SEDAR

Southeast Data, Assessment, and Review

SEDAR 14
Stock Assessment Report

Caribbean Queen Conch

SEDAR 14
Stock Assessment Report 3

2007

SEDAR
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SEDAR 14

Stock Assessment Report 1

Caribbean Queen Conch

SECTION I. Introduction

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1. SEDAR Overview

SEDAR (Southeast Data, Assessment and Review) was initially developed by the Southeast Fisheries Science Center and the South Atlantic Fishery Management Council to improve the quality and reliability of stock assessments and to ensure a robust and independent peer review of stock assessment products. SEDAR was expanded in 2003 to address the assessment needs of all three Fishery Management Council in the Southeast Region (South Atlantic, Gulf of Mexico, and Caribbean) and to provide a platform for reviewing assessments developed through the Atlantic and Gulf States Marine Fisheries Commissions and state agencies within the southeast.

SEDAR strives to improve the quality of assessment advice provided for managing fisheries resources in the Southeast US by increasing and expanding participation in the assessment process, ensuring the assessment process is transparent and open, and providing a robust and independent review of assessment products. SEDAR is overseen by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: the Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commissions: the Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment workshop, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products.

SEDAR workshops are organized by SEDAR staff and the lead Council. Data and Assessment Workshops are chaired by the SEDAR coordinator. Participants are drawn from state and federal agencies, non-government organizations, Council members, Council advisors, and the fishing industry with a goal of including a broad range of disciplines and perspectives. All participants are expected to contribute to the process by preparing working papers, contributing, providing assessment analyses, and completing the workshop report.

SEDAR Review Workshop Panels consist of a chair, a reviewer appointed by the Council, and 3 reviewers appointed by the Center for Independent Experts (CIE), an independent organization that provides independent, expert reviews of stock assessments and related work. The Review Workshop Chair is appointed by the SEFSC director and is usually selected from a NOAA Fisheries regional science center. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers to the review workshop.

SEDAR 14 was charged with assessing yellowfin grouper, mutton snapper, and Queen conch in the waters of the U.S. Virgin Islands and Puerto Rico. This task was accomplished through workshops held between March and July 2007.

2. Queen Conch Management Review

Table 1. General Management Information

Species	Queen conch (*Strobmus gigas*)
Management Unit	U.S. Caribbean, Conch FMU (Queen conch, indicator species)
Management Unit Definition	Queen conch, conch other
Management Entity	Caribbean Fisheries Management Council
Management Contact	Miguel Rolon; Graciela Garcia-Moliner
Current stock exploitation status	Overfishing
Current stock biomass status	Overfished

Table 2. Specific Management Criteria. Values in Table 2 are for the Conch FMU (Queen conch, Indicator Species)

Criteria	Current		Proposed	
	Definition	Value	Definition	Value
MSST	MSST = B_{MSY}(1-c); where c = the natural mortality rate (M) or 0.50, whichever is smaller.	1,404,000 lbs Bcurr/MSST=1.43 Bcurr/Bmsy=1.00	MSST = B_{MSY}(1-c); where c = the natural mortality rate (M) or 0.50, whichever is smaller.	UNK (SEDAR 14)
MFMT	Specify an MSY control rule to define ABC = F_{MSY}. When the data needed to determine F_{MSY} are not available, use natural mortality (M) as a proxy for F_{MSY}.	F_{MSY} = 0.30 Fcurr/Fmsy=1.00	Specify an MSY control rule to define ABC = F_{MSY}. When the data needed to determine F_{MSY} are not available, use natural mortality (M) as a proxy for F_{MSY}.	UNK (SEDAR 14)
MSY	Yield at F_{MSY}. In the absence of MSY estimates, the proxy for MSY will be derived from recent average catch (C), as: MSY = C / [(F_{CURR}/F_{MSY}) x (B_{CURR}/B_{MSY})].	452,000 pounds	Yield at F_{MSY}. In the absence of MSY estimates, the proxy for MSY will be derived from recent average catch (C), as: MSY = C / [(F_{CURR}/F_{MSY}) x (B_{CURR}/B_{MSY})].	UNK (SEDAR 14)
F_{MSY}	M	0.30	F_{MSY}	UNK (SEDAR 14)
OY	Yield at F_{OY}. F_{OY} = 0.75F_{MSY}.	424,000 pounds	Yield at F_{OY}. F_{OY} = 0.75F_{MSY}.	UNK (SEDAR 14)
F_{OY}	F_{OY} = 0.75F_{MSY}.	0.225	F_{OY} = 0.75F_{MSY}.	UNK (SEDAR 14)

M	n/a	0.30	SEDAR 14	UNK (SEDAR 14)
Probability value for evaluating status		Not Spec.		Not Spec.

Table 3. Stock Rebuilding Information

Rebuilding Parameter	Value
Rebuilding Plan Year 1	11/28/05-11/28/06
Generation Time (Years)	5 years
Rebuilding Time (Years)	15 years
Rebuilt Target Date	11/28/20
Time to rebuild @ F=0 (Years)	?
Other?	
Other?	

Specific Rebuilding Schedule: (provide table of levels of exploitation or landings specified in the rebuilding plan)

(No rebuilding schedule provided)

Table 4. Stock projection information.

(No projection details provided)

Table 5. Regulatory History

5.1 Federal (EEZ) FMP and Amendments

FMP/Amendment	Description of Action	Effective Date
Queen Conch FMP (61 FR 65481)	Restricted the taking of queen conch in or from the EEZ around Puerto Rico and the USVI in order to restore overfished stocks. ‘Hookah’ gear prohibited	1/13/97
Amendment 1 (SFA) (FR Reference)	Objectives were to (1) define the FMU and FMU sub-units; (2) specify biological reference points and stock status determination criteria; (3) regulate fishing mortality (possession prohibited except during October 1 through June 30 in the area east of 64^0 34’ W which includes Lang Bank); (4) rebuild overfished stocks; (5) conserve and protect yellowfin grouper; (6) achieve bycatch mandates; and (7) achieve the essential fish habitat mandates Landings of conch required ‘intact’ (alive and in shell)	11/28/05

5.2 Territorial regulations, USVI

Species	Regulation Type	Authority	Effective Date
Red, black, tiger, yellowfin, and yellowedge groupers	Closed Season (February 1- April 30)	USVI Commercial Fishing Regulations Chapter 9, Subchapter 316	July 5, 2006
Mutton and lane snappers	Closed Season (March 1 – June 30)		
Black, blackfin, vermilion, and silk snappers	Closed Season (October 1 – December 31; STT/STJ)		
Nassau groupers	Prohibited possession		
All reef fishes (excepting baitfishes)	Prohibited use of gill and trammel nets		
	Fish be landed with heads and fins intact		
Conch	Size limit (9" shell length or 3/8" lip thickness), 150 conch per day per fisher, landed alive and whole in shell,	USVI Commercial Fishing Regulations Chapter 9A, subchapter 316-1 & 316-4	1994
Conch	Closed season (July 1 – September 30) (In 1997, applied August 15 - September 30)	Admin. Order 97-11	1997
Spiny lobster	Size limit (31/2 " carapace length), landing restrictions (landed whole, no females with eggs), gear restrictions (no spearfishing, hooks, gigs, or use of chemicals)	USVI Commercial Fishing Regulations Chapter 9A, subchapter 319	1981
Goliath grouper	Prohibited possession or sale	USVI Commercial Fishing Regulations Chapter 2, subchapter 102	1994
All species	Commercial permit moratorium	USVI Commercial Fishing Regulations	August 24, 2001
All species (excluding baitfish and blue runner)	Prohibition of fishing and anchoring	National Park Service (VI Coral Reef National Monument)	??
All species	Prohibition of fishing and anchoring	Buck Island /reef National Monument (36 CFR part 7, 57.73)	??

5.3 Territorial Regulations, Puerto Rico.

Species	Regulation Type	Effective Date
All	Mandatory commercial license and permit, Puerto Rico	1994
Queen Conch	Hookah gear prohibited in Puerto Rico	2004
Queen Conch	Conch must be brought to boat ‘intact’ (but may be landed otherwise) in Puerto Rico	2007

Table 6. Regulatory Timeline Summary

Table 6.1. Recreational Regulations Summarized by Year

	Bag Limits			Size limits			Seasonal closures			Fishery Closure	
YEAR	PR	USVI	EEZ	PR	USVI	EEZ	PR	USVI	EEZ	USVI	EEZ
	ea/boat	ea/boat	ea/boat[i]	9” TL or 3/8” LT			July 1 - Sept 30				-
1988-94										1	
1994	-	6/24	-		✓		-	✓	-	-	-
1995	-	6/24	-		✓		-	✓	-	-	-
1996	-	6/24	3/12		✓		-	✓	✓	-	-
1997	-	6/24	3/12		✓	✓	✓	✓	✓	-	-
1998	-	6/24	3/12		✓	✓	✓	✓	✓	-	-
1999	-	6/24	3/12		✓	✓	✓	✓	✓	-	-
2000	-	6/24	3/12		✓	✓	✓	✓	✓	-	-
2001	-	6/24	3/12		✓	✓	✓	✓	✓	-	-
2002	-	6/24	3/12		✓	✓	✓	✓	✓	-	-
2003	-	6/24	3/12		✓	✓	✓	✓	✓	-	-
2004	3/12	6/24	3/12	✓	✓	✓	✓	✓	✓	-	-
2005	3/12	6/24	3/12	✓	✓	✓	✓	✓	✓	-	2
2006	3/12	6/24	3/12	✓	✓	✓	✓	✓	✓	-	2
2007	3/12	6/24	3/12	✓	✓	✓	✓	✓	✓	-	2

i. 12 conch per boat limit applies if more than four people are aboard
1. USVI Conch fishery closed, 1988 - 1994.
2. EEZ Closure: West of 64°34W; St. Croix (Only open in Lang Bank)

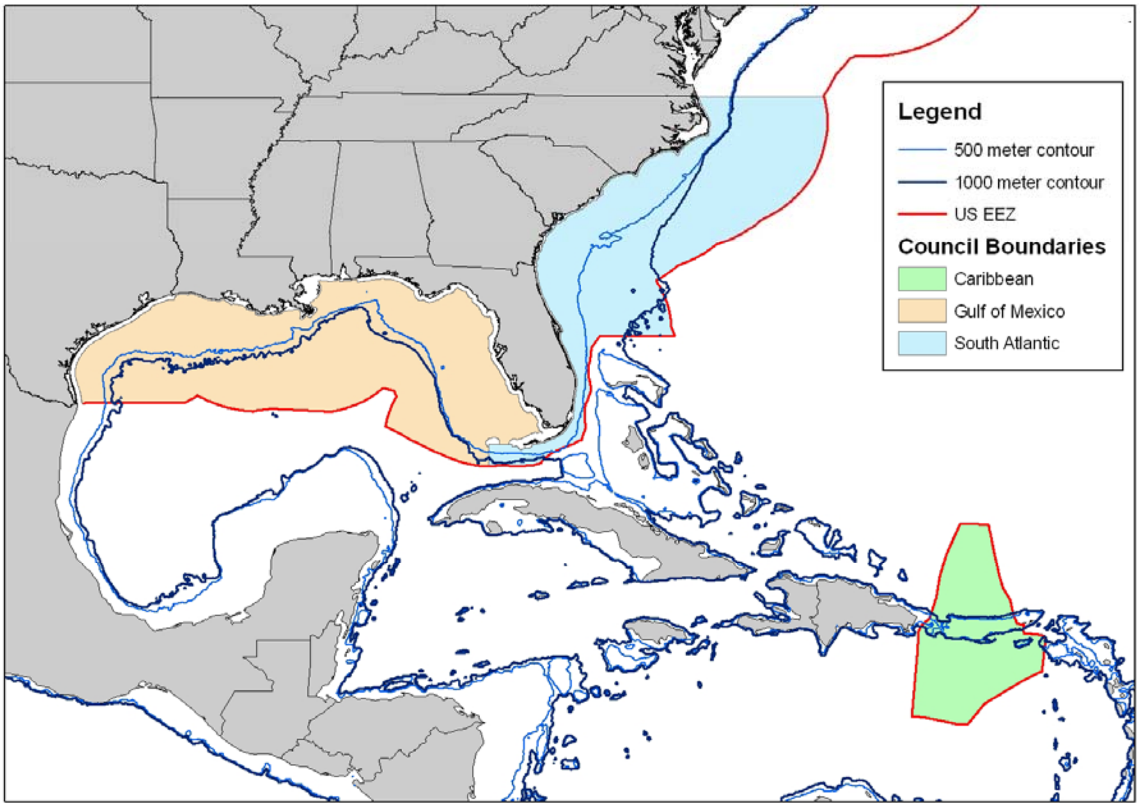
Table 6.2. Commercial Regulation Summarized by Year.

	Trip Limit			Size Limit[i]			Season			Fishe	
YEAR	PR	USVI	EEZ	PR	USVI	EEZ	PR	USVI	EEZ	PR	U
	Daily # per Fisher/Boat						July 1 - Sept 30				
1988	-	-	-	-	-	-	-	-	-	-	
1989	-	-	-	-	-	-	-	-	-	-	
1990	-	-	-	-	-	-	-	-	-	-	
1991	-	-	-	-	-	-	-	-	-	-	
1992	-	-	-	-	-	-	-	-	-	-	
1993	-	-	-	-	-	-	-	-	-	-	
1994	-	150/450	-	-	9”	-	-	✓	-	-	
1995	-	150/450	-	-	9”	-	-	✓	-	-	
1996	-	150/450	150/450	-	9”	9”	-	✓	✓	-	
1997	-	150/450	150/450	-	9”	9”	✓	✓	✓	-	
1998	-	150/450	150/450	-	9”	9”	✓	✓	✓	-	
1999	-	150/450	150/450	-	9”	9”	✓	✓	✓	-	
2000	-	150/450	150/450	-	9”	9”	✓	✓	✓	-	
2001	-	150/450	150/450	-	9”	9”	✓	✓	✓	-	
2002	-	150/450	150/450	-	9”	9”	✓	✓	✓	-	
2003	-	150/450	150/450	-	9”	9”	✓	✓	✓	-	
2004	150/450	150/450	150/450	9”	9”	9”	✓	✓	✓	-	
2005	150/450	150/450	150/450	9”	9”	9”	✓	✓	✓	-	
2006	150/450	150/450	150/450	9”	9”	9”	✓	✓	✓	-	
2007	150/450	150/450	150/450	9”	9”	9”	✓	✓	✓	-	

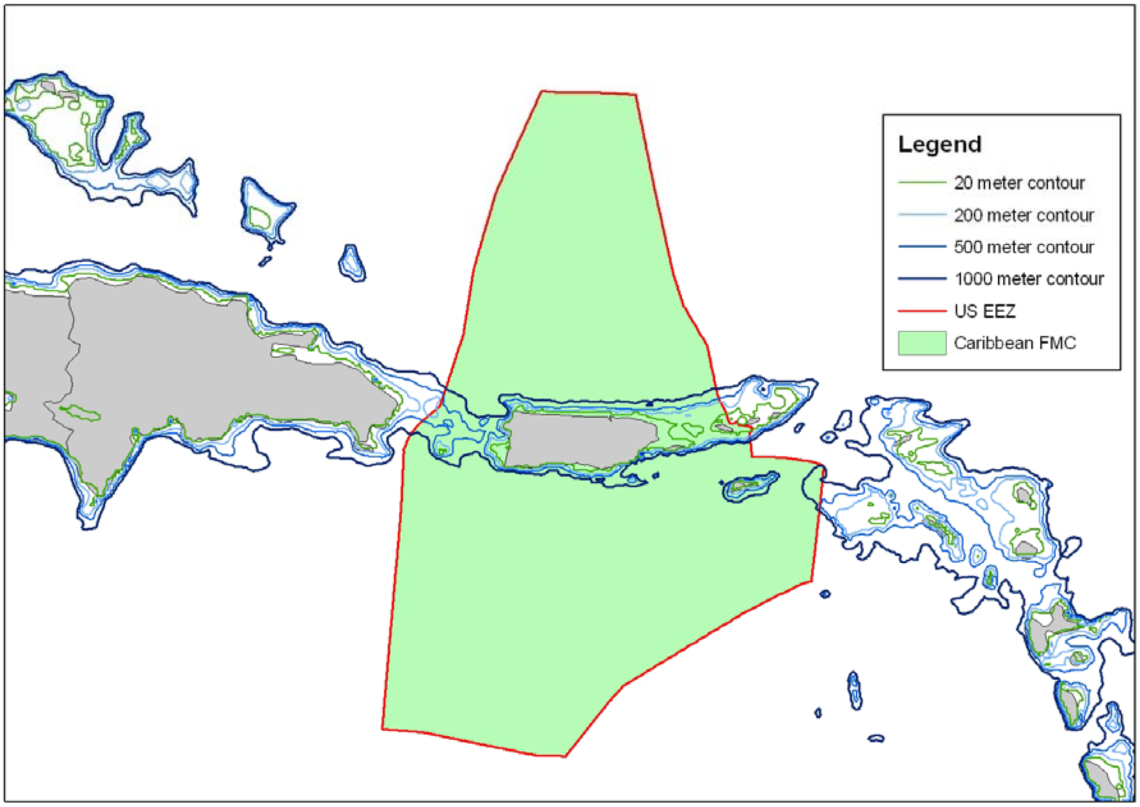
1. EEZ Closure: West of 64°34W; St. Croix Only open in Lang Bank, STX
i. Lip Thickness >3/8”; either 9” (22.9 cm) TL or 3/8” (9.5 mm) LT

3. Southeast Region Maps

Southeast Region including Council and EEZ Boundaries



Caribbean Council and EEZ.



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Caribbean Queen Conch

SECTION II. Data Workshop

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SEDAR 14

Queen Conch

Data Workshop Report

Table of Contents

1. Introduction

1.1. Workshop Time and Place

The SEDAR 14 data workshop was held March 12 - 16, 2007, in St. Thomas, USVI.

1.2. Terms of Reference

1. Characterize stock structure and develop a unit stock definition. Provide a map of stock distribution.
2. Tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling. Provide distribution maps.
3. Provide measures of population abundance that are appropriate for stock assessment. Document all programs used to develop indices, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey effort. Consider relevant fishery dependent and independent data sources; develop values by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision. Evaluate the degree to which available indices adequately represent fishery and population conditions. Recommend which data sources should be considered in assessment modeling.
4. Characterize commercial and recreational catch, including both landings and discard removals, in weight and number. Evaluate the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions if feasible. Provide maps of fishery effort and harvest.
5. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity and coverage where possible.
6. Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report).

1.3. List of Participants

NAME	Appointed by/Affiliation
Appointed Panelists	
Josh Bennett	NOAA Fisheries/SEFSC
Nancie Cummings	NOAA Fisheries/SEFSC
Guillermo Diaz	NOAA Fisheries/SEFSC
Rene Esteves	CFMC/UPR
Ron Hill	NOAA Fisheries/SEFSC
Chris Jeffrey	NOAA Fisheries/NOS
Hector López-Pelet	DRNA/PR/LIP
Jimmy Magner	CFMC AP
Andy Maldonado	CFMC AP
Kevin McCarthy	NOAA Fisheries/SEFSC

Luis Rivera..DRNA/PR/LIP
Aurea Rodriguez ....CFMC/UPR
Michelle Scharer ....CFMC/UPR
William Tobias .... CFMC SSC
Wes Toller .... CFMC AP
Steve Turner..NOAA Fisheries/SEFSC

Council Representatives
David Olsen .... CFMC SSC

STAFF
John Carmichael.. SEDAR
Tyree Davis..NOAA Fisheries/SEFSC
Graciela Garcia-Moliner……………………………………………….…CFMC
Rachael Lindsay.. SEDAR

1.4. Supporting Documents

Working Papers Prepared for the data workshop

Document #	Title	Authors
Documents Reviewed at the Data Workshop		
SEDAR14-RD01	Expansion of the SEAMAP_C fishery independent sampling program. Overview Document.	Cummings, N., R. Trumble, R. Wakeford
SEDAR14-RD02 MRAG Americas 2006	A pilot program to assess methods of collection bycatch, discard, and biological data in the commercial fisheries of St. Thomas, US Caribbean. CRP Report, SERO Grant # NA05NMF4540042	Trumble, R. J., D. Olsen, N. Cummings.
SEDAR14-RD03 MRAG Americas 2006	A pilot program to assess methods of collection bycatch, discard, and biological data in the commercial fisheries of the US Caribbean. CRP Report, SERO Grant # NA04NMF4540214	Trumble, R. J., et al.
SEDAR14-RD04 MRAG London 2005	Fisheries management decisions with limited resources and data: PARFish Synthesis Document.	Walmsley, S. F., P.A. H. Medley, C.A. Howard
SEDAR14-RD05 PR DNER 2005	Bycatch study of Puerto Rico's marine commercial fisheries. Grant NA04NMF433071	Matos, D.
SEDAR14-RD06 MS Thesis UPR 2005	Dispersal of reef fish larvae from known spawning sites in La Parguera	Esteves Amador, R. F.
SEDAR14-RD07 MRAG Rpt. 2003	Integrated fisheries management using Bayesian multi-criterion decision making (R7947)	Medley, P. A.
SEDAR14-RD08 MARFIN NA04NMF433071 2005	Bycatch Study of Puerto Rico's Marine Commercial Fisheries.	Matos, D.

Reference Documents Available at the Data Workshop

SEDAR14-RD01	Expansion of the SEAMAP_C fishery independent sampling program. Overview Document.	Cummings, N., R. Trumble, R. Wakeford

SEDAR14-RD02 MRAG Americas 2006	A pilot program to assess methods of collection bycatch, discard, and biological data in the commercial fisheries of St. Thomas, US Caribbean. CRP Report, SERO Grant # NA05NMF4540042	Trumble, R. J., D. Olsen, N. Cummings.
SEDAR14-RD03 MRAG Americas 2006	A pilot program to assess methods of collection bycatch, discard, and biological data in the commercial fisheries of the US Caribbean. CRP Report, SERO Grant # NA04NMF4540214	Trumble, R. J., et al.
SEDAR14-RD04 MRAG London 2005	Fisheries management decisions with limited resources and data: PARFish Synthesis Document.	Walmsley, S. F., P.A. H. Medley, C.A. Howard
SEDAR14-RD05 PR DNER 2005	Bycatch study of Puerto Rico's marine commercial fisheries. Grant NA04NMF433071	Matos, D.
SEDAR14-RD06 MS Thesis UPR 2005	Dispersal of reef fish larvae from known spawning sites in La Parguera	Esteves Amador, R. F.
SEDAR14-RD07 MRAG Rpt. 2003	Integrated fisheries management using Bayesian multi-criterion decision making (R7947)	Medley, P. A.
SEDAR14-RD08 MARFIN NA04NMF433071 2005	Bycatch Study of Puerto Rico's Marine Commercial Fisheries.	Matos, D.
SEDAR14 RD09 SERO CRP NA05NMF4540042 2006	A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of St. Thomas, U.S. Caribbean	Trumble, R. J., D. Olsen, and N. Cummings.
SEDAR14-RD10 SERO CRP NA04NMF4540214 2006	A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of the US Caribbean	Trumble, R. J. et al.

2. A Review of Queen Conch (Strombus gigas) Life-history

2.1. Introduction

The queen conch, *Strombus gigas* L., occurs throughout the Caribbean and into the Gulf of Mexico, south Florida, the Bahamas, and Bermuda. The conch fishery was once the second most valuable in the greater Caribbean region (Berg and Olsen, 1989) with an estimated 1992 harvest value of U.S. $30 million (Appeldoorn and Rodriguez, 1994). A steady decline of the species resulted in conch being listed as commercially threatened by the Convention on the International Trade in Endangered Species (CITES) in 1985 (Wells et al., 1985). Declines in conch abundance persisted causing CITES in 1992 to downgrade the status of queen conch to a listing in Appendix II, which requires signatory nations to manage conch stocks closely, and to monitor exports carefully to prevent extinction of the species. Many nations now have strict regulations regarding harvest of conch, designed to preserve their stocks.

As recognized at the Queen Conch Stock Assessment and Management Workshop (CFMC/CFRAMP, 1999), queen conch have a number of life history traits that make the use of assessment methodologies designed for finfish assessment problematic. Growth of conch (shell length) is deterministic and soft tissue weight is constant in older individuals. Conch cannot be accurately aged. Conch morphology is highly plastic and may be quite variable among populations separated over short spatial scales. Also, reproduction in conch is characterized by multiple spawning events over many months and little information exists regarding larval transport among populations. A review of queen conch life history is presented here.

2.2. Taxonomy

Queen conch, *Strombus gigas*, are prosobranch mesogastropods in the Family Strombidae. Members of this Family usually have thick, heavy shells with conical spires that may be ornamented. In addition, shells of species in this Family often have a wing-like, broad lip with an anterior notch (the “stromboid notch”). The stromboid notch is particularly conspicuous in the genus *Strombus*. Six species of *Strombus* occur in the greater Caribbean region. Queen conch is the largest of those.

2.3. Distribution and Habitat

Queen conch occur throughout the Caribbean from the Orinoco River in Venezuela into the southern Gulf of Mexico, in the nearshore waters of the Caribbean islands to south Florida and Bermuda. Usually, conch are found in discrete aggregations that may include hundreds of thousands of individuals. Conch are found in shallow, clear water of oceanic or near-oceanic salinities at depths generally less than 75 meters and most often in water less than 30 meters deep. Conch are likely limited to that depth range by limits in seagrass and algae cover. Seagrass meadows, coral rubble, algal plains, and sandy substrates are the preferred habitat.

2.4. Growth

Conch growth, as measured by shell length (tip of the spire to anterior edge of the shell), is deterministic. Maximum shell length is attained at sexual maturity and corresponds with the formation of the flared lip of the shell. Shell length may decrease in older individuals due to erosion of the shell. Shell thickness, including thickness of the shell lip, increases with age. Interior volume of the shell decreases with age such that very old individuals have significantly smaller body size (CFMC/CFRAMP, 1999). Lip thickness has been used to age adult conch, at least relatively (Appeldoorn, 1988a; CFMC/CFRAMP, 1999).

Deterministic growth may affect estimates of juvenile growth, age, and mortality (CFMC/CFRAMP, 1999). Length-frequency analysis of large juveniles may be misleading because mean size of the largest juveniles will be less than the true mean size of the largest juvenile size class because as juveniles begin to mature and cease growth, new smaller juveniles enter the largest juvenile size class affecting the mean size. Relative numbers of large juveniles decrease with a concomitant increase in the relative number of adults. Growth of additional juveniles into the largest size class will change the shape of the frequency mode and increase the variance of growth estimates. L_∞ will likewise be affected (CFMC/CFRAMP, 1999).

Prior to maturation, growth of juvenile conch can be measured by increase in shell length. Appeldoorn (1990) provided equations describing juvenile conch growth for a population near La Parguera, Puerto Rico (southwest coast) developed from (1) length-frequency analysis and (2) growth-increment data.

(1) $L_t = 340(1-e^{-0.437(t-0.462)})$
(2) $L_t = 460(1-e^{-0.25(t-0.244)})$

Where L=length in millimeters and t=age in years. Although shell length ceases to increase in adult conch, shell lip thickness increases over time (until the shell begins to erode in old adults) and has been used to estimate adult conch growth since maturation. Appeldoorn (1988a) provided the following equation for determining age from maturation in years (t) from lip thickness (LT) measured in millimeters.

$$LT_t = 54.9(1-e^{-0.3706t})$$

Berg (1976) reported von Bertalanffy parameters for conch growth in shell length for animals in St. John and St. Croix, US Virgin Islands.

	L_∞	k	Phi
St. John	260.4	0.516	1.323
St. Croix	241.7	0.420	1.212

Queen conch are often landed after removal from the shell, therefore length/meat weight relationships are particularly important. CFMC/CFRAMP (1999) provided a number of equations illustrating the relationship between weight (meat, tissue, shell) and shell length for juvenile and adult conch and lip thickness of adult conch from La Parguera, Puerto Rico. Their table is reproduced here:

Group	Regression equation Y=a + b(x)	r2	N	Mean x	Mean y
Meat Weight					
J Log(MW)=	-2.535+3.486 Log(L)	0.926	94	1.838	1.254
A Log(MW)=	-1.510+2.804 Log(L)	0.494	130	2.393	1.392
A Log(MW)=	2.212+0163 Log(LP)	0.274	131	2.394	1.117
A Log(MW)=	-1.357+2.571 Log(L)+0.135 Log(LP)	0.684	130		
A Log(MW+100)=	1.797+0.232 Log(L)	0.354	130	2.101	1.117
Tissue Weight					
J Log(TW)=	-2.286+3.459 Log(L)	0.925	94	2.053	1.254
A Log(TW)=	-1.444+2.928 Log(L)	0.524	130	2.632	1.392
A Log(TW)=	2.469+0.147 Log(LP)	0.214	131	2.633	1.117
A Log(TW)=	-1.294+2.726 Log(L)+0.118 Log(LP)	0.659	130		
A Log(TW+100)=	1.764+0.403 Log(LP)	0.321	130	2.121	1.117
Shell Weight					
J Log(SW)=	-1.786+3.517 Log(L)	0.878	94	2.626	1.254
A Log(SW)=	-0.286+2.530 Log(L)	0.347	130	3.237	1.392
A Log(SW)=	2.952+0.256 Log(LP)	0.579	131	3.237	1.117
A Log(SW)=	0.013+2.129 Log(L)+0.273 Log(LP)	0.822	130		
A Log(SW+100)=	2.793+0.293 Log(L)	0.633	130	3.720	1.117

All weights are in grams, length is in cm, and lip thickness is in mm. N is sample size. Logs are base 10. Meat weight=MW, wet-tissue weight=TW, shell weight=SW, juvenile =J, adult=A, shell length=L, lip thickness=LP. Mean x and y values are provided to permit conversion to y=u+vx where v=b/r and u=(mean y)-v(mean x).

2.5. Morphology

Conch shell morphology is highly plastic (Clerveaux et al., 2005) and habitat appears to exert a strong influence on juvenile and adult morphology (Martin-Mora et al., 1995). Food availability and quality differences among areas may be important indirect influences on conch morphology and growth. Appledoorn (1994) found differences in adult shell length among sampled areas in Puerto Rico. Similarly, Stoner and Ray (1996) observed adult shell length and lip thickness differences among sites in the central Bahamas. In addition, the presence of predators also affects juvenile conch growth. Delgado et al. (2002) showed that juvenile conch grew more slowly and had heavier shells when exposed to predators (spiny lobsters) than did conch held in the absence of predators.

The abiotic factors of depth and substrate type have also been implicated as factors affecting conch growth and morphology. With increasing depth, conch were observed to have slower growth (measured as shell length), tighter coiling of the shell resulting in a wider shell, thicker shells, and fewer, longer spines (Alcolado, 1976).

Growth rate is positively correlated with final shell length, where slow growing conch tend to reach smaller final shell lengths than do faster growing conch (Alcolado, 1976). In addition, Alcolado (1976) found that age at maturation was greater for slow growing than for fast growing conch. Area specific growth and maturity presents problems for stock assessments because growth and maturity found in any particular area may not be applied to conch throughout the region of interest.

2.6. Reproduction

Queen conch are dioecious and fertilization is internal. Both males and females may copulate with multiple individuals over the spawning season. Multiple males may fertilize individual egg masses from a single female (Steiner and Siddall, pers. comm. in CFMC/CFRAMP, 1999). An additional complicating aspect of conch reproduction is the ability of females to store eggs for several weeks (D'Asaro, 1965). Stoner et al. (1992) found that spawning increased as a linear function of bottom water temperature, but declined during and after the warmest period. They suggest that photoperiod plays an important role in the timing of conch reproduction. Several authors have noted differences in spawning season at various locations throughout the species range.

Females lay demersal egg masses, generally on patches of bare sand, but occasionally in seagrass. Egg production is highly variable both in terms of the number of egg masses spawned each year and the number of eggs per egg mass. Appeldoorn (1993) examined individual female reproduction over a spawning season with conch held at two densities ($0.2/m^2$ and $0.014/m^2$) in enclosures. Food limitation in the higher density treatment negatively affected fecundity such that fewer egg masses were produced and those egg masses contained fewer eggs than egg masses produced in the low density treatment. Females in the low density treatment produced an average of 13.6 egg masses containing an average of 750,000 eggs each (Appeldoorn, 1993). High density treatment females produced and average of 6.7 egg masses of 500,000 eggs. Individual variation was high with on individual producing 25 egg masses, one of which contained 1.5 million eggs. Appeldoorn (1993) reported a significant relationship, for the low density treatment, between female age (determined from lip thickness) and total fecundity:

$$Log_{10}(Fecundity)=4.157 + 2.012Log_{10}(Age) \qquad r^2=0.672, N=10$$

An additional equation to describe the relationship between conch age and fecundity was developed by Appeldoorn (1993). He assumed that fecundity was proportional to tissue wet weight and used as a guide the Gompertz function to predict weight from age for the average adult in the La Parguera population. The equation developed,

$$E_t=E_{max}(1-e^{-K(t-32)})$$

includes fecundity at age t (E_t), average maximum fecundity for an individual (E_{max}), the instantaneous growth constant (K), and the age in years at the onset of maturation (3.2 in La Parguera). By age 6 (2.8 years after the onset of maturation), 95% of the adult conch growth occurs, based upon the tissue growth equation. K was therefore estimated as 1.07 from $t_{.95}$=3/K.

Stock size may pay an important role in conch reproduction. Appeldoorn (1995) hypothesized that the repeated cycle of copulation and spawning stimulated reproductive a positive feedback relationship and reproductive output is increased. Too small a stock size might disrupt that feedback relationship.

2.7. Natural mortality

Conch are estimated to have a longevity of up to 30 years (Glazer, pers. comm..). High predation induced mortality is likely for juvenile conch, but decreases significantly among larger juveniles (Appeldoorn 1988b; Ray et al. 1994). Adult conch are thought to have low rates of natural mortality, however few studies have examined this question.

Appeldoorn (1988b) examined the relationship between age and natural mortality. He derived a relationship between juvenile age and natural mortality and estimated natural mortality for adult conch aged at 4.25 years as M=0.52. Natural mortality of older conch have not been estimated, therefore natural mortality rates for the majority of the lifespan of queen conch are unknown. The age-mortality relationship that Appeldoorn derived was further developed by omitting mortality estimates of small juveniles that were not yet epibenthic and therefore not available to the fishery. The estimate of adult natural mortality was included in fitting the age/mortality relationship with the inverse model of Caddy. This model was believed to be the most appropriate because extrapolated adult survival rates were consistent with the estimated longevity of conch. The age-mortality equation provided by CFMC/CFRAMP (1999) was:

$$M_t = -0.242 + 4.33/t \qquad \text{where } t=\text{age}$$

This equation results in negative values for M with older ages and CFMC/CFRAMP (1999) recommended restricting mortality to a minimum M=0.1. Once M=0.1, natural mortality should be assumed to be constant with older conch.

Stoner and Glazer (1998) investigated natural mortality rate in juvenile queen conch in Florida and the Bahamas. They reported that M varied greatly among seasons, habitats, and conch aggregation density. Estimates of M ranged from 12.0 for small (45mm) conch to 1.0 for large juveniles (175-215mm). At one site, estimates of M varied from 1.0 to 4.0 over a seven year period, however a second site located approximately 35 miles from the first had an average M of 4.71 over time for conch of similar size.

2.8. Migration/dispersal

Embryonic development of conch proceeds rapidly, although the duration is temperature dependent. The larval shell develops within 24 hours and the free swimming veliger larvae emerge from the eggs within 72 hours. The queen conch larval phase has been estimated to be less than a month in the wild (Davis, 1994). Hatchery reared larvae usually require 16 to 40 days to become competent and metamorphose (pers. obs.). Both observations suggest the potential for long distance transport by surface currents.

Once conch settle to the benthos, dispersal ability is greatly reduced. In a mosaic of benthic habitats, dispersal will be dependent upon the extent of suitable habitat. Sandt and Stoner (1993) report movement of juvenile conch from unvegetated areas to adjacent seagrass meadows at approximately 35-54 mm shell length. Stoner and Ray (1996) found evidence of migration of juvenile conch from shallow water nursery sites to deeper water areas as the conch matured. In the Bahamas, adult conch were observed to move seasonally from sand plains to hard bottom areas (Stoner and Sandt, 1992). Glazer et al. (2003) tracked adult conch with sonic tags for one year to estimate seasonal movement and home ranges in the Florida Keys. They report home ranges of <1 to approximately 60 hectares with most individuals moving over home ranges of less than eight hectares.

2.9. Genetic stock assessment

The population structure of queen conch has been studied by Mitton et al. (1989) and Campton et al. (1992) for populations in Bermuda; the Florida Keys; Bimini, Bahamas; Turks and Caicos Islands; several sites in the Lesser Antilles; and Belize. Both studies compared variation in allozyme allele frequencies among populations and both inferred high levels of gene flow. Mitton et al. (1989) reported that conch populations were not panmictic. Conch in Bermuda were isolated from Caribbean populations and Mitton et al. attributed that isolation to current patterns. Heterogeneity in allele frequencies was observed within some island groups, which the authors suggested also resulted from current patterns. Campton et al. (1992) sampled conch in the Florida Keys for three years, reporting significant spatial and temporal genetic variation although genetic similarity among populations was high. The authors suggest that variation in current patterns and other transport processes (e.g. wind driven currents) may allow for much variation in the source and supply of larvae to any particular location.

Two features of allozyme studies limit their usefulness for fine-scale population structure. First, allozymes tend to be slowly evolving relative to the time-scale of population processes, and typically have low levels of polymorphism. This can result in a low-resolution view of population structure. Second, alleles are scored on a gel as fast, slow, intermediate, etc., using standard electrophoretic techniques, but these alleles cannot be related in a hierarchy or phylogeny based on their mobility. This limits the analytical possibilities of allozyme data. Both technical advances in generating high resolution population genetic markers and analytical advances have been made since the pioneering work of Mitton et al., 1989, and Campton et al., 1992.

Morales (2004) compared partial sequences of the 16S rRNA gene from 13 sites in the Caribbean region, including Puerto Rico. Total sample size was 94 individuals with four to 17 individuals per site. He found evidence of connectivity among distant locations throughout the region and concluded that gene flow is likely facilitated by larval transport.

Steve Palumbi is currently examining the population genetics of conch from the Florida Keys through the Bahamas and Turks and Caicos Islands. He preliminarily reports some differentiation among populations in the Bahamas (Palumbi, pers. comm..).

2.10. Discussion

Many aspects of the life history of queen conch are problematic for traditional stock assessment methods. Deterministic growth, inadequate methods for aging adults, highly variable fecundities are among the problems conch life history characteristics present to successful stock assessment. Magnitude and sources of larval supply are poorly understood. Although population genetic studies have been completed, such studies often address population connectivity on timescales greater than those of interest to stock assessment. Finally, many of the life-history characteristics of queen conch vary over relatively small spatial scales. That particular characteristic of queen conch biology may be the most troublesome for stock assessment.

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3. Commercial Statistics

3.1. Fishery Dependent Data

The Working Group included Hector Lopez, Luis Rivera and Andy Maldonado from Puerto Rico, William Tobias and Jimmy Magner from the Virgin Islands, Graciela Garcia-Moliner from the Caribbean Fishery Management Council, Josh Bennett and Steve Turner from the NOAA Fisheries Service in Miami. The group was later joined by other participants including Wes Toller and David Olsen from the Virgin Islands and Nancie Cummings from NOAA Fisheries. Steve Turner was the overall leader and Graciela Garcia-Moliner lead reporting on recreational fisheries.

3.2. Commercial Fishery (may be subdivided by gears/fleets) (TOR 4, 5)

3.2.1. Commercial Landings

3.2.1.1. Puerto Rico

The Department of Natural Environmental Resources, Fisheries Statistics Program has primary responsibility for the collection of fisheries statistics for the Commonwealth of Puerto Rico. Fishery landings have been collected annually since 1967; landings information for some years in the 1950s and early 1960s. Landings from 1967-1982 apparently exist, but were not available to the working group.

Fisheries landings were collected from voluntarily reporting fishermen until 2004 when reporting became mandatory (however after 2003 some fishermen continued to not report – see section 2.1.1.3). Total landings are calculated by expanding reported landings to account for the proportion of fishermen who did not report.

Species identification

Cummings (SEDAR14 DW 7) referring to Matos (2004) states that mutton snapper is at times confused with deep water snappers. One participant in the working group from Puerto Rico indicated that in general landings of valuable snappers such as mutton were accurately identified while landings of less valuable species might be aggregated.

Cummings (pers. comm.) indicated that the identification of yellowfin grouper in Puerto Rican landings was thought to be reliable.

Reported landings

Reported Puerto Rican landings since 1983 for queen conch, mutton snapper and yellowfin grouper are shown in Tables 1-3.

Conch landings are reported as meat weights. In 2003 fishermen began cleaning conch (removing the head and viscera). The working group was told that about 50% of the conch landings in 2003 were cleaned and that by 2004 all fishermen were thought to have been reporting cleaned conch weight. A conversion factor of 1.5 was recommended for calculating uncleaned weight from cleaned weight (G. Garcia-Moliner pers. comm.).

The conch landings included in this report have NOT been corrected for this change; it is recommended that analyses using these data correct for this change. The working group recommended that consideration be given to determining when individual ports changed from reporting uncleaned to reporting cleaned conch and that the correction factor be applied on a port by port basis until all ports were thought to be reporting cleaned conch.

Sampling fractions and Under/Over reporting

Puerto Rican landings are tabulated from voluntary fishermen's reports. The total number of fishermen is thought to be known from mandatory licenses. The annual reporting fractions (reporting fishermen / licensed fishermen) for 1972-2005 are shown in Table 4. To calculate total landings, reported landings are divided by the annual, island-wide sampling fraction.

Matos (2004b) reported that there were instances when the landings reported by individual fishermen differed from what was actually landed, and this finding was corroborated by Puerto Rican fishermen and port agents at the meeting. Apparently there are a number of reasons why a fisherman might prefer to record less or more landings than actually made. The degree of under-reporting and over-reporting was not known. No adjustments of mis-reporting were made by the SEDAR 14 Data Workshop.

Calculated total landings

Total landings in Puerto Rico for conch, mutton snapper and yellowfin grouper are shown in Table 5-7. The yellowfin grouper landings are not presented by gear because of potential confidentiality issues; over all years the dive, hook and line and trap fisheries have dominated the landings.

The U.S. Virgin Islands landings statistics have not recorded landings by species, so only landings of finfish are included in this report (see below). For comparison the total Puerto Rican landing of all finfish combined are presented in Table 8.

3.2.1.2. Virgin Islands

The largest islands of the United States Virgin Islands (USVI) are St. Thomas, St John and St Croix. St Thomas and St John are on the same platform as Puerto Rico and the British Virgin Islands. St. Croix is on a different platform 40 miles south of St. Thomas / St. John and separated by at deep oceanic trench.

