishing it is impossible to say whether there is an increase in catch per gear (i.e. an increase in abundance of fish) or whether the fishers are just spending more time fishing (with or without the same number of gears). Details on effort allow for identifying more subtle changes in fishing practice. For example, it is possible that in 1995 a fisher deployed his/her two entanglement nets for one-hour (i.e. two gear-hours) to generate a total catch of 5 kg at a rate of 2.5kg per gear-hour, and 2.5kg per gear per trip; while in 2000 the fisher deployed the same two nets for two-hours (i.e. four gear-hours), and caught 10kg, still therefore only at a rate of 2.5kg per gear-hour (i.e. indicating the same abundance of fish), but at a rate of 5kg per gear per trip. This is misleading because it suggests an increase in catch-rate (i.e. fish abundance) but in fact it required the fisher deploy the gear in 2000 for twice as long as in 1995, that is to say there has been no net increase in kg/gr/hr, a more accurate unit for CPUE, than kg/gr/trip.

6. Description of Methods for the analysis of fisheries data

6.1. Estimates of Total Catch/Value

In order to estimate total catch/total value for districts/CMAs a simple equation was utilized (Figure 6). Estimation of total catch/value per year for each major vessel/gear combination (and estimates of annual totals for district and CMA) was only undertaken for the years 2002, 2003 and 2004 due to the lack of effort data for the years 1996-2001.

Figure 6 - Total Catch Estimate Equation (Anon, 2002)



6.2. Total Catch Estimate Equation Components

Boat Activity Coefficient: Although some data for the BAC survey exists it was not sufficient to use and so a figure of 1.00 was used for the BAC (which assumes that all fishers go fishing every day that it is possible).

Active Days: Data for Active days were also collected but it was largely incomplete and a figure of 21 days was taken as the number of days, on average, that the fleet could go fishing each month (when weather conditions were suitable etc, TCZCDP, pers. comm.).

CPUE: CPUE is defined as catch (kg) per hour. Effort (in hours) is not differentiated between hours actually on the fishing grounds, and hours spent travelling to the grounds.

Frame Survey Data: Data from the 2001 Marine Fisheries Frame Survey was utilized to provide a count of the number of boats using a particular gear combination in each major stratum (i.e. district or CMA). These data are not routinely collected with the CMA identified and so each landing site was allocated to a particular CMA by TCZCDP staff.

6.3. Standardising CPUE data for between-year comparisons

- It was observed in Section 4.1 that the majority of data collected under the first protocol was collected from Kigombe village, in what is now Mtang'ata CMA. Only modest amounts of data exist for Kipumbwi village and only for 1996, 1997 and 1999 and even fewer data exist for Ushongo (covering five-months in 1999). Therefore in order to make meaningful comparisons between the pre-2001 data and that produced under the 2nd and 3rd sampling protocols, data for CPUE analysis from post-2001 were restricted to what was sampled at Kigombe village;

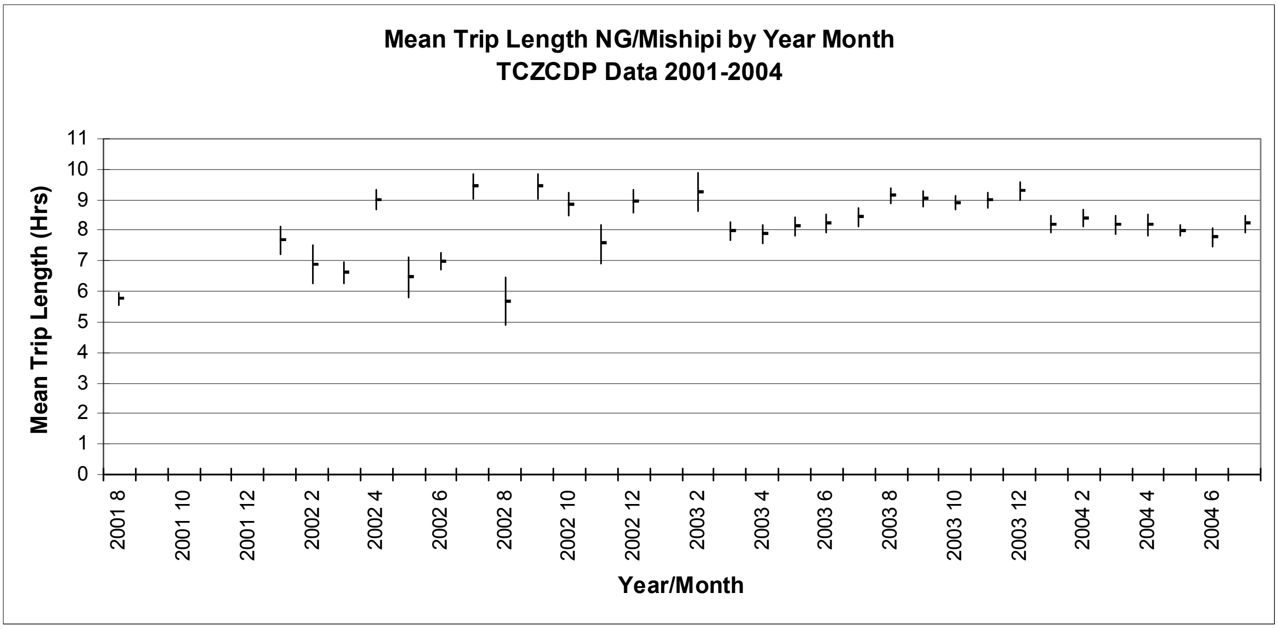
- For analysis of CPUE by month those months for which sample size, N, is greater that 20, are presented with 90% confidence intervals. Those months where N<20 are presented a single points without confidence intervals;

- Data for spatial analysis over the period 1995-2004 was restricted to the principle ground (i.e. from where the majority of the fishing effort was recorded pre-2001) of Majivike. Analyses related to wider geographical coverage of course sought to utilise all available (post-2001) data;

- No zero-catch fishing trips were recorded under the 1st protocol, as noted in 4.1, and therefore in a further attempt to standardize the data across the years, zero-catches were excluded from the CPUE data derived from the 2nd and 3rd protocols;

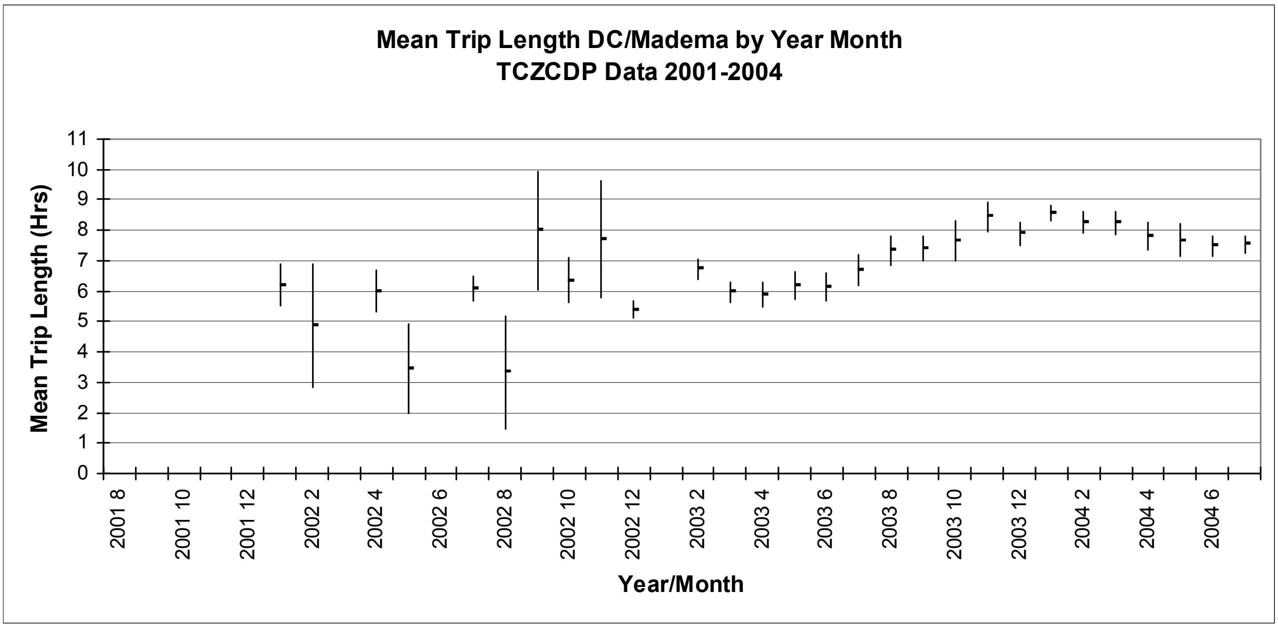
- Because effort was only recorded as a 'trip', with length of trip unknown, pre-2001 the only comparable CPUE index that could be used was catch per gear/trip, even though true effort data does exist in post-2001 data. It might be argued that one could take the mean trip length (for each boat/gear combination) from periods that included such information in the monitoring profile and apply this to periods when no such data was collected. This was in fact investigated as an option. Figure 7 presents data on the mean trip length for ngalawas (outrigger canoes) using mishipi (handlines). The graph would seem to indicate that trip length varies between years, and also seasonally (within year), and an ANOVA (single-factor) revealed a significant difference between the data ($F = 13.23$, $Fcrit_{0.05,\ 354}$ 1.747). On the basis that it would be very subjective to allocate annual mean trip lengths (would one take data from 2002 or 2003 for example?) let alone seasonal mean trip lengths it was felt that allocating mean trip length was not a sensible option and would just add further caveats to the analyses.

Figure 7 - Mean Trip Length (Hrs) for Ngalawa/Mishipi



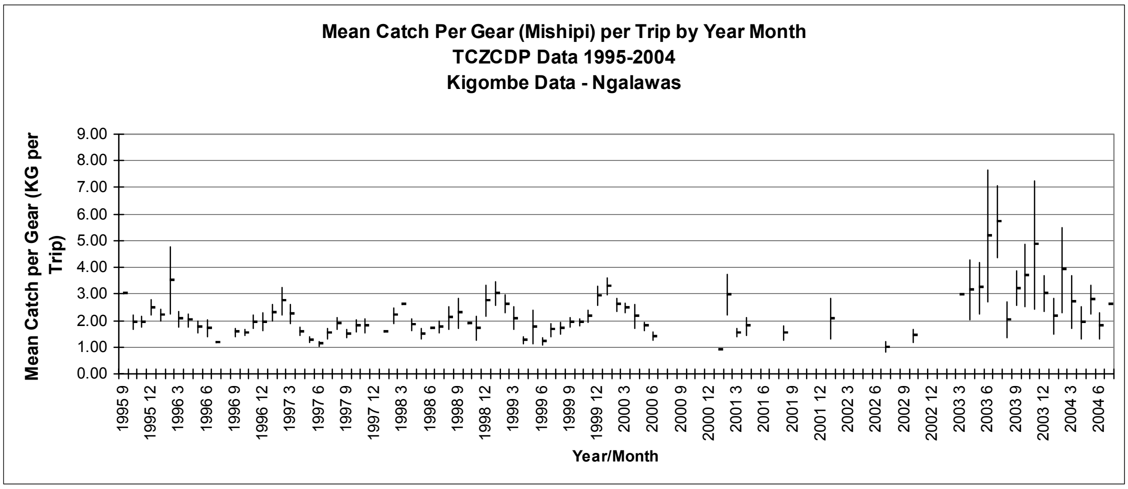
Perhaps the gear most likely to remain deployed for a set period of time (e.g. from dusk to dawn) is the fish trap (madema). However, analysis of data from post-2001 for mtumbwi (dug-out canoe) using madema in fact indicates that the trip length of this gear also varies both seasonally and inter-annually (see Figure 8). Similar seasonal and inter-annual variations can be observed for other vessel/gear combinations thus making any attempt to establish a mean trip length to apply to pre-2001 data very difficult and statistically dubious.

Figure 8 - Mean Trip Length (Hrs) for Mtumbwi/Madema



- Substantial gaps exist in the CPUE data across the years for Kigombe data. Reference to Figure 9 clearly shows those gaps between June 2000 (2000 6) and March 2003 (2003 3) as they relate even to the most abundant dataset for ngalawa using mishipi. Despite these missing data, and at the request of TCZCDP, the full range of data is included in the analysis.

Figure 9 - Mean CPUE (Kg/Gr/Trip, with 90% CI) by Year/Month for Kigombe (Ngalawa/Mishipi), 1995-2004



Furthermore, the 12-months of annual data were aggregated not as January-December but over the period of March to February. In this way the maximum amount of data could be incorporated into the analyses.

6.4. Statistical Tests

ANOVA (with single factor) was used to evaluate the presence of significance differences between groups (years) with the null hypothesis that H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$. Where ANOVA indicated a significant difference a multiple (pair-wise) comparison Tukey Test was employed, with the Kramer modification for unequal sample size (Zar, 1999, p212), to determine between which groups' population means a difference existed. Not all years were included in the comparison because the profile of the sampled data was not equal within year; that is to say that some years had relatively few data, or data that were primarily taken from one season or another, and apparent seasonal differences in CPUE had already been observed in the data. Therefore to minimize any bias associated with this, and yet to maximize the amount of data that could legitimately be included, the period of March to February was taken as a 'year' and the *years* 1996/97, 1997/98, 1998/99, 1999/00 and 2003/04 were compared.

The data were tested for normality using both Excel Descriptive Statistics and Systat (V.10.2) using the Kolmogorov-Smirnov one-sample test reporting skewness and kurtosis. The data does appear to show some deviation from normality revealing positiveness skewness (a long right-tail) and positive kurtosis (longer tails than expected). In this case a nonparametric analysis of variance (e.g. Kruskal-Wallis Test) might be considered appropriate but Zar (1999) indicates that a single-factor analysis of variance (such as is proposed here, the single-factor being CPUE):

'…is also robust with respect to the assumption of the underlying populations' normality. The validity of the analysis is affected only slightly by even considerable deviations from normality (in skewness and/or kurtosis), especially as n increases.' (Zar, 1999, p185)

Given that the number of groups (years) was relatively small (five) the Bonferroni Test (also available as a post-hoc test in Systat) was used to double check the findings of the Tukey test. Statistical tests differ in their power hence the double-check using the Bonferroni test (Simon Nicholson, pers. comm.). The results of these analyses are presented in Section 7 and more details on the equations employed are presented in Appendix 2 - Description of Pair-wise Comparisons.

7. Results from analysis of the fisheries data

7.1. Total Catch and Value for the Region, by District and by CMA

Annual estimates of catch and corresponding value for the years 2002-2004 for Tanga Region, the three Districts, and the six CMAs are given in Tables 12-14.

