Assessment of demersal stocks shared by Trinidad and Tobago and Venezuela

D.L. Die, J. Alió, L. Ferreira, L. Marcano, S. Soomai

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Foreword

This document contains the report of the FAO/WECAFC Workshop on assessment of demersal stocks shared by Trinidad and Tobago and Venezuela, which was held in Chaguaramas from 18 to 22 November 2002. The event was hosted by the Government of Trinidad and Tobago. Principal funding for the workshop was provided under the FAO FishCode Programme through component projects “Management for Responsible Fisheries” (GCP/INT/648/NOR), with Trust Fund support from the Government of Norway, and “Responsible Fisheries for Small Island Developing States” (GCP/INT/823/JPN), with Trust Fund support from the Government of Japan. The workshop report is based on the work of D.L. Die (FAO/FishCode Consultant), J. Alió (Researcher, INIA), L. Ferreira (Fisheries Officer, MALMR), L. Marcano (Researcher, INIA) and S. Soomai (Fisheries Officer, MALMR), with the technical assistance of Kevern Cochrane (Senior Fishery Resources Officer, FAO) and the editorial assistance of the FishCode Programme staff.

The *FAO/FishCode Review* series publishes results of studies, missions, consultations, workshops, meetings and other project activities undertaken through the Programme, in furtherance of the objective of facilitating implementation of the 1995 FAO Code of Conduct for Responsible Fisheries and related international fisheries instruments and plans of action. Individual issues in the series are distributed to appropriate governments, regional bodies, meeting participants and Programme partners. For further information on Programme background, publications and activities, please consult **www.fao.org/fi/fishcode**.

J. Eric Reynolds
Programme Coordinator, FishCode
Fishery Policy and Planning Division
FAO Fisheries Department, Rome

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ABSTRACT

This document reports on the FAO/WECAFC workshop on assessment of demersal stocks shared by Trinidad and Tobago and Venezuela held in Chaguaramas (Trinidad) from 18 to 22 November 2002. The objectives of the workshop were to encourage assessment of shrimp stocks shared by Trinidad and Tobago and Venezuela, evaluate the impact of fishing on shrimp stocks and make recommendations for their management. Recommendations were made to the national fisheries departments of the two countries with regard to the minimum biological data requirements for continued assessment and management of the shrimp fisheries. Discussions were also held on: the available data that could be used in a future assessment of shared fish resources and in future bio-economic analyses, and in planning the collaborative work to facilitate these assessments and analyses; the effects of changes in gear technology; and the future working plan for the ad hoc Working Group. Results were presented to fisheries managers of Trinidad and Tobago and Venezuela on the last day of the workshop.

The main conclusion of the assessment carried out during the workshop – despite uncertainties concerning data gaps – is that some shrimp stocks are being severely overfished and are suffering from this overfishing. Two management recommendations were presented regarding the implementation of fisheries controls, and nine recommendations were proposed in order to better direct data collection and future research on the shrimp and groundfish fisheries including bio-economic modelling.

Keywords: Code of Conduct for Responsible Fisheries; fisheries management; coastal fisheries; marine fisheries; shrimp fisheries; Latin America and the Caribbean.

Contents

Abbreviations

ANOVA	analysis of variance
CPUE	catch per unit of effort
d-a-s	days at sea
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
INIA	Instituto Nacional de Investigaciones Agrícolas
LCCC	length-converted catch curve
MALMR	Ministry of Agriculture, Land and Marine Resources (Trinidad and Tobago)
MSY	maximum sustainable yield
TLCA	tuned length cohort analysis
WECAFC	Western Central Atlantic Fishery Commission

1 INTRODUCTION

1.1 Objectives of the workshop

In March 2001, ministers from the countries in the Brazil-Guianas Shelf region (FAO, 2001), including Trinidad and Tobago and Venezuela, agreed to

- recognize and support the important role played by the ad hoc Working Group, within the framework of WECAFC, in providing an effective mechanism for the interaction of fisheries managers and scientists at the regional level and for the generation and sharing of information and analyses essential for responsible management of these valuable resources;

[and]

- continue supporting the work of .. fishery management institutions [so as] to build and strengthen them as necessary [and] support their ongoing full participation in the activities of the ad hoc Working Group.

In support of these agreements, scientists from Trinidad and Tobago and Venezuela decided to organize a workshop, with the support of FAO, so as to update the status of the resources shared by both countries. The overall goal for this meeting was to evaluate the biological effects of the existing shrimp trawl fisheries in Trinidad and Tobago and Venezuela and to propose management recommendations for these fisheries. The recommendations were to include advice with regard to the minimum biological data requirements for continued assessment and management of the shrimp fisheries in the two countries.

1.2 Workshop logistics

The workshop was hosted by the Government of Trinidad and Tobago at the Fisheries Department laboratory in Chaguaramas, from 18 to 22 November 2002. Scientists from Trinidad and Tobago, Venezuela and FAO attended the workshop (see Appendix A). The workshop was organized and coordinated by Mr Bissesar Chakalall (FAO), with the support of the FAO FishCode Programme. Dr David Die (FishCode consultant) served as the lead technical advisor (see also Appendix B, Terms of Reference). The Trinidad and Tobago Fisheries Department provided computers for participants and made an Internet connection available to allow e-mail access. This allowed Venezuelan scientists to receive additional data from their colleagues in Cumaná during the workshop.

1.3 Work plan

During the meeting, the original list of objectives (see Appendix C) was slightly modified. It was agreed that overall workshop goals would be met by achieving the following:

a) Undertaking joint assessments of shrimp stocks shared by Trinidad and Tobago and Venezuela. Following is the list of species considered in order of priority:[1]

[1] Objective *a* is a combination of objectives *a, b, d* and *e* from the original list (see Appendix C).

- *Farfantepenaeus subtilis;*
- *Litopenaeus schmitti;*
- *Farfantepenaeus notialis/Farfantepenaeus brasiliensis;* and
- *Xiphopenaeus kroyeri*.

The assessment models to be used are either length-based cohort analyses or biomass dynamic models, to address the following issues:

- variability in recruitment;
- relative contributions of spawner-stock biomass and environment to recruitment variability;
- identification and quantification of sources of uncertainty; and
- uncertainty in management advice.

b) Based on these assessments, evaluate the impact of fishing on shrimp stocks and prepare recommendations for management of stocks.[2]

c) Based on the above assessments (conducted using data available from existing shrimp biological data collection programmes in the two countries) submit recommendations to the national fisheries departments with regard to the minimum biological data requirements for continued assessment and management of the shrimp fisheries.[3]

In addition to the work on shrimp, time permitting, discuss the following related issues:

d) Describe the available data on fish that could be used in a future assessment of shared fish resources, and to plan collaborative work to facilitate such an assessment;

e) Describe the available data on bio-economics that could be used in a future collaborative bio-economics analysis, and to plan collaborative work to facilitate such analysis;

f) Discuss the possibility that the ad hoc Working Group analyse the impact of changes in gear technology as developed by the Global Environment Facility (GEF) project;[4]

g) Discuss the future working plan for the ad hoc Working Group on the Shrimp and Groundfish Fisheries on the Brazil-Guianas Shelf;

h) Present the results of the assessment conducted during the workshop to managers at the end of the workshop; and

i) Prepare a report of the workshop.[5]

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[2] Objective *b* is the same as objective *c* from the original list.
[3] Objective *c* is the same as objective *f* from the original list.
[4] The project "Reduction of environmental impact from tropical shrimp trawling through the introduction of bycatch reduction technologies and change of management" (EP/GLO/201/GEF) is funded by the Global Environmental Facility (GEF), implemented by the United Nations Environmental Programme (UNEP) and executed by FAO and the governments and private sector of the twelve participating countries and the Southeast Asian Fisheries Development Center (SEAFDEC).
[5] Required by the Terms of Reference (see Appendix B).