The Government of the Virgin Island began requiring the reporting of commercial landings in 1972-1973. The first USVI reported landings in the database are from 1974. The Virgin Islands Code requires that commercial fishers submit catch reports on an annual basis for every day fished as a requirement for annual license renewal. . The Division of Fish and Wildlife requests that the catch reports be submitted on a monthly basis. In recent years approximately 200 fishers were registered in the island group of St. Croix (173 in 2005-2006) and approximately 175 in St. Thomas/St. John (178 in 2005-2006). Since 1990, this number has remained relatively stable. However, prior to 1990, the number of registered fishers showed greater variability for both island groups and especially for St Thomas/St John (Figure 1).

Data collected for the purpose of monitoring fisheries landings have generally been species specific for conch and lobster while for finfish the landings were reported in aggregated gear categories (hookfish, potfish, trapfish,…) before the mid/late 1990s and in species groups since then.

In any given year some licensed fishermen reported landings for only some months and some licensed fishermen did not reported at all. Therefore for conch both reported landings and calculated total landings are presented. Additionally calculated total landings of finfish are presented for comparison with Puerto Rico.

Biological sampling in the Virgin Islands has recorded information on the entire catch of finfish by species. The numbers of mutton snapper and yellowfin grouper measured are presented as are the associated length compositions.

Species identification

Finfish are not recorded by species in U.S. Virgin Islands landings statistics.

Conch landings primarily reflect captures of queen conch. Some whelk landings have in the past been combined with conch landings, however the proportion of whelk in the total landings is thought to be quite low.

Reported Landings

The total amount of conch landings reported by cooperating Virgin Island fishers is shown in Table 9 by island group and gear.

Under Reporting and Expansion Factors

The annual reporting rate by fishers has varied greatly since 1974. In particular, the proportion reporting has varied from < 20% for St. Croix in several years in the 1970s to > 90% for both island groups (Figure 2) in most recent years (97% in St. Croix in 2005-2006 and about 80% in St. Thomas / St. John). A substantial portion of this inter-annual variability is attributed to discontinuities and irregularities in administrative oversight of the landings program. Since about 1990, the Division of Fish and Wildlife resumed administrative responsibility of the program and reporting frequency has steadily improved to the present high levels.

Adjustments (expansion factors) were used to correct for non-reporting as part of the estimation of total landings by commercial fishers. Non- reporting by commercial fishers falls into two overlapping classes. Class I - Fishers who failed to submit one or more of the required 12 monthly reports within any year. Class II - Fishers who obtained licenses but failed to submit all monthly reports for a given fishing year. The strategy to develop appropriate expansion factors had to account for both classes of non-reporting.

To address the first type of non-reporting (Class I), a correction factor for missing monthly reports was developed. This factor replaces missing information with average landings derived from reported information on a fisher-by fisher basis. It assumes that of individual reporting fishermen the landings within months that were reported are representative of the landings within months that were not reported. For example, if a fisher reported zero landings for 10 months and did not report for two months, the remaining two months were replaced with zero landings. If a fisher reported an average of 100 lbs of landings per month for 10 months, then 100 lbs was assumed for each of the two missing months.

The Class I correction assumes that reporting behavior was similar among months. This assumption was verified by examination of reporting trends during periods of low, intermediate and high reporting compliance (Figure 3).

The Class I expansion factors, which correct for partial year reporting by individual fishers, were calculated in the following manner.

Given:

R_{iyf} as the number of monthly reports submitted by a fisher (f) from an island group (i, either St Thomas / St John or St Croix) in a year (y).

W_{iyfm} as the weight of landings reported by a fisher in a month (may be 0 for some months).

Then the Class I expansion factor (E1) is:

$$E1_{iyf} = 12 / R_{iyf}$$

and the expanded weight (W') per fisher is :

$$W'_{iyf} = \sum_{m} W_{iyfm} * E1_{iyf}$$

To address the second type of non-reporting (Class II, licensees who never reported within a year), expansion factors were calculated for two periods:, one for 1991-2005 and one for the earliest year through 1990 due to the concern that the proportion of fishers reporting no landings appeared to be unusually low in most years before 1991 (see above). Considerable uncertainty exists about this expansion factor, because of concerns that the proportion of non-reporters who did not fish might have been higher than the proportion of reporting fishermen who did not fish.

Let:

L_{iy} be the number of licenses issued for an island group in a year
F_{iy} be the number of fishers who filed at least one report for an island group in a year
P_{iy} be the number of fishers who filed at least one report and reported some landings
Z_{iy} be the number of fishers who filed at least one report but reported no landings in any report.

Then the 1991-present expanded landings are:

$$W''_{iy} = \sum_{f} W'_{iyf} * \frac{L_{iy}}{F_{iy}}$$

For 1990 and earlier, the 1991-2005 data were used to calculate the proportion of reporting fishers, p, which reported no landings:

$$p = \frac{\sum_{y=1991}^{2005} Z_{iy}}{\sum_{y=1991}^{2006} P_{iy}}$$

$$Z'_{iy} = p * P_{iy}$$

Then the Annual expansion factor, E2, is:

$$E2_{iy} = \frac{L_{iy}}{P_{iy} + Z'_{iy}}$$

and the estimated total expanded landings are:

$$W''_{iy} = \sum_{f} W'_{iyf} * E2_{iy}$$

The effective expansion factors derived using the reported and calculated total landings (calculated total / reported) are shown in Table 10 and Figure 4 for the two island groups (St. Thomas / St. John and St. Croix). In some years differences can be observed between the sampling fractions for conch and finfish. Those differences must be due to differences in the number of monthly reports by fishermen landing finfish and fishermen reporting conch (class 1 expansion factors) because those expansion factors are calculated for each fisherman while the annual expansion factor is calculated for the entire fleet for each island group.

Calculated total landings and uncertainty

Total landings were calculated from the reported landings as defined above. The calculated total landings of conch by island group are shown in Table 11. The calculated total landings of all finfish by island group are shown in Tables 12 and 13

.

3.3. Commercial Discards

In general all sizes of fish caught by commercial fishers are retained in Puerto Rico and the Virgin Islands. In the Virgin Islands feasibility studies for measuring bycatch in a pilot observer program were conducted in 2005-2006 and showed that considerable numbers of finfish were being discarded. A size limit was established for conch in 1988 in St. Croix and in 1994 in St. Thomas / St. John, but because conch are primarily harvested by hand (divers), it is thought that nearly all are of legal sizes.

Matos *et al*. (in press-a) indicated that conch, mutton snapper and yellowfin grouper were all discarded in Puerto Rico. In the relatively small number of trips reported on in Matos *et al* mutton snapper were observed being discarded in trammel net and trap fisheries, and Matos (pers. comm.) noted that discarding of mutton snapper may have increased in recent years, because of recent management measures including a closed season for several snappers. No conch or yellowfin grouper were observed being discarded in the beach seine, hood and line, trammel net and trap fishing observed by Matos *et al.* Conch are thought to be released alive (Matos pers. comm.)

Studies in the Virgin Islands to determine the feasibility of collecting daily catch reports with species specific information on landings and discards have recorded mutton snapper discards off St. Thomas / St. John (MRAG 2007a); both mutton snapper and yellowfin grouper are also known to be discarded off St. Thomas / St. John primarily in the southeast section off those islands and to decreasing extent further west (Olsen, pers comm.). During a comparable study on St. Croix (MRAG 2006b), discards of sub-adult mutton snapper were recorded but no yellowfin grouper were observed in catches or discards. As in Puerto Rico, recent species specific area closures off the Virgin Islands are thought to have increased discarding (Olsen, pers. comm.). Ongoing research by the St. Thomas Fishermen's Association from 1500 trips and 80,000 trap hauls, indicates a discard rate of approximately 2 fish per trap haul. That survey indicates high discard rates of mutton snapper and some discarding of yellowfin grouper. The main reasons for discarding include the size of the fish being too small, the lack of a commercial market for the species or the presence of Ciguatera in the members of that species from the capture area.

3.4. Commercial Effort

Commercial fishing effort levels were not examined by the working group. Puerto Rican statistics primarily consist of reported trips (some aggregated trips can be identified in the data base) and U.S. Virgin Island landings statistics record individual trips. Both data bases are for reporting fishermen and would require expansion to calculated total fishing effort.

3.5. Biological Sampling

Biological sampling of commercial landings has been conducted for many years both in Puerto Rico and the Virgin Islands. In Puerto Rico substantial numbers of finfish have been measured annually, while in the Virgin Islands funding limitations have resulted in recent years in which few or no fish were measured. Very little information on the sizes of commercially harvested conch exist for either Puerto Rico or the U.S. Virgin Islands.

Available samples were filtered to remove potentially erroneous observations. Filtering was done to remove lengths which were considered above or below normal lengths for the species and weights which were out of range given the observed length and a length:weight equation (Bohnsack and Haper 1988).

3.5.1. Puerto Rico

3.5.1.1. Number of samples

The number of mutton snapper with accepted measurements in Puerto Rico by gear are shown in Table 14 and the number of yellowfin grouper are shown in Table 15. The proportion of length measurements of mutton snapper rejected through filtering as described above was often 3-4%, though in two years (1986 and 1990) roughly 15% was excluded and in most years during 1992-1997 6-9% was excluded.

Very few or no conch have been measured; no tabulations were made.

3.5.1.2. Sampling Intensity

Sampling fractions for the Puerto Rican fisheries were calculated from the number of fish measured and the number of fish landed as derived from the calculated total landings given above.

Sampling fractions for Puerto Rico have ranged from less than 0.1% to well more that 5% in a few strata. Generally the largest mutton snapper fishery, hook and line, has been sampled at roughly 1% in most years since about 2000 and the second largest fishery, trap, continues to be sampled at roughly 0.1% to 0.5% (Table 16). Landings of yellowfin grouper were quite low (Table 7), and the annual sampling fractions were quite variable. There were many years when sampling did not occur, but when it did occur sampling fractions by gear were often above 1%. Over all years the first and third most important fisheries for yellowfin grouper, dive and trap, have been sampled at 1%-2% while the second most important yellowfin grouper fishery, hook and line, has been sampled at less than 0.1%.

3.5.1.3. Length distributions

The length frequency distributions for mutton snapper caught by the Puerto Rican hook and line, seine and trap fisheries are shown in Figures 5-7. Length frequency distributions for yellowfin grouper from the trap fishery for 1983 – 1991 are shown in Figure 8.

3.5.1.4. Adequacy for characterizing the catch

Spawning area closures for snappers and groupers have been implemented in recent years. Those restrictions could have resulted in changes in the size composition and catch rates of mutton snapper and yellowfin grouper.

3.5.2. Virgin Islands

3.5.2.1. Number of samples

The numbers of mutton snapper and yellowfin grouper landed in St. Thomas / St. John with accepted length measurements are presented in Table 17 and the numbers for St. Croix are presented in Table 18.

Very few or no conch have been measured; no tabulations were made.

3.5.2.2. Sampling Intensity

Sampling intensity for mutton snapper and yellowfin grouper landed in the Virgin Islands were not calculated because species specific landings are not available.

3.5.2.3. Length distributions

The length frequency distributions for mutton snapper are shown for the St. Croix hook and line fishery in Figure 9 and for the St. Thomas / St. John and St. Croix trap fisheries in Figures 10 and 11. The length frequency distributions for yellowfin grouper for the St. Thomas / St. John and St. Croix trap fisheries in Figures 12 and 13.

3.5.2.4. Adequacy for characterizing catch

In about 1993 the government of the Virgin Islands prohibited fishing on spawning aggregations. The size composition of mutton snapper and yellowfin grouper landed during the spawning season could differ before and after that prohibition went into effect.

3.6. Commercial Catch-at-Age/Length

Age and length composition of the entire catch were not created.

3.7. Comments on adequacy of data for assessment analyses

The empirical expansion factors used to calculate total landings from fishermen's reports and the associated assumption that non-reported trips are similar to reported trips suggest that there is probably considerable uncertainty about the total landings for conch in both Puerto Rico and the U. S. Virgin Islands and for mutton snapper and yellowfin grouper in Puerto Rico. The effective expansion factor for the Virgin Islands in recent years has been relatively lower (1.1 to 1.4) than in the past (Table 10), and as a result the conch landings from the St. Croix management group are probably more reliable than in earlier years.

Prior to 1987 landings in Puerto Rico of various snapper species may have included multiple species (Matos *et al.* in press-b). Some uncertainty exists as to whether mutton snapper may at times be included with other species or other species called mutton snapper; the working group believed that in general mutton snapper landings reflected the actual landings of that species.

As noted above, the Puerto Rican landings of conch since 2003 have not been corrected for the change in reporting uncleaned flesh weight to reporting cleaned flesh weight. For use in stock assessment, the landings need to be corrected for this change (see section 2.1.1.3)

Absence of species specific information for finfish on the Virgin Island's commercial landings will make it difficult to perform conventional stock assessments which require information on the total catch for mutton snapper and yellowfin grouper.

Absence or low level of size composition sampling for the Virgin Islands in many years will make it difficult to perform size based assessment analyses.

Various area and spawning season closures could result in shifts in observed size composition and catch rates. Care should be exercised when analyzing such fishery dependent data sets to consider such potential effects.

3.8. Research Recommendations

Continuous biological sampling in the Virgin Islands at sufficient levels to adequately characterize size and age composition.

Link biostatistical data for a fishing trip from Puerto Rico to all of the landings records for that trip.

Ensure that the catch and effort data of individual fishers in Puerto Rico can be identified over time.

Eliminate the need for expansion factors by obtaining information on all landings.

Table 1. Reported ('as landed') Puerto Rican commercial landings of conch in pounds by gear. An asterisk (*) indicates that landings were reported but are not shown to protect possible confidentiality. A dash (-) indicates that no landings were reported. Prior to 2003, all landings presumably are uncleaned conch, thus including head and viscera in the reported weights. In 2003 fishermen who accounted for about 50% of the landings began cleaning conch (removing head and viscera) and by 2004 all fishermen were cleaning conch; the landings data presented here have not been adjusted for any changes in cleaning.

	diving	traps	other	total
1983	399,665	*	*	399,880
1984	294,773	-	-	294,773
1985	258,716	1,096	1,013	260,825
1986	185,972	1,409	979	188,360
1987	142,994	-	-	142,994
1988	213,173	6,754	10,780	230,707
1989	148,078	5,519	6,654	160,251
1990	104,305	3,047	623	107,975
1991	106,331	1,261	506	108,098
1992	87,436	1,793	1,729	90,958
1993	158,085	3,408	3,119	164,612
1994	158,579	7,480	4,788	170,847
1995	202,408	4,346	7,528	214,282
1996	227,192	5,279	7,395	239,866
1997	225,620	2,860	10,168	238,648
1998	244,920	2,774	13,261	260,955
1999	206,643	3,018	4,439	214,100
2000	269,182	2,953	9,243	281,378
2001	236,286	5,288	3,373	244,947
2002	225,790	8,034	1,873	235,697
2003	184,738	2,666	760	188,164
2004	212,312	1,475	2,405	216,192
2005	193,483	484	1,734	195,701

Table 2. Reported commercial landings of mutton snapper in Puerto Rico in pounds whole weight. Landings of finfish in the Virgin Islands are not recorded by species. Other gear includes seines, trammel nets, longline and unknown.

	diving	gill nets	hook and line	traps	other	total
1983	3,013	3,368	16,221	37,564	4,975	65,141
1984	570	3,322	15,966	26,793	6,435	53,086
1985	1,141	6,260	15,247	19,956	3,029	45,633
1986	2,868	6,434	8,098	11,162	1,776	30,338
1987	1,151	3,334	6,990	6,221	2,363	20,059
1988	2,251	3,158	9,195	5,227	1,723	21,554
1989	4,189	2,714	13,179	9,065	2,609	31,756
1990	3,502	2,542	10,906	7,005	1,237	25,192
1991	3,689	4,424	19,259	11,861	2,906	42,139
1992	2,029	2,020	16,565	9,160	2,742	32,516
1993	3,209	2,283	12,615	8,720	2,532	29,359
1994	2,205	3,829	18,497	9,432	5,766	39,729
1995	3,140	6,781	51,302	14,183	4,529	79,935
1996	3,489	9,901	40,662	15,809	6,601	76,462
1997	3,433	9,625	38,448	18,087	7,009	76,602
1998	5,086	7,629	40,341	18,817	5,564	77,437
1999	5,146	10,988	53,277	22,671	4,295	96,377
2000	6,224	15,221	40,245	21,404	3,784	86,878
2001	5,990	12,371	44,677	20,303	5,282	88,623
2002	8,234	11,987	43,830	22,139	5,717	91,907
2003	4,159	7,083	44,317	19,693	4,820	80,072
2004	6,109	4,554	19,165	13,928	3,387	47,143
2005	5,097	2,356	16,057	8,790	1,261	33,561

Table 3. Reported commercial landings of yellowfin grouper in Puerto Rico in pounds whole weight. Landings of finfish in the Virgin Islands are not recorded by species. An asterisk (*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	total
1983	-
1984	-
1985	-
1986	-
1987	*
1988	460
1989	1,249
1990	559
1991	1,702
1992	921
1993	1,483
1994	448
1995	827
1996	1,617
1997	2,088
1998	1,793
1999	3,350
2000	2,298
2001	3,641
2002	6,916
2003	4,893
2004	2,189
2005	753

Table 4. Sampling fractions representing the annual proportion of Puerto Rican fishermen which reported landings. These were used to calculate total landings from reported landings for Puerto Rico.

1972	0.60	
1973	0.60	
1974	0.60	
1975	0.60	
1976	0.60	
1977	0.60	
1978	0.68	Weiller and Suarez-Caabro, 1980
1979	0.75	Calderon, 1983 (Coop. Sci Rpt) and Collazo and Calderon
1980	0.75	Calderon, 1983 (Coop. Sci. Rpt) and Collazo and Calderon
1981	0.75	Calderon, 1983 (Coop. Sci. Rpt) and Collazo and Calderon
1982	0.75	Calderon, 1983 (Coop. Sci. Rpt) and Collazo and Calderon
1983	0.61	Calderon, 1983 (Coop. Sci. Rpt) and Collazo and Calderon
1984	0.59	Garcia-Moliner 1986
1985	0.56	Garcia-Moliner 1986
1986	0.75	Matos-Caraballo and Rivera-Alvarez, 1994
1987	0.75	Matos-Caraballo and Rivera-Alvarez, 1994
1988	0.56	Matos-Caraballo and Sadovoy, 1990 (Tech Rpt)
1989	0.51	Matos-Caraballo and Sadovoy, 1990 (Tech Rpt)
1990	0.51	Matos-Caraballo and Sadovoy, 1990 (Tech Rpt)
1991	0.51	Matos-Caraballo and Sadovoy, 1991
1992	0.60	Matos-Caraballo, 1993 (p 5)
1993	0.60	Matos-Caraballo, 1994 (p 4)
1994	0.64	Matos-Caraballo, 1998
1995	0.71	Matos-Caraballo, 1998
1996	0.71	Matos-Caraballo, 1998
1997	0.78	Matos-Caraballo, 1998
1998	0.78	Matos-Caraballo, 1998
1999	0.78	Matos-Caraballo, 2000 (Coop. Sci. Rpt.)
2000	0.57	Matos-Caraballo, 2002
2001	0.68	Matos-Caraballo, 2002
2002	0.86	Matos-Caraballo, 2004
2003	0.56	Matos-Caraballo, 2004
2004	0.61	Matos-Caraballo, 2004
2005	0.50	Matos-Caraballo

Table 5. Calcuated total landings of conch from Puerto Rico as landed (1983-2002 landings are uncleaned meats, while about 50% of 2003 and all of 2004-2005 are cleaned meats). An asterisk (*) indicates that landings were reported but are not shown to protect possible confidentiality. A dash (-) indicates that no landings were reported.

	diving	traps	other	total
1983	654,309	*	*	654,309
1984	499,038	-	-	499,038
1985	461,559	1,952	1,803	465,314
1986	247,461	1,872	1,301	250,634
1987	190,140	-	-	190,140
1988	379,584	12,014	19,175	410,773
1989	289,578	10,788	12,996	313,362
1990	203,928	5,952	1,213	211,093
1991	207,584	2,451	981	211,016
1992	145,267	2,980	2,871	151,118
1993	262,854	5,668	5,182	273,704
1994	246,788	11,646	7,451	265,885
1995	283,709	6,079	10,566	300,354
1996	318,563	7,407	10,377	336,347
1997	288,018	3,642	13,007	304,667
1998	312,940	3,545	16,975	333,460
1999	263,941	3,854	5,649	273,444
2000	470,975	5,163	16,187	492,325
2001	346,077	7,735	4,935	358,747
2002	261,141	9,320	2,143	272,604
2003	328,259	4,740	1,333	334,332
2004	345,709	2,404	3,921	352,034
2005	386,966	968	3,468	391,402

Table 6. Calculated total landings of mutton snapper from Puerto Rico in pounds whole weight.

	diving	gill nets	hook and line	seine	traps	other	total
1983	4,899	5,462	26,309	6,428	61,049	1,657	105,804
1984	950	5,582	26,850	8,603	45,023	2,245	89,253
1985	2,018	11,076	27,011	2,160	35,333	3,218	80,816
1986	3,784	8,493	10,679	1,422	14,731	921	40,030
1987	1,513	4,389	9,198	1,940	8,184	1,170	26,394
1988	3,965	5,567	16,196	1,371	9,148	1,674	37,921
1989	8,125	5,213	25,533	3,416	17,537	1,661	61,485
1990	6,753	4,916	21,092	1,578	13,502	822	48,663
1991	7,105	8,539	37,256	2,579	22,893	3,060	81,432
1992	3,337	3,324	27,409	2,740	15,108	1,795	53,713
1993	5,277	3,767	20,769	3,266	14,382	916	48,377
1994	3,380	5,914	28,556	3,701	14,503	5,215	61,269
1995	4,343	9,453	71,647	2,135	19,590	4,137	111,305
1996	4,801	13,724	56,625	2,100	21,761	7,052	106,063
1997	4,265	12,052	48,601	2,154	22,527	6,637	96,236
1998	6,363	9,577	51,017	1,668	23,538	5,323	97,486
1999	6,439	13,791	67,508	1,543	28,408	3,847	121,536
2000	10,784	26,423	69,912	693	37,004	5,864	150,680
2001	8,633	17,877	64,818	3,963	29,159	3,681	128,131
2002	9,353	13,557	49,988	3,651	24,969	2,849	104,367
2003	7,229	12,352	78,382	4,363	34,372	4,116	140,814
2004	9,680	7,280	30,909	2,146	22,206	3,314	75,535
2005	10,194	4,712	32,114	462	17,580	2,060	67,122

Table 7. Calculated total landings of yellowfin grouper from Puerto Rico in pounds whole weight. An asterisk (*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	total
1983	-
1984	-
1985	-
1986	-
1987	*
1988	809
1989	2,433
1990	1,076
1991	3,310
1992	1,518
1993	2,457
1994	690
1995	1,148
1996	2,241
1997	2,648
1998	2,264
1999	4,243
2000	3,990
2001	5,281
2002	7,969
2003	8,667
2004	3,523
2005	1,506

Table 8. Calculated total landings of finfish in pounds whole weight from Puerto Rico. An asterisk (*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	Puerto Rico											
	cast nets	diving	gillnet	hook and line	long line	seine	trammel net	trap	nets	multiple	unknown	total
1974	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-
1983	26,315	178,544	672,774	1,357,314	48,176	348,159	-	2,534,512	-	-	-	5,165,794
1984	*	147,370	571,693	962,303	44,653	247,686	-	2,288,946	-	-	*	4,294,821
1985	33,519	111,204	646,338	1,321,928	39,234	184,734	*	1,785,772	-	-	*	4,124,994
1986	17,069	82,523	474,928	1,049,216	12,909	118,804	-	1,055,622	-	-	-	2,811,071
1987	24,227	81,116	399,480	779,072	15,926	153,143	*	896,859	-	-	*	2,349,917
1988	10,163	141,477	456,467	1,129,185	41,223	162,735	*	917,105	-	-	*	2,869,119
1989	16,647	164,193	436,895	1,435,232	50,201	242,446	21,457	1,372,390	-	-	2,137	3,741,598
1990	11,031	153,213	521,616	1,417,778	54,505	166,498	138,100	1,190,167	-	-	282	3,653,190
1991	33,385	178,553	630,055	1,509,966	38,573	237,032	256,184	1,227,428	-	-	-	4,111,176
1992	24,715	118,624	248,947	1,206,755	30,202	135,806	392,880	789,338	-	-	-	2,947,267
1993	21,669	154,977	397,202	1,464,192	46,135	168,581	421,378	869,451	-	-	-	3,543,585
1994	43,251	149,658	471,783	1,573,435	31,096	136,101	242,807	928,496	-	-	-	3,576,627
1995	39,345	213,750	424,303	2,199,639	55,080	194,234	293,927	987,732	-	-	-	4,408,010
1996	34,021	197,932	499,840	1,901,299	68,606	168,138	392,453	920,486	-	-	-	4,182,775
1997	36,370	182,934	568,594	1,862,952	72,569	157,072	288,566	924,909	-	-	-	4,093,966
1998	*	245,694	502,889	1,595,872	94,032	84,425	267,035	773,310	-	-	*	3,593,422
1999	40,341	218,245	564,307	1,602,034	84,141	80,151	182,226	685,030	-	-	-	3,456,475
2000	54,961	361,134	743,406	2,167,708	205,999	103,903	137,659	871,336	-	-	-	4,646,106
2001	37,961	314,827	647,422	1,894,209	75,306	113,227	76,961	925,619	-	-	-	4,085,532
2002	31,269	279,389	511,235	1,369,599	61,402	98,123	84,251	648,092	-	-	-	3,083,360
2003	27,760	186,546	452,832	1,699,737	56,051	129,807	126,500	714,357	-	-	-	3,393,590
2004	25,367	192,880	257,956	1,113,956	39,662	107,096	82,945	459,304	-	-	-	2,279,166
2005	*	189,322	175,226	1,448,532	41,884	37,460	53,500	376,966	-	-	*	2,352,054

Table 9. Reported landings of conch in the U.S. Virgin Islands in pounds of uncleaned meat. An asterisk (*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	St. Thomas / St. John			St. Croix		
	diving	unknown and other	total	diving	unknown and other	total
1974	-	*	*	-	-	-
1975	-	2,161	2,161	-	*	*
1976	-	*	*	-	657	657
1977	-	741	741	-	7,737	7,737
1978	-	2,439	2,439	-	17,302	17,302
1979	-	6,598	6,598	-	4,978	4,978
1980	-	4,197	4,197	-	12,315	12,315
1981	-	2,728	2,728	-	21,306	21,306
1982	-	4,190	4,190	-	16,878	16,878
1983	-	7,954	7,954	-	12,699	12,699
1984	-	5,540	5,540	-	24,224	24,224
1985	-	3,827	3,827	-	16,196	16,196
1986	-	6,036	6,036	-	8,576	8,576
1987	-	6,502	6,502	-	20,058	20,058
1988	-	743	743	-	9,253	9,253
1989	-	*	*	-	4,060	4,060
1990	-	-	-	-	14,276	14,276
1991	-	-	-	-	41,876	41,876
1992	-	*	*	-	18,622	18,622
1993	-	5,387	5,387	-	26,416	26,416
1994	-	1,889	1,889	-	36,682	36,682
1995	-	1,478	1,478	*	35,698	35,698
1996	-	2,601	2,601	13,571	22,379	35,950
1997	*	1,606	1,606	33,738	13,635	47,372
1998	715	*	715	59,471	4,544	64,015
1999	1,620	*	1,620	49,693	2,534	52,226
2000	1,083	*	1,083	72,461	4,488	76,949
2001	1,847	*	1,847	110,017	3,427	113,444
2002	2,172	*	2,172	113,141	3,401	116,542
2003	2,555	784	3,339	105,946	2,258	108,204
2004	1,022	*	1,022	123,281	1,977	125,258
2005	429	*	429	149,724	6,325	156,049

Table 10. Effective expansion factors for the Virgin Islands.

	St. Thomas / St. John		St. Croix	
	finfish	conch	finfish	conch
1974	12.70			
1975	4.04	5.09	22.29	18.65
1976	7.75	13.14	10.31	12.50
1977	2.03	1.79	3.62	6.16
1978	1.54	1.70	3.94	4.04
1979	1.78	3.62	4.84	11.20
1980	2.69	2.98	7.95	7.91
1981	3.07	2.81	6.75	6.47
1982	2.30	2.63	2.70	2.61
1983	1.70	1.76	1.77	1.65
1984	1.54	1.64	1.46	1.45
1985	1.80	1.85	5.03	1.49
1986	1.86	1.92	2.82	4.76
1987	1.89	1.77	1.55	1.75
1988	1.31	1.26	2.14	1.96
1989	1.36	1.39	6.97	11.55
1990	1.54		2.03	2.28
1991	1.77		1.69	1.94
1992	1.51	1.58	1.53	1.58
1993	1.44	1.53	1.50	1.62
1994	1.40	1.61	1.31	1.53
1995	1.33	1.36	1.27	1.48
1996	1.12	1.11	1.50	1.73
1997	1.22	1.21	1.23	1.35
1998	1.49	1.62	1.23	1.27
1999	1.26	1.24	1.35	1.42
2000	1.24	1.24	1.33	1.35
2001	1.19	1.21	1.17	1.23
2002	1.11	1.12	1.08	1.09
2003	1.25	1.21	1.33	1.23
2004	1.14	1.49	1.35	1.34
2005	1.23	1.23	1.45	1.40

Table 11. Calculated total landings of conch in the U.S. Virgin Islands in pounds of uncleaned meat. An asterisk (*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	St. Thomas / St. John	St. Croix		
	total	diving	unknown and other	total
1974	*	-	-	-
1975	10,991	-	*	*
1976	*	-	8,210	8,210
1977	1,327	-	47,639	47,639
1978	4,151	-	69,957	69,957
1979	23,900	-	55,753	55,753
1980	12,488	-	97,410	97,410
1981	7,655	-	137,755	137,755
1982	11,030	-	44,055	44,055
1983	14,011	-	20,938	20,938
1984	9,111	-	35,240	35,240
1985	7,068	-	24,124	24,124
1986	11,584	-	40,784	40,784
1987	11,527	-	35,171	35,171
1988	938	-	18,155	18,155
1989	*	-	46,876	46,876
1990	-	-	32,539	32,539
1991	-	-	81,156	81,156
1992	*	-	29,515	29,515
1993	8,233	-	42,857	42,857
1994	3,042	-	55,987	55,987
1995	2,014	*	*	52,761
1996	2,892	60,034	1,980	62,014
1997	2,020	58,723	5,035	63,758
1998	1,158	74,268	6,955	81,223
1999	2,011	70,652	3,343	73,995
2000	1,344	97,574	5,976	103,550
2001	2,237	135,572	4,116	139,688
2002	2,423	122,821	4,326	127,147
2003	4,056	130,182	3,091	133,273
2004	1,524	165,068	2,856	167,924
2005	526	209,450	9,433	218,883

Table 12. Calculated total landings of finfish in pounds whole weight from the island group St. Thomas / St. John. An asterisk (*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	St. Thomas / St. John											
	cast nets	diving	gillnet	hook and line	long line	seine	trammel net	trap	nets	multiple	unknown	total
1974	-	1,174	-	24,241	-	-	-	592,415	39,451	-	-	657,281
1975	-	11,780	-	59,958	-	-	-	886,321	89,501	-	-	1,047,560
1976	-	7,074	-	206,772	-	-	-	1,424,104	79,146	-	-	1,717,096
1977	-	*	-	81,444	-	-	-	344,589	57,189	-	*	483,732
1978	-	4,075	-	50,617	-	-	-	434,865	138,233	-	-	627,790
1979	-	7,700	-	75,028	-	-	-	535,332	176,141	-	-	794,201
1980	-	25,475	-	128,011	-	-	-	958,470	221,039	-	-	1,332,995
1981	-	13,552	-	117,666	-	-	-	1,145,048	149,024	-	-	1,425,290
1982	-	10,143	-	70,902	-	-	-	820,602	106,459	-	-	1,008,106
1983	-	13,210	-	70,474	-	-	-	727,846	82,717	-	-	894,247
1984	-	13,720	-	102,258	-	-	-	690,963	64,884	-	-	871,825
1985	-	6,571	-	123,861	-	-	-	843,144	77,109	-	-	1,050,685
1986	-	4,129	-	158,525	-	-	-	763,923	95,902	-	-	1,022,479
1987	-	1,676	-	171,785	-	-	-	702,743	51,522	-	-	927,726
1988	-	1,522	-	160,695	-	-	-	550,554	60,327	-	12,619	785,717
1989	-	7,244	-	143,000	-	-	-	496,249	74,703	-	12,426	733,622
1990	-	4,436	-	131,087	-	-	-	458,871	80,875	-	-	675,269
1991	-	1,532	-	184,373	-	-	-	600,354	177,643	-	99	964,001
1992	-	5,597	-	214,950	-	-	-	625,023	90,911	-	14,301	950,782
1993	-	8,513	-	207,605	-	-	-	579,613	191,760	-	25,734	1,013,225
1994	-	8,903	-	209,246	-	-	-	538,942	120,968	-	24,551	902,610
1995	-	5,778	-	192,107	-	-	-	453,701	113,673	-	22,502	787,761
1996	-	5,727	-	137,339	-	-	-	375,028	73,471	-	14,397	605,962
1997	1,450	12,347	*	181,507	-	5,975	-	477,040	69,056	105	*	768,294
1998	8,181	8,057	*	173,320	-	29,366	-	531,375	42,314	1,577	*	801,630
1999	17,376	10,141	*	169,970	-	51,353	-	397,297	7,735	2,052	*	656,577
2000	8,401	8,021	*	217,908	-	64,449	-	365,170	-	155	*	664,552
2001	7,737	7,001	*	258,290	-	74,742	-	430,287	-	3,800	*	782,215
2002	9,376	8,112	*	243,205	-	85,323	-	428,949	-	1,583	*	777,161
2003	15,473	11,087	*	220,678	-	79,192	-	510,959	-	1,636	*	839,407
2004	13,511	3,278	*	169,465	-	82,873	-	482,118	-	3,026	*	754,482
2005	7,873	8,831	*	163,621	*	82,820	-	475,907	-	19,024	*	758,469

Table 13. Calculated total landings of finfish in pounds whole weight from the island group St. Croix. Note that dive landings may include gill and trammel net landings, because at times divers use nets to fish. An asterisk (*) indicates that landings were reported but are not shown to protect confidentiality. A dash (-) indicates that no landings were reported.

	St. Croix											
	cast nets	diving	gillnet	hook and line	long line	seine	trammel net	trap	nets	multiple	unknown	total
1974	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	6,507	-	-	-	299,130	39,743	-	-	345,380
1976	-	*	-	96,881	-	-	-	364,027	*	-	13,568	474,476
1977	-	*	-	50,760	-	-	-	124,233	*	-	8,345	183,338
1978	-	30,510	-	47,866	-	-	-	137,770	4,919	-	-	221,065
1979	-	12,531	-	33,602	-	-	-	262,277	20,823	-	-	329,233
1980	-	17,783	-	54,158	-	-	-	215,819	24,419	-	-	312,179
1981	-	19,596	-	209,166	-	-	-	319,589	41,975	-	-	590,326
1982	-	5,320	-	145,638	-	-	-	244,943	10,124	-	-	406,025
1983	-	8,176	-	113,805	-	-	-	269,074	12,584	-	-	403,639
1984	-	7,135	-	149,133	-	-	-	238,840	26,390	-	-	421,498
1985	-	4,408	-	115,665	-	-	-	695,502	15,129	-	-	830,704
1986	-	3,265	-	131,000	-	-	-	429,242	69,343	-	-	632,850
1987	-	14,339	-	152,996	-	-	-	368,382	56,793	-	-	592,510
1988	-	7,848	-	145,606	-	-	-	246,500	17,688	-	-	417,642
1989	-	52,148	-	76,975	-	-	-	421,313	49,361	-	-	599,797
1990	-	41,677	-	214,536	-	-	-	426,998	71,501	-	-	754,712
1991	-	38,267	-	305,127	-	-	-	424,828	66,581	-	-	834,803
1992	-	23,864	-	275,120	-	-	-	375,736	74,491	-	-	749,211
1993	-	75,136	-	335,536	-	-	-	349,400	111,341	-	-	871,413
1994	-	88,579	-	280,783	-	-	-	260,641	104,926	-	-	734,929
1995	*	36,470	*	205,707	-	-	-	180,215	117,179	-	1,793	543,161
1996	*	65,790	52,177	210,990	-	11,303	-	214,306	94,966	-	*	656,088
1997	*	49,237	102,100	237,851	-	37,698	-	228,119	25,292	26,880	*	713,520
1998	*	53,826	62,973	209,947	-	39,486	-	192,400	-	96,201	*	679,705
1999	*	83,069	120,199	259,714	-	38,105	-	214,003	-	59,216	*	775,768
2000	*	171,291	127,766	269,257	-	46,329	-	175,619	-	63,026	*	853,342
2001	*	150,700	122,413	310,984	-	43,359	-	164,017	-	113,453	*	906,011
2002	*	186,705	138,903	351,785	-	47,809	-	193,282	-	28,467	*	948,069
2003	*	265,586	151,011	374,824	-	36,903	-	148,100	-	52,266	*	1,031,764
2004	*	291,921	169,098	317,311	-	31,845	-	179,331	-	60,566	*	1,050,838
2005	*	393,127	161,079	383,917	-	62,855	44,040	172,771	-	35,442	*	1,253,807

Table 14. Numbers of mutton snapper with accepted length measurements from Puerto Rico by gear.

	dive	gillnet	hook & line	seine	trap	other	total
1983	-	-	1	-	58	-	59
1984	4	-	26	-	216	5	251
1985	1	-	14	-	113	1	129
1986	-	16	16	66	113	8	219
1987	2	1	3	14	33	3	56
1988	3	8	26	24	49	50	160
1989	6	20	22	3	48	63	162
1990	5	105	48	54	43	22	277
1991	5	3	297	5	80	30	420
1992	13	-	203	88	34	55	393
1993	2	8	104	44	14	3	175
1994	1	1	38	38	8	-	86
1995	3	-	84	7	5	-	99
1996	4	-	10	2	6	-	22
1997	-	4	7	-	31	-	42
1998	12	13	106	52	28	2	213
1999	12	130	60	27	68	6	303
2000	11	-	141	73	66	3	294
2001	16	6	43	124	57	3	249
2002	8	-	162	170	100	15	455
2003	-	3	301	214	37	21	576
2004	9	4	138	202	42	1	396
2005	21	4	131	85	20	-	261
2006	9	-	13	196	6	-	224

Table 15. Numbers of yellowfin grouper with accepted length measurements from Puerto Rico by gear.

	dive	hook & line	trap	other	total
1983	-	1	2	-	3
1984	1	1	29	-	31
1985	-	2	39	1	42
1986	4	4	25	5	38
1987	4	-	7	2	13
1988	3	4	19	1	27
1989	8	1	18	1	28
1990	1	7	-	-	8
1991	2	-	10	-	12
1992	-	3	-	5	8
1993	-	3	-	-	3
1994	-	1	-	-	1
1995	4	-	-	-	4
1996	-	-	-	-	-
1997	8	5	-	-	13
1998	-	1	-	-	1
1999	6	6	-	-	12
2000	21	3	1	-	25
2001	2	-	-	-	2
2002	1	3	-	-	4
2003	1	1	-	-	2
2004	1	-	-	-	1
2005	-	1	-	-	1
2006	-	-	-	-	-

Table 16. Mutton snapper sampling fractions from Puerto Rico.

	dive	gillnet	hook & line	seine	trap
1983			0.0%		0.3%
1984	1.7%		0.3%		1.2%
1985	0.5%		0.4%		0.8%
1986		0.2%	0.8%	9.3%	3.6%
1987	0.2%	0.1%	0.2%	0.5%	1.8%
1988	0.3%	0.2%	0.6%	3.4%	1.3%
1989	0.5%	1.1%	0.3%	0.1%	0.3%
1990	0.4%	2.9%	1.0%	7.6%	0.6%
1991	0.4%	0.0%	3.6%	0.2%	0.3%
1992	2.3%		2.5%	4.8%	0.8%
1993	0.3%	0.3%	3.3%	2.4%	0.3%
1994	0.3%	0.0%	0.8%	1.6%	0.1%
1995	0.2%		0.4%	0.2%	0.1%
1996	0.6%		0.1%	0.1%	0.0%
1997		0.0%	0.1%		0.3%
1998	1.4%	0.1%	1.6%	4.2%	0.2%
1999	0.5%	0.5%	0.2%	1.6%	0.3%
2000	0.3%		1.2%	9.8%	0.3%
2001	0.6%	0.0%	0.3%	3.1%	0.5%
2002	0.1%		1.1%	5.8%	0.4%
2003		0.0%	1.0%	5.1%	0.1%
2004	0.3%	0.0%	0.8%	14.6%	0.2%
2005	0.6%	0.0%	1.8%		0.1%
2006					

Table 17. Numbers of mutton snapper and yellowfin grouper with accepted length measurements from St. Thomas / St. John by gear.

	mutton snapper				yellowfin grouper		
	traps	**other**	**total**		**traps**	**other**	**total**
1983	-	-	-	1983	-	-	-
1984	38	2	40	1984	148	7	155
1985	87	17	104	1985	156	70	226
1986	13	-	13	1986	31	7	38
1987	7	-	7	1987	2	-	2
1988	-	-	-	1988	-	14	14
1989	-	-	-	1989	-	-	-
1990	-	-	-	1990	-	-	-
1991	6	-	6	1991	-	-	-
1992	2	-	2	1992	3	-	3
1993	4	-	4	1993	2	-	2
1994	4	-	4	1994	4	-	4
1995	-	2	2	1995	-	-	-
1996	-	-	-	1996	-	-	-
1997	-	-	-	1997	-	-	-
1998	-	-	-	1998	-	-	-
1999	-	-	-	1999	-	-	-
2000	-	-	-	2000	-	-	-
2001	-	-	-	2001	-	-	-
2002	13	5	18	2002	5	11	16
2003	3	-	3	2003	-	-	-
2004	2	-	2	2004	1	-	1
2005	39	-	39	2005	-	-	-
2006	22	-	22	2006	8	-	8

Table 18. Numbers of mutton snapper and yellowfin grouper with accepted length measurements from St. Croix by gear.

	mutton snapper					yellowfin grouper		
	hook & line	traps	other	total		traps	other	total
1983	8	30	53	91	1983	12	12	24
1984	188	20	247	455	1984	13	31	44
1985	63	4	17	84	1985	16	36	52
1986	3	20	2	25	1986	45	4	49
1987	10	25	3	38	1987	38	1	39
1988	88	18	-	106	1988	48	-	48
1989	7	14	-	21	1989	42	-	42
1990	2	5	1	8	1990	2	1	3
1991	9	11	1	21	1991	5	3	8
1992	4	2	-	6	1992	4	-	4
1993	5	2	1	8	1993	-	-	-
1994	1	8	-	9	1994	5	1	6
1995	2	-	1	3	1995	-	-	-
1996	1	-	-	1	1996	-	-	-
1997	-	2	-	2	1997	-	-	-
1998	-	1	-	1	1998	1	-	1
1999	-	10	-	10	1999	-	-	-
2000	-	1	-	1	2000	-	-	-
2001	-	-	-	-	2001	-	-	-
2002	-	6	5	11	2002	3	-	3
2003	1	-	15	16	2003	-	1	1
2004	-	-	1	1	2004	-	-	-
2005	1	14	1	16	2005	-	-	-
2006	-	-	-	-	2006	-	-	-

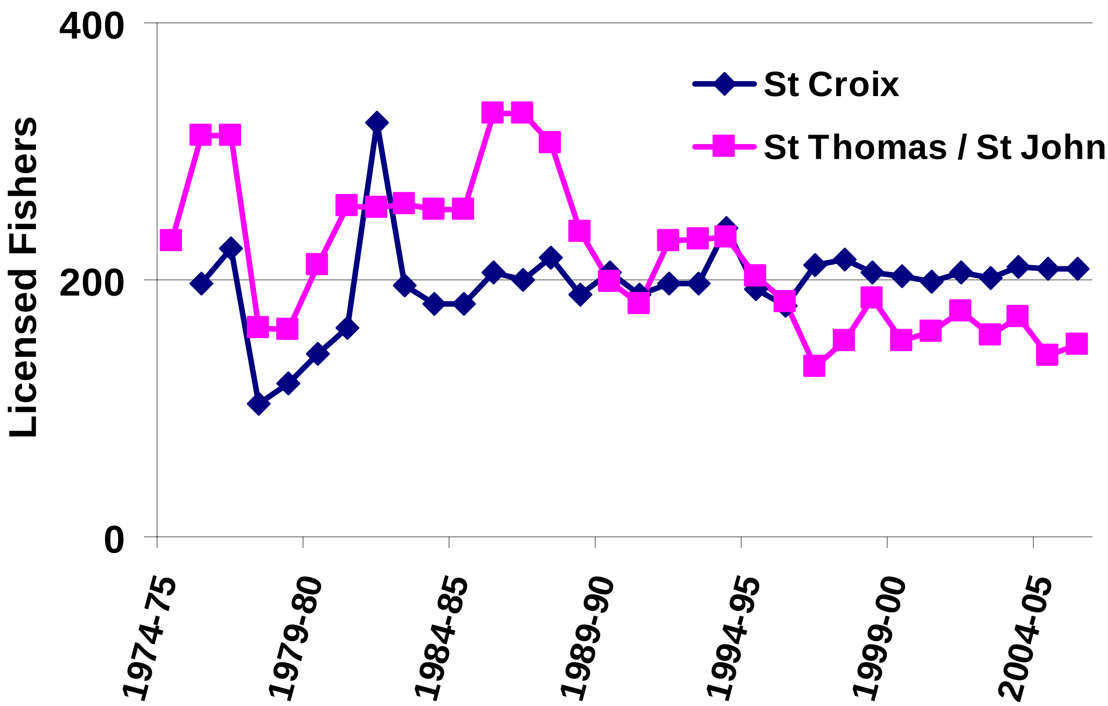


Figure 1. Number of licensed fishers in the Virgin Islands since 1974.