Table 12 - Annual Estimates of Catch/Value for Tanga Region, 2002-2004. * Tsh1090:1USD

Year	Annual Estimate of Catch (MT)	Annual Estimate of Value (Tsh)	Annual Estimate of Value (USD*)
2002	6,966.31	3,472,138,886	3,185,449
2003	7,880.45	3,318,202,807	3,044,223
2004	6,188.57	2,593,711,101	2,370,551

Table 13 - Annual Estimates of Catch/Value by District, 2002-2004. * Tsh1090:1USD

District	Year	Annual Estimate of Catch (MT)	Annual Estimate of Value (Tsh)	Annual Estimate of Value (USD*)
Muheza	2002	1,016.18	527,192,239	483,663
Muheza	2003	639.24	377,365,104	346,207
Muheza	2004	676.34	481,237,536	441,502
Pangani	2002	1,760.23	579,271,330	531,442
Pangani	2003	1,328.99	426,303,171	391,104
Pangani	2004	940.84	344,601,172	316,148
Tanga	2002	4,189.90	2,365,675,317	2,170,344
Tanga	2003	5,912.22	2,514,534,532	2,306,912
Tanga	2004	4,571.39	1,767,872,393	1,612,901

Table 14 - Annual Estimates of Catch/Value by CMA, 2002-2004 Tsh1090:1USD

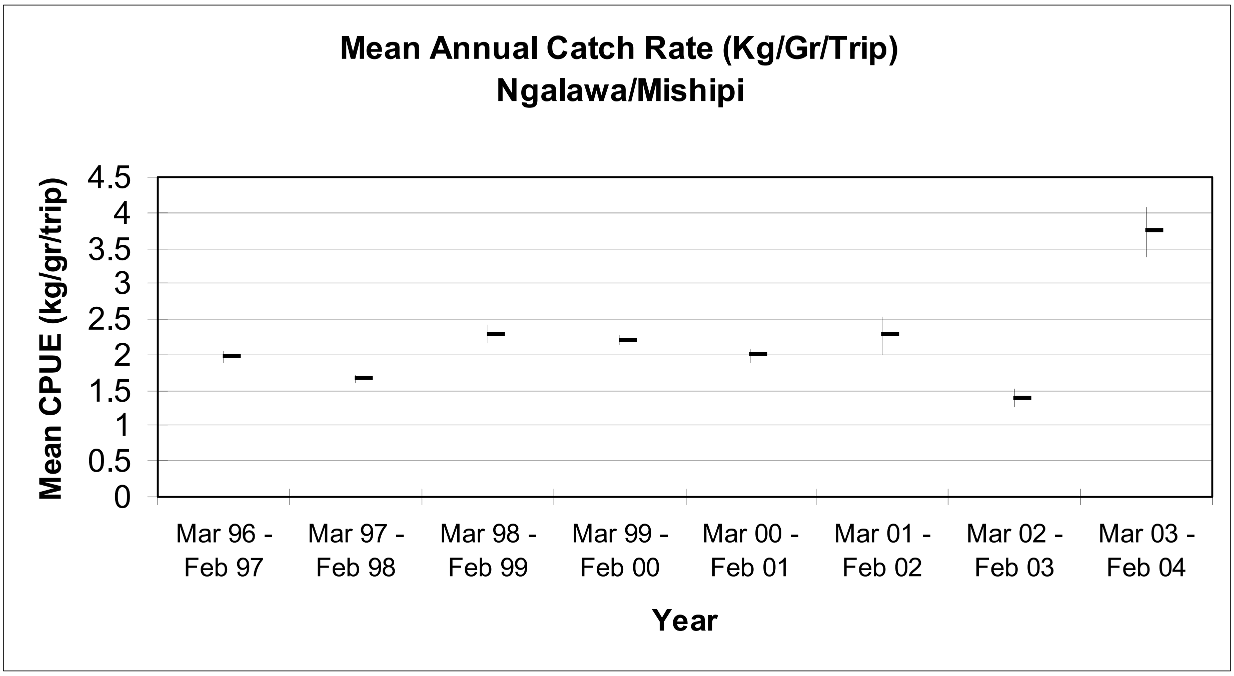
CMA	Year	Annual Estimate of Catch (MT)	Annual Estimate of Value (Tsh)	Annual Estimate of Value (USD*)
Boma - Mahandakini	2002	276.55	164,804,759	151,197
Boma - Mahandakini	2003	315.90	178,704,974	163,950
Boma - Mahandakini	2004	308.86	223,861,020	205,377
Boza - Sange	2002	1,143.52	391,220,710	358,918
Boza - Sange	2003	985.14	323,646,530	296,923
Boza - Sange	2004	804.61	277,864,926	254,922
DeepSea - Boma	2002	565.26	315,589,901	289,532
DeepSea - Boma	2003	417.13	299,457,449	274,732
DeepSea - Boma	2004	347.59	274,254,830	251,610
Mkwaja - Sange	2002	284.63	81,609,735	74,870
Mkwaja - Sange	2003	116.84	39,945,664	36,647
Mkwaja - Sange	2004	148.93	49,324,894	45,252
Mtang'ata	2002	171.55	92,640,135	84,991
Mtang'ata	2003	195.66	139,621,673	128,093
Mtang'ata	2004	108.37	58,832,409	53,975
Mwarongo - Sahare	2002	3,561.12	1,703,771,362	1,563,093
Mwarongo - Sahare	2003	5,650.05	2,196,027,073	2,014,704
Mwarongo - Sahare	2004	4,691.85	1,537,349,027	1,410,412

7.2. The Spatial and Temporal profile of Fishing Effort and Catch-rate

7.2.1. Annual Variations in CPUE for Ngalawa using Mishipi

Figure 10 presents a simple graph of mean annual catch-rate by year (where data are available) for the Kigombe Village data for ngalawas (outrigger canoes) using mishipi (handline). This graph indicates that there has been an increase in CPUE since 1996, although the increase has been slow through 2000 and with the major increase in CPUE occurring in 2003/04.

Figure 10 - Mean Annual CPUE (kg/gr/trip) for Ngalawa/Mishipi 1996-2004 from Kigombe village. Error bars represent 90% Confidence Intervals.

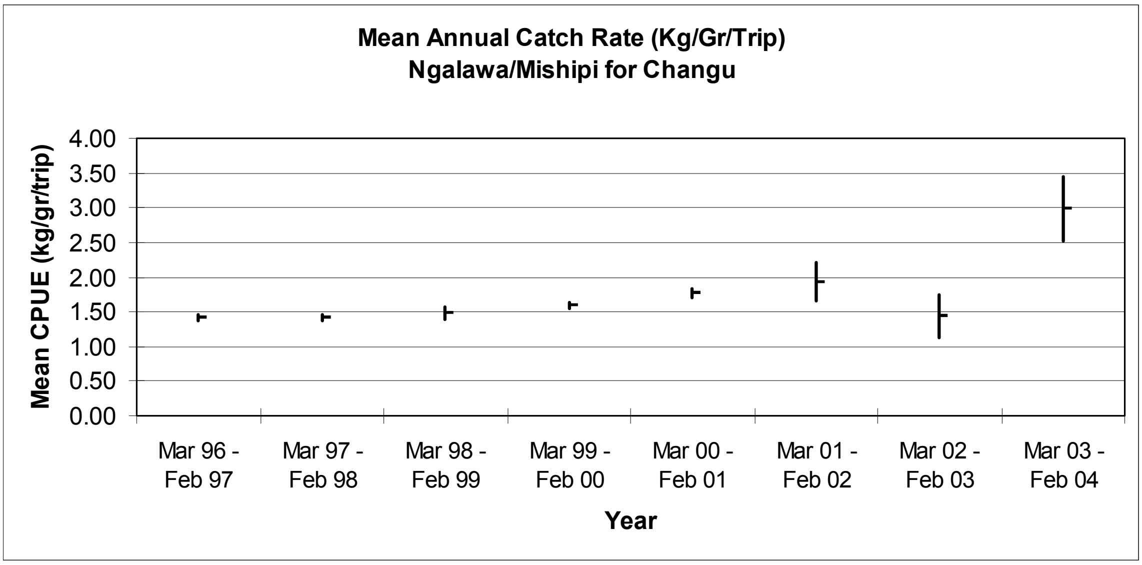


In order to test of the significance of this difference a Tukey Test (Kramer Modification) for multiple pair-wise comparisons was conducted. A Bonferroni test was also undertaken. As one might expect, from looking at the graphical representation of the data, 2003/04 data is significantly different (i.e. the CPUE is statistically significantly higher) from that of data from all previous years. And again as one would expect from the graphical presentation, the years 1998/99, 1999/00, 2000/01 and 2001/02 are not significantly different from each other. CPUE data from 2002/03 is significantly lower than all other years.

The data presented in Figure 10 aggregates the catch from all species caught by this vessel/gear combination and divides it by the total fishing effort. There are some problems with grouping the data from a multi-species fishery together because it assumes that each of the species that make up the fishery are similar in catchability and/or response to management activities. The average CPUE across the species caught by this gear might therefore hide the fact that some species are making a better recovery than others, or conversely may be in decline.

Figure 11 presents data on the catch of *changu* (emperors [Lethrinidae] and snapper [Lutjanidae]) only using this same vessel/gear combination. This group of species comprises about 40% of the catch-weight of this gear but is the largest single species group contributor to the catch. There are some differences in the catch-rate to be seen compared with the aggregated data, with arguably more of an upward trend in the mean CPUE figures. However, the mean CPUE for 2001/02 is not in fact statistically significantly higher than the preceding year and therefore the apparent trend is not statistically significant. Only 2003-04 is significantly different (higher) from all previously years.

Figure 11 - Mean Annual CPUE (kg/gr/trip) for *Changu* Ngalawa/Mishipi 1996-2004 **(with 90% Confidence Intervals)**



One is left therefore with a suggestion of a fairly constant, possibly increasing, CPUE (i.e. *changu* resource abundance) over the duration of the Programme with a sudden increase in CPUE in 2003/04. But it is difficult to say much more than that in terms of the resource of *changu* as a whole in the areas fished by this selection of fishers from Kigombe Village. *Changu*, as a group, are not only caught by mishipi and so this analysis can only relate to the species (and particular ages of those species) that comprise the resource of *changu* that is vulnerable to this particular vessel/gear combination. Because the species in this broad group differ in their ecology and behaviour it is likely that different species of *changu* will be vulnerable to different vessels/gears and/or at different times of the year. For example, in similar small-scale coastal fisheries in neighbouring Kenya, McClanahan and Mangi (2004) showed that *Lethrinus harak* comprised about 13% of the catch of gillnet fishers, but a less significant 2-3% of the catch of fish-traps. *Lethrinus sanguineus* (~28%) and *Lethrinus mahsenoides* (~27%) on the other hand were the dominant species in the catch of mishipi fishers. So to say that *changu* have increased in abundance based on the evidence from ngalawa/mishipi may only relate to certain species. Between 1995 and 2001 TCZCDP data only records the single grouping of *changu* and so it is not possible to differentiate between Lethrinid species over this time series of data in the same way that McClanahan and Mangi were able to with their data.

7.2.2. Seasonal Variations in CPUE for Ngalawas using Mishipi

Figure 12 presents monthly CPUE data (with 90% confidence interval) for ngalawas using mishipi to examine seasonal and monthly patterns and to glean other information about the fishery.

There is an apparent seasonality indicated by the data, which is particularly obvious in data collected under the 1st protocol. The CPUE typically has its peak around February-March of each year, coinciding with calmer weather typically associated with North-East Monsoon (Kaskazi) and its lowest values around May-June-July, coinciding with the period of cooler temperatures and higher mean wind speeds associated with the South-East Trade Winds (Kusi). In fact the apparent relationship is on the face of it very strong. There are three immediate candidates, firstly that the local abundance of fish is higher during the warmer period of the Kaskazi due to the reported increase in productivity levels associated with nutrient-rich currents flowing south (Sharp, 1983); secondly, that catch-rates increase because of some change in catchability of the gear, in other words, the fishing gears are more effective at catching fish during this period; or thirdly, the fishing grounds that fishers can reach in the Kaskazi are more productive or have larger fish than those they typically target during the Kusi. A fourth explanation concerns trip length: this is generally probably longer during the Kaskazi than during Kusi (e.g. see Figure 8), and so the observed increased catch per trip (per gear) might simply reflect the fact that the fishers are active for longer each day and therefore are likely to catch more, i.e. their catch per trip will be higher. If CPUE were based on catch per gear-hour the actual trip length would be already accounted for and therefore that any seasonal increase in CPUE would result from some other feature of the fishery, perhaps related to abundance, fishing grounds targeted or the catchability of the gear.

The relatively tight confidence intervals around the early data points (under the 1st protocol) are also noteworthy, when compared to those generated by the 2nd and 3rd protocol. The data indicate that the range of CPUE one is likely to record from any one trip is smaller during, for example in 1996 that in 2003. In August 2003 the data show that one could predict (with 90% confidence) that an ngalawa fisherman using mishipi would catch between 1.46 and 2.59 kg/trip for each handline used, with an average catch of 2.02 kg/gr/trip. In August 1999, the fisher would on average catch between 1.50 and 1.88 kg/gr/trip with a mean of 1.69 kg/gr/trip. The mean catch is higher in 2003 but the range of catch he could expect is also higher *about* that mean. Tight confidence intervals indicate a low variance between individual samples and this can be an indication that the data were perhaps not collected in a proper fashion.

Figure 13 presents data for ngalawa vessels using mishipi gear for the period August 2001 to July 2004, using kg/gr/hr as the unit of catch-rate. In other words it doesn't matter if the fishers spend all day or just 1 hour fishing, nor how many gears they are using. The CPUE should reflect either an increase in abundance, an increase in catchability or some spatial movement that allows them to fish in grounds where resources are more abundant or individually larger (assuming no significant change in handling time is associated with landing larger fish). There is no apparent significant increase or decrease in CPUE over the period of these data.

Figure 12 - Mean CPUE (Kg/Gr/Trip, with 90% CI) by Year/Month for Kigombe (Ngalawa/Mishipi), 1995-2004