2 SHRIMP ASSESSMENTS

2.1 Description of the Trinidad and Tobago and Venezuela trawl fleets

The Trinidad and Tobago trawl fleet has been categorized into four types based on vessel length, engine horsepower and degree of mechanization (Fabres, 1989). The artisanal trawl fleet comprises pirogues, which are further categorized into type-I and type-II vessels. The type-I (6.7 m–9.8 m in length) usually carry two outboard engines and are generally smaller (Maharaj *et al*., 1993) than the type-II (7.9 m–10.4 m in length) which utilize an inboard engine (Kuruvilla *et al*., 2000). The semi-industrial vessels (also referred to as type-III) range from 9.3 m–12.1 m in length and carry inboard diesel engines of about 165 HP–250 Hp, while the industrial trawlers (type-IV) are double-rigged and measure from 10.9 m–23.6 m in length, with a 365 Hp–425 Hp inboard diesel engine (Kuruvilla *et al*., 2000).

Based on a 1998 vessel census, the Trinidad and Tobago trawl fleet comprises a total of 113 vessels: 13 artisanal type-I and 71 artisanal type-II vessels; 10 semi-industrial type-III vessels; and 19 industrial type-IV vessels (Chan A Shing 1999). All trawler types operate in the Gulf of Paria on the west coast of Trinidad. The industrial trawlers, and to a much lesser extent the semi-industrial trawlers, also operate in the Columbus Channel on the south coast, and on the north coast of Trinidad. From 1977 until 1995, 60–70 artisanal vessels were permitted to trawl in the Orinoco Delta of Venezuela under an agreement between the two countries.

The Venezuelan trawl fishery comprises two fleets: one industrial and the other artisanal. The industrial trawl fleet comprises 88 vessels (mostly metal vessels 24 m–30 m in length). This fleet operates in the southern Gulf of Paria and in front of the Orinoco river delta. The artisanal fleet of trawlers comprises 28 wooden vessels (8 m in length with outboard engines) and operates in the northern area of the Orinoco river delta.

2.2 Data preparation

Catch and fishing effort

A detailed analysis of the available catch and effort data by month and fleet for the period 1992 to 2001 indicates that there are some year/month/fleet combinations for which data are not available. Data from Venezuela are available only for *Litopenaeus schmitti* (industrial and artisanal fleets) and *Farfantepenaeus subtilis* (only industrial fleet). Venezuela has no data on *F. subtilis* for the artisanal fleet, but catches of this species are thought to be small (L. Marcano, personal communication). Data for the industrial type-IV fleet from Trinidad and Tobago are available only for 1999 to 2001. Some data are also missing for trawl type-II operating in the northern Gulf of Paria and type-III for Trinidad and Tobago; however, no other major gaps exist in the catch and effort series for the type-I and -II fleets fishing in Venezuela and the type-II fleet fishing in the southern Gulf of Paria.

For the period 1973 to 1991, yearly catch and effort estimates were obtained following the same procedures and assumptions used in the 1997 workshop (Marcano *et al.,* 1997):

- For years in the period 1973 to 1983 for which no catch/effort report was available, the reported average catch/effort for the period 1980 to 1985 from the same fleet was used instead.

- Effort for the different fleets was expressed in type-IV units by calculating a fishing power factor for each fleet. Fishing power factors were based on estimates of relative area swept from average vessel/gear information for each fleet.
- Catch per unit of fishing effort (CPUE) was estimated for each fleet as the ratio of the yearly catch and the yearly effort.
- For the type-IV fleet, effort was estimated to be proportional to the effort of the type-III fleet. It was thought that the development of effort in the Trinidad type-IV fleet is more likely to be similar to the development of effort of the type-III fleet (both from Trinidad) than to the effort of the Venezuelan industrial fleet.
- For the type-IV fleet, CPUE was estimated to be proportional to that of the industrial Venezuelan fleet. Type-IV vessels are about 30% smaller and less powerful than the Venezuelan industrial vessels; however, they are twice as large as type-III vessels. In addition, type-IV vessels, like the Venezuelan industrial trawlers, are double-rigged while the type-III vessels operate only one net. The main fishing area of type-IV vessels (southern Trinidad) is also more comparable to that of the Venezuelan industrial vessels than the area most fished by type-III vessels (Gulf of Paria).

The proportionality factor for CPUE for the Trinidad and Tobago type-IV fleet versus the Venezuelan industrial fleet was recalculated on the basis of estimates for months for which data were available for both fleets (April 1991 to March 1992 and 1999 to 2001). Estimates of the ratio of effort of type-III vs. type-IV fleets were calculated for a similar period.

The species composition of landings by type-III fleets is very different from that of type-IV fleets, as the proportion of *F. subtilis* is much higher in fleet IV than in fleet III for most months during the period 1999 to 2001. The species composition of landings by type-IV for 1992 to 1998 was therefore assumed to be constant and equal to the average species composition for the period 1999 to 2001.

For the period 1992 to 2001, new monthly estimates were developed during the workshop with the following additional assumptions:

- when catch and effort were missing for one or two months in a row for fleets I, II or III, they were calculated as the average of the previous and following month's effort and catch [e.g. $F_{II,94,8}$ = average ($F_{II,94,7}$, $F_{II,94,9}$)].
- for catch and effort for March to December 1998 for fleets II and III, for which no data are available, the average of the monthly catch and effort for the same months in 1997 and 1999 were used [e.g. $C_{III,98,5}$ = average ($C_{III,97,5}$, $C_{III,99,5}$)].

The monthly effort data by fleet for 1992 to 2001 are given in Table 1.

Landings of all shrimp species are highly seasonal. Estimated landings of *F. subtilis* for Venezuela, for example, showed a decline from about 90 t/month in 1992 to 20 t/month in 1997; this had increased back to about 50 t/month by 2001. Landings for the same species from Trinidad and Tobago were in general lower than those from the Venezuelan fleet, averaging about 30 t/month (see Figure 1, p. 7).

Landings of *L. schmitti* for both the Venezuelan fleet and the Trinidad and Tobago fleet were lower than those for *F. subtilis*, averaging about 20 t–30 t/month for each of the two fleets (see Figure 2, p. 7).

Table 1. Monthly fishing effort for each of the fleets landing shrimp, 1992 to 2001.*

TT Artisanal										
Month	**Fishing effort (hours) by year**									
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Jan	13 620	*13 794*	12 033	13 576	16 111	12 407	11 281	8 925	10 534	15 848
Feb	11 083	15 472	15 010	23 123	14 547	12 321	7 141	10 188	*9 559*	16 940
Mar	18 440	13 104	20 102	24 186	11 623	9 346	*12 827*	*12 922*	9 536	18 392
April	14 673	15 900	18 022	24 811	11 559	10 093	*13 138*	*12 857*	*14 600*	15 429
May	15 416	22 209	17 417	28 475	12 224	5 995	*14 350*	17 182	*14 635*	15 672
Jun	14 486	20 162	11 409	17 954	12 522	7 723	*14 762*	23 741	17 359	13 028
July	12 100	13 125	11 941	14 538	9 268	8 071	*7 491*	6 612	15 723	14 711
Aug	8 448	8 718	11 053	*12 447*	11 743	6 515	*11 023*	*12 397*	15 508	15 318
Sept	6 159	7 888	8 626	11 523	8 881	*6 238*	*10 010*	*11 517*	13 651	14 703
Oct	6 830	8 356	*9 306*	9 160	7 165	6 589	*13 112*	16 079	14 586	15 436
Nov	8 508	10 493	*8 713*	10 506	7 917	6 811	*10 520*	7 871	14 654	14 929
Dec	*7 198*	7 232	10 638	9 739	7 742	*5 820*	*10 447*	*8 052*	12 885	15 694
TT Semi-industrial										
Month	**Fishing effort (hours) by year**									
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Jan	5 046	*3 311*	3 584	5 552	2 575	3 993	3 467	3 365	4 500	5 169
Feb	5 825	3 311	2 867	7 228	2 402	3 576	3 754	3 602	*3 946*	5 121
Mar	5 010	4 330	4 234	6 754	2 400	3 866	*4 051*	*4 236*	3 392	5 669
April	6 032	4 760	4 615	8 064	3 129	3 929	*4 083*	*4 236*	*4 033*	5 878
May	4 896	3 760	3 427	5 584	3 221	4 083	*4 477*	4 870	*4 033*	4 779
Jun	4 581	4 001	2 966	5 358	2 871	3 175	*3 581*	3 986	4 673	5 694
July	4 140	3 299	2 964	4 060	2 809	3 584	*3 776*	3 968	4 696	4 678
Aug	4 176	3 531	4 095	*3 703*	2 310	3 372	*3 566*	*3 760*	4 927	5 331
Sept	3 935	3 754	4 001	3 345	2 986	4 081	*3 921*	*3 760*	4 667	5 784
Oct	4 739	3 441	4 300	4 199	2 582	3 282	*3 417*	3 552	4 533	5 434
Nov	4 026	3 810	3 843	4 173	2 846	3 948	*3 715*	3 482	5 214	3 870
Dec	*4 026*	3 351	4 258	3 847	3 057	3 583	*3 533*	*3 482*	4 355	5 473
TT Industrial										
Month	**Fishing effort (hours) by year**									
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Jan	*7 107*	*4 663*	*5 048*	*7 820*	*3 627*	*5 624*	*4 883*	8 554	6 574	6 938
Feb	*8 204*	*4 663*	*4 038*	*10 180*	*3 383*	*5 037*	*5 287*	11 520	8 381	6 425
Mar	*7 056*	*6 099*	*5 963*	*9 513*	*3 380*	*5 445*	*5 706*	9 434	8 275	9 975
April	*8 496*	*6 704*	*6 500*	*11 358*	*4 407*	*5 534*	*5 750*	10 546	6 283	6 668
May	*6 896*	*5 296*	*4 827*	*7 865*	*4 537*	*5 751*	*6 305*	9 336	8 364	7 350
Jun	*6 452*	*5 635*	*4 177*	*7 546*	*4 044*	*4 472*	*5 043*	10 944	8 100	5 973
July	*5 831*	*4 646*	*4 175*	*5 718*	*3 956*	*5 048*	*5 318*	9 720	6 864	8 310
Aug	*5 882*	*4 973*	*5 768*	*5 215*	*3 254*	*4 749*	*5 023*	8 400	6 703	7 130
Sept	*5 542*	*5 287*	*5 635*	*4 711*	*4 206*	*5 748*	*5 522*	8 016	7 723	12 775
Oct	*6 675*	*4 846*	*6 056*	*5 914*	*3 637*	*4 623*	*4 813*	9 480	5 400	10 950
Nov	*5 670*	*5 366*	*5 413*	*5 877*	*4 008*	*5 561*	*5 232*	7 800	7 390	9 205
Dec	*5 670*	*4 720*	*5 997*	*5 418*	*4 306*	*5 046*	*4 975*	7 368	10 337	8 620

*Numbers in red italics represent estimated data.

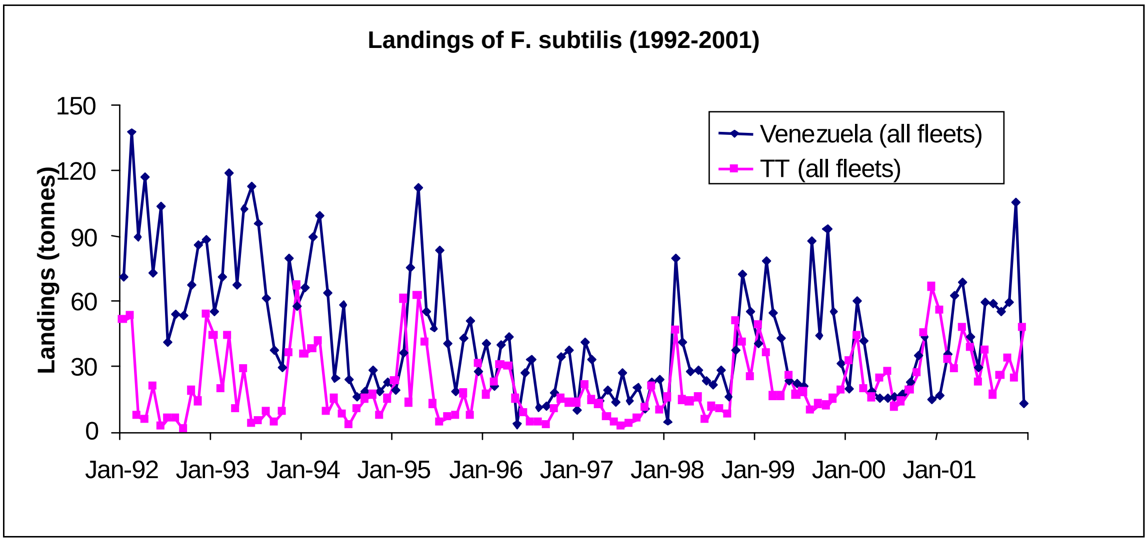
(cont.)

Table 1 (cont.)

Venezuela Artisanal										
Month	**Fishing effort (d-a-s)** by year**									
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Jan			176	228	422	415	362	521		
Feb			174	261	413	382	425	513		
Mar			198	293	396	372	470	607		
April			187	242	371	304	568	628		
May			200	281	350	269	438	560		
Jun		185	204	277	231	320	426	561		
July		286	207	415	142	195	554	484		
Aug		233	205	355	710	174	482	621		
Sept		175	231	372	394	312	637	577		
Oct		176	209	470	570	428	721	815		
Nov		172	209	403	709	399	651	971		
Dec		175	209	352	319	383	481	710		
Venezuela Industrial										
Month	**Fishing effort (d-a-s)** by year**									
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Jan	660	351	681	390	350	272	151	710	296	370
Feb	1 125	860	966	798	409	595	552	856	894	926
Mar	792	1 494	1 186	634	722	771	889	1 321	1 151	982
April	791	647	957	805	659	708	855	1 192	842	899
May	236	996	864	934	308	767	970	1 594	1 123	1 433
Jun	824	1 314	870	1 118	341	727	1 030	885	1 138	1 164
July	735	989	621	861	860	666	495	1 180	840	1 209
Aug	1 092	1 212	542	791	460	401	611	1 268	863	1 711
Sept	1 018	1 145	540	999	717	543	815	1 114	913	891
Oct	940	1 258	521	1 167	605	487	634	1 095	1 057	936
Nov	1 136	1 446	500	597	668	425	926	1 114	936	1 418
Dec	603	1 050	603	254	628	590	741	794	909	98

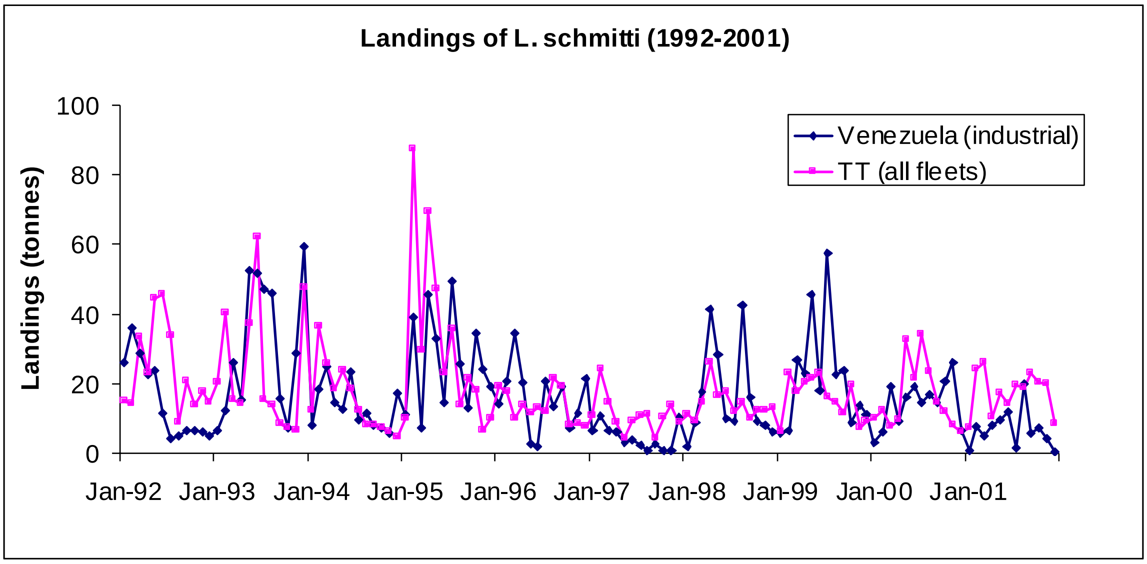
**D-a-s = days at sea.

Figure 1. Estimated monthly landings (tonnes) of brown shrimp *F. subtilis* in the Gulf of Paria-Orinoco Delta region for Venezuela and Trinidad and Tobago, 1992 to 2001.*



*Landing estimates from Trinidad and Tobago were estimated during the workshop.

Figure 2. Estimated monthly landings of white shrimp *L. schmitti* in the Gulf of Paria-Orinoco Delta region for Venezuela and Trinidad and Tobago, 1992 to 2001.*



*Landing estimates from Trinidad and Tobago were estimated during the workshop.

Sex ratio and length frequency

The biological samples for the period 1992 to 2001 contain information on length frequency and species composition. The species composition obtained in these samples was used to calculate landings by species. Unfortunately there are samples missing for many gear and month combinations. Therefore a procedure was used to estimate species composition and length frequency for those months for which no biological data were available. The procedure used was based on the correlation of the mean lengths of *F. subtilis* individuals across fleets, and is given as follows:

- No artisanal data are available for Venezuela; however, the catch was assumed to be composed exclusively of *L. schmitti*, and the length frequency distributions used were taken from Trinidad and Tobago type-I and type-II fleets (southern Gulf of Paria).
- There are no data for type-I and -II fleets operating in Venezuela for certain months; the data used are samples from fleet type-II (southern Gulf of Paria).
- There are no data for fleet IV for the period 1992 to 1998; data used are samples from fleet III.
- No data are available for the Venezuelan industrial fleet for 1992 to 1996; data used are samples from the Trinidad and Tobago fleet IV.
- There are gaps of a few months for fleet II (southern Gulf of Paria); data used are taken from Trinidad and Tobago fleet I (Venezuela) or, when these were not available, from fleet II (northern Gulf of Paria).
- There are gaps of a few months for fleet II (northern Gulf of Paria); data were taken from fleet II (southern Gulf of Paria).
- There are gaps of a few months for fleet III; data were taken from fleet II (northern Gulf of Paria), and, when these were not available, from type-II (southern Gulf of Paria).

Data substitutions such as these obviously created unavoidable biases. The average length of shrimp caught by fleet III is smaller than that caught by fleet IV. The proportion of *F. subtilis* in fleet III is also smaller than that observed in fleet IV. As a result, the estimated length frequency for *F. subtilis* is likely to be biased towards smaller sizes for all months for which no samples were collected in the industrial fleets (1992 to 1998). The most reliable length composition for *F. subtilis* probably derives from data from the most recent period, 1999 to 2001. The length frequencies obtained during the workshop should be used as the basis for further length-based assessments.

2.3 Assessments with production models

Farfantepenaeus brasiliensis

Along the northern coast of Venezuela and Trinidad, from the Unare Lagoon and the Piritu Islands to the northeastern coast of Trinidad, trawlers catch a mixture of shrimp species. The most valuable of all the shrimp resources is *F. brasiliensis*, which dominates the landings and which is also, because of its large size, a highly priced export product. There are three major fishing grounds in this area: the Unare region, where vessels fish offshore to the Piritu Islands; an area east of Margarita island, to the *promontorio de Paria*; and the area north of Trinidad. The first two areas are fished by Venezuelan vessels based in Guanta and Cumaná. The area north of Trinidad is not commonly fished at present, mainly because Trinidad has restricted the areas open to trawling along this coast. The frequency with which vessels from Trinidad fished this area in the past is not known, but it has been assumed that most of the catch was historically made by Venezuelan vessels, and that therefore the catch from these vessels ought to represent the total catch of this species in this area.

There are no genetic or tagging studies to support the identification of stocks of *F. brasiliensis*; however, for the Brazil-Guianas area, it has been suggested that the larvae of this species tend to migrate westward with the prevailing currents and recruit to nursery areas along the coast. Juveniles then move offshore and progressively migrate to deeper waters as they move east. If the same migration hypothesis is applied to the area between Unare and Trinidad, it is possible that the shrimp in all these areas constitute a single stock. There is some evidence that the largest shrimp are caught in the eastern-most areas of the Venezuelan fishing grounds (L. Marcano, personal communication). A biomass dynamic model was applied to the Venezuelan CPUE data collated for 1970 to 2001. BIODYN software (Punt and Hilborn, 1996) was used initially to examine how the data fit the dynamic model and to obtain initial parameter estimates. The final fit of the biomass dynamic model was carried out with ASPIC v 3.91 (Prager, 1992), which also produces bootstrap estimates of confidence limits for management parameters.

Landings declined from 800 tonnes in 1971 to about 600 tonnes in 1983; they attained 1 100 tonnes in 1984 and remained around that level until 1992 when they declined again to about 600 tonnes in 2000 (see Figure 3, p. 10). CPUE (kg per day) declined rapidly from 140 kg to 50 kg between 1970 and 1978. After this date the decline was much smaller, and by 2001 CPUE averaged about 40 kg per day. The CPUE predicted by the biomass dynamic model follows a much more gradual decline than the observed data, and also fails to fit the sharp decline of the 1970s (see Figure 4, p. 10).

Estimates of management parameters obtained from the biomass dynamic model suggest that the stock is being fished at the optimum biological level (Table 2, p. 11). Estimated biomass declined by about half from its virgin level and current biomass as a proportion of B_{msy} is 1.17 (80% C.L. 1.12, 1.41). Fishing mortality was well below F_{msy} until 1985, when the rates increased. From 1985 to 1994 fishing mortality fluctuated around F_{msy} (Figure 5, p. 11). In the next seven years (1995-2001) fishing mortality had been slightly lower than F_{msy}, and the fishing mortality ratio (F_{2002}/F_{msy}) at that time was 0.87 (80% C.L. 0.65, 1.01). The maximum sustainable yield was estimated to be 784 t (80% C.L. 653, 847).

It must be stressed that there are significant uncertainties in this assessment. First, the biomass dynamic model fails to fit the initial sharp decline in CPUE. Such a decline can be explained by the model only if accompanied by an initial period of large catches, something not observed in the data for this stock. In addition, the fit suggests that the biomass at the beginning of the data period (1970) was well above carrying capacity. This can happen in shrimp fisheries as a result of a strong recruitment; however, it must be regarded as an indication that the assessment results could be somewhat optimistic.

Farfantepenaeus subtilis

The ad hoc Working Group made a first assessment of the stock of *F. subtilis* in the Gulf of Paria-Orinoco Delta region during the 1997 meeting of the working group by using data from Venezuela and Trinidad with a biomass dynamic model for the period 1973 to 1996. Collection of catch and effort data has recently substantially improved for Trinidad; during the present workshop, catch and effort for Trinidad was recalculated for the period 1992 to 2001. Uncertainties regarding catches made by the Trinidad fleet prior to 1992 remain; the data used by Marcano *et al.* (1997) for that period were the same as those used here. As for *F. brasiliensis*, both BIODYN and ASPIC were used to fit the biomass dynamic models for *F. subtilis*.

Figure 3. Estimated yearly landings of pink-spotted shrimp *F. brasiliensis* by the Venezuelan industrial fleet, 1970 to 2001, in the area between Unare and Trinidad.

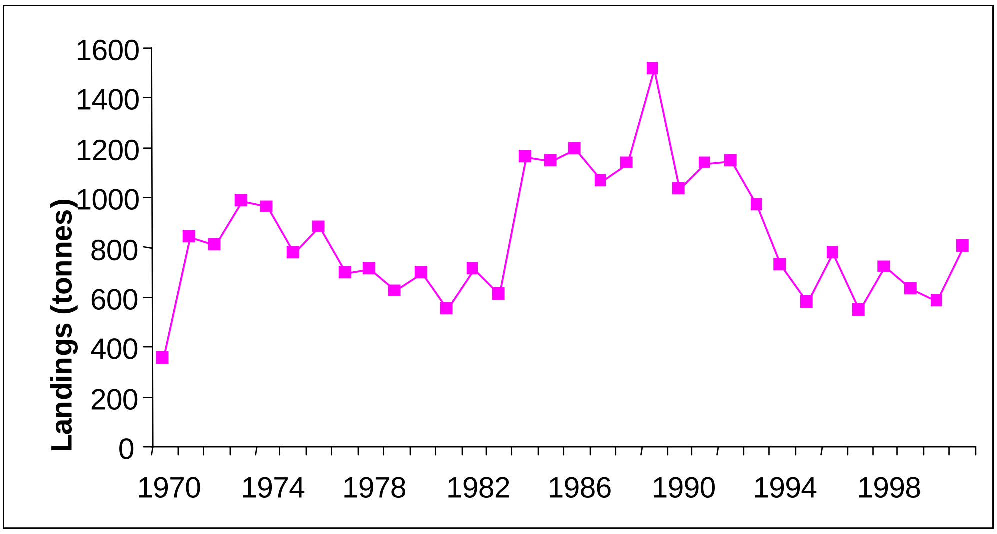
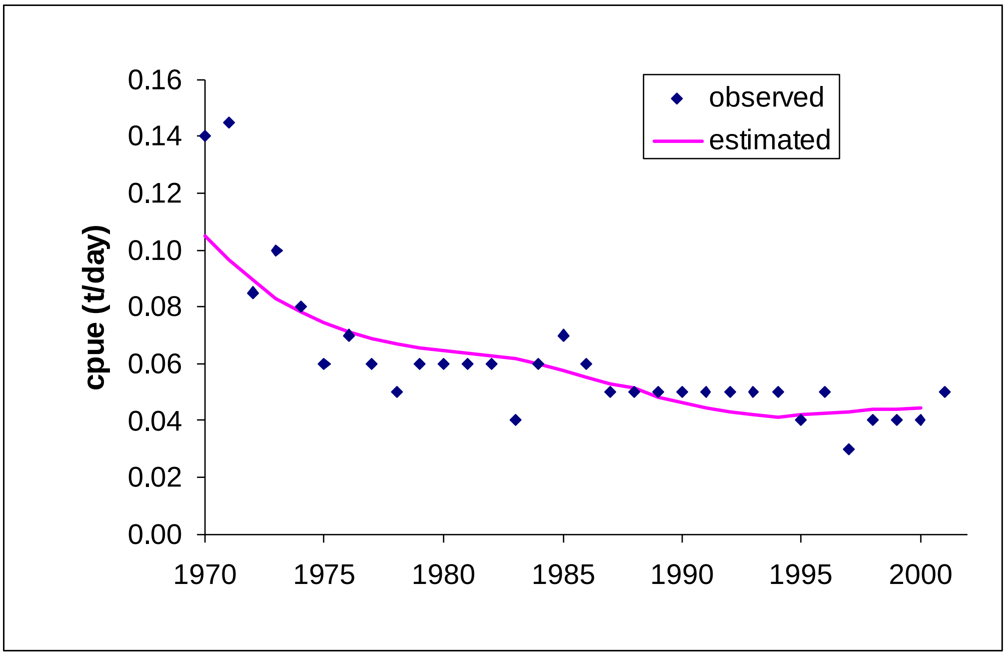


Figure 4. Observed CPUE (tonnes/day) of pink-spotted shrimp *F. brasiliensis* in northeastern Venezuela, from Unare to Paria (points).*



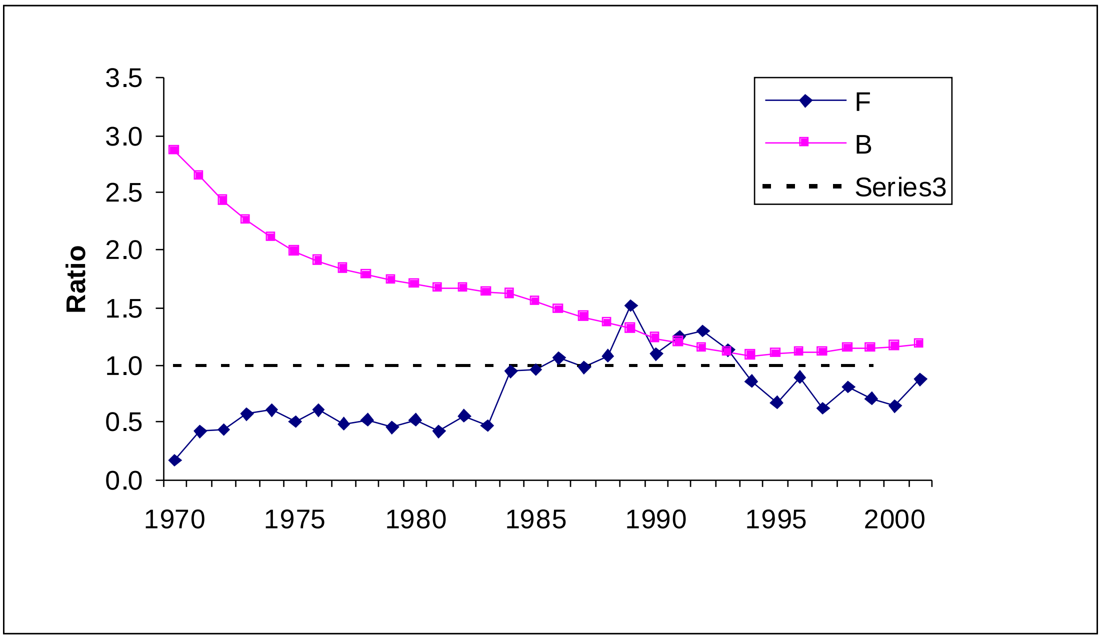
*Line represents the estimated CPUE according to a biomass dynamic model fitted with ASPIC software.

The nominal CPUE data from the Venezuelan industrial fleet and all Trinidad fleets combined appear to show a marked decline throughout the entire time series. Currently CPUE averages about 40 kg per day, or about one-quarter of what it was in the early 1970s when CPUE averaged about 160 kg per day (see Figure 6, p. 12). The CPUE predicted by the biomass dynamic model closely follows the average rate of decline; however, the fluctuations

Table 2. Management parameters estimated by bootstrapping procedure in ASPIC for pink-spotted shrimp *F. brasiliensis* stock between Unare and Paria.

Parameter	*Estimate*	*Lower 80%CL*	*Upper 80%CL*
B_{1973}/B_{msy}	2.87	n.a.	3.04
MSY (t)	784	653	857
B_{msy} (t)	8 635	7 323	12 430
B_{2002}/B_{msy}	1.17	1.12	1.41
F_{2002}/F_{msy}	0.87	0.65	1.01

Figure 5. Estimated ratios of biomass to the biomass that produces MSY (B/B_{msy}) and fishing mortality to the fishing mortality that produces MSY (F/F_{msy}) for pink-spotted shrimp *F. brasiliensis* in northeastern Venezuela, from Unare to Paria.*



*Estimates are derived from a biomass dynamic model fitted with ASPIC software; the horizontal broken line represents a ratio of 1.

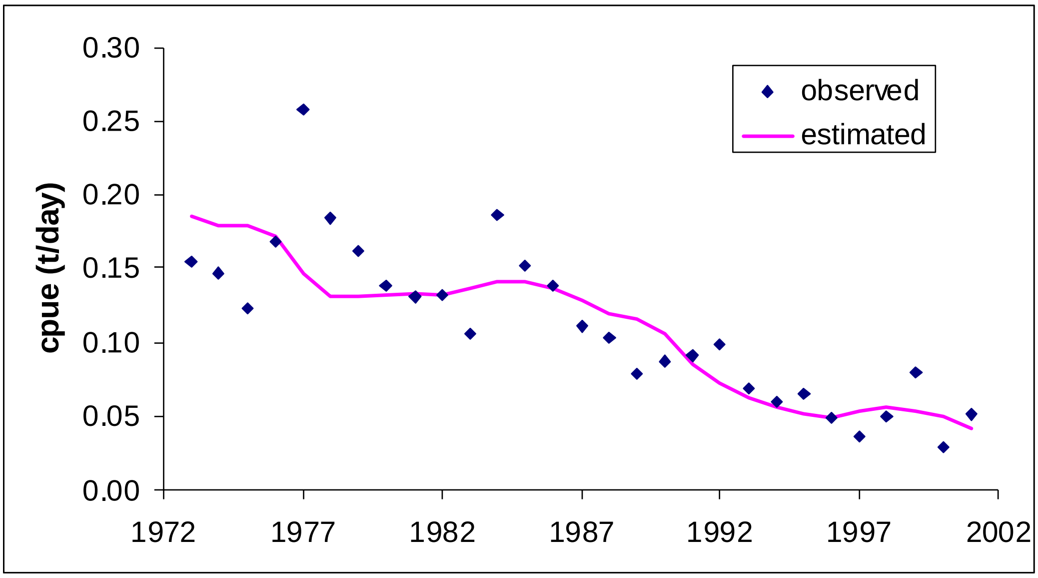
observed in the data do not follow those predicted. This is to be expected because it is unlikely that such a model would predict the sharp variations in annual CPUE observed for this stock. Such variations could be caused, for example, by environmentally driven variability in catchability.

The ASPIC model encountered difficulties in estimating the parameter *r* from the data, suggesting that the data are not informative enough for the estimation of all parameters in the model. As an alternative, results were obtained for three different values of *r:* 0.2; 0.4; and 0.8.

The exact results differ depending on the *r* value used; however, the overall diagnostic of the status of the stock is independent of *r*. Current fishing mortality is several times greater than F_{msy}, the current biomass is around 20% of the B_{msy}, and the value of MSY is between 1 000 and 1 200 tonnes (see Table 3). The stock is therefore severely overfished and suffers considerably from this.

In this report we present the detailed results for the case where r = 0.4 (Table 3). The biomass trend estimated by the model suggests that the stock was already overfished (less than B_{msy}) by the late 1970s and that it has declined even further since then (see Figure 7). Estimates of management parameters suggest that the stock is being severely overfished, with the current biomass ratio equal to 0.23 (80% C.L. 0.12, 0.35), less than one-quarter of the B_{msy}. Fishing mortality estimates for the entire period have been greater than F_{msy}, indicating that overfishing has been taking place since the 1970s. Currently, the fishing mortality ratio is 3.42 (80% C.L. 2.52, 4.97), more than three times greater than F_{msy} (compare with Figure 7 and Table 4). The maximum sustainable yield is estimated around 1 100 tonnes (80% C.L. 1,040, 1,320); however, because of severe overfishing and low biomass, the 2002 replacement yield[6] is only 440 tonnes. If recent catch levels continue to be harvested, the stock and catch rates will continue to decline even further.

Figure 6. Observed catch per unit of effort (tonnes/day) of brown shrimp *F. subtilis* in the Gulf of Paria-Orinoco Delta region (points).*



*Line represents the estimated catch per unit of effort according to a biomass dynamic model fitted with ASPIC software.

[6] Replacement yield is the greatest yield that can be harvested without causing a further decline in the biomass of the stock.

Table 3. Management parameters estimated with biomass dynamic model for brown shrimp *F. subtilis* in the Gulf of Paria-Orinoco Delta region.*

Parameter	*r* = 0.2	*r* = 0.4	*r* = 0.8
B_{1973}/B_{msy}	1.08	1.26	1.42
MSY (t)	1 019	1 110	1 202
F_{msy}	0.1	0.2	0.4
B_{msy} (t)	10 900	5 552	3 005
B_{2002}/B_{msy}	0.20	0.23	0.23
F_{2002}/F_{msy}	4.39	3.41	2.91

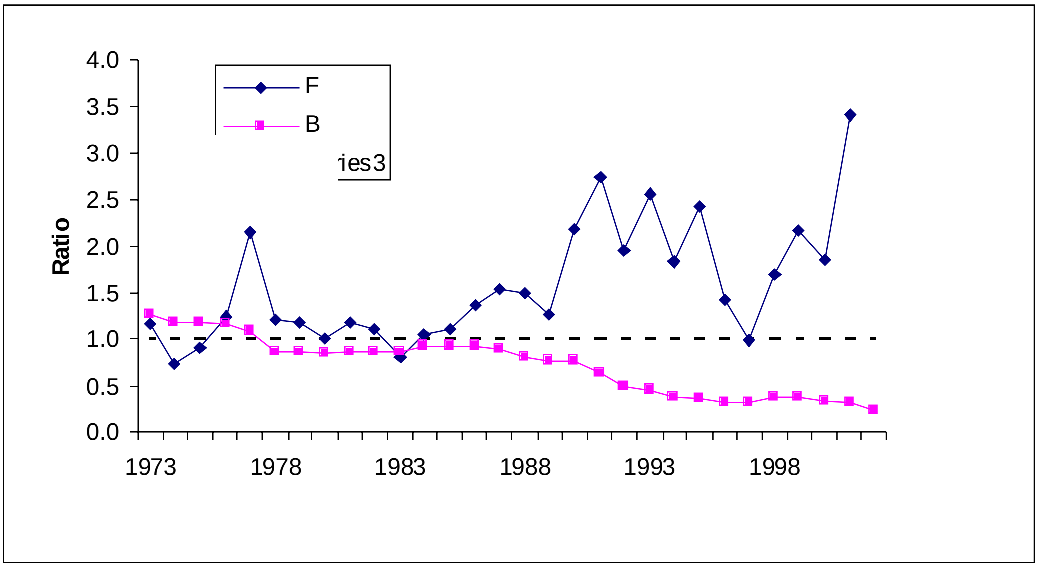
*Fits were obtained with ASPIC software by fixing the value of *r*.