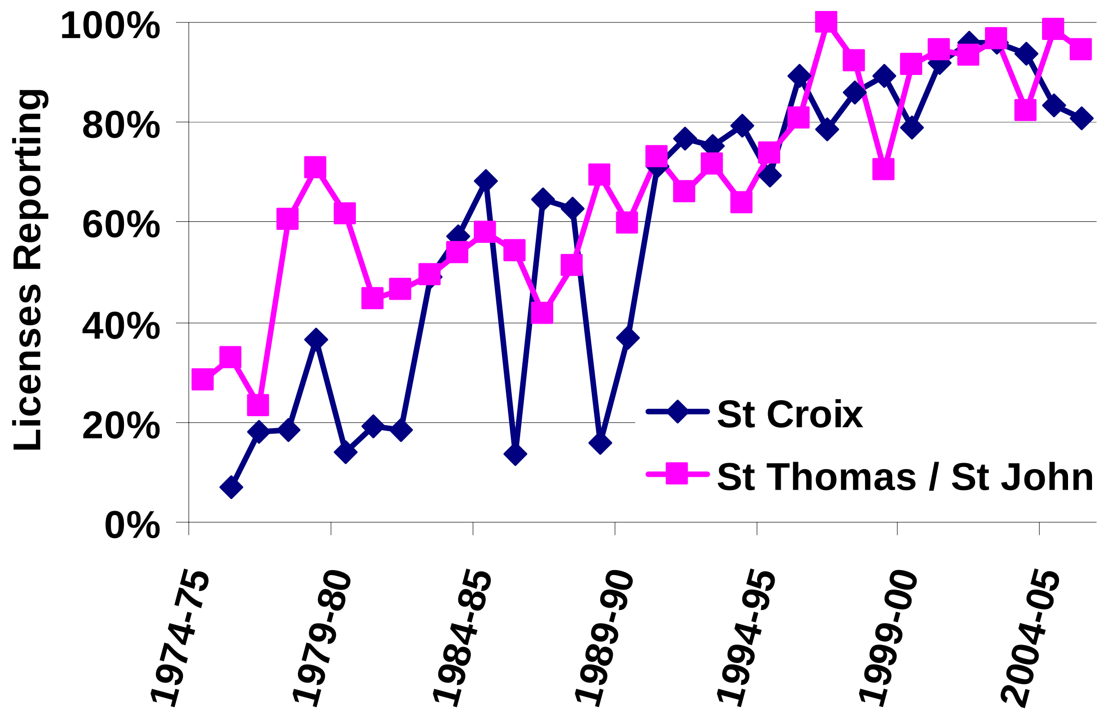


Figure 2. Percentage of Virgin Island license holders who reported landings.

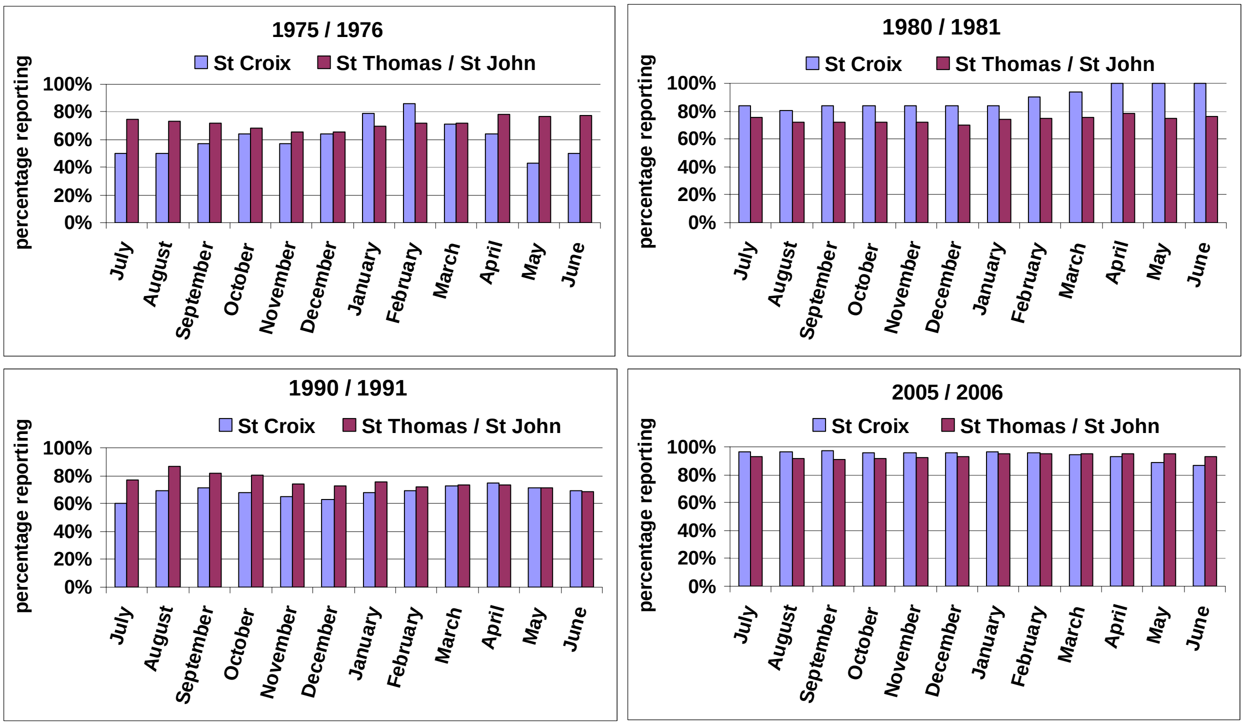


Figure 3. Percentage of licensed fishermen reporting by month for four fishing years.

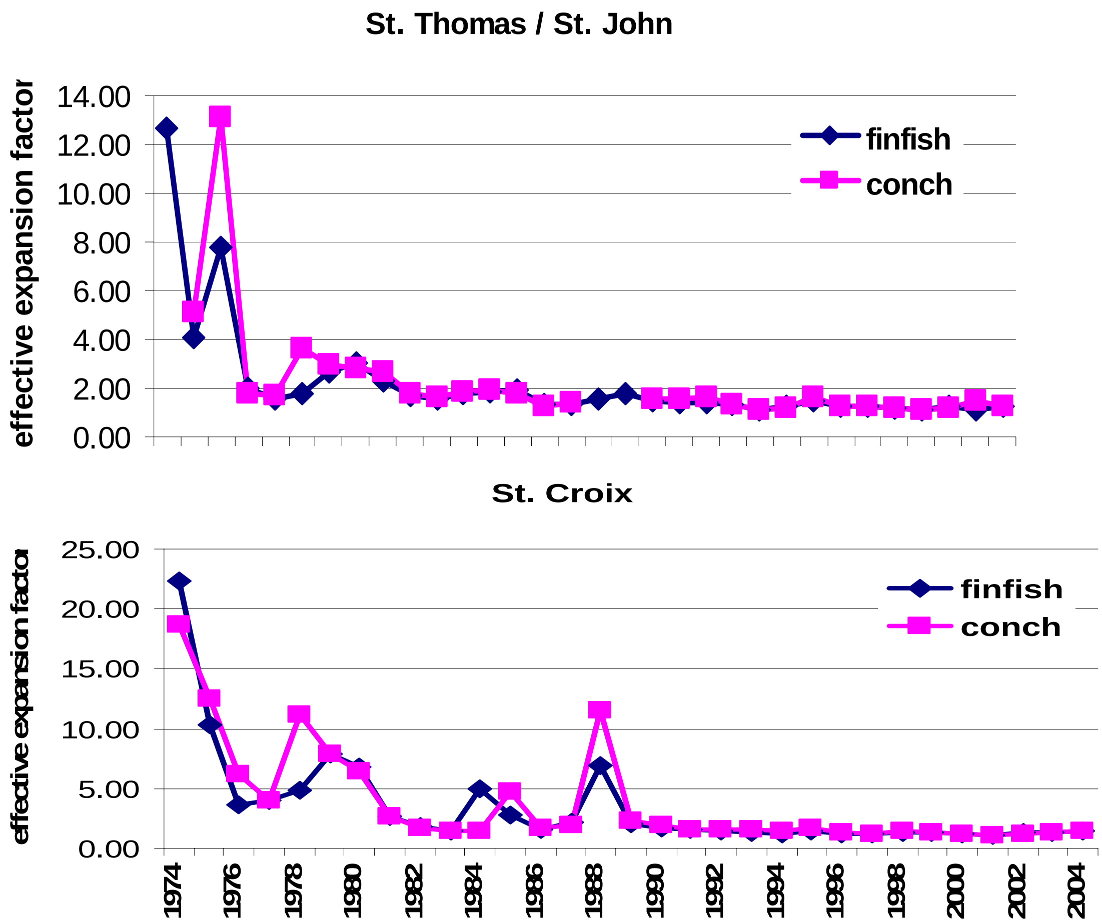


Figure 4. Effective expansion fractions for Virgin Island landings derived by dividing calculated total landings by reported landings.

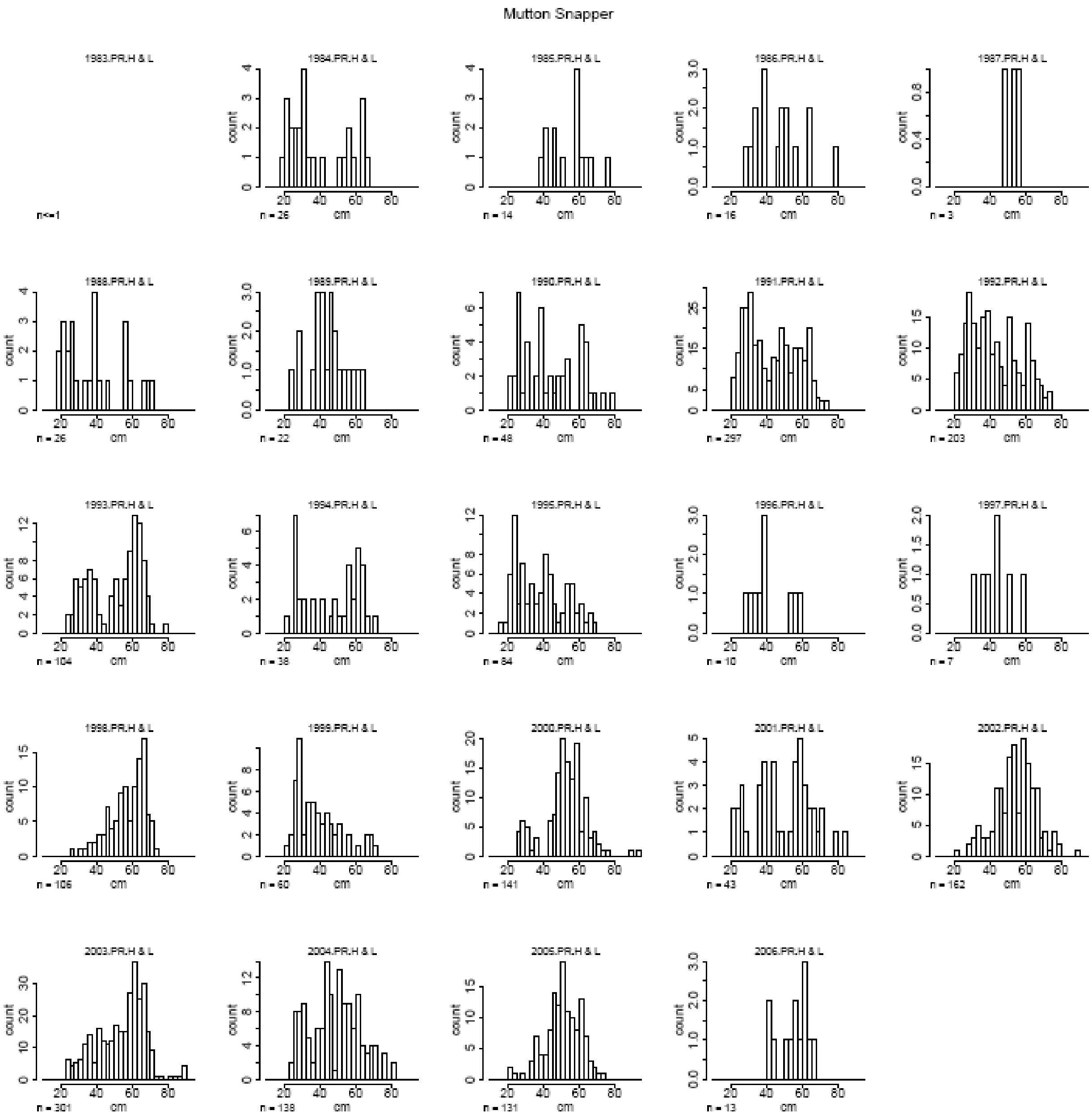


Figure 5. Number of mutton snapper at length (cm) from Puerto Rican landings by hook and line fisheries from 1983 through 2006. Note that the vertical axes vary in scale.

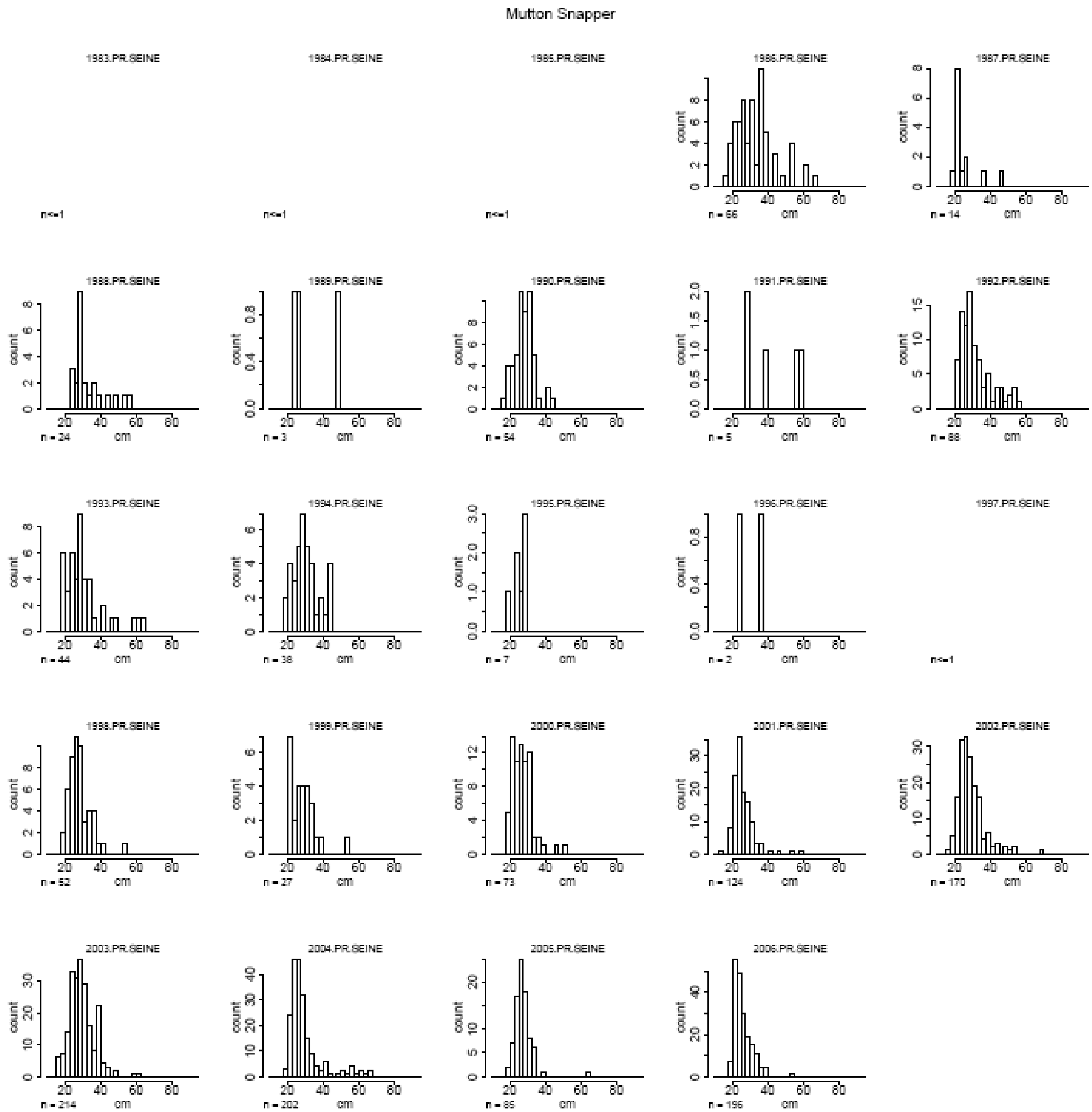


Figure 6. Number of mutton snapper at length (cm) from Puerto Rican landings by seine fisheries from 1983 through 2006. Note that the vertical axes vary in scale.

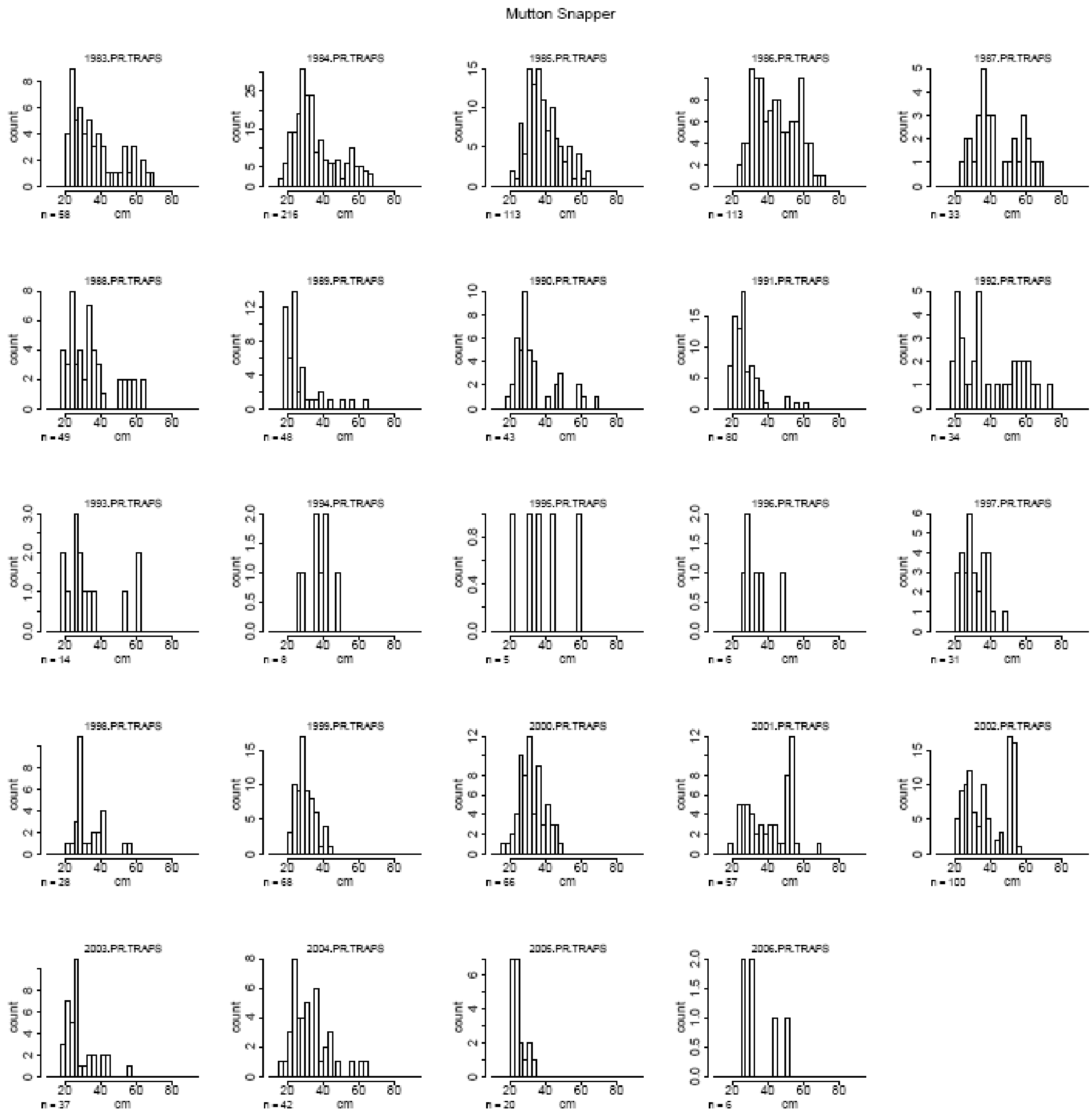


Figure 7. Number of mutton snapper at length (cm) from Puerto Rican landings by trap fisheries from 1983 through 2006. Note that the vertical axes vary in scale.

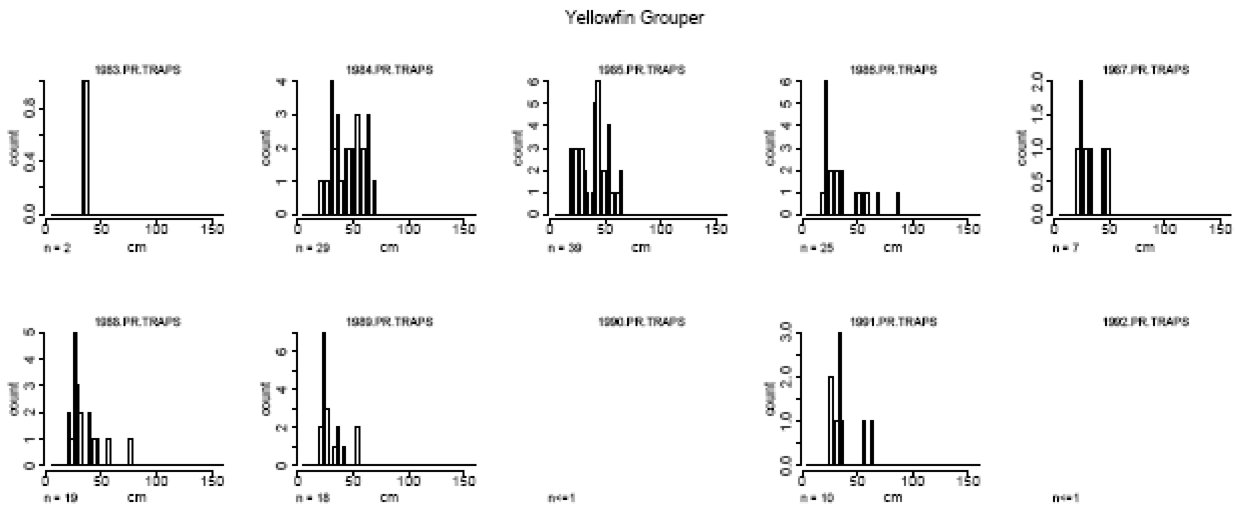


Figure 8. Number of yellowfin grouper at length (cm) from Puerto Rican landings by trap fisheries from 1983 through 1992. Note that the vertical axes vary in scale.

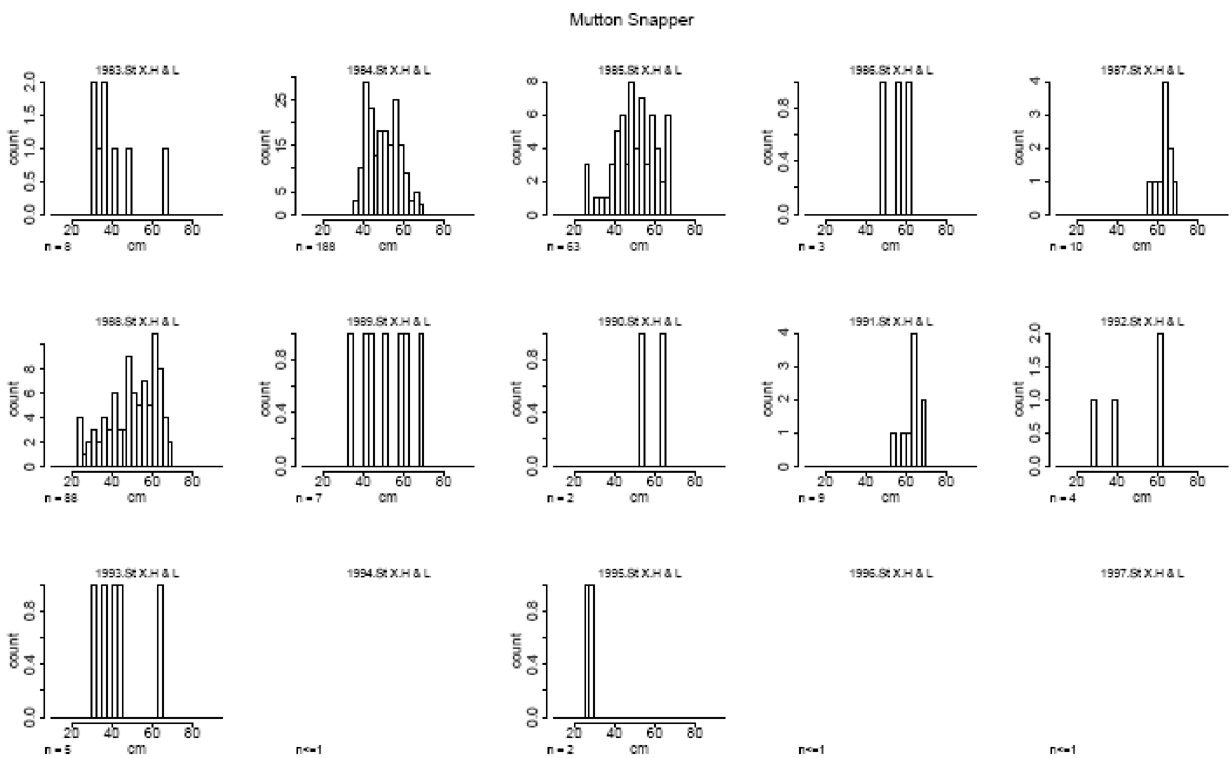


Figure 9. Number of mutton snapper at length (cm) from St. Croix (figures are mis-labeled) landings by hook and line fisheries from 1983 through 1995. Note that the vertical axes vary in scale.

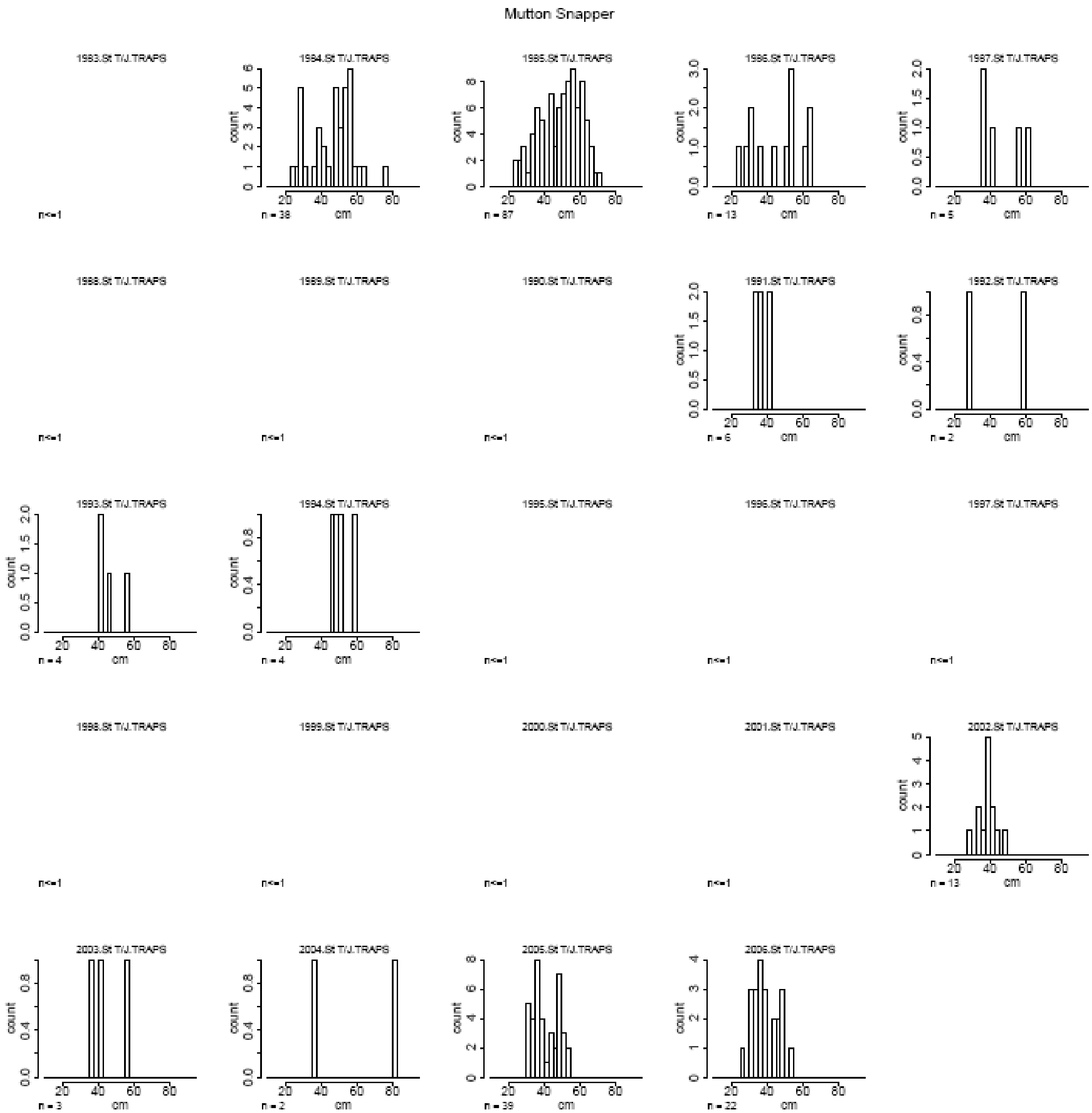


Figure 10. Number of mutton snapper at length (cm) from St. Thomas / St. John (figures are mis-labeled) landings by trap fisheries from 1984 through 2006. Note that the vertical axes vary in scale.

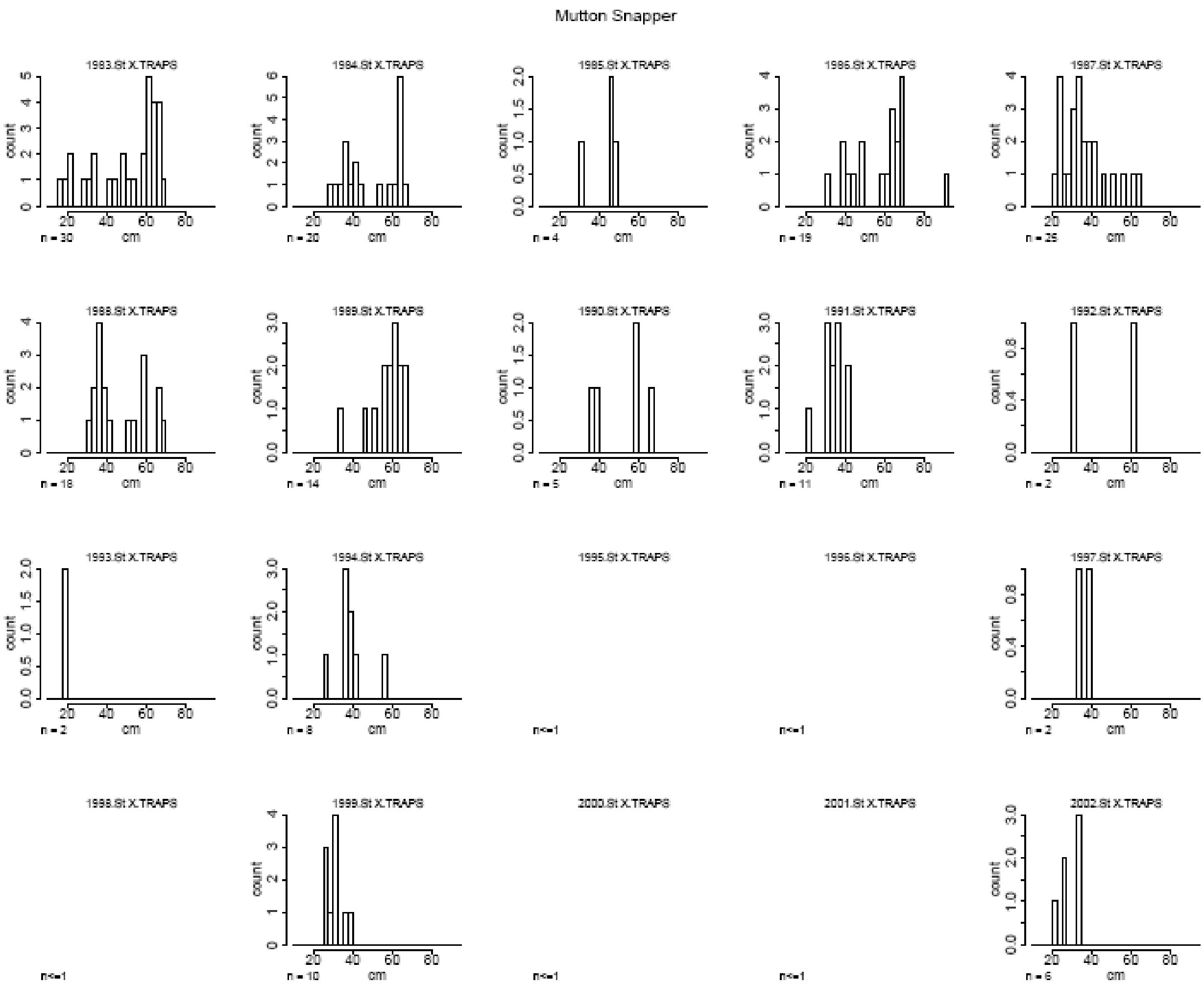


Figure 11. Number of mutton snapper at length (cm) from St. Croix (figures are mis-labeled) landings by trap fisheries from 1984 through 2002. Note that the vertical axes vary in scale.

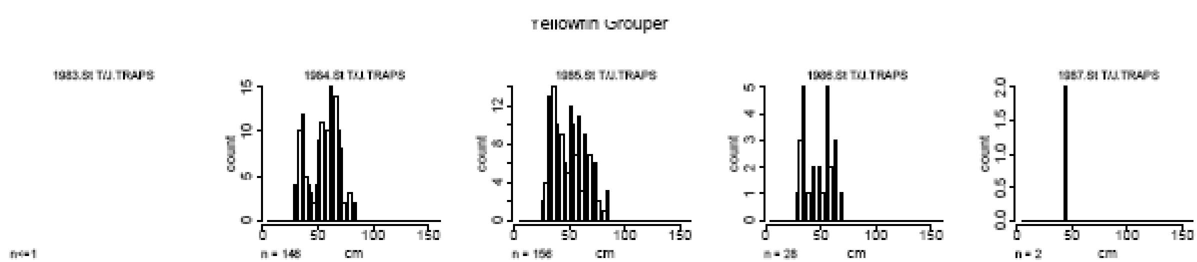


Figure 12. Number of yellowfin grouper at length (cm) from St. Thomas / St. John (figures are mis-labeled) landings by trap fisheries from 1984 through 1987. Note that the vertical axes vary in scale.

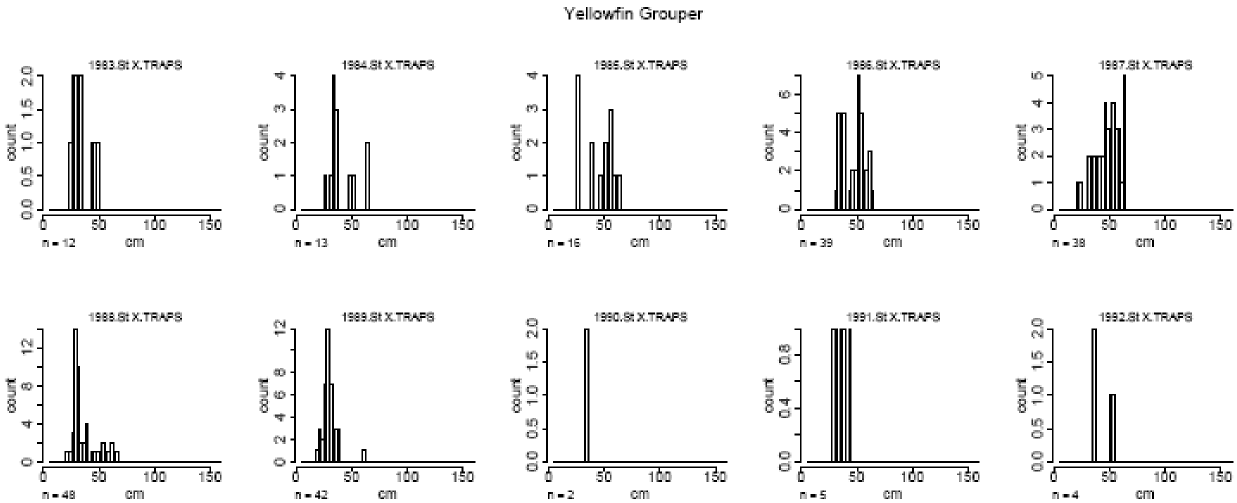


Figure 13. Number of yellowfin grouper at length (cm) from St. Croix landings by trap fisheries from 1983 through 1992. Note that the vertical axes vary in scale.

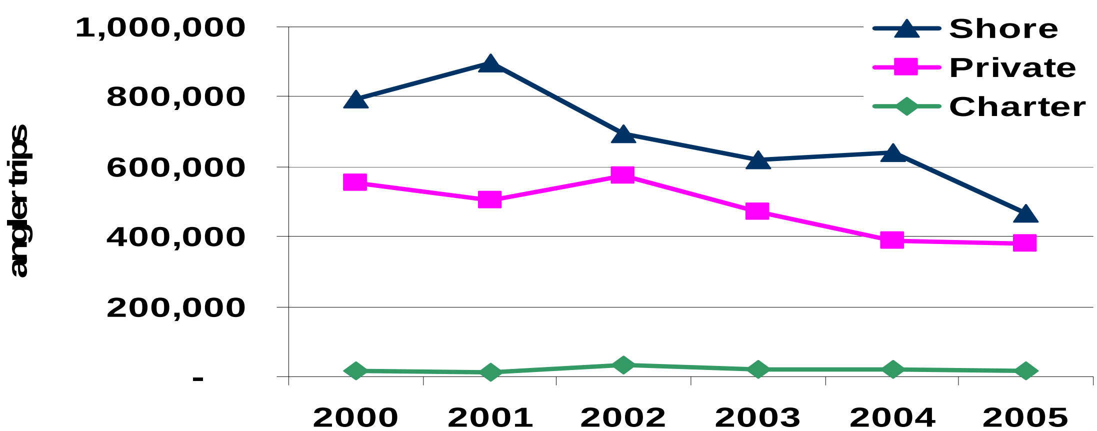


Figure 14. Estimated angler trips for Puerto Rico by mode from the Marine Recreational Fisheries Statistical Survey.

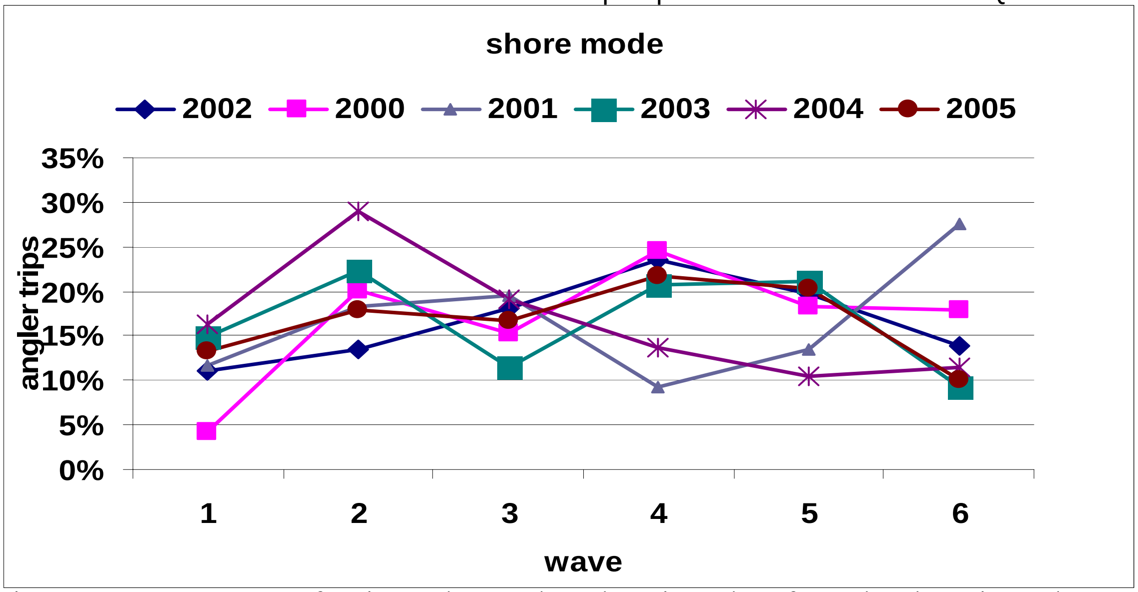


Figure 15. Percentages of estimated annual angler trips taken from the shore in each two month period (wave).