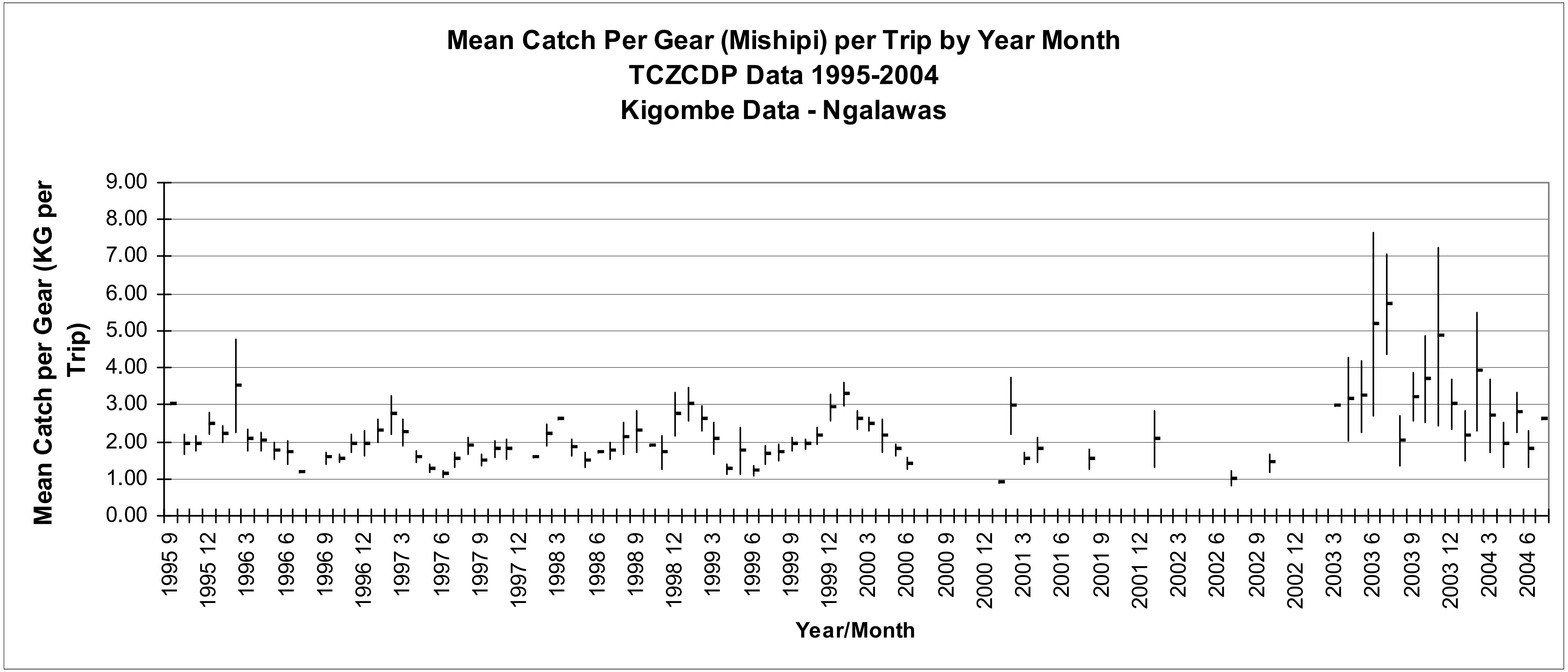
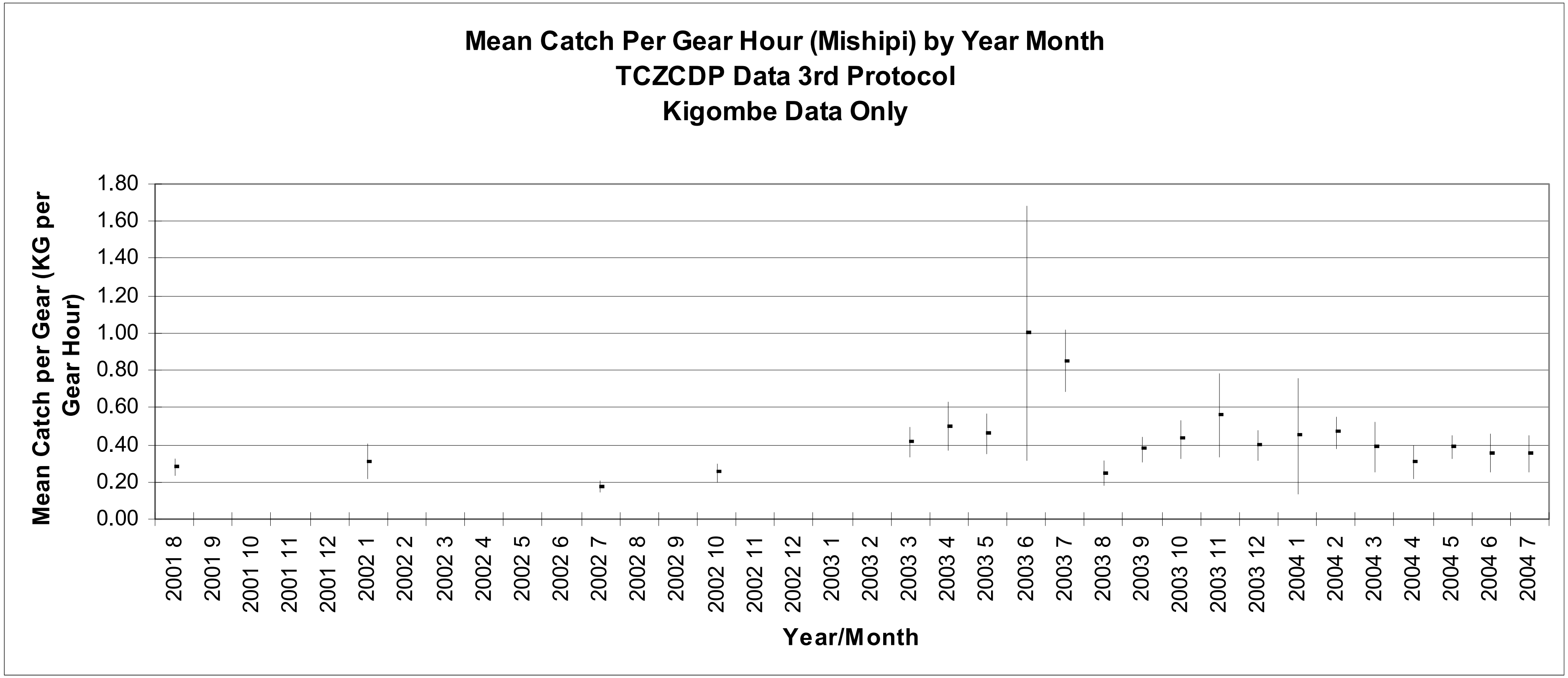


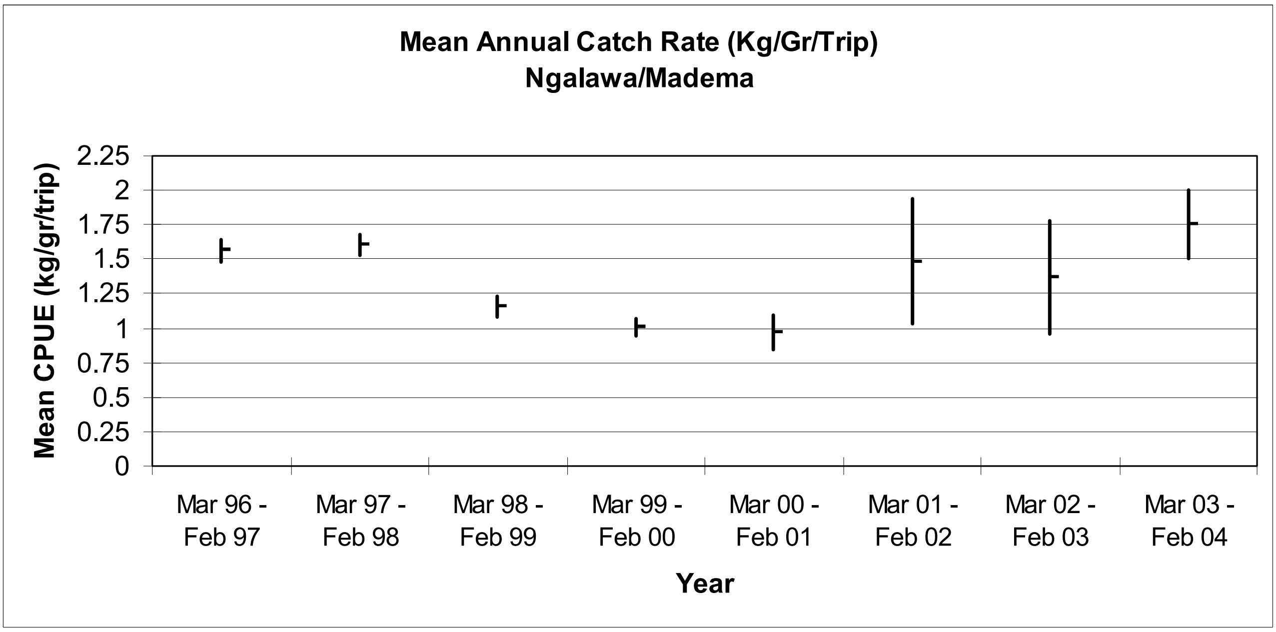
Figure 13 - Mean CPUE (Kg/Gr/Hr, with 90% CI) by Year/Month for Kigombe (Ngalawa/Mishipi), 2001-2004



7.2.3. Annual Variations in CPUE for Ngalawa using Madema

Figure 14 presents a simple graph of mean annual catch-rate by year for the Kigombe data for ngalawas using madema (fish traps). This graph indicates that there was actually a decrease in CPUE from 1996 through 1999/00, with a recovery in 2003/04.

Figure 14 - Mean Annual CPUE (kg/gr/trip) Ngalawa/Madema (with 90% Confidence Interval)



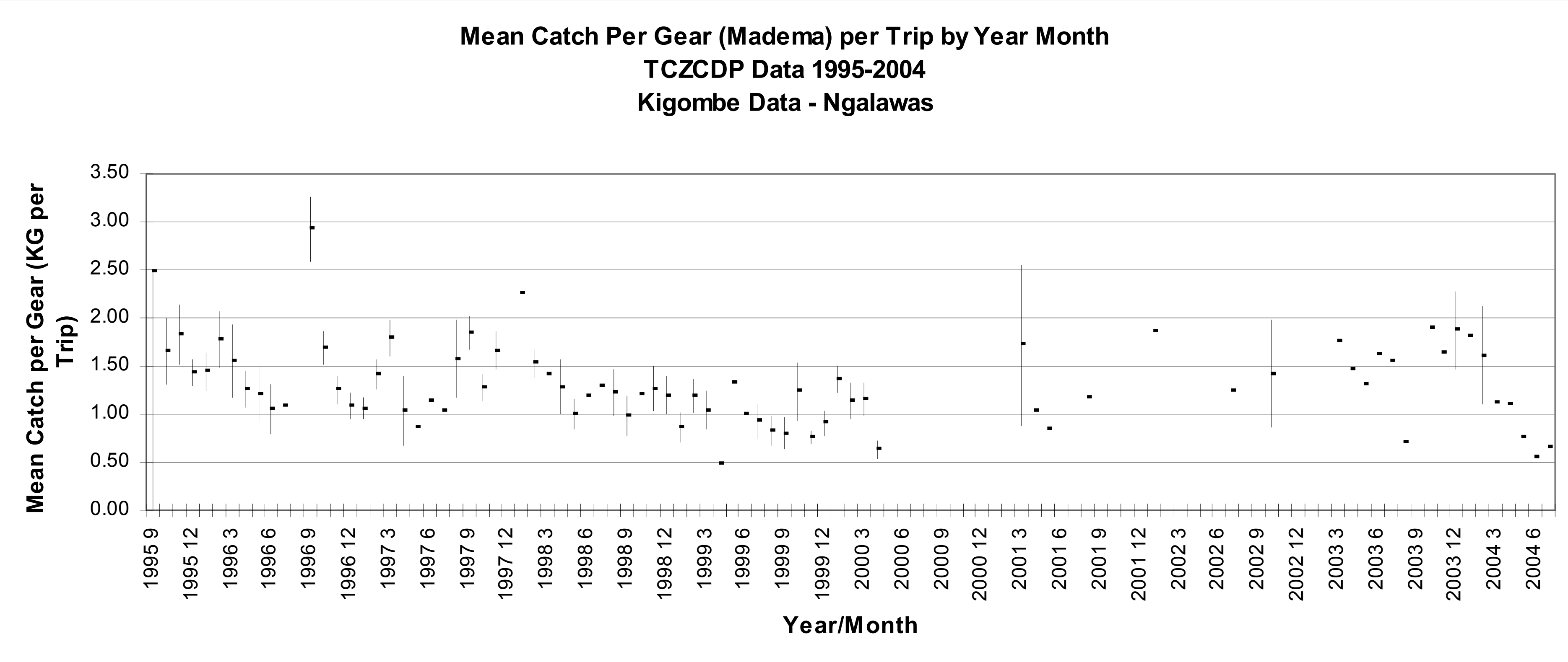
Again to test the significance of the differences between years, annual mean CPUE data was compared using the same Tukey Test. Statistical analyses show that the CPUE in 1998/99, 1999/00 and 2000/01 were significantly lower than the previous year of 1996/97 and 1997/98, and were also significantly lower than the most recent data from 2003/04. CPUE for 2003/04 is not significantly different from 2001/02 or 2002/03. The pattern shown indicates a significant decline between 1997/98 and 2000/01, but significant recovery from 2001/02.

7.2.4. Seasonal Variations in CPUE for Ngalawas using Madema

Figure 15 presents monthly CPUE data for ngalawas using madema. The high proportion of N<20 (as indicated by lack of CI bars) suggests that the required sampling sizes designed into the 3rd Protocol are not being achieved.

Although not as clear as with mishipi data, the data presented in Figure 15 does show an apparent seasonal trend similar to mishipi data with lowest CPUE in May-June. Because of the relatively few monthly data available from 2002 onwards from Kigombe a further graph of gr/hr CPUE was not produced.

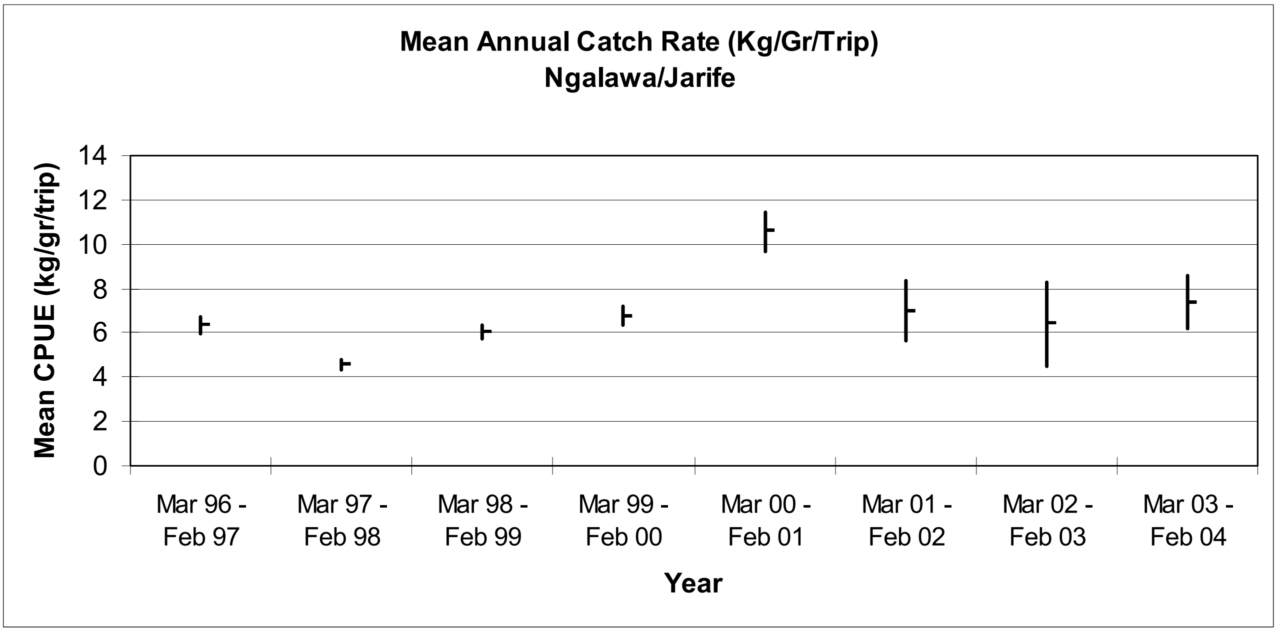
Figure 15 - Mean CPUE (Kg/Gr/Trip, with 90% CI) by Year/Month for Kigombe (Ngalawa/Madema), 1995-2004



7.2.5. Annual Variations in CPUE for Ngalawa using Jarife

Figure 16 presents a simple graph of mean annual catch-rate by year for the Kigombe data for ngalawas using jarife (shark net in English though catches are predominantly rays, see section 7.3 below). This graph would seem to indicate a decrease in CPUE between 1996/97 and 1997/98, with a recovery in 1998/99 which continued through to a peak in 2000/01, dropping again after this.

Figure 16 - Mean Annual CPUE (kg/gr/trip) Ngalawa/Jarife (with 90% Confidence Interval)



To test the significance of the differences between years, annual mean CPUE data was compared using the Tukey Test. The results show that the peak in 2000/01 was significantly higher than all other mean annual catch-rates, and the drop in 1997/98 was significantly lower than all other years. Data for 2001/02 through 2003/04 are statistically different from that of 1997/98, but are not different from 1996/97, 1998/99 and 1999/00, suggesting that CPUE in the latest years was similar to the level recorded in the earlier years.