Table 4. Management parameters estimated by bootstrapping procedure in ASPIC for brown shrimp *F. subtilis* in the Gulf of Paria-Orinoco Delta region.*

Parameter	*Estimate*	*Lower 80%CL*	*Upper 80%CL*
B_{1973}/B_{msy}	1.27	0.81	1.77
MSY (t)	1 100	1 040	1 320
B_{msy} (t)	5 550	5 200	5 350
B_{2002}/B_{msy}	0.23	0.12	0.35
F_{2002}/F_{msy}	3.42	2.52	4.97

*Fits were obtained with ASPIC software by fixing the value of r to 0.4.

Figure 7. Estimated ratios of biomass to the biomass that produces MSY (B/B_{msy}) and fishing mortality to the fishing mortality that produces MSY (F/F_{msy}) for brown shrimp *F. subtilis* in the Gulf of Paria-Orinoco Delta region.*



* Estimates are derived from a biomass dynamic model fitted with ASPIC software; the horizontal line represents a ratio of 1.

The results of this assessment are more uncertain than those reported for *F. brasiliensis*, and the bootstrap estimates of confidence limits are conditional on a fixed value of *r* = 0.4. The real uncertainty associated with the management parameters is therefore likely to be greater than the one reported above. It is unlikely, however, that the uncertainty is high enough to call the main conclusion of this assessment into question – namely, that the stock is being severely overfished and is suffering from this overfishing.

2.4 Management recommendations

Although there is significant uncertainty in the precise status concerning both shrimp stocks, the main conclusions of the assessments are likely to be robust. The stock of pink-spotted shrimp in Unare-Paria is probably being fished at the level that should produce maximum sustainable yield.

> ***Recommendation 1:*** Managers should not allow fishing mortality to increase in the pink-spotted shrimp fishery of Unare-Paria.

The stock of brown shrimp in the Gulf of Paria-Orinoco Delta region has been suffering from severe overfishing for at least two decades and, as a consequence, the stock is now severely overfished. If harvest is allowed to continue at current levels, both the stock and catch rates will continue to decline even further, leading to decreases in annual catch.

> ***Recommendation 2:*** Managers should introduce measures to reduce fishing mortality on the brown shrimp stock of the Gulf of Paria-Orinoco Delta region.

Recommendations 1 and 2 require managers to control fishing mortality. In shrimp trawl fisheries this can be achieved in many different ways and it is for the managers to consider how the control should be exerted. Among the tools most effectively used by other countries to control fishing mortality in similar shrimp trawl fisheries are: controlling the number of licenses/vessels; seasonal closures; and gear and vessel restrictions. The mix of measures that should be used to control fishing mortality in each fishery depends on the capacity and management priorities set for each country. However, the presence of shared stocks between Venezuela and Trinidad and Tobago requires that both countries develop a common strategy for effort control. This strategy should clearly establish the type of management tools that each country will use to control fishing effort and how this effort will be monitored in the future.

2.5 Research recommendations

Length-based assessments of F. subtilis, L. schmitti, F. notialis *and* X. kroyeri

The shrimp assessments conducted during the workshop were performed with production models. However, as indicated in the sub-section “Sex ratio and length frequency” (under section 2, “Shrimp Assessments”, p. 3), length frequency data are available for the Trinidad and Tobago fleets for five shrimp species (*F. subtilis, L. schmitti, F. notialis, F. brasiliensis, and X. kroyeri*) for the period 1992 to 2001 which can be used to attempt length-based cohort analyses for some of the stocks. Much of the workshop time was spent estimating catch and effort and length frequencies for the gear and month combinations for which no data were available, thus leaving no time for the proper assessments *per se*.

It was agreed that joint Trinidad and Tobago/Venezuela assessments should be conducted for *F. subtilis* and *L. schmitti,* which are important species for both countries. In addition, Trinidad and Tobago is to conduct assessments for *F. notialis* and *X. kroyeri*. *F. notialis* is the major shrimp species caught by the type-III fleet (representing about 60%–70% of the shrimp catch of this fleet), and this species is also dominant in the type-IV and type-II catches (up to about 40% of the total shrimp catch of these fleets). *X. kroyeri* is important for the artisanal fleet operating in the Gulf of Paria, where it represents from 10%–40% of the shrimp catch.

Length frequencies were raised to the total catch of Trinidad and Tobago for all fleets by year and month for 1992 to 2001 for *F. subtilis* and *L. schmitti* for males and females separately. In addition, for *F. subtilis*, for males and females separately, length frequencies were raised to the catch of all fleets (Trinidad and Tobago and Venezuela). Length converted catch curve analysis (LCCC) and tuned length cohort analysis (TLCA) were attempted for *F. subtilis* males for 1999.

> ***Recommendation 3:*** Development of catch-at-size matrices for shrimp landings should be completed and length-based VPA assessments conducted for *F. subtilis* and *L. schmitti* jointly for Trinidad and Tobago and Venezuela, and for *F. notialis* and *X. kroyeri* for Trinidad and Tobago in this order of priority.

***Assessment of* X. kroyeri**

An effort is still necessary to provide managers with scientific information on *X. kroyeri* to assist in managing this stock. Past experience from the working group has indicated that the quality of information on *X. kroyeri* is poor and thus not very useful for managers; including information for determining whether the stock is being overfished or not or the definition of optimum harvest strategies. This stock was discussed by the working group, but it was decided that time would be better invested on other, more important, stocks. This decision reflects what the working group expected in terms of scientific results were they to work on a stock with so few data available.

If countries regard this stock as important in making management decisions, scientists should be asked to focus on it independently of the scientific returns obtained from such work. Presently there are concerns about the adequacy of the data available for quantitative assessments, although it was agreed that Trinidad and Tobago could attempt a length-based assessment for *X. kroyeri*.

> ***Recommendation 4:*** Given the concerns about the adequacy of the information to carry out an assessment, managers should manage the *X. kroyeri* stock in a precautionary fashion. In addition, consideration should be given to providing the resources required to improve data for the stock and providing scientists with the time necessary to work on it. Investment of resources in data collection and scientists' time should be commensurate with the relative value that managers put on this stock as opposed to other shrimp and fish stocks.

Shrimp discards

In Venezuela, there is evidence that the artisanal fleet in the Orinoco is landing only the larger shrimp, because the processing company will not accept small shrimp. Observer trips suggest that the small shrimp are discarded at sea or sold through a different market channel. Sampling for one year carried out in Trinidad (type-II (Gulf of Paria)) suggests that there is not much shrimp being discarded. However, according to observers, there is discarding on type-III vessels, especially during some seasons.

> ***Recommendation 5:*** Monitoring of shrimp discards is important and should be part of an at-sea observer programme that should be implemented for all shrimp fisheries in the area.

Shrimp sampling programme

The shrimp fishery in Trinidad and Tobago is complex because of the large variety of fleets that land shrimp, rendering the collection of reliable length samples difficult.

> ***Recommendation 6:*** To improve the design of the sampling programme in Trinidad and Tobago, it is important to analyse the current length data being collected (e.g. run an ANOVA) to determine the main sources of variation of shrimp length.