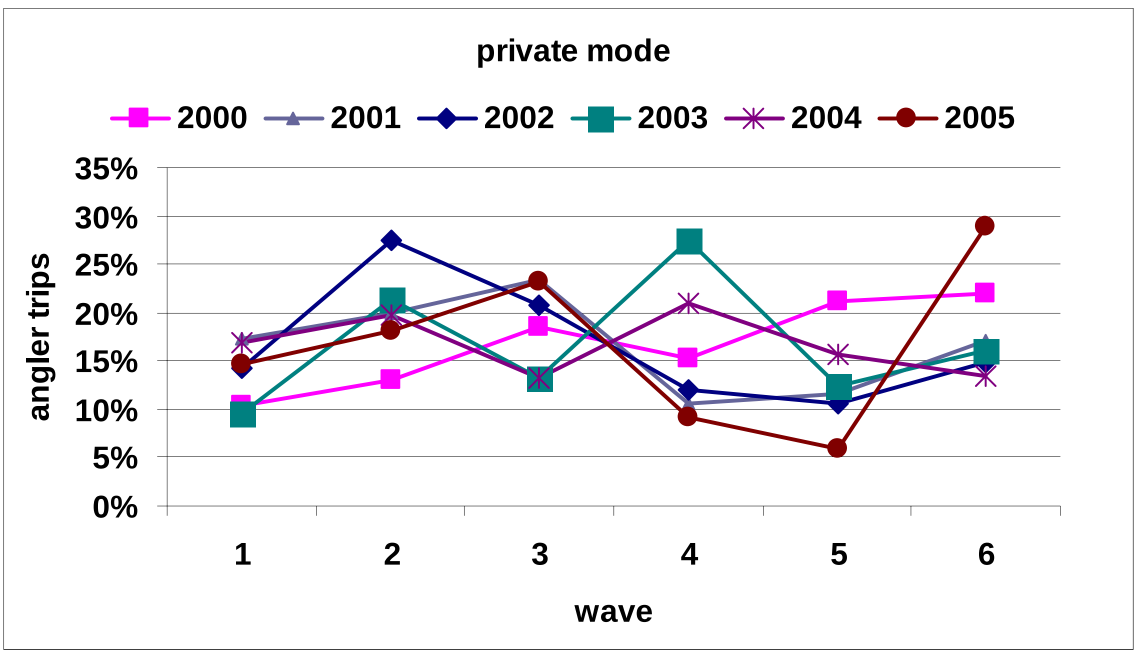


Figure 16. Percentages of estimated annual trips taken by private mode anglers in each two month period (wave).

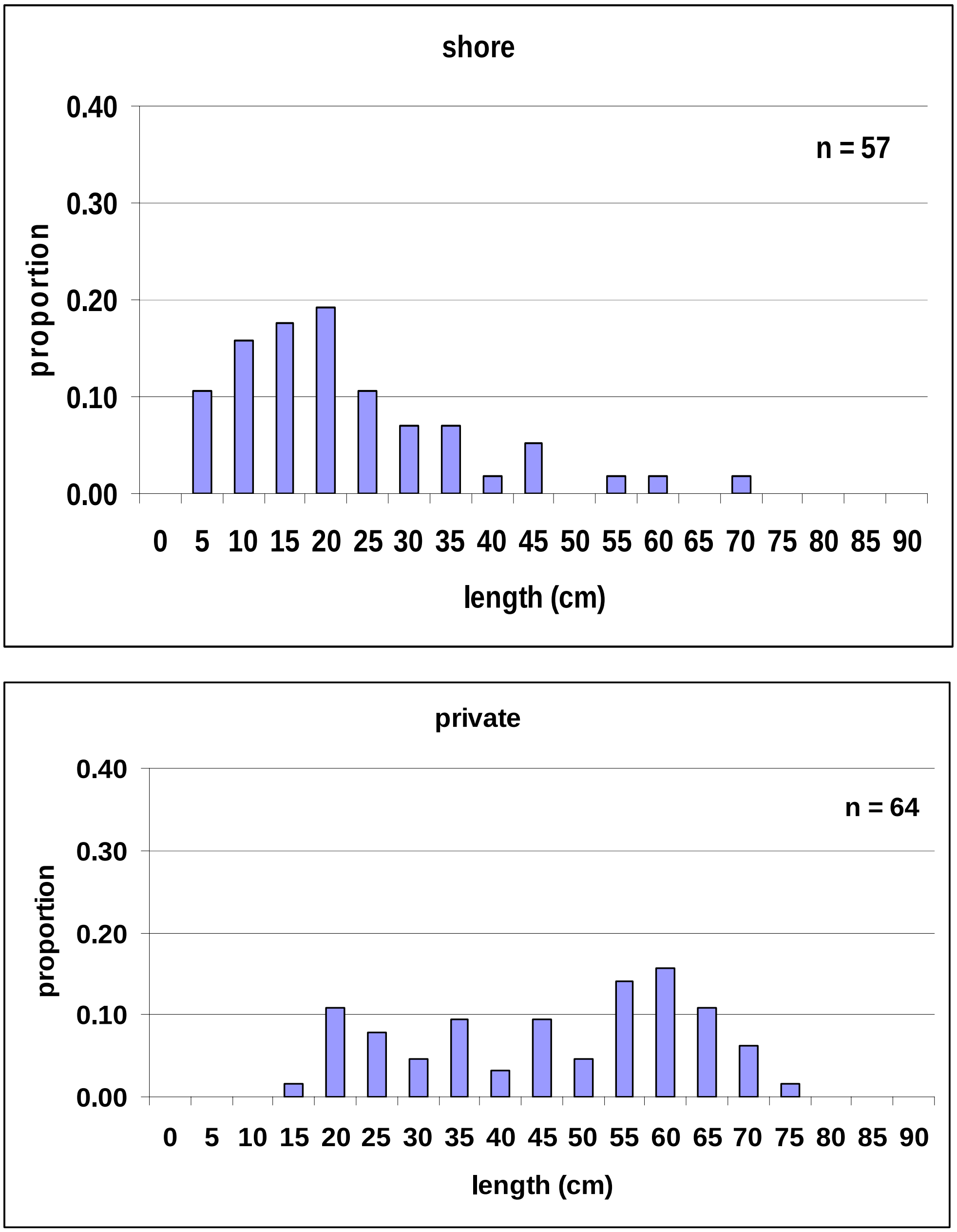


Figure 17. Length distributions of mutton snapper caught by recreational anglers in Puerto Rico fishing from shore or fishing from private or rental boats (private) durng 2000-2005.

4. Recreational Fishery

4.1. Overview

Limited discussions of the recreational fisheries were held in the working group on catch statistics. Graciella Molinar-Garcia and Steve Turner led the discussions and wrote the reports. Primary information is provided in this section. A detailed overview of the recreational fishery in the U.S. Caribbean is included in Appendix 1. That document provides recent and historical information on the fishery management units, cathes, effort, fishers, vessels and fleets

The recreational harvest of marine species in the US Caribbean is thought to be large, but until recently there have been very few surveys to document the recreational catch and effort. Apparently recreational effort is particularly high during holidays such as Easter week and summer vacations when large numbers of families camp along the shore and harvest fish and shellfish in near shore waters.

In the year 2000 the Marine Recreational Fisheries Statistical Survey (MRFSS) was initiated in Puerto Rico by the Department of Natural and Environmental Resources and by a private contractor in the U.S. Virgin Islands. The sampling efforts were unsuccessful in the Virgin Islands and were not continued in subsequent years in that area. Sampling in Puerto Rico has continued since 2000,. The MRFSS collects catch information on finfish, but generally does not include invertebrates such as conch and lobster. However a special survey to record the number of participants in the recreational conch fishery was conducted by MRFSS in May through September of 2000; it estimated that there were 50,000 participants in the recreational fishery for conch in Puerto Rico and the Virgin Islands during that four month period.

4.2. Recreational Effort

The annual number of recreational angler trips in Puerto Rico as estimated by MRFSS declined from 2000 to 2005 for both shore and private mode fishing (Figure 14.). The number of trips by shore mode anglers declined about 40% from the 2000-2002 average and private mode (on private vessels and rental vessels) angler trips declined about 30%. In 2005 shore mode anglers took about 470,000 trips and private mode anglers took and about 380,000 trips. In contrast the MRFSS survey estimated that the number of angler trips aboard charter boats ranged from about 10,000 trips to about 35,000 trips during 2000-2005.

In Puerto Rico and the U.S Virgin Islands recreational fishing activity by residents is thought to be high during Easter week (when fish consumption increases) and during summer holidays. The MRFSS estimates of shore mode indicates increases in the percentage of angler trips in both shore and private mode from January-February (wave 1) to March-April (Figures 15 and 16). In most years a greater percentage of the annual effort occurred in March-April than in May-June and the March-April effort often represented a similar percentage as in June-July and August-September.

The MRFFS estimated that there were about 55,000 angler trips in the St. Thomas in 2000 compared to more than 1.4 million angler trips in Puerto Rico that same year; about 85% of the estimated angler trips in St. Thomas were by private mode anglers and the remainder was by shore mode anglers. The reliability of the MRFSS estimates for St. Thomas is uncertain due to the difficulties in executing the survey.

4.2.1. Recreational Catch (landings and discards)

SEDAR14 DW03 reported that the MRFSS estimates of the number of mutton snapper killed each year ranged from about 6,000 to about 25,000 and the number released alive ranged from less than 1,000 to about 6,500 each year (Matter 2007). In most years no yellowfin grouper were observed caught by anglers interviewed in the MRFSS field surveys; in the two years when yellowfin grouper were observed the estimated total kill was less than 1,000 fish and none were reported released alive. The calculated coefficients of variation about the estimated kill in Puerto Rico ranged from about 30% to 50% for mutton snapper in private and shore modes, though it is likely that the true uncertainty is higher.

4.2.2. Biological Sampling

There were 111 mutton snapper measured in the MRFSS survey in Puerto Rico in 2000-2005. Roughly 80% of the mutton snapper caught by shore more were less than 30 cm, while about 75% of the mutton snapper caught by private mode anglers were 30 cm or greater (Figure 17).

There were 5 yellowfin grouper measured in the MRFSS survey in Puerto Rico in 2001 and 2003. Those fish ranged from about 60 cm to about 85 cm (Matter 2007).

4.2.3. Sampling Intensity

The MRFSS survey in Puerto Rico observed roughly 0.1% to 0.25% of the estimated total landings of mutton snapper (Matter 2007). However when mutton snapper were observed, nearly all were measured.

4.2.4. Length – Age distributions

Length and age distributions of the catches were not estimated.

4.2.5. Adequacy for characterizing catch

The MRFSS may provide useful information on the magnitude of the recreational landings of mutton snapper taken in the shore and private mode fisheries in Puerto Rico. However the time series is short which is likely to present problems for conventional stock assessment methods.

The MRFSS estimates of the recreational landings of yellowfin grouper in Puerto Rico indicate that the landings are quite low.

The exclusion of conch from the MRFSS is problematic for conducting stock assessments of that species, because the recreational harvest is thought to be large.

The absence of multi-year estimates of the magnitude of species specific catches of finfish in the Virgin Islands for both the recreational and commercial fisheries will be problematic conventional stock assessments for mutton snapper and yellofin grouper.

The absence of estimates of recreational landings of queen conch may not be problematic for St Thomas / St. John because the landings are thought to be low. However the recreational landings of conch in the St. Croix and Puerto Rico are thought to be relatively large and thus the absence of recreational landings estimates would likely be problematic for conventional stock assessments of those resources.

4.3. Research Recommendations

Conduct surveys to estimate the magnitude of the U. S. Virgin Islands recreational landings for all species including conch and lobster. It is possible that using a Virgin Islands constractor would improve the likelihood of success of the survey.

Include conch and lobster in the MRFSS for Puerto Rico.

To adequately characterize catch rates and sizes of mutton snapper caught by recreational anglers in Puerto Rico, very substantial increases in dockside sampling will be needed

4.4. Recreational Fishing in Puerto Rico and the USVI

SEDAR 14
(Yellowfin grouper, mutton snapper, and queen conch)
Graciela Garcia Moliner, Vivian M. Matter, Wes Toller, W. Tobias and Steve Turner

4.4.1. Preface

There is no monitoring of the recreational fishing sector in the US Caribbean other than MRFSS in Puerto Rico. The samples from the MRFSS for yellowfin grouper between 2000 and 2006 are 4; 111 for mutton snapper and none for queen conch. Although the harvest by recreational fishers is believed to be significant, other than MRFSS estimates there are no hard data to estimate this catch.

Local knowledge indicates that the harvest of juvenile fish during camping trips to the shore line (e.g., Eastern week, summer vacations, etc.) could be potentially very high but there is no documentation of these events.

4.4.2. Definition of FMU

The 2005 SFA Amendments to the FMPs redefine FMUs in the Queen Conch and Reef Fish FMP. The FMU in the QC FMP include primarily Strombus gigas , the indicator species for a group that includes the smaller conchs (S. pugilis, S. gallus, S. raninus, S. costatus) and Charonia variegate, Cassis madagascarensis, Fasciolaria tulipa, and Astrea tuber. The greatest part of the catch is S. gigas (A. Maldonado, PR Conch Fisher) and there is very little landing by conch fishers of other species.

The RF FMP FMUs were grouped in units corresponding to similar biological parameters, fishing depth, and occurrence in the multi species landings. The mutton snapper (Lutjanus analis) is in Snapper Unit 3 which includes L. synagris, L. jocu, L. apodus, L. griseus, and L. mahogany. The mutton snapper and lane snapper show the highest landings of the unit and mutton snapper is the indicator species on the unit.

The yellowfin grouper (Mycteroperca venenosa) is the indicator species within Grouper Unit 4 which includes M. bonacci, M. tigris, E. flavolimbatus, and E. morio.

4.4.3. Background Information

The Comprehensive SFA Amendment (2005) includes some of the information available from the recreational harvest but no sector of the recreational/charter fishery has ever been required to surrender landings data nor have these sectors been monitored as regularly as the commercial sector. The reports and studies on the biology of the species including size distributions, length at maturity, age and growth, etc. have seldom if ever included samples from the recreational/ charter harvest with the exception perhaps of HMS.
The SFA document also identified the gaps in the information. One of the largest gaps in information identified was the scarcity of recreational (private, charter, shoreline, divers) data, especially total harvest, catch and effort, and biological parameters of the species such as weights, gear used, areas fished, etc. for the species harvested recreationally.

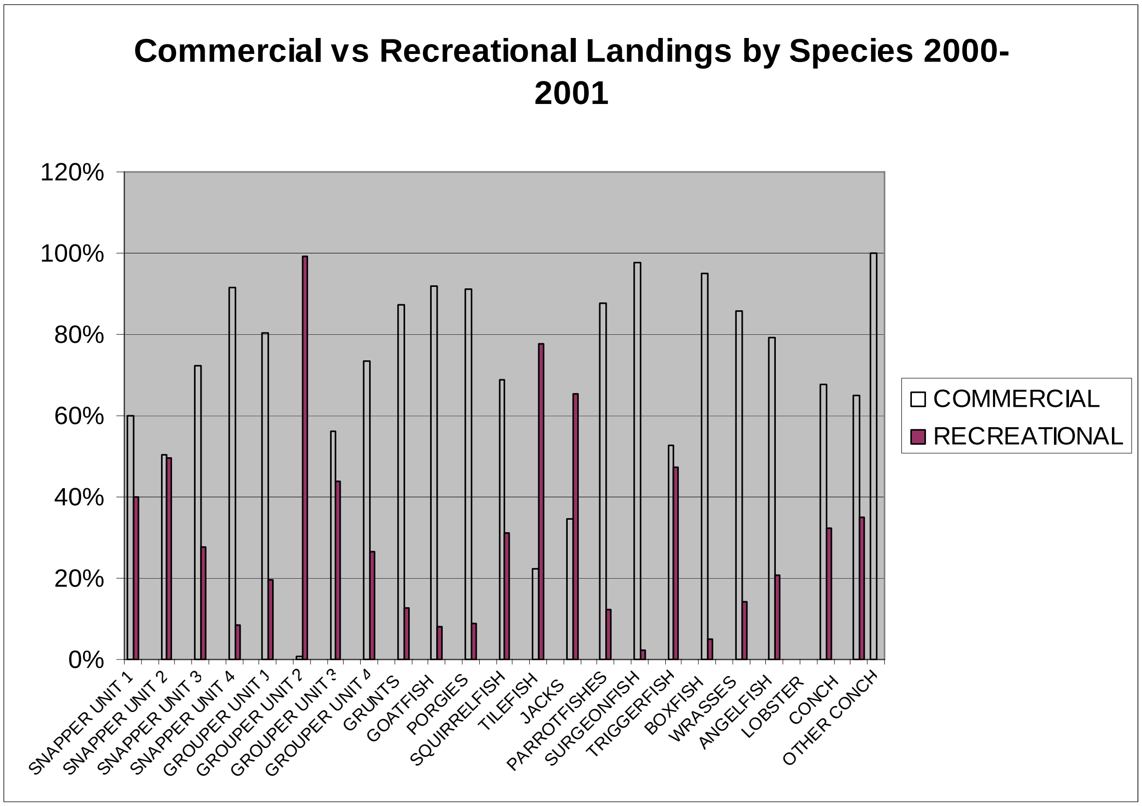
4.4.4. Recreational Catch

4.4.4.1. Puerto Rico

MRFSS was expanded to Puerto Rico at the end of 1999. Data from this survey indicate that total recreational landings in Puerto Rico were 2.8 million lbs and 1.7 million lbs in 2000 and 2001, respectively. Recreational fishermen landed, on average, 1.03 million lbs of Council-managed species, annually, in Puerto Rico during that time period (see Appendix 1; Tables 6 and 7 of the SFA Amendment (2005)). The MRFSS does not collect data on USVI fisheries. Table 6 of the SFA (2005) explains how data on the recreational fishery of Puerto Rico were extrapolated to estimate average, annual, recreational landings in USVI fisheries of 303,069 lbs. Total average annual recreational landings for Puerto Rico and the USVI combined are estimated at 1.3 million lbs. This estimate is only for the reef fish managed by the CFMC. Dolphin fish alone accounts for over 1,000,000 pounds landed per year by the recreational sector. The MRFSS does not collect data on the invertebrates and the estimated landings from the recreational catch are from a survey during 2000 conducted for a period of 3 months in Puerto Rico.

Total recreational finfish catch (i.e., of Council-managed species) for Puerto Rico was 43.77% of commercial finfish landings. For Puerto Rico, the majority of catch occurred in state waters. However, deep water snappers are reported by recreational fishers as much as they are reported by commercial fishers. Most of the fishing for deep water snappers takes place in federal waters. “Other Fishes” (not identified in the MRFSS data set) and snappers make up the majority of the recreational landings in state waters. Dolphin and tuna dominated the recreational catch in the EEZ. Recreational landings of spiny lobster in Puerto Rico reached 128,560 lbs in 2000 and 142,707 lbs in 2001. Recreational landings of queen conch in Puerto Rico are estimated at 140,157 lbs in 2000 and 124,085 lbs in 2001. There is apparently a significant number of fish that are released because (1) they might be ciguatoxic, (2) the charters do not allow fishers to keep most of the catch, (3) fishers are just fishing for fun and/or relaxation. However, this deserves further investigation since in some cases the release of certain edible species is 100%.

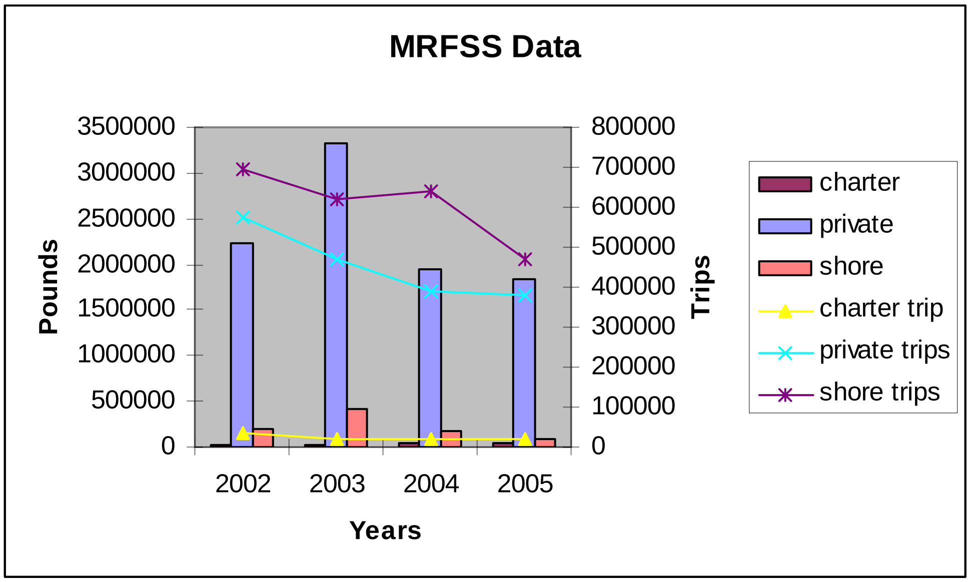
The MRFSS included an add-on to survey partipants in the queen cocn fishery for waves 3 and 4 in 2001. The number of partipants was estimated at over 50,000 for Puerto Rico and the USVI. If these 50,000 harvest the recreational bag limit (3 conch or 1 pound of conch per fisher), the total harvest can be as high as 50,000 pounds per year.



The figure above, that needs to be updated, shows the distribution of harvest by recreational and commercial fishers in the US Caribbean. The recreational fisheries include Goliath grouper (99% recreational), tilefish (78%), jacks (65%), queen snapper (50%), silk snapper (40%) queen conch (35%) and spiny lobster (35%). The overlap in species harvested of commercial value is significant. It is not known if there is a surplus of the species harvested in the reef fish category and thus there is a need to assess the data. In 2000, there were 2,786 field intercepts from MRFSS. In 2001, there were 222,128 recreational fishers in Puerto Rico (MRFSS). The information on the landings by species and mode, including the number of fishers involved in the fisheries has been requested from MRFSS. The data available on size distribution of yellowfin grouper and mutton snapper from 2000 to 2006 show a total of 5 yellowfin and 111 mutton. No samples for queen conch are available.

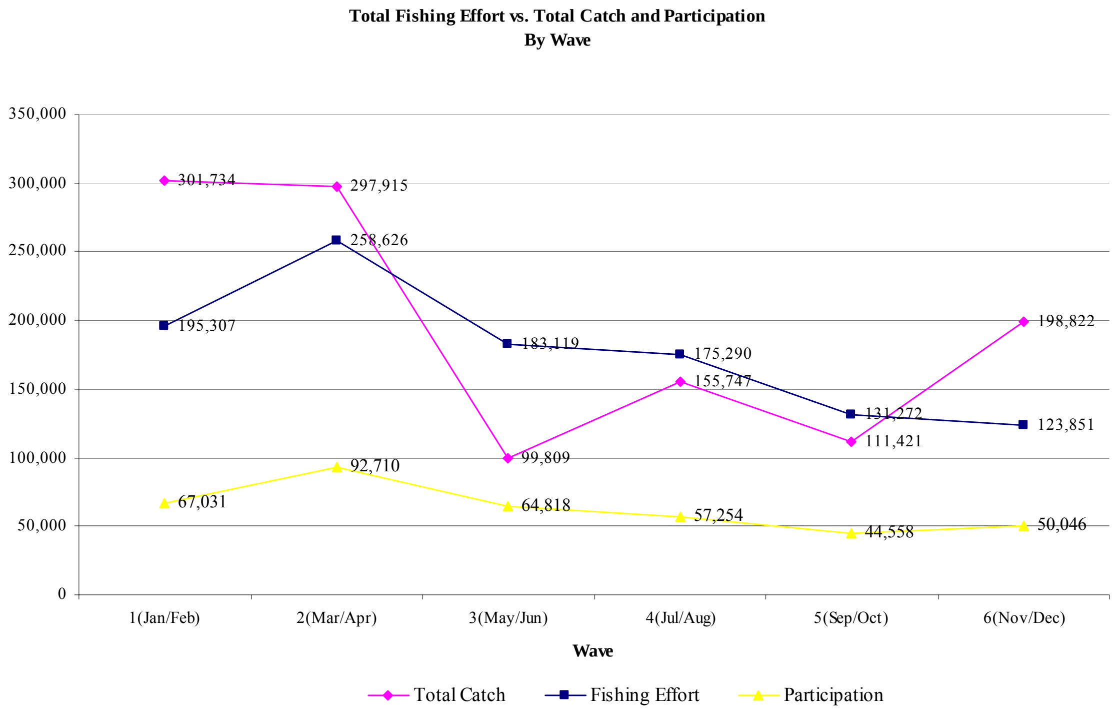
Appeldoorn and Valdés-Pizzini (1996) conducted a three-month survey targeting Puerto Rican recreational boat users who trailered their boats. A total of 312 boats were surveyed; 41 reported fishing and four of these reported fishing for queen conch while snorkeling. They also sampled finfish during the survey and showed that many of the fishes harvested by the recreational sector were juveniles. They also reported that, aside from clupeids taken for use as bait, the most caught species were silk snapper, red hind, and lane snapper. Most trips targeted groupers and snappers. This corroborates the available MRFSS data for Puerto Rico, which indicates that silk snapper, lane snapper, queen snapper, black durgeon, and red hind were the predominant recreational species. Jacks also were a major recreational target, but were not identified by individual species.

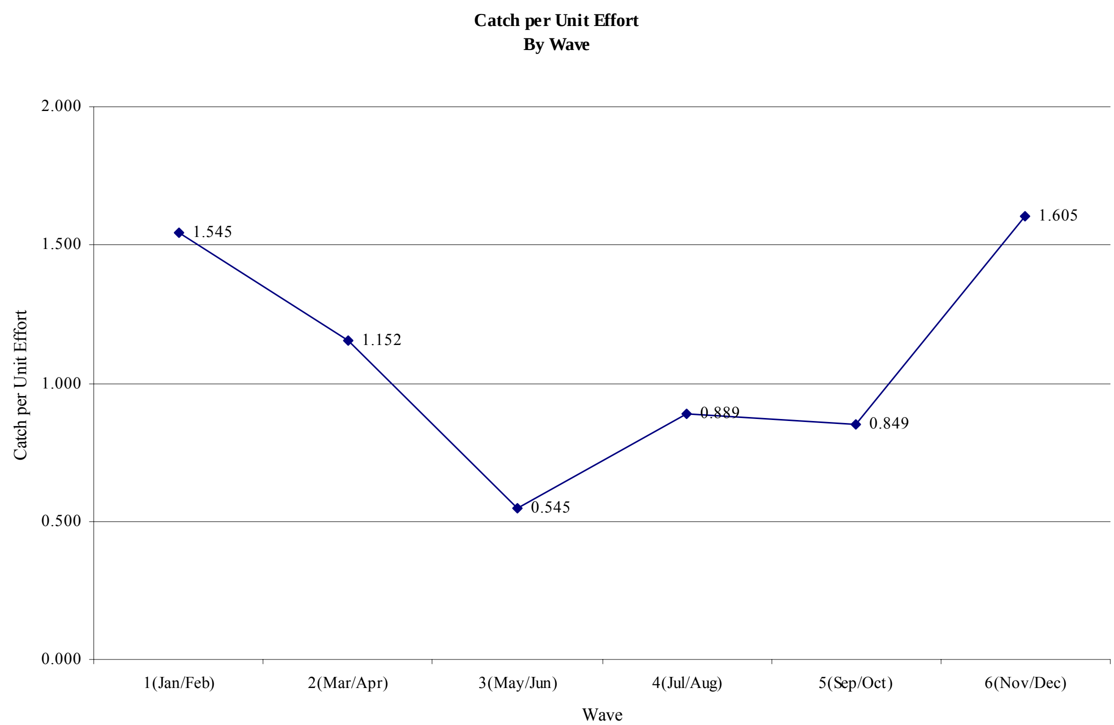
The MRFSS query showed that most of the harvest of dolphin, tunas and mackerels and barracuda is from the EEZ; some groupers and snappers (including yellowfin grouper (n=2 out of 5) and mutton snapper (n=12 out of 111) are reported from the area beyond the 10 mile territorial limit for the years 2001-2005. The size distribution of the mutton snapper indicates that 56 are under the minimum size at maturity for females (Figuerola and Torres) determined from the commercial catch and 55 are over the minimum size.



The figure shows the decrease in the number of trips taken from 2002 to 2005 for each of the fishing modes reported to MRFSS (lines) as well as the changes in the catch. At this time there is no further breakdown of species being landed for each year beyond the general categories of dolphin fish, tunas, mackerels and groupers, etc. The data have been requested from the NMFS. Dolphin fish and tunas account for about 50% of the totals reported. Landings estimates range from a low of 2 million pounds to 3.5 million pounds in 2003. It is not known if the survey effort has decreased or if the number of participants has decreased.

(DRNA PR 2005) reported for 2004 that shoreline trips accounted for 60% of the recreational/charter fishing trips with private/rental trips accounting for 38% and charter trips 2.1%. The seasonality of the trips varies for each mode but the period January through April appears significantly different from the rest of the year for all modes; highest number of trips was recorded during March-April (Holy Week, a religious period when fish consumption increases) as well as highest catch. Fishing effort being highest in the March-April months does not coincide with highest CPUE. Highest CPUE was reported during November-December. Highest number of charter trips was reported during January-February and November-December. The number of charter increases during the high, non-local tourist season. Private/rental boats showed increased number of trips during March-April and July-August (summer vacation and local-Caribbean wide high tourist season).





(CLAPP AND MAYNE, INC. 1979) indicated the most common used gear by recreational fishers was hook and line (62% casting/fishing rod) and 43% bottom fishing) with a proportion corresponding to 98% of the respondents using this gear (85% of the commercial fishers used this gear). The other most common gear was speargun (28%) for recreational fishers (commercial fishers with 25%). Less than 27% of the respondents used nets or traps when recreationally fishing (over 50% of the commercial fishers reported using traps and nets). The MRFSS database needs to be assessed for the use of other gears by recreational fishers in Puerto Rico.

4.4.4.2. USVI

There are no on-going projects in the USVI to collect recreational data from the reef fish or queen conch fishery. One project collected information from the logbooks voluntarily filled out by offshore recreational fishermen, and the second project collected information from nearshore recreational fishermen. Both projects ended in 2001. The offshore fishermen target primarily blue marlin, dolphin fish and wahoo. Of 563 recreational nearshore anglers interviewed in the USVI between 1995 and 1998, fishermen most frequently reported catch of French grunts, jacks, and yellowtail snappers (I. Mateo, USVI/DPNR). The reports available from the USVI describe the recreational shoreline, pier, tournament and offshore private boat fishing activity. There is no detailed information on the charter fleets of the USVI. The offshore marlin fleet was monitored (e.g., Brandon 1989, Friedlander 1995) since the area has been described as one of the most productive marlin grounds in the Caribbean. There are no yellowfin grouper reported from the recreational sector in the USVI (W. Toller and T. Tobias); mutton snapper were sampled from the shoreline fishers. The data need to revised. (TO DO)

Other surveys reported on non-charter recreational activity (JENNINGS 1992), marine recreation services (HINKEY-MACDONALD; QUINN and others 1994) and socio-economics of recreational boating and fishing ((OLSEN 1979) but all with very limited information on the charter operations and with limited sampled data on recreationally caught fish. One report estimated a charter fleet of about 150 for St. Thomas, with over 40 of these vessels coming from the US mainland during the marlin season, and about 30 charter operations in St. Croix.

The first quantitative report on the shoreline recreational fishery of St. Croix shows that two (out of a total of 48 species reported) of the most frequently caught fishes (mojarras and anchovies) were primarily used as bait for barracuda and yellowtail snapper (Adams 1997). It also suggests that the shoreline fishery is declining, with CPUE declining since 1995, with increased effort every year. Among the species landed were red hind, yellowtail snapper, and seven other species of snappers, grunts, etc. These were caught using hook and line and nets (Adams 1995).

(Mateo; R. Gomez; K. Roger Uwate; B. Kojis, and D.C. Plaskett 2000) offers the most complete information on the limited sampling that was done between 1995 and 2000 of the recreational survey in St. Thomas and St. Croix. The species reported during shoreline tournaments (limited to Mother's Day tournament in St. Thomas offer a limited glimpse at the species caught (fate unknown) of very small reef fish (the heaviest fish was a trunkfish weighing 3.42 pounds).

Jennings (1992), from a telephone survey conducted in 1986, estimated fish harvest by recreational fishermen in the USVI at 24,648 kg-fish annually (54,226 lbs. /year). The most frequently reported species were yellowtail snapper and red hind, in addition to mackerels and tunas reported specifically from St. Croix. In the mid-1980s, 10% of the residents of the USVI fished recreationally. Jennings (1992) indicates that the proportion of anglers fishing from the shoreline in St. Croix was higher than in St. Thomas/St. John. Bottom fishing and trolling from recreational vessels were the most frequent fishing activities targeting reef fish and were most common in St. Thomas.

(OLSEN 1979) estimated the recreational (based on a 12% response rate) landings at about 448,600 pounds annually. Furthermore, for reef fish (over 105,000 pounds annually) combined with the commercial catch of 1.6 million pounds annually was so close to the estimated MSY (Kumpf 1978) that "It is clear that the user groups are approaching a situation where allocation may be required (page 16)."{The SFA (2005) estimate for the recreational catch in the US Caribbean was estimated at about 1 million pounds compared to the commercial catch of 2.2 million pounds.}

In 1978 there were 1,789 registered boats in the USVI. The definition of recreational fisherman was at the time all inclusive " is part of a population which may range from resource users that haul up to 100 traps three days a week to the snorkeler who may use the resource once … a month". The work of Olsen has not been repeated in the USVI and the information contained therein needs to be updated. The report includes information on the household income, boat characteristics (HP Length, etc.) fishing gear and the general information on age, ethnicity, education as well as the expenditures and costs associated to recreational fishing. In 1978-1979, less than 2% of the fleet carried passengers for hire. The charter fleet was not adequately sampled but it was estimated at 200 to 300 vessels employed in the charter business.

Harvesting preferences at the time (OLSEN 1979) included lobster diving, spearfishing and diving for conch; in terms of effort the dolphin and the snappers and groupers were most frequently sought. Trap fishing was also included in the results but appears to be from commercial fishers rather than recreational as the estimated landings are over 1 million pounds.

4.4.5. Social and Economic Information

In 1988, the marine recreational fishing activities needed little development in the USVI ((GRIFFITH; JOHNSON and others 1988)), while more effort was needed in Puerto Rico in support of recreational fisheries. The pilot work of the MRFSS and the socio-economic survey indicated that commercial fishers were already partaking on the development of a recreational fishery on the Island. In 1988, there were 4 charters in Puerto Rico and 4 in St. Thomas that were identified and the recommendation was to support the expansion of this fleet. At the same time it was recommended that the recreational fishing sector be monitored and data be collected to manage the fleet.

There are few studies after the 1980's collection of papers and virtually no monitoring of the recreational fishing activity until 2000 in Puerto Rico and 2002 in the USVI. The (H. JOHN HEINZ III CENTER) report includes a brief discussion on the lack of information on the recreational sector, the need for data collection and the management burden carried by the commercial fishers in the US Caribbean.

4.4.6. Fishers

Presently, Puerto Rican recreational fishermen 13 years and older (excluding those fishing off charter or head boats) are required to have a license. Information on the recreational fleet, charter fleet, and fishing enterprises other than the licensed commercial fleet is scant. Queries run on the NOAA Fisheries MRFSS dataset indicate that Puerto Rico had 222,128 recreational fishermen in 2001, and 28,757 of these were from out-of-state. In contrast, Schmied (1989) reported only 81,000 resident marine recreational fishermen (from about 23,000 boats) for Puerto Rico. A creel census of 132 recreational shoreline anglers and 20 boat-based anglers was conducted in the area of Guanica State Forest between October 1997 and September 1998 (Silva et al. no date). The age of anglers was not dominated by any one group, but the 41-50 year old group (24.4%) was the most common. Shoreline-based angler effort was highest in August, June, and October; and lowest in January and March. Recreational anglers in Puerto Rico made approximately 1.4 million fishing trips in 2001 (NMFS 2002), of which 0.9 million were from shore, 0.5 million were from private boat, and 11,000 were from charter boat. This work needs to be revised for species sampled.

A telephone survey of a subset of USVI registered boat owners (n=120) who used their vessels for recreational fishing was conducted in 2000 (Eastern Caribbean Center 2002). Based on that survey the number of boat-based recreational fishermen was estimated at 2,509 for the USVI (712 from St Croix and 1,797 from St. Thomas/St. John). These fishermen were predominantly male (96.7%), with a mean age of 47.5 years old, and were of various ethnic heritages, education levels, and income levels. The number of recreational fishermen in the USVI (boat-based and shore-based fishermen) was estimated to be around 11,000 people in 1999, about 9.2% of the population, which is roughly the same proportion that Jennings (1992) found in 1986 (see Mateo 1999; Eastern Caribbean Center 2002). A survey of 312 boats taken at boat ramps stated that only 41 vessels (13%) reported fishing as one of their activities (Appeldoorn and Valdés-Pizzini 1996). Of these 41 vessels, 80% used hook and line/rod and reel gears.

A total of 814 recreational anglers were counted on St. Croix, of which 404 were interviewed (Eastern Caribbean Center 2002). The highest fishing effort took place in the afternoon hours and during the months of May through July. Most of the fishing areas however are nursery grounds where juveniles of species occur. The USVI Division of Fish and Wildlife, Department of Planning and Natural Resources (DPNR) is currently assessing the recreational fishery of the USVI.

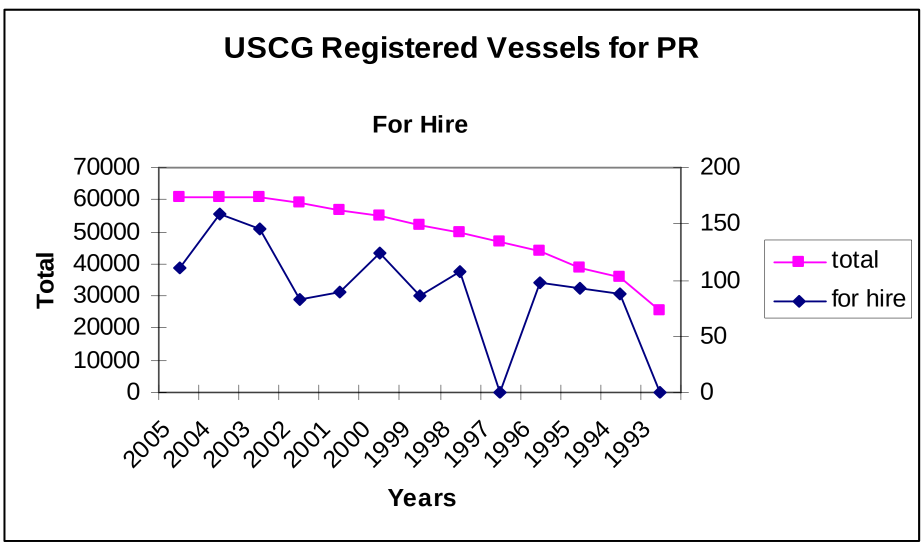
Eastern Caribbean Center survey (2002) found that trolling was reported as the most common boat-based fishing method in the USVI (59.7%), followed by bottom fishing (22.7%). However, Jennings (1992) states that bottom fishing (70%) was more common than trolling (20%) in 1986. Eastern Caribbean Center (2002) found that about half (53.3%) the USVI recreational fishermen fished in territorial waters (< 3 mi from shore), while 46.7% fished in federal waters. The most preferred fish group was snappers, followed by dolphin and tuna, and the majority of the catch (72.9%) was used for personal consumption. On average USVI boat-based fishermen make two fishing trips a month and fish about 4 hours per trip (Eastern Caribbean Center 2002). The total USVI boat-based recreational fishing hours in 2000 was estimated to be 320,204 hours.

The average cost of a USVI recreational fishing trip was $125.11, which included gear, bait, ice, refreshments, food, fuel, launching fees, lodging, auto transportation, and charter and guide fees, among other costs (Eastern Caribbean Center 2002). Most gear was purchased in the USVI (77%), but about half of the electronics were bought outside the USVI. Average USVI boat ownership costs were about $2,104.13 annually. Total boat-based recreational fishing expenditures in the USVI in 2000 were approximately $5.9 million, with St. Thomas/St. John contributing about $4.8 million to the total.

4.4.7. Boats

All recreational vessels in Puerto Rico must be registered with the DNER. There are a number of charter boats (trolling and bottom fishing), diving boats, shoreline fishermen, and recreational fishing boats (privately-owned vessels) but information on fishing effort, catch, or other information is largely unknown. Most of the information available from the recreational fishing sector deals with tournament data on species such as marlin and dolphin.

The total number of recreational boats registered in Puerto Rico in 1995 (DNER 1995 unpublished data) was reported as 35,931 registered vessels – including personal watercrafts (jet skis). The total number of boats registered in Puerto Rico during 1996 was 44,049, indicating an increase of 8,118 boats in one year. The total number of registered vessels (also including jet skis) in Puerto Rico during 2005 was 61,026. The number of for-hire (passenger and commercial other than commercial fishing vessels) was 93 (for 1995), 98 (for 1996) and 111 for 2005. The figures below show the number of registered vessel for Puerto Rico, by size, from 1993 to 2004(2005).



From 2004 to 2005, the number of for-hire vessels decreased from159 to 111. No explanation is available for the drop in for hire vessels.

Eastern Caribbean Center (2002) reported 2,462 registered boat owners in the USVI, with 566 of these from St. Croix and 1,896 from St. Thomas/St. John. However, the number of recreational vessels registered in the USVI in 1997 was estimated to be 5,000 (L. Roberts, USVI/DPNR Division of Environmental Enforcement personal communication). In addition, numerous other recreational vessels are reported in transit through the USVI. Average USVI recreational boat length is 22.8 ft, with most (81.6%) less than 30 ft, while only 5% were 40 ft or greater in length (Eastern Caribbean Center 2002). Downs et al. (1997) found eight charter fishing businesses operating in St. Thomas and two in St. John run mostly by “continentals” from the mainland U.S., with vessel sizes ranging from 25 to48 feet in length. None of these vessels was licensed to carry more than six passengers, and the larger vessels were crewed by a captain and mate. These charter vessels tended to target pelagic fishes and sharks, and the catch not retained by customers was sold to restaurants and hotels. The fees for charter and commercial boats are $37.50, $75.00, $150.00, $225.00 and $300.00 for vessels in the categories < 16'; 16 – 26', 26 – 40', 40 – 65' and >65'. The recreational vessels in the same categories pay a fee of $25, 50, 100, 150 and 200.