7.2.6. Seasonal Variations in CPUE for Ngalawas using Jarife

Figure 17 presents monthly CPUE data for ngalawas using jarife. Although not as clear as with mishipi data, the data do show a similar seasonal trend of increased catch-rates during the Kaskazi, and notably with distinct peaks around March in 2003 and 2004. Figure 18 presents data for the period August 2001 to July 2004, using kg/gr/hr as the unit of catch-rate. A degree of seasonal change in CPUE is suggested but again no strong pattern is apparent. In general data using gear-numbers for jarife needs to be carefully considered because it appears that the number of individual nets (often 50m pieces) that make up a single *net* are not accurately recorded, either from misunderstanding of the fisher of the question (i.e. they report they use one *net*), or because these nets experience considerable wear and particularly tear during use and repairs are frequent. The precise number and length of each section may therefore not be known by the fishers themselves.

As observed with mishipi data, the possibly El Niño related decline in CPUE was in 1997/98 indicating what might be a more rapid response to the EL Niño event compared with the madema fishery. This may reflect some species or even ecosystem effect of El Niño that impacts differently the species typically caught using mishipi/jarife compared to those species taken by madema. Again these CPUE data might reflect a change in some other parameter of the fishery, not related to the El Niño at all.

Figure 17 - Mean CPUE (Kg/Gr/Trip, with 90% CI) by Year/Month for Kigombe (Ngalawa/Jarife), 1995-2004

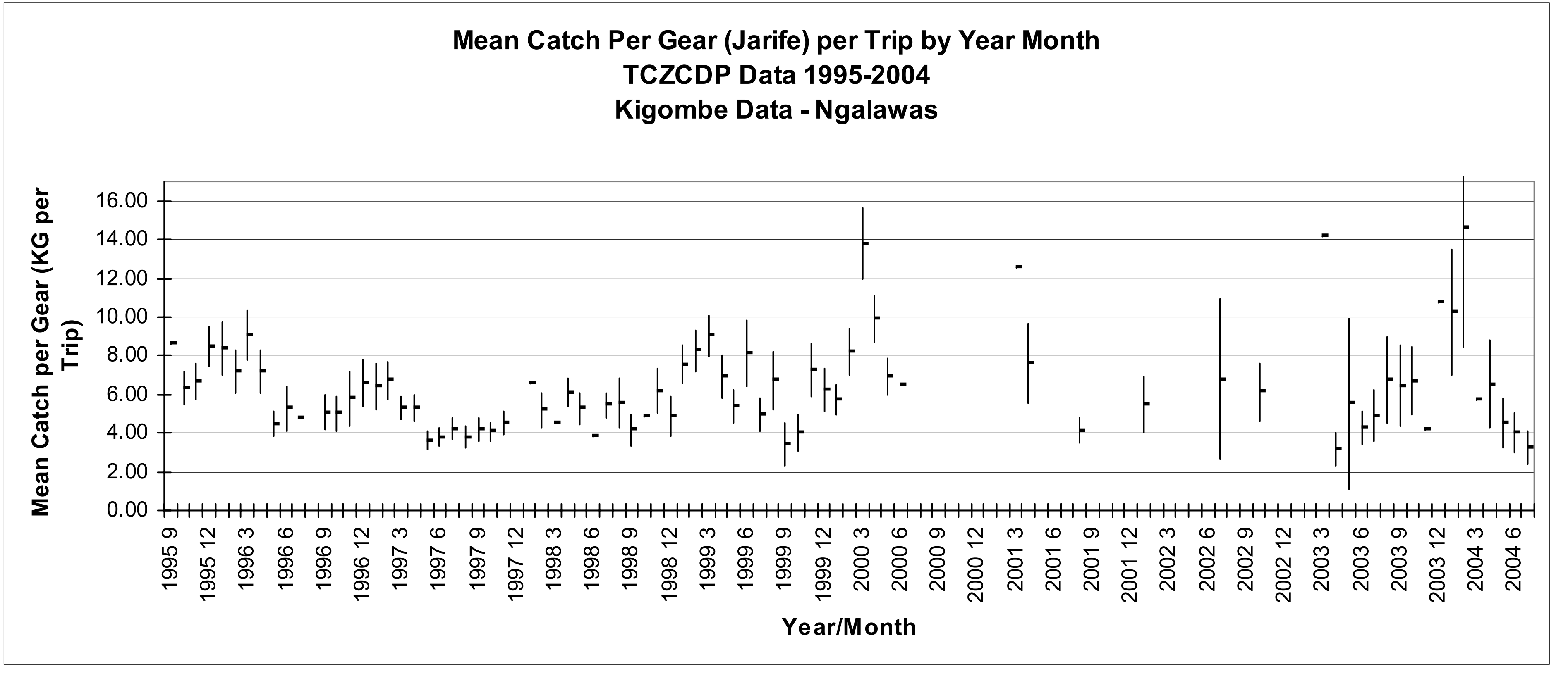
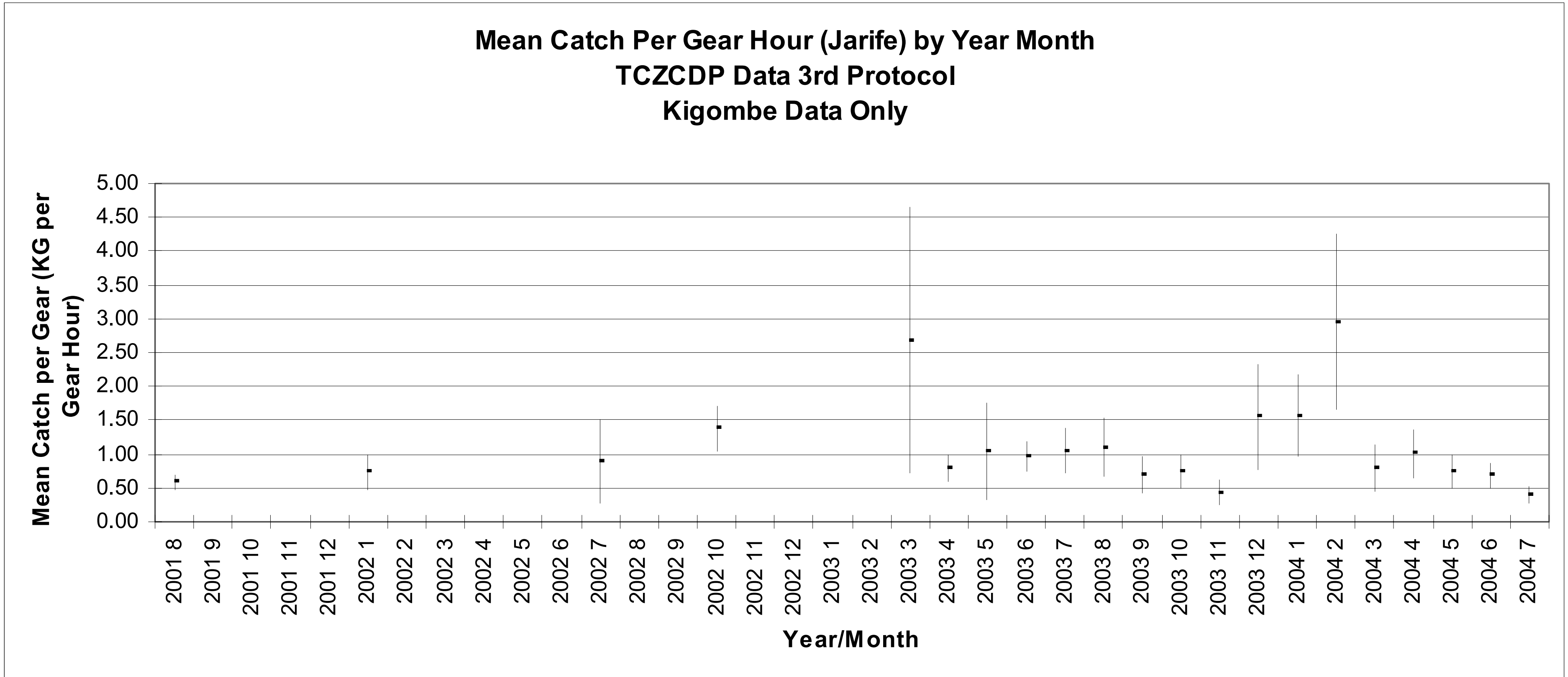


Figure 18 - Mean CPUE (Kg/Gr/Hr, with 90% CI) by Year/Month for Kigombe (Ngalawa/Jarife), 2001-2004



7.3. Catch Composition

The 1st Protocol did not have any limitation placed on the species (groups) recorded and so Table 15, Table 16 and Table 17 present major species/groups data, as a proportion of the total catch, from the 1st Protocol for three gear types, deployed from ngalawas.

Table 15 - Major Species groups in Ngalawa/Mishipi Data (1st Protocol) N ~ 85

Local Name	Species/Family	Proportion of Total Catch (wt)
Changu	Lethrinidae/Lutjanidae	0.39
Chafi	Siganidae	0.19
Fulusi	Coryphaenidae	0.07
Koana	Nemipteridae	0.06
Taa	Rays	0.04
KoleKole	Carangidae	0.02
Sansali	Xiphiidae	0.02
Jodari	Scombridae	0.02
Chewa	Serranidae	0.02
Songoro	Rachysentridae	0.01
Papa	Sharks	0.01

* The use of the approximate sign ~ for the total number of different species/group names reported in the 1st Protocol data is in recognition of the use of common names in the database but a definitive list of spellings has not been completed.

Table 16 - Major Species groups in Ngalawa/Jarife Data (1st Protocol) N ~ 70

Local Name	Species/Family	Proportion of Total Catch (wt)
Taa	Rays	0.72
Papa	Sharks	0.08
Kolekole	Carangidae	0.04
Pungu	Myliobatidae	0.03
Songoro	Rachycentridae	0.02
Hongwe	Catfish	0.01
Gayogayo	Rays	0.01
Chewa	Serranidae	0.01
Pandu	Carangidae	0.01

Table 17 - Major Species groups in Ngalawa/Madema Data (1st Protocol) N ~ 40

Local Names	Species/Family	Proportion of Total Catch (wt)
Chafi	Siganidae	0.81
Changu	Lethrinidae/Lutjanidae	0.06
Kangu	Lethrinidae	0.03
Mkundaji	Mullidae	0.02
Pono	Scaridae	0.01
Taa	Rays	0.01
Kangaja	Acanthuridae	0.01
Chewa	Serranidae	0.01
Kanda	Lobotidae	0.004
Kolekole	Carangidae	0.003
Vitamba		0.002

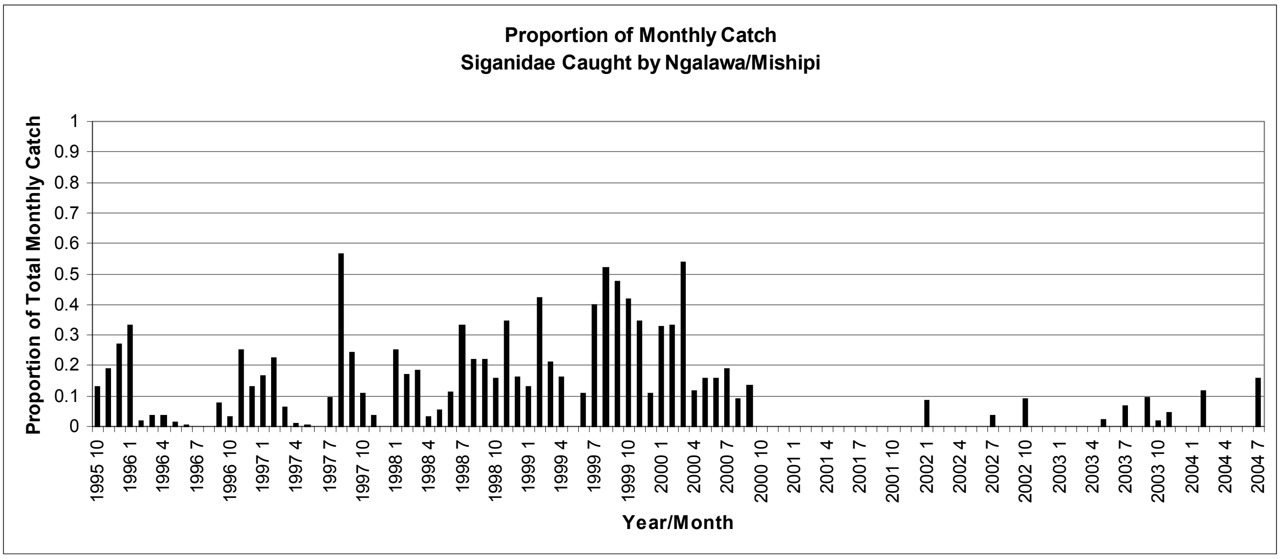
An obvious point to make is that for all three of these gear-types the catch is largely dominated by one or two (ki-swahili) groups. It is therefore recommended that any research activities to be undertaken by TCZCDP, the Fisheries Division's Tanzanian Fisheries Research Institute (TAFIRI) or the Institute of Marine Science (IMS), should target the species to which these local names refer, particularly the typically highly vulnerable rays that appear to dominate the jarife catch.

It is expected that the reduction in the use of dynamite and beach-seine nets would result in some recovery in the abundance of species vulnerable to those gears. However, there are few data available in Tanzania on the species composition of beach-seine/dynamite catches so it is not easy to know for which species one should be looking for a recovery in. In fisheries elsewhere where dynamite is used the resources targeted tend to be small-pelagic species including Sardines (*Sardinella* spp.; *dagaa*), Fusiliers (Caesionidae; *Mbono*) and Indian Mackerel (*Rastrelliger kanagurta*; Kibua/Vibua), all of which school tightly and are therefore a relatively easy target and make for efficient use of the explosive charge. Few data exist for sardinella, but both Indian Mackerel and Fusiliers are routinely recorded under the 2nd and 3rd Protocols although only relatively few records exist for them from the 1st Protocol. Despite the fact that Fusiliers are routinely recorded under the most recent protocols very data exist so far, with only 49 occurrences in the entire database and the data for Indian Mackerel is very patchy and with an enormous variability. Neither the data for Fusiliers nor Indian Mackerel are suitable for interpreting any significant changes in relative abundance.

In neighbouring Kenya, McClanahan and Mangi (2004) did record the species composition of beach-seines used in the southern part of the country. The dominant species were Common Ponyfish (Latin: *Leiognathus equulus*; Ki-Swahili: Potwe), Marbled Parrotfish (*Leptoscarus vaigiensis*; Pono), Sky Emporer (*Lethrinus mahsena*; Changu, Tuku) and White-spotted Rabbitfish (*Siganus sutor*; Chafi). There are no specific data in the TCZCDP database on ponyfish, the marbled parrotfish, or the sky emperor and only under the 2nd and 3rd Protocols was the whitespotted rabbitfish specifically identified. All these species are certainly present in Tanzania and have been observed in beach-seine catches (pers. obs.).

Figure 19 presents data on Siganidae caught with mishipi (again, all data are from Kigombe). There does not appear to be any clear increase in relative abundance of Siganidae (NEI) over the years. Arguably there are peaks in relative abundance around August through January/February (Kaskazi) but the data are relatively scattered but overall, the relative abundance somewhat inexplicably, actually declines. A significant proportion of the total data for this vessel/gear combination in the 3rd Protocol is 'Others' (although this doesn't appear on the data collection form itself), so it is not possible to make any assessment of what might be *replacing* Siganidae in the mishipi catch. A factor in the apparent seasonality may be the geographical distribution of the fishing effort, with habitats perhaps favoured by Siganidae being more accessible during the Kaskazi, although a lot more detailed knowledge on the fishing grounds is needed before it is possible to say more on this.

