13 STOCK ASSESSMENT OF TWO SCIAENID FISHERIES IN THE WEST COAST OF TRINIDAD AND TOBAGO

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13.1 Introduction

The sciaenid fisheries is a part of the groundfish fisheries in Trinidad and Tobago and dominated by two species, *Micropogonias furnieri,* the whitemouth croaker and *Cynoscion jamaicensis,* the Jamaica weakfish. The fisheries are based mainly in the Gulf of Paria on the west coast of Trinidad. These two species are considered the most commercially important and are the most abundant of the sciaenids landed on the west coast. Most artisanal fishing is done in depths between 9–14m, although these species are also caught by the offshore shrimp trawlers. The artisanal vessels used in the catching of groundfish are pirogues 6-10m long and are constructed of wood and fiberglass or fiberglass coated wood. These vessels may use one or two 45 to 75HP outboard engines (Henry and Martin 1992). There is no mechanisation of operations, but most vessels carry ice chests for catch storage. Vessels are owned by private individuals with some persons owning more than one. The Fisheries Division vessel census conducted in January 1998, identified 728 vessels on the west coast of Trinidad which operate gears that capture groundfish. In 1994, croaker accounted for 65% (627 t) of the total landings and 63% (TT$2.6M) of the total value of the groundfish landed by the artisanal fishery, apart from trawling. Jamaica weakfish accounted for 9% by weight (87 t) and 15% by value (TT$0.6M).

Stock assessments of these sciaenid fisheries are difficult due to the combination of biological and fishery features such as lack of appropriate biological understanding of the dynamics of the species and the usually high exploitation exerted on the species. Besides fishing by artisanal and semi-industrial trawlers which accounts for major landings of groundfish in the form of bycatch or as a targeted species according to the season, five other gear types are used to catch these species. The main fishing gears used to target sciaenids are the monofilament demersal set gillnet, known locally as “transpearing”, multifilament gillnets or “fillet, which, though set at the surface, also catch groundfish due to deployment at shallow depths, demersal longlines or “palangue”, banking and a-la-vive (two other line methods). The mesh sizes for the gillnets range from 95-114 mm (Henry and Martin 1992) and 24.5-38 mm stretched mesh for the trawl nets (Trinidad Fisheries Division Trawler Gear Survey 1991). The species are often landed in small amounts in many places along the shoreline from artisanal, semi-industrial and industrial fishing vessels.

Many fish stock assessment techniques applicable to sciaenids require numbers of animals caught, not yield and thus the total landings in weight for each landed place must be converted to numbers of animals. Once the number of animals within given age or size intervals are known, cohort analysis can be used to estimate the fishing mortality rate and population size. However, biological samples of these species have not been sufficient to generate the minimum data required to express total landings in numbers by size categories. This report presents the combined assessments carried out at the 2nd CFRAMP/FAO Stock Assessment Workshop in Liliendaal, Guyana, 1998 (FAO 1999a and 1999b) and the 3rd CFRAMP/FAO Stock Assessment Workshop in Belém, Brazil, 1999 (this workshop). This is a first attempt to assess the *Micropogonias furnieri* and *Cynoscion jamaicensis* stocks in Trinidad and Tobago making use of monthly catch and effort data available for the period 1989-1997.

13.2 Data

The landings and fishing effort of sciaenid fisheries on the west coast of Trinidad are collected by enumerators based at the major landing sites. The data over the periods 1989-1994 and 1995-1997 are stored in a DBASE and an ORACLE database respectively and raised to the entire fleet to account for non-enumerated fishing days and vessels. This data gathering, however, does not represent a complete fishery statistical system since it lacks components for the collection of biological data from the artisanal and industrial fleets. In addition, there is no collection of landings and effort data from the industrial fleet. During this workshop analyses were made of monthly CPUE corresponding to *M. furnieri* and *C. jamaicensis* landed by six gear types. This information corresponds to 9 years of monthly data, which could be used to assess monthly stock biomass and fishing mortality if a catchability coefficient could be estimated.

13.3 Stock assessment methods

The following stock assessment algorithm was used in the analysis:

1. Fishing effort was standardised for the different gear types used in the sciaenid fisheries and for months following the analysis of variance technique of Robson (1966). This technique consists in defining CPUE for a given gear type i and month j as a function of a standard gear type s and month m. Thus CPUE can be expressed as:

$$CPUE_{i,j} = CPUE_{s,m} * \rho_i * D_j * error_{i,j}$$

where ρ_i is the fishing power of gear i relative to gear s, D_j is the relative abundance in month j relative to month m and error is a measurement error associated with the CPUE estimation procedure. This multiplicative model is logarithmically transformed and the resulting log-linear model identified with a singular (no interaction terms) "analysis of variance" of the form:

$$Y_{i,j} = \mu + \alpha_i + \beta_j + \varepsilon_{i,j}$$

where μ is the log of $CPUE_{s,m}$, α_i is the log of ρ_i , β_j is the log of D_j and ε_{ij} is the log of $error_{ij}$. Therefore, the analysis of variance will provide estimates of each factor i and j if log of $CPUE_{ij}$ are available for each i and j. This procedure is contained in a FPOW-FORTRAN routine.

2. Based on observed CPUE trends, locales of seasonal CPUE depletions were identified and the time scale was split to include only the depletion months observed in the locales. Then, a DeLury-type estimator (Chien and Condrey 1985) was used to obtain seasonal estimates of the catchability coefficient for each species separately. Catchability estimates derived from the Chien and Condrey method use catch in numbers per unit effort (CPUE), cumulative catch in numbers and average effort data over a number of time periods to estimate catchability in the following process. For a number of successive time periods, CPUE is regressed against cumulative catch (accumulated to half way through the time period) to yield an estimate of the slope q' using the following linear regression model:

$$CPUE_t = qN_0 - q' K_t$$

$$\text{where} \quad q' = \frac{1}{f_t}\left(1 - e^{-(qf_t + M)}\right)$$

where q is the catchability coefficient, N_o is the population size at the beginning of the depletion period, f_t is the average fishing effort corresponding to the depletion period selected, M is the natural mortality rate and K_t is the cumulative catch during the depletion period. In this study, catch was not available in numbers but in weight, thus a growth effect on catchability should be expected. However, the species are rather long-lived and growth during a depletion period of a few months was assumed negligible when compared to the mortality processes.