García-Moliner et al. (2002) found that fishing charter activity has increased in the U.S. Caribbean since the survey by (Downs; J.S. Petterson; E. Towle, and L.L. Bunce 1997). In 2000, a survey identified 46 year-round charter-fishing operations, 27 in the USVI and 19 in Puerto Rico. These operations included 60 vessels. Additional seasonal operations exist during the June-September blue marlin season. Most of the charter vessels fish off shore and target pelagic species, but some offer inshore and reef fish trips as well. The charter industry considered reef fish availability as “fair.” Charter and head boats are not required to maintain records and there is no information available to describe activities of these groups, targeted species, effort, etc. Establishment of needed socioeconomic research and expanded data collection from charters is necessary to assess the US Caribbean fisheries. Both the yellowfin grouper and the mutton snapper are listed in the surveys as target species. No data are available on the amount of fish harvested.

Of over 100 dive-charter operations in the U.S. Caribbean, 37% of those in Puerto Rico and 21% of those in the USVI allowed fishing ((Garcia-Moliner; W.R. Keithly, and I.N. Oliveras 2001)). Fishing during dive trips targeted lobsters, queen conch (hand harvest) and fish (spear fishing).

4.4.8. Charter

The for-hire boating activity has changed considerably over the years. The sport fishing industry for highly migratory species such as the blue marlin was the predominant sector of the charter operations. Figure of the for-hire vessels from 1993 to 2005 shows the changes in the industry. There are missing data for 1993, 1997 and 2005, and changes in the reporting that merit further investigation. The for-hire vessels carrying more than 6 passengers are required, among other things, a USCG Captain license. Efforts are being made to acquire any data that are available to further identify the charter operations in the US Caribbean.

The work done in the 1970s and 1980s pointed to the potential development of these activities in the US Caribbean (e.g., (CLARK; DITTON and others 1994), (CHAPARRO 1992), (VALDES-PIZZINI and others 1988), (VALDES-PIZZINI and others), (VALDES-PIZZINI 1986)). At the time, there was information on the cost of operation, the investment and return of recreational fishing, etc. Recent studies on the socio-economics of the charter and recreational fishing sectors are not available.

Over the past few decades there has been further development of the near shore for hire fishing operations with diversification to include: the flats (tarpon and snook), the reefs (groupers and snappers) ((Thoemke 2000), (GARCIA-MOLINER and others 2002)), the near shore pelagics such as mackerels and the dolphin and wahoo in addition to the well established fleet for marlin and other bill fish and tuna.

4.4.9. Problems and Recommendations

The information and data that is currently not available is directly relevant to disseminating the status of managed marine resources (e.g., MSY, OY, etc.), as well as evaluating potential impacts resulting from any proposed management alternatives. Because of the lack of discrete biological data for the U.S. Caribbean, managers are handicapped and must rely on related studies conducted, and information gathered, in other geographic areas.

The first attempt through Dingell-Johnson funds to collect recreational (sports) fishing data was in 1973 (PRDNER –Suarez-Caabro El Mar de Puerto Rico 1979). A total of 1,564 questionnaires were sent out, receiving 296 in return of which 284 were active sports fishers in 1972-1973. In 1971, the 284 fishers landed 215,000 lbs and based on this an estimated 1,000,000 lbs were reported as landed by the sportsfisher in Puerto Rico. At the time there were an estimated 2,500 boats between 20 and 45’ for sport fishing. Sixty five per cent (65%) of the respondents had their own vessel and mostly fished with rod and reel. The most commonly landed fish were groupers (Epinephelus sp.) but, by weight, the most landed were blue marlin and dolphin fish. Schmied (1989) reported 81,000 resident marine recreational fishers (over 23,000 boats) for Puerto Rico. The reports for D-J have been requested from PR DNER (follow up).

The most recent published information on recreational fishing activity, other than for pelagic species, dates back to 1986 (Jennings, 1992) in the U.S. Virgin Islands, and 1989 in Puerto Rico. Jennings (1992), from a telephone survey conducted in 1986, indicates that in St. Croix the proportion of anglers fishing from the shoreline is higher than in St. Thomas/St. John. Bottom fishing and trolling from recreational vessels were the most frequent fishing activities targeting reef fish and were most common in St. Thomas.

A total of 814 anglers were counted on St. Croix, of which 404 were interviewed. The highest fishing effort took place in the afternoon hours and during the months of May through July. Most of the fishing areas however are nursery grounds where juveniles of species occur. The U.S. Virgin Islands Division of Fish and Wildlife, Department of Planning and Natural Resources (DPNR) is currently assessing the recreational fishery of the U.S. Virgin Islands.

Recreational fishing activity has continued to increase but with little data collection effort. This activity has always been assumed to be for sport and pleasure and with the ultimate fate of the product to be consumed at home – for personal use or be given away; not entered into commerce. It is primarily in tournaments that the amount of fish harvested exceeds the “for personal use” definition. The disposition of the excess harvest is unknown.

There is a bag limit in place for the queen conch (across jurisdictions) that establishes a catch of three conchs per fisher to a maximum of 12 per boat per day. The sale of queen conch and fish by recreational fishers is currently prohibited.

Appendix 1: From Table 7 of the Comprehensive SFA Amendment (2005): Recreational and commercial catch for the US Caribbean (requested update will be available after March 2007)

Table 7. Continued.

REEFFISHES					
GRUNTS	172,960	25,168	198,128	87%	13%
GRUNT, WHITE					
PORKFISH					
MARGATE					
GRUNT, BLUESTRIPED					
GRUNT, FRENCH					
GRUNT, TOMTATE					
GRUNTS, UNC					
GOATFISH	22,752	1,995	24,747	92%	8%
GOATFISH, SPOTTED					
GOATFISH, YELLOW					
GOATFISHES, UNC					
PORGIES	41,143	3,947	45,090	91%	9%
PORGIES, UNC					
PORGY, JOLTHEAD					
SEA BREAM					
PORGY, SHEEPSHEAD					
PORGY, PLUMA					
SQUIRRELFISH	19,104	8,710	27,814	69%	31%
BIGEYE					
SQUIRRELFISH, LONGSPINED					
SQUIRRELFISHES, UNC					
SOLDIERFISH, BLACKBAR					
SQUIRRELFISH					
TILEFISH	667	2,331	2,998	22%	78%
TILEFISH, UNC					
TILEFISH, BLACKLINE					
TILEFISH, SAND					
JACKS	117,226	220,802	338,028	35%	65%
BLUE RUNNER					
HORSE-EYE JACK					
BLACK JACK					
ALMACO JACK					
BAR JACK					
GREATER AMBERJACK					
JACK, YELLOW					
JACKS, UNC					
PARROTFISHES	278,244	38,593	316,837	88%	12%
PARROTFISH, BLUE					
PARROTFISH, MIDNIGHT					
PARROTFISH, PRINCESS					
PARROTFISH, QUEEN					
PARROTFISH, RAINBOW					
PARROTFISH, REDFIN					
PARROTFISH, REDTAIL					
PARROTFISH, STOPLIGHT					
PARROTFISH, REDBAND					
PARROTFISH, STRIPED					
PARROTFISH, UNC					

Table 7. Continued.

SURGEONFISH	34,883	833	35,716	98%	2%
TANG, BLUE					
SURGEON, OCEAN					
DOCTORFISH					
SURGEONFISHES, UNC					
TRIGGERFISH	110,050	98,228	208,278	53%	47%
FILEFISH					
FILEFISH, SCRAWLED					
FILEFISH, WHITESPOTTED					
TRIGGERFISHES, UNC					
TRIGGERFISH, OCEAN					
DURGON, BLACK					
TRIGGERFISH, SARGASSUM					
TRIGGERFISH, QUEEN					
BOXFISH	108,428	5,624	114,052	95%	5%
BOXFISH, UNC					
COWFISH, HONEYCOMB					
COWFISH, SCRAWLED					
TRUNKFISH					
TRUNKFISH, SPOTTED					
TRUNKFISH, SMOOTH					
WRASSES	58,602	9,798	68,400	86%	14%
HOGFISH, SPANISH					
WRASSES, UNC					
PUDDINGWIFE					
HOGFISH					
ANGELFISH	6,391	1,688	8,079	79%	21%
ANGELFISH, QUEEN					
ANGELFISH, GRAY					
ANGELFISH, FRENCH					
Finfish Total =	2,288,550	1,001,735	3,290,285	70%	30%

SPINY LOBSTER FMP					
LOBSTER, SPOTTED SPINY					
LOBSTER, SPINY	370,856	175,784	546,640	68%	32%
QUEEN CONCH FMP					
CONCH	287,364	151,584	438,948	65%	35%
OTHER CONCH	1,616	0	1,616	100%	0%
GranTot =	2,948,386	1,329,103	4,277,489	69%	31%

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5. Indices Of Abundance

Tables 5-1 and 5-2 summarize the available indices of abundance and potential data sets for developing indices of abundance of queen conch, yellowfin grouper, and mutton snapper in Puerto Rico and the U.S. Virgin Islands. The data sources, units, available years, and methodologies used to construct indices for the data workshop are summarized in Table 5-1. The recommendations of the SEDAR 14 DW index of abundance working group for use of the various known data sets are described in detail below, and in Table 5-2.

5.1. Fisheries Dependent Indices

A number of indices were developed for queen conch in Puerto Rico and the US Virgin Islands using available commercial effort and landings data. Models developed by Valle-Esquivel for the 2002 assessment were used, as well as, newly developed models.

Nominal CPUE series from Puerto Rico commercial effort and landings data were prepared for yellowfin grouper and mutton snapper. A number of data issues were presented in plenary for discussion and clarification.

5.1.1. Puerto Rico Queen Conch

5.1.1.1. General Description:

The construction of the commercial handline index is described in the document SEDAR 14-DW-5.

Landings and fishing effort of commercial vessels operating in Puerto Rico are monitored by the Fisheries Research Laboratory of the Puerto Rico Department of Natural and Environmental Resources (DNER). The program collects landings and effort data from coastal municipalities and major fishing centers in Puerto Rico. The available catch per unit effort (CPUE) series, from 1983 – 2005 were used to develop several abundance indices for queen conch. An initial series of indices were developed using the models of Valle-Esquivel (2002a) from a previous queen conch assessment. New models were also developed for Puerto Rico and southwest Puerto Rico.

In Puerto Rico fishers may report multiple trips on a single sales record (report to DNER). Only single trip records were included in the dataset. Two approaches were used to define single record trips and an index was constructed for each approach. One approach defined single trip records if the sales record indicated that trips=1 or if trips was reported as 0 or if number of trips was missing (Valle-Esquivel, 2002b). A second approach included only those data that included trips=1 on the sales record. Trips were additionally limited to those that reported SCUBA, skin diving, or spear fishing as the fishing gear used.

Puerto Rico lognormal 2002 model

Indices of abundance were constructed using the lognormal model of Valle-Esquivel (2002a). Following Valle-Esquivel's methods, trips that reported landings beyond 99.5% of the combined multispecies cumulative distribution of landings or less than 1% of the conch landings distribution were excluded from the analyses. A factor, COAST, was included that divided the island into four regions: north (fishing centers 10-170), east (180-251), south (260-362), and west (370-423; see Valle-Esquivel, 2002b for a map of these locations). This definition of COAST differs from Valle-Esquivel (2002a) in that there are only four regions defined rather than seven. This was done to ensure larger sample size for the analyses. Year, month, and gear were also included as additional factors in the analysis. CPUE was defined as pounds of conch landed per trip. The Valle-Esquivel 2002 lognormal model was fit using the procedure Proc Mixed in SAS and included a correction of log transform bias modified from an algorithm developed by Lo et al. (1992).

Puerto Rico delta lognormal 2002 model

A second pair of indices was constructed using the Valle-Esquivel 2002 delta lognormal model. The dataset used to construct two indices including factors similar to those described for the lognormal (positive trips) indices above. Trips in the delta lognormal analyses included all trips with the reported gears SCUBA, skin diving, and spear fishing with the pounds landed limitations listed above. The assumption was that such trips had the potential to catch conch. The development of the delta lognormal indices included a binomial model of the proportion positive trips in addition to the lognormal model on positive trips following the methods of Lo et al. (1992). The two definitions of single trips (trips=1, 0, or missing vs. trips=1), coast, month, and year were again included separately in two versions of the final model (Valle-Esquivel, 2002a).

Southwest Puerto Rico lognormal 2002 model

The dataset used to construct these indices was limited to trips landing conch in southwestern Puerto Rico (fishing centers 370-384) and included significant factors from the Valle-Esquivel 2002 lognormal model for southwest Puerto Rico. Only positive trips were included in these analyses and the two definitions of single record trips (trips=1, 0, or missing and trips=1) limited the dataset for the analyses. The factor COUNTY (Lajas, Cabo Rojo, and Mayaguez; see Valle-Esquivel, 2002a for a map of these locations) was included rather COAST (Valle-Esquivel, 2002a). Other factors were similar to the previous analyses. The index was developed following the methods described for the Puerto Rico lognormal 2002 model.

Additional Indices

Additional lognormal and delta lognormal indices were developed for Puerto Rico and southwest Puerto Rico. The two approaches to defining single record trips (i.e. trips=1, 0, missing vs. trips=1 reported on the sales record) were used to develop separate indices. Data were further limited by including only trips that reported using SCUBA, skin diving, or spear fishing and excluded trips that reported landings beyond 99.5% of the combined multispecies cumulative distribution of landings or less than 1% of the conch landings distribution.

5.1.1.2. Index Development

For the Puerto Rico lognormal and delta lognormal indices, seven factors were considered as possible influences on the CPUE and the proportion of positive trips:

Factor	Levels	Value
YEAR	23	1983-2005
MONTH	12	January-December
WAVE	6	Two month periods; January-February, etc.
SEASON	4	Three month periods; January-March, etc.
GEAR	3	SCUBA, skin diving, spear fishing
COAST	4	North, east, south, west as defined above
TARGET*	2	1=only conch landed, 0=other species landed, may also have landed conch

*TARGET was excluded from the binomial portion of delta lognormal analyses because all TARGET=1 trips are positive

An initial lognormal model on positive trips was developed for Puerto Rico. CPUE was defined as pounds of conch landed/trip. The final lognormal model was fit using the procedure Proc Mixed in SAS and included a correction of log transform bias modified from an algorithm developed by Lo et al. (1992).

The delta lognormal model approach (Lo et al., 1992) was also used to develop standardized indices of abundance for the conch data. This method combines separate GLM analyses of the proportion of successful trips (trips that landed conch) and the catch rates on successful trips to construct a single standardized CPUE index.

Southwest Puerto Rico

Indices developed from southwest Puerto Rico data followed the methods and data limitations listed above for the indices constructed for the whole island. For the southwest

Puerto Rico lognormal and delta lognormal indices, five factors were considered as possible influences on the CPUE and the proportion of positive trips:

Factor	Levels	Value
YEAR	23	1983-2005
SEASON	4	Three month periods; January-March, etc.
GEAR	3	SCUBA, skin diving, spear fishing
COUNTY	3	Fishing centers of Lajas, Cabo Rojo, and Mayaguez
TARGET*	2	1=only conch landed, 0=other species landed, may also have landed conch

*TARGET was excluded from the binomial portion of delta lognormal analyses because all TARGET=1 trips are positive

5.1.1.3. Results:

Replication of 2002 Puerto Rico indices

Puerto Rico Lognormal

The updated indices were very similar regardless of how trips were defined and were generally similar to the 2002 index over the second half of the time series beginning in 1992 (Figure 5-1). Until 1989, the updated indices had highly variable mean CPUEs and differed from the 2002 index during 1984 and 1986. Relative abundance indices and coefficients of variation are provided in Table 5-3. Since 1990 there was no apparent trend in CPUE in either the updated indices or the 2002 index. Differences between the updated indices and the 2002 index may be due to updated data and edits of those data. Sample sizes are generally low during the first five years of the time series and any data edits may have a substantial effect on the analyses. Also, redefining COAST to ensure adequate sample size probably explains some of the observed differences. The reliability of the Puerto Rico landings and effort data prior to 1989 were questioned during plenary session at the SEDAR 14 data workshop. During those years the data collection program was beginning and data collection was not fully standardized. It was recommended that data from those years be excluded from analyses.

Puerto Rico Delta-lognormal

The updated delta-lognormal indices (trips=1, 0, or were missing and trips=1) are similar to the 2002 index (Figure 5-1), although there are differences in some years, particularly prior to 1989. Relative abundance indices and coefficients of variation are provided in Table 5-3. As with the lognormal indices, differences may be due to data updates and editing completed since 2002 and the redefined factor COAST. CPUEs varied considerably over time during the first six to seven years of each time series, perhaps due to the haphazard nature of early data collection. There was no clear trend in CPUE over the remainder of the series.

Southwest Puerto Rico Lognormal

The updated lognormal index (trips=1, 0, or were missing) was more similar to the 2002 index than the updated index developed from data where only trips=1 were included (Figure 5-1). After 1989 all three indices were in general agreement and none had any apparent trend in CPUE since 1989. Relative abundance indices and coefficients of variation are provided in Table 5-3. Minor differences in the 2002 index and the updated index (trips=1, 0, or missing) may, again, be due to problems during the initial years of data collection and subsequent data editing since 2002.

Additional Puerto Rico Indices

Puerto Rico lognormal indices

Relative abundance indices and coefficients of variation are provided in Table 5-4. The standardized indices are provided in Figure 5-1. These two indices are very similar, with large variability early in the time series and no apparent trend in CPUE since 1990.

Puerto Rico delta-lognormal indices

Relative abundance indices and CVs are provided in Table 5-4. The delta-lognormal Puerto Rico standardized abundance indices are shown in Figure 5-1. These two indices differed in a few of the initial years of the time series and diverged again beginning in 1998. CPUEs for trips=1 were slightly higher over the last seven years of the series.

Southwest Puerto Rico lognormal indices

Relative abundance indices are shown in Figure 5-1. Relative abundance indices and coefficients of variation are provided in Table 5-5. These two indices differ little aside from some differences early in the time series. Neither had a strong trend in CPUE since 1990, although there was a slight increase in mean CPUE over the 1990-2005 period. As in the other Puerto Rico indices, data collection issues prior to 1989 may be the cause of the highly variable CPUEs during the beginning of this time series.

Southwest Puerto Rico delta-lognormal indices

Relative abundance indices and CVs are provided in Table 5-5. The delta-lognormal southwest Puerto Rico standardized abundance indices are shown in Figure 5-1. These two indices differed greatly only in 1988, however they were both much lower in the first two years of the series than were the CPUEs of the lognormal indices for southwest Puerto Rico. In addition, the delta-lognormal indices had higher CPUEs in 1992 and 1993 than did the lognormal indices. Over the last 11 years, however, all the indices were in close agreement and showed no strong trend in CPUE, although there has been perhaps a slight increase in mean CPUE.

5.1.1.4. Utility:

The SEDAR 14-DW working group recommends further exploration of the Puerto Rico dataset that should include constructing revised indices with the following guidelines:

1) eliminate data from the years prior to 1989
2) include only those trips clearly labeled as "Trips=1"
3) include only those trips landed from fishing centers identified as having conch landings or that had >1% of reported landings and were contiguous with other centers identified as important for conch landings
4) include only those trips where scuba, skindiving, or spearfishing were reported as the gear used

5) exclude trips reported during the closed season (closed July-September beginning 1996 in Federal waters and 1999 in territorial waters)
6) convert landed pounds reported per trip beginning in 2003 to account for changes from uncleaned to cleaned conch landings; for 2003 landings should be divided by 0.833 (50% of landings were cleaned) and 2004-2005 landings should be divided by 0.667 (100% of landings were cleaned)
7) examine the feasibility of identifying lobster trips and eliminating them from the conch data set

5.1.2. Puerto Rico Commercial Yelowfin Grouper

5.1.2.1. Data sources and Methods

Data concerns and approaches to construction of possible commercial yellowfin grouper indices are described in the document SEDAR 14-DW06.

Preliminary information on commercial nominal landings and catch per unit of effort (CPUE) of yellowfin grouper (Cummings and Matos-Caraballo 2006) was discussed by the SEDAR DW participants. Data sources and a description of the data were included. The source of this data set is the commercial finfish sales records collected by the Puerto Rico Department of Natural Environment and Resources (DNER), Fisheries Statistics Program (FSP) and was available electronically since about 1983 (Matos-Caraballo, 2004). Information recorded on each sales record usually included: the date (year, month, day) the landed catch was sold, fisherman identification, municipality and fishing center, and gear used. Sometimes, but not continuously, information was also recorded on: gear quantity, number hours fished, and the minimum and maximum depth fished. Each sales record included an additional variable, NTRIPS, representing the number of unique fishing trips that represent the landed catch. Thus, a single sales record could be reflective of one or more fishing trip events. The complete dataset of commercial sales records included observations sales of finfish and shellfish for 1983-2005. Data for 2006 are not yet available.

For purposes of calculating nominal CPUE for this study, the measure of catch was the landed weight in pounds. CPUE was computed as the landed weight per trip. Although some records included information recorded for gear quantity or hours fished, the majority of records did not therefore the unit of effort was a fishing trip. As mentioned previously, sometimes a sales record reflected the combined landings from more than a single trip. For these multi-trip records, CPUE was computed as landings weight divided by the number of trips.

5.1.2.2. Preliminary results on yellowfin grouper nominal commercial CPUE

Sales of yellowfin grouper occurred in all years since the 1987. The distribution of the landings by gear categories, as reflected in the sales records, was used to identify the primary gears employed in harvesting yellowfin grouper in Puerto Rico. This information indicates that landings of yellowfin grouper in Puerto Rico have been from three main gears historically: dive (37% of landings by weight), traps (34%), and hook and line (26%).

The data set was also evaluated in terms of the number of observations for each of these three gears across all years, 1983-2005, that could be included in subsequent general linear model analyses of these data. It should be noted that in most years less than 100 sales records were reported landing yellowfin grouper across all gears (Table 5-6), thus concerns regarding models containing a large number of parameters was raised by some in the group.

Criteria for data exclusion in further CPUE analyses were considered next. The distribution of values recorded for the 'NTRIPS' variable was also examined for the yellowfin grouper data. Values ranging from 0, missing, 1 up to and including NTRIPS='43' were recorded in the data. The SEDAR 14 participants further discussed procedures to be used to select data for inclusion in the CPUE calculations. Previously, SEDAR8 yellowtail snapper evaluations only included observations of landings in the CPUE analyses in which the NTRIPS variable was less than or equal to 7. A about 69% of the yellowfin grouper sales observations had the 'NTRIPS' variable coded as '1'. Records for which the NTRIPS variable was coded as '0' or 'blank' were eliminate from the analyses as was previously done in SEDAR 8 yellowtail snapper analyses and also for this SEDAR queen conch CPUE analyses. Figure 5-2 shows that the standard deviation of mean CPUE per trip of yellowfin grouper was much larger for records where NTRIPS was coded as '1', suggesting that some of these records could included multi-trip events. It was not clear from inspection of these statistics that selection of the input data for use in further CPUE calculations could be based on the 'NTRIPS' variable alone.

A discussion of possible modeling approaches of the yellowfin grouper Puerto Rico CPUE data took place. It was recommended that a simple general linear model be used containing auxiliary terms that included: year, month (or season), geographical area (municipality or fishing center) and gear for reducing the variation in CPUE. Based on the preliminary nominal CPUE examinations and also a criterion of requiring a minimum of 10 CPUE samples per cell it was recommended to have more extensive discussions by the fishery experts participating at the meeting (fishery agents and commercial fishermen) and the analysts regarding data selection. The task of this sub group was to further identify spatial areas in which yellowfin grouper could be expected to be found biologically and also could be expected to be fished during the year.

Yellowfin grouper nominal CPUE by gear for the years 1983-2005 is presented in Table 5-7.

5.1.2.3. Utility:

The SEDAR 14-DW working group recommends further exploration of the Puerto Rico dataset that should include constructing indices with the following guidelines:

1) two fishery sampling agents, in addition to a commercial fisherman from the southwest coast of Puerto Rico, identified specific municipalities to be included in further CPUE examinations. During some of the discussion, an additional agent from the east coast of Puerto Rico was called to confer on inclusion/exclusion of a particular fishing area. These recommendations will be used to restrict data selection to specific areas.

2) the agents reviewed the individual data file and identified several observations that were key punch errors and should be deleted from the dataset. These suggestions would be used to remove outliers from the data set. In addition, port agents and fishers recommended excluding trips with reported landings of yellowfin grouper of 1,000 pounds or more.

3) the group participants recommended including in the analysis trips that could have potentially landed yellowfin grouper but did not (zero catch trips). In order to carry out this task, re-construction of trips is necessary. It was recommended that unique trips be identified for years where the unique trip identification variable was not recorded (i.e., prior to 2003) by using a computer generated variable that included information on date landed, fisherman id, municipality, fishing center, gear, and NTRIPS variable. Finally as part of this third task, the group made the recommendation to incorporate species information into the selection of zero trips. Although the group did not select a single method for selecting zero trip landings, it was recommended to consider the Stephens and MacCall (2004) approach and also possibly to include zero trips from records that also caught one of the other grouper species from the yellowfin grouper management unit. These recommendations will be used to aid in selection of zero trip records.

5.1.3. Puerto Rico Commercial Mutton Snapper

5.1.3.1. Data sources and Methods

Data concerns and approaches to construction of the commercial mutton snapper index are described in the document SEDAR 14-DW7.

Preliminary information on commercial nominal landings and catch per unit of effort (CPUE) of mutton snapper (Cummings and Matos-Caraballo 2006) was discussed by the SEDAR DW participants. Data sources, a description of the available data, and calculation of CPUE were as described in section 5.1.2.

5.1.3.2. Preliminary results on mutton snapper nominal commercial CPUE

Landings of mutton snapper occurred in all years since the 1983. The distribution of the landings by gear categories, as reflected in the sales records, was used to identify the primary gears employed in harvesting mutton snapper in Puerto Rico. This information indicates that four main gears have historically been used to harvest mutton snapper in Puerto Rico: traps, hook and line, nets, and dive gear on occasion. Historically, traps harvested about 32% of the total combined landed weight across all years and hook and line gear harvested about 40%. Nets and dive gear harvested about 14% and 10% each.

The data set was also evaluated in terms of the number of observations of CPUE available for each of major gears across all years, 1983-2005. In some years the number of samples of CPUE approaches 25 or fewer for a particular gear, indicating that the number of terms included in a general linear model applied to the data might be limited (Table 5-8).

Criteria for data exclusion in further CPUE analyses were considered next. The distribution of values recorded for the ‘NTRIPS’ variable was examined for the mutton snapper data. Values ranged from 0, missing, 1 up to and including NTRIPS=’99’. The SEDAR 14 participants further discussed procedures to be used to select data for inclusion in the CPUE calculations. Previously, SEDAR8 yellowtail snapper evaluations only included observations of landings in the CPUE analyses in which the NTRIPS variable was less than or equal to 7. About 68% of the mutton sales (landings) observations had the ‘NTRIPS’ variable coded as ‘1’. Records for which the NTRIPS variable was coded as ‘0’ or ‘blank’ were eliminated from the analyses as previously done in SEDAR 8 yellowtail snapper analyses and also for this SEDAR queen conch CPUE analyses. Figure 5-3 shows that the standard deviation of mean CPUE per trip of mutton snapper was much larger for records where NTRIPS was coded as '1', suggesting that some of these records may have included multi-trip events. It was not clear from inspection of these statistics that selection of the input data for use in further CPUE calculations could be based on the 'NTRIPS' variable alone.

A discussion of possible modeling approaches of the mutton snapper Puerto Rico CPUE data took place. It was recommended that a simple general linear model be used containing auxiliary terms that included: year, month (or season), geographical area (municipality or fishing center) and gear for reducing the variation in CPUE. Based on the preliminary nominal CPUE examinations and also a criterion of requiring a minimum of 10 CPUE samples per cell it was recommended to have more extensive discussions by the fishery experts participating at the meeting (fishery agents and commercial fishermen) and the analysts regarding data selection. The task of this sub group was to further identify spatial areas in which mutton snapper could be expected to be found biologically and also could be expected to be fished during the year.

Mutton snapper nominal CPUE by gear for the years 1983-2005 is presented in Table 5-9.

5.1.3.3. Utility:

The SEDAR 14-DW working group recommends further exploration of the Puerto Rico dataset that should include constructing indices with the following guidelines:

1) two fishery sampling agents, in addition to a commercial fisherman from the southwest coast of Puerto Rico, identified specific municipalities to be included in further CPUE examinations. During some of the discussion, an additional agent from the east coast of Puerto Rico was called to confer on inclusion/exclusion of a particular fishing area. These recommendations will be used to restrict data selection to specific areas.

2) the agents reviewed the individual data file and identified several observations that were key punch errors and to be deleted from the dataset. These suggestions will be used to remove outliers from the data set. In addition, port agents and fishers recommended excluding trips reporting landings of more than 3,000 pounds of mutton snapper.

3) the group participants recommended that trips be included in the analysis where mutton snapper could potentially have been caught. In order to carry out this task, re-construction of trips is necessary. It was recommended that unique trips be identified for years where the unique trip identification variable was not being recorded (i.e., prior to 2003) by defining individual trips as data with unique combinations of the variables date landed, fisherman id, municipality, fishing center, gear, and NTRIPS. Finally as part of this third task, the group made the recommendation to incorporate species information into the selection of zero trips. Although the group did not select a single method for selecting zero trip landings, it was recommended to consider the Stephens and MacCall (2004) approach and also investigate the possibility of including zero trips from records

that also caught one of the other snapper species from the mutton snapper management unit. These recommendations would be used to aid in selection of zero trip records.

Following the Data Workshop the recommendations above in items 1-3 will be carried out and used to generate new data sets which would be further evaluated with general linear models for mutton snapper in Puerto Rico.

5.1.4. Us Virgin Islands Commercial Conch

5.1.4.1. General Discussion:

The construction of the commercial indices is described in the document SEDAR 14-DW-5. In the US Virgin Islands, commercial fishers report catch and effort data on a monthly basis to the US Virgin Islands Division of Fish and Wildlife (DFW). A separate data set is maintained for St. Croix, but data from St. Thomas and St. John are contained in a single database.

The available catch per unit effort (CPUE) series, from 1986-2005 were used to develop several abundance indices for queen conch. An initial abundance index for St. Croix was developed using the model of Valle-Esquivel (2002a) from a previous queen conch assessment. New models were also developed for St. Croix and for St. Thomas/St. John.

5.1.4.2. Methods:

St. Croix lognormal (positive trips) 2002 model

This index was constructed from a dataset that included all trips reporting conch landings, regardless of gear used. The dataset included conch landings and effort for the years 1989-2005. Area was defined as southwest, southeast, east, northeast, northwest, and west St. Croix. The index was developed using the 2002 model of Valle-Esquivel.

St. Croix 2007 lognormal model

Methods used to construct an additional index of abundance from St. Croix conch landings and effort information followed the methods previously described for developing the Puerto Rico lognormal models. All trips that reported conch landings were included in the analysis, regardless of the gear employed. Data for the years 1986, 1988, and 1999 were excluded from the analysis because data from those years were insufficient for the analysis. For the St. Croix lognormal index, three factors were considered as possible influences on the CPUE per trip:

Factor	Levels	Value
YEAR	17	1987, 1990-2005
SEASON	4	Three month periods; January-March, etc.
AREA	6	Northeast, east, southeast, southwest, west, and unknown

St. Thomas/St. John

Methods for constructing the lognormal index for St. Thomas and St. John were similar to those used to develop previously described lognormal indices. All positive conch trips were included in the dataset. Data for the year 1986 were insufficient for the analysis and the years

1988-1994 were excluded because the fishery was closed. For the St. Thomas/St. John lognormal indices, three factors were considered as possible influences on the CPUE and the proportion of positive trips:

Factor	Levels	Value
YEAR	12	1987, 1995-2005
SEASON	4	Three month periods; January-March, etc.
AREA	3	North of the islands, south of the islands, unknown

5.1.4.3. Results:

Replication of 2002 St. Croix lognormal

The updated index differs from the 2002 index, but most of those differences are minor and overall trends in each index are similar (Figure 5-4). Relative abundance indices and coefficients of variation are provided in Table5-10. Yearly differences in CPUE between indices, as with the Puerto Rico indices, may be due to data updates since 2002. For example, data were insufficient from 1998 to include that year in constructing the 2002 index, however additional data now included in the St. Croix dataset allowed for 1998 to be added to the time series. The updated index has a clear decreasing trend during 1989-1992, but no obvious trend after 1992. In the 2002 index, that initial decreasing trend is less clear and a slight increasing trend is apparent from 1998-2001. In the updated index, that trend is less apparent.

Additional USVI indices

St. Croix lognormal index

Relative abundance indices are shown in Figure 5-4. Relative abundance indices and coefficients of variation are provided in Table 5-10. The index has a steady decline in CPUE over the first four years of the continuous series, however the CPUE calculated for these data from 1987 is lower than the 1990 and 1991 mean CPUEs. After 1993 there was, perhaps, a very slight increase in CPUE through 2005.

St. Thomas/St. John lognormal index

The standardized CPUE series is shown in Figure 5-4. Relative abundance indices and coefficients of variation are provided in Table 5-10. The index had a much higher CPUE in 1987 than was observed in the continuous portion of the index (1995-2005). During that period, the index showed no trend, although CPUE in 2005 was somewhat lower than other years. No index was developed for the 2002 assessment due to insufficient data. The dataset used to generate this index included 756 positive conch trips over the entire time series.

5.1.4.4. Utility:

The SEDAR 14-DW working group recommends the further exploration of the Virgin Islands dataset and construction of indices of abundance with the following recommendations:

1) exclude west and northwest St. Croix from the analyses because conch do not occur in those areas
2) exclude years 1988-1993 in St. Thomas/St. John analysis (harvest prohibited)
3) include only scuba trips in the analyses

4) exclude scuba trips that reported more than 100 pounds of parrotfish landed, those trips involved net fishing for parrotfish and were likely not in conch habitat
5) determine hours fished per vessel and include that information as a measure of effort
6) exclude 1987 data from the St. Thomas/St. John analysis
7) determine if data are adequate for construction of a St. Thomas/St. John index
8) exclude trips from July-September (harvest prohibited)
9) assume trips with reported landings of "shellfish" or "unclassified shellfish" were reporting conch landings
10) include trips with reported gears of "freediving", "scuba", or "unknown"
11) examine the feasibility of identifying lobster trips and eliminating them from the conch data set

5.1.5. Us Virgin Islands Commercial Yellowfin Grouper

No indices for US Virgin Islands yellowfin grouper were presented at the data workshop.

5.1.5.1. Utility:

The SEDAR 14-DW working group recommends that available Virgin Islands commercial data be examined to determine its appropriateness for use in constructing standardized indices.

1) determine if data are adequate to develop separate indices for St. Croix and St. Thomas/St. John
2) examine the utility of the Stephens and MacCall 2004 species association method for defining yellowfin grouper trips
3) examine alternatives to recommendation 2 above for defining yellowfin grouper trips, e.g. a gear configuration based method
4) work with fishers/port agents to identify gear configurations and fishing areas specific to yellowfin grouper and to identify possible outliers in the data

5.1.6. Us Virgin Islands Commercial Mutton Snapper

No indices for US Virgin Islands mutton snapper were presented at the data workshop.

5.1.6.1. Utility:

The SEDAR 14-DW working group recommends that available Virgin Islands commercial data be examined to determine its appropriateness for use in constructing standardized indices.

1) determine if data are adequate to develop separate indices for St. Croix and St. Thomas/St. John
2) examine the utility of the Stephens and MacCall 2004 species association method for defining mutton snapper trips
3) examine the feasibility of identifying mutton snapper trips as all trips that reported landing any species within the mutton snapper fishery management unit
4) work with fishers/port agents to identify gear configurations and fishing areas specific to mutton snapper

5.1.7. Marine Recreational Fishery Statistics Survey (Mrfss)

5.1.7.1. General Description:

Puerto Rico and US Virgin Islands yellowfin grouper and mutton snapper catch estimates, sampling fractions, and size data collected in the Marine Recreational Fishery Statistics Survey (MRFSS) are provided in SEDAR14-DW03. MRFSS is a sample-based survey of recreational fishers that provides information on participation, effort, and species-specific catch. The MRFSS sample design in the US Caribbean is based on an intercept survey of anglers and telephone survey of coastal households.

Data are available from Puerto Rico from 2000 to present, however data from the US Virgin Islands is only available for 2000. Yellowfin grouper catches were only reported during 2001 and 2003. Mutton snapper were reported in each year, 2000-2005 in Puerto Rico. No mutton snapper were reported from the US Virgin Islands during the single year available (2000). Only five yellowfin grouper have been observed and measured. Approximately 140 mutton snapper were weighted and measured. Catch estimates range from 5,700 to 25,300 mutton snapper per year and 250 to 935 yellowfin grouper per year. Effort was not reported in the SEDAR14-DW03 document, however those data are available.

MRFSS does not collect data on queen conch recreational landings.

5.1.7.2. Utility:

The SEDAR 14-DW working group recommends that mutton snapper MRFSS data from Puerto Rico be examined to determine its appropriateness for use in constructing standardized indices.

1) examine the utility of the Stephens and MacCall 2004 species association method for defining mutton snapper trips in Puerto Rico
2) MRFSS US Virgin Islands data are insufficient for developing indices for any of the species of interest
3) MRFSS data are insufficient for developing indices of abundance of yellowfin grouper in Puerto Rico

5.2. Fisheries Independent Indices

A summary of available fishery independent data sources along with recommendations on their utility for the current assessments is provided in Table .

5.2.1. SEAMAP – Caribbean: Reef Fish Sampling

Target:	Reef fish	**Duration:**	1991 to present
Coverage:	western PR, south St. John	**Data:**	SEAMAP

5.2.1.1. Description:

The Southeast Area Monitoring and Assessment Program for the Caribbean (SEAMAP-C) is a cooperative program between the National Marine Fisheries Service, the Dept. of Natural and Environmental Resources in Puerto Rico and the Dept. of Planning and Natural Resources, Division of Fish & Wildlife in the US Virgin Islands. Sampling is conducted in quadrants within a sample area defined for each island. Areas off St. Croix, St. Thomas, and western PR are included. From 1992-2002, 1098 individual fish from 39 species were captured from St. Croix; 1490 fish from 65 species were captured from St. John. Across all years, only 17 species with more than 5 individuals were captured from St. Croix; 28 species with more than 5 individuals were captured for St John. SEAMAP-C is a multiyear data set, originally targeting red hind spawning areas but other species are taken by trap and hook-and-line sampling. Data from Puerto Rico have not been examined but are requested from SEAMAP.

5.2.1.2. Pros:

Repeated sampling, same method across all locations, sampling deeper than divers, broad range of species, CPUE calculated as minutes of fishing time.

5.2.1.3. Cons:

Interannual variability unknown, overall numbers of yellowfin grouper represent: by biomass: 2.07% (5 kg) in 1992/3, 4.87% (6.22 kg) in 1994/5, 0.48% (1.56 kg) in 1999/2000 of the catch for all gear types south of St. John. For frequency 2.01% (caught 10 times, rank 8) in 1992/3; 1.56% (caught 4 times, rank 9) in 1994/5; 0.41% (caught 3 times, rank 25). Mean sizes (SL cm +/- SD) ranged from 325.4 +/- 58.1 in 1992/3; 465.5 +/- 89.6 in 1994/5; and 267.7 +/- 136.6 in 1999/2000. No mutton snapper (0) caught in Virgin Islands sampling. only STJ and STX sampled, not STT

5.2.1.4. Utility:

Conch-no, mutton snapper-no, yellowfin grouper-maybe yes, if data can be obtained in a timely manner.

5.2.2. Reef Fish Surveys (SEAMAP-like) (PR DNER)

Target: Reef fish **Duration:** 1988 to present
Coverage: western PR, SE St. Thomas **Data:** DNER; SEAMAP

5.2.2.1. Description:

Similar sampling program as SEAMAP surveys, predates SEAMAP. Multiyear data set, targeting reef fishes with trap and hook-and-line sampling. Extent of data unknown but requested.

5.2.2.2. Pros:

Repeated sampling, same method across all locations, sampling deeper than divers, broad range of species, CPUE (calculated as minutes of fishing time).

5.2.2.3. Cons:

Interannual variability unknown, sampling intensity not generally all that high, overall numbers of yellowfin grouper and mutton snapper (0) low

5.2.2.4. Utility:

conch-no, mutton snapper-unknown, yellowfin grouper-maybe yes, if data can be obtained in a timely manner.

5.2.3. Territorial Coral Reef Monitoring [St. Croix and St. Thomas (by Univ. of the Virgin Islands, USVI Div. Fish and Wildlife)]

Target:	Reef fish and benthos	**Duration:**	2001 to present
Coverage:	USVI (St. Thomas/Croix)	**Data:**	VI DFW

5.2.3.1. Description:

Surveys of reef fish (transects and roving diver) and benthos (coral), expected to continue long-term

5.2.3.2. Pros:

Common method between STX and STT/J, repeat surveys of same site, provides density estimates, roving diver includes elusive/cryptic species

5.2.3.3. Cons:

Not all data readily available, numbers are low for both finfish species, short time series

5.2.3.4. Utility:

mutton snapper-yes, yellowfin grouper-yes, conch-no; assuming data are available

5.2.4. Commonwealth Coral Reef Monitoring in Puerto Rico

Target:	Reef fish and benthos	**Duration:**	2001 to present
Coverage:	Vieques, Desecheo,	**Data:**	UPRM; DNER

5.2.4.1. Description:

Surveys of reef fish and benthos (coral), expected to continue long-term. Some focus on deeper, shelf edge reefs. Dr. Garcia also has been involved with CariComp surveys (reef fish and benthos) of permanent stations and CFMC-funded deeper reef surveys (140-160 ft). Generally, all timed surveys rather than area-based.

5.2.4.2. Pros:

Most spatially comprehensive around PR

5.2.4.3. Cons:

Timed surveys, no true density methods, numbers reported low for both species 4 sightings of mutton snapper, 3 sightings of yellowfin grouper, no time-series.