Figure 19 - Proportion of Monthly Catch of Siganidae (Ngalawa/Mishipi)



As one might expect, given that they are herbivores, Siganidae are dominant in the madema fishery, see Figure 20, typically contributing 70-80% of the total catch. Again the peak contribution is around August through January/February and again the relative contribution in the more recent catch data appears reduced compared with pre-2001 data.

Figure 20 - Proportion of Monthly Catch of Siganidae (Ngalawa/Madema)

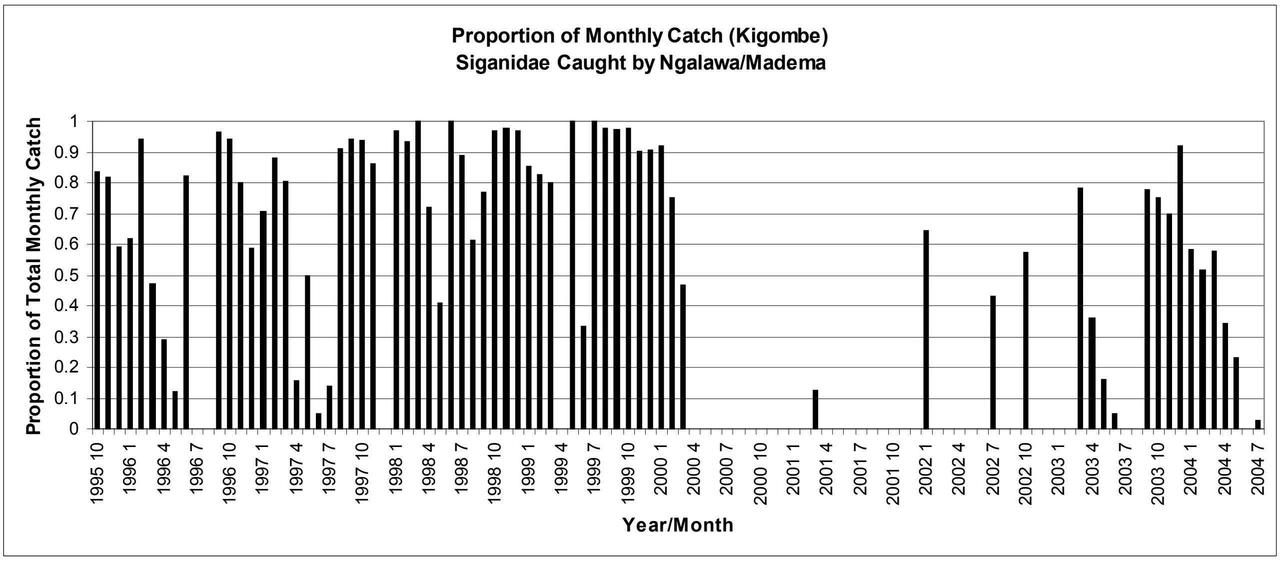


Figure 21 presents data for Lethrinidae (NEI) caught from ngalawa vessels using mishipi gear. A strong apparent seasonality is present in landings but a slightly different picture emerges with the typical peak relative abundance being earlier in the year (during the Kusi) than is perhaps the case for Siganidae. In the more recent data the relative contribution appears to be more similar to the previous years' data. Again the issue of the geographical location of fishing effort during the Kusi may be an issue here.

Figure 21 - Proportion of Monthly Catch of Lethrinidae (Ngalawa/Mishipi)

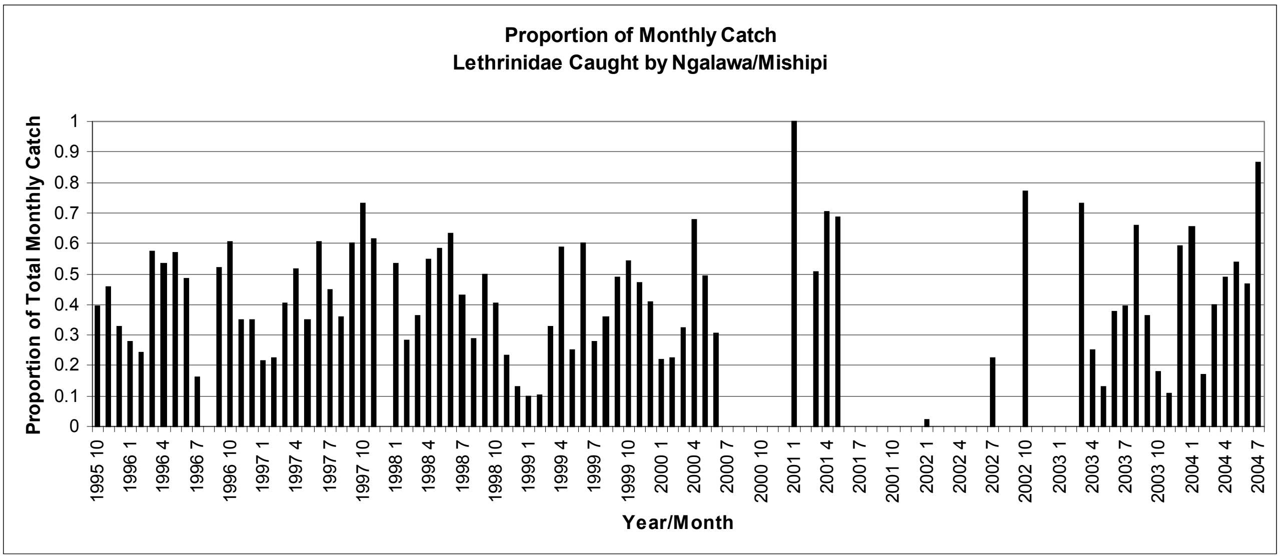
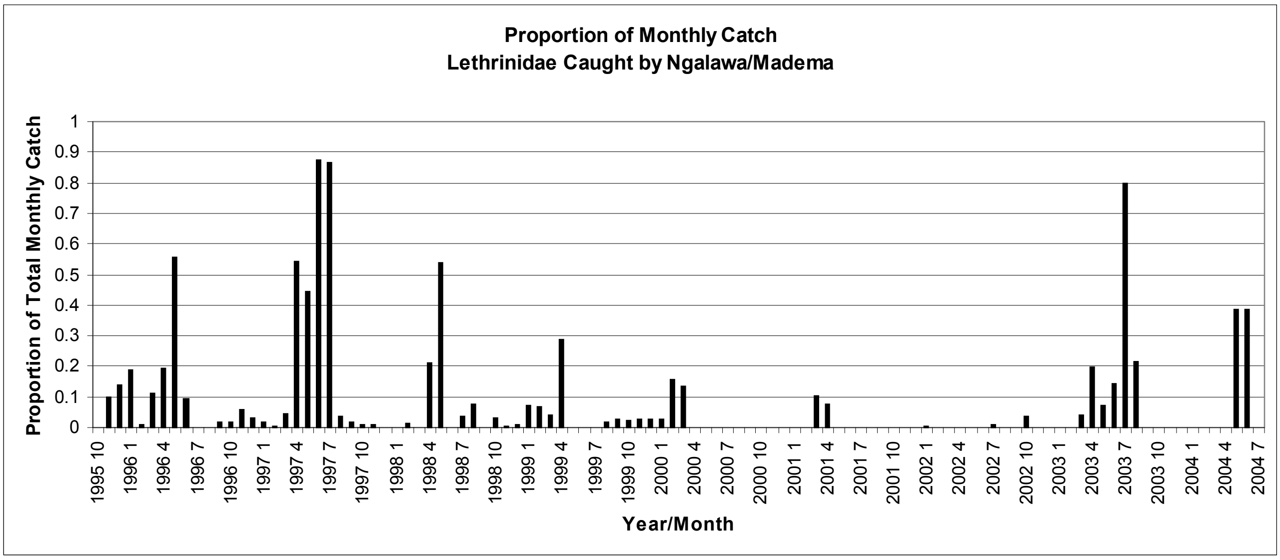


Figure 22 presents data on catches of Lethrinidae using madema. The data show a very strong seasonality in the capture these species, with clear peaks at the same time of year (Kusi) as with the mishipi fishery, but with very few data outside of this period. In both cases, the same type of vessel is being used, but Lethrinidae appear to be much more seasonally available. The question of whether the fishers are operating in different grounds might be accounted for by the fact that the peaks in Lethrinidae are at approximately the same time each year. So assuming the fishers are using the same grounds each year, these data would seem to indicate a strong seasonal variation in Lethrinidae's vulnerability to madema. Again there is little in the way of an apparent increase in the relative abundance of these species in the catch.

Figure 22 - Proportion of Monthly Catch of Lethrinidae (Ngalawa/Madema)



So overall, there is little evidence that the populations of the groups that these species belong to are showing any sort of dramatic recovery in abundance. This might be because the period since the beach-seine ban was introduced is still relatively short and it might also be because the ban on both beach-seining and dynamite-fishing is not complied with. There is evidence for example from TCZCDP records that the use of beach-seines persists (TCZCDP Mid-Term Review, 2001).

7.4. Variations in Price of Fish by Species/Species Group

Data on prices by species only exists from the 1st Protocol and so it is not possible to undertake an analysis of price variation within species/species groups beyond 2001. However it is possible to look at data for just the 1st Protocol. Figure 23, Figure 24 and Figure 25 present data on the mean price per kilo for Chafi (Siganidae), Changu (Lethrinidae) and Taa (Rays). No data is available for species-specific pricing in data from the 2nd and 3rd Protocol because individual data were not collected, just the total value of the catch. The extent to which these prices are meaningful are perhaps limited anyway because observations at market places suggest that sales are often made by string of fish, which often comprise more than one species/group. The picture from the data as it stands indicates a falling mean price over the period, particularly pre-1998.

Figure 23 - Mean Price per Kilo for Chafi 1995-2001 Kigombe (with 90% Confidence Interval)

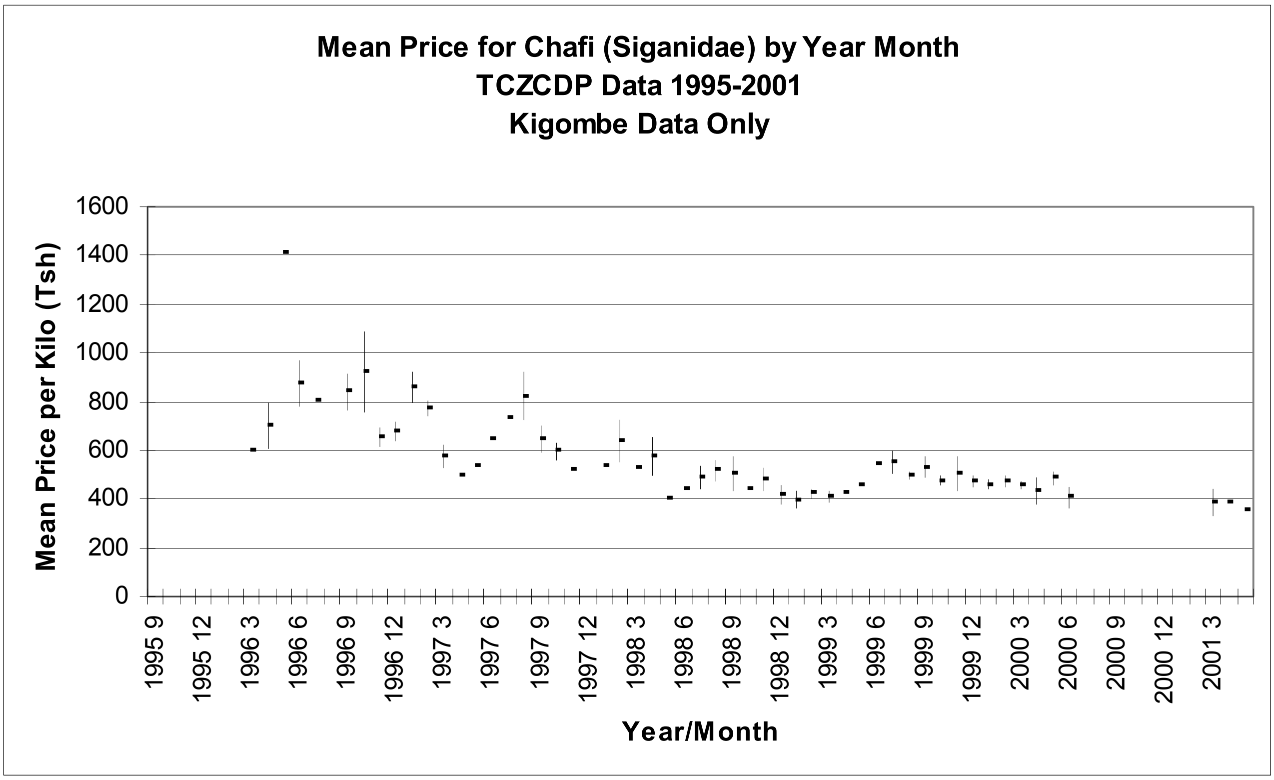


Figure 24 - Mean Price per Kilo for Changu 1995-2001 Kigombe (with 90% Confidence Interval)