The catchability parameter is then estimated as:

$$q = -\frac{1}{f}\left[\mathrm{Ln}(1 - q'f) + M\right]$$

The depletion equation assumes recruitment does not occur during the regressed range, an assumption that can be broken by many tropical species. Recruitment will cause the (K, CPUE) points to be moved up and to the right due to the catch of animals not in the cohort, thereby decreasing the slope of the regression line, which should be considered when assessing the results.

3. A seasonal (monthly) average abundance by species was estimated as the simple ratio of standardized CPUE and seasonal catchability.
4. The seasonal (monthly) fishing mortality rate was estimated as the ratio of catch to average abundance.
5. Then, yield-per-recruit using the population parameters defined for the two species in last year's workshop was obtained. These yield per recruit computations were done using the Thompson and Bell discrete model. Similarly, estimates of egg-per-recruit were calculated using a maturity and fecundity schedule. These estimates were used to define reference fishing mortality rates (those F-values maximizing yield-per-recruit and spawning-per-recruit at a prescribed level of pristine spawning). These mortality reference points were then compared with already estimated seasonal F-values. This comparison provides a general sense of the status of exploitation of the two stocks.

13.4 Results and discussion

During the period 1989-1994 all trips made for a particular gear type were recorded as the effort directed towards the species. For the period 1995-1997, however, only those trips, which caught the species by a particular gear type, were recorded as effort. Recognising this difference, total trips during the period 1995-1997 were obtained from the field data in order to make the data sets compatible.

The FPOW-FORTRAN routine has memory allocation restrictions, which did not allow the performance of an ANOVA for the entire time period in the standardisation of fishing effort. As such, a double standardisation of fishing effort was performed, standardising by sectors of time relative to a common year base 1989 with the banking gear as standard. Five data sets were constructed for *M. furnieri* as follows: I – 1989, 1990, 1991; II – 1989, 1992, 1993; III – 1989, 1994; IV – 1989, 1995, 1996 and V – 1989, 1997 (Fig. 13.1).

The four data sets for *C. jamaicensis* were as follows: I – 1989, 1990, 1991; II – 1989, 1992, 1993; III – 1989, 1994, 1995; IV – 1989, 1996, 1997 (Fig. 13.2).

In this process, the α and β estimates changed with the data set for each year. Thus, standardisation was subsequently done across α and β using the link to 1989. To achieve this, the ratio of CPUE was calculated from I/II, I/III, I/IV and I/V. Then, for *M. furnieri* the standardised CPUE for 1992 and 1993 were multiplied by I/II, CPUE for 1994 by I/III, CPUE for 1995,1996 by I/IV and CPUE for 1997 by I/V (Fig. 13.3).

For *C. jamaicensis*, the standardised CPUE for 1992 and 1993 were multiplied by I/II, CPUE for 1994, 1995 by I/III and CPUE for 1996 and 1997 by I/IV (Fig. 13.4).

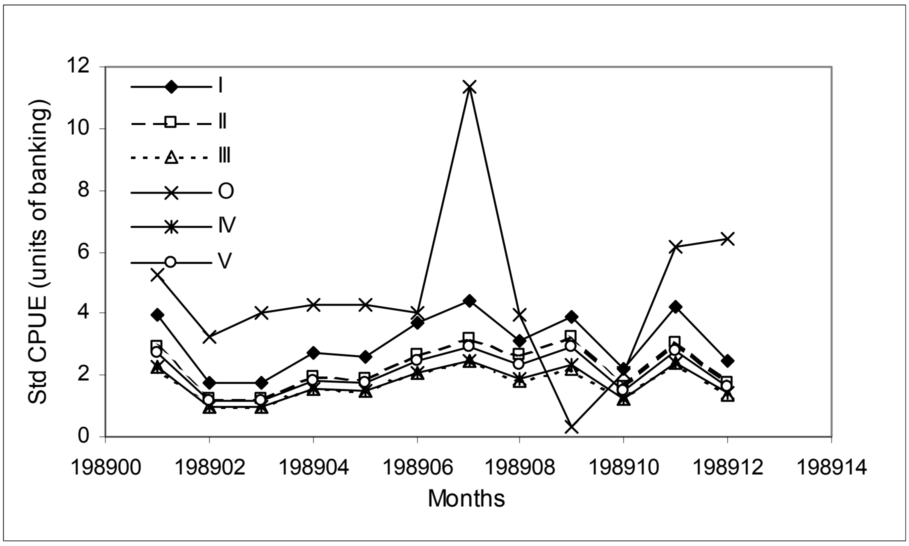

Figure 13.1 Monthly standardised CPUE of *M. furnieri* values derived from fishing power estimates using the CPUE for six gear types for the periods I - 1989, 1990, 1991; II - 1989, 1992,1993; III - 1989, 1994; IV - 1989, 1995, 1996; V - 1989, 1997. CPUE for banking for 1989 used as standard

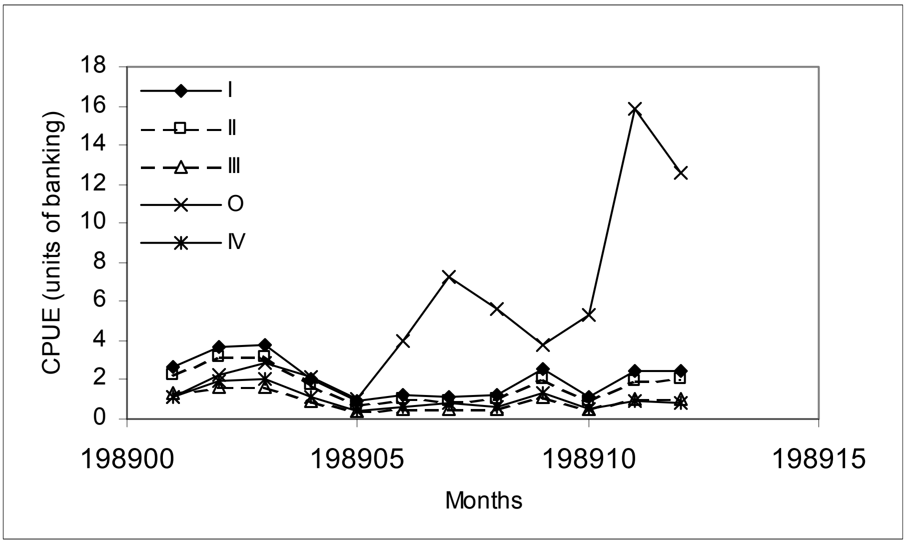

Figure 13.2 Monthly standardised CPUE of *C. jamaicensis* values derived from fishing power estimates using the CPUE for six gear types for the periods I - 1989, 1990, 1991;II - 1989, 1992,1993; III - 1989, 1994, 1995; IV - 1989, 1996, 1997. CPUE for banking for 1989 used as standard