5.2.4.4. Utility:

mutton snapper-no, yellowfin grouper-no, conch-no

5.2.5. PR Deep Reef Surveys

A series of deep reef site assessments have been undertaken by Univ. of PR-Mayagüez (Dr. Reni Garcia) funded by the CFMC with NOAA Coral Reef Conservation Program funds. Surveys include 30, 40 and 50 m depths, replicate 10 m transects. At Desecheo, 2004-5, no mutton snapper or queen conch were recorded but yellowfin grouper were recorded at 30 m depth on two of five 10 x 3 m transects (on one: 1-25 cm, and on the other: 1-25 cm and 1-50 cm). At 40 m depth, 5 yellowfin grouper were recorded across 3 of 5 transects: 1-40cm; 3-60 cm; and 1-75 cm. At 50 m depth, 2 (1-40, 1-45cm) were recorded on 1 of 5 transects. In deep surveys around Vieques, mutton snapper were reported in 30-40 m depths, (1-40 cm) and also in 40m depth (1-60 and 1-75 cm) In work just completed at Bajo de Cico, 8 yellowfin grouper were reported on transects in 30-50 m depth. Earlier deep water surveys were conducted in 1980-84 (NMFS) depths of 90-180m showed the highest CPUE for mutton snapper (personal communication, Graciela García-Moliner,). Surveys conducted with the Johnson SeaLink by NMFS in 1985 also reported mutton snapper in 60-150 m depth. Although the numbers from the various deep water surveys do not provide enough observations for stock assessment, they help establish preferred depth ranges for mutton snapper and yellowfin grouper and point to the need for additional deep water surveys for certain species.

5.2.5.1. Pros:

Deeper reef surveys, confirms depth ranges/preferences

5.2.5.2. Cons:

Spatially limited, temporally limited

5.2.5.3. Utility:

mutton snapper-no, conch-no, yellowfin grouper – yes, assuming data are available

5.2.6. AUV:

Surveys using an autonomous underwater vehicle (AUV) have been conducted along portions of the deep shelf of PR and VI (personal communication, Graciela García-Moliner). Images are being analyzed for benthic composition; video also documents various organisms. Queen conch were documented at 40 m confirming the likelihood of deep water populations or portions of populations.

5.2.6.1. Pros:

Good spatial coverage across PR and VI

5.2.6.2. Cons:

No temporal replication, data not currently analyzed for conch or finfish

5.2.6.3. Utility:

Demonstrates depth ranges (i.e. conch) but data not readily available.

5.2.7. Monitoring Reef Fish Populations in the VI National Park

Target:	Reef fish, conch, lobster	**Duration:**	1982 to present
Coverage:	St. John; Buck Island, STX	**Data:**	PIs; VINPS?

5.2.7.1. Description:

Resource monitoring by the park is probably the most temporally comprehensive of all existing or recent programs. Surveys target reef fishes, queen conch, benthic composition (e.g., corals, seagrass communities). Surveys have included intensive short-term monitoring (monthly at 2 sites from 1988-1991), annual surveys at several sites and a number of other specific survey projects. Visual surveys have been conducted in quasi-permanent sites complemented by trap surveys at various intervals. Visual surveys used consistent or calibrated methods to document all non-cryptic species in all size classes. NPS Inventory and Monitoring Program has now assumed responsibility of the monitoring efforts with monitoring conducted by NPS in collaboration with cooperators (e.g., NOAA NOS/CCMA Biogeography Team/NOAA Coral Reef Conservation Program. Datasets and field log books from J. Randall have been obtained by PI – Jim Beets and comparisons between Randall's surveys of the 1950-60s are possible.

5.2.7.2. Pros:

good temporal data, spatially good for STJ, includes sites in St. Croix

5.2.7.3. Cons:

only STJ, number still low, only chosen as "best" reef sites

5.2.7.4. Utility:

for both mutton snapper and yellowfin grouper, for conch-yes, assuming data are available

5.2.8. Caribbean Reef Fish Surveys (NOAA Ocean Service Biogeography Team)

Target:	Reef fish and benthos	**Duration:**	2001 to present
Coverage:	La Parguera; Buck Island, St. Croix; St. John	**Data:**	NOS BT; web

5.2.8.1. Description:

Consists of habitat-stratified 20 x 4 m surveys for reef fish and benthic characteristics. In first five years program surveyed almost 2000 sites for fish assemblage structure and associated fine scale habitat utilization patterns. Surveys focused on La Parguera, PR, Buck Island, STX and VINPS St. John. In Virgin Island surveys: 1 STX yellowfin grouper, 29 STJ, 41 STX mutton snapper. In La Parguera, PR 4 mutton snapper; ~900 conch total (not targeted).

5.2.8.2. Pros:

number of samples good, spatial coverage good in VI, uniform methodology

5.2.8.3. Cons:

Only La Parguera in PR, no St. Thomas, short time series

5.2.8.4. Utility:

conch – yes to define habitat utilization and overall population estimates, yellowfin grouper-no, mutton snapper-calculate density to compare to historical estimates, identify size-specific habitats.

5.2.9. Monitoring Reef Ecology, Coral Disease and Restoration

Target:	Reef fish, conch, and lobster	**Duration:**	1997 to present
Coverage:	Mona and Desecheo Islands, La Parguera, PR	**Data:**	SEFSC (PI)

5.2.9.1. Description:

Survey both permanent sites and random locations examining changes in coral reef ecology (e.g., coral disease, bleaching) and responses of reef fish assemblages. Surveys 2-3 times per year, ~70 modified AGRRA transects (30 x 2 m) for reef fish and benthos, point count surveys, and arc surveys of coral disease. Bank, shelf and shelf edge reefs, mainly adult habitats, does not target typical nursery habitats. Numbers of these species low: 6 yellowfin grouper over 8 year time frame, no mutton snapper.

5.2.9.2. Pros:

number of samples good, spatial coverage good for western PR, uniform methodology linking habitat characteristics with reef fish assemblages

5.2.9.3. Cons:

Only La Parguera, Mona, Desecheo in PR, no VI, medium time series

5.2.9.4. Utility:

conch-no, yellowfin grouper-no, mutton snapper-no.

5.2.10. Coral Reef Ecosystem Studies

Target:	Reef fish, corals, urchins, sedimentation	**Duration:**	2001 to present
Coverage:	La Parguera, Culebra, St. John	**Data:**	UPRM; NOS web

5.2.10.1. Description:

NOAA NCCOS-grant funded partnership with UPR as lead. Projects are studying causes of reef degradation. Reef fish and benthic composition studied in permanent replicate transects (multiple depth strata) in forereef habitats of 8 different reefs. In 576 transects (25x 4 m2) from 2004-5: 2 mutton snapper (25, 30 cm FL), yellowfin grouper: (0).

5.2.10.2. Pros:

repeat surveys over 5-6 yr period, lots of samples

5.2.10.3. Cons:

only forereef habitats, numbers are low

5.2.10.4. Utility:

conch-no, yellowfin grouper-no, mutton snapper-no

5.2.11. Population and habitat-use studies of queen conch, St. John

Target: Queen conch
Coverage: Shallow water bays of St. John
Duration: 2005-2006

5.2.11.1. Description:

Tag-and-recapture, habitat use, and sonic racking study of queen conch in 2 bays in St. John. Arrays of hydrophone receivers are set in positions around the bays so that a positive signal on a receiver correlates to time spent in a particular habitat. Long-term data are being analyzed although the third year of the study is 2007. Numbered tags are being used to estimate population size and demographic rates (Jolly-Seber). Concurrent quantification of habitat characteristics are being recorded for correlation with size-specific habitat selections.

5.2.11.2. Pros:

dedicated conch survey, habitat use info, large number of tags.

5.2.11.3. Cons:

spatially limited, only two bays, only STJ, short timeframe, third year of data being collected.

5.2.11.4. Utility:

conch-yes, mapping habitat utilization patterns and habitat-extrapolations for population estimates, independent estimate of mortality rate.

5.2.12. REEF and AGRRA surveys

Target: Reef fish
Coverage: All areas, potentially
Duration: 1990 to present

5.2.12.1. Description:

Trained volunteer divers (Novice to expert) submit personally collected data. AGRRA actually funds some expeditions to collect data. Other analyses have looked at frequency of occurrence as metric for abundance. Size estimates also available. Site referenced. 2500 hours for USVI and 800 hours for Puerto Rico; includes BVI sites for platform-based area coverage.

5.2.12.2. Pros:

larger area, large number of samples

5.2.12.3. Cons:

variability in observers, relative abundance

5.2.12.4. Utility:

finfish only-sighting frequency analysis over time possible, depending on data availability.

5.2.13. Trap Impacts on Coral Reefs and Associated Habitats

Target: Fish and lobster traps Note: Studying impacts to habitat but also collecting catch composition from traps sampled
Coverage: All US Caribbean
Duration: 2001 to present

5.2.13.1. Description:

Examines the distribution and density of traps fished, the placement of traps by habitat type, the seasonal changes in distribution of traps among habitats, and the potential for damage by traps to various habitats such as sea grasses, macroalgae, sponges, and hard and soft corals.

Species composition of trap catches are analyzed by habitat. Divers survey traps for catch composition and damage to habitat caused by traps.

5.2.13.2. Pros:

large spatial coverage, multi-year, multi-habitat

5.2.13.3. Cons:

traps provide only relative density of fish and fail to sample all sizes of fish, traps are inappropriate for conch sampling

5.2.13.4. Utility:

not useful for conch, may provide habitat specific relative densities of yellowfin grouper and mutton snapper

5.2.14. Shallow water surveys of adjacent habitats

Target: Reef fish, conch, and lobster Note: Compares sampling methods and habitat use; mainly juveniles and subadults
Coverage: Shallow water bays of St. John
Duration: 2001-2003; 2005

5.2.14.1. Description:

Random visual transects and lift net samples in three bays in St. John. Sampled multiple habitats; including seagrass, mangrove, coral rubble, and sandy bottoms. Sampled fall and spring with eight samples in each habitat for 32 total samples per season. Visual transects complemented the lift net sampling effort. A small number of conch (approximately 21 juveniles) observed, but no yellowfin grouper or mutton snapper observed.

5.2.14.2. Pros:

standardized sampling methodology, densities of animals determined

5.2.14.3. Cons:

limited spatial coverage, sampling effort may be inappropriate for larger size classes of yellowfin grouper and mutton snapper

5.2.14.4. Utility:

may be used to help estimate juvenile conch densities in some habitats, not useful for yellowfin grouper or mutton snapper

5.3. Conch Habitat Affinity Analysis To Determine Domain (Island) Wide Estimates Of Conch Abundance

5.3.1.1. General Description:

The SEDAR 14 indices working group recommends that population estimates of queen conch be developed from available fishery independent data. The objective of this analysis is to determine whether the spatial distribution of immature and mature conch is affected by benthic habitats and to determine specific conch habitat preferences, if such preferences are detectable with the available data. Such preferences will then be used to develop domain-wide estimates of conch abundance for the three island jurisdictions governed by the Caribbean Fisheries Management Council.

Datasets to be analyzed:

1. NOAA Biogeography's (NOAA BP) conch data from La Parguera, Puerto Rico, St John, and St. Croix.
2. NOAA conch data from Fish Bay, St. John
3. SEAMAP conch data, if such data are available

Proposed Analytical Methods

Conch habitat preferences will be explored by analyzing the presence and variation in the abundances of immature and mature conch in different habitats. These habitat affinities (by life stage if possible) will then be used to identify habitats that are not used by conch, as well as those habitats that are utilized or preferred by conch. Conch data by life stage will be overlaid on the NOAA benthic habitat maps in ArcView GIS to determine abundance in different habitats classifications. NOAA benthic maps contain 27 benthic classifications. Appropriate multivariate approaches (e.g., PCA, Factor Analysis, Multivariate analysis of Variance) will be used to determine the fewest number of classifications that significantly ($P < 0.05$) affect the presence/absence ratios and abundances of conch life stages. Appropriate multiple comparison tests will then be used to identify which of the habitat classifications show differences in conch presence/absence ratios and abundances. Domain (island) wide estimates of immature and mature conch abundances will then be developed from proportional-area weighted mean estimates of conch abundance in each habitat classifications. Population estimates of conch abundance will then be provided for use as inputs into production models.

Some basic criteria to be met by the conch data the analysis described above

Every habitat classification in the island domain must have been sampled for conch. For example, the above analysis would be invalid if some of the habitat classifications in St. Croix, were never sampled by NOAA BP to determine if conch were present or not. If such a scenario occurs, the benthic classifications would be aggregated upwards until all available habitats have some minimal number of samples on them before the analysis is conducted. At worst, two habitat classifications – hard bottom and soft bottom – could be used because NOAA BP sampling is stratified by those two classifications. This should not be a problem with Ron Hill's data because a complete census that sampled most or all habitats for conch was conducted in Fish Bay.

Conch data sets are large enough to provide the minimum number of samples to adequately describe conch abundances within each benthic classification. Some power or variance analyses would be needed to determine either the minimum number of samples needed to estimate conch abundance within each benthic classification with some predefined level of precision or 2) the power (confidence) associated the conch estimates based on the number of samples available in each benthic classification. Again, NOAA BP sampling was not optimized for conch detection, and such analyses were not done *a priori* with respect to conch.

5.3.1.2. Utility:

The SEDAR 14-DW working group recommends developing queen conch population estimates based upon extrapolations from observed habitat specific conch densities and estimates of total area of conch habitat.

5.4. Research Recommendations:

1) Fisheries-independent survey efforts currently rarely include stations in deep water, the preferred habitat of adult mutton snapper and adult yellowfin grouper. In addition, large aggregations of queen conch have been reported in deep water by commercial fishers. The group highly recommends the initiation and continued funding of such surveys. As trends can be regional in nature, the group highly recommends that such surveys be conducted throughout Puerto Rico and the US Virgin Islands.

2) The commercial landings data from Puerto Rico and the US Virgin Islands have been incompletely entered and a variety of problems are known to exist in those data. The group strongly recommends that every effort be made to resolve the problems with those data. This should include extensive meetings with port samplers and others familiar with the US Caribbean fisheries.

3) The group recommends that tag-recapture studies of mutton snapper, yellowfin grouper, and queen conch be conducted in Puerto Rico and the US Virgin Islands to determine habitat utilization and movement of those species.

4) Ongoing long-term monitoring studies should be expanded spatially and include data useful for stock assessment, e.g. size-frequency and density information.

5) It is suggested that areas exploited by fishermen be compared to those areas where monitoring has been ongoing to further knowledge of essential habitat for these species and improve the design of monitoring efforts (i.e., ensure that monitoring is reflective of fished conditions).

6) The group recommends that efforts be made to monitor spawning aggregations of finfish to improve measures of population abundance. Collection of historical indicators of spawner abundance (e.g., directed visual census, analysis of catch statistics for spawning peaks, etc).

7) The group encourages the collection and documentation, for this and future Caribbean assessments, of historical information for qualitative and/or quantitative comparisons of current conditions.

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Table 5-1. A summary of catch series from Puerto Rico and the US Virgin Islands available for the SEDAR14 data workshop.

Fishery Type	Data Source	Area	Years	Catch Units	Effort Units	Standardization Method	Age Range	USE for BASE
COM Mutton Snapper	PR	Whole island	1983-2005	Pounds	Trip	Nominal series presented	Adults	REVIEW after revisions
COM Yellowfin grouper	PR	Whole island	1983-2005	Pounds	Trip	Nominal series presented	Adults	REVIEW after revisions
COM Conch	PR	Whole island	1983-2005	Pounds	Trip	Lognormal on positive SCUBA, skin diving, spear fishing trips	Adults	NO
COM Conch	PR	Whole island	1983-2005	Pounds	Trip	Delta-lognormal on all SCUBA, skin diving, spear fishing trips	Adults	REVIEW after revisions
COM Conch	PR	SW PR	1983-2005	Pounds	Trip	Lognormal on positive SCUBA, skin diving, spear fishing trips	Adults	NO
COM Conch	PR	SW PR	1983-2005	Pounds	Trip	Delta-lognormal on all SCUBA, skin diving, spear fishing trips	Adults	NO
COM Conch	St. Croix	Whole island	1987-2005	Pounds	Trip	Lognormal on positive trips	Adults	REVIEW after revisions
COM Conch	St. Thomas/ St. John	2: north, south	1987, 1995-2005	Pounds	Trip	Lognormal on positive trips	Adults	NO

Table 5-2. *Pros and Cons for each constructed index and each data set to be used for population estimates as identified by the SEDAR 14-DW.*

Fishery Dependent Indices

Commercial: Puerto Rico *(Working group recommended revisions and subsequent review of indices of conch and finfish)*

Pros: 1) Relatively long time series (1983-2005, recommend using data beginning in 1989)
2) Large sample sizes
3) Includes landings in all areas in Puerto Rico

Cons: 1) Influenced by regulatory changes
2) Difficulty in estimating an informative measure of effort
3) Difficulty in identifying a conch trip
4) Some recognized data problems including: reports of multiple trips per trip ticket, missing data elements, temporal change in data reliability
5) Data time series may not pre-date period of heavy exploitation, if occurring, of these fisheries

Commercial: US Virgin Islands (*Working group recommended revisions and subsequent review of conch and finfish)*

Pros: 1) Relatively long time series (1987-2005)
2) Relatively large sample sizes of conch in St. Croix
3) Includes landings in all areas in of the US Virgin Islands
4) Data are trip specific

Cons: 1) Influenced by regulatory changes
2) Difficulty in estimating an informative measure of effort
3) Difficulty in identifying a conch trip
4) Some recognized data problems including: missing data elements,
5) Data entry ongoing
6) Data are not species specific for finfish
7) Data time series may not pre-date period of heavy exploitation, if occurring, of these fisheries

Fishery Independent

Conch Habitat Affinity Analysis To Determine Domain (Island) Wide Estimates Of Conch Abundance (working group recommends incorporating data from several sources to develop habitat specific abundance estimates)

Data sources to include:

Caribbean Reef Fish Surveys (NOAA Ocean Service Biogeography Team)

Pros: 1) large number of samples
2) spatial coverage good in USVI

3) uniform methodology

Cons: 1) only sampled La Parguera in Puerto Rico
2) no St. Thomas samples
3) short time series

Table 5-2. *Pros and Cons for each constructed index and each data set to be used for population estimates as identified by the SEDAR 14-DW, continued.*

Population and habitat-use studies of queen conch, St. John (NOAA Fisheries SEFSC)

Pros: 1) dedicated conch survey
2) habitat use information
3) large number of samples

Cons: 1) spatially limited, only two bays, only STJ
2) short timeframe, third year of data being collected.

SEAMAP – Caribbean: Reef Fish Sampling (USVI DFW, PR DNER, NOAA Fisheries)

Pros: 1) repeated sampling
2) uniform method across all locations
3) sampling deeper than diver surveys
4) broad range of species
5) CPUE calculated as minutes of fishing time.

Cons: 1) interannual variability unknown
2) overall numbers of yellowfin grouper low
3) no mutton snapper caught in Virgin Islands sampling
4) only St. John and St. Croix sampled

Table 5-3. Standardized CPUE and coefficients of variation by year for Puerto Rico lognormal (positive trips), delta lognormal, and southwest Puerto Rico lognormal commercial conch fishery indices where trips=1, 0, or missing and the indices where trips=1. Based upon the Valle-Esquivel 2002 models.

Year	PR Lognormal Model				PR Delta Lognormal Model				SW PR Lognormal Model			
	Trips=1, 0, or missing		Trips=1		Trips=1, 0, or missing		Trips=1		Trips=1, 0, or missing		Trips=1	
	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV
1983	1.282722	0.161695	1.099804	0.167158	0.472855	0.383906	0.364786	0.416774	1.493672	0.281423	1.567923	0.245642
1984	2.508396	0.153447	2.434079	0.180734	1.801727	0.332789	1.585428	0.417208	3.070987	0.26103	4.460373	0.282318
1985	1.088235	0.170069	1.050679	0.16931	1.440829	0.3164	1.551966	0.323901	1.444196	0.301989	1.198006	0.23584
1986	1.542049	0.15579	1.697731	0.203917	2.563627	0.262299	1.917167	0.456917	1.910584	0.225756	2.048343	0.266807
1987	1.346603	0.157584	1.03739	0.305655	1.809497	0.287755	0.570267	0.727135	1.301137	0.221555	0.722823	0.379946
1988	1.560645	0.1652	1.640188	0.163937	2.151744	0.288612	2.543118	0.2914	1.5664	0.236788	1.43374	0.173994
1989	1.140635	0.161176	1.223981	0.159457	1.120185	0.320149	1.337631	0.324764	0.593139	0.220396	0.580967	0.159862
1990	0.695147	0.157777	0.63508	0.160638	0.721901	0.314215	0.648881	0.338351	0.561266	0.225545	0.491667	0.163184
1991	0.749652	0.157621	0.716621	0.158009	0.929416	0.296753	0.966622	0.307566	0.524998	0.221647	0.487396	0.165809
1992	0.747949	0.162803	0.75098	0.165327	1.028009	0.294148	1.148681	0.304257	0.702287	0.221927	0.860309	0.166397
1993	0.776497	0.157039	0.807141	0.15606	1.03573	0.289302	1.245904	0.290505	0.873223	0.211985	0.807508	0.153404
1994	0.68958	0.155265	0.706432	0.153856	0.747211	0.305859	0.877519	0.308207	0.737437	0.209947	0.653285	0.149378
1995	0.744887	0.155634	0.768953	0.153894	0.833951	0.303571	0.972865	0.306277	0.730817	0.213712	0.665385	0.153315
1996	0.742986	0.162214	0.775257	0.160511	0.779788	0.316577	0.889434	0.322741	0.599489	0.210391	0.553306	0.148866
1997	0.74287	0.155184	0.77052	0.153497	0.733774	0.313473	0.833421	0.319288	0.662222	0.213197	0.596606	0.151922
1998	0.974463	0.155207	0.964206	0.157481	0.708691	0.336545	0.737794	0.351042	0.772075	0.214123	0.722079	0.156054
1999	0.891705	0.155666	0.908196	0.154115	0.642454	0.340678	0.749846	0.344202	0.965166	0.214043	0.901261	0.153686
2000	0.725493	0.15924	0.762746	0.157963	0.516868	0.342576	0.604965	0.348247	0.764296	0.211794	0.727772	0.150676
2001	0.766742	0.155771	0.802683	0.15397	0.486229	0.345585	0.566074	0.350698	0.731213	0.21163	0.678899	0.150466
2002	0.774117	0.155457	0.80902	0.153664	0.533528	0.34091	0.620155	0.345813	0.743309	0.211374	0.698865	0.150037
2003	0.967044	0.159243	1.020742	0.157355	0.624091	0.350515	0.729741	0.355495	0.768018	0.210585	0.732815	0.149001
2004	0.816224	0.163761	0.854192	0.161989	0.595181	0.347971	0.688838	0.353315	0.708761	0.211261	0.678488	0.149777
2005	0.725359	0.156473	0.76338	0.154633	0.722715	0.316686	0.848897	0.320738	0.775311	0.211632	0.732182	0.149957

Table 5-4. Standardized CPUE and coefficients of variation by year for Puerto Rico lognormal (positive trips) and delta lognormal commercial conch fishery indices where trips=1, 0, or missing and the indices where trips=1. Based upon 2007 models.

Year	PR Lognormal Model				PR Delta Lognormal Model			
	Trips=1, 0, or missing		Trips=1		Trips=1, 0, or missing		Trips=1	
	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV
1983	1.212704	0.149167	0.985188	0.156955	0.447889	0.378449	0.239321	0.337349
1984	2.534744	0.141872	2.834725	0.170564	1.824073	0.327509	1.522793	0.431169
1985	0.984127	0.158441	0.931166	0.159485	1.305432	0.310199	1.183355	0.340747
1986	1.589742	0.144034	1.637202	0.190178	2.647886	0.255409	1.820928	0.440123
1987	1.320054	0.145915	1.098653	0.290027	1.777172	0.281404	0.552695	1.023056
1988	1.422814	0.153011	1.43932	0.15399	1.965195	0.28205	2.373774	0.209313
1989	1.049614	0.149532	1.089552	0.150022	1.032705	0.314385	1.05626	0.239494
1990	0.733982	0.146035	0.650816	0.151025	0.763664	0.30825	0.663796	0.252593
1991	0.768586	0.146001	0.728229	0.148578	0.954689	0.290553	0.908222	0.229759
1992	0.789181	0.150974	0.795708	0.15591	1.086739	0.287542	1.054247	0.244392
1993	0.797377	0.145444	0.814184	0.146701	1.065586	0.282994	1.141153	0.219404
1994	0.706862	0.143698	0.710811	0.144518	0.767378	0.299933	0.777478	0.225717
1995	0.762867	0.144055	0.776596	0.14461	0.855689	0.297597	0.896294	0.218202
1996	0.75838	0.150375	0.784931	0.151218	0.79746	0.310404	0.863286	0.226537
1997	0.760426	0.143485	0.775	0.144083	0.752533	0.30761	0.79638	0.221928
1998	0.9728	0.143109	0.93897	0.147626	0.708822	0.330875	0.812451	0.238211
1999	0.971964	0.143349	0.97937	0.144121	0.701607	0.334925	0.862937	0.233343
2000	0.773146	0.146984	0.802364	0.148117	0.551863	0.336676	0.819318	0.224717
2001	0.784109	0.143608	0.810937	0.144142	0.498184	0.339917	0.750141	0.221688
2002	0.798568	0.143164	0.821623	0.143714	0.551424	0.335139	0.76715	0.222152
2003	0.980454	0.146794	1.020672	0.14734	0.633954	0.344703	1.053428	0.22152
2004	0.802393	0.151035	0.824453	0.151959	0.58622	0.341781	1.022651	0.217366
2005	0.725105	0.144163	0.749529	0.144671	0.723834	0.310505	1.061944	0.206665

Table 5-5. Standardized CPUE and coefficients of variation by year for southwest Puerto Rico lognormal (positive trips) and delta lognormal commercial conch fishery indices where trips=1, 0, or missing and the indices where trips=1. Based upon 2007 models.

Year	SW PR Lognormal Model				SW PR Delta Lognormal Model			
	Trips=1, 0, or missing		Trips=1		Trips=1, 0, or missing		Trips=1	
	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV
1983	1.385494	0.272632	1.239216	0.316398	0.212139	0.745186	0.148417	0.820828
1984	2.883343	0.254585	4.143085	0.34211	1.027988	0.599848	1.117671	0.838149
1985	1.341667	0.294138	1.024057	0.310511	1.330679	0.538979	1.035409	0.535551
1986	2.048733	0.217009	2.205534	0.30898	3.190641	0.310297	3.457101	0.529509
1987	1.281536	0.213953	0.718493	0.41265	1.756551	0.34313	1.312088	0.722221
1988	1.648921	0.229789	2.57767	0.275935	1.950217	0.39206	3.732525	0.330373
1989	0.583586	0.212208	0.67097	0.211799	0.685911	0.377829	0.661113	0.372761
1990	0.58085	0.218255	0.473091	0.233902	0.763696	0.356702	0.518179	0.381178
1991	0.533879	0.214203	0.444225	0.254127	0.690214	0.355017	0.567481	0.36505
1992	0.724648	0.214219	0.817199	0.261615	1.298867	0.266932	1.495859	0.309913
1993	0.892167	0.204193	0.866256	0.244737	1.61294	0.250609	1.587273	0.287259
1994	0.773839	0.202313	0.511062	0.2191	1.247194	0.277841	0.758617	0.307652
1995	0.696536	0.205899	0.571294	0.22343	0.737189	0.390322	0.644198	0.368977
1996	0.627168	0.20282	0.522196	0.220015	0.672587	0.380058	0.577961	0.364613
1997	0.692875	0.2052	0.544536	0.222703	0.672912	0.406482	0.516619	0.3973
1998	0.818966	0.204701	0.608645	0.226152	0.468793	0.500542	0.298528	0.506501
1999	1.035642	0.204792	0.879431	0.223368	0.698943	0.475645	0.607881	0.450638
2000	0.804153	0.202769	0.69944	0.215946	0.740849	0.419613	0.558955	0.423137
2001	0.696244	0.202389	0.643116	0.216873	0.607935	0.429313	0.552436	0.413629
2002	0.718684	0.202098	0.674885	0.217455	0.612452	0.433575	0.533645	0.426123
2003	0.759812	0.201434	0.711587	0.218614	0.76566	0.396999	0.760493	0.372452
2004	0.688098	0.202147	0.625713	0.235913	0.582909	0.432944	0.630879	0.393653
2005	0.783158	0.203031	0.828301	0.230882	0.672736	0.427904	0.926669	0.368234

Table 5-6. Relative Contribution (% weight) of commercial CPUE samples by Gear and year for yellowfin grouper, all observations where NTRIPS>=1 included. N=number of trips.

Year	Cast Net		Dive, Spear, Scuba		Net		Other		Pot		Hook and Line		Seine		Vertical Line		All	
	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %
1987	.	.	.	.	.	.	.	.	0	.	0	.	.	.	.	.	0	.
1988	.	.	3	14.3	.	.	2	9.5	6	28.6	10	47.6	.	.	.	.	21	100
1989	.	.	7	24.1	.	.	.	.	14	48.3	6	20.7	.	.	2	6.9	29	100
1990	.	.	18	78.3	.	.	.	.	3	13	2	8.7	.	.	.	.	23	100
1991	.	.	11	30.6	1	2.8	.	.	10	27.8	14	38.9	.	.	.	.	36	100
1992	.	.	13	37.1	4	11.4	.	.	10	28.6	8	22.9	.	.	.	.	35	100
1993	.	.	25	69.4	1	2.8	.	.	7	19.4	3	8.3	.	.	.	.	36	100
1994	1	5.6	10	55.6	.	.	.	.	1	5.6	6	33.3	.	.	.	.	18	100
1995	.	.	12	32.4	1	2.7	.	.	6	16.2	16	43.2	1	2.7	1	2.7	37	100
1996	.	.	19	29.2	2	3.1	.	.	21	32.3	23	35.4	.	.	.	.	65	100
1997	.	.	19	35.8	2	3.8	.	.	11	20.8	21	39.6	.	.	.	.	53	100
1998	.	.	15	31.3	7	14.6	.	.	7	14.6	19	39.6	.	.	0	0	48	100
1999	.	.	50	53.2	9	9.6	.	.	10	10.6	25	26.6	.	.	.	.	94	100
2000	.	.	37	36.3	18	17.6	.	.	25	24.5	21	20.6	.	.	1	1	102	100
2001	.	.	61	41.2	16	10.8	.	.	23	15.5	48	32.4	.	.	.	.	148	100
2002	.	.	52	35.9	11	7.6	.	.	46	31.7	36	24.8	.	.	.	.	145	100
2003	.	.	16	10.3	9	5.8	.	.	103	66.5	27	17.4	.	.	.	.	155	100
2004	.	.	24	17.9	2	1.5	.	.	81	60.4	27	20.1	.	.	.	.	134	100
2005	.	.	9	8.9	2	2	.	.	84	83.2	6	5.9	.	.	.	.	101	100
All	1	0.1	401	31.3	85	6.6	2	0.2	468	36.6	318	24.8	1	0.1	4	0.3	1280	100

Table 5-7. Nominal unadjusted commercial yellowfin grouper CPUE (Landed weight per trip) by year and gear, all observations where NTRIPS>=1 included. Note, during the SEDAR14 DW the fishery agents identified and error in the landings records for year 2000, thus these tables will be revised for subsequent analyses. N=number of observations.

Year	Cast Net		Dive, Spear, Scuba		Net		Other		Pot		Hook and Line		Seine		Vertical Line		All	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
1987	.	.	.	.	.	.	.	.	0	.	0	.	.	.	.	.	0	.
1988	.	.	3	55	.	.	2	6.5	6	7.4	10	20.7	.	.	.	.	21	20.4
1989	.	.	7	19.2	.	.	.	.	14	17.5	6	17.8	.	.	2	11.6	29	17.6
1990	.	.	18	16.5	.	.	.	.	3	24.4	2	1.2	.	.	.	.	23	16.2
1991	.	.	11	15	1	2	.	.	10	16.5	14	44.1	.	.	.	.	36	26.4
1992	.	.	13	9.7	4	6.4	.	.	10	13	8	16.7	.	.	.	.	35	11.9
1993	.	.	25	18.3	1	7	.	.	7	14.6	3	16.7	.	.	.	.	36	17.1
1994	1	0.8	10	20	.	.	.	.	1	15	6	10.9	.	.	.	.	18	15.6
1995	.	.	12	9	1	3.3	.	.	6	19.3	16	14.4	1	22	1	74	37	15
1996	.	.	19	11.4	2	10.5	.	.	21	4.7	23	7.6	.	.	.	.	65	7.9
1997	.	.	19	23.7	2	9.5	.	.	11	36.4	21	23.9	.	.	.	.	53	25.9
1998	.	.	15	29.1	7	6.6	.	.	7	7.5	19	9.1	.	.	0	.	48	14.8
1999	.	.	50	19.9	9	1.6	.	.	10	7.5	25	6.5	.	.	.	.	94	13.3
2000	.	.	37	15.2	18	2.2	.	.	25	28	21	8.9	.	.	1	4	102	14.6
2001	.	.	61	19.1	16	5	.	.	23	8.1	48	11.3	.	.	.	.	148	13.3
2002	.	.	52	26.9	11	1.8	.	.	46	13	36	9.9	.	.	.	.	145	16.4
2003	.	.	16	35	9	6.1	.	.	103	5.6	27	137	.	.	.	.	155	31.6
2004	.	.	24	32.8	2	17	.	.	81	5.3	27	34.6	.	.	.	.	134	16.3
2005	.	.	9	13.4	2	4	.	.	84	5.9	6	21.4	.	.	.	.	101	7.4
All	1	0.8	401	20.8	85	4.4	2	6.5	468	9.6	318	26	1	22	4	25.3	1280	16.9

Table 5-8. Relative Contribution (% weight) of commercial CPUE samples by Gear and year for mutton snapper, all observations where NTRIPS>=1 included. N=number of trips.

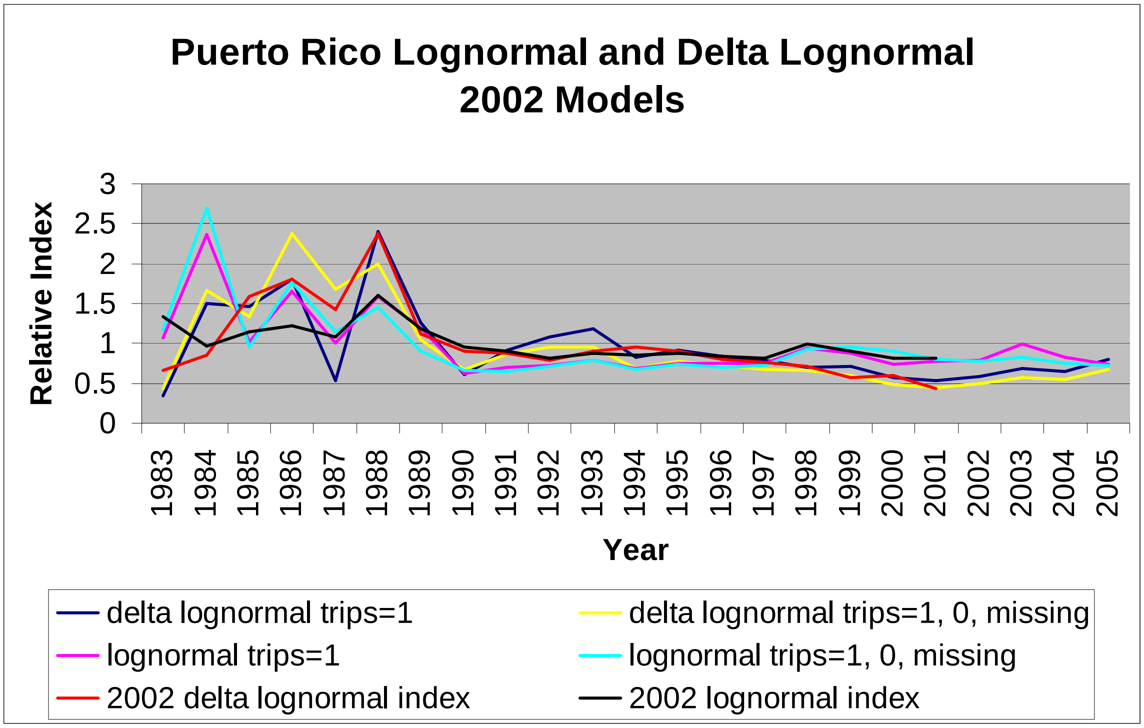
Year	Cast Net		Dive, Spear, Scuba		Net		Other		Pot		Hook and Line		Seine		Vertical Line		All	
	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %
1983	2	0.1	69	3.8	96	5.3	.	.	1,048	57.6	479	26.3	101	5.6	24	1.3	1,819	100
1984	1	0.8	4	3.1	6	4.6	.	.	91	69.5	20	15.3	7	5.3	2	1.5	131	100
1985	.	.	40	3	189	14.4	.	.	590	44.9	436	33.2	42	3.2	18	1.4	1,315	100
1986	3	1	25	8.3	48	16	.	.	114	38	93	31	10	3.3	7	2.3	300	100
1987	1	1.3	5	6.6	6	7.9	.	.	39	51.3	24	31.6	1	1.3	0	0	76	100
1988	2	0.2	108	10.8	144	14.3	2	0.2	258	25.7	423	42.1	29	2.9	38	3.8	1,004	100
1989	5	0.4	154	12.5	144	11.7	1	0.1	396	32.1	479	38.8	33	2.7	21	1.7	1,233	100
1990	1	0.1	157	15.8	117	11.8	.	.	287	29	417	42.1	2	0.2	10	1	991	100
1991	9	0.5	179	10.2	255	14.6	.	.	537	30.7	720	41.1	21	1.2	29	1.7	1,750	100
1992	1	0.1	83	7.4	135	12	.	.	334	29.8	514	45.8	26	2.3	29	2.6	1,122	100
1993	10	0.8	142	10.7	133	10	.	.	377	28.3	601	45.1	51	3.8	19	1.4	1,333	100
1994	21	1.4	115	7.5	185	12.1	.	.	469	30.6	650	42.4	29	1.9	65	4.2	1,534	100
1995	32	1.1	163	5.7	278	9.7	.	.	856	29.9	1,355	47.3	88	3.1	91	3.2	2,863	100
1996	14	0.5	224	7.7	486	16.7	.	.	717	24.7	1,333	45.9	58	2	72	2.5	2,904	100
1997	43	1.7	237	9.2	497	19.4	.	.	519	20.2	1,197	46.7	45	1.8	26	1	2,564	100
1998	7	0.3	213	9.1	278	11.9	.	.	713	30.6	1,017	43.6	15	0.6	90	3.9	2,333	100
1999	6	0.2	285	7.7	598	16.2	.	.	1,216	32.9	1,439	38.9	22	0.6	134	3.6	3,700	100
2000	9	0.2	313	7.9	648	16.4	.	.	1,297	32.8	1,532	38.8	18	0.5	135	3.4	3,952	100
2001	10	0.2	340	8	706	16.6	.	.	1,291	30.4	1,738	40.9	44	1	120	2.8	4,249	100
2002	4	0.1	397	8.8	750	16.7	.	.	1,374	30.6	1,755	39.1	60	1.3	154	3.4	4,494	100
2003	.	.	386	8.7	673	15.2	.	.	1,657	37.5	1,516	34.3	61	1.4	129	2.9	4,422	100
2004	.	.	689	20.1	410	11.9	.	.	1,217	35.5	991	28.9	40	1.2	84	2.4	3,431	100
2005	.	.	536	20.9	234	9.1	.	.	801	31.3	904	35.3	12	0.5	73	2.9	2,560	100
All	181	0.4	4,864	9.7	7,016	14	3	0	16,198	32.3	19,633	39.2	815	1.6	1,370	2.7	50,080	100

Table 5-9. Nominal Unadjusted Commercial Mutton snapper CPUE (Landed weight per trip) by year and gear, all observations where NTRIPS>=1 included.

	Cast Net		Scuba		Net		Other		Pot		Hook and Line		Seine		Line		All	
Year	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
1983	2	15.8	69	19.6	96	10.8	.	.	1048	11.5	479	14.1	101	9.3	24	16.7	1819	12.4
1984	1	60	4	9.5	6	89.7	.	.	91	43.4	20	59.9	7	152	2	179	131	55
1985	.	.	40	5.9	189	10	.	.	590	9.1	436	10.5	42	9.4	18	24.4	1315	9.8
1986	3	7.4	25	7.7	48	18.1	.	.	114	8.8	93	10.5	10	4.7	7	11.4	300	10.6
1987	1	6	5	3	6	19.5	.	.	39	7.2	24	8.2	1	30	0	.	76	8.5
1988	2	7.5	108	16.8	144	20.1	2	8	258	13.3	423	17.7	29	22.7	38	21.5	1004	17
1989	5	59.9	154	21.2	144	13.3	1	2	396	15.5	479	18.1	33	29.8	21	19.6	1233	17.6
1990	1	15	157	13	117	12.8	.	.	287	9.8	417	11.6	2	85	10	9	991	11.5
1991	9	23.1	179	10.4	255	11.4	.	.	537	9.4	720	12	21	9.5	29	11.5	1750	11
1992	1	9	83	13.3	135	11.6	.	.	334	8.5	514	12.7	26	15.4	29	14.2	1122	11.4
1993	10	5.1	142	9	133	10.1	.	.	377	8.8	601	9.3	51	35.1	19	7	1333	10.1
1994	21	43.4	115	11.2	185	14.6	.	.	469	10.2	650	19.5	29	70.4	65	11.8	1534	16.4
1995	32	19.7	163	9.3	278	12.8	.	.	856	8.6	1355	25.3	88	13.7	91	7.8	2863	17.2
1996	14	6.9	224	7.8	486	12	.	.	717	8.6	1333	18.3	58	14.2	72	9.5	2904	13.7
1997	43	14.8	237	9.4	497	9.9	.	.	519	8.5	1197	21.2	45	12.5	26	14	2564	15
1998	7	12.4	213	10.4	278	12	.	.	713	8.9	1017	16.8	15	23.3	90	6.2	2333	12.9
1999	6	7.1	285	9.2	598	11.9	.	.	1216	10.3	1439	16.4	22	23.2	134	6.8	3700	12.8
2000	9	6.1	313	13.7	648	12.6	.	.	1297	10.6	1532	13.9	18	17.2	135	9.2	3952	12.4
2001	10	21.6	340	13.4	706	13.7	.	.	1291	9.7	1738	17.9	44	52.9	120	7.1	4249	14.4
2002	4	13.1	397	15.5	750	11.7	.	.	1374	9.7	1755	14.6	60	50.4	154	8.6	4494	13
2003	.	.	386	10.7	673	11.2	.	.	1657	11.7	1516	28.8	61	40.3	129	12.6	4422	17.8
2004	.	.	689	8.8	410	12.8	.	.	1217	11.4	991	19.3	40	32.6	84	16.5	3431	13.7
2005	.	.	536	9.4	234	10.4	.	.	801	11	904	17.7	12	19.3	73	13.1	2560	13.1
All	181	19	4864	11.3	7016	12.2	3	6	16198	10.5	19633	17.8	815	26.8	1370	10.8	50080	14

Table 5-10. Standardized CPUE, coefficients of variation and 95% confidence intervals for St. Croix lognormal commercial conch fishery indices: Valle-Esquivel (2002) model and 2007 model and for the lognormal St. Thomas/St. John lognormal commercial conch fishery index.