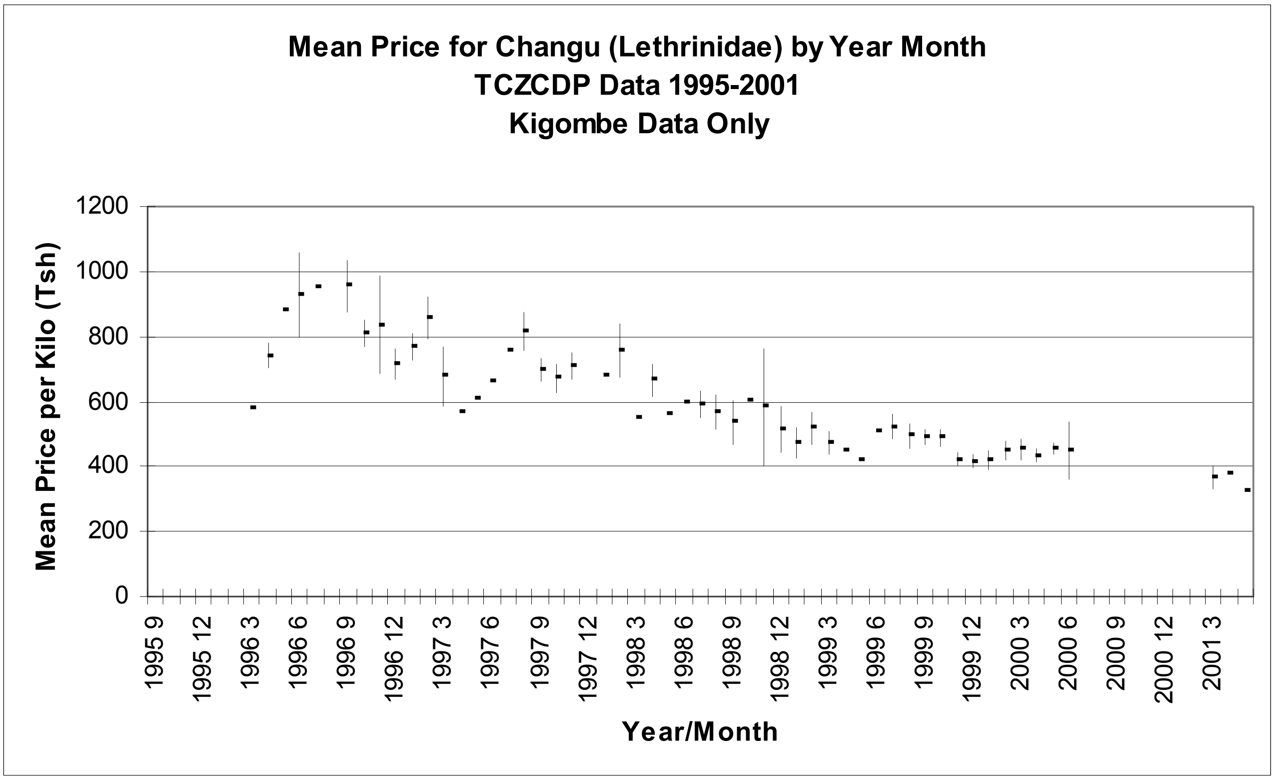
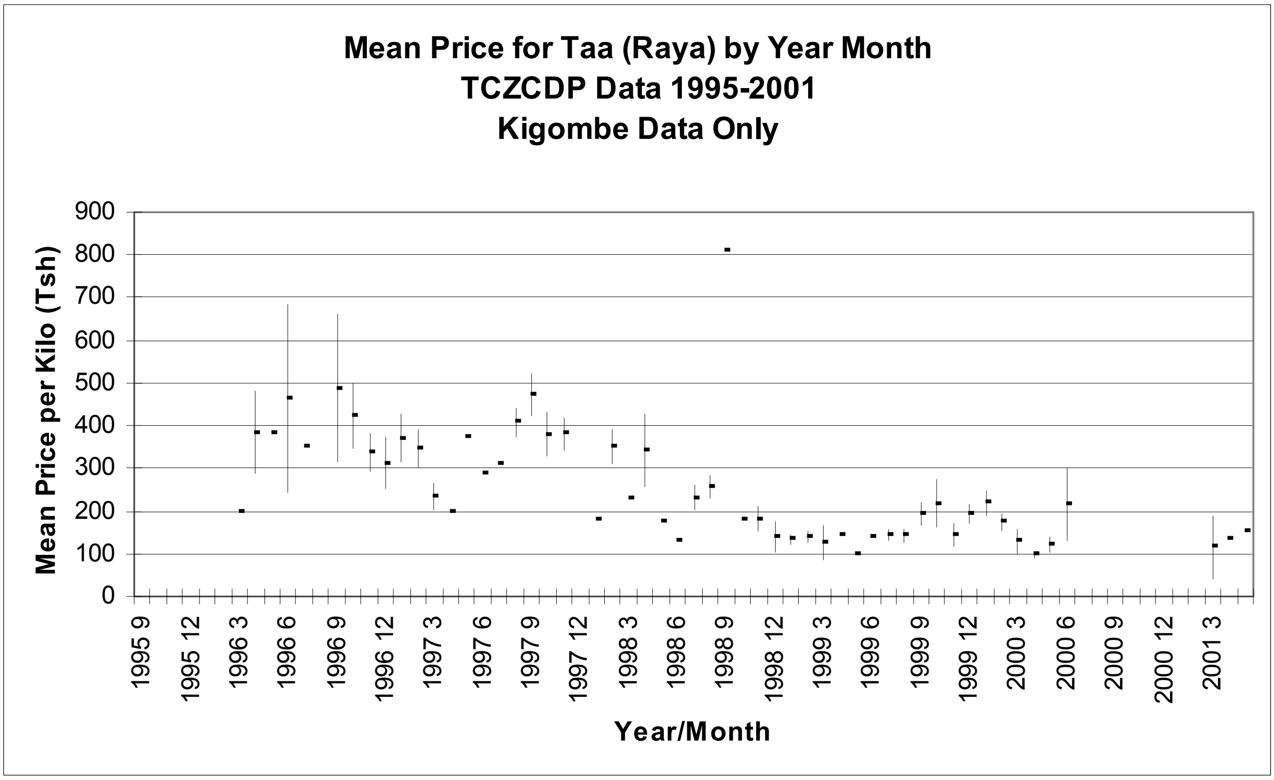


Figure 25 - Mean Price per Kilo for Taa 1995-2001 Kigombe (with 90% Confidence Interval)



It is possible to look at mean price variations paid for entire catches across the period of 1996 (when price data was first collected) through 2004. Building on the separate price and mean catch analyses produced in Horrill et al. (2001) further data from the 3rd Protocol were added and a graph produced of mean catch per trip against mean price per kilo by year and month (again just for Kigombe Village data). The data are presented in Figure 26. The prices were adjusted by fixing the annual price (value) of a US Dollar (in Tanzanian Shillings) to the 1996 mean annual US$ exchange rate against the Tanzanian Shilling using data obtained from the Tanzania Bureau of Statistics.

It is difficult from this data to immediately determine the nature of the relationship between price and the supply of fish, and an analysis of price elasticity of supply would be a useful. Price elasticity of supply (PEoS) describes how sensitive supply is to the price of a good or service. Producers (fishers in this case) will theoretically supply less of a product if the price is high (because they can earn a certain level of revenue supplying fewer units of goods or services than when the price per unit is low). If fishers are sensitive to this opportunity they would be able to spend less time fishing for the same income, and perhaps engage in other economic/subsistence activities. If supply is not sensitive then they will still supply as much fish as they can whatever the price at market. Selections of a run of price increase were made from the data for each of 6 CMAs and the mean catch per trip was used as a proxy for the supply (assuming that the mean catch from the sample reflected the mean catch across the entire fishery in each CMA and therefore the total level of supply). In all CMAs, except Boza-Sange, the price elasticity of supply was less than 1, which by rule of thumb indicates that supply is not sensitive to price. Boza-Sange had a PEoS of 1.4, which suggests some sensitivity to price.

There are two important caveats in interpreting such an analysis. Firstly, the quality of the estimate of the total fish supply is very important but because the VAS and BAC data are not adequately collected the detailed monthly estimate of catch (supply) may be relatively low in accuracy. Secondly, if prices are fixed by buyers in exchange for a loan *before* fishers go out fishing they are become somewhat independent on the actual supply. A useful activity for TCZCDP would be to undertake a survey of market auctioneers and/or senior fishers to evaluate their perceptions of price changes and influences on price. If data on the costs of fishing gear was obtained over the period in question then it would be possible to develop a Terms of Trade Indicator analysis (James Wilson, SADC/MCS Economist, pers. comm.)

Another way of looking at the relationship between supply and price of fish can be illustrated graphically by scatter-plots of mean catch (again as a proxy for supply) against the mean price per kilogramme) from 2003/04 data. The only CMA that appears to have a significant relationship between price and supply is Mwarongo-Sahare, which includes Tanga Town, a major market, and possibly Mtang'ata. Note that mean price per kilogramme of fish appears to reduce as one moves south from Boma-Mahandakini in the north of Tanga Region to Mkwaja-Sange in the south. This may reflect the poorer infrastructure and distance to the main market of Tanga.

Figure 26 - Mean Catch per Trip and Price Data for Kigombe

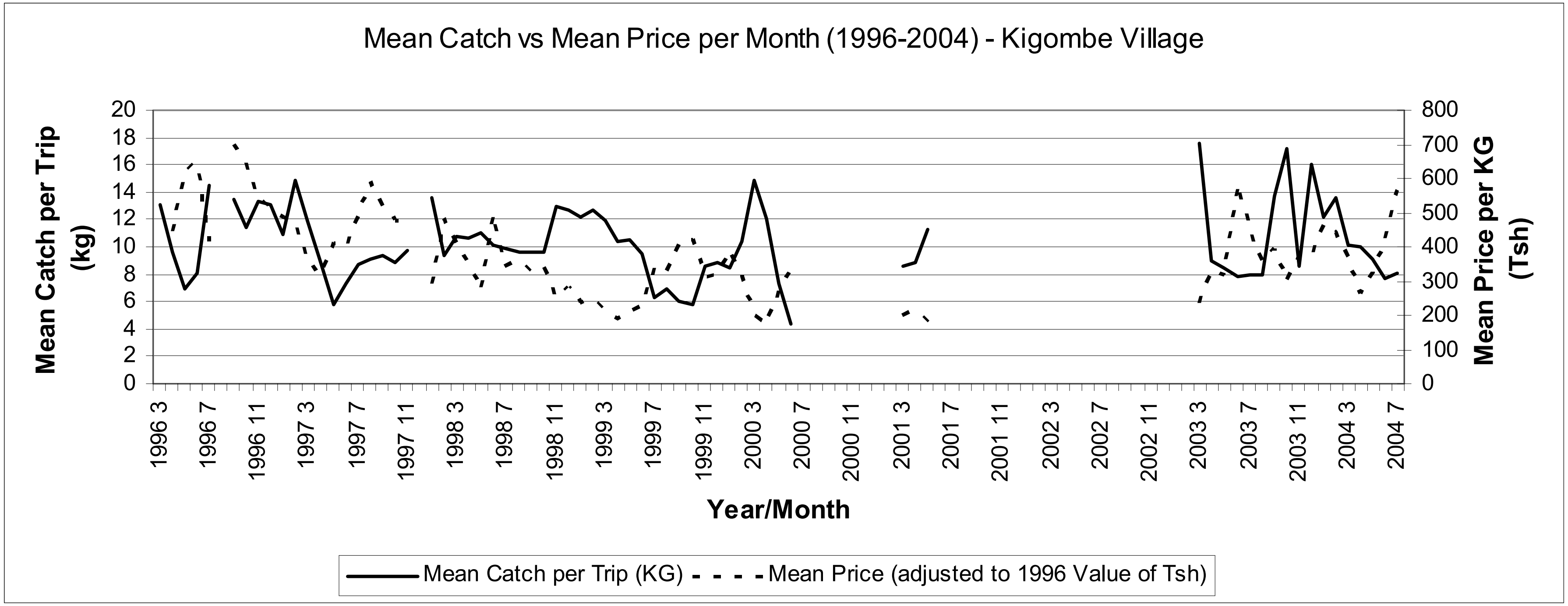
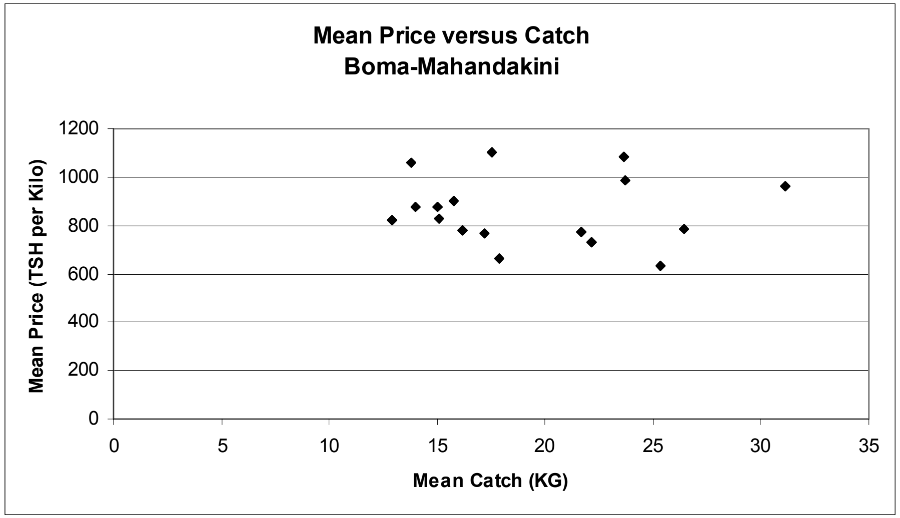
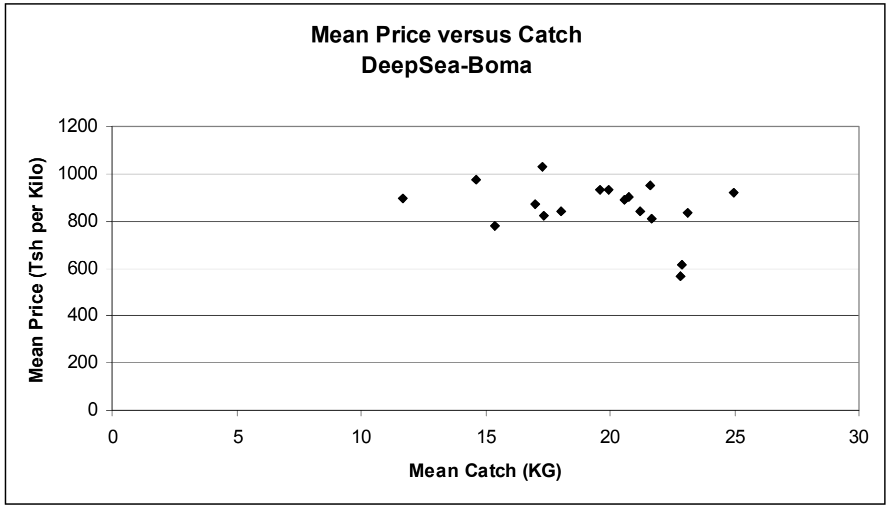


Figure 27 - Mean Price against Mean Catch (2003/04) for each CMA

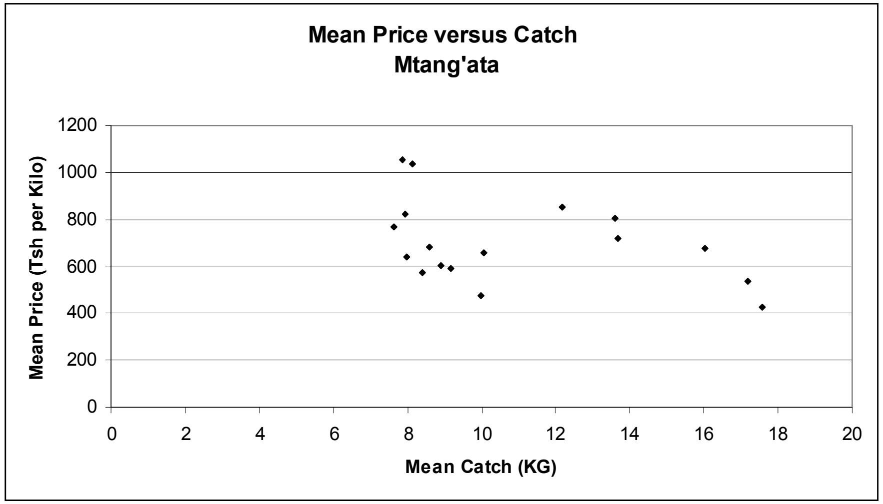
a)



b)



c)



d)