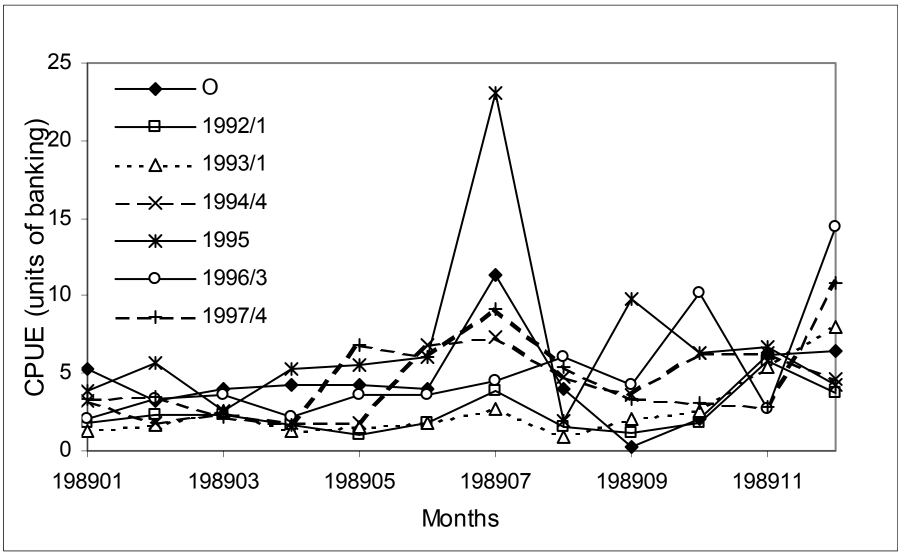

Figure 13.3 Standardised CPUE for *M.furnieri* for 1992, 1993,1994, 1995,1996 and 1997 compared with CPUE values for the year 1989 with banking used as the standard. (Ratios of relative abundance derived from fishing power estimation for 1989,1990, 1991 against 1 = 1989, 1992, 1993; 2 = 1989, 1994; 3 = 1989, 1995, 1996; 4 = 1989, 1997)

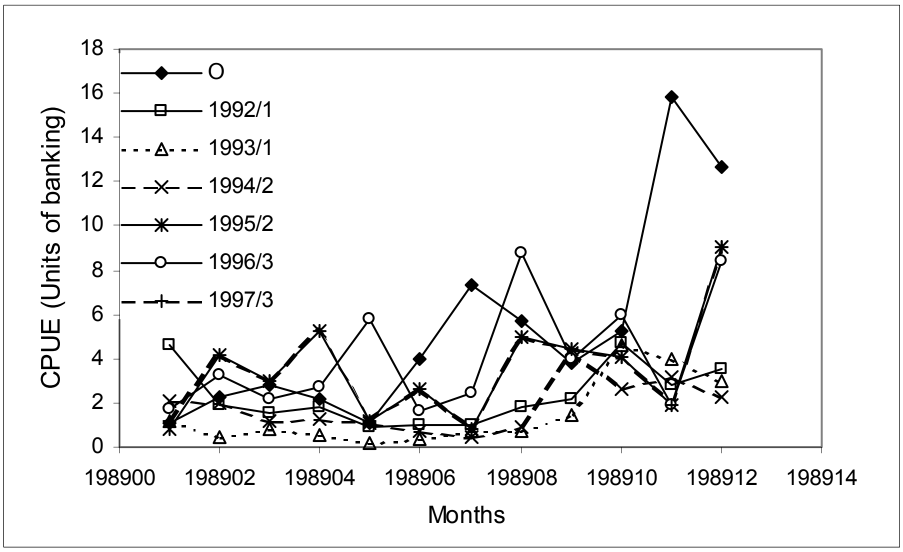

Figure 13.4 Standardised CPUE for *C. jamaicensis* for 1992, 1993,1994, 1995,1996 and 1997 compared with cpue values for the year 1989 with banking used as the standard. (Ratios of relative abundance derived from fishing power estimation: 1= 1989,1990, 1991to values for 1989, 1992, 1993. 2 = ratio of values for 1989, 1990, 1991 to 1989, 1994, 1995. 3= ratio of values for 1989, 1990, 1991 to 1989, 1996, 1997)

Using these results, standardised CPUE was then plotted against monthly cumulative catch for each year, where monthly cumulative catch was determined from the total landings by month for the six gear types. Plots of the monthly CPUE on cumulative monthly catch are given in Figures 13.5 and 13.6 by biological year.

Based on the observed CPUE trends, locales of seasonal CPUE depletions were identified for both species using the plots in Figures 13.5 and Figure 13.6. It must be noted that the selection of these depletion months/points were based on the changes in the CPUE values and not the cumulative catch. The seasonal CPUE depletion locales identified for *C. jamaicensis* and *M. furnieri* are set out in Table 13.1.

Table 13.1 Depletion months defined for *M. furnieri* and *C. jamaicensis*

M. furnieri	***C. jamaicensis***
Month-Year	**Month-Year**
Nov 89 - Feb 90	Nov 89-Aug 90
Dec 90 - May 91	Oct 90-July 91
Dec 91 -May 92	Nov 91-July 92
Nov 92 - Feb 93	Oct 92-July 93
Dec 93 -May 94	Oct 93-Aug 94
Dec 94 -May 95	Oct 94-July 95
Sept 95 -Apr 96	Dec 95-June 96
Jan 97 -Apr 97	Sept 96-Mar 97

Identification of depletion locales in the plots were more conspicuous for *C. jamaicensis* than in *M. furnieri* which could be due to *C. jamaicensis* displaying a higher seasonal recruitment pattern. This may be explained by the spawning behaviour of *C. jamaicensis* in the Gulf of Paria, which shows a peak spawning in February that coincides with the periods of highest salinity and temperature (Shim 1981). It is also reported that spawning is continuous with a peak observed during the dry season (January to June) based on the presence of juveniles year round in the Gulf of Paria (Manickchand–Heilman and Julien–Flus 1990).

According to Shim (1981), recruitment of juveniles of *C. jamaicensis* begins early in May and continues until November in the Gulf of Paria (Shim 1981). Juveniles 5 – 10 cm in length are recruited into the fishery within a few months of hatching. In *M. furnieri* spawning frequency, determined by the frequency of females with hydrated eggs, were estimated at 12 times per year (Manickchand–Heilman and Ehrhardt 1996). In Northwestern Trinidad spawning was observed year round with peaks in the dry season (Manickchand-Heileman and Julien-Flus 1990).

Following on this, the De Lury-type estimator (Chien and Condrey 1985) was used to obtain seasonal estimates for each species separately. Plots for the Chien and Condrey method to estimate the catchability coefficient for the 89/90, 90/91, 91/92, 92/93, 93/94, 94/95 and 96/97 biological period for *C. jamaicensis* and *M. furnieri* are given in Figures 13.7 and 13.8. The catchability coefficient q for the seasonal CPUE locales set out in Table 13.1 as well as instantaneous fishing mortality rate F for the biological years constructed for each species are shown in Table 13.2.

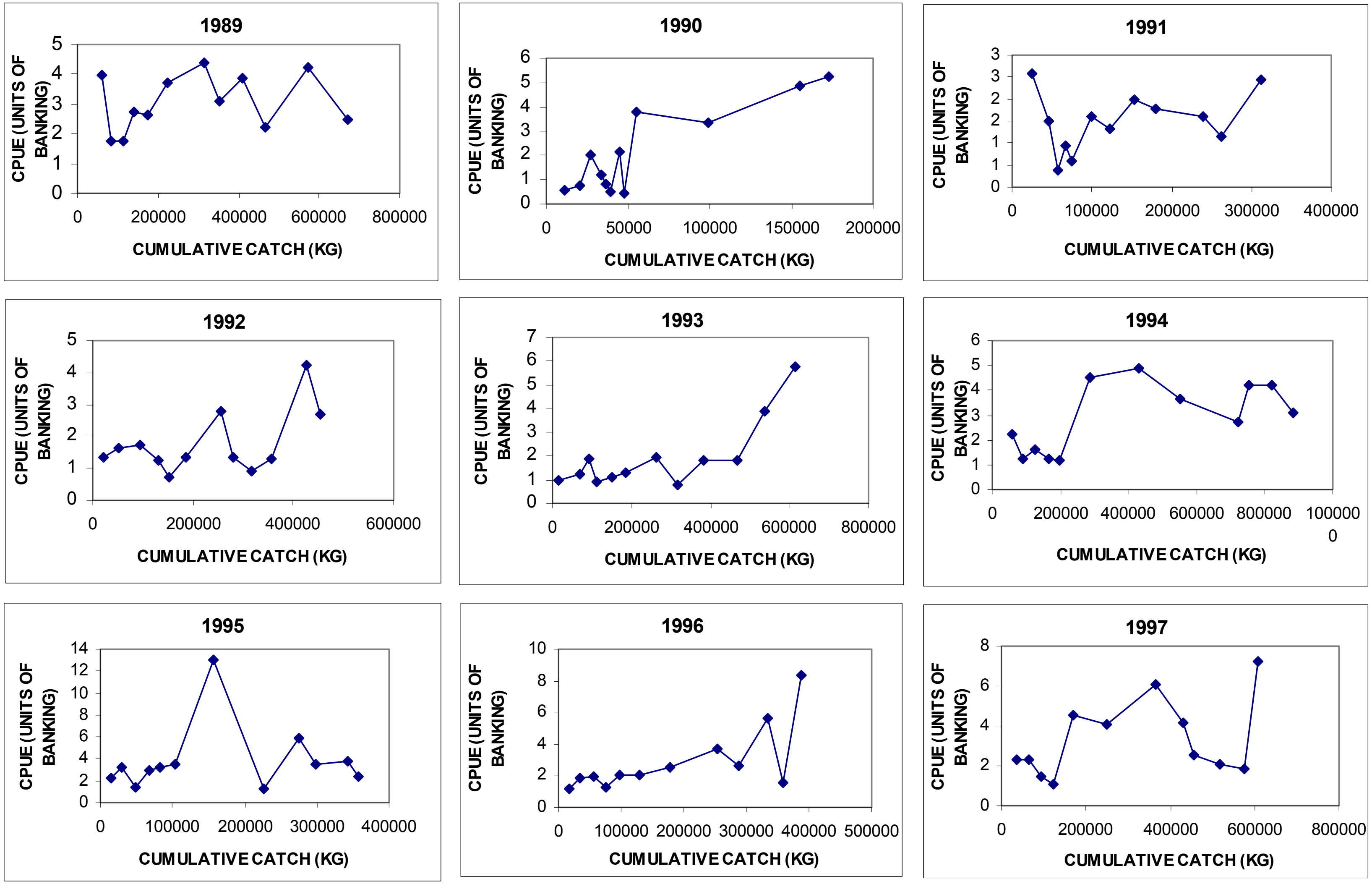

Figure 13.5 CPUE, measured in units of banking, against cumulative catch for *Micropogonias furnieri* for the period 1989-1997 on the west coast of Trinidad

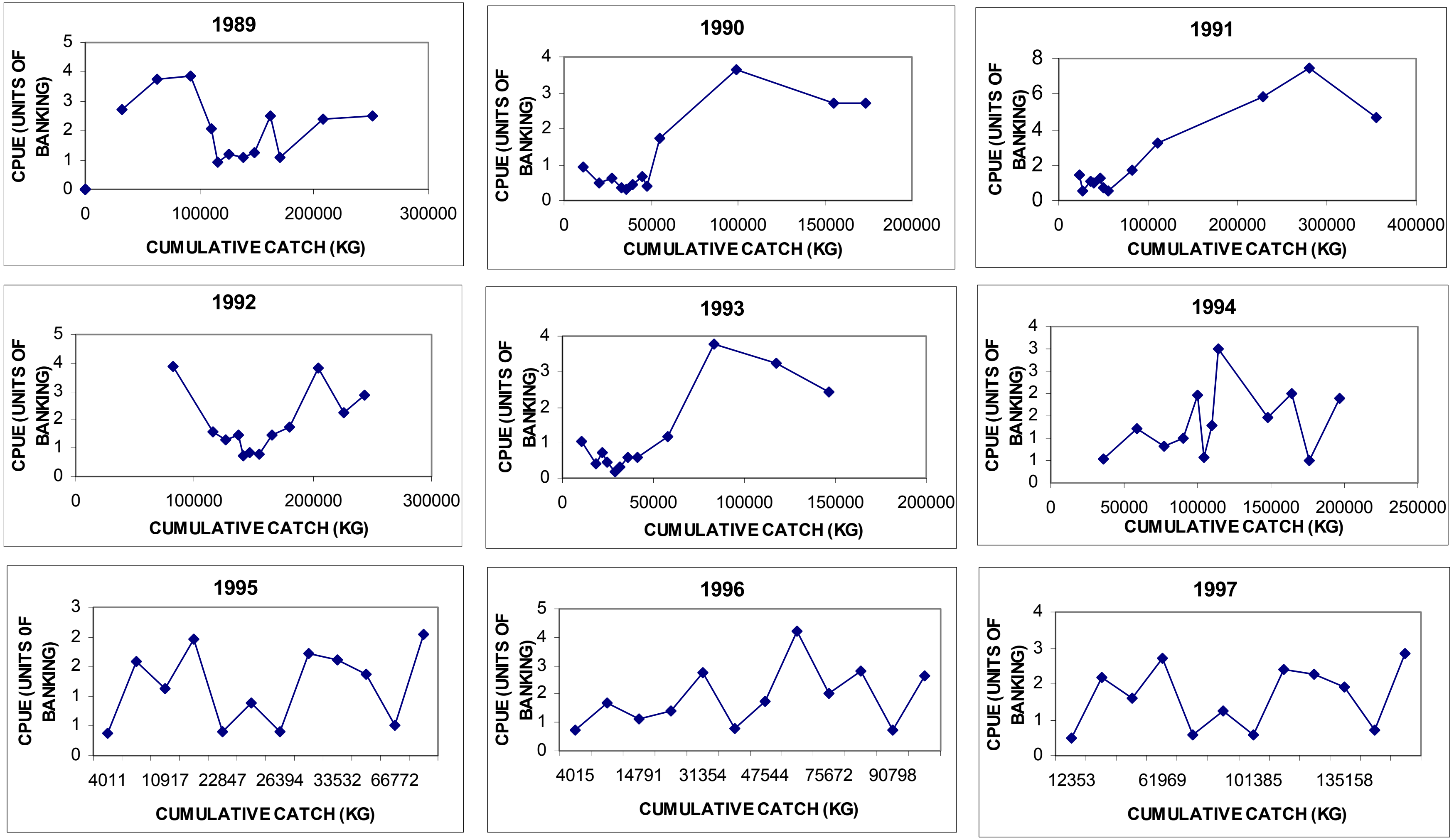

Figure 13.6 CPUE, measured in units of banking, against cumulative catch for *Cynoscion jamaicensis* for the period 1989-1997 on the west coast of Trinidad

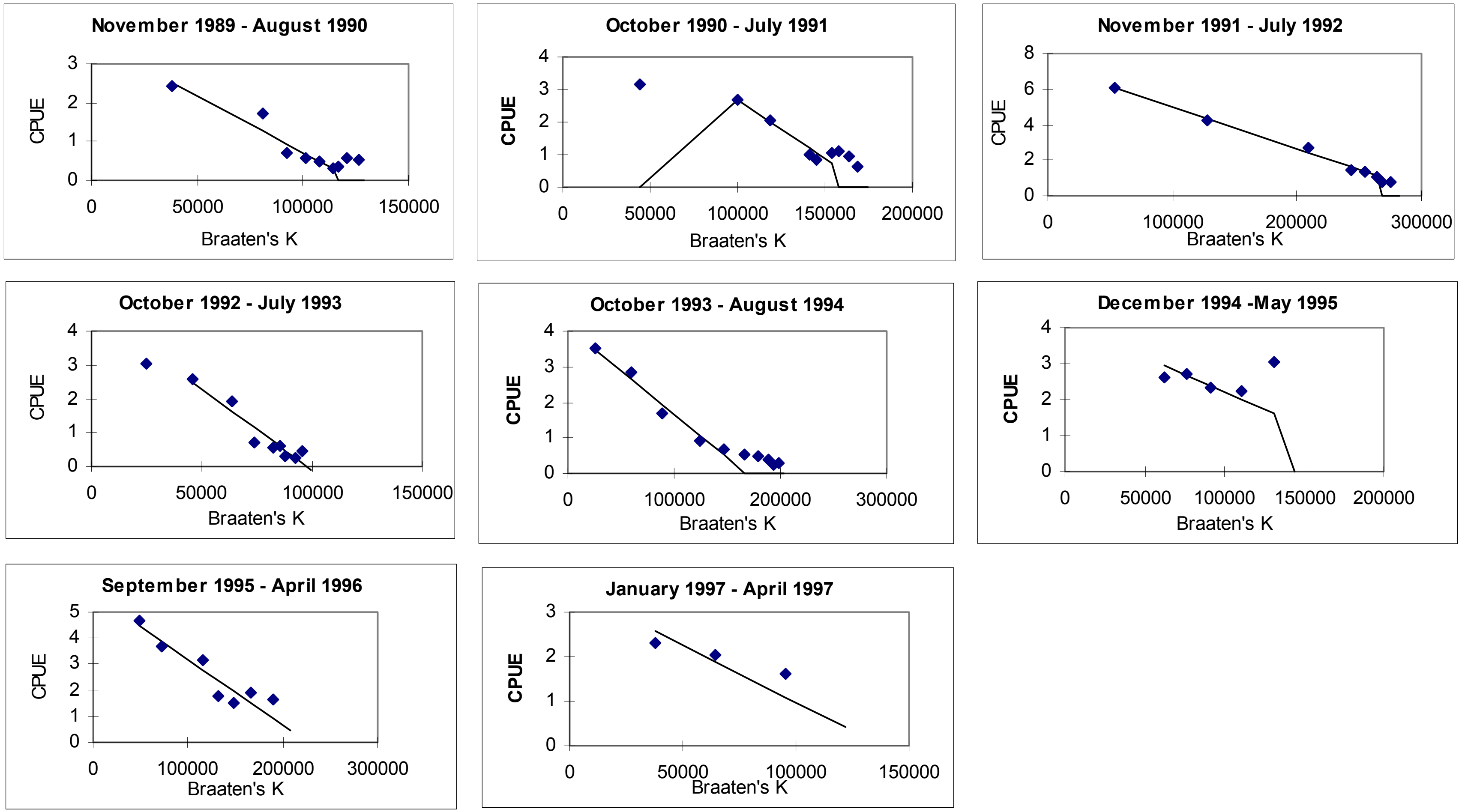

Figure 13.7 Depletion trends used in catchability coefficient , q, estimations for *Micropogonias furnieri* for eight biological years from 1989/1990, 1990/1991, 1991/1992, 1992/1993, 1993/1994, 1994/1995, 1995/1996 and 1996/1997. Braaten's K is the cumulative catch to half way through the time period, corrected for M

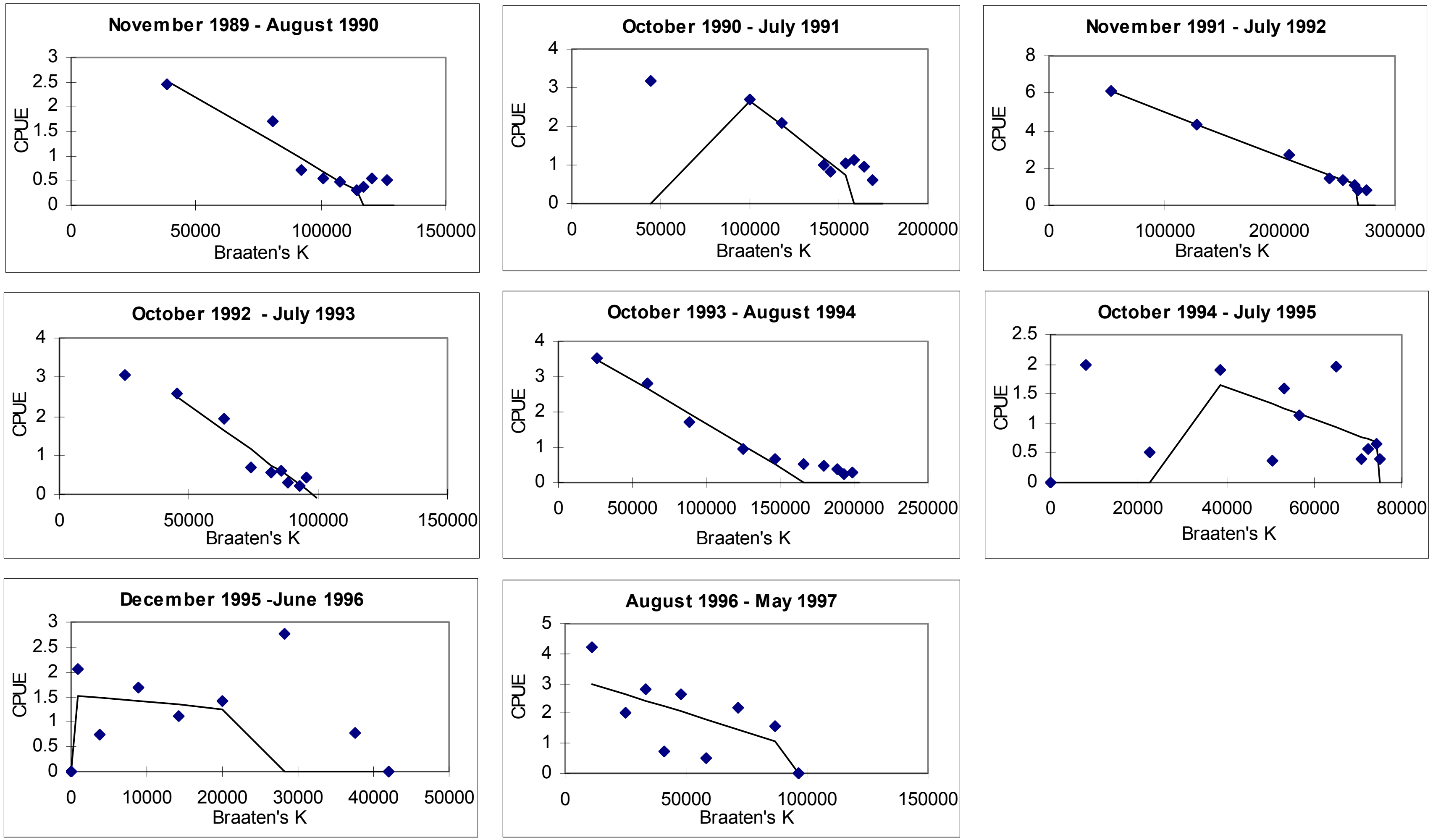

Figure 13.8 Depletion trends used in catchability coefficient , q, estimations for *Cynoscion jamaicensis* for eight biological years from 1989/1990, 1990/1991, 1991/1992, 1992/1993, 1993/1994, 1994/1995, 1995/1996 and 1996/1997. Braaten's K is the cumulative catch to half way through the time period, corrected for M

Table 13.2 Catchability coefficient, q and fishing mortality, F, for biological years constructed for *M. furnieri and C. jamaicensis*

Micropogonias furnieri			***Cynoscion jamaicensis***		
Biological Year	**q**	**F**	**Biological Year**	**q**	**F**
Jul 1989–Jun 1990	3.01E-05	21.27	Aug 1989 – Jul 1991	2.79E-05	4.00
Jul 1990 – Jun 1991	1.00E-04	37.93	Jul 1990 – Jun 1991	1.98E-05	2.08
Jul 1991 – Jun 1992	6.91E-06	1.70	Aug 1991 – Jul 1992	2.83E-05	4.18
Jul 1992 – Jun 1993	5.32E-05	40.34	Aug 1992 – Jul 1993	5.78E-05	7.05
Jul 1993 – Jun 1994	2.56E-05	24.78	Aug 1993 – Jul 1994	2.37E-05	5.74
Jul 1994 – Jun 1995	1.52E-05	4.84	Aug 1994 – Jul 1995	2.35E-05	2.32
Jul 1995 – Jun 1996	2.38E-05	4.02	Aug 1995 – Jul 1996	6.64E-06	0.62
Jul 1996 – Jun 1997	1.32E-05	3.40	Aug 1996 – Jul 1997	2.47E-05	2.82

Based on the locales of seasonal monthly depletion, biological years were constructed for both species by extrapolating the months from which the catchability coefficient, q, was calculated. This gave a complete biological year and assumes that the catchability coefficient calculated from the depletion months was valid for this period. Natural mortality was taken from the literature as 0.36 yr^{-1} (Ehrhardt and Arena 1977).

Seasonal (monthly) average abundance which is the average biomass after the catch was removed, was calculated from the ratio of standardised CPUE and seasonal catchability, where the catchability coefficient q was taken as the average q from the locales of seasonal depletions. The instantaneous fishing mortality rate F was estimated as the ratio of catch to average abundance. An initial, or start of the season, biomass

[Biomass = Z * average abundance / (1 - exp(-Z))]

was then estimated for these biological years.

Some of the monthly F values obtained within the biological year were relatively high for both species. In some instances, these F values were unusually high which can be due to the selection of months comprising the biological year. Months at the beginning of the biological year with a high F value may be better fitted in the previous or subsequent biological year.

The high fishing mortality may be due to the following:

(i) Depletion is occurring in a very small localised area, the Gulf of Paria;

(ii) These species may later be quickly replenished from continued influx of fish from another source outside the Gulf of Paria;

(iii) Both species are subjected to exploitation by 6 gear types. Some of these gears, due to small mesh sizes being used in a mainly inshore fisheries, as in the shrimp trawl fishery, catch fish of all sizes thus creating the potential for very high exploitation

(iv) In the methods used, the seasonal trends of recruitment may affect the ability to generate appropriate decreasing trends in CPUE on cumulative monthly catches.

(v) Migration out of the area which is interpreted as mortality due to a decrease in biomass of both species.

Table 13.3 Parameters used in the yield per recruit analysis for *Cynoscion jamaicensis* and *Micropogonias furnieri*

M.furnieri						***C.jamaicencis***				
L_∞ =74.1						L_∞ =36.25				
K = 0.145						**K =**0.396				
t_o =-0.145						t_o=-0.24				
a=4.78E-05						**a**=0.00449				
b=3.0375						**b**=3.297				
Age (Years)	**Length (cm)**	**Sel.***	**Mat.***	**Fecundity**	**Weight (kg)**	**Length (cm)**	**Sel.***	**Mat.***	**Fecundity**	**Weight (kg)**
1	11.3	0.3	0.1	146	0.076	14.1	0.6	0.1	484	0.027
2	19.8	0.7	0.3	3246	0.415	21.3	1	0.8	4887	0.108
3	27.1	1	0.8	18686	1.081	26.2	1	1	15380	0.213
4	33.5	1	1	60042	2.045	29.5	1	1	29663	0.315
5	39.0	1	1	139560	3.242	31.7	1	1	44343	0.399
6	43.7	1	1	264359	4.597	33.2	1	1	57228	0.464
7	47.8	1	1	435398	6.037	34.2	1	1	67516	0.512
8	51.4	1	1	648368	7.504	34.9	1	1	75258	0.546
9	54.4	1	1	895433	8.951	35.3	1	1	80867	0.570
10	57.1	1	1	1167024	10.345	35.6	1	1	84832	0.586
11	59.4	1	1	1453315	11.663	35.8	1	1	87588	0.598
12	61.4	1	1	1745223	12.889	36.0	1	1	89485	0.605
13	63.1	1	1	2034995	14.018	36.1	1	1	90780	0.611
14	64.6	1	1	2316437	15.046	36.1	1	1	91660	0.614
15	65.9	1	1	2584931	15.974	36.2	1	1	92256	0.616

*Selectivity and Maturity as a proportion of the stock.

The asymptotic (L_∞) length for *M. furnieri* is 82.9cm for females and 65.3cm for males as calculated from ageing using otoliths (Manichchand-Heileman and Kenny 1990). Asymptotic (W_∞) weight was 3641.6g for *M. furnieri*. Actual observed sizes caught are within the range 10-40cm in length. These differences between observed and expected maximum lengths imply a very intense exploitation on the resources that has considerably reduced the larger (thus older) animals in the stock. This condition may justify the estimated F-values.

A yield per recruit analysis was performed using the von Bertalanffy parameters for the respective species (L_∞, K, t_0). Table 13.3 gives the values and parameters used in yield and egg per recruit calculations and Figures 13.9-13.10 show the plots.

In the case of *M. furnieri* the $F_{0.1}$ is 0.192 with a corresponding YPR of 28 grams per recruit and the eggs per recruit as a proportion of the unexploited state is 0.284. For *C. jamaicensis* the $F_{0.1}$ is 0.255 at which level the YPR is 39.8 grams per recruit and egg per recruit as fraction of pristine egg per recruit is 0.313.

The estimated F values in each season from the depletion analyses obtained for the years 1995, 1996 and 1997 for *C. jamaicensis* and *M. furnieri* were considerably lower than those obtained using CPUE for the period 1989-1994. The F-values obtained for the nine year period, 1989-1997, are however still well above the optimum biological condition of the species and therefore indicate that the resources are not generating optimum yield and most likely experiencing severe spawning potential decreases.

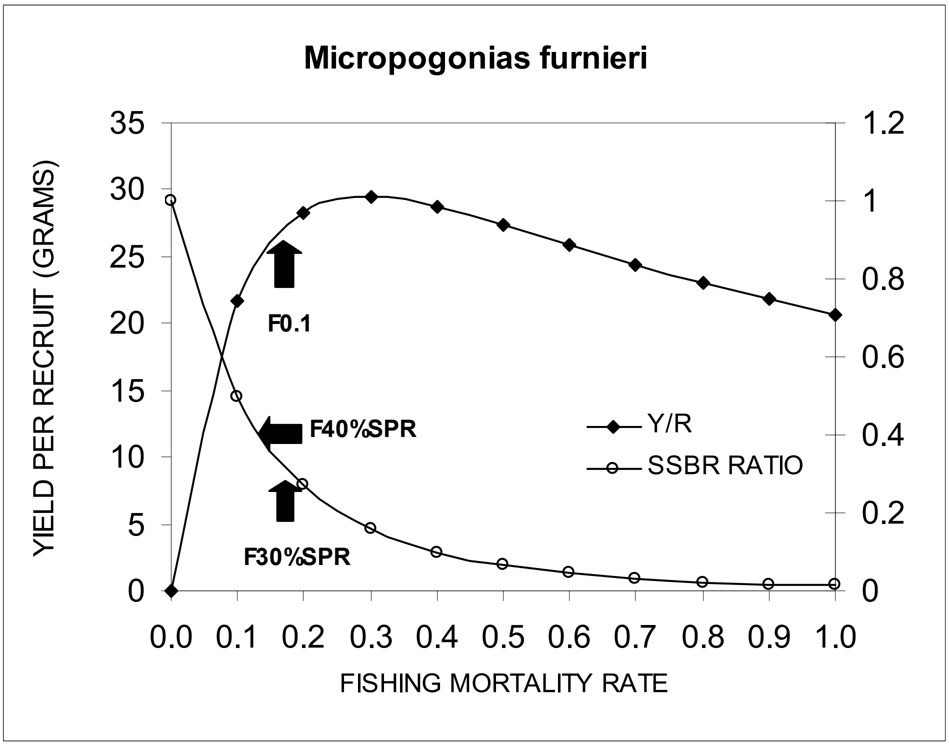

Figure 13.9 Yield per recruit plot for *Micropogonias furnieri*

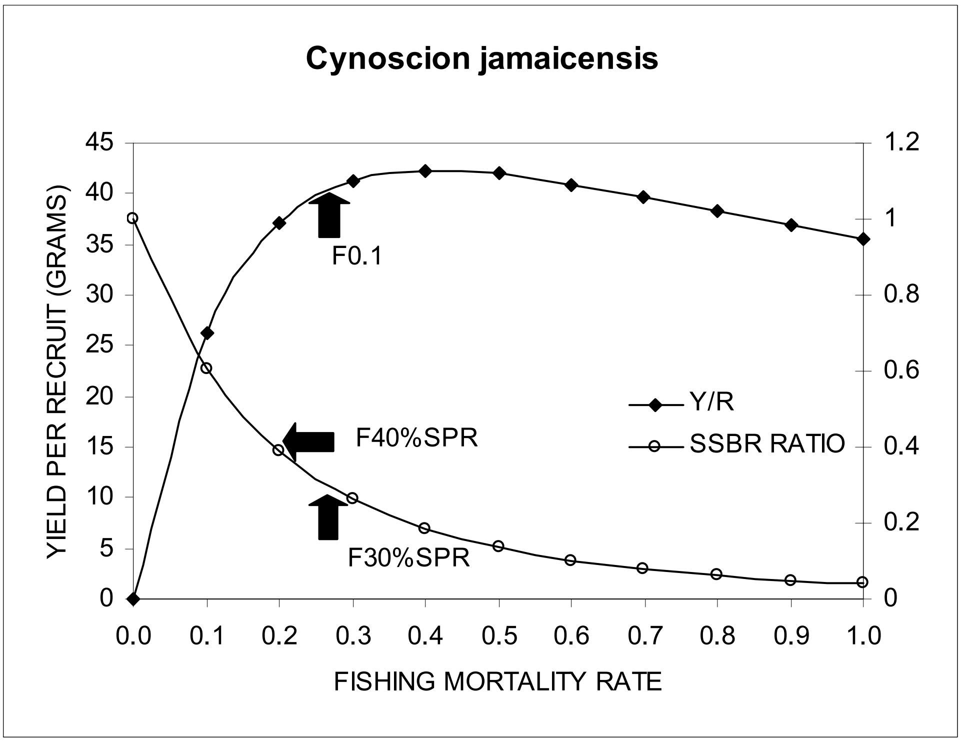

Figure 13.10 Yield per recruit plot for *Cynoscion jamaicensis*

13.5 Conclusion

The results of this assessment clearly indicate a very intensive exploitation of these resources. This may be attributed to the combined effort of six gear types operating in the Gulf of Paria. The analysis, however, used CPUE for the Trinidad and Tobago artisanal fleet. Information from the Trinidad and Tobago industrial trawl fleet or other fleets operating in the Gulf of Paria was not available and hence the biomass and F-values generated from this analysis may not adequately represent the status of the fisheries. Changes in biomass and F values may also be influenced by migration of the species and not mortality. In addition to this, the parameters used in the yield per recruit analyses were from the literature due to the unavailability of this information based on the Trinidad stock. It is therefore recommended that a biological sampling programme be implemented for the groundfish species so that data on the size structure of both species are collected from both the artisanal and industrial fleets.

At this workshop, a joint analysis was also performed with Venezuela for *M. furnieri*, which used artisanal and industrial data from both countries (Alio *et al.* 1999). The results showed a high level of exploitation of the resources and follow on the general conclusions of this assessment.