Year	St. Croix Valle-Esquivel (2002) model		2007 model		St. Thomas/St. John 2007 model	
	Standardized Index	CV	Standardized Index	CV	Standardized Index	CV
1987			1.048149	0.092857	2.392383	0.149968
1988						
1989	1.898464	0.169204				
1990	1.323547	0.104035	1.351498	0.094254		
1991	1.186801	0.09427	1.266331	0.088657		
1992	0.896275	0.11149	0.939493	0.108302		
1993	0.829043	0.101493	0.938642	0.096256		
1994	0.808983	0.091266	0.836016	0.08448		
1995	0.850487	0.087207	0.872414	0.080787	0.969322	0.17084
1996	0.897622	0.089972	0.951415	0.08305	0.989909	0.148489
1997	0.858614	0.092535	0.96174	0.086507	0.896049	0.152357
1998	0.81742	0.093922	0.891322	0.088144	0.896181	0.1698
1999	0.894163	0.090851	0.974385	0.084589	0.884017	0.154583
2000	0.887948	0.088211	0.916369	0.083484	0.897828	0.162443
2001	1.102336	0.08885	1.118235	0.08398	0.78297	0.152125
2002	0.924561	0.087845	0.98061	0.082632	0.912055	0.150476
2003	0.860567	0.089555	0.919877	0.084801	0.970568	0.148414
2004	0.929532	0.089489	0.968062	0.083698	0.878436	0.164623
2005	1.033637	0.088973	1.065439	0.08424	0.530282	0.174166



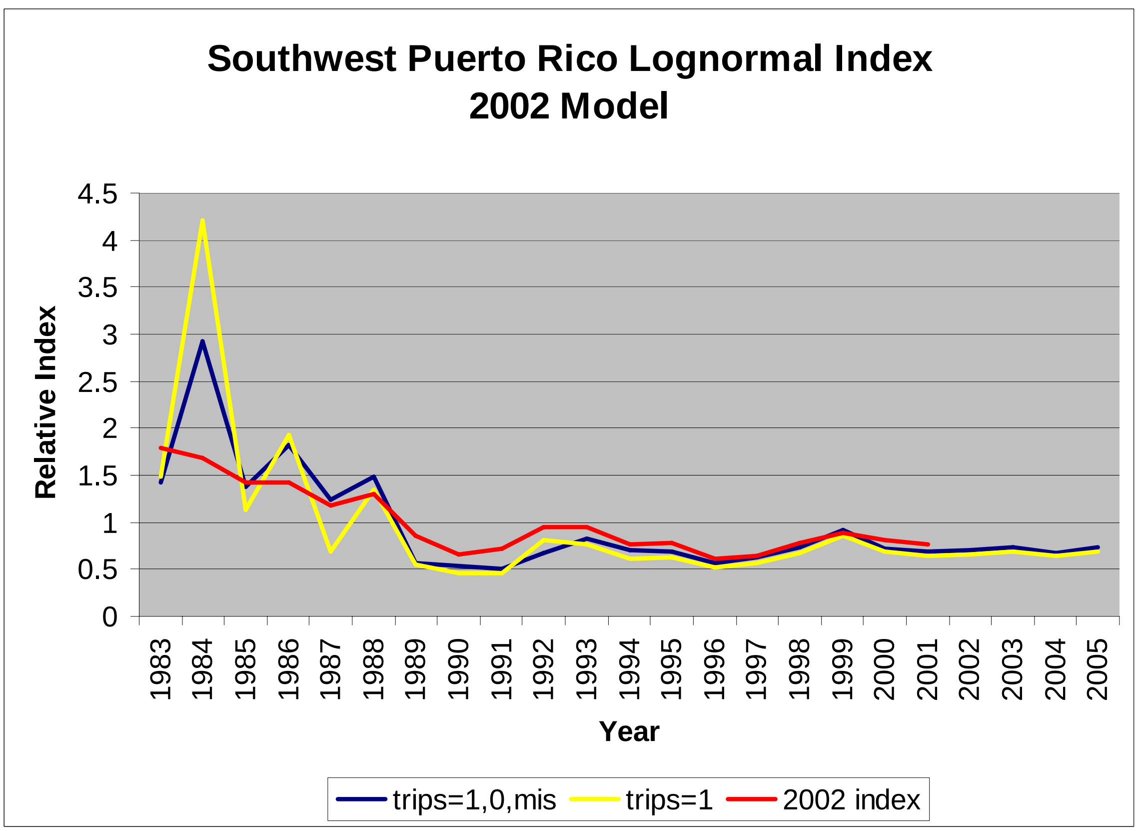
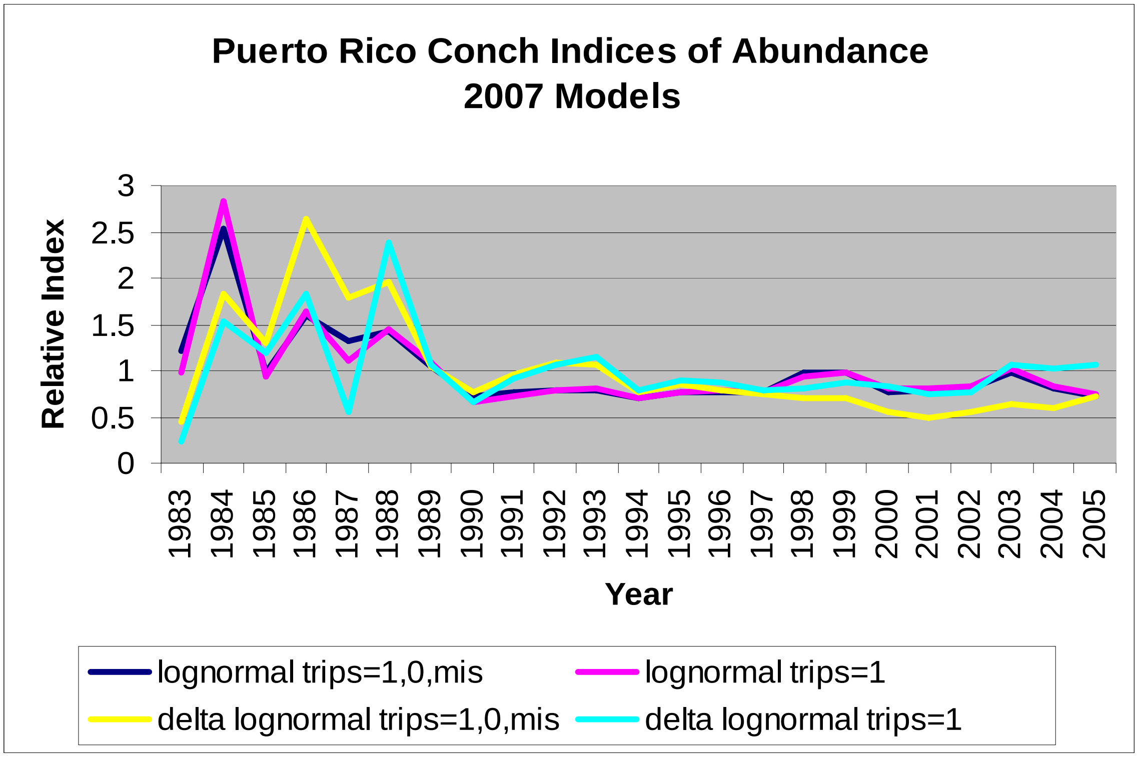


Figure 5-1 Puerto Rico queen conch indices of abundance.



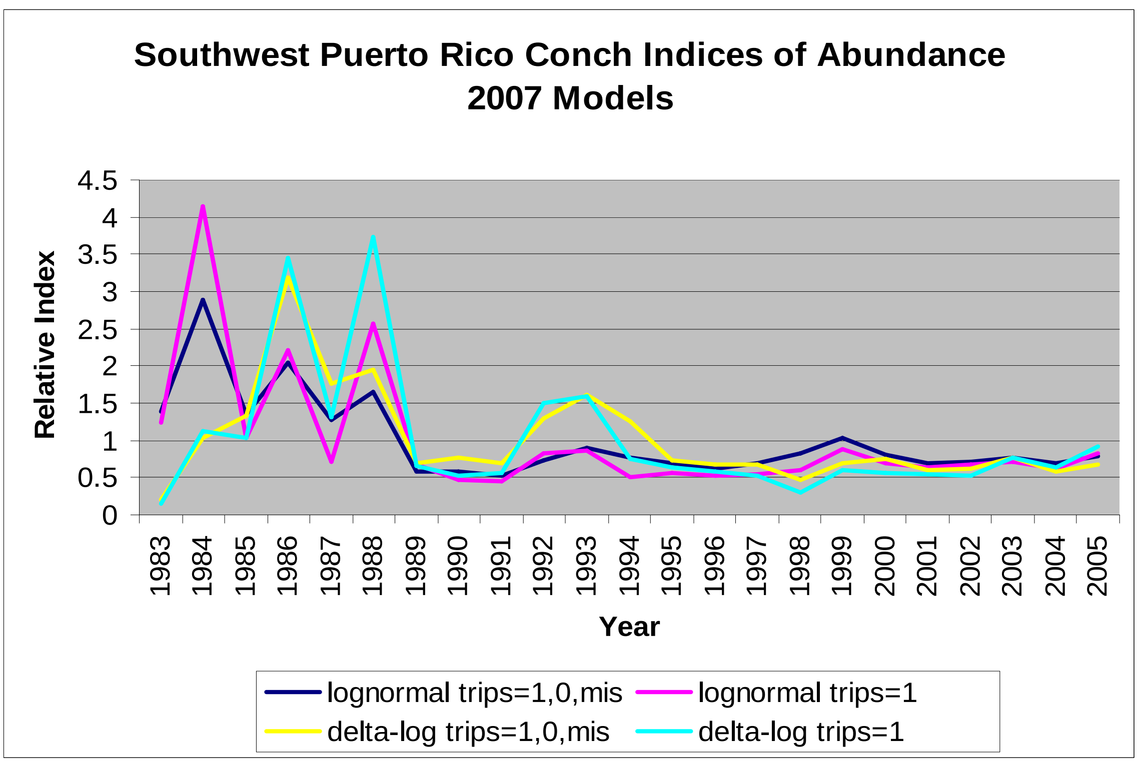


Figure5-1 Puerto Rico queen conch indices of abundance, continued.

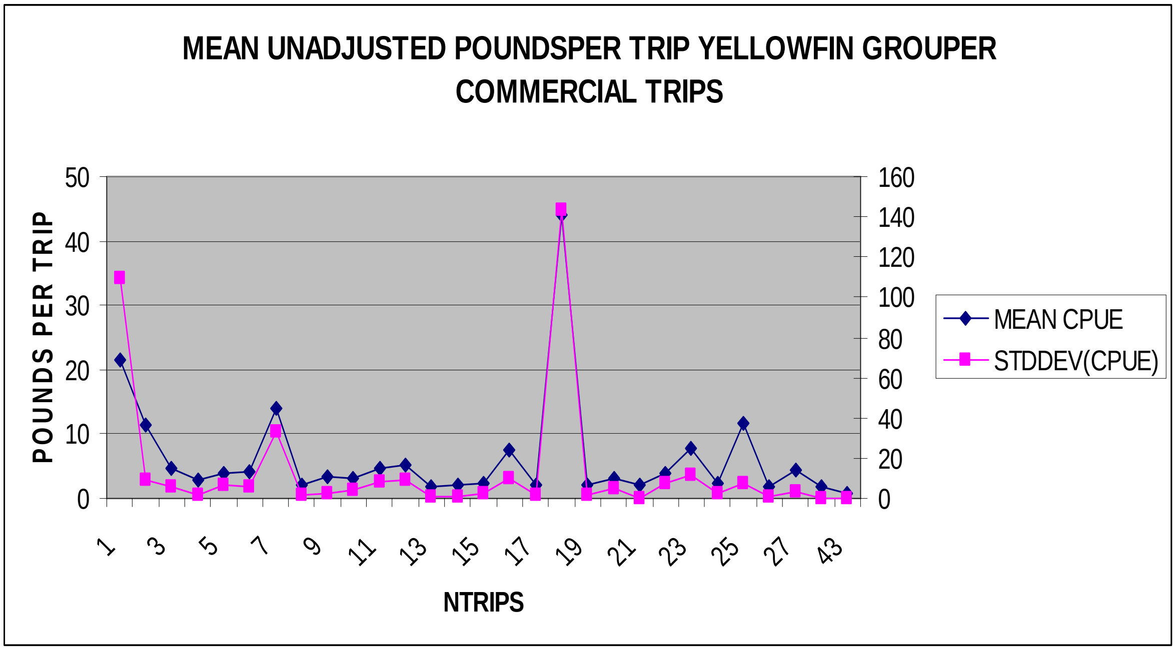


Figure 5-2. Mean CPUE (landed weight per trip) and standard deviation of the mean CPUE of Puerto Rico commercial landings.

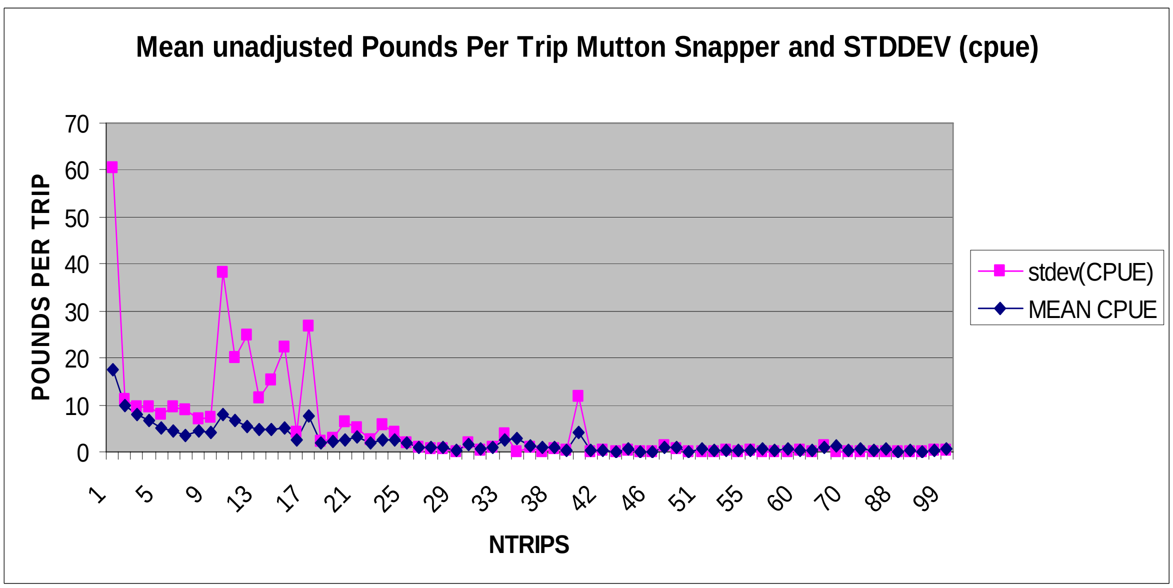


Figure 5-3. Mean CPUE (landed weight per trip) and standard deviation of the mean CPUE of Puerto Rico commercial landings.

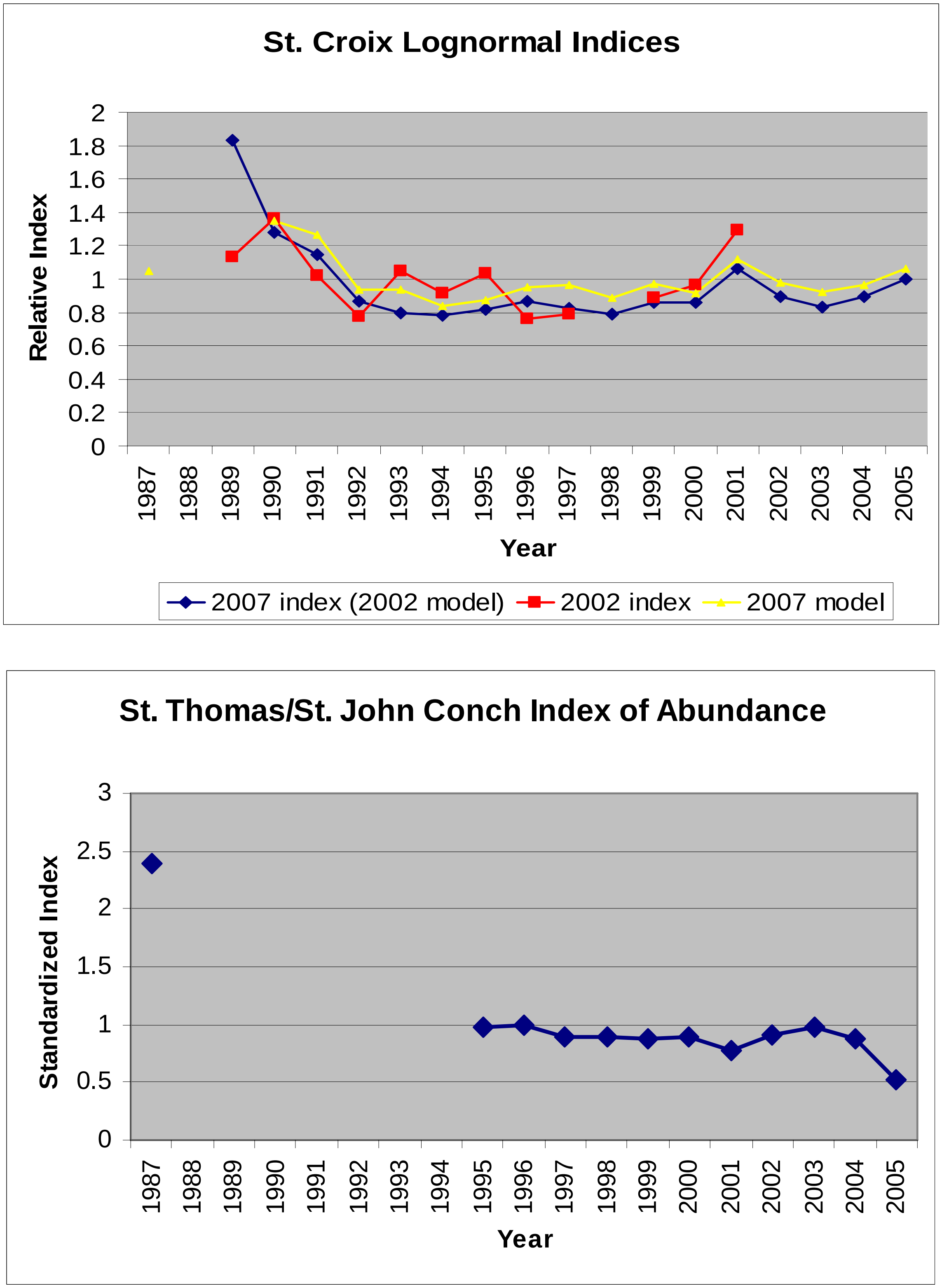


Figure 5-4. US Virgin Islands queen conch indices of abundance.

SEDAR 14

Stock Assessment Report 3

Caribbean Queen Conch

SECTION III. Assessment Workshop

SEDAR
4055 Faber Place #201
Charleston, SC 29405

SEDAR 14 Assessment Workshop Report

Queen Conch

Table of Contents

1. Workshop Proceedings

1.1. Introduction

1.1.1. Workshop Time and Place

The SEDAR 14 Assessment Workshop was held June 4 - 8, 2007 in St. Thomas, USVI.

1.1.2. Terms of Reference

1. Review any changes in data following the data workshop and any analysis suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.
2. Develop population assessment models that are compatible with available data and recommend which model and configuration is considered most reliable or useful for providing advice. Document all input data, assumptions, and equations.
3. Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates.
4. Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and 'goodness of fit'.
5. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations, values, and figures.
6. Provide estimates for SFA criteria. This may include evaluating existing SFA benchmarks or estimating alternative SFA benchmarks (SFA benchmarks include MSY, Fmsy, Bmsy, MSST, and MFMT); recommend proxy values where necessary.
7. Provide declarations of stock status relative to SFA benchmarks.
8. Estimate an Allowable Biological Catch (ABC) range.
9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following guidelines.
   A) If stock is overfished:
      F=0, F=current, F=Fmsy, Ftarget (OY),
      F=Frebuild (max that rebuild in allowed time)
   B) If stock is overfishing:
      F=Fcurrent, F=Fmsy, F= Ftarget (OY)
   C) If stock is neither overfished nor overfishing:
      F=Fcurrent, F=Fmsy, F=Ftarget (OY)
10. Evaluate the results of past management actions and, if appropriate, probable impacts of current management actions with emphasis on determining progress toward stated management goals.

11. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity.
12. Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report) and prepare a first draft of the Assessment Advisory Report.

1.1.3. Workshop Participants

NAME	Affiliation
Workshop Panel	
Richard Appeldoorn	CFMC SSC/UPRM
Daniel Matos-Cayaballo	PR DNER
Nancie Cummings	NMFS SEFSC
Guillermo Diaz	NMFS SEFSC
Ron Hill	NMFS SEFSC
Joe Kimmel	NMFS SERO
Andy Maldonado	CFMC AP
Kevin J. McCarthy	NMFS SEFSC
Council Representative	
David Olsen	CFMC/VI DWF
Staff	
John Carmichael	SEDAR
Graciela Garcia-Moliner	CFMC
Patrick Gilles	NMFS SEFSC
Rachael Lindsay	SEDAR

1.1.4. Workshop Documents

Working Papers

SEDAR14-AW1	An Examination of the Mutton snapper, Lutjanus analis, Commercial Catch per Unit of Effort Data in Puerto Rico from 1983-2005 Available for Use in Developing Estimates of Abundance	Cummings, N
SEDAR14-AW2	Habitat based analysis Mutton	Jeffries, C.
SEDAR14-AW3	Habitat based analysis conch	Jeffries, C.
SEDAR14-AW4	On diver catch-per-unit-effort series as measures of relative abundance of queen conch and their use in stock assessments for the islands of Puerto Rico and Saint Croix	Diaz, G.
SEDAR14-AW5	Estimation of mutton snapper total mortality rate from length observations.	Gedamke
SEDAR14-AW6	Revised queen conch (Strombus gigas) standardized catch rates for Puerto Rico and U.S. Virgin Islands commercial fisheries	McCarthy, K. J.
SEDAR14-AW7	Comments on Puerto Rico landings and biostatistical sampling	Matos, D.

Reference Documents

SEDAR14 RD09 NMFS-SEFSC-304 1992	Shallow water reef fish stock assessment for the U.S. Caribbean.	Appeldoorn, R. et al.
SEDAR14-RD10	Coral reef fisheries uses in Puerto Rico and USVI.	anon.
SEDAR14-RD11 SFD-02/03-184 2002	Standardized catch rates and preliminary assessment scenarios for queen conch (Strombus gigas) in the U.S. Caribbean	Valle-Esquivel, M.
SEDAR14-RD12 SFD-01/02-169 2002	U.S. Caribbean queen conch (Strombus gigas) data update with emphasis on the commercial landings statistics.	Valle-Esquivel, M.
SEDAR14-RD13 NMFS-Pro. Paper 5	Detecting fish aggregations from reef habitats mapped with high resolution side scan sonar imagery.	Rivera, J. A. et al.
SEDAR14-RD14 Bull Mar Sci 62(2) 1998	VARIATION IN NATURAL MORTALITY. IMPLICATIONS FOR QUEEN CONCH STOCK ENHANCEMENT	Stoner, A. & R. A. Glazer
SEDAR14-RD15 Fish Bull 96:885-899 1998	Settlement and recruitment of queen conch, *Strombus gigas,* in seagrass meadows: associations with habitat and micropredators	Stoner, A. W., M. Ray-Culp, S. M. O'Connell
SEDAR14-RD16 Mar Ecol Prog Ser 202:297-302 2000	Evidence for Allee effects in an over-harvested marine gastropod: density-dependent mating and egg production	Stoner, A. W. and M. Ray-Culp
SEDAR14-RD17 ICES Mar. Sci Symp 199:247-258 1995	Stock assessment of a large marine gastropod (*Strombus gigas)* using randomized and stratified towed diver censusing.	Berg, C. J. Jr., and R. A. Glazer
SEDAR14-RD18 Sociedad de Cinecias Naturales La Salle. Tomo XLVIII. Supl No. 3 1988	COMMERCIAL CATCH LENGTH-FREQUENCY DATA AS A TOOL FOR FISHERIES MANAGEMENT WITH AN APPLICATION TO THE PUERTO RICO TRAP FISHERY	Dennis, G.
SEDAR14-RD19 Mar Ecol Prog Ser 257:275-289 2003	What constitutes essential nursery habitat for a marine species? A case study of habitat form and function for queen conch	Stoner, A. W.
SEDAR14-RD20 Jou. Shellfish Res 15(2) 407-420 1996	LARVAL SUPPLY TO QUEEN CONCH NURSERIES: RELATIONSHIPS WITH RECRUITMENT PROCESS AND POPULATION SIZE IN FLORIDA AND THE BAHAMAS	Stoner, A. W., R. A. Glazer, P. J. Barile
SEDAR14-RD21 Mar Ecol Prog Ser 106:73-84 1994	High-density aggregation in queen conch *Strombus gigas:* formation, patterns, and ecological significance	Stoner, A. W. and J. Lally
SEDAR14-RD22 J. Shellfish Res. 17(4) 955-969 1998	MESOSCALE DISTRIBUTION PATTERNS OF QUEEN CONCH *(STROMBUS* GZGAS LINNE) IN EXUMA SOUND, BAHAMAS: LINKS IN RECRUITMENT FROM LARVAE TO FISHERY YIELDS	Stoner, A. W., N. Mehta, and M. Ray-Culp.

SEDAR14-RD23 Mar Bio 116:571-582 1993	Aggregation dynamics in juvenile queen conch *(Strombus gigas)* : population structure, mortality, growth, and migration	Stoner, A. W., R. Ray
SEDAR14-RD24 Fish Bull 94:551-565 1996	Queen conch, *Strombus gigas,* in fished and unfished locations of the Bahamas: effects of a marine fishery reserve on adults, juveniles, and larval production	Stoner, A. W.
SEDAR14-RD25 Fish Bull 92:171-179 1994	Queen conch, *Strombus gigas,* reproductive stocks in the central Bahamas: distribution and probable sources	Stoner, A. W., K. C. Schwarte
SEDAR14-RD26 Mar. Fish. Rev. 59(3) 1997	The status of queen conch research in the Caribbean	Stoner, A. W.
SEDAR14-RD27 TAFS 135:476-487 2006	Estimating Mortality from Mean Length Data in Nonequilibrium Situations, with Application to the Assessment of Goosefish	Gedamke, T., Hoenig, J. M.
SEDAR14-RD28 Fed-State Proj. No. NA77F0087 2000	Puerto Rico/NMFS Cooperative Fisheries Statistics Program 1997-2000	Matos, D.
SEDAR14-RD29 PR DNER 2004	Comprehensive Census of the Marine Fishery of Puerto Rico, 2002	Matos, D.
SEDAR14-RD30 CMFC Report 1984	Report on the reef fish size frequency survey July - September 1983	Morales-Santana, I.
SEDAR14-RD31 CFMC 1997	International queen conch conference proceedings, San Juan, PR, July 1996	Posada, J. M. and G. Garcia-Moliner, eds.
SEDAR14-RD32 NOAA/NOS undated NA03NOS426024	Marine resource conditions for reef fishes and seagrass around St. John, USVI: Historical to present	Beets, J. and L. Muehlstein.
SEDAR14-RD33 SEFSC undated manu.	Queen conch CPUE assessment in PR & USVI's : Preliminary report.	Rivera, J. A.
SEDAR14-RD34 UPR/SEAMAP-C 2005	St. Croix and St. Thomas/St. John fisheries independent trap and line survey, 1992-2002.	Whiteman, E. A.
SEDAR14-RD35 PR Dept. of Agr., Agr. and Fish. Contr. IV(4) 1972	A report on fisheries statistics program in Puerto Rico from 1967 to 1972	Juhl, R. & J. A. Suarez Caabro
SEDAR14-RD36 PR Dept. of Agr., Agr. and Fish. Contr. III(1) 1975	La Pesca en Puerto Rico, 1970	Juhl, R. & J. A. Suarez Caabro
SEDAR14-RD37 Comm Fish. Rev. USFWS Reprint 866 1970	Puerto Rico's commercial fisheries. A statistical review.	Suarez-Caabro, J. A.
SEDAR14-RD38 PR Dept. of Agr., Agr. and Fish. Contr. II(1) 1975	Puerto Rico commercial fisheries, 1968-1969	Suarez-Caabro, J. A.

SEDAR14-RD39 PR Dept. of Agr., Agr. and Fish. Contr. IV(1) 1972	Status of fisheries in Puerto Rico, 1971.	Juhl, R. & J. A. Suarez Caabro
SEDAR14-RD40 PR Dept. of Agr., Agr. and Fish. Contr. V(3) 1973	Status of fisheries in Puerto Rico, 1972.	Suarez-Caabro, J. A.
SEDAR14-RD41 PR Dept. Nat. Res; Fish. Res. Lab. Tech. Rpt. 1(1) 1986.	Overview of Puerto Rico's small scale fisheries statistics, 1972 - 1978	Weller, D. & J. A Suarez-Caabro.
SEDAR14-RD42 PR Dept. of Agr., Agr. and Fish. Contr. VII(1) 1975	Status of fisheries in Puerto Rico, 1974.	Rolon, M.
SEDAR14-RD43 PR Dept. of Agr., Agr. and Fish. Contr. VIII(4) 1976	Status of fisheries in Puerto Rico, 1975.	Suarez-Caabro, J. A. & M.A. Abreu Volmar
SEDAR14-RD44 PR Dept. of Agr., Agr. and Fish. Contr. IX(1) 1978	Status of fisheries in Puerto Rico, 1976.	Abreu Volmar, M. A.
SEDAR14-RD45 CODREMAR, Fish. Res. Lab. Tech. Rpt. 1(2) 1987-1988	Status of fisheries in Puerto Rico, 1979-1982	Collazo, J. & J. A. Calderon
SEDAR14-RD46 NMFS/SERO State-Fed Proj. SF23 1986	CODREMAR/NMFS Cooperative statistics program. Completion report.	Garcia-Moliner, G. & J. Kimmel
SEDAR14-RD47 Comm. Fish. Res. and Dev. Act Pgm. 2-395-R 1986	Puerto Rico commercial fisheries statistics for 1983 - 1986.	Garcia-Moliner, G. & J. Kimmel
SEDAR14-RD48 PR Dept. Nat. Res; Fish. Res. Lab. Tech. Rpt. 1(1) 1994	Overview of Puerto Rico's small scale fisheries statistics, 1983 - 1987	Matos, D. and C. R. Alvarez

2. Panel Recommendations and Comment

2.1. Discussion and Critique of Each Model Considered

Preliminary production model (ASPIC) runs were completed for Puerto Rico and St. Croix queen conch, however those analyses were not continued because the available data were inadequate and conclusions resulting from analyses based upon those data would likely be erroneous. This decision was based upon the arguments in SEDAR 14-AW-04, summarized here.

Surplus production models, as have been previously used in queen conch assessments in the US Caribbean (Anon. 1999, Valle 2002), require at least one series of yield and one index of stock abundance or effort as input. Incremental changes in effort should result in proportional changes in catch. Standardized catch-per-unit-effort (CPUE) series from the commercial fisheries were the only available stock abundance measures available prior to the assessment workshop (Table 1). As discussed in at the workshop (summarized in section 2.1.1), the diver-based CPUE data available for the queen conch assessment do not vary even when landings have an 8-fold increase (Figure 1, years 1992-2006) or a marked decrease (Figure 2, for the years 1989-1992). The only available CPUE series does not meet the assumption of a production model that changes in catch are reflected by incremental changes in effort.

Uncertainties are also associated with the landings estimates. On many occasions some fishers did not submit landing reports, therefore, expansion factors were used to raise the reported landings to account for incomplete reporting. Also, in Puerto Rico there were instances when the landings reported by individual fishers differed from what was actually landed (Matos-Caraballo, 2004). In both Puerto Rico and St. Croix there were no current estimates of recreational harvest. The single estimate of recreational harvest available was from Puerto Rico in 1986 where recreational harvest was estimated to be 35% of the commercial landings, suggesting that queen conch harvest by the recreational sector is potentially important. With such uncertain and inadequate available data, the decision was made to not continue an assessment of queen conch stocks in Puerto Rico or St. Croix using production models dependent upon diver-based CPUE series.

2.1.1 Catch per Unit Effort

Discussion on catch per unit effort (CPUE) for conch revolved around two points. The first concerned what constituted a directed conch trip, given that conch fishers routinely target other species, particularly spiny lobster, while fishing conch. The second point regarded what zero-caught-conch trips should not be counted toward estimating CPUE. Specifically, identify and use only data from those areas where vessels in the conch fishery operate (e.g., excluding north coast dives) and excluding trips where lobsters were caught but no conch were caught. These guidelines were accepted based on both the knowledge of local scientists and commercial fishers and the behavior of subsequent standardized CPUE.

The resulting CPUE trends showed a distinct flat trend despite evidence from resource surveys that densities have increased and in the face of an 8-fold increase in catch from St. Croix over the past decade (a trend that has accelerated over the last three years). There was also a significant reduction of conch landings in Puerto Rico during the period 1988-1992 that, according to local commercial fishers, was the result of low conch densities. The estimated standardized CPUE for that period, however, did not show any declining trend. The regulatory catch quota (150 conch/commercial fisher/day) that was introduced during the CPUE time series introduces a confounding effect. Commercial fishers stated they have been able to catch the daily quota dispite any changes in stock abundance.

The consensus interpretation is that CPUE was, at best, an index of aggregation density rather than overall abundance of the stock. This interpretation was supported by a review of the data that showed that the marked increase in landings in St. Croix catch was due to a concomitant increase in the number of fishing trips.

In summary, while an acceptable measure of standardized CPUE was developed, it was uninformative of stock abundance.

2.1.2. **Resource Surveys**

The assessment workshop panel strongly recommends expanding existing fishery independent surveys of queen conch populations in the US Caribbean. Available data are summarized below and in section 3.

Periodic transect surveys were available for Puerto Rico (west and east coasts), St. Thomas-St. Thomas, and St. Croix. PR surveys date back to 1986, while those in the USVI date back to 1981. In Puerto Rico and the USVI, current surveys are conducted every 5 years as part of SEAMAP-Caribbean. Additional recent data are available from limited-area benthic surveys conducted by NOS-CCMA in the protected areas of St. John and St. Croix.

The consensus was that these surveys offer much promise for developing an index of conch abundance and that they could be coupled with landings data to get an indication of relative fishing pressure. In addition, such indices may be compared to approximate target values developed or used elsewhere in the Caribbean (see below). Difficulties remain with respect to the data needed and best approach for expanding the limited survey results over some portion or the entire shelf.

Initial population estimates were made for Puerto Rico, St. John and St. Croix. Results for Puerto Rico (Table 2) had Yield/Biomass values ranging from 0.26 to 1.17. A similar calculation for recent landings in St. Croix yielded a Yield/Biomass ratio of 0.195. Calculations for St. Croix were considered more reliable due to the greater proportion of the shelf mapped and known area. For Puerto Rico there was also considerable uncertainty in total yield, as reported landings are expanded by as much as a factor of two for some years.

Resource surveys clearly show that densities were increasing in Puerto Rico and St. Croix (adults only), the two areas that support commercial fisheries. Both had current average densities of approximately 30 conch/ha. The most recent survey in Puerto Rico also showed an increase in both the proportion of adults and a shift in the age structure to older individuals, while still showing evidence of substantial juvenile recruitment. In Puerto Rico, this most recent survey may evidence a response to the application of the full extent of management measures in both local waters and the relatively small portion of the shelf within the EEZ. Size limits, daily quotas, and closed seasons in the EEZ went into effect in 1997. The closed season was extended into local waters in 1999, while the other measures were extended 2004. The closure of the EEZ occurred in 2005. In St. Croix these measures (except the EEZ closure) went into effect in 1994. However, newly protected areas have been initiated in St. Croix, which may contribute to the density increase. Data for St. John show a sustained decline in adults since 1981, while data for St. Thomas show mixed results.

The conch FMP currently has an estimated MSST of 1,404,000 lbs and an MSY of 452,000 lbs. Density-based estimates of total stock biomass (adults only) for Puerto Rico (1,897,000 lbs) and St. Croix (668,000 lbs) sum to the approximate value of the MSST. On the other hand, the yield for these areas (723,719) is 60% greater than the recommended MSY.

The density values can also be compared to approximate target values developed or used elsewhere in the Caribbean, as illustrated in Figure 3. Here, the density levels for Puerto Rico are plotted against values obtained elsewhere in the Caribbean for surveys that can be construed as being shelf wide. The increasing trend in conch density (juveniles and adults) for Puerto Rico over the last decade is shown by the arrow. Also shown is the observed limit (50 conch/ha) found by Stoner and Ray (1996) below which reproductive activity (copulation and egg deposition) was found to decline (in proportion to density decline). Also shown is the density level used to estimate stock size at MSY on Pedro Bank, based on one-half the observed density in the 20-30m stratum, which at the time was assumed to be unfished (Appeldoorn, 1995). Observed densities for both Puerto Rico and St. Croix are still substantially below both of these levels.

Lastly, catch rates per hectare can be compared to the predicted MSY for the Turks and Caicos. This was taken as the commercial catch (87 kg/km^2, Ninnes 1994) plus that for local consumption (51 kg/km^2, Olsen 1985), which totals 3.04 lbs/ha. In Puerto Rico, the most recent harvest was very similar, at 3.10 lbs/ha. For St. Croix, the value was more than double, at 7.39 lbs/ha.

For St. Croix, all calculations were made assuming the whole of the shelf to be exploited. However, most, if not all, of the recent survey stations were located within the Buck Island National Coral Reef Monument or the East End Marine Park, both of which are protected areas. Thus, it is possible that the increase in density observed in recent years may reflect a sharp reduction in exploitation rate, and expansion of density values over the whole of the shelf would be inappropriate. Under this scenario, expected biomass would be lower and exploitation rates would be much higher. Unfortunately, there was no representative from CCMA or the Virgin Islands present to address the question of exploitation/enforcement within the protected areas.

For Puerto Rico, observed densities were also expanded over the whole shelf, despite the fact that essentially no fishing occurs along the north coast and the western margin of the western shelf is within the EEZ and currently closed to fishing. Proportionally, however, the sum of these areas is still small relative to the whole shelf, so their impact on the conclusions would be low.

2.2. Discussion of YPR, SPR, Stock-Recruitment

What was discussed/recommended?

2.3. Recommended SFA parameters and Management Criteria

The AWP did not estimate any SFA parameters.

2.4. Status of Stock Declarations

The AWP did not estimate any SFA benchmarks, therefore, the status of the stock could not be evaluated.

2.5. Recommended ABC

The AWP did not estimate any ranges of ABC.

2.6. Discussion of Stock Projections

The AWP did not perform any projections to evaluate the future status of the stock.

2.7. Management Evaluation

The Caribbean Fishery Management Council is charged with developing Annual Catch Limits for queen conch. Management benchmarks (e.g. FMSY, BMSY) could not be estimated, therefore it was not possible to perform an evaluation of current management regulations. The workshop panel recommends expansion of fishery independent surveys of queen conch populations, however, it is unclear how density surveys can be used to set Annual Catch Limits. It is also unclear how density surveys can be used to assess (and hence open) the closed areas on the Puerto Rico and St. Thomas/St- John EEZ.

2.8. Research Recommendations

1. The efforts to analyze the available data were greatly enhanced by the presence of local fishers and agency representatives. However, there was no local representative from the USVI Division of Fish and Wildlife assigned to the

meeting, while the Puerto Rico representative could not attend the full term of the meeting. There must be greater buy-in from the local agencies such that knowledgeable representatives are present for the full term of the meeting. Greater efforts should be made to attract the participation of local fishers.

2. Data from past density surveys should be re-analyzed so that values can be expanded on the basis of both habitat and depth, including confidence limits. Habitats should be matched to those available for existing/planned habitat maps. As a subportion of this, the data for the Puerto Rico 1986 survey should be entered into electronic and GIS formats. This could be done using NOAA's Data Rescue funds.

3. Expansion factors for both Puerto Rico and the USVI should be calculated for conch fishers only.

4. Assessment of the spatial and temporal variations and dynamics of the resource, fishery, habitat and species interactions would be greatly enhanced if traditional ecological knowledge were obtained from fishers. Efforts should be made to incorporate fishers into the process, particularly using NOAA's CRP funds.

5. The impact of the recreational fishery is unknown and must be quantified.

6. Considering the established and potential value of resource surveys, mechanisms should be identified to increase their aerial coverage.

7. More detailed spatial expansions of survey densities should be planned in preparation of the 2010 Conch Update. For this, significant improvements in available data and analyses are required, including but not limited to the following:
    A. Detailed bathymetry data for PR and USVI
    B. Analysis of the impact of closed areas
    C. Inclusion of more detailed habitat maps for the PR western platform currently in progress
    D. Quantified size/age structure of the exploitable stock.

8. The only estimate to date of fishing mortality came from a tagging study in the 1980's. New tagging studies should be initiated to quantify rates of exploitation. This would allow existing SPR models for conch to be used in assessments.

9. Another issue remaining is to investigate the potential impact of very old conch in deep refuges, especially with respect to reproduction, coupled with studies to age very old conch. Such refuges may be substation off St. Thomas/St. John, in patches in Puerto Rico and potentially in protected areas on all three platforms.

10. Intersessional data evaluation workshops for CFMC managed species or species-complexes should be conducted by the Council so that SEDAR level analyses are limited to those where data are sufficient to warrant such an analysis.

11. There needs to be a complete review of the potential data collection programs, including commercial and recreational catch, biostatistical sampling and fishery-independent surveys for Puerto Rico and US Virgin Islands with the purpose of identifying what relevant information could be obtained and modifying sampling procedures accordingly, including the identification of key economic and ecological indicator species.

3. Data Review and Update

Estimation of queen conch populations for the US Caribbean

During the SEDAR 14 Assessment Workshop (4-8 June 2007) various techniques were evaluated to assess the current stock status of queen conch (*Strombus gigas*). Of those investigated, the most promising approach was comparison of changes in habitat-based densities throughout the years where comparable surveys have been conducted. Considering each island separately, data from those surveys were expressed as densities per unit area and then extrapolated to island-wide population estimates based on available bathymetry and benthic habitat maps. Population sizes were compared to reported landings to see if predicted populations could reasonably support the catch.

Methods

Queen conch populations have been surveyed in Puerto Rico and the Virgin Islands since about 1981. In the Virgin Islands, beginning in 1981, 22 transects around the islands of St. Thomas and St. John (considered as a unit; St. Thomas=10 transects, St. John=12 transects) and 22 transects around St. Croix were surveyed, documenting density and size distribution by transect, depth and habitat (Wood and Olsen 1983). This initial effort was followed by repeated surveys under the SEAMAP-C program and resource evaluations by the Virgin Islands National Park: 1985 (St. John only, Boulon 1987); 1990 (all USVI, Friedlander et al. 1994); 1996 (St. Thomas and St. John only, Friedlander 1997); and 2001 (all USVI, Gordon 2002, Valle-Esquivel 2006). An additional site (Saba Island) was added for the St. Thomas surveys in 2001 following observations by DFW staff of abundant juvenile conch. For 2001, a total of 11 sites were surveyed in St. Thomas and 12 sites were surveyed in St. John. Of the 22 original transects surveyed in

1981 around St. Croix only 16 were resurveyed in 2001 because of limited study time. The experimental design for these surveys has generally been focused on examining the long-term trends in queen conch stocks based on repeated surveys through time. For this analysis, we are comparing each island separately, with St. Thomas/St. John lumped together when necessary. The current SEAMAP-C conch survey is planned for 2007/8.

Around Puerto Rico, similar queen conch surveys were conducted in 1986, 1995/96, 2001/02, and 2006 by both the University of Puerto Rico (for PR DNER/SEAMAP-C and the Caribbean FMC) and by PR DNER under SEAMAP-C. Surveys included stratification by conch/non-conch habitat (1995/96, 2006) as well as random (1987, 2001/02). Effort varied by survey based on resource availability: 1986 (Torres Rosado 1987, Southwest/La Parguera only); 1995/96 (Appeldoorn 1996, Mateo 1997, Mateo et al. 1998, West coast: 60 stations; East coast: 29 stations); 2001 (Appeldoorn 2002, West and Southwest coasts: 60 stations); 2006 (Jiménez, personal communication 2007, West coast: 46 stations, South coast: 13 stations, East coast: 40 stations). Sampling methods were consistent with surveys conducted in USVI. Size estimates and density data are available as density by transect, habitat and depth.

In addition to these surveys, two projects, conducted under the NOAA Coral Reef Conservation Program, are collecting data that can provide recent comparisons. NMFS SEFSC has been conducting studies of queen conch in two of the bays of St. John, using tagging and sonic tracking to look at habitat use, conch movements and migrations. Densities, by size and life stage are available by transect area, by depth, and by habitat within the bounds of the areas surveyed. NOS Biogeography Team has been surveying reef fish in St. John, parts of St. Croix and La Parguera, Puerto Rico since 2001. Since 2004 they have included records of queen conch when encountered on their surveys, recording size, maturity state, depth, and habitat. Both studies provide estimates of conch densities by area that were used for these comparisons.

Parameters

Surveys are described above. Densities were calculated based on mean densities of conch per transect. For SEAMAP-C-type surveys, transect areas were estimated by the difference between starting and ending positions; widths were 4 m. Densities were taken as calculated in Valle-Esquivel 2006. For NOS reef fish surveys, transects were 100 x 4 m wide. For SEFSC tagging study transects are based on length of tracks recorded by GPS; widths were 10 m.

Area of the insular shelves for each island was calculated for all areas less than 50 m based on available bathymetry (UPR).

Conch weight conversions were taken from studies in Puerto Rico. Numbers of adult conch were converted to uncleaned meat weight using 0.80377 lbs/conch. Lacking precise sizes for juveniles, it was assumed that juvenile populations would be similar to the distribution published in Mateo et al. 1998 having two principle nodes approximately 12.5 and 17.5 cm shell length. Juvenile abundances were divided equally into these two size classes and converted into weight using the equation from Appeldoorn (1988) [as reported in Report on the Queen Conch Stock Assessment and Management Workshop, Belize City, Belize 15-22 March 1999 (CFMC and CFRAMP)] and subsequent conversion of grams (gm) to pounds (lbs.):

$$\text{Log[weight (gm)]} = -2.535 + 3.486[\text{Log (Length)}]$$

Estimates of Population Size and Biomass

St Croix (Area: 32014 ha)						
YEAR	**DENSITIES**		**POPULATION**			**BIOMASS (Adult/Juv)**
	ADULT	**JUVE.**	**ADULT**	**JUVE.**	**TOTAL**	**(UNCLEANED LBS)**
1981	7.6	na	243,306	na	243,306	195, 562/na
2001	25.5	74	816,357	2,369,036	3,185,393	656,163/213,853
2004/6	26.1	60.4	835,005	1,933,950	671,152	671,152/174,578

St Thomas (Area: 12,004 ha)						
YEAR	**DENSITIES**		**POPULATION**			**BIOMASS (Adult/Juv)**
	ADULT	**JUVE.**	**ADULT**	**JUVE.**	**TOTAL**	**(UNCLEANED LBS)**
1990	11.8	1.6	141,527	19,086	160,613	113,755/1,723
1996	32.2	31.5	386,409	377,646	764,055	310,584/34,090
2001	24.2	1.9	289,897	22568	312,464	233,010/2,037

St John (Area: 4699 ha)						
YEAR	**DENSITIES**		**POPULATION**			**BIOMASS (Adult/Juv)**
	ADULT	**JUVE.**	**ADULT**	**JUVE.**	**TOTAL**	**(UNCLEANED LBS)**
1981	52.4	na	246,296	na	246,296	197,965/na
1985	31.3	na	147,045	na	147,045	118,190/na
1990	8.08	0.7	37,971	3,102	41,073	30,520/289

1996	4.8	5.2	22,557	24,296	46,853	18,130/2193
2001	1.5	4.2	7002	19,597	26,599	5,628/1769
2004/6[1]	9.7	35.4	72,832	169,838	242,670	58,540/15,331
2005/7[2]	5.3	24.5	24,907	115,136	140,042	20,019/10,393
Sources: 1. NOS surveys, 2. SEFSC conch tagging						

Puerto Rico (Area: Total: 157,348 ha; West coast: 78,674; East coast: 78,674)						
YEAR	**DENSITIES**		**POPULATION**			**BIOMASS (Adult/Juv)**
	ADULT	**JUVE.**	**ADULT**	**JUVE.**	**TOTAL**	**(UNCLEANED LBS)**
1986	8.11	na	1,276,090	na	1,276,090	1,025,683/na
1995 east	2.5	4.7	200,461	372,285	572,746	161,125/33,606
1995west	2.0	3.7	156,404	290,463	446,868	125,713/26,220
1995 TOT			356,865	662,749	1,019,613	286,837/59,826
2001	4.3	10.1	675,022	1,595,506	2,270,528	542,562/144,026
2006	15	16.9	2,360,216	2,659,177	5,019,393	1,897,071/240,044

Future Work Recommended

Additional estimates of population sizes could be made from available "density by habitat" and/or "density by depth" data from these same surveys. The results of combining both habitat and depth are likely to be most accurate and could be accomplished with additional manpower and time for extrapolation of survey densities to population estimates.

4. Stock Assessment Models and Results

No assessments were performed for queen conch due to a lack of adequate data. Data deficiencies include a complete lack of recreational catch statistics, uncertainty in the commercial catch statistics (i.e. expansion factors used in the Puerto Rico landings), CPUE series that do not reflect stock abundance, and a lack of biological sampling.

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Table 1. Data availability summary for Caribbean queen conch.

	Puerto Rico	St. Thomas, USVI	St. Croix, USVI
Commercial Landings	Since 1967 available on	Since 1974 Questions about expansion factors	Since 1975 Questions about expansion factors
Commercial Lengths	No information (See Rivera 1999)	No info No information	Some from late 1990s (See Rivera 1999)
Commercial Discard	don’t exist	don’t exist	don’t exist
Recreational Landings	No information except one estimate from early 1980s	No information	No information
Recreational Lengths	No information (60 individuals only 12 adults)(see Appeldoorn and Valdez-Pizzini 1996)	No information	No information
Recreational Discard	don’t exist	don’t exist	don’t exist
Age Samples	Survey	none	Survey
Fishery Independent Indices and Surveys	Habitat based population estimates Seamap every 5 years	Habitat based population estimates Seamap every 5 years	Habitat based population estimates Seamap every 5 years
Fishery Dependent Indices (CPUE)	CPUE not reliable abundance measure	NO.	CPUE not reliable abundance measure
Life History	Age and growth, La Parguera Maturity by age Fecundity by length		Age and growth
Stock ID	No Information	No Information	No Information
Management Issues	Size and bag limits Closed areas and seasons	Size and bag limits Closed areas and seasons	Size and bag limits Closed areas and seasons

Table 2. Initial calculations of conch stock biomass for Puerto Rico (adult) based on spatial expansion of survey densities. These are compared to estimates of total yield.

Year	Number	Biomass(lb)	Yield(lb)	Y/B
1996	1,019,613	346,663	336,000	0.97
2001	2,270,528	686,589	358,000	0.52
2006	2,360,216	1,897,071	487,000	0.26

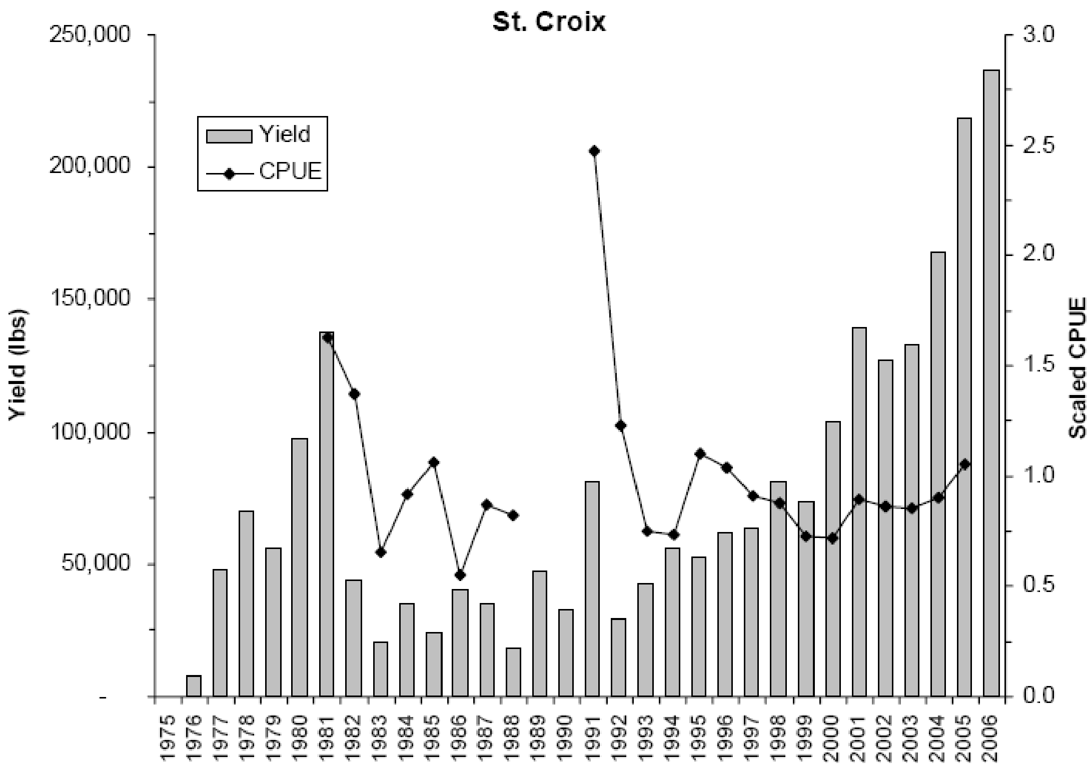

Figure 1. Estimated total yield and standardized CPUE, estimated using ‘trip’ as unit-of-effort for queen conch for the island of St. Croix.

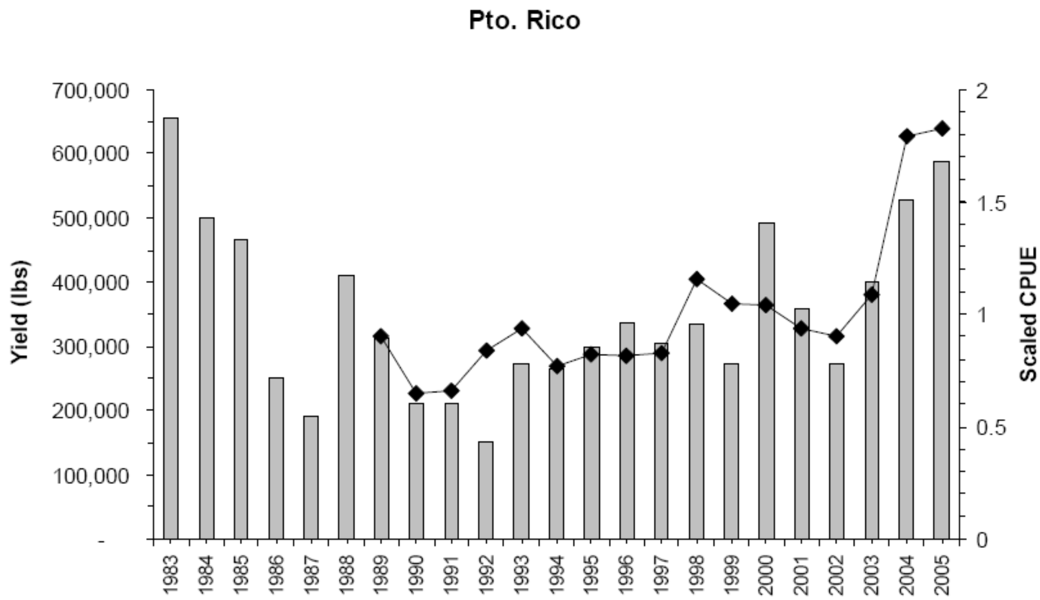

Figure 2. Estimated total yield and standardized CPUE, estimated using 'trip' as unit-of-effort, for queen conch for the island of Puerto Rico.

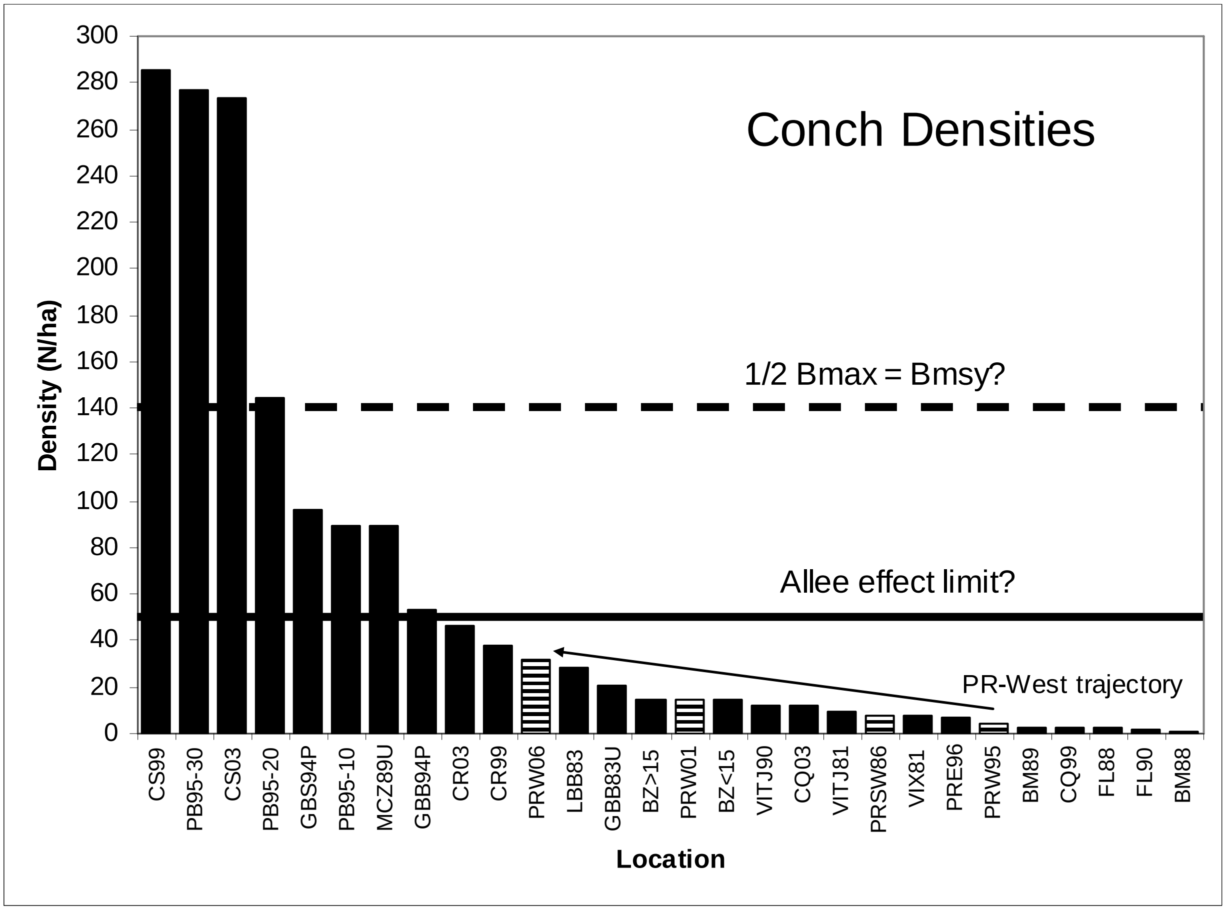

Figure 3. Conch densities for shelf wide surveys throughout the Caribbean. Densities are unadjusted for any potential differences, such as habitat distributions, proportion of juveniles, etc. Striped values are values for western Puerto Rico. Solid line represents the density below which reduced reproductive output may be expected based on studies in the Bahamas. Dashed line represents the level at which density is ½ the maximum density observed in the deep stratum on Pedro Bank, assumed to reflect virgin stock density there. Arrow shows the general direction of density increase off western Puerto Rico over the past 10 years.

SEDAR 14

Stock Assessment Report 3

Caribbean Queen Conch

SECTION IV. Review Workshop

SEDAR
4055 Faber Place #201
North Charleston, SC 29401

SEDAR 14 Review Workshop

Review Panel Consensus Summary

Executive summary

The SEDAR 14 Review Workshop met in San Juan, Puerto Rico, from 23 to 27 July 2007. The Panel itself comprised the Chair and three reviewers appointed by the Center for Independent Experts (CIE). The workshop was also attended by five US technical experts, the SEDAR facilitator, one representative from Caribbean Fishery Management Council (CFMC), one representative from Puerto Rico Department of Natural Resources, two representatives from the University of Puerto Rico and one representative from NMFS Headquarters. All documentation, including background documentation provided to earlier Data Workshop(DP) and Assessment Workshop (AW), was provided to the Review Pane (RP0 in good time for prior review, and was comprehensive for the job in hand.

The RP endorses the conclusion of the DW and AW that the available data on queen conch abundance and fishing pressure are inadequate or insufficiently informative to allow a stock assessment or associated projections and benchmark statistics to be presented. The RP considers that all the available options for queen conch stock assessment have been explored by the DW and AW using the existing data. The RP agrees that production modeling approaches are inappropriate given incomplete landings data and CPUE data that are not informative of stock abundance. Fishery-independent resource surveys appear to offer the most promise for future stock assessments. Low spatial and habitat coverage and small numbers of conch observed during visual surveys preclude reliable estimation of stock abundance at present, although results are at least indicative of increases in conch numbers around Puerto Rico and St Croix.

The RP agrees that the three highest priorities for the future are: (i) to strive for increased compliance with reporting requirements to eliminate the need for expansion factors to be applied to reported landings; (ii) to estimate the recreational portion of the total catch in all future years; and (iii) to improve the spatial and habitat coverage of fishery-independent resource surveys.

Even with improved estimates of total conch abundance from resource surveys, development of population benchmarks will remain problematic. The RP considers that the approach taken by the AW of comparing conch density estimates from Puerto Rico and US Virgin Islands(USVI) with those from other areas of the Caribbean offers some promise in this context. It was suggested that a proxy for Bmsy could be derived from density estimates from quasi-unexploited areas, but more information is needed on the influence of population structure and habitat

preferences before this type of proxy would be defensible. Marine Protected Areas around Puerto Rico and USVI may provide useful local insight into unfished densities. The RP agreed with the AW recommendation that intersessional data evaluation workshops should be carried out before SEDAR level stock assessments are programmed, and suggested that the next workshop should be held in 3 years time.

Table of Contents

1. Introduction

1.1. Workshop Time and Place

The SEDAR 14 Review Workshop was held July 23 - 27, 2007, in San Juan, Puerto Rico.

1.2. Terms of Reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment*.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock*.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation*.
4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); provide estimated values for management benchmarks, a range of ABC, and declarations of stock status*.
5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition* (e.g., exploitation, abundance, biomass).
6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters*. Ensure that the implications of uncertainty in technical conclusions are clearly stated.
7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations**.
8. Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.
9. Review the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment.
10. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Complete the Advisory Report summarizing key assessment results. (Reports to be drafted by the Panel during the review workshop with a final report due two weeks after the workshop ends.)

* The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the review panel to deviate from assessments provided by the assessment workshop panel are provided in the *SEDAR Guidelines* and the *SEDAR Review Panel Overview and Instructions*.

** The panel shall ensure that corrected estimates are provided by addenda to the assessment report in the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above.

1.3. Workshop Participants

Review Panel

- John Butler .... Chair/NOAA Fisheries SWFSC
- Mike Armstrong .... CIE/CEFAS
- Michael Bell .... CIE
- Henrik Sparholt .... CIE/ICES

Council Appointed Observers

- Richard Appeldoorn .... CFMC SSC/UPR
- Francisco Pagan .... UPR
- Daniel Matos .... PR DNR

Analytical Team

- Nancie Cummings .... NOAA Fisheries SEFSC
- Guillermo Diaz .... NOAA Fisheries SEFSC
- Todd Gedamke .... NOAA Fisheries SEFSC
- Clay Porch .... NOAA Fisheries SEFSC
- Steve Turner .... NOAA Fisheries SEFSC

Observers

- Lynn Waterhouse .... VIMS
- Bill Michaels .... NOAA Fisheries S&T

Staff

- John Carmichael .... SEDAR Coordinator
- Tyree Davis .... SEFSC
- Graciela Garcia-Moliner .... CFMC
- Rachael Lindsay .... SEDAR

1.4. Review Workshop Working Papers & Documents

Working Papers:

SEDAR14-RW01	Estimating mutton snapper mortality rates from mean lengths and catch rates in non-equilibrium conditions.	Gedamke and Porch
SEDAR14-RW02	SEDAR 14 Assessment Workshop Data and analytical status overview	SEDAR 14 AW Panel
SEDAR14-RW03	Standardized visual counts of mutton off the US Virgin Islands and their possible use as indices of abundance.	Gedamke and Porch
SEDAR14-AW01-1	Updated commercial catch per unit effort indices for mutton snapper line and pot fisheries in Puerto Rico, 1983-2006. Addendum 1 to SEDAR14-AW01.	Cummings, N.
SEDAR14-AW05-1	Revised estimates of mutton snapper total mortality rates from length observations. Addendum 1 to SEDAR14-AW05	Gedamke, T.

Reference Documents:

SEDAR14-RD49 US Geol. Surv., Carib. Field Station, St. John, USVI 2003	Temporal analysis of monitoring data on reef fish assemblages inside Virgin Islands National Park and around St. John, US Virgin Islands, 1988-2000	Beets, J. and A. Friedlander
SEDAR14-RD50 TAFS 135:476-487 2006	Estimating mortality from mean length data in nonequilbrium situations, with application to the assessment of goosefish.	Gedamke, T. and J. M. Hoenig
SEDAR14-RD51 Caribbean Coral Reef Institute (CCRI) 2007	Reef fish spawning aggregations of the Puerto Rican shelf. Final Report	Ojeda, E.

2. Review Panel Consensus

2.1. Statements addressing each TOR

1) Evaluate the adequacy, appropriateness, and application of data used in the assessment.

The data were inadequate to provide information on queen conch stock status. This was because: (a) landings data were incomplete, missing the recreational component in most years; (b) trends in commercial CPUE were not informative of stock abundance; and (c) expansion of habitat-specific survey densities to domain-wide abundance estimates were based on low survey coverage and small sample sizes of conch.

2) Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

To the extent possible given the paucity of available data, appropriate methods were correctly applied.

3) Recommend appropriate estimates of stock abundance, biomass, and exploitation.

No recommendation can be made on estimates of queen conch stock abundance, biomass and exploitation, but preliminary calculations based on habitat-specific densities could provide a basis to provide defensible estimates in the future.

4) Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); provide estimated values for management benchmarks, a range of ABC, and declarations of stock status.

Estimates for population benchmarks are not available, nor would it be appropriate to calculate values given the available information. A preliminary approach to estimating a Bmsy proxy based on comparison of survey densities with other areas experiencing much lower levels of exploitation shows promise for the future but is not yet sufficiently developed to provide a benchmark for management purposes. Marine Protected Areas hold the potential to evaluate unfished densities and hence provide a value for Bmsy proxy.

5) Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).

There was no model or data basis for projections of future stock status and none were attempted.

6) Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

Statistical uncertainty around total abundance estimates from fishery-independent surveys was characterized adequately using appropriate methods. The implications of the high uncertainty were clearly recognized in that the abundance estimates were not carried forward to provide management recommendations.

7) Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.

The Stock Assessment Report provides a clear and concise summary of the stock assessment analyses performed. The interpretation of results is consistent with the consensus reached by the Review Panel.

8) Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.

The Data Workshop (DW) comprehensively addressed all its terms of reference. The Assessment Workshop (AW) completely addressed its terms of reference regarding data treatment, development of approaches to stock assessment, recommendations for future research and report preparation, but owing to inadequate data was unable to evaluate stock status in relation to benchmarks for fishery management. Provision of a concise summary of research recommendations collated from the Data Workshop and Assessment Workshop reports would improve the focus of the Review Workshop.

9) Review the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment.

The RP reviewed the wide range of research recommendations provided by the DW and AW in relation to immediate and longer-term needs for improving the assessment of the stocks and the provision of management advice. The RP provided additional recommendations where appropriate. The research recommendations are reviewed in a separate section of this report (see below under Additional Comments).

It is recommended that the next assessment be deferred until an inter-sessional data evaluation workshop can demonstrate significant progress in the improvement of resource survey and landings data. An interval of 3 years would be appropriate for an inter-sessional workshop.

2.2. Analyses and Evaluations

No requests were made for additional analyses or sensitivity runs for queen conch.

2.3. Additional Comments

The conclusion that the available data on queen conch fisheries and stock abundance around Puerto Rico and USVI are inadequate to allow a stock assessment or calculation of benchmark statistics was strongly endorsed by the RP. A commitment to long-term research and data collection to address these deficiencies in data and knowledge is essential for effective management supported by robust assessments, and adequate resources need to be provided to collect essential data to support scientifically based management of queen conch in the region. The RP however recognizes the significant effort that has been put into data collection in the region and emphasizes that these have provided a valuable framework for identifying the priorities for future data collection to support stock assessment and fishery management. The DW and AW have made a number of recommendations for future research and monitoring which are reviewed below alongside further recommendations of the RP.

Recommendations of the Data Workshop

Life history

The DW made no recommendations for future research into queen conch life history. Biological parameters for queen conch are generally well characterized from the literature, although variations in growth and maturation over small spatial scales mean that there is uncertainty about area-specific parameters. This is not presently a limiting factor for stock assessment, principally because there are neither data nor model structures available for analytical assessment of conch stocks, but use of yield or spawner per recruit analyses to develop biological reference points would need to account for this fine scale variation. In common with many other species, empirical information is lacking on natural mortality after early life stages, but assumed values and their relationship with age appear to be adequate at present.

The RP made no specific recommendations for high priority research into conch life history parameters, but there was a general view that more information is needed on stock identity and the spatial scale of population processes at each life stage. Genetic studies indicate population connectivity between different areas of the Caribbean, but this does not preclude the existence of stock units that are effectively self-contained at time scales relevant to stock assessment and fishery management. Modeling of conch larvae dispersal by surface currents may shed some light on this issue.

Commercial statistics

The DW recommended that Puerto Rico conch landings for recent years should be corrected for the change from reporting uncleaned to reporting cleaned meat weights and that this should be done on a port-by-port basis. Landings included in the DW report were not corrected, but approximate corrections at the scale of the entire Puerto Rico fishery were applied in figures presented in the AW report and during the RW meeting. The RP agreed that it was a high priority to apply such corrections in presenting time-series of conch landings data.

The DW also made the following recommendations regarding the collection of statistics on the commercial fisheries for the three species considered by SEDAR 14:

DW1) Continuous biological sampling in the Virgin Islands at sufficient levels to adequately characterize size and age composition.

DW2) Link biostatistical data for a fishing trip from Puerto Rico to all of the landings records for that trip.

DW3) Ensure that the catch and effort data of individual fishers in Puerto Rico can be identified over time.

DW4) Eliminate the need for expansion factors by obtaining information on all landings.

The first recommendation relates mostly to finfish, but it is also true that future assessments may benefit from more information on the composition of conch catches. Ideally, continuous sampling should be maintained at sufficient levels to allow calculation of required indicator statistics, but occasional intensive sampling may provide a viable alternative. The definitions of 'sufficient' and 'occasional' can only be judged in a risk assessment context, the relevant question being what precision around indicator statistics is required for management purposes. In the absence of information on which indicator statistics might be desirable the RP is unable to provide more specific recommendations on sampling of conch catch composition.

Recommendations DW2-4 reflect the urgent need for accurate gear-specific total landings and effort data across the whole of the assessed area, and for comprehensive qualifying data to be matched with individual catch records such that meaningful and properly standardized CPUE estimates can be calculated. The RP regards these recommendations as being of the highest possible priority. Future progress in developing stock assessments and population benchmarks for queen conch depends critically on the availability of comprehensive, quantitative information on fishery removals and the associated fishing effort. This will remain true even if, as seems likely, fishery independent indices are used as the primary source of information on stock abundance. ABCs and related statistics will always need to be calculated with reference to complete landings data. The RP further recommends investigation of uncertainty around estimated expansion factors and hence around estimated total landings. This might be achieved by bootstrap sampling of the reported landings data, preferably on a species-specific basis. There also needs to be some evaluation of the assumption that available landings declarations are representative of all license holders. One possible approach would be to examine fishery returns from long-term license holders who have only recently submitted logbook records. If this subset of records is representative of the whole it would be reasonable to suppose that the calculated expansion factors are not biased.

The RP also recommends exploration of alternative approaches to estimating total landings and fishing effort directed at queen conch. These might include randomized sampling of catches at landing sites, aimed at statistical estimation of landings quantities that might circumvent the possible biases involved in expanding incomplete log-book records. Another approach that could be considered is the use of internet forms to allow fishers to enter catch and effort data directly. In this context it is worth emphasizing the desirability of developing partnerships with local fishers to collect data and to conduct research.

Recreational fishing

In common with other species, the recreational catch of queen conch may be considerable. Recreational fish catch estimates for Puerto Rico are available for 2000 onwards, but unfortunately conch and other invertebrates were not included in the MRFSS. Based on a one-off survey in 2000, recreational catches of conch were estimated to be at a level of about a third of the commercial landings by Puerto Rico in 2000-2001[1], i.e. around a quarter of the total landings. Clearly, the recreational catch of queen conch is an important omission from the Puerto Rico total landings data for other years and from the USVI total landings data in all years[2]. Furthermore, it is difficult to interpret even relative trends without more information on the variability of recreational effort between years[3]. The DW made the following recommendations relevant to recreational fishing for queen conch:

DW5) *Conduct surveys to estimate the magnitude of the U. S. Virgin Islands recreational landings for all species including conch and lobster. It is possible that using a Virgin Islands contractor would improve the likelihood of success of the survey.*

DW6) *Include conch and lobster in the MRFSS for Puerto Rico.*

<u>The RP strongly endorses these two recommendations for both Puerto Rico and USVI and considers that they should be given high priority in the immediate term</u>. Information on total landings is crucial for calculation of ABCs and associated benchmark statistics. <u>The RP further recommends that, in common with the expansion factors for commercial landings statistics (see above), the uncertainty around the current and future recreational landings estimates be investigated</u>. The current figures for Puerto Rico can be regarded as indicative rather than definitive estimates, and the application of the same expansion factor to USVI is somewhat tenuous. Unlike the commercial landings, it would be unrealistic to suppose that 100% coverage of recreational landings could ever be achieved. This makes it important to characterize the uncertainty around all recreational landings estimates.

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[1] The figures appear to be derived from the observation that recreational catches during a 3 month period were at around 50% of the *reported* landings over the same period. No adjustment seems to have been made for differences in commercial reporting rates between years.

[2] Tentative estimates for the USVI have been made for the same years, assuming that the same relationship exists with commercial landings (SFA Amendment, 2005).

[3] The AW report also mentions a similar proportion of recreational landings (35% of commercial landings) for Puerto Rico in 1986, but this would be a slender basis from which to infer a constant proportional contribution over time.

Indices of abundance

Both fishery-dependent and fishery-independent indices were examined by the DW. A number of recommendations were made on the analysis of CPUE, mainly concerning filtering of trip records and adjustment for reporting cleaned or uncleaned meat weights. These recommendations were taken on board by the AW, but owing to the lack of relationship between conch density and the ability of commercial divers to catch their daily quotas the resulting indices were considered not to be informative of stock abundance. The RP agrees that under current fishing practices it is unlikely to be feasible to measure diver effort in any way that would allow calculation of CPUE values that are responsive to abundance changes. The RP considers that low priority should be given to further analyses of queen conch CPUE data, given the likelihood that fishery-independent stock indices will be used as the main source of information on stock status in the near future, but the situation might change if alternative effort measures could be devised and recorded. This does not, of course, mean that reduced emphasis should be placed on collecting reliable records on fishing effort. Examination of effort trends is an important component of monitoring for overall fishery 'health', and trends in effort directed at queen conch may in themselves be indicative of changes in abundance.

The DW provided additional recommendations on indices of abundance for species considered by SEDAR 14, of which the following are relevant to queen conch:

DW7) *Fisheries-independent survey efforts currently rarely include stations in deep water, the preferred habitat of adult mutton snapper and adult yellowfin grouper. In addition, large aggregations of queen conch have been reported in deep water by commercial fishers. The group highly recommends the initiation and continued funding of such surveys. As trends can be regional in nature, the group highly recommends that such surveys be conducted throughout Puerto Rico and the US Virgin Islands.*

DW8) *The commercial landings data from Puerto Rico and the US Virgin Islands have been incompletely entered and a variety of problems are known to exist in those data. The group strongly recommends that every effort be made to resolve the problems with those data. This should include extensive meetings with port samplers and others familiar with the US Caribbean fisheries.*

DW9) *The group recommends that tag-recapture studies of mutton snapper, yellowfin grouper, and queen conch be conducted in Puerto Rico and the US Virgin Islands to determine habitat utilization and movement of those species.*

DW10) *Ongoing long-term monitoring studies should be expanded spatially and include data useful for stock assessment, e.g. size-frequency and density information.*

DW11) *It is suggested that areas exploited by fishermen be compared to those areas where monitoring has been ongoing to further knowledge of essential habitat for these species and improve the design of monitoring efforts (i.e., ensure that monitoring is reflective of fished conditions).*

DW12) *The group encourages the collection and documentation, for this and future Caribbean assessments, of historical information for qualitative and/or quantitative comparisons of current conditions.*

The RP agreed that all of these recommendations are valid for queen conch, with varying degrees of urgency, but more specific information is required on precisely what is needed and on the proposed methods of addressing them. Recommendation DW8 regarding commercial landings data should be clarified. The high priority that should be given to attempts to improve compliance with reporting requirements has already been noted above. However, the completeness of commercial fishing records is less of an issue in the context of abundance indices, principally because commercial CPUE is not informative as an index. It is nonetheless desirable to ensure that qualifying data for landings records are as comprehensive as possible, for example allowing the efforts of individual fishers to be followed. Significant progress with identifying improved measures of effort may change the priority of this recommendation.

Recommendations DW7, DW10 and DW11 are relevant to fishery-independent surveys, specifically visual surveys that generate habitat-specific queen conch density estimates that can be expanded to domain-wide stock abundance estimates. This assessment method is the most promising for queen conch stock assessments in the near future; the RP took the view that high priority should be given to expanding the spatial coverage and habitat coverage of the fishery-independent surveys with a view to improving the precision of stock abundance estimates. This type of assessment might also benefit from the inclusion of information on how fishing effort is distributed between areas of similar habitat, so that, for example, fishing intensity as well as habitat classification could be used to stratify the density estimates.

The RP agreed that tagging studies of queen conch should be conducted in both Puerto Rico and USVI. Recommendation DW9 relates to the use of tagging to determine patterns of movement and habitat utilization. The RP endorses this recommendation as a medium- to long-term priority, and further recommends that serious consideration should be given to tagging sufficient numbers of conch to allow conclusions to be drawn about population dynamics as well as movement patterns. Modeling of recaptures potentially allows estimation of, among other parameters, rates of both fishing and natural mortality. Even if large-scale, long-term tagging studies prove not to be feasible, short-term, intensive tagging experiments conducted alongside the fishery can be extremely informative, particularly if both commercial and experimental operations are used to generate recaptures and recoveries.

Recommendation DW12 relates to the collation of conch density estimates from different areas of the Caribbean experiencing varying levels of exploitation. Preliminary results of such an exercise constructed by the AW show considerable promise as an innovative approach to placing survey findings in the context of potential population benchmarks. The RP considered that progress with this approach is a high, short-term priority, and recommended that further attention be paid to the influence of habitat type and stock structure (juveniles and adults) on the comparisons. The RP also took the view that the establishment of Marine Protected Areas in the waters of Puerto Rico and USVI holds potential for shedding light on unfished conch densities in the area. This might provide an improved basis for calculating a Bmsy proxy than comparisons with quasi-unexploited densities in other areas of the Caribbean. The AW suggested that conch densities measured around Puerto Rico are below the 'Allee effect limit', this being the threshold below which reduced reproductive output may be expected based on studies in the Bahamas. The RP recommends examination of whether the mean conch densities reported are representative of effective local densities that may exist in patches, hence whether Puerto Rico conch stocks are in fact reproductively compromised to the extent shown. This would need to be addressed before precautionary advice could be offered on the basis of such evidence.

Recommendations of the Assessment Workshop

The AW rejected the use of production (biomass dynamic) models for assessing Puerto Rico queen conch stocks, on the grounds that landings data are incomplete, lacking particularly the recreational component, and that CPUE data do not effectively index stock abundance. Similarly, for reasons stated above, diver CPUE data alone cannot be used to infer trends in stock abundance. The RP agreed with these conclusions and with the decision of the AW to concentrate primarily on fishery-independent surveys. The RP further recommended that stock assessments based on primarily on fishery-dependent data should not be attempted until it can be demonstrated that landings data are complete and that there are informative indices of stock abundance.

The AW compiled the following list of research recommendations for queen conch:

AW1) *The efforts to analyze the available data were greatly enhanced by the presence of local fishers and agency representatives. However, there was no local representative from the USVI Division of Fish and Wildlife assigned to the meeting, while the Puerto Rico representative could not attend the full term of the meeting. There must be greater buy-in from the local agencies such that knowledgeable representatives are present for the full term of the meeting. Greater efforts should be made to attract the participation of local fishers.*

AW2) *Data from past density surveys should be re-analyzed so that values can be expanded on the basis of both habitat and depth, including confidence limits. Habitats should be matched to those available for existing/planned habitat maps. As a subportion of this, the data for the Puerto Rico 1986 survey should be entered into electronic and GIS formats. This could be done using NOAA's Data Rescue funds.*

AW3) *Expansion factors for both Puerto Rico and the USVI should be calculated for conch fishers only.*

AW4) *Assessment of the spatial and temporal variations and dynamics of the resource, fishery, habitat and species interactions would be greatly enhanced if traditional ecological knowledge were obtained from fishers. Efforts should be made to incorporate fishers into the process, particularly using NOAA's CRP funds.*

AW5) *The impact of the recreational fishery is unknown and must be quantified.*

AW6) Considering the established and potential value of resource surveys, mechanisms should be identified to increase their aerial coverage.

AW7) More detailed spatial expansions of survey densities should be planned in preparation of the 2010 Conch Update. For this, significant improvements in available data and analyses are required, including but not limited to the following:

A Detailed bathymetry data for PR and USVI

B Analysis of the impact of closed areas

C Inclusion of more detailed habitat maps for the PR western platform currently in progress

D Quantified size/age structure of the exploitable stock.

AW8) The only estimate to date of fishing mortality came from a tagging study in the 1980s. New tagging studies should be initiated to quantify rates of exploitation. This would allow existing SPR models for conch to be used in assessments.

AW9) Another issue remaining is to investigate the potential impact of very old conch in deep refuges, especially with respect to reproduction, coupled with studies to age very old conch. Such refuges may be substation off St. Thomas/St. John, in patches in Puerto Rico and potentially in protected areas on all three platforms.

AW10) Intersessional data evaluation workshops for CFMC managed species or species complexes should be conducted by the Council so that SEDAR level analyses are limited to those where data are sufficient to warrant such an analysis.

AW11) There needs to be a complete review of the potential data collection programs, including commercial and recreational catch, biostatistical sampling and fishery independent surveys for Puerto Rico and US Virgin Islands with the purpose of identifying what relevant information could be obtained and modifying sampling procedures accordingly, including the identification of key economic and ecological indicator species.

<u>The RP was supportive of all recommendations in this comprehensive list</u>, several of which re-iterate suggestions by the DW. <u>The RP draws particular attention to recommendations AW2, AW6 and AW7 which provide specific comments on improving and extending the existing fishery-independent surveys and their analyses</u>. Recommendations AW3, AW5 and AW11 relate to improved collection of commercial and recreational fishery statistics, the importance of which has already been emphasized above. The DW suggested tagging studies to examine patterns of movement and habitat utilization; recommendation AW8 suggests extending tagging studies to examine exploitation rates. <u>The RP endorses this recommendation as a priority for the medium- to long-term, with the suggestion that the feasibility of small-scale intensive tagging experiments be examined in addition to more extensive experiments</u>.

Recommendation AW9 is for investigation of the reproductive contribution of very old conch in deep water refuges. Given the implications for spatial management of the resource, and the context this would supply for interpretation of assessment outcomes in relation to potential population benchmarks, this recommendation should be prioritized for the medium-term.

The AW made two recommendations (AW1 and AW10) relevant to future queen conch stock assessment meetings. The RP notes recommendation AW10 to conduct intersessional data evaluation workshops. Given the current lack of a definitive stock assessment for conch the RP considers data evaluation workshops to be a high priority and recommends that the next workshop be held within the next 3 years to maintain impetus particularly on improvements to fishery monitoring and resource surveys. The time-scale for future stock assessments would be dictated by the progress demonstrated at these intersessional workshops.

2.4. Recommendations for Future SEDAR Assessments

The RP considers that future SEDAR assessments for queen conch will only be appropriate once significant progress has been made on improving both fishery statistics and fishery-independent indices. As stated above, this would involve collation of complete landings data, including recreational landings and robust expansion factors for historical landings, and calculation of informative indices of stock abundance. The RP re-iterates its endorsement of the AW recommendation for intersessional data evaluation workshops and suggests that the first of these should occur within 3 years. Given satisfactory progress demonstrated at such a workshop, it would then be a priority to schedule a SEDAR meeting within 2-3 years of the intersessional workshop.

2.5. Reviewer Statements

The RP consisted of a chair appointed by NMFS and three independent reviewers appointed by the Center for Independent Experts. The consensus summary reported in this document represents the joint work of all members of the RP. The conclusions, findings and recommendations of the RP are agreed to by its members.

3. Written Comment submitted to the Review Panel

No written comments were submitted.