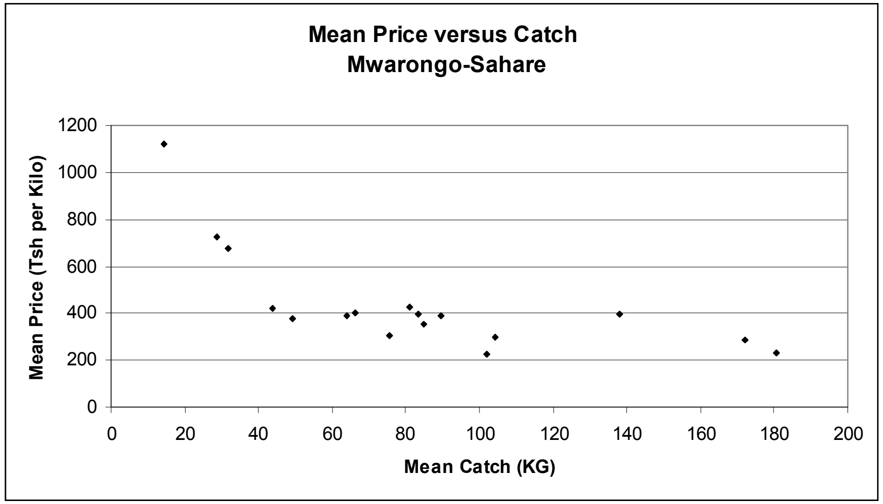
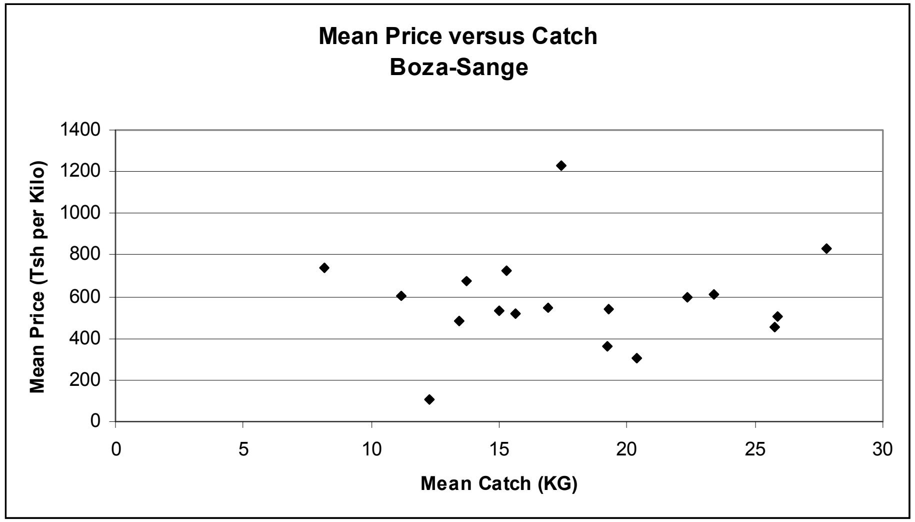
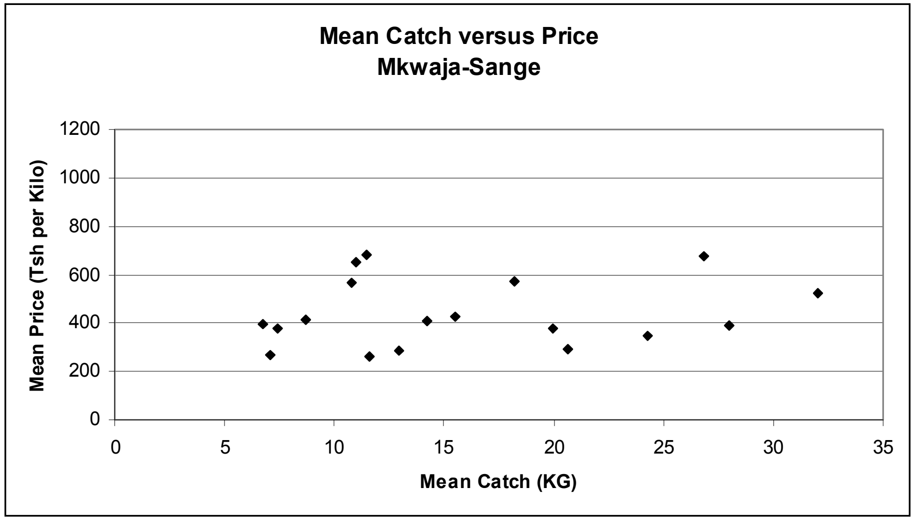


Figure 27 (Continued) - Mean Price against Mean Catch for each CMA

e)



f)



7.5. The Use of Different CMAs by Local Fishers

A large number of fishing grounds (498) were recorded in the post-2001 data although some of these may not be unique and may differentiate in the database because of differences in spelling. TCZCDP is currently updating its list of fishing grounds and so far 112 have been specifically identified as belonging to a particular CMA or district. Because only three CMA plans were referenced (Mkwaja-Sange, Boza-Sange and Mtang'ata) the analysis is on a sub-set of data which covers approximately 50% of the fishing trips recorded in the 2nd and 3rd Protocols. These fishing grounds particularly relate to the CMAs of Mtang'ata (44 grounds) and northern Boza-Sange (40 grounds) located close to Tanga Town and the TCZCDP offices. Nine grounds are identified as occurring in more than one CMA. With the completion of the GIS system and the geo-referencing of fishing grounds a more complete picture of movement of fishers between CMAs can be developed. This has important implications related to individual CMA management efficacy, estimates of yields by CMA and estimates of revenues generated from individual CMA marine resources.

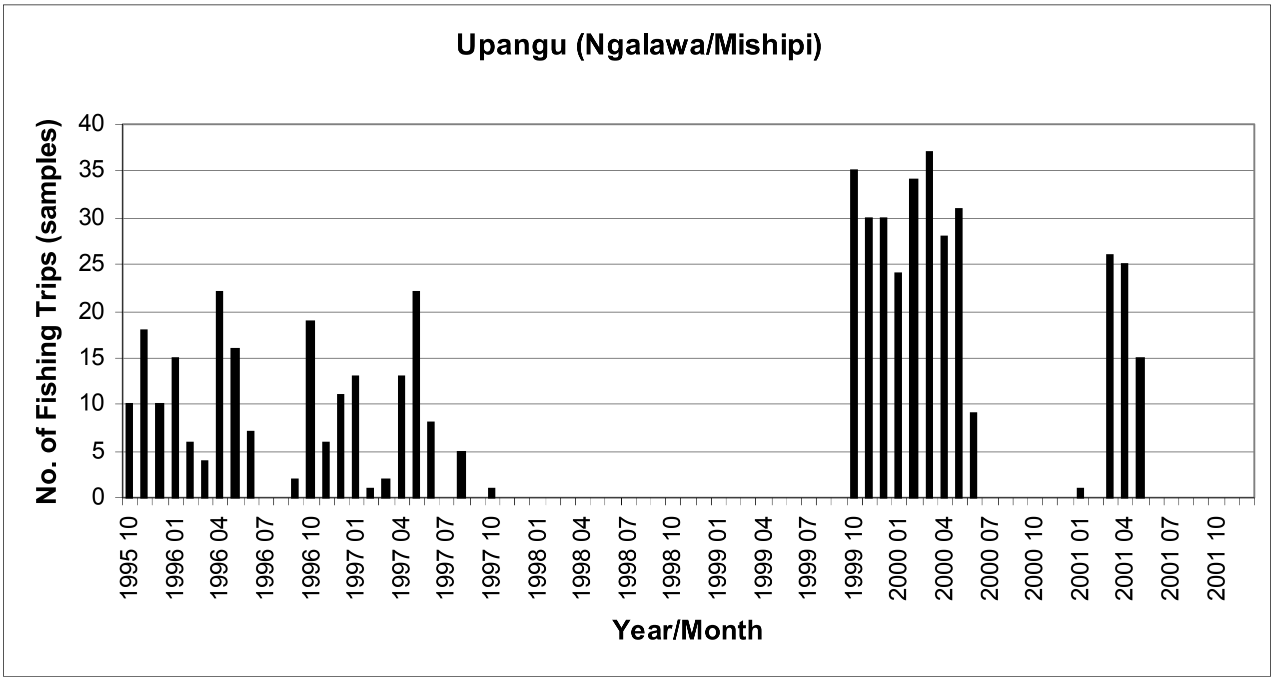
At this stage therefore, the analysis was limited to comparing data from the CMA in which the landing site is located (Home CMA) with the CMA in which the stated fishing grounds are located (Fishing ground CMA location) see Table 18. As noted previously some grounds are cross-border and therefore the actual fishing effort may have taken place inside one or both of the relevant CMAs. There are also likely to be vessel/gear and seasonal differences in the extent fishers range from their home port, but at this stage the analysis is limited to aggregated data. **Table 18** presents data on the major grounds identified from the data, and for which a location is known. Notable in these data are the fact that non-specific grounds (Any Open Water) feature prominently in the percentages of trips undertaken, particularly for Mkwaja-Sange, and less so for Boza-Sange and Boma-Mahandakini. These CMAs have relatively few reef complexes and this may explain the more prominent use of a non-specific term for the fishing ground. This has management implications as far as closure of grounds is concerned. The large (~ 20km in length) Karange reef complex, which dominates the southern part of Mwarongo-Sahare, and Majivike (in the northern part of Mtang'ata CMA) also feature prominently. In terms of use of neighbouring CMAs, the evidence is still limited, although there is apparent use of Boza-Sange CMA by fishers landing in DeepSea-Boma CMA, at least 50kms to the north. Confirmation is needed that the name of Kijamboni is not also used to identify (a different) fishing ground within DeepSea-Boma CMA.

As would be expected where closed areas have been established (and therefore no fishing should legally occur) only limited analysis was possible on the efficacy of these closed reefs. However a number of observations are possible using what data are available. Mtang'ata CMA has established four closed areas during the course of the programme. In 1996 Kitanga and Upangu reefs were closed to fishing, but were re-opened (largely for political reasons) in 1999. In 2001, and after negotiations between stakeholders, Makome and Shenguwe reefs were closed and remained closed to fishing at the time of writing. Figure 28 presents data on the sampled fishing effort from Upangu Reef between 1995 and 2001. Note that the closed area was not initially respected by all fishers but reported fishing effort inside the closed area had ceased by October 1997. The reef was opened to legal fishing in October 1999.

Table 18 - Location of Fishing Grounds in relation to Home CMA

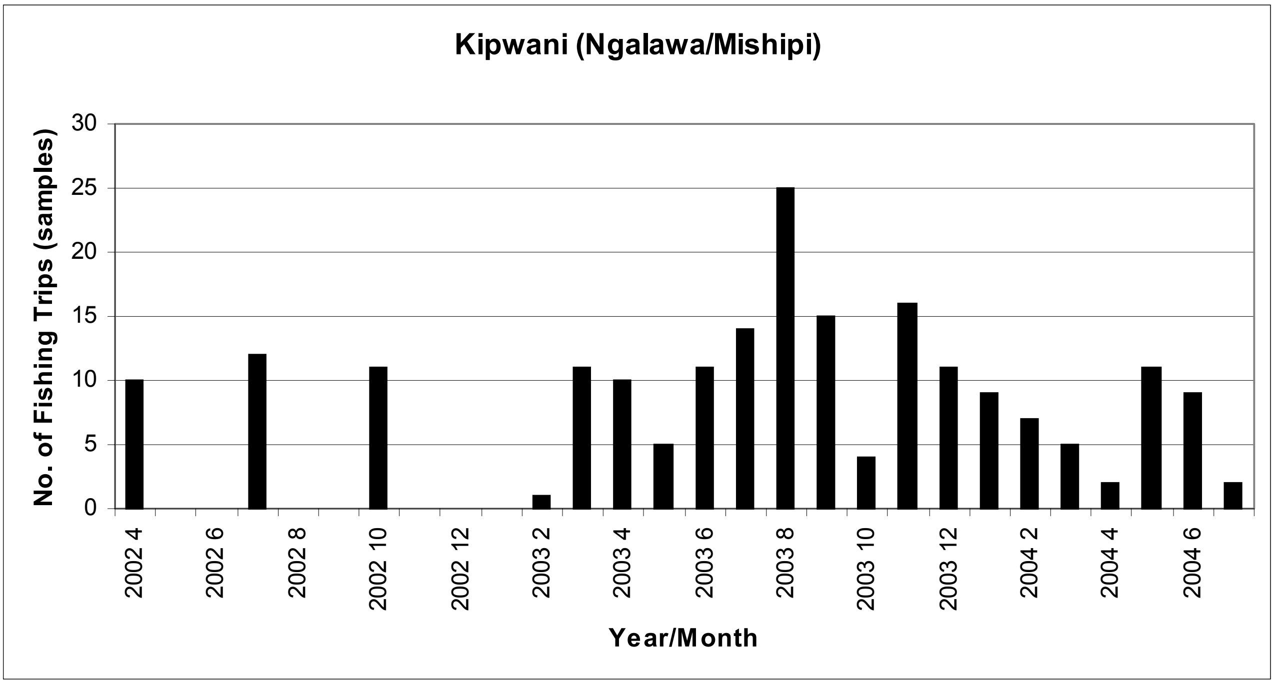
Home CMA	Fishing ground name	CMA Location of Fishing Ground	No. of Trips	Percentage of Total Trips from Home CMA
Mkwaja-Sange	Mkondoni	Any Open Water	182	44%
Mwarongo-Sahare	Karange	Mtang'ata and Mwarongo-Sahare	1439	32%
Mtang'ata	Majivike	Mtang'ata	657	30%
Boza-Sange	Mkondoni	Any Open Water	452	26%
Boma-Mahandakini	Mkondoni	Any Open Water	310	17%
Boza-Sange	Stahabu	Boza-Sange	226	13%
Mkwaja-Sange	Vijamba tisa	Mkwaja-Sange	49	12%
Mwarongo-Sahare	Funguni	Mtang'ata	505	11%
Mtang'ata	Chanjale	Mtang'ata	213	10%
Boza-Sange	Dindini	Boza-Sange	147	8%
DeepSea-Boma	Kijambani	Boza-Sange	324	8%
Mtang'ata	Upangu	Mtang'ata	167	8%
Mtang'ata	Funguni	Mtang'ata	160	7%
Mkwaja-Sange	Mafui	Mkwaja-Sange	26	6%
Mtang'ata	Kange	Mtang'ata	135	6%
Boza-Sange	Mkadamu	Boza-Sange	105	6%
Mkwaja-Sange	Sange	Boza-Sange and Mkwaja-Sange	22	5%
Boza-Sange	Mijimile	Boza-Sange	82	5%
DeepSea-Boma	Milangoni	Boza-Sange	186	5%
Mtang'ata	Kandacha	Mtang'ata	97	4%
Mtang'ata	Taa	Mtang'ata	91	4%
Mwarongo-Sahare	Jambe	Mwarongo-Sahare	182	4%
Boza-Sange	Dacha	Boza-Sange	67	4%
Mtang'ata	Kitanga	Mtang'ata	83	4%
Mtang'ata	Topeni	Any Open Water	70	3%
Boza-Sange	Rasini	Mtang'ata	54	3%
Mkwaja-Sange	Funguni	Mtang'ata	11	3%
DeepSea-Boma	Taa	Mtang'ata	109	3%

Figure 28 - Sampled Fishing Activity at Upangu Reef, Mtang'ata CMA



Data for the Kipwani Closed Reef, in Mwarongo-Sahare CMA is quite different (see Figure 29). This closed area was established in 2000 but it is clear from the figure that there has been substantial encroachment by fishers since the nominal closure. In fact analyses of the CMA reveals that these data on 'poaching' were recorded in Boma-Mahandakini CMA, located on the northern boundary of the Tanga Region, some distance from Mwarongo-Sahare CMA. It is not possible at this stage to determine whether this is in fact genuine illegal fishing (by fishers from Boma-Mahandakini), or whether there is another fishing ground in Boma-Mahandakini CMA that is *also* called Kipwani. Note in both examples presented here, the data is only for *sampled* fishing trips, and therefore one would expect that the actual total numbers of fishing trips to these two reefs would be higher.

Figure 29 - Apparent Illegal Fishing Activity at Kipwani Reef, Mwarongo-Sahare CMA



8. Discussion and Recommendations

This section provides some discussion and recommendations in relation to current and potential management activities of TCZCDP. Table 19 presents a summary of the objectives and result areas for 5 of the 6 CMAs in Tanga Region. A general comment on the full management plans from which **Table 19** was derived is that there is typically a lack of Quantity, Quality and Time (QQT) for the Objectively Verifiable Indicators (OVIs). Currently the OVIs include statements such as 'Income and Catch of resident fishers increased', but without any QQT it is not easy to effectively evaluate whether the objectives have been met: what level of increase is expected, and when will it be delivered? Although it is recognized that developing meaningful QQT is not without difficulties, especially in fisheries management. The data presented in this report indicate that for Kigombe Village (Mtang'ata CMA) it is unlikely that these objectives have been met, while for the remaining CMAs, the time-series is just 2-3 years and so far the indications are that no clear pattern of increase in either income or fish stocks has occurred. The result areas that relate to fisheries in particular are highlighted.