Confidentiality of data

Data used for assessment should not be compromised by their possible value for compliance. This is especially important in the case of shared fisheries such as those in the Gulf of Paria and the Orinoco delta, for which two separate countries have established fishing agreements.

> ***Recommendation 7:*** The working group should ensure that "commercial in confidence" data released during the meetings of the working group are presented in such a way that they cannot be used to identify non-compliance.

3 FISH STOCK ASSESSMENTS

No fish stock assessments were conducted during the workshop; however, the data and research requirements that would support such assessments were discussed and are presented below.

Venezuela has continued to collect observer data and landings of fish for industrial trawlers. Observers are measuring *Macrodon ancylodon, Micropogonias furnieri* and *Cynoscion virescens*. Some data on *Lutjanus synagris* are being collected from the artisanal fishery. Highest priority of assessment continues to be *M. ancylodon*. The last assessment was carried out with a yield-per-recruit model in 1997 in Port of Spain. There is also information on discard rates, and biological information on discards. Research has been carried out recently on *C. jamaicensis* in the northern part of Sucre and northern Trinidad. Landings and catch rates have continued to increase for some of these species, most likely due to increased retention/targeting. Data are also available on the artisanal fleet from Sucre, where catch and effort and biological samples are being collected.

Trinidad and Tobago conducted an assessment for *M. furnieri* and *C. jamaicensis* with depletion modelling and bio-economic models in 1998. Data have been collected since 1999 showing that *M. ancylodon* is being caught in large numbers. There is information on discards for one year for the type-II and -III trawl fleets and some data on catch and effort for the multi-gear artisanal fleets (gillnets, demersal longlines, handlines). One of the recommendations for Trinidad and Tobago from previous meetings of the ad hoc Working Group is the implemention of a biological data collection programme for the groundfish fishery. This programme would facilitate the conduct of age-structured biological and bio-economic analyses in order to provide more refined assessments of the status of the fishery.

> ***Recommendation 8:*** Both countries agreed to put greater priority on biological sampling (length frequency, ageing and maturity) for *M. ancylodon*, *M. furnieri*, *C. virescens*, *C. jamaicensis* and *L. synagris*. Venezuela also agreed to pay more attention to biological sampling of the juveniles of these species in the Pedernales area. To assist with the design of their groundfish biological sampling programme, the

Trinidad and Tobago scientists could benefit from examining the biological programme in place in Venezuela.

Recommendation 9: Biological and fishery sampling of fish species should be designed to satisfy the data needs of assessment models. These are presently:

- the determination of the species composition of the landings of the various fleets;
- the characterization of fish bycatch and target species; and
- the assessment of discarding rates of priority species.

4 BIO-ECONOMIC MODELLING

Although participants expressed interest in updating the bio-economic analyses conducted during the last working group workshop (Cumaná, 2000), they were not discussed for lack of time. Substantial progress was made in the basic fishery information (catch and effort) required for the bio-economic models, as well as in the shrimp assessments using production models conducted at this workshop. Further, the results from the shrimp length-based assessments to be conducted should provide important input parameters to the models. In addition, Trinidad and Tobago has new economic data from a costs and earnings study conducted for its trawl fleets in mid-2002. Because of the recent large changes that have occurred in world shrimp prices and in the economic situation of Venezuela, it is essential that economic data be collected for Venezuela before the bio-economic analyses are updated.

Recommendation 10: Venezuela should update basic economic data pertaining to its trawl fisheries.

Recommendation 11: The next bio-economic assessment for Trinidad and Tobago and Venezuela should cover both shrimp and groundfish, and data should be treated separately for each of the various trawl fleets.

5 PRESENTATION OF WORKSHOP RESULTS

During the workshop, participants prepared a presentation on the assessment results for the fishery managers of Trinidad and Tobago and Venezuela. Representatives of the Trinidad and Tobago Ministry of Agriculture, Land and Marine Resources and the Venezuelan Embassy in Port of Spain attended the presentation on the last day of the workshop. Mr Chakalall welcomed attendees on behalf of FAO. Dr David Die presented the overall objectives of the workshop and the structure of the presentation and introduced each of the sections of the presentation. Ms Lara Ferreira, Ms Suzuette Soomai and Mr Jose Alió then presented the assessment results. Ms Sita Kuruvilla presented a summary of progress of the GEF project studying the impacts of changes in trawl gear technology. Electronic copies of the presentation are available from Dr Die.

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APPENDIX A

WORKSHOP PARTICIPANTS

Trinidad and Tobago

Fisheries Division
Ministry of Agriculture, Land and Marine Resources
St. Clair Circle, St. Clair, Port of Spain

- Ms Lara Ferreira, Fisheries Officer
- Ms Sita Kuruvilla, Fisheries Officer
- Ms Suzuette Soomai, Fisheries Officer

Venezuela

Instituto Nacional de Investigaciones Agricolas (INIA)
Sucre/Nva. Esparta, Avenida Carupano, Caiguire
Apdo No. 236, Cumaná 6101

- Mr Jose Javier Alió Mingo, Researcher
- Mr Luis Marcano, Researcher

FAO

Mr Bisessar Chakalall
Senior Fishery Officer
FAO Sub-regional Office
Barbados

Dr David Die
303 Galen Drive, #110
Key Biscayne, Florida 33149
United States of America

APPENDIX B

TERMS OF REFERENCE

PREPARATION FOR AND TECHNICAL SUPPORT FOR A WORKSHOP ON THE SHRIMP RESOURCES OF TRINIDAD AND TOBAGO AND VENEZUELA

1. The consultant will assist the national focal points from Trinidad and Tobago and Venezuela in preparing the data and information required for the workshop, and will provide technical support in other matters related to the workshop as required.

2. During the workshop, the consultant will provide technical support and leadership to the participants, assisting them to prepare for and undertake any assessments, data analyses or related work to assess the status of *Farfantepenaeus subtilis*, *Litopenaeus schmitti*, *F. notialis* and *Xiphopenaeus kroyeri*, or as agreed upon by the countries in consultation with FAO.

3. The consultant will assist the participants in writing up a suitable technical report on the assessments and the implications of the assessments for management of the fisheries targeting these resources, and will be responsible for production of the final report.

Total time required:

- 2 days preparation for the workshop and finalization of the report;
- 5 days for participation in the workshop; and
- 2 days travel.

APPENDIX C

ORIGINAL MEETING OBJECTIVES

The overall goal for the 2002 meeting is to evaluate the biological impacts of, and make management recommendations for the existing shrimp trawl fisheries in Trinidad and Tobago and Venezuela. These recommendations should include advice with regard to the minimum biological data requirements for continued assessment and management of the shrimp fisheries of the two countries.

The overall goal will be met by achieving the following objectives.

a) To undertake joint length-based cohort analyses on shrimp stocks shared by Trinidad and Tobago and Venezuela. This will include:

- *F. subtilis*
- *L. schmitti*

b) To undertake length-based cohort analyses on other priority shrimp stocks for these two countries. This will include:

- *F. notialis* for Trinidad and Tobago
- *X. kroyeri* for Trinidad and Tobago

c) Based on the above assessments, to evaluate the current status of the most important shrimp stocks for the two countries and the impact of fishing on them, and make recommendations for their management.

d) To investigate variability in recruitment in the shrimp stocks and to evaluate the relative contributions of spawner-stock biomass and environment to recruitment variability.

e) To consider the sources of uncertainty in the above assessments and analyses, to quantify these where possible and evaluate their impact on the results and conclusions of the assessments.

f) Based on the above assessments conducted using data available from existing shrimp biological data collection programmes in the two countries, to make recommendations to the national fisheries departments with regard to the minimum biological data requirements for continued assessment and management of the shrimp fisheries.