SEDAR

Southeast Data, Assessment, and Review

SEDAR 14
Stock Assessment Report

Caribbean Mutton Snapper

SEDAR 14
Stock Assessment Report 2

2007

SEDAR
4055 Faber Place #201
North Charleston, SC 29401
(843) 571-4366

Table of Contents

SEDAR 14

Stock Assessment Report 2

Caribbean Mutton Snapper

SECTION I. Introduction

Introduction

Table of Contenst

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. Mutton Snapper Management Overview

Table 1. General Management Information

Species	Mutton snapper (*Lutjanus analis*)
Management Unit	U.S. Caribbean, Snapper Unit 3 (Mutton snapper, indicator species)
Management Unit Definition	Gray snapper, lane snapper, mutton snapper, dog snapper, schoolmaster snapper, mahogany snapper
Management Entity	Caribbean Fisheries Management Council
Management Contact	Miguel Rolon; Graciela Garcia-Moliner
Current stock exploitation status	Not overfishing
Current stock biomass status	Not overfished

Table 2. Specific Management Criteria. Values in Table 2 are for Snapper Unit 3 (Mutton Snapper, 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.	1,682,000 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,	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)	UNK (SEDAR 14)

	use natural mortality (M) as a proxy for F_{MSY}.		as a proxy for F_{MSY}.	
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})].	542,000 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} = $0.75F_{MSY}$.	508,000 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 Specified)		(Not Specified)

NOTE: “Proposed” columns are for indicating any definitions that may exist in FMPs or amendments that are currently under development and should therefore be evaluated in the current assessment. Current is for definitions in place now.

Table 3. Stock Rebuilding Information

The stock is not under a rebuilding plan.

Table 4. Stock projection information.

No projection details provided.

Table 5. Quota Calculation Details

The stock is not managed by quota.

Table 6. Regulatory History

6.1 Federal (EEZ) FMP and Amendment overview.

FMP/Amendment	Description of Action	Effective Date
Shallow Water Reef Fish FMP (50 FR 34850)	(1) established criteria for construction of fish traps; (2) required owner identification and marking of gear and boats; (3) prohibited the hauling of or tampering with another person's traps without the owner's written consent; (4) prohibited the use of poisons, drugs, other chemicals, and explosives for the taking of reef fish; (5) established a minimum size limit on the harvest of yellowtail snapper (i.e., established 8" minimum size to be increased one inch per year until a size of 12" is obtained) and Nassau grouper (i.e., established 12" minimum size to be increased one inch per year until a size of 24" is obtained); and (6) established a closed season for Nassau grouper(i.e., January 1 through March 31).	Effective 9/22/85, except for the minimum mesh size on traps of 1¼ inches, which was effective 9/22/86.
Emergency Interim Rule (54 FR 50624)	Implemented a 14 square nautical mile closed area southwest of St Thomas, USVI to fishing during the spawning season of red hind	12/6/89 through 2/28/90
Amendment 1 (55 FR 46214)	(1) increased the minimum allowable mesh size used in fish traps to 2 inches; (2) prohibited the harvest or possession of Nassau grouper; (3) implemented a 14 square nautical mile closed area southwest of St Thomas, USVI to fishing during the spawning season of red hind; (4) prohibited the possession of dynamite or similar explosive substances on board vessels in the fishery.	11/29/90, except the 2 inch mesh size allowance for fish traps, which was effective 9/14/91

Regulatory Amendment (56 FR 48755)	(1) modified scheduled changes in mesh size requirements, and (2) changed the requirements for degradable panels for fish traps in the shallow-water reef fish fishery; prescribed minimum allowable mesh sizes for fish traps of (1) 1.5 inches for hexagonal mesh; (2) 1.5 inches for square mesh through 9/13/93; and (3) 2.0 inches for square mesh effective 9/14/93.	9/20/91, except the 2.0 square inch mesh requirements, which became effective 9/14/93
Amendment 2 (58 FR 53145)	(1) incorporated the major species of the deep-water reef fish fishery and the marine aquarium finfish fishery into the reef fish management unit; (2) retitled the FMP to encompass the revised management unit; (3) restricted the collection of marine aquarium fishes to hand-held dip nets and slurp guns; (4) prohibited the harvest/possession/sale of certain species used in the marine aquarium trade; (5) removed a requirement that the two escape panels required for each fish trap be located on opposite sides of the trap; (6) prohibited the harvest and possession of jewfish (goliath grouper); (7) closed two additional red hind spawning aggregation areas from December through February (one West of Puerto Rico and one East of St. Croix); and (8) closed a spawning aggregation area for mutton snapper from March through June of each year(South if St. Croix).	11/15/93
Regulatory Amendment (61 FR 64485)	Adjusted the boundary of the existing red hind spawning aggregation seasonal/area closure in the EEZ off western Puerto Rico and added two additional red hind spawning aggregation seasonal/area closures (West of Puerto Rico).	12/7/96
Interim Rule (70 FR 300)	Prohibited fishing for or possessing any species of fish, except highly migratory species, within the Grammanik Bank closed area on a temporary basis.	2/1/05 through 4/30/05

Amendment 3 (SFA) (70 FR 62073)	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 (Closed seasons for red, black, tiger, yellowfin, or yellowedge grouper [from February 1 through April 30], Grammanik Bank [all species from February 1 through April 30], additional red hind closure (off Puerto Rico west of 67^0 10' W from December 1 until the end of February], vermilion, black, silk, or blackfin snapper [from October 1 through December 31], lane or mutton snapper [April 1 through June 30], prohibition of gill and trammel nets, fish must be landed with head and fins intact; (4) rebuild overfished stocks; (5) conserve and protect yellowfin grouper; (6) achieve bycatch mandates; and (7) achieve the essential fish habitat mandates	11/28/05

6.2 USVI Regulations

Species	Regulation Type	USVI	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		

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
Mutton Snapper	State waters (0 to 3nm) seasonal closure, April 1 - June 30	Territorial Law	2006
All species (excluding baitfish and blue runner)	Prohibition of fishing and anchoring	National Park Service (VI Coral Reef National Monument)	UNK
All species	Prohibition of fishing and anchoring	Buck Island /reef National Monument (36 CFR part 7, 57.73)	UNK

6.3 Puerto Rico Regulations

Species	Regulation Type	Effective Date
All	Mandatory commercial license and permit, Puerto Rico	1994
Mutton Snapper	Spawning season closure, May 1 - 31	2004
Mutton Snapper	Spawning season closure, April 1 - May 31	2007

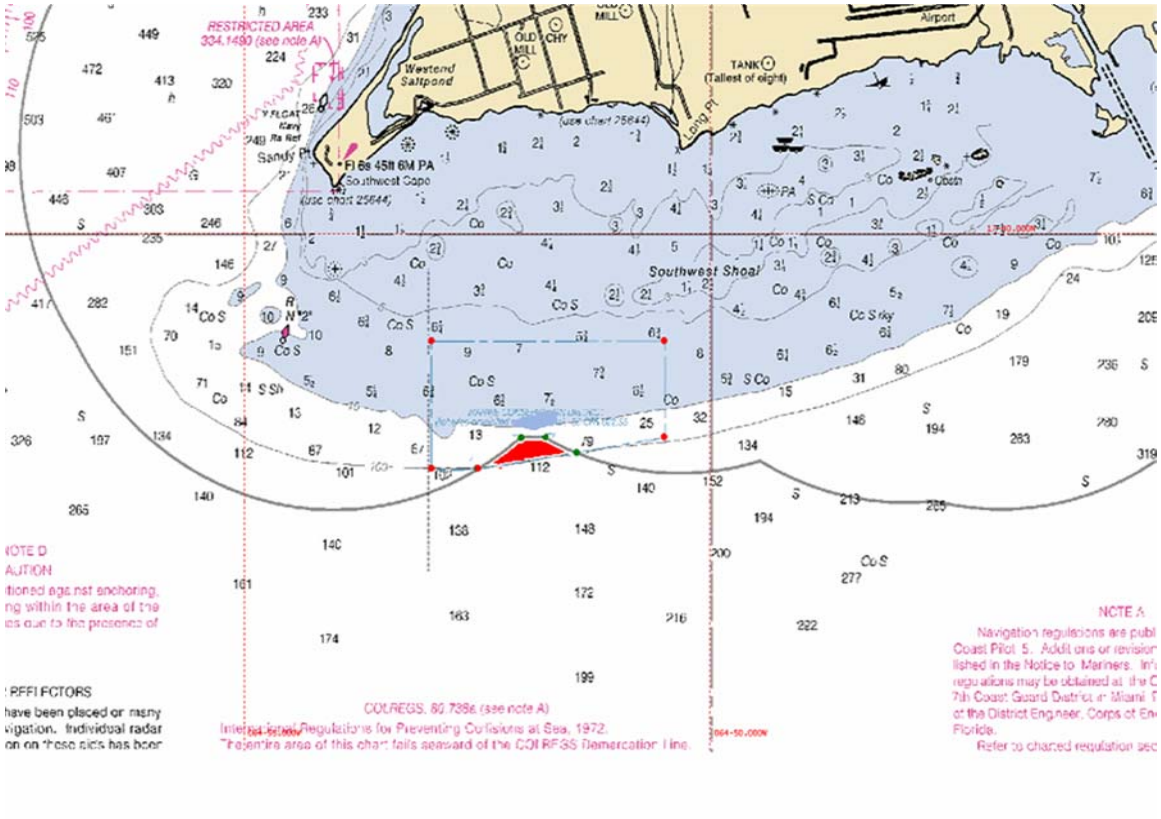


Figure 1. Mutton Snapper closed area, offshore southern St. Croix, established by CFMC in 1993. (EEZ closure denoted by red shading in lower center area of figure above; state waters closed area designated by blue line and red corners)

Table 7. Regulatory Overview for Mutton Snapper, Commercial and Recreational Fisheries, by Year and Area.

Reg/Area	Seasonal Closure			Area Closures		
Year	PR	USVI	EEZ	PR	USVI	EEZ
Key	1= April 1 - June 30 (11/28/05) 2 = May 1 - 31 3 = April 1-May 31			1. Spawning aggregation, 3/1 -6/30 2. Hind Bank, all year 3. Grammanik Bank, 2/1 - 4/30 4. Closure to bottom tending gear, all year (SEE DETAIL NOTES BELOW)		
1988						
1989						
1990						
1991						
1992						
1993						
1994					1	1
1995					1	1
1996					1	1
1997					1	1
1998					1	1, 2
1999					1	1, 2
2000					1	1, 2
2001					1	1, 2
2002					1	1, 2
2003					1	1, 2
2004	2				1	1, 2
2005	2			4	1, 4	1, 2, 3,4
2006	2	1	1	4	1, 4	1, 2, 3, 4
2007	3	1	1	4	1, 4	1, 2, 3, 4

Seasonal Closure 1, 2, 3: Spawning season closures.

Area Closure 1. Amendment 2 closed a spawning aggregation area for mutton snapper from March through June of each year (South of St. Croix). The area closed is shown in figure 1 above.

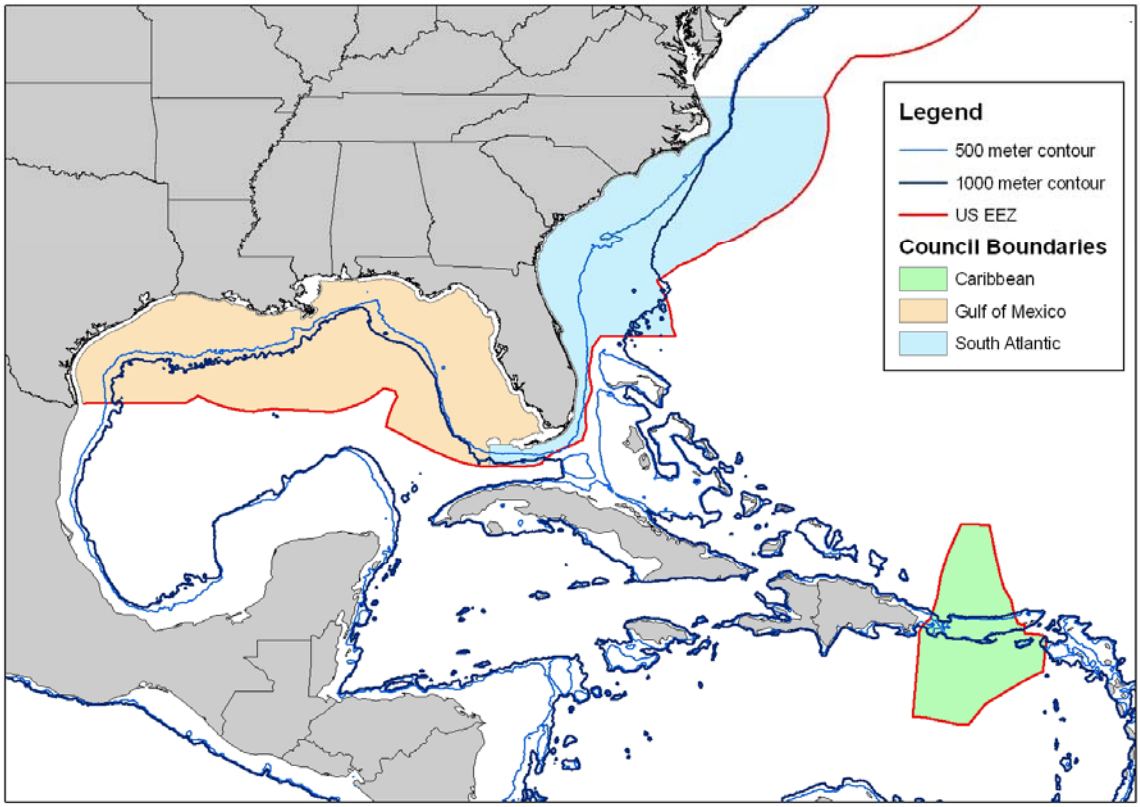
Area Closure 2: Hind Bank. 16 mi^2 area closed to fishing year round.

Area Closure 3: Grammanik Bank. Closed to fishing (except HMS) February 1 - April 30.

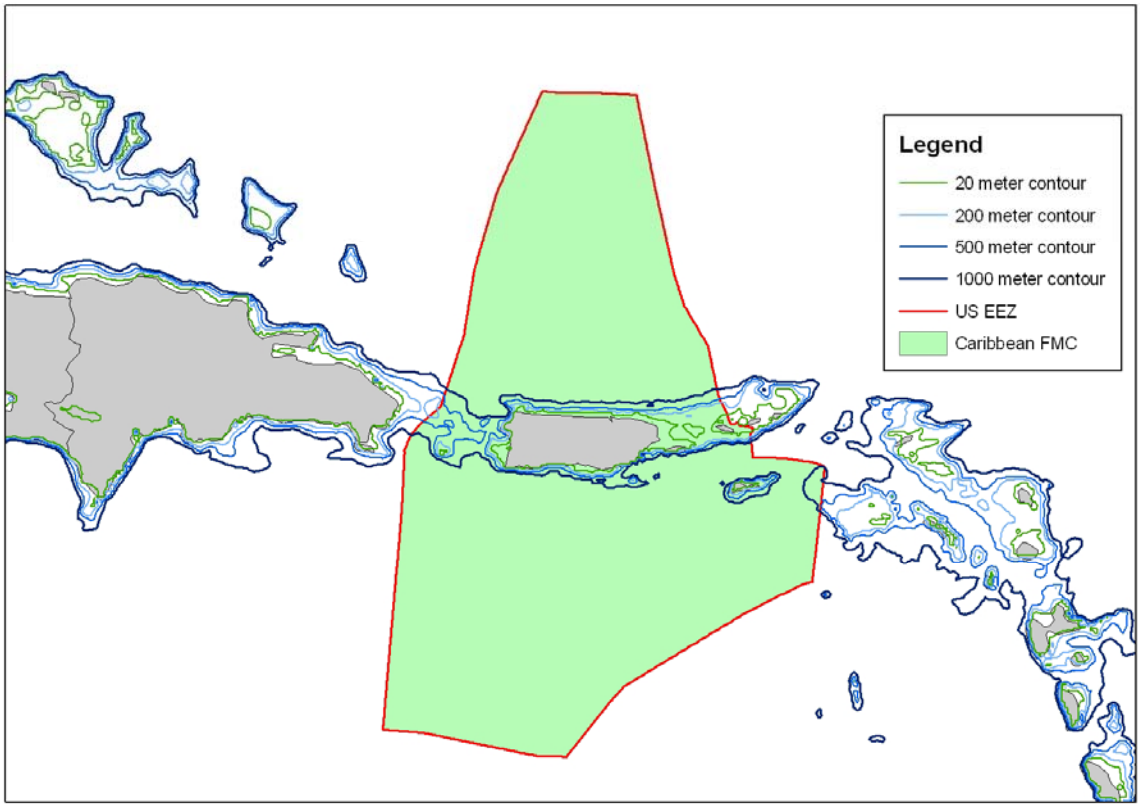
Area Closure 4: 2005 SFA EFH : ban bottom tending gear (gill nets, trammel nets, traps and bottom longlines) from all identified spawning aggregation sites (mutton snapper off St. Croix, Lang Bank off St. Croix, Bajo de Cico, Tourmaline and Abrir La Sierra off the west coast of Puerto Rico).

3. Southeast Region Maps

Southeast Region including Council and EEZ Boundaries



Caribbean Council and EEZ.



SEDAR 14

Stock Assessment Report 2

Caribbean Mutton Snapper

SECTION II. Data Workshop

SEDAR
4055 Faber Place #201
North Charleston, SC 29401
(843) 571-4366

SEDAR 14

Data Workshop Report

Mutton Snapper

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
Joe Kimmel	NOAA Fisheries/SERO
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 Representative
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-DW1	Important aspects of the life history of Yellowfin Grouper, *Mycteroperca venenosa*, with emphasis on populations in the Caribbean.	Cummings, N.
SEDAR14-DW2	Important Aspects of the life history of Mutton Snapper, *Lutjanus analis*, with emphasis on populations in the Caribbean.	Cummings, N.
SEDAR14-DW3	Recreational survey data for yellowfin grouper and mutton snapper in Puerto Rico and the US Virgin Islands	Matter, V
SEDAR14-DW4	A Review of Queen Conch (Strombus gigas) Life-history	McCarthy, K.
SEDAR14-DW5	Queen conch (Strombus gigas) standardized catch rates from the Puerto Rico and US Virgin Island commercial fisheries	McCarthy, K.
SEDAR14-DW6	Information on Commercial Removals of the Yellowfin Grouper, *Mycteroperca venenosa*, in Puerto Rico from 1983 through 2005 with notes on nominal catch per unit of effor**t**	Cummings, N., Matos-Caraball, D.
SEDAR14-DW7	Information on Commercial Removals of the Mutton snapper, *Lutjanus analis*, in Puerto Rico from 1983 through 2005 and trends in nominal catch per unit of effort	Cummings, N., Matos-Caraball, 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.

2. Life History Group Report

Interest in the stock status of the mutton snapper, *Lutjanus analis*, in the U.S. Caribbean (Puerto Rico and the U.S. Virgin Islands) prompted the need to review and assemble the available biological and fishery information for this species. Historically this species has been an important component of commercial fisheries of Puerto Rico, Cuba, and Florida (Matos-Caraballo et al. 2004, Evermann and Marsh, 1900, Schroeder, 1924). The mutton snapper is also a popular game fish. This species battles hard when hooked and can be challenging for sport anglers. Mutton snapper is frequently seen on the menus in restaurants owing to its sweet tasting, firm white flesh suitable for both baking and broiling. Apparently cheek and throat meats from larger mutton snapper are considered gourmet items. The mutton snapper is considered one of the most delicious saltwater fishes. Whole fish sell for 6-8 $ per pound in St. Croix and Puerto Rico (Wes Toller (A. Maldonado, pers. com.) and mutton snapper fillets may sell for as much as 12 $ per pound in Miami seafood markets (Watanabe 2001).

Information on life history and ecology is a critical component of stock assessment evaluations. This report synthesizes the available biological information on mutton snapper, with emphasis on published and un-published information from the U.S. Caribbean, for use in SEDAR stock assessment evaluations. This is review also made extensive use of material referenced in Froese and Pauly (2007).

2.1. Stock Definition and Description

The mutton snapper management stock of the U.S. Caribbean is defined as those individuals from the population found within territorial and U.S. EEZ waters of Puerto Rico and the US Virgin Islands. Mutton snapper are part of the reef fish management unit (Snapper Unit 1) in the Caribbean Fishery Management Council's Reef Fish Fishery Management Plan. Presently the U.S. Caribbean population of mutton snapper is managed assuming one stock.

The Life History Working Group noted that the likelihood of recruitment into areas of Puerto Rico, the British Virgin Islands and the northern U.S. Virgin Islands (St. Thomas/St. John) from areas to the east (*i.e.*, Saba Bank, Anguilla, St. Marten (Netherlands Antilles) is rather remote. For example, Roberts (1997) suggested that the probability is low for marine species with a short larval duration period such as the mutton snapper (13-19 days according to (Clarke et al., 1997, see Figures 1 and 2)). Recent studies on larval dispersal patterns of Caribbean reef fish suggest that retention is more prevalent and more important than long distance dispersal (Swearer et al. 1999, Taylor and Hellberg, 2003). However, results presented in Swearer et al. (1999) also suggest that recruitment of reef fish larvae to St. Croix (southern U.S. Virgin Islands) from eastern source populations is plausible.

Contrary to recruitment of fishes that reproduce over a long period, the short spawning season of the mutton snapper is more likely to be influenced by inter-annual variability of the physical processes acting over the larvae. Not enough evidence is available for understanding the implications of inter-annual variability on dispersal of propagules from mutton snapper spawning aggregations (Esteves, 2005).

Ongoing molecular research on the lutjanid family succeeded in identifying individual mutton snapper larvae collected from Southwestern Puerto Rico. Subfamily distinction and phylogenetic analyses were performed as well. These data are crucial to design further molecular analyses to detect stock structure and genetic differentiation of mutton snapper populations within the Caribbean (A. Rodríguez, pers. com.).

Limited information exists to document adult movement in mutton snapper; however the available information from studies off Florida suggests adult movement is restricted to only a few miles (Beaumariage, 1969). Mueller (1995) reported limited movement of mutton snapper over artificial unexploited reefs in the Bahamas. Based on the short length of the planktonic phase, information on prevailing surface currents, the low probability of larval input from adjacent regions, and indication of restricted movement of adults the life history sub-group suggested a two stock hypothesis for populations in the U.S. Caribbean: one stock on the Puerto Rico geological platform (*i.e.*, Puerto Rico, St. Thomas/St. John (U.S. Virgin Islands) and the British Virgin Islands (BVI) and, one stock around St. Croix, U.S. Virgin Islands.

2.2. Species Description and Taxonomy

The mutton snapper (Figure 1) was first described by Georges Cuvier in 1828 from a Hispanolan specimen (cited in Froese and Pauly 2007). These authors list a variety of common names for this species including: "mutton snapper, mutton fish, king snapper, virgin snapper, and snapper". Frequently in the Caribbean, this species is referred to as pargo colorado, pargo criollo, pargo mulato, and sama (Froese and Pauly 2007).

The mutton snapper is a relatively deep-bodied fish with a sharply pointed anal fin. The pectoral fin is long, reaching just past the anal origin, with dorsal spines (total): 10 - 11; dorsal soft rays (total): 13 - 14; anal spines: 3; anal soft rays: 7 – 8. The preopercular notch and knob are weak. Scale rows on back rise obliquely above lateral line. There is a distinct black spot on the upper back just above the lateral line and below the anterior `dorsal fin rays. A pair of blue stripes occurs on the cheek below the eye. Mutton snappers are very colorful, with olive green on their backs and upper sides and a red tinge on the lower sides and undersides. Two color forms are the norm, 1) the barred form usually seen in resting phase, during feeding, and during encounters with other fishes and 2) the plain (uniform) color seen when the fish is swimming. Even though they are sometimes confused with the lane snapper (*L. synagris*), the latter has a yellow pelvic fin and a round anal fin (Figure 1a, b). The mutton snapper anal fin is pointed and all of the mutton snapper's fins are red. The mutton snapper is sometimes confused by fishers with silk snapper, and in Puerto Rico has been marketed as silk snapper (*L. vivanus)*. Nevertheless, mutton snappers have fairly small teeth (Froese and Pauly 2007 and http://www.flmnh.ufl.edu/fish/gallery/descript/muttonsnapper/muttonsnapper.html.) Watanabe (2001) notes that while the mutton snapper has a distinct chevron-shaped vomerine tooth patch on the upper palate without a posterior extension, the silk snapper has a posterior extension of this patch.

Figure 2 provides a comparison of the frequently observed snappers, particularly those that the mutton snapper is most often is visually confused with. The mutton snapper has been described as solitary and wary rarely found in groups except during spawning aggregations (Anderson, 2002).

Biostatistical data from commercial catch samples suggests that the mean maximum length for *L. analis* in Puerto Rico ranges from 54 to 79 cm fork length and mean maximum weight is between 2.4 and 8.9 kg. In the U.S.Virgin Islands the mean maximum length for *L. analis* ranges from 46 to 78 cm fork length and mean maximum weight is between 9.3 kg and 11.4 kg (J. Bennett, pers. com.)

2.3. Distribution

The mutton snapper is found in the western Atlantic Ocean from Massachusetts to southeastern Brazil (Anderson, 2002). It is most common in the tropical waters of southern Florida, the Bahamas, and the Caribbean (Allen, 1985, Cervigón, 1993). It is also found in the Gulf of Mexico (Figure 3, (http://www.flmnh.ufl.edu/fish/gallery/descript/muttonsnapper/muttonsnapper.html).

2.4. Habitat Utilization

Mutton snapper frequently inhabit nearshore open waters; both adults and juveniles but primarily juveniles, use grass flats, tidal mangrove creeks, and shallow protected bays (Allen, 1985). Embryological and larval development of mutton snapper is thought to occur in the oceanic habitat (Claro, 1981). Juveniles have been observed in mangroves at "La Pitahaya", Southwestern Puerto Rico (Andi Maldonado pers. com) and have been reported inhabiting soft bottom areas, particularly populations in the northern part of the distribution (i.e., Gulf of Mexico). Randall (1968) reported that "although this species may be seen over reefs, it is

usually encountered in more open water over sand bottom". Anderson stated that *L. analis* "is found most commonly over vegetated sand bottoms and in bays and estuaries along mangrove coasts." Adults also live in or near patch reefs (natural or artificial) of coral and rock rubble and sponge patches (Bortone and Williams, 1986). Some authors have reported that larger individuals inhabit deeper waters but tend to swim to shallower areas in search of food (e.g. Claro, 1981).

The bathymetric distribution of the mutton snapper was reported by Allen (1985) in Froese and Pauly (2007) as 25-95 m, 2007. Thompson and Munro (1974a) report that this species was captured on mud slopes off the southeast coast of Jamaica at depths of 100-120 m (Thompson and Munro 1974a). Roe (1976) reported a depth range of 8-151 m for mutton snapper taken in exploratory surveys from the Carolinas, the northern and southern Gulf of Mexico, Cuba and Hispaniola and Puerto Rico. In the U.S. Virgin Islands, Brownell and Rainey (1971) caught one adult mutton snapper in a fish trap at 44 fathoms near the shelf edge southeast of St. John. However, large individuals are not uncommonly observed in shallow (< 5 m depth) low-relief habitats (W. Toller, pers. com.) and in bays (R. Hill, pers. com.) of the U.S. Virgin Islands.

Apparently, there is a tendency of adults when established in an area, to remain there. Although small aggregations have been observed to form during the day, disbanding at night, generally it is thought that the mutton snapper is not found in large groups, except in days prior to spawning where large aggregations have been observed along the shelf edge (Thompson and Munro, 1974; Claro, 1981).

In an evaluation of fish assemblages in seagrass, algal plain, sand, patch reef and rubble habitats within the St. Croix southeastern backreef lagoonal system, Mateo and Tobias (2006) reported mutton snapper occurring only in seagrass, however the frequency of occurrence was very low. Toller (2005) reported mutton snapper occurring in patch relief habitat off the western end of St. Croix in depths of 18-35 m.

Underwater visual surveys throughout Mona Island, Puerto Rico have shown that early stage juveniles (<17 cm FL) of *L. analis* occur in shallow seagrass habitat of backreef, lagoon zones. Juveniles (18-33 cm FL) occur in seagrass and linear reef habitats in lagoon and forereef zones. Adults (>34 cm FL) have been observed in scattered coral/rock in unconsolidated sediments, colonized pavement, colonized pavement with sand channels, linear reef and spur and groove habitat on the bank/shelf zone at depths between 4 and 21 meters (Schärer, pers. com.).

In a study off Curacao (Netherlands, Antilles), Nagelkerken et al. (2001) suggested that mutton snapper juveniles favored mud flats but depended on both mangroves and seagrass. Nagelkerken et al. (2000) suggested that mutton snapper utilizes both mangroves and seagrass beds as nursery habitat.

Off the Florida Keys, Bartels and Ferguson (2006) reported settlement stage (mean size= 3.6 cm) mutton snapper occurring in shallow, shorefront seagrass beds at depths of 0.3 to 1.2 m. Mutton snapper were observed during all months sampled, June to November and peaked in August. Mutton snapper were rarely found in hardbottom habitat in that study.

2.5. Diet

2.5.1.1. Diet preferences

Mutton snapper are both nocturnal and diurnal predators on crustaceans and fishes. They forage over sand, sea grass and coral rubble substrates (Randall, 1967). The mutton snapper was characterized as a generalist, opportunistic carnivore by Duarte and Garcia (1999) who reported continuous feeding for this species in a study of mutton snapper off Colombia. Their results indicated that mutton snapper prefer crabs (Portunid family), bony fish, followed by stomatopods and shrimps. In general, crabs make up about one half (45%) of their diet by volume followed, by fish (30%) and gastropods (13%) with the remaining prey items being octopods, hermit crabs, and shrimp (Randall, 1967). Dietary changes have been observed in the mutton snapper depending on life history stage. Larval mutton snapper feed on plankton, with settlement juvenile mutton snapper feeding on larger zooplankton and small invertebrates (Claro and Colás, 1987). Although adults feed on a variety of prey, such as fish, crabs, shrimp, and snails, fish are the major food items.

2.5.1.2. Feeding Behavior

Mueller et al. (1994) and Watanabe (2001) both identified picking (activity spent capturing prey), winnowing (capture and subsequent separation of prey from debris), and midwater strikes (rapid chases, lateral headbutts, display of dark barred color patterns, and dorsal fin extension, jaw snapping) as the primary feeding modes for mutton snapper. Winnowing was usually associated with shallow and/or sandy areas the seagrass bed (Mueller et al., 1994). These authors reported that feeding activity mode varied depending mainly on time of day and behavioral mode but not according to fish size. These investigators also reported that feeding behavior of L. analis was atypical of other snappers. They noted that L. analis forms dominance hierarchies and feeds diurnally. Mueller et al. (1994) presented support for this dominance characteristic in the mutton snapper as a wide variety of displacement type behavior was observed in the field. Watanabe (2001) also described the mutton snapper as an atypical lutjanid in regards to feeding behavior. Whereas most snappers are nocturnal predators, the mutton snapper feeds during all times of the day.

2.5.1.3. Predators

Natural predators of the mutton snapper include other large fishes, particularly other snappers and sharks such as e.g., (Bortone and Williams 1986).

2.5.1.4. Growth

Conversion formulae for length to length and weight to length transformations are provided in Tables 1 and 2 for mutton snapper. Table 3 provides a summary of published information on growth rates. Table 4 provides a summary of published and unpublished information on maximum observed sizes of the mutton snapper throughout the range. Only limited data were available from the U.S. Caribbean. Based upon fishery dependent data from fishery biostatistical samples, a range of observed weights and lengths were compiled for U.S. Caribbean mutton snapper stocks. Maximum length observed in Puerto Rico ranged from 54 to 79 cm FL and maximum observed weight was between 2.4 and 8.9 kg between 1983 and 2006.

In the US Virgin Islands, the maximum length observed ranged from 46 to 78 cm FL and maximum observed weight was between 9.3 and 11.4 kg.

The largest male and female observed in a study conducted in Puerto Rico between February 2000 and May 2001 measured 70 cm FL and 69 cm FL, respectively (Figuerola and Torres, 2001). Mason and Manooch (1985) reported mutton snapper as large as 86 cm TL for fish sampled from headboat catches from Jacksonville Beach (Florida) to Key West from 1976 to 1981.

Stevens (2004) provided values of mutton snapper maximum size and weight of 82 cm and 10 kg citing information from Watanabe (2001) and Barbieri and Colvocoresses, 2003). Barbieri and Colvocoresses study included fish sampled from fishery independent sampling off Florida's east cost. Stevens (2004) also gave a range of lifespan of 15-20 years for mutton snapper). Rojas (1960) reported maximum size in the population to be 68 cm SL.

Thompson and Munro (1974) reported the maximum observed size of mutton snapper off Jamaica, to be 75 cm TL (60 cm SL). Bohlke and Chaplin (1968, reported in Thompson and Munro (1974) reported maximum observed size to be 64.2 cm FL for Mutton snapper in the Bahamas.

Roe (1976) reported mutton snapper from exploratory surveys up to 10 kg in size off the Carolinas and Campeche and 7.7 kg off Cuba.

Maximum reported age is 17 years for Puerto Rico populations (Figuerola and Torres, 2001). Maximum age values of about 8 years were given for fish from Cuban waters (Claro, 1981, Montes, unpub., Pozo, 1979, and Claro, 1976 cited by Grimes, 1987). Burton (2002) reported fish up to age 17 in his recent study of Florida east coast fish.

Allen (1985, cited in Froese and Pauly 2002) reported an approximate life span was given of 14 years. Druzhinin (1970) in his review of the range and biology of Lutjanidae snappers reported a maximum size of 77 cm SL and 15 kg for the mutton snapper.

Burton (2002) described growth in mutton snapper sampled from recreational headboats and commercial vessels off Florida between 1992 and 2000. Recent studies of lutjanids suggest that they are a long-lived family, with age estimates of the gray and mutton snapper (*L.griseus* and *L.analis*) to 24 and 29 years (Burton, 2001, 2002), He also concluded that mutton snapper, (*Lutjanus analis*), from the same general location, completed forming an annulus in late spring (Russell et al., 2003) .

Benetti et al. (2002) reported mutton snapper growth as 16.5 g to 302.8 g (25.6 cm TL) in 246 d in floating net cages in an outdoor pond (7 m depth) artificial condition. Growth rates for hatchery raised, cage cultured fish were summarized by the length-weight relationships for two stock densities (Table 4).

2.6. Maturation and Reproduction

2.6.1.1. Spawning Period

In Puerto Rico, mutton snapper spawn during spring and summer- April and May coinciding with just after a full moon (Figuerola and Torres, 2001, Rivera, unpublished data). Esteves (2005) reported mutton snapper aggregating for spawning off La Parguera (Puerto Rico) in April. Grimes (1987) citing Erdman (1956) reported that mutton snapper off the northeastern Caribbean including, the Virgin Islands, spawned during March. In Cuba, Claro (1981) reported spawning mutton snapper observed from 3-4 days before the full moon from February to May, to about seven days after the full moon, at depths of 20-40 m.

In the Florida Keys mutton snapper have been reported to spawn during late spring/summer (May-June peak) in the Florida Keys and late summer and fall off Cuba (Bortone and Williams, 1986).

Domeier and Colin (1997) described an aggregation of L. analis in the Turks and Caicos Islands in April 1992. Domeier et al. (1996) identified a spawning aggregation at Riley's Hump. Craig (1966, cited in Burton, 1985) observed concentrated commercial fishing on an apparent "spawning run" of mutton snapper in August at Long Cay, Belize. Apparently off Belize mutton snapper spawn in the late spring (Heyman, 2001). According to reports, About 3 or 4 days before and after the full and new moons in April and May the whale sharks, roam up and down the coast, the Gladden Spit area about 26 miles off the coast of Placencia. Reportedly during those months when mutton and dog nappers are spawning the whales ingest the spawn as food http://www.ctbelize.com/belize_whale_shark.html .

Hatchery experiments indicate that larvae are planktonic at less than 10 mm TL and the pelagic larval duration (PLD) lasts from 13-19 days (Clarke et al., 1997). Newly hatched larvae measured from 2.2-2.5 mm (SL) with feeding beginning at 2.6-2.8 mm (24-48 h post-hatch). Lindeman et al. reported the PLD to range from 27 to 37 days, with a mean of 31 days. Watanabe (2001) reported that movement of juvenile mutton snappers of < 7 cm into seagrass beds in Florida and Cuba peaked in August and September.

Esteves (2005) provided information on larval dispersal off southwest Puerto Rico. Esteves concluded that mean flow of 7.3 km per day promoted fish eggs and early stage larvae to be dispersed away from the shelf-edge off La Parguera on a west south-west direction towards Mona Passage during the time of mutton snapper spawning aggregation in 2003. However, the surface flow follows the bathymetry northward along the Cabo Rojo–Mayagüez shelf; potentially leading to final recruitment destinations along the west coast of the island during this particular spawning year (Esteves, 2005, Figure 4).

2.6.1.2. Maturation size and age

Size at maturity and age at first maturity were reported by Froese and Pauly (2007) as 47.3 cm TL and 3.1 years, respectively. Figuerola and Torres (2001) estimate size at 50% maturity as 33 cm FL and 41.4 cm FL for males and females, respectively, based on the Puerto Rican survey. They indicate that all males and females are probably mature at 43.1 cm FL and 45 cm FL, respectively. That study, which was based on fishery dependent data, notes that 53% of males and 72% of females were taken prior to achieving sexual maturity. Stevens (2004) citing Watanabe (2001) and Barbieri and Colvocoresses (2003) reported age at maturity of 3 years for

the mutton snapper for fish in the south Atlantic. Druzhinin (1970) citing Rojas (1960) reported the size and weight at which mutton snapper reach sexual maturity to be 40.2 cm SL and 1.24 kg.

Grimes (1985) concluded from empirical regressions of length at sexual maturity vs. maximum observed length in the population for a variety of snappers, that on the average, snappers mature at about 43-51% of the maximum length in the population. Also, he concluded that males mature at slightly smaller size than females.

Using Grimes approximation, maturation would occur at 33 cm (Puerto Rico), 41 cm (Florida East coast) and 35 cm (Cuba) for mutton snapper and are consistent with observations from histological examinations.

Watanabe (2001) reported from hatchery observations, that sexual maturity occurs at age 3 in mutton snapper. Females matured at about 45-47 cm TL (about 1.6 to 2.0 kg) and males at 38 to 47 cm (about 1.7 to 1.8 kg). Watanabe's laboratory calculated maturations sizes are also consistent with those from histological studies of specimens obtained in natural populations.

2.6.1.3. Fecundity

Estimates of fecundity from the ovary of an individual fish sampled off Jamaica contained about 1,355,000 eggs (Thompson and Munro, 1974, Rojas, 1960). Stevens (2004) citing Watanabe (2001) and Barbieri and Colvocoresses (2003) reported a range of fecundity of 373,000 – 1, 400,000 eggs for the mutton snapper for fish in the south Atlantic.

2.7. Spawning Aggregations (SPAG's)

This species has been observed to occur in groups for spawning, sometimes offshore (Burton et al., 2005, Bortone and Williams, 1986, Figuerola and Torres, 2001, Rivera unpub.). Erdman (1976) reported that individuals have been observed in spawning condition in the U.S. Caribbean from February through July. In Puerto Rico some degree of reproduction occurs from February to June (Figuerola and Torres, 2001; Esteves 2005) but spawning activity generally peaks during the week following the full moon in the months of April and May. Spawning aggregations are known to occur north of St. Thomas and south of St. Croix, USVI in March, April, and May around the full moon (Rielinger, 1999, Rivera, unpub.).

More detailed information exists for Puerto Rico mutton snapper SPAGS (Esteves, 2005). Mutton Snappers aggregated at the La Parguera shelf edge during night time the week following the full moon of April and May of 2003 at an average depth of 20-40 m over rocky coralline bottoms and sandy bottoms with abundant gorgonians. Port surveys and fishermen interviews revealed that 2003 was a year of record mutton snapper landings. April 22, 2003 was the day of the largest catch with approx. 4,000 lbs of mutton snapper landed. Three fishing boats caught more than a hundred individual fish each. The fishermen with the largest catch had 140 individuals, weighing in at 1,300 lbs. All of the 126 sampled fish had mature gonads, or showed signs of recent spawning. Fish weights ranged between 7 and 18 lbs. The average standard body length was 55 cm. Fishermen interviewed agreed that most of the fish where caught when the clouds covering the moon dispersed from 4:30am to 6:00am (Esteves, 2005).

2.8. Natural Mortality (M)

Ault (1998) reported a natural mortality rate of 0.214 for mutton snapper in the Florida Keys. Ault used the method of Alagaraga (1984) based on lifespan to compute M. Using estimates of longevity (i.e., tmax) for Puerto Rico of 17, M was also estimated using the 'rule of thumb approach for (Hoenig, 1983) where M~2.98/tmax yields an estimate of 0.17 for M. In addition, the regression estimator of Hewitt and Hoenig (2004) of ln (M)= 1.44- 0.982 x Ln (tmax) gives a value of 0.26.

2.9. Conservation Status

The U.S. Caribbean stocks of mutton snapper are considered not overfished and not undergoing overfishing by the Caribbean Management Fishery Council (CFMC 2005). Federal management regulations for this species include the prohibition of possession of mutton snapper (or lane snapper) from April 1 through June 30 in the US Virgin Islands and Puerto Rico federal waters (i.e., EEZ- waters extending to 200 nautical miles offshore of the Commonwealth of Puerto Rico and the three-mile seaward boundary of the territory of the U.S. Virgin Islands (CFMC, Shallow Water Reef Fish (SWRF) FMP Amendment 3, SFA, 70 FR 62073, implemented on November 28, 2005, see http://www.caribbeanfmc.com/pdfs/Carib_SFA_finalrule1%2010-28-05.pdf). In addition there was a regulation implemented on November 15, 1993 which closed fishing on a spawning aggregation area for mutton snapper from March 1st through June 30th of each year south of St. Croix , (CFMC, SWRF FMP (56 FR 48755), Amendment 2 (58 FR 53145). In Puerto Rico territorial waters there is a closed season for the mutton snapper from April 1st to May 31st (Commonwealth of Puerto Rico, 2004) since 2005.

The status of mutton snapper in the Gulf of Mexico is unknown. (Stevens, 2004 citing 2002 Report to Congress NMFS 2003a). Mutton snapper are not overfished and not undergoing overfishing in the South Atlantic (Stevens, 2004). Stevens (2004) reported an Overall Seafood Rank as 'Caution'for mutton snapper populations in the Gulf of Mexico and South Atlantic, in her Seafood Watch Report summarizing the ranking for the continental populations of mutton snapper. The 'Seafood Rank' value was developed from information on five criteria that included: inherent vulnerability to fishing pressure, status of stocks, by catch nature, effects of fishing practices on habitats and ecosystems and effectiveness of the management regime.

The International Union for the Conservation of Nature and Natural Resources (IUCN) has identified the mutton snapper as Vulnerable.[1]

2.10. Other Topics of interest

The mutton snapper is marketed mainly fresh or frozen. Reports of ciguatera poisoning in this fish are mixed. Olsen et al. (1984) reported that ciguatera occurred in the mutton snapper off St. Thomas, US Virgin Islands.

[1] VULNERABLE (VU) - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E) as described by the IUCN.

Bunkley-Williams et al. (1999) reported the occurrence of isopods in the mouth of mutton snapper collected off Rio Hacha (Columbia) in 1987.

The mutton snapper population in the northern areas of the distribution (i.e., Gulf of Mexico) experiences mortality in the young juvenile stages from shrimp trawlers, thus this indirect source of mortality has been said to be one of the limiting factors on the overall health of the mutton snapper stocks in these regions.

Recent information on finfish discards in the U.S. Caribbean suggests that mutton snapper are not frequently discarded (MRAG, 2006a, 2006b, Matos-Caraballo 2006)

Uncertainty in the recorded landings of the mutton snapper in Puerto Rico exists. Matos et al. (2004) reported that the mutton is confused with deep water snappers, particularly the silk snapper (*L.vivanus*) in Puerto Rico and is frequently marketed as silk snapper.

Declining stocks of snappers in general increases the demand for high quality food fish such as the mutton snapper. Increasing exploitation on the mutton snapper adds to the demand for consideration as a prime aquaculture candidate for this species (Watanabe, 2001). Benetti et al. (2002) provided a progress report that detailed results of hatchery production of the mutton snapper. These authors reported voluntary spawning events in brood stock retained in the Florida Keys. Benetti et al. (2002) also described preliminary results of an offshore aquaculture demonstration project off the Island of Culebra (Puerto Rico).

2.11. Research Recommendations

2.11.1. Early life history

1) Conduct studies on temporal (intra- and inter-annual) variability of oceanographic processes in relation to larval dispersal to quantify the degree of connectivity between platforms of the currently managed stock units.
2) Examine early larval dispersal patterns (post fertilization to pre-flexion) using genetic markers and otolith microchemistry where possible.
3) Identify essential habitats according to life history stage, including critical recruitment and post-settlement (nursery) habitats.

2.11.2. Adult Populations

4) Identify additional past and present spawning aggregation sites and characterize migration corridors.
5) Define the spatial scale of migrations by individuals participating in spawning aggregations through tag and release studies.
6) Evaluate the potential to use census data obtained from spawning aggregations as fisheries independent data for assessing stock status (i.e. sex ratio, average size, density) and for monitoring populations.

2.11.3. Stock Identification

7) Investigate population genetic structure of mutton snapper "stocks" within the U.S. Caribbean and in relation to the wider Caribbean.
8) Examine ontogenetic shifts in habitat usage and diel foraging patterns.

2.12. References

Alagaraga, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. Indian Journal of Fisheries,31: 177-208.

Allen, G.R. 1985. FAO Species Catalog Vol. 6. Snappers of the World. An Annotated and Illustrated Catalogue of Lutjanid species known to Date. FAO Fish. Synop. 6(125): 208 pp.

Anderson, W.D. 2002. Lutjanidae. Pp. 1479-1504 In: Carpenter, K.E. (Ed.) The Living Marine Resources of the Western Central Atlantic. Volume 2: Bony Fishes. Part 2 (Opistognathidae to Molidae), sea turtles and marine Mammals. FAO Species Identification Guide for Fishery Purposes and American Society of Ichthyologists and Herpetologists Special Publication No. 5. 2002. Rome, FAO, 2127 pp.

Ault, J. S., S.G. Smith, and J.A. Bohnsack. 2005. Evaluation of average length as an estimator of exploitation status for the Florida coral-reef fish community. ICES Journal of Mar. Sci. 62:417-423.

Bartels, C. and K. I. Ferguson, 2006. Preliminary observations of abundance and distribution of settlement-stage snappers in shallow, nearshore seagrass beds in the Middle Florida Keys. Proc. Gulf and Carib. 57:235-247.

Barbieri, L.R. and J.A. Colvocoresses. 2003. Southeast Florida reef fish abundance and biology: Five-year performance report to the U.S. Department of Interior Fish and Wildlife Serv. F-73, 66 pp.

Beaumariage, D.S. 1969. Returns from the 1965 Schlitz tagging program including a cumulative analysis of previous results. Fla. Dep. Nat. Resour. Tech. Ser. No. 59:1-38.

Benetti, D.D., J. Alarcon, O. Steven, G Banner-Stevens, W.Matzey, B. O'Hanlon, J. Ayvazian, J. Rivera, N. Strattman, F. Rotman, and B. Kim. 2002a..Hatchery production of mutton snapper (*Lutjanus analis*) and other high value marine food fish. Progress Rpt. October 1, 2001-September 30, 2002, NOAA, National Marine Aquaculture Initiative (NMAI), DOC/NOAA/NMAI Grant No. 06RG-0068, 8pp.,

Benetti, D., J. Matera, O. Stevens, J. Alarcón, M. Feeley, F. Rotman, Y. Minemoto, G. Banner-Stevens, J. Fanke, S. Zimmerman and L. Eldridge. 2000b. Growth, Survival, and Feed Conversion Rates of Hatchery-Reared Mutton Snapper *Lutjanus analis* Cultured in Floating Net Cages. Journal of the World Aquaculture Society: Vol. 33 (3):349–357.

Bortone, S. A. and J.L. Williams. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (South Florida): Gray, Lane, Mutton and Yellowtail snappers. Biological Rpt. 82(11.52) TR EL-82-4. 18pp. Also available at http://fwie.fw.vt.edu/WWW/macsis/lists/M010182.htm .

Brownell, W.N. and William W. E. Rainey. 1971. Research and development of deep water commercial and sport fisheries around the Virgin Islands Plateau. Special Report, Caribbean Research Institute. Contribution Number 3, Virgin Islands Ecological Research Station, 53 pp.

Bowlike, J.E. and C.C.G.Chaplin. 1968. Fishes of the Bahamas and adjacent tropical waters. Livingstone Publishing Co., Wynewood, PA 771 pp.

Bunkley-Williams, L., E.H.Williams, Jr., and J.Garzon-Ferreira. 1999. Some isopod and copepod parasites (Crustacea) of Colombian marine fishes. Contrib. Jour. Sci., 35(3-4):311-314.

Burton, M.L. 2002. Age, growth and mortality of mutton snapper, *Lutjanus analis*, from the east coast of Florida, with a brief discussion of management implications. Fish. Res. 59:31-41.

Burton, M.L., K.J. Brennan, R. C. Munoz, and Parker, R.O. 2005. Preliminary evidence of increased spawning aggregations of mutton snapper (*Lutjanus analis*) at Riley's Hump two years after establishment of the Tortugas South Ecological Reserve. Fish. Bull. 103(2):404-410.

Cervigón, F., 1993. Los peces marinos de Venezuela. Volume 2. Fundación Científica Los Roques, Caracas,Venezuela. 497 p.

Development of larvae and juveniles of the mutton snapper (*Lutjanus analis*), lane snapper (*Lutjanus synagris*) and yellowtail snapper (*Ocyurus chrysurus*). Bull. Mar. Sci. 6:511-537.

Claro, R. and I. Colás, 1987. Algunos elementos del balance energético del pargo criollo, *Lutjanus analis* (Cuvier, 1828), en condiciones experimentales. Rep. Invest. Inst. Oceanol. Acad. Cienc. Cuba, 58:1-19.

Claro, R. 1981. Ecología y ciclo de vida del pargo criollo, *Lutjanus analis* (Cuvier), en la plataforma Cubana. Acad. Cienc. Cuba, Inf. Cient.-Tec. 186, 83p.

Claro, R. 1976. Ecología y dinámica de algunos indices biológicos en los lutjánidos de Cuba. Tesin. Acad. Cienc. URSS, Inst. Morfol. Evol. Ecol. Animal.

Commonwealth of Puerto Rico, Department of Natural and Environmental Resources, 2004, Puerto Rico Fishing Regulations #6768, February 11, 2004

Craig, A. K. 1966. Geography of fishing in British Honduras and adjacent coastal waters. Tech. Rep. Coastal Studies Lab. No. 28, Louisiana State Univ., Baton Rouge, LA.

Domeier, M. L., and P. L. Colin. 1997. Tropical reef fish spawning aggregations: defined and reviewed. Bull. Mar. Sci. 60:698−726.

Druzhinin, A.D. 1970. The range and biology of snappers. Journal of Ichthyology, 10(6): 717-736.

Duarte, L.O. and C.G. Garcia. 1999. Diet of the mutton snapper *Lutjanus analis* (Cuvier) from the gulf of Salamanca, Columbia, Caribbean Sea. Bull. Mar. Sci. 65(2), pp. 453-465.

Erdman, D.S. 1956. Recent fish records from Puerto Rico. Bull. Mar. Sci. Gulf Caribb. 6:315-340

Esteves, R. F. 2005. Dispersal of reef fish larvae from known spawning sites in La Parguera. A Thesis in partial fulfillment of the requirements for the degree of Master of Marine Science, Univ. of Puerto Rico, Mayaguez Campus, 53pp.

Evermann, B. W. and Marsh, M. C. 1899. Descriptions of new genera and species of fishes from Puerto Rico. Rep. U. S. Fish Comm. 351-362.

Figuerola Fernández, M. and W. Torres Ruiz. 2001. Aspectos de la biología reproductiva de la sama (*Lutjanus analis*) en Puerto Rico y recomendaciones para su manejo. Informe Final Laboratorio de Investigaciones Pesqueras, Puerto Rico Departamento de Recursos Naturales y Ambientales.

Froese, R. and D. Pauly. Editors. 2007. FishBase.World Wide Web electronic publication. www.fishbase.org, Revsion 01/2007.

Grimes, C.G. 1987. Reproductive biology of the Lutjanidae: A Review. P. 239-294. In: Polovina, J.J. and S. Ralston (eds.) Tropiocal snappers and groupers: Biology and Fisheries Management. Westview Press. Boulder and London. 659 pp.

Hewitt, D.A. and J.M. Hoenig. 2004. Comparison of two approaches for estimating natural mortality based on longevity.

Heyman, W. 2003. Session introduction: conservation of multi-species reef fish spawning aggregations. Proc. Gulf Caribb. Fish. Inst. 54:650−651.

Heyman, W.D., R.T. Graham, B. Kjerfve, R.E. Johannes. 2001. Whale sharks *Rhincodon typus* aggregate to feed on fish spawn in Belize. Mar Ecol Prog Ser. 215: 275–282, 2001

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82:898-903.

Mason, D. L. and C.S. Manooch, III. 1985. Age and growth of mutton snapper along the east coast of Florida. Fish. Res. 3:93-104.

Matos-Caraballo, D. M. Cartagena-Haddock and N. Peña-Alvarado. 2004, Job V. Historical landings and biostatistical CFSP data analysis for five important species. Portrait of the Fishery of mutton snapper *Lutjanus analis* in Puerto Rico during 1988-2001.

Mateo, I. and W. J. Tobias. A comparison of fish assemblages among five habitat types within a Caribbean lagoonal system. Gulf and Caribbean res. 19:21-31.

Matos-Caraballo, Daniel. 2006. Final Report Title: Bycatch Study of the Puerto Rico's Marine Commercial Fisheries, Puerto Rico's Department of Natural and Environmental Resources, Grant Number – NA04NMF43307, 11 pp.

MRAG, Americas, Inc., 2006a. Final Report: A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of the US Caribbean. A Cooperative Research Program Report Submitted to Southeast Regional Office National Marine Fisheries Service Grant No. NA04NMF4540214, 59 pp.

MRAG, Americas, Inc. 2006b. Final Report (Revised). A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of St. Thomas, U.S. Caribbean A Cooperative Research Program Report Submitted to Southeast Regional Office National Marine Fisheries Service Grant No. NA05NMF4540042, 80 pp.

Montes, M. Unpublished data. Caracteristicas peculiares del pargo en la zona D. Inst. Nac. Pesca Cent. Inf. Pesca Cuba (Mecanog.).

Mueller et al. (1994). Size structure of mutton snapper, *Lutjanus analis*, associated with unexploited artificial reefs in the central Bahamas. Fish. Bull., 93(3):573-576.

Nagelkerken, I., S. Kleijnen, T. Klop, R.A.C. J. van den Brand, E. Cocheret de la Moriniere, and G. van der Velde. 2001. Dependence of Caribbean reef fishes on mangrove and seagrass beds as nursery habitats: a comparison of fish faunas between bays with and without mangroves/seagrass beds. Mar. Ecol. Prog. Ser. 214:225-235.

Nagelkerken, I., G. van der Velde, M.W. Gorissen, G.J. Meijer, T. van't Hof, and C. den Hartog. 2000. Importance of mangroves, seagrass beds and the shallow coral reef as a nursery for important coral reef fishes, using a visual census technique. Estuaries, Coastal and Shelf Science, 51:31-44.

NOAA Fisheries, *2002 Report to Congress: Sustaining and Rebuilding the Status of U.S. Fisheries* ("Status Report") (2003), *available at* http://www.nmfs.noaa.gov/sfa/reports.html.

Olsen, D.A., D.W. Nellis and R.S. Wood, 1984. Ciguatera in the Eastern Caribbean.. Mar. Fish. Rev. 46(1):13-18.

Pozo, E. 1979. Edad y crecimiento del pargo criollo (*Lutjanus analis*) (Cuvier 1928) en la plataforma nororientel de Cuba. Rev. Cubana Invest. Pesq. 4(2):1-24.

Randall, J.E. 1967. Food habits of reef fishes of the West Indies. Stud. Trop. Oceanogr. 5:665-847.

Randall, J.E., 1968. Caribbean Reef Fishes. T.F.H. Publications, Inc. Neptune City, New Jersey, 318 pp.

Rielinger, D.M. 1999. Spawning Aggregations in the Gulf of Mexico, South Atlantic and Caribbean: A Source Document for Fisheries Management. February.

Rivera, José. Unpublished Document. Proposal Draft entitled: Identification of spawning grounds for the red hind and mutton snapper in the U.S. Virgin Islands and Puerto Rico. NOAA, NMFS, Miami Laboratory Protected Resources and Marine Mammals Division, Cabo Rojo, Puerto Rico, 3 pp.

Roberts, Callum M. 1997. Connectivity and management of Caribbean coral reefs. Science 278: 1454-1457. In snapper-grouper fishery resources of the Western Central Atlantic Ocean, Florida Sea Grant Program Rep. No. 17, pp. 129-164.

Roe, R. 1976. Distribution of snappers and groupers in the Gulf of Mexico and Caribbean Sea as determined from exploratory fishing data. Proceedings: Colloquium on snapper-grouper fishery resources of the Western Central Atlantic Ocean, Florida Sea Grant Program Rep. No. 17, pp.129-164.

Rojas, L.E. 1960. Estudios estadísticos y biológicos sobre el pargo criollo, *Lutjanus analis.* Cent. Invest. Pesq. Notas sobre Invest. 2, 16pp.

Rielinger, D.M. 1999. Spawning Aggregations in the Gulf of Mexico, South Atlantic and Caribbean: A Source Document for Fisheries Management. February.

Russell, D.J. A.S. Fletcher, J.R.Ovenden and R. Street. 2003. Biology, Management and Genetic Stock Structure off Mangrove Jack, (*Lutjanus argentimaculatus) in Australia.* Coastal Resources Assessment Group Department of Primary Industries Northern Fish. Centre PO Box 5396 Cairns Qld 4870. FRDC Project Number 1999/122, 199 p.

Schroeder, W.C. 1924. Fisheries of Key West and the clam industry of Southern Florida. U.S. Bur. Fish. Doc. 962, 74pp.

Sosa-Cordero, E., A. Medina-Quej, R. Herrera, and W. Aguilar-Dávila. 2002. Agregaciones reproductivas de peces en el Sistema Arrecifál Mesoamericano: Consultoría Nacional – Mexico. Informe preparado para el consultor internacional, Research Planning Inc., y Proyecto SAM-Banco Mundial-Belice.

Stevens, M. M. 2004. Commercially important Gulf of Mexico/South Atlantic snappers (red snapper, vermillion snapper, yellowtail snapper, with minor reference to gray snapper, mutton snapper, and lane snapper). Seafood Watch, Seafood Report, Monterey Bay Aquarium, Final Rpt. April 20, 2004, 29pp.

Swearer, S.E., J.E. Caselle, D.W. Lea, and R.W. Warner. 1999. Larval retention and recruitment in an island population of a coral reef fish. Nature 402(16):799-802.

Taylor, M.S. and M.E. Hellberg. 2003. Genetic evidence for local retention of pelagic larvae in a Caribbean reef fish. Science 299:107-109.

Thompson, R. and J.L. Munro. 1974. The biology, ecology and bionomics of the snappers, Lutjanidae, pp. 94-109 In: Caribbean Coral Reef Fishery Resources, Ed. By J.L. Munro. ICLARM Studies and Reviews 7.

Watanabe, W.O. 2001. Species Profile Mutton snapper. Southern Regional Aquaculture Center, SRAG Pub. No. 725, 9pp.

2.13. Tables

Table 1. Mutton snapper length conversion formulae (Tabled data reprinted from Froese and Pauly (2007), equation form = Unknown Length = a + b * Known Length).

Unknown length	a	b	Known length	r	Length range (cm)			Sex
FL	0.450	1.120	SL		6	-	74	Unsexed
FL	0.640	0.920	TL		30	-	60	Unsexed
SL	0.080	0.890	FL		6	-	74	Unsexed
TL	0.891	1.080	FL	0.995		-		unsexed
TL	0.000	1.083	FL		-			unsexed
TL	0.700	1.090	FL		22	-	45	Unsexed
TL	0.000	1.239	SL		-			unsexed

Table 2. Mutton snapper weight – length equation parameters (Tabled data reprinted from Froese and Pauly (2007), equation form = log (W)=log(a) + b * log(L)).

a	b	Sex	Length (cm)	Length type	No.	Country	Locality
0.0114	2.530	male	23.0 - 73.0	FL	1010	Cuba	Northeast zone
0.0092	2.590	female	23.0 - 73.0	FL	1051	Cuba	Northeast Zone
0.0354	2.770	unsexed	559			Cuba	Northeast zone
0.0221	2.950	unsexed	21.0 - 77.0	FL	53	Puerto Rico	
0.0161	3.011	unsexed	12.0 - 72.0	FL	365	USA	S.Florida
0.0146	3.034	unsexed	26.0 - 63.0	FL	17	US Virgin Is	St. Croix
0.0152	3.040	unsexed	18.0 - 72.0	FL	974	Cuba	Swest Zone
0.0100	3.045	unsexed	35.0 - 75.0	FL	140	USA	Fl east coast
0.0113	3.050	unsexed		TL		USA	Fl east coast, 1992-2000
0.0137	3.060	unsexed	18.0 - 68.0	FL	1154	Cuba	Northwest Zone
0.0104	3.070	unsexed	- 85.0	FL	274	Venezuela	
0.0120	3.100	unsexed	12.0 - 74.0	FL	1609	Cuba	Southwest Zone
0.0195	3.100	unsexed	8.5 - 50.5	SL	294	Colombia	Gulf of Salamanca,1995-97
0.0056	3.175	unsexed	23.0 - 61.0	FL	27	US Virgin Is	St.T./St. John
0.0042	3.320	unsexed	20.0 - 80.0	FL	445	Colombia	Atlantic coast

Table 3. Information on the growth rate and asymptotic size of the mutton snapper (Estimates taken from Froese and Pauly, 2007).

L Infinity	Length Type	K	T-zero	Sex	M	Temp ©	Country	Locality
78	FL	0.246				27.2	Cuba	
80.8	FL	0.132	-1.42			27.2	Cuba	Northeast Zone
82	FL	0.2			0.31	27.2	Cuba	Northwest Zone
86	TL	0.153	-0.58			22.5	USA	Florida east coast
86.9	TL	0.16	-0.94			23	USA	Florida east coast
88	FL	0.152				27.2	Cuba	Zone B
103	TL	0.17	-0.62			27.2	Venezuela	Northern coast
118	FL	0.1				27.2	Cuba	Zone C
118	FL	0.13				27.2	Cuba	

Table 4. Maximum Reported Values for Size and Age of Mutton Snapper, *Lutjanus analis*

Location	Wt. (kg)	SL (cm)	FL (cm)	TL (cm)	Age (years)	Reference
Puerto Rico	-	60	70	-	17	Figuerola & Torres, 2001
Jamaica	-	60	-	75	-	Thompson & Munro, 1974
Cuba	7.7	-	-	-	-	Roe, 1976
Cuba	-	-	-	-	8	Claro, 1981
Carolinas/Campeche	10	-	-	-	-	Roe, 1976
Bahamas	-	-	64.2	-	-	Bohlke & Chaplin, 1968
Florida, East Coast	-	-	-	-	17	Burton, 2002
Florida Keys area	-	-	-	86	-	Mason & Manooch, 1985
Unspec.	-	-	-	-	14	Allen, 1985
Unspec.	10	-	-	[82 TL?]	15-20	Stevens, 2004
Unspec.	-	68	-	-	-	Rojas, 1960
Unspec.	15	77	-	-	-	Druzhinin, 1970

2.14. Figures

<picture removed to reduce size>

Figure 1. Mutton snapper, Lutjanus analis, depicting colorful forms and characteristic spot along the upper back and blue stripes on the cheek region below the idea. A illustrates olive green form, B illustrates swimming phase color. Photos reprinted from http://www.flmnh.ufl.edu/fish/gallery/descript/muttonsnapper/muttonsnapper.html.

<picture removed to reduce size>

Figure 2. Photo comparison of snappers: A. mutton (*L. analis*), B. northern red (*L. campechanus*), C. Mahogany (*L. mahogoni*), and D. Lane (*L. synagris*). Photos reprinted from http://www.flmnh.ufl.edu/fish/gallery/descript/muttonsnapper/muttonsnapper.html .

<picture removed to reduce size>

Figure 3. Mutton snapper distribution map taken from Froese and Pauly (2007).

<picture removed to reduce size>

Figure 4. Proposed dispersal trajectories of larvae spawned at La Parguera following the mutton snapper massive spawning fish event of April, 2003.

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.

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 mutton snapper landings are

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.

The mutton snapper

.

Reported Landings

There are no species specific reported landings for the USVi historical dataset. 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 conchs 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.

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 11. 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 12. 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 13. 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 14. 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 15. 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 16. 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 17. 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	-	-	-

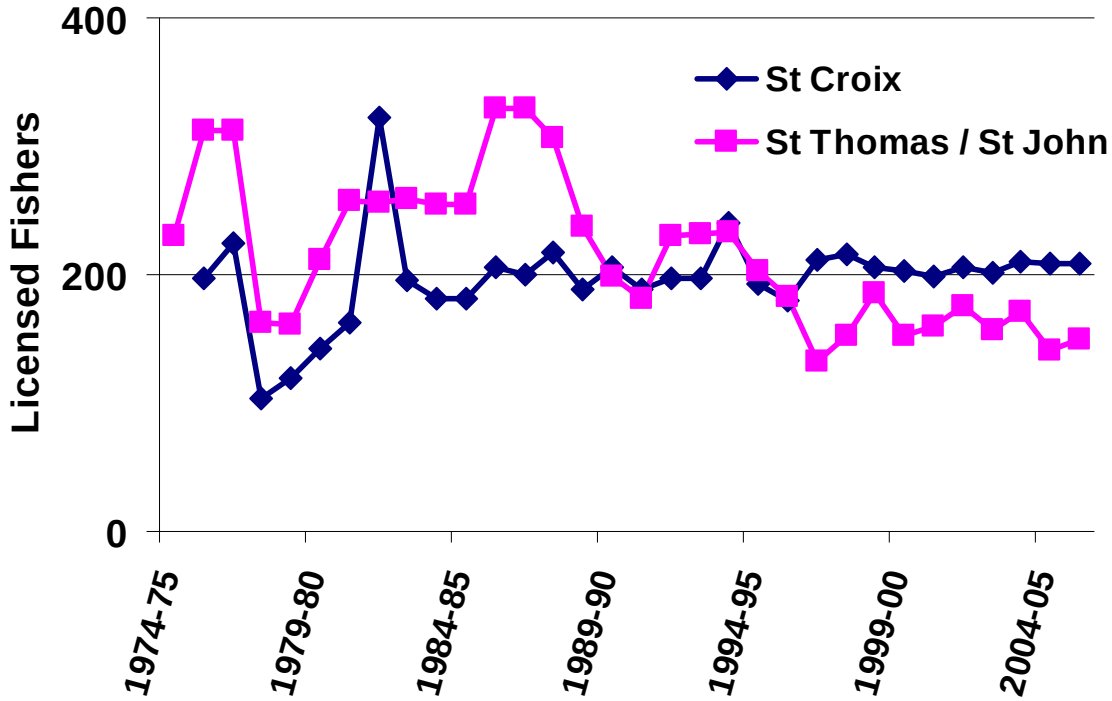


Figure 1. Number of licensed fishers in the Virgin Islands since 1974.

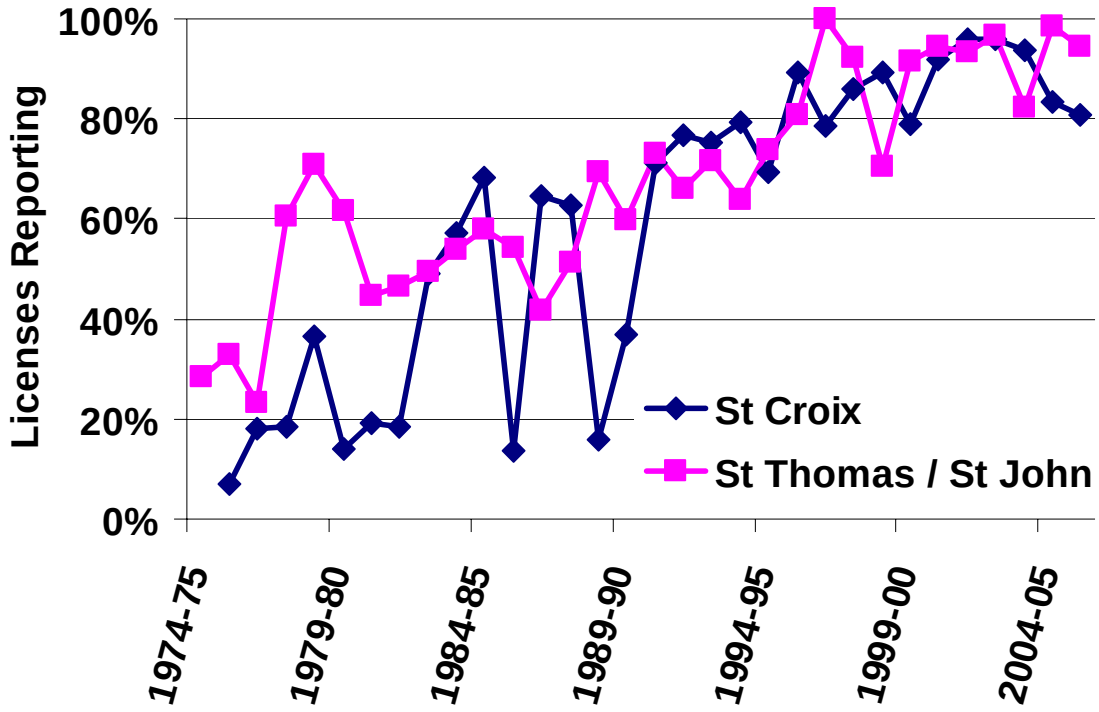


Figure 2. Percentage of Virgin Island license holders who reported landings.

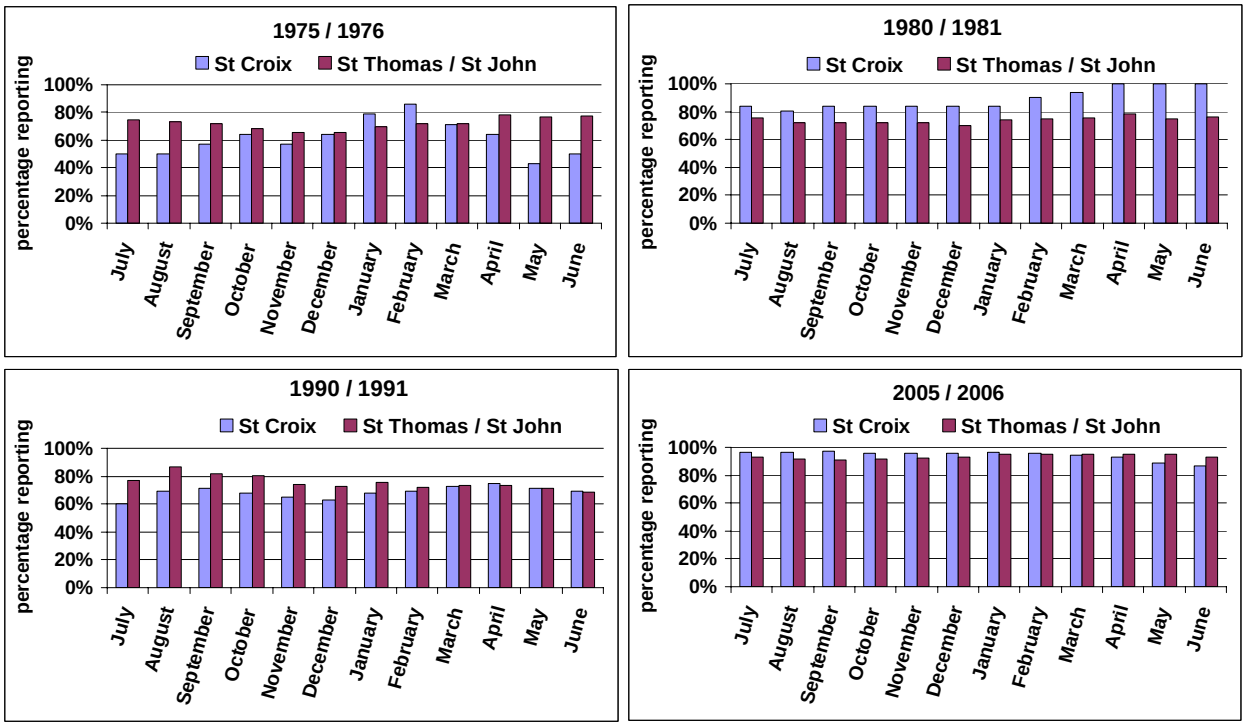


Figure 3. Percentage of licensed fishermen reporting by month for four fishing years.

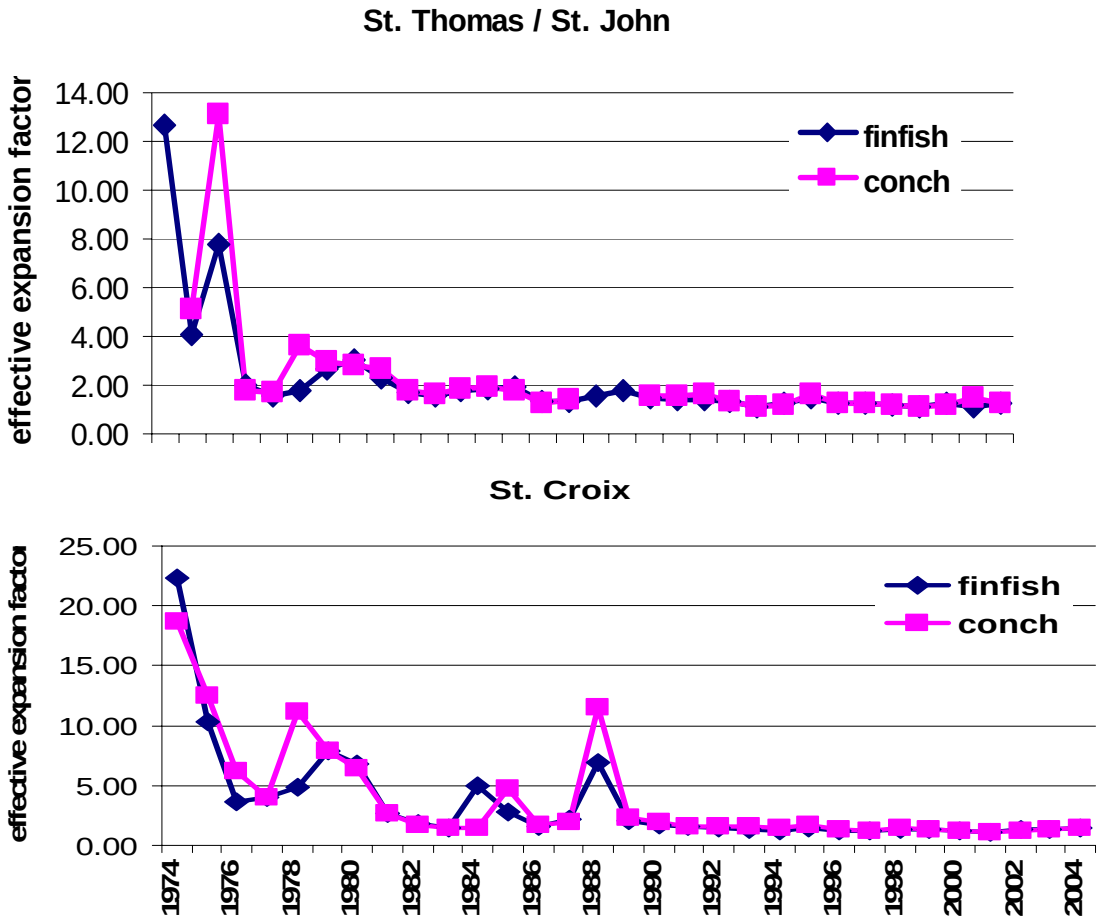


Figure 4. Effective expansion fractions for Virgin Island landings derived by dividing calculated total landings by reported landings.

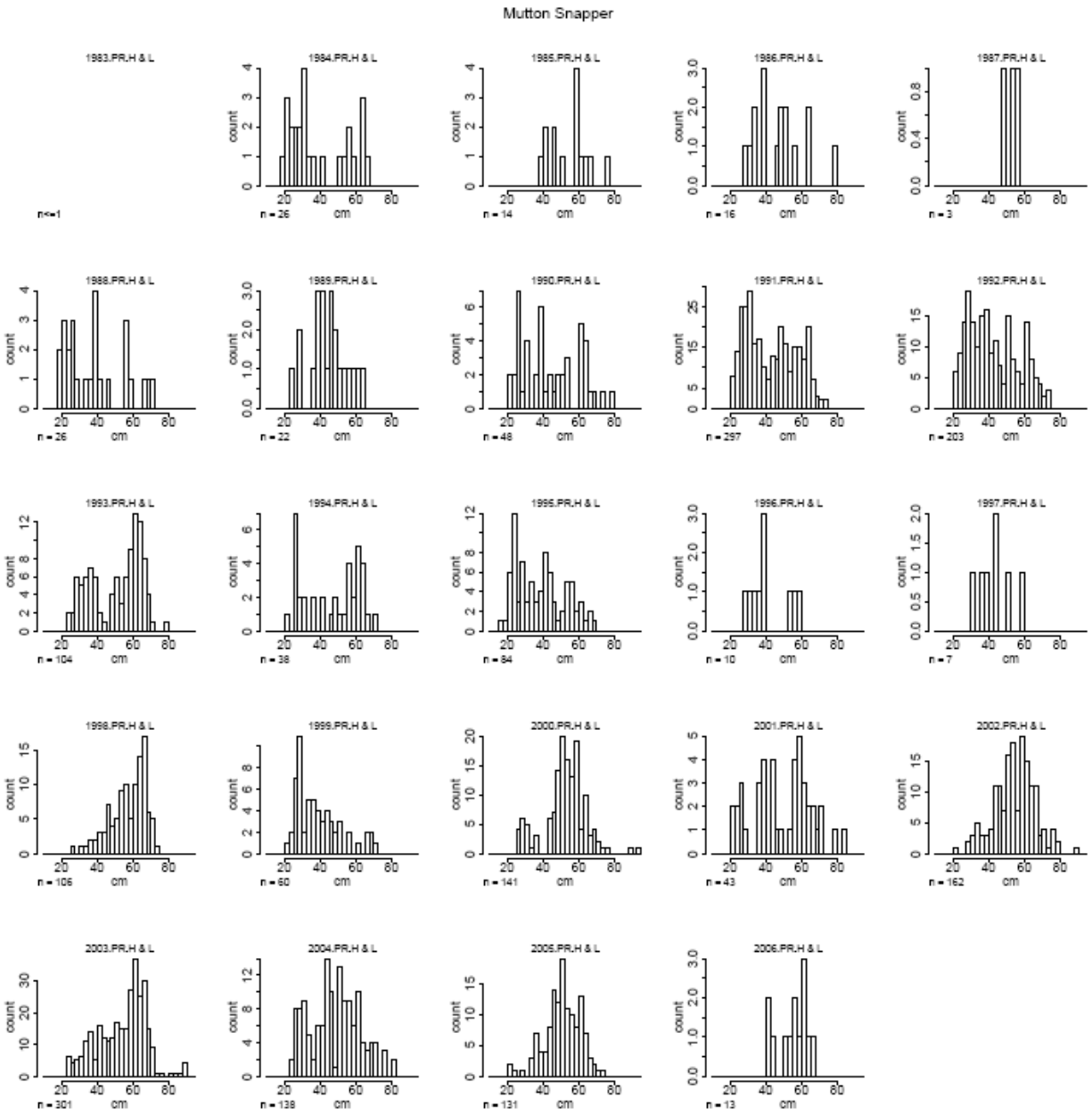


Figure 5. Number of mutton snapper at length (cm) from Puerto Rican landings by hook and line fisheries from 1983 through 2006. Note that the vertical axes vary in scale.

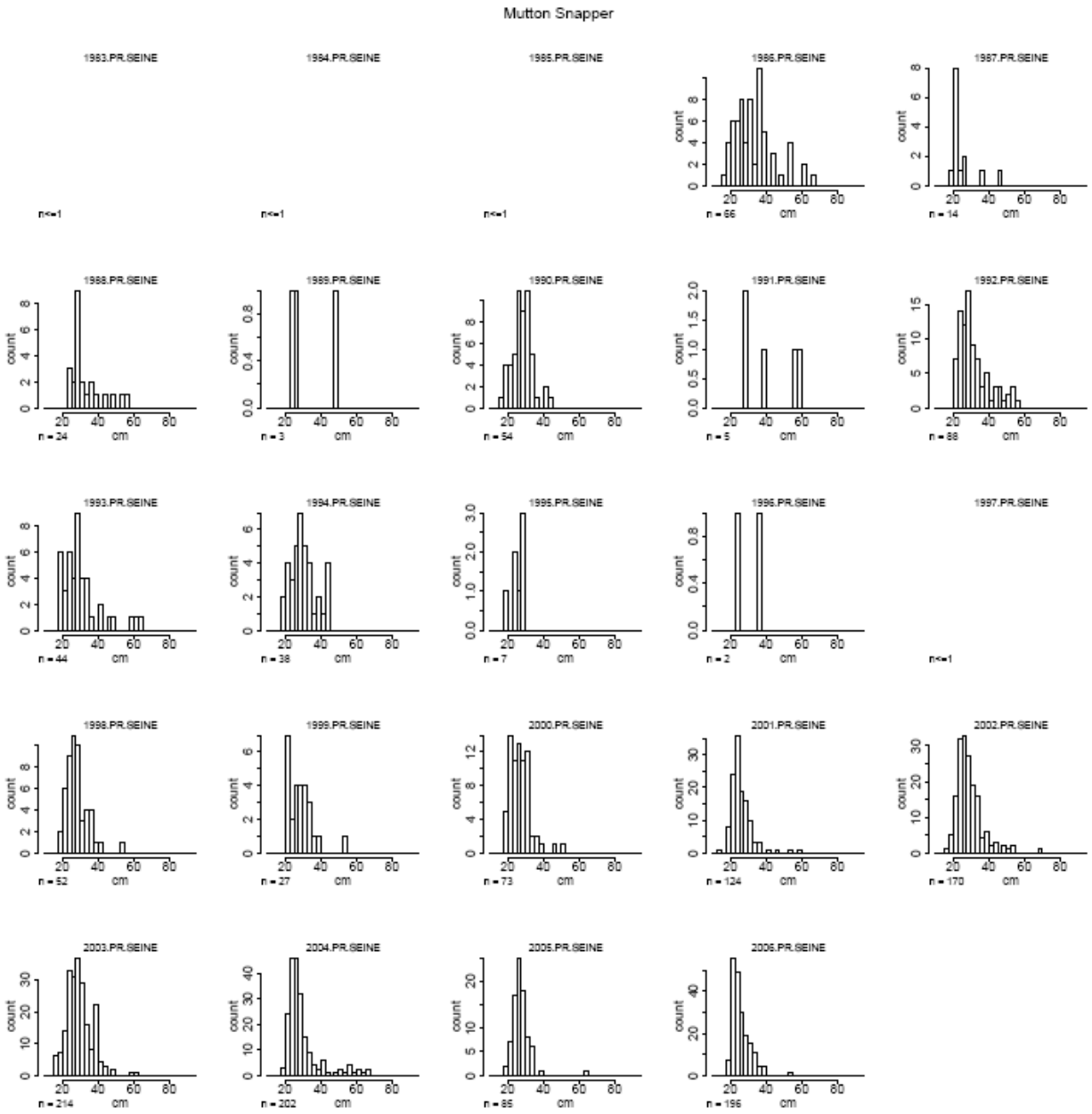


Figure 6. Number of mutton snapper at length (cm) from Puerto Rican landings by seine fisheries from 1983 through 2006. Note that the vertical axes vary in scale.

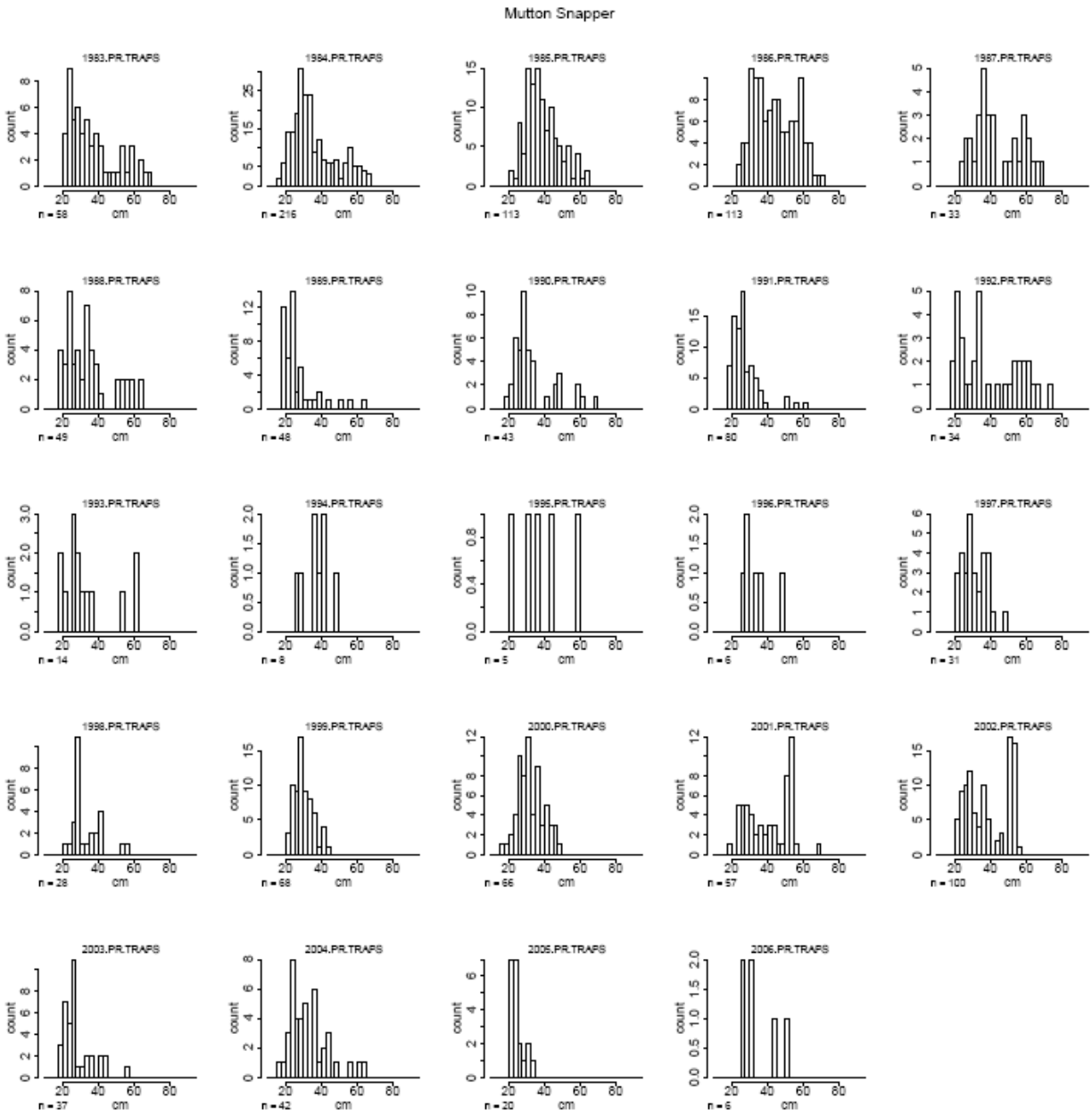


Figure 7. Number of mutton snapper at length (cm) from Puerto Rican landings by trap fisheries from 1983 through 2006. Note that the vertical axes vary in scale.

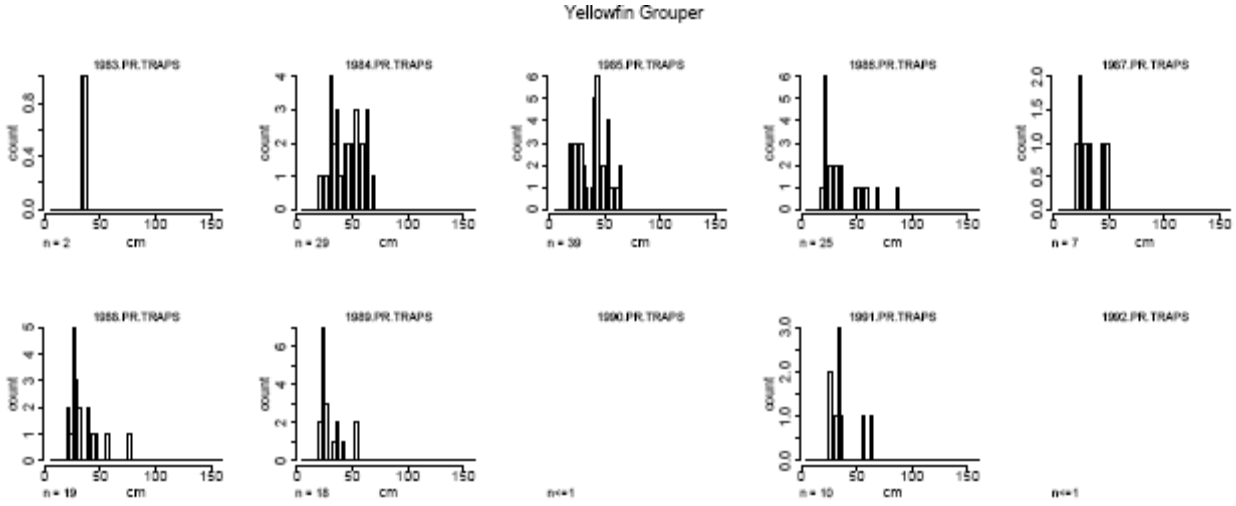


Figure 8. Number of yellowfin grouper at length (cm) from Puerto Rican landings by trap fisheries from 1983 through 1992. Note that the vertical axes vary in scale.

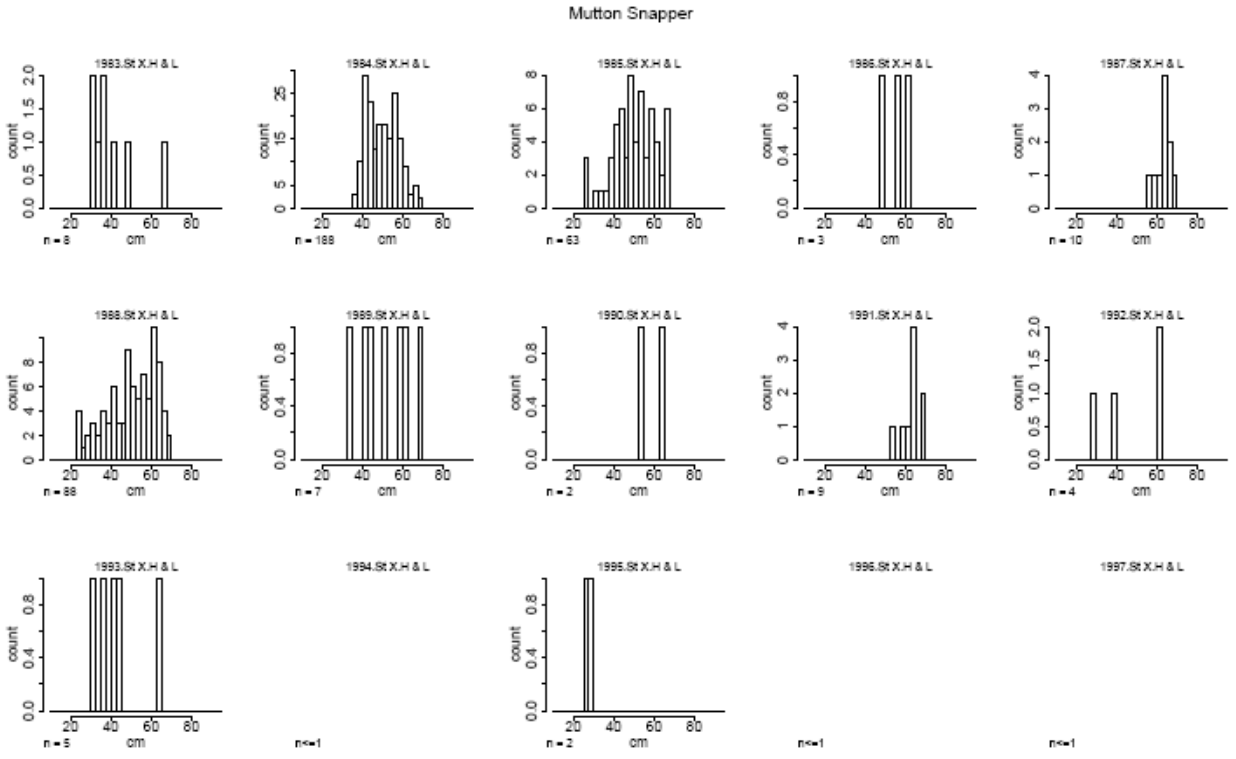


Figure 9. Number of mutton snapper at length (cm) from St. Croix (figures are mis-labeled) landings by hook and line fisheries from 1983 through 1995. Note that the vertical axes vary in scale.

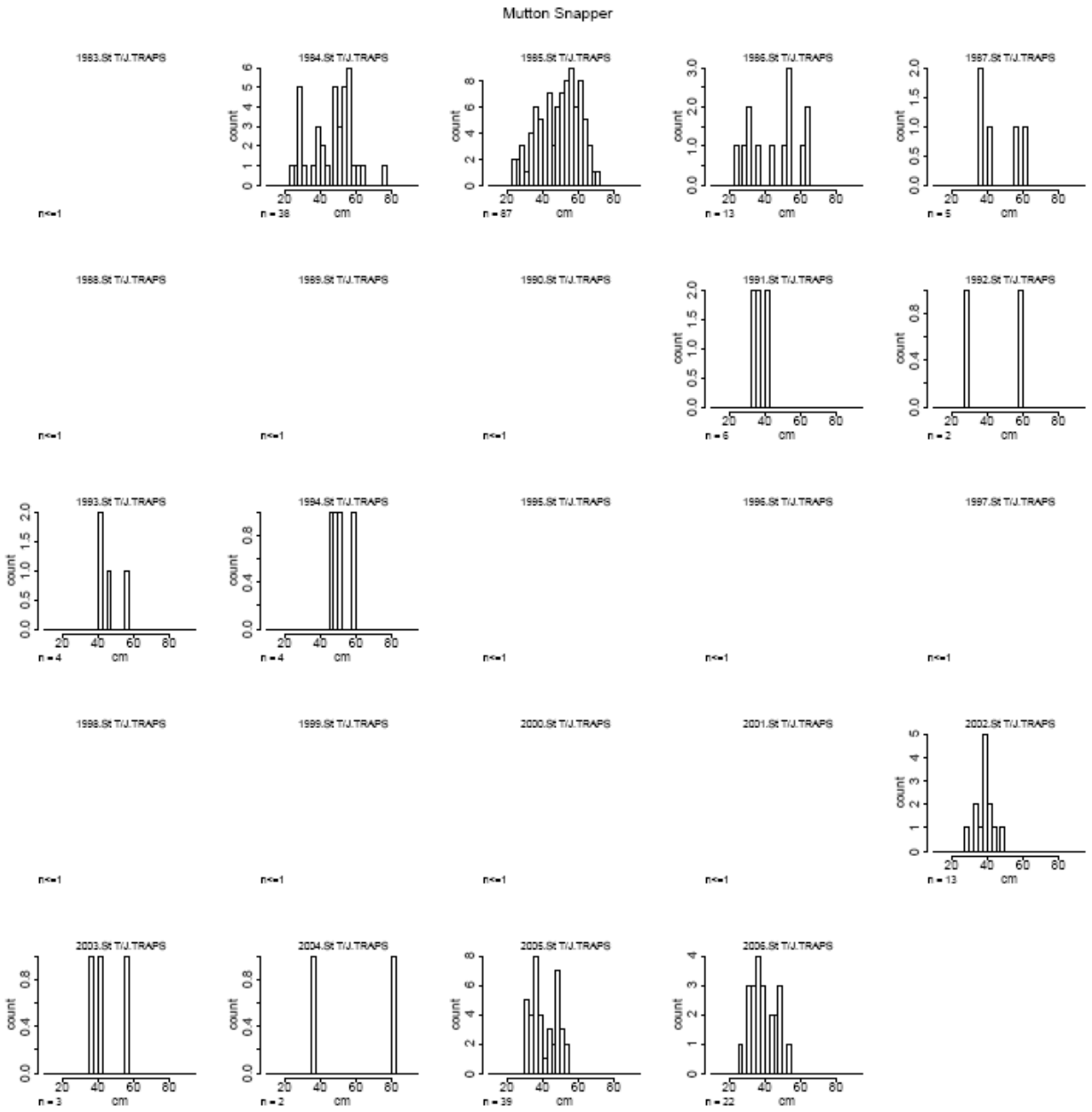


Figure 10. Number of mutton snapper at length (cm) from St. Thomas / St. John (figures are mis-labeled) landings by trap fisheries from 1984 through 2006. Note that the vertical axes vary in scale.

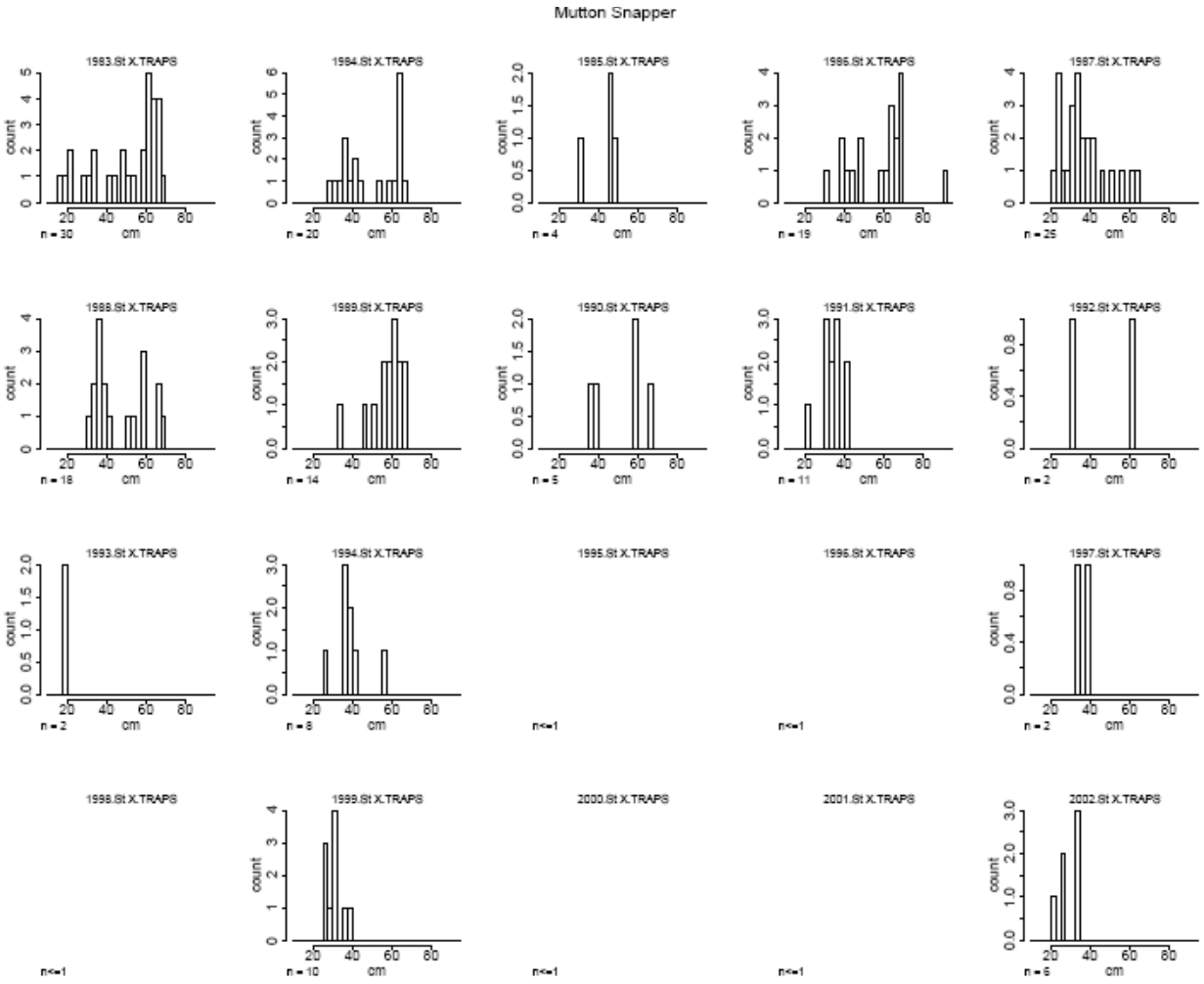


Figure 11. Number of mutton snapper at length (cm) from St. Croix (figures are mis-labeled) landings by trap fisheries from 1984 through 2002. Note that the vertical axes vary in scale.

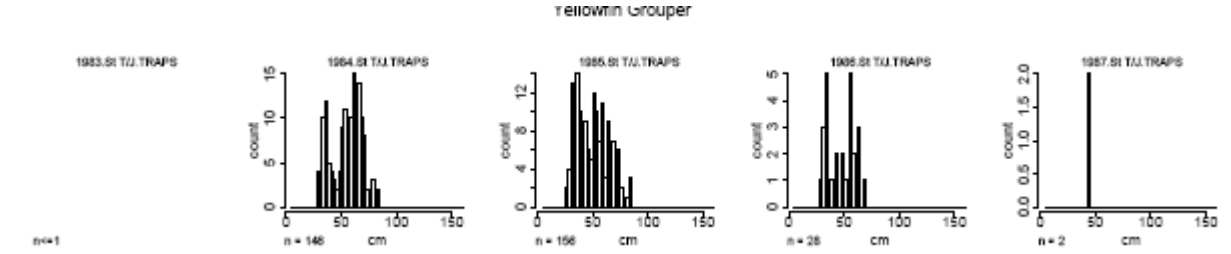


Figure 12. Number of yellowfin grouper at length (cm) from St. Thomas / St. John (figures are mis-labeled) landings by trap fisheries from 1984 through 1987. Note that the vertical axes vary in scale.

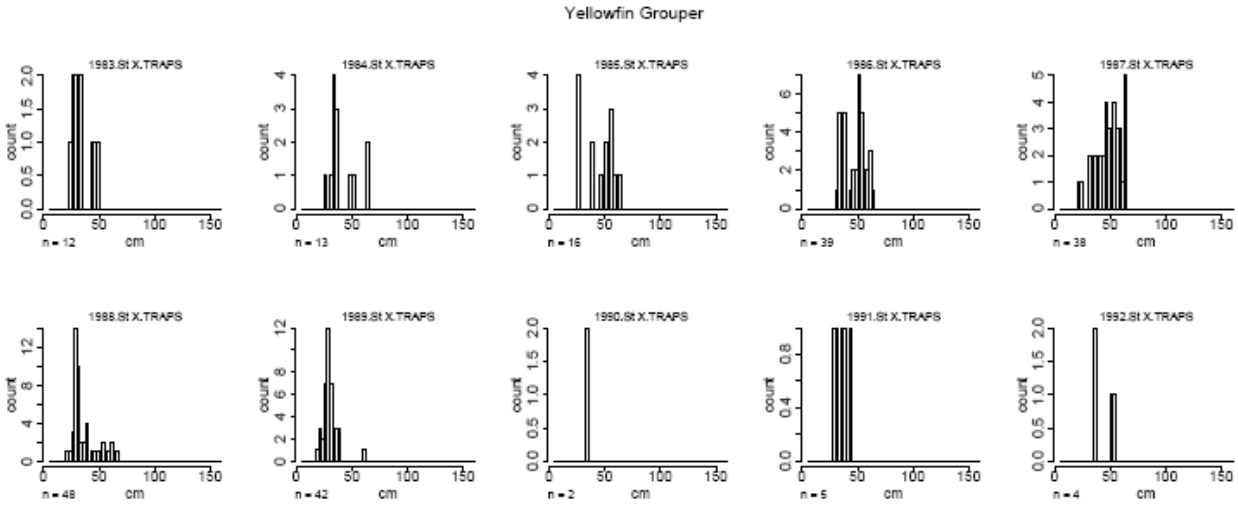


Figure 13. Number of yellowfin grouper at length (cm) from St. Croix landings by trap fisheries from 1983 through 1992. Note that the vertical axes vary in scale.

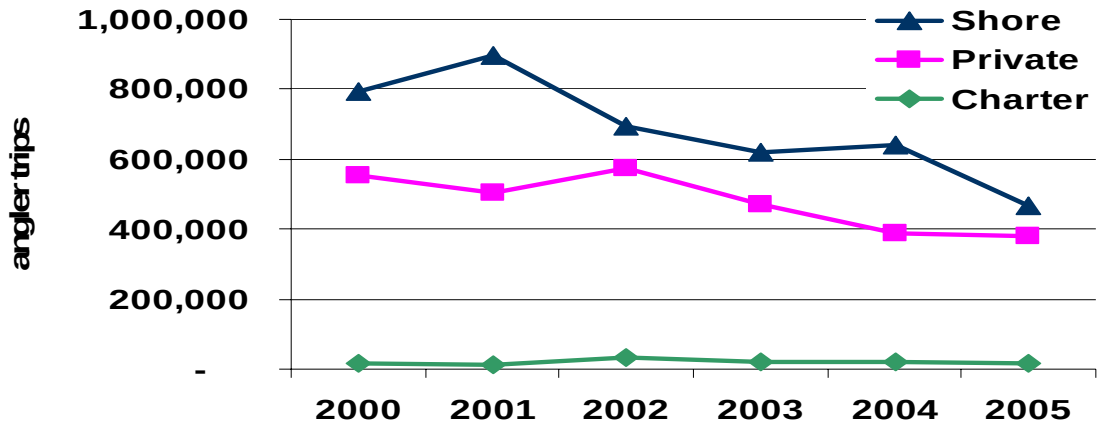


Figure 14. Estimated angler trips for Puerto Rico by mode from the Marine Recreational Fisheries Statistical Survey.

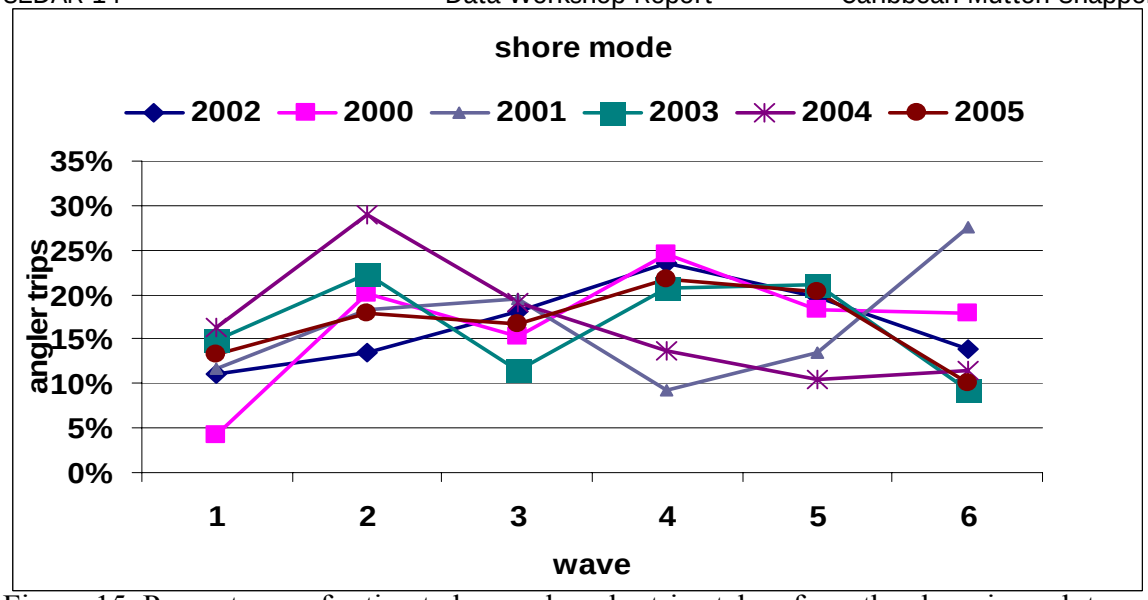


Figure 15. Percentages of estimated annual angler trips taken from the shore in each two month period (wave).

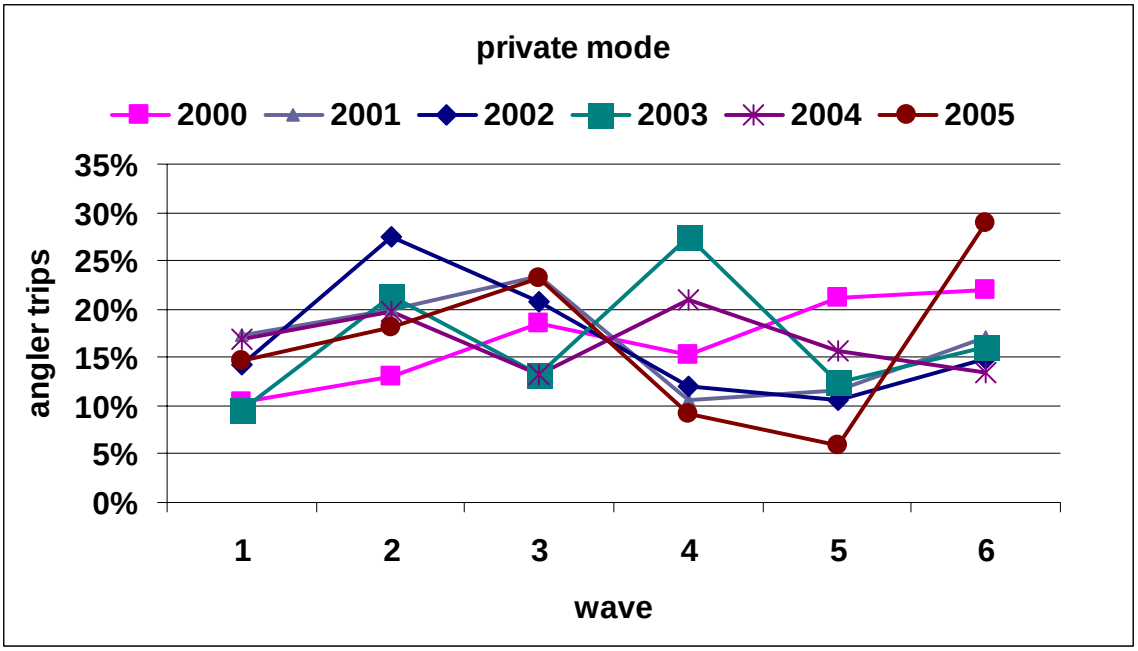


Figure 16. Percentages of estimated annual trips taken by private mode anglers in each two month period (wave).

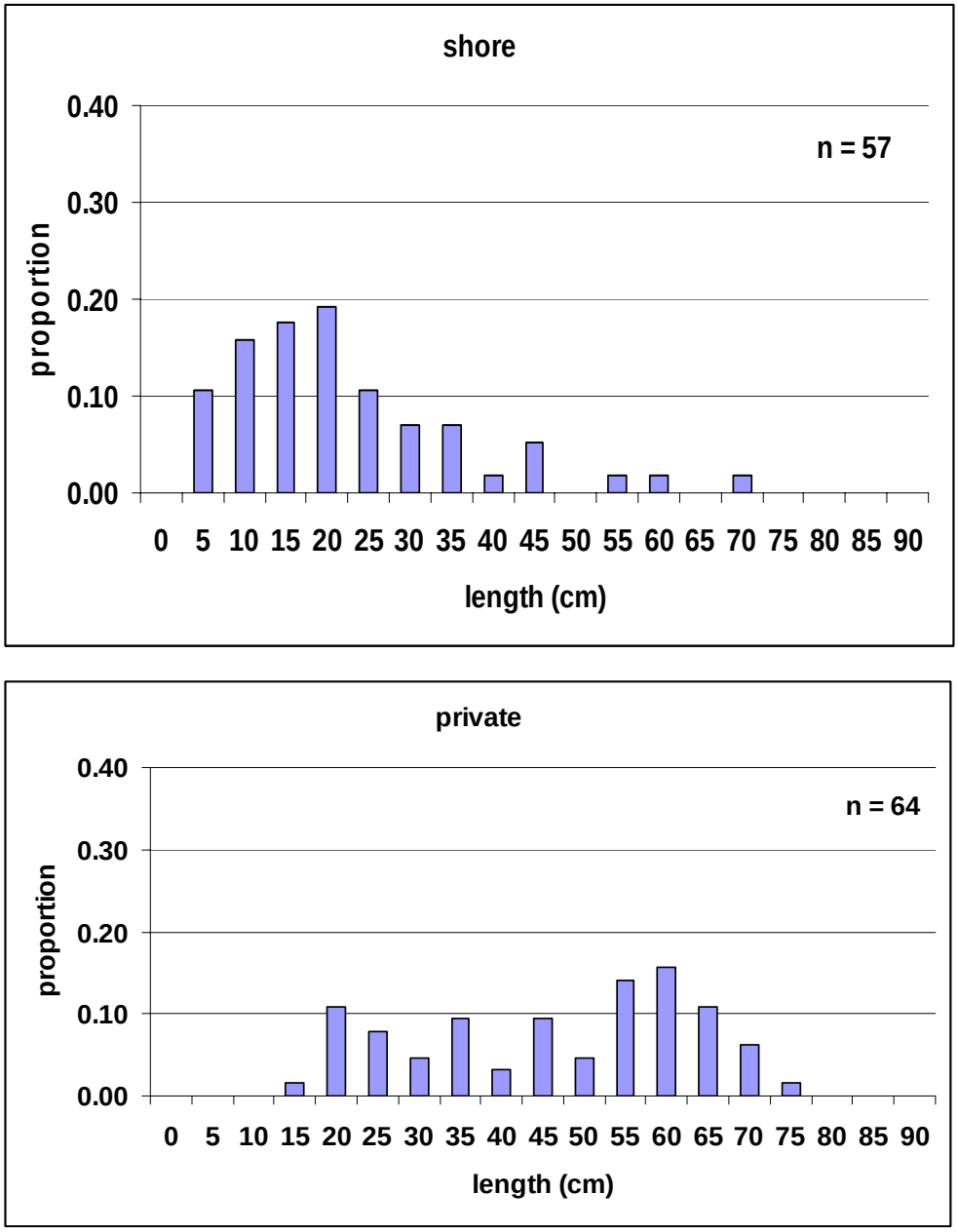


Figure 17. Length distributions of mutton snapper caught by recreational anglers in Puerto Rico fishing from shore or fishing from private or rental boats (private) durng 2000-2005.

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.

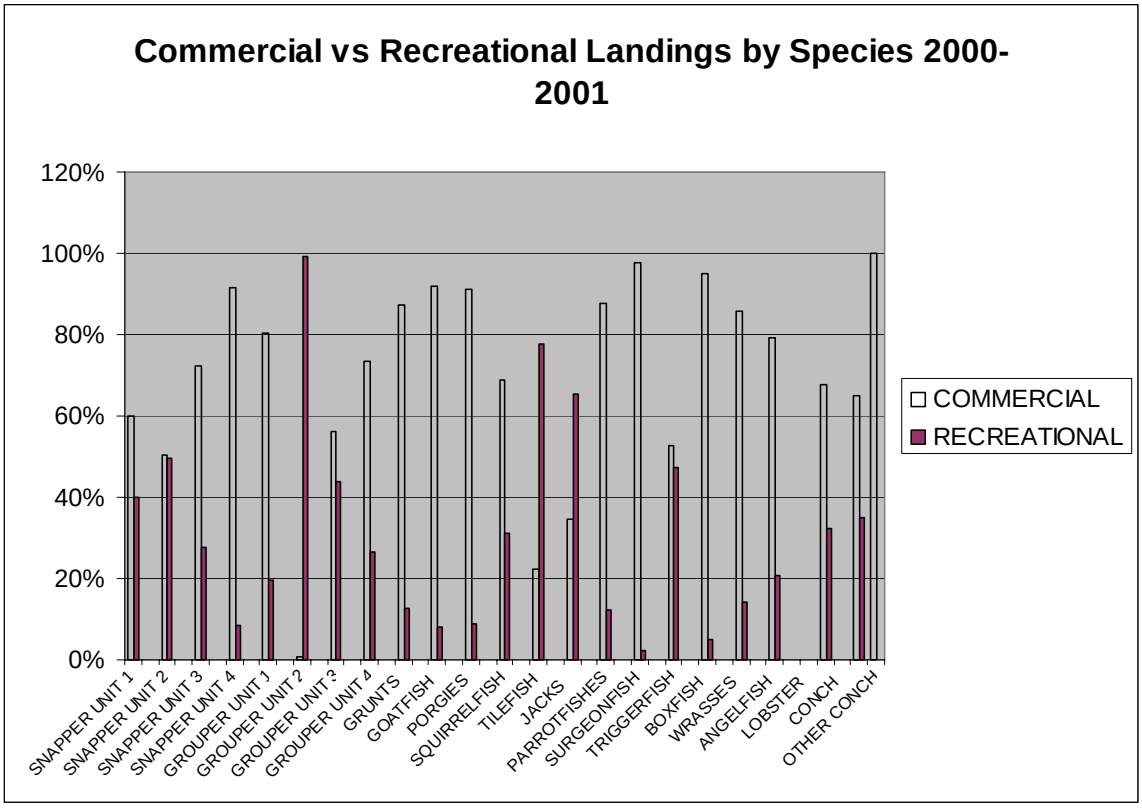
4.4.4. RECREATIONAL CATCH

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.

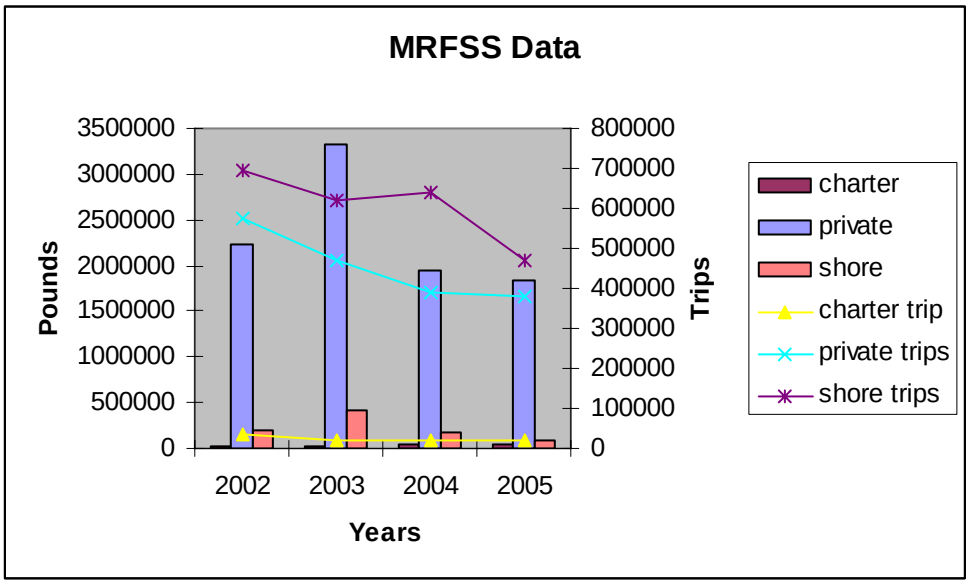


The figure above, that needs to be updated, shows the distribution of harvest by recreational and commercial fishers in the US Caribbean. The recreational fisheries include Goliath grouper (99% recreational), tilefish (78%), jacks (65%), queen snapper (50%), silk snapper (40%) queen conch (35%) and spiny 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.

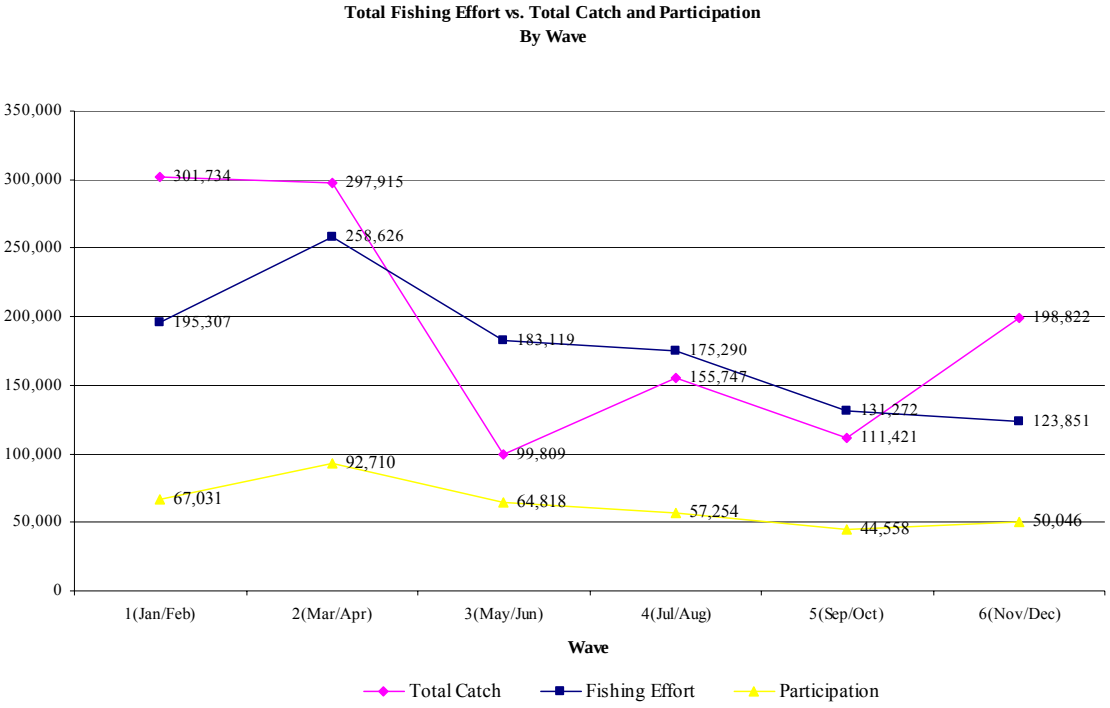
The MRFSS query showed that most of the harvest of dolphin, tunas and mackerels and barracuda is from the EEZ; some groupers and snappers (including yellowfin grouper (n=2 out of 5) and mutton snapper (n=12 out of 111) are reported from the area beyond the 10 mile territorial limit for the years 2001-2005. 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.

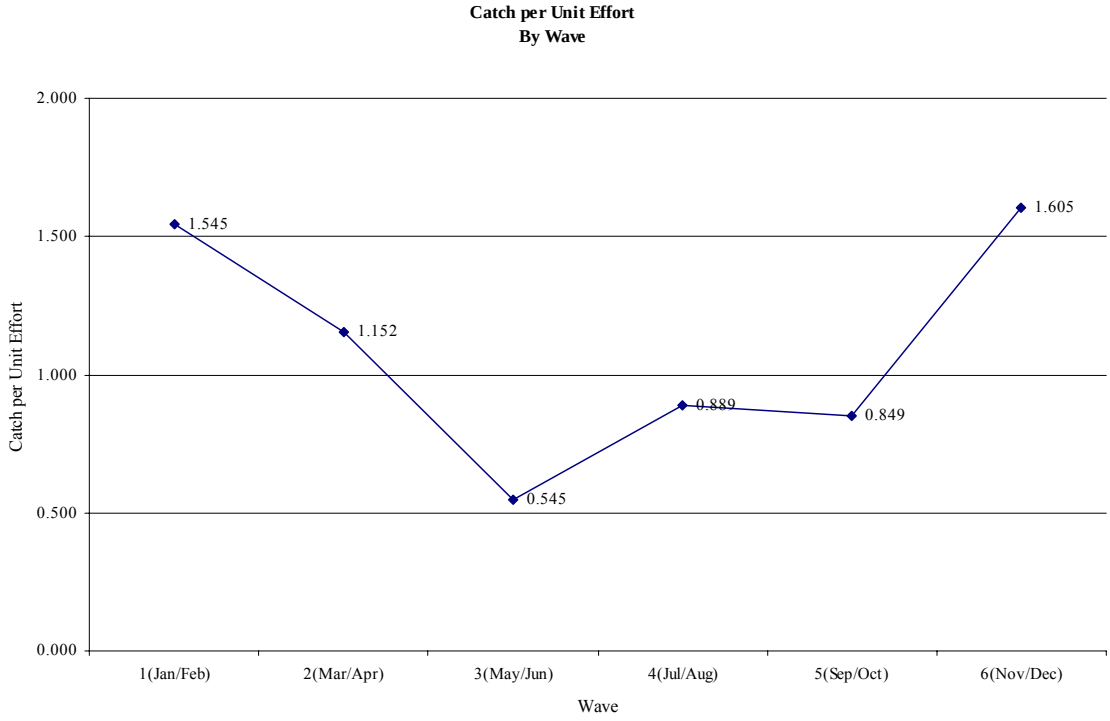


The figure shows the decrease in the number of trips taken from 2002 to 2005 for each of the fishing modes reported to MRFSS (lines) as well as the changes in the catch. At this time there is no further breakdown of species being landed for each year beyond the general categories of dolphin fish, tunas, 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.

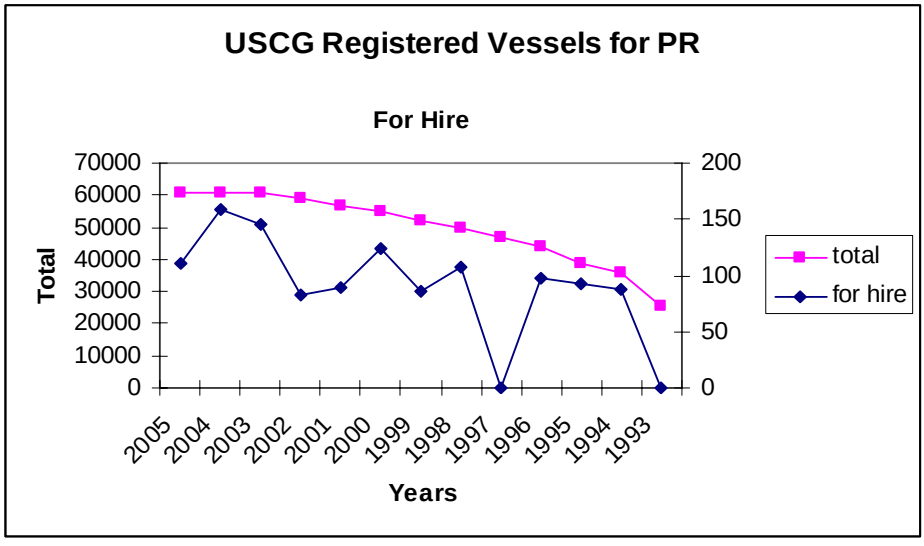
Eastern Caribbean Center survey (2002) found that trolling was reported as the most common boat-based fishing method in the USVI (59.7%), followed by bottom fishing (22.7%). However, Jennings (1992) states that bottom fishing (70%) was more common than trolling (20%) in 1986. Eastern Caribbean Center (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 GRUNT, WHITE PORKFISH MARGATE GRUNT, BLUESTRIPED GRUNT, FRENCH GRUNT, TOMTATE GRUNTS, UNC	172,960	25,168	198,128	87%	13%
GOATFISH GOATFISH, SPOTTED GOATFISH, YELLOW GOATFISHES, UNC	22,752	1,995	24,747	92%	8%
PORGIES PORGIES, UNC PORGY, JOLTHEAD SEA BREAM PORGY, SHEEPSHEAD PORGY, PLUMA	41,143	3,947	45,090	91%	9%
SQUIRRELFISH BIGEYE SQUIRRELFISH, LONGSPINED SQUIRRELFISHES, UNC SOLDIERFISH, BLACKBAR SQUIRRELFISH	19,104	8,710	27,814	69%	31%
TILEFISH TILEFISH, UNC TILEFISH, BLACKLINE TILEFISH, SAND	667	2,331	2,998	22%	78%
JACKS BLUE RUNNER HORSE-EYE JACK BLACK JACK ALMACO JACK BAR JACK GREATER AMBERJACK JACK, YELLOW JACKS, UNC	117,226	220,802	338,028	35%	65%
PARROTFISHES PARROTFISH, BLUE PARROTFISH, MIDNIGHT PARROTFISH, PRINCESS PARROTFISH, QUEEN PARROTFISH, RAINBOW PARROTFISH, REDFIN PARROTFISH, REDTAIL PARROTFISH, STOPLIGHT PARROTFISH, REDBAND PARROTFISH, STRIPED PARROTFISH, UNC	278,244	38,593	316,837	88%	12%

Table 7. Continued.

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

4.5. Literature Cited

Bohnsack, J, and D. Harper. 1988. NOAA Tech. Memo SEFSC 215, 31p. DENR PR. 2005. Puerto Rico marine recreational fishery statistics program.

Matos, D. 2000. Puerto Rico/NMFS Cooperative Statistics Program 1997-2000. Final Report. 73p. 2004. Comprehensive census of the marine fishery of Puerot Rico, 2002.

Matos, D. M. Haddock and N. Alvarado. In press-a. Bycatch study of the Puerto Rico's marine commercial fisheries. Proc. Gulf Carib. Fish. Inst. 9p. In press-b. Portrait of the Fishery of Mutton Snapper Lutjanus analis in Puerto Rico 1988 – 2001. Proc. Gulf Carib. Fish. Inst.

Matter, V.M. 2007. Recreational survey data for yellowfin grouper and mutton snapper in Puerto Rico and the US Virgin Islands. SEDAR14-DW03. 9p.

MRAG, Americas. 2006a. A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of St. Thomas, U.S. Caribbean. Coop. Res. Prog. Final Report (revised). 63p 2006b. A pilot program to assess methods of collecting

bycatch, discard, and biological data in the commercial fisheries of the US Caribbean. Coop. Res. Prog. Final Report (revised). 67p.

Appeldoorn, Richard And Valdes-Pizzini, M. Survey Of Recreational Fishing For The Queen Conch, Strombus Gigas, L. In Puerto Rico. Notes: Cd#1

Appeldoorn, Richard S. And Valdes-Pizzini, Manuel. Survey Of Recreational Fishing In Puerto Rico With Emphasis On Queen Conch: Submitted To ; 1996.

Chaparro, Ruperto. Developing Strategies To Enhance Charter Boat Fishing Operations In Puerto Rico And The United States Virgin Islands: Rum-Upr Sea Grant College Program; 1992 Mar.

Clapp And Mayne, Inc. Fishermen In Puerto Rico, Socio-Economic Profile: Nmfs; 1979.

Clark, Don J.; Ditton, Robert B. And Others. La Importancia Economica De La Pesca Recreativa De Agujas En Puerto Rico: The Billfish Foundation. Fort Lauderdale, Florida; 1994 Dec.

Downs, M. A.; J.S. Petterson; E. Towle, And L.L. Bunce. Rapid Socio-Economic Evaluation Of The Proposed Marine Conservation District St. John, Usvi. Cfmc; 1997.

Drna Pr. Puerto Rico Marine Recreational Fishery Statistic Program : Pr Dner; 2005.

Eastern Caribbean Center, University Of The Virgin Islands. Telephone Survey Of Boat-Based Marine Recreational Fishing In The U.S. Virgin Islands, 2000: Eastern Caribbean Center, University Of The Virgin Islands. Report Submitted To Dfw, Dpnr Usvi; 2002 May.

Garcia-Moliner, G.; W.R. Keithly, Jr., And I.N. Oliveras. Recreational Scuba Diving Activity In The U.S. Caribbean. Proceedings Gulf And Caribbean Fisheries Institute. 2001; 52:363-371.

Garcia-Moliner, Graciela; Mateo, Ivan And Others. Recreational Chartered Fishing Activity In The Us Caribbean: Proceedings Of The 53rd Annual Gcfi (2000); 2002.

Griffith, David C.; Johnson, Jeffrey C And Others. Developing Marine Recreational Fishing In Puerto Rico And The Us Virgin Islands: Final Report For Noaa/Nmfs (S-K) Submitted To The National Marine Fisheries Service; 1988 Jun.

H. John Heinz Iii Center. Improving Federal Fisheries Management In The Caribbean Region: The H. John Heinz Iii Center For Science, Economics And Environment. A Summary Of Views Presented During The Caribbean Regional Roundtable.

Hinkey-Macdonald, Lynne; Quinn, Norman J. And Others. Part I A Survey Of Marine Recreation Services In The U.S. Virgin Islands And Part Ii Technical Report On The Marine Survey Recommendations Workshop: Sea Grant Upr Pru-T-92-001; 1994 Feb.

Jennings, Cecil A. Survey Of Non-Charter Boat Recreational Fishing In The U.S. Virgin Islands:

Bulletin Of Marine Science; 1992.

Mateo, Ivan; R. Gomez; K. Roger Uwate; B. Kojis, And D.C. Plaskett. Activity And Harvest Patterns In The Us Virgin Islands Recreational Fisheries October 1995- September 2000. 2000: 59.

Olsen, David A. Socio-Economic Survey Of Recreational Boating And Fishing In The U.S. Virgin Islands: Under Irf, For Nmfs; 1979 May.

Thoemke, K. Puerto Ricoan Potpourri. 2000; 15, (4): 64-70.

Valdes-Pizzini, Manuel. Marine Recreational Fisheries Development In Puerto Rico And The U.S. Virgin Islands: Strategy And Current Approaches: Paper Presented At The 39th Annual Meeting Of The Gulf And Caribbean Fisheries Institute. Hamilton, Bermuda; 1986 Nov.

Valdes-Pizzini, Manuel. Developing Marine Recreational Fishing In Puerto Rico And The U.S. Virgin Islands: For: Noaa/Nmfs; 1988 Jun.

Valdes-Pizzini, Manuel; Chaparro, Ruperto And Others. In Support Of Marine Recreational Fishing: Research Report. Project No. Na86-Wc-H-06109. Pru-T-91-001.

Valdes-Pizzini, Manuel; Chaparro-Serrano, Ruperto And Others. Assessment Of Access And Infrastucture Needs Of Puerto Rico And The United States Virgin Islands, In Order To Support Increased Marine Recreational Fishing: Final Report Submitted To Nmfs; 1988 May.

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.

5.5. Literature Cited

Cummings, N. and D. Matos-Caraballo. 2007. Information on commercial removals of the yellowfin grouper, *Mycterperca venenosa*, in Puerto Rico from 1983 through 2005 with notes on nominal catch per unit of effort. SEDAR14-DW6.

Cummings, N. and D. Matos-Caraballo. 2007. Information on commercial removals of the mutton snapper, *Lutjanus analis*, in Puerto Rico from 1983 through 2005 with notes on nominal catch per unit of effort. SEDAR14-DW7.

Lo, N.C., L.D. Jackson, J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

Matos-Caraballo, Daniel. 2004. Job V. Historical landings and Biostatistical CFSP data analysis for five important species. Portrait of the fishery of mutton snapper, *Lutjanus analis,* in Puerto Rico during 1988-2001. [In: Puerto Rico/NMFS Cooperative Fisheries Statistics Program April 2001-March 2004. Puerto Rico, DNER, Mayaguez Puerto Rico, Contract Report No. NA17FT1006] pp156-169.

Stephens, A. and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fish. Res. 70:299-310.

Valle-Esquivel, M. 2002a. Standardized catch rates and preliminary assessment scenarios for queen conch (*Strombus gigas*) in the U.S. Caribbean. NOAA/NMFS Southeast Fisheries Science Center Sustainable Fisheries Division Contribution No. SFD-02/03-184. pp. 65.

Valle-Esquivel, M. 2002b. U.S. Caribbean queen conch (*Strombus gigas*) data update with emphasis on the commercial landings statistics. NOAA/NMFS Southeast Fisheries Science Center Sustainable Fisheries Division Contribution No. SFD-01/02-169. pp. 118.

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.

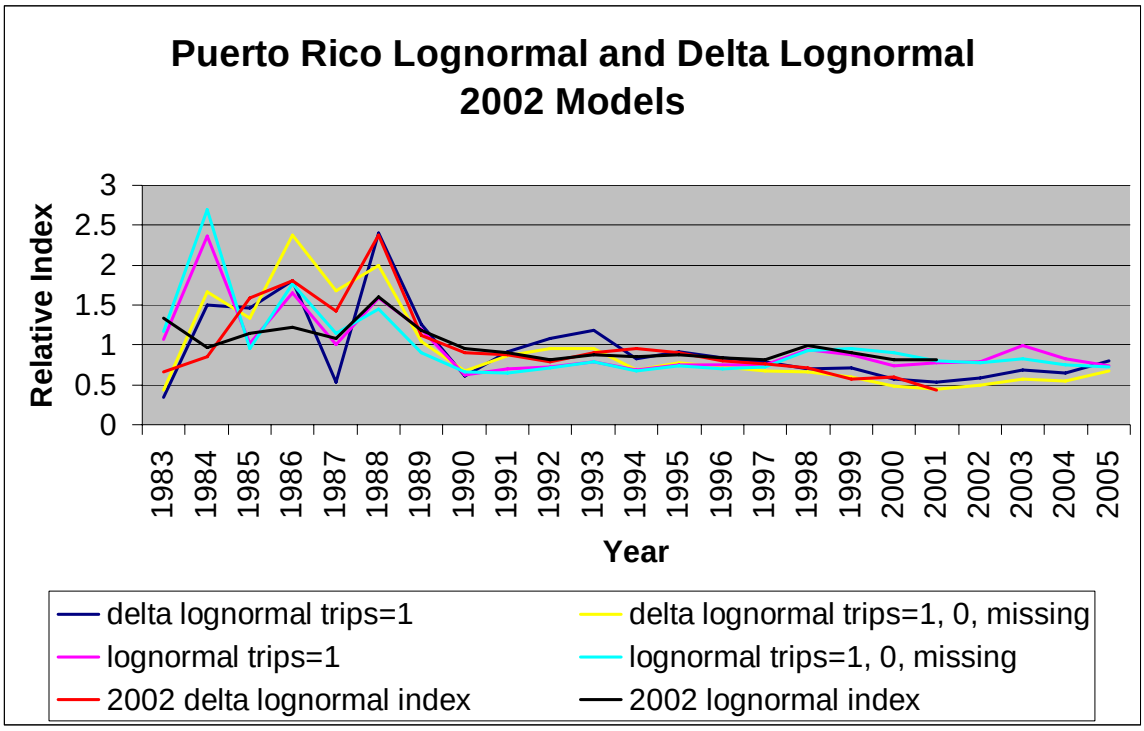
Year	Cast Net		Dive, Spear, Scuba		Net		Other		Pot		Hook and Line		Seine		Vertical Line		All	
	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %	N	Row %
1983	2	0.1	69	3.8	96	5.3	.	.	1,048	57.6	479	26.3	101	5.6	24	1.3	1,819	100
1984	1	0.8	4	3.1	6	4.6	.	.	91	69.5	20	15.3	7	5.3	2	1.5	131	100
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				St. Thomas/St. John	
	Valle-Esquivel (2002) model		2007 model		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



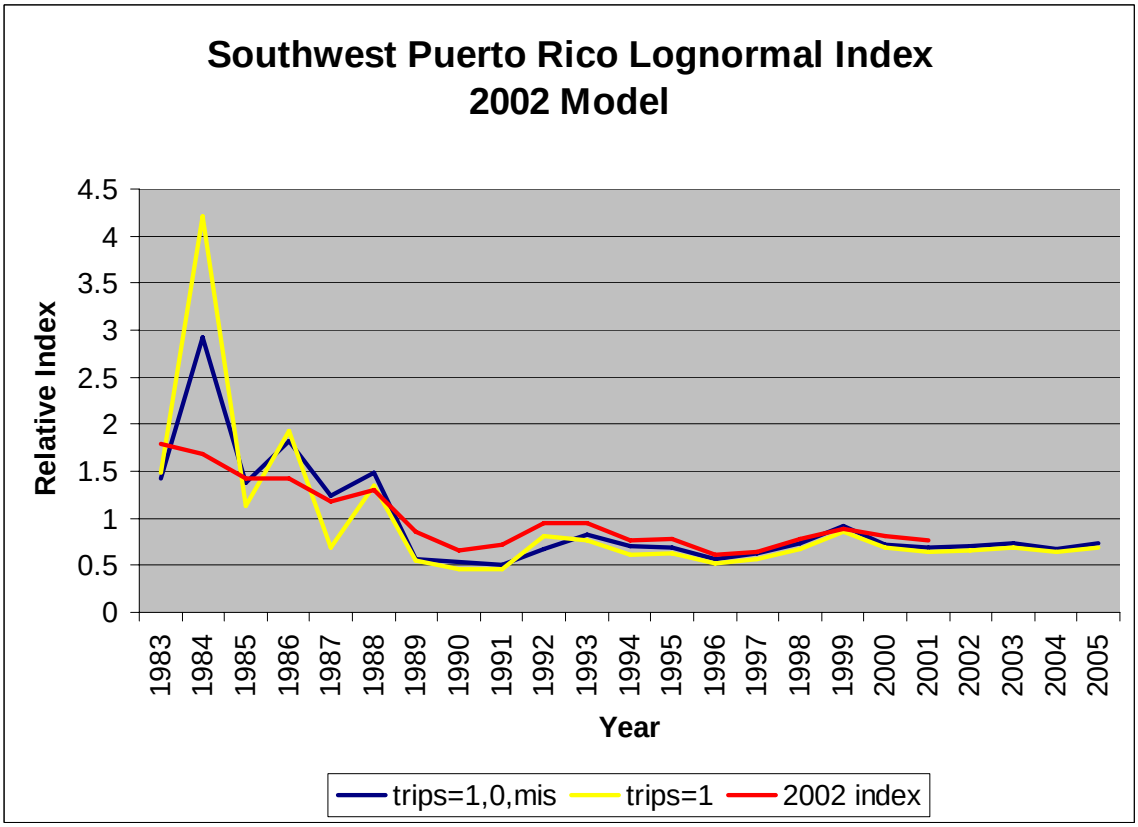