There are three clear fisheries themes in the result areas:

- Reduced Destructive Fishing;
- Reduced User Conflicts/Access Issues;
- Increased Fish Stocks.

Table 19 - Objectives/Result Areas for Tanga CMAs

	Deep Sea-Boma	**Mwarongo-Sahare**	**Mtang'ata**	**Boza-Sange**	**Mkwaja-Sange**
Objective	Increased coastal natural resources and its products and sustainable use in Deep Sea-Boma management area	Income for residents of the 12 villages increased through increased production of fish and seaweed	Income of fishers in Mtang'ata through increased fish catch, seaweed production and reliable fish market	Income of the residents of the villages increased through increased fish catch	Income of the residents of Sange-Mikocheni and Mkwaja villages increased through increased and sustainable use of coastal resources
Result Area 1	Reduced illegal use of coastal natural resources	Reduced incidences of illegal use of coastal resources	Destructive resource use reduced	Reduced illegal fishing	Seaweed production increased
Result Area 2	Increased fish, prawns and crabs	Reduced number of visiting fishers	Fishing pressure reduced by decreased number of visiting fishers	Reduced legal but destructive fishing activities	Increased fish catch
Result Area 3	Reduced user conflicts	Increased production of seaweed	Reduced number of legal but destructive fishing	High fishing pressure reduced by decreasing fishers and/or vessels	High pressure reduced by decreasing fishers/vessels
Result Area 4	Reduced legal but destructive fishing techniques	Increased fish stocks	Increased seaweed production	Water pollution from sisal waste, human excreta and coconut husks reduced	Illegal cutting of mangroves reduced
Result Area 5	Increased seaweed production	No conflicts between fishers and seaweed growers that results in loss of seaweed production	Fish stocks increased	Illegal cutting of mangroves reduced	Increased protection of turtles
Result Area 6	Increased mangrove forest		Reliable market for fish	Increased production of turtles	
Result Area 7			Guidelines for selling coastal areas		
Result Area 8			Conflicts between users reduced		

8.1. Reduced Destructive Fishing

The analyses presented here do not relate to the issues of the control of destructive fishing activities, although the TCZCDP reports success in this area of fisheries management through their gear-exchange programme (some beach-seines exchanged in return for gill-nets), and through village-based patrols to monitor use of beach-seine and (in cooperation with local law enforcement agencies) the incidence of dynamite fishing. In terms of increasing the abundance of fish this can only be a positive activity and one which should be supported in the future activities of TCZCDP.

8.2. Reduced User Conflicts/Access Issues

The analyses in this report cannot specifically comment on the reduction of user conflicts, although no doubt this is reported elsewhere by TCZCDP. Nor can these analyses throw significant light on issues of access to CMA fishing grounds by what are termed in the management plans 'visiting fishers'. Section 7.5 (The Use of Different CMAs by Local Fishers) analysed some aspects of this by comparing between the CMA in which a fishing trip took place and the CMA in which the fish were landed. This provides some insight into the migration in/out of a CMA, but cannot tell us much more than that because there is no information currently recorded that identifies in which CMA the vessel is registered or indeed whether it is registered in Tanga Region at all. The evidence so far does indicate that some migration takes place between CMAs, and that certain CMAs are probably net exporters of fishing effort. For example, 11% of fishing trips for boats based in Mwarongo-Sahare CMA actually fished in Mtang'ata CMA while 32% of fishing trips for boats based in Mwarongo-Sahare CMA took place in a fishing ground (Karange) that appears to straddle both Mwarongo-Sahare CMA and Mtang'ata CMA. This has implications for both the management of fishing effort within a CMA, and also for estimates of the value of catch derived from a particular CMA. What is perhaps surprising is that there appears to be some migration of fishing effort between Deep Sea-Boma CMA and both Mtang'ata and Boza-Sange CMAs to the south, which represents a (roundtrip) migration in excess of 40 kilometers. On the other hand it appears that most reef names relate to a physical characteristic, size, geographical location, or some other obvious feature and so it is possible that the different CMAs in fact use of similar names for reefs.

Recommendation 1: Complete the mapping of the fishing grounds with local fishers and enter into the GIS system available at TCZCDP HQ.

Recommendation 2: Develop a registration system for fishing vessels/Utilise current licensing system and modify data collection form/database to allow recording of the registration number and therefore the home CMA/District of each vessel.

8.3. Increased Fish Stocks

One of the key result areas in the CMA management plans is that activities effect an increase in fish stocks and that this increase in abundance of marine resources lead to an increase in fisher income. **Table 20** presents a summary of the key observations arising from the annual mean CPUE analysis undertaken in Section 7.2.

Table 20 - Summary Table of Results from Inter-Annual CPUE Comparisons

Vessel/Gear Combination	Key Observations	Discussion Point
Ngalawa/Mishipi	**Increase in CPUE:** Between year comparisons of mean CPUE reveal significant increase in the year 2003/04 over '96/97, '97/98, '98/99 and '99/00 data. No significant difference between '98/99 and '99/00 data.	Abundance of species targeted by this gear has increased but due to gaps in data for '00/01, '01/02 and '02/03 it is not possible to determine whether this increase is a feature of that year only.
Ngalawa/Madema	**No Change:** Between year comparisons of mean CPUE do not reveal any significant differences between 1996/97, '97/98 and 2003/04. CPUE data in 1998/99 and '99/00 are not significantly different from each other but are significantly different from other years.	Relative abundance of species or cohorts of species targeted by madema has recovered to levels seen in 1996-1998 after a decline in 1998-2000.
Ngalawa/Jarife	**No Change:** Between year comparisons of mean CPUE do not reveal any significant differences between 1996/97, (arguably '98/99), '99/00 and 2003/04. Mean CPUE in 1997/98 is significantly lower than other years.	The relative abundance of species targeted by jarife appears to have dipped in 1997/98 but recovered over the following years for which there are adequate data.

The picture from **Table 20** is not clear in terms of portraying a universal increase in abundance of fishery resources within the TCZCDP area that can be linked to management activities. Clearly any understanding that can be derived from the analyses is constrained by the gap in data for 2000-2003, the limited geographical range of data collection prior to 2002 and the limits inherent in the data itself (sample sizes, lack of fishing effort etc).

In all CMAs effective management activities are limited to restriction of destructive fishing and the imposition of very small closed areas and it is a moot point as the extent of the impact that these activities will have on overall resource productivity in the CMAs and the Tanga Region. It largely depends on the relative contribution of the destructive fishing to overall fishing mortality and the extent to which the closed areas have any spill-over effect. However, data does indicate that at least some fishing is reported on four of the seven closed areas (Makome, Kitanga, Kipwani and Chundo/Kiroba reefs) and literature suggests that even modest amounts of fishing can have relatively significant impacts on resource productivity. There is also going to be some degree of time-lag before the results of the fisheries management activity is seen as an increase in resource abundance, particularly for longer-lived (slow-growing) species and so for the recently (since 2000) declared CMAs it is perhaps early to expect marked improvements.

The lack of a more lengthy time-series is unfortunate because single year increases (or decreases) in CPUE (e.g. 2003/04) should be treated with caution. The FAO observed that '*The spatial distribution of living aquatic resources is dynamic, changing seasonally and sometimes markedly from year to year. Changes in distribution can cause changes in catchability by the fishery or by survey gear. These could be interpreted as changes in abundance, leading to incorrect decisions on management action being taken. Therefore, CPUE data should not be used alone without some additional information on geographic distribution and trends in stock distribution.'* In fact the somewhat anomalous decline observed in data from the madema fishery for 1998-2000 may be a case in point. This might be due to any number of factors but it may be related to the El Niño event that took place in 1997/98. The severe coral bleaching that occurred during this event may well have had an impact in subsequent years on fish populations associated with coral reefs.

The bi-annual underwater visual census (UVC) activities of the TCZCDP will shed some additional light on the recovery/increase in fish stocks (see the separate Reef Assessment Report by TCZCDP, in prep.).

General Information Management Recommendations

From the analysis of the TCZCDP database it is clear that there are some issues related to meeting the data requirements of the current 3rd Data Collection Protocol.

> **Recommendation 3:** TCZCDP to investigate alternative means of objectively verifying increases in fish abundance. For example the use of trial fishing activities, and the use of targeted stock assessment activities (e.g. PARFISH/Trophic-level analysis/the use of life-history parameters.

8.3.1. Supervision of Data Collectors

Analyses reported under IUCN-EARO Contract No. TCZCDP/2001/01 (Tanga Fisheries Permit System), and confirmed under this Consultancy, showed that the required sample sizes for various vessel/gear combinations are not always being achieved. It is also possible, although not proven either way, that isolated field data-collectors are perhaps not collecting data in the correct fashion. This calls into question the statistical validity of analyses done using these (incomplete) data. Adequate supervision is also important for reasons related to the morale of the field workers, who are likely to benefit from regular and frequent visits from TCZCDP central office staff. This is an issue often raised in other fisheries data collection programmes in Tanzania and the Region as a whole and so is certainly not limited to TCZCDP. In Mozambique, for example, the government's fisheries research institute (IIP) provides data collectors with a monthly work schedule and un-announced visits are made by supervisors to check on the performance of the data collectors on days scheduled for data collection activities.

> **Recommendation 4:** A programme of field supervision, regular training updates for field staff and unannounced site visits is established

8.3.2. Data Management

The dataset being generated by TCZCDP is extensive, and increasingly demands an effective data management system. There are a number of benefits from establishing a system which include:

- To make regular and effective backups of the database;
- The ability to identify when data collectors have not collected adequate samples (for reasons that may include logistics, lack of cooperation, or insufficient supervision). Regular checks on monthly data profiles can highlight problems that can then be addressed;
- To check for incorrect data entry (from data form to database);
- To check for mis-spellings of species, fishing grounds etc. The scale of this problem does seem to have diminished in recent years as the TCZCDP database now has fixed look-up tables that do not require the data-entry clerk to type names/grounds into the database, they can just be selected from an existing list. And the issue should become less important as the experience of TCZCDP staff charged with data entry grows;
- To check that BAC/VAS data are collected to allow for a better estimate of total catches/revenues (and to better understand the fishing effort of individuals compared with effort spent on other activities (e.g. farming etc);

> **Recommendation 5:** There is an urgent need for a sampling and information management post to be created within the TCZCDP administration. Alternatively, a regular and frequent consultancy could be used to undertake management of the data.

8.3.3. *Fishing Gear Definitions*

There would be value in TCZCDP re-visiting the current fishing gear definitions used by the Programme. Currently the gear definitions are rather vague and open to interpretation both for the monitoring programme and for the Frame Survey data and it would be very useful for a review of these and a field manual produced and training given to data collectors. Possible funding for this activity might be sourced from the FAO. It is vital that this be undertaken in collaboration with the Fisheries Division.

Recommendation 6: Review Gear Definitions

8.3.4. *Species Identification*

Refresher training should be provided to all data collectors and supervisory staff on species identification. This is necessary under the current data collection protocol, which limits collection of detailed data to a pre-determined list of species, and would be particularly crucial if a programme of length-frequency data collection is established.

Recommendation 7: Refresher training on Species Identification

8.3.5. *Harmonising Data Collection with District Fisheries Office Activities*

TCZCDP in increasingly mainstreamed into regular District Government activities and programmes and yet two independent data collection system still exist. Table 9 presented evidence that there appears to be some difference between the results from the two systems. This is not an efficient use of scarce human and financial resources in the three districts.

Recommendation 8: Initiate discussions with District Government/Fisheries Division on harmonizing data collection activities within the Tanga Region

9. References and further reading

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Appendix 1 - Vessel and Fishing Gear Descriptions

Table 21 - Vessel Codes

TCZCDP Vessel Code	Ki-Swahili Vessel Name	Description
MS	Mashua	Wooden sailing vessel, with transom stern (to 10m)
NG	Ngalawa	Dug-out canoe with outriggers (to 8m)
DH	Dau	Wooden sailing vessel, with pointed stern and prow (to 10m)
DC	Mtumbwi	Dug-out canoe without outriggers (to 3m).
BT	Boti	A motorized vessel of any size/type

Table 22 - Fishing Gear Codes

TCZCDP Gear Code	Fisheries Division Gear Code	Gear (Ki-Swahili / English)
Ch	Di *	Chupa za Kuzamia/Diving
FF	FF	Fish-Fence
Ja	SN	Jarife/Sharknet/Seine Net
Ka	LL	Kaputi/Longline
Ki	SC	Kimia/Scoop-Net
Ku	Di *	Kuzamia/Senga/Diving
Ma	TP	Madema/Fish-Trap
Mi	HL	Mishipi/Handline
Ny	GN	Nyavu/GillNet
Ri	RN	Ringi/Ring Net
Si	SN	Sinia/Sharknet/Seine
To	SP	Tomo Kuchokoa/Spear
Wa	WW	Wachokoaji

Appendix 2 - Description of Pair-wise Comparisons

ANOVA (with single factor) was used to evaluate the presence of significance differences between groups (years) with the null hypothesis that H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$. Where ANOVA indicated a significant difference a multiple comparison Tukey Test was employed, with the Kramer modification for unequal sample size (Zar, 1999, p212), to determine between which groups' population means a difference existed.

The data were tested for normality using both Excel Descriptive Statistics and Systat (V.10.2) using the Kolmogorov-Smirnov one-sample test reporting skewness and kurtosis. Skewness is '*a measure of the symmetry of the distribution about its mean*' (Systat) and kurtosis indicates the length of the 'tails' in relation to what one expect in a normal distributed dataset. The data does appear to show some deviation from normality revealing a positiveness skewness (a long right-tail) and positive kurtosis (longer tails than expected). In this case a nonparametric analysis of variance (e.g. Kruskal-Wallis Test) might be considered appropriate but Zar (1999) indicates that a single-factor analysis of variance (such as is proposed here, the single-factor being CPUE):

'…is also robust with respect to the assumption of the underlying populations' normality. The validity of the analysis is affected only slightly by even considerable deviations from normality (in skewness and/or kurtosis), especially as n increases.' (Zar, 1999, p185)

The analyses were initially performed in Excel spreadsheets. The means are sorted in order of increasing magnitude and then pair-wise differences, $\overline{X}_B - \overline{X}_A$, are tabulated (Zar 1999, p211). Equation 1 presents the calculation of the standard error, used in this test.

Equation 1: Standard Error (Kramer, 1956; Tukey, 1953)

$$SE = \sqrt{\frac{s^2}{2}\left(\frac{1}{n_A} + \frac{1}{n_B}\right)}$$

Where s^2 is the error mean square from the analysis of variance of the complete data set (across groups) and n is the number of data in each of groups A and B. Equation 2 presents the calculation of Tukey's 'q' value.

Equation 2: Calculation of Tukey's '*q*' value

$$q = \frac{\overline{X}_B - \overline{X}_A}{SE}$$

Where $\overline{X}_A, \overline{X}_B$ are the means of each group.

If the q-value is equal to or greater than the critical value, $q_{\alpha,v,k}$, then the H_0: $\mu_B = \mu_A$ is rejected. This critical value is called the 'Studentized range', abbreviated q, and is dependent on α (the significance level), v (the error DF for the analysis of variance), and k (the total number of means tested) (Zar, 1999 p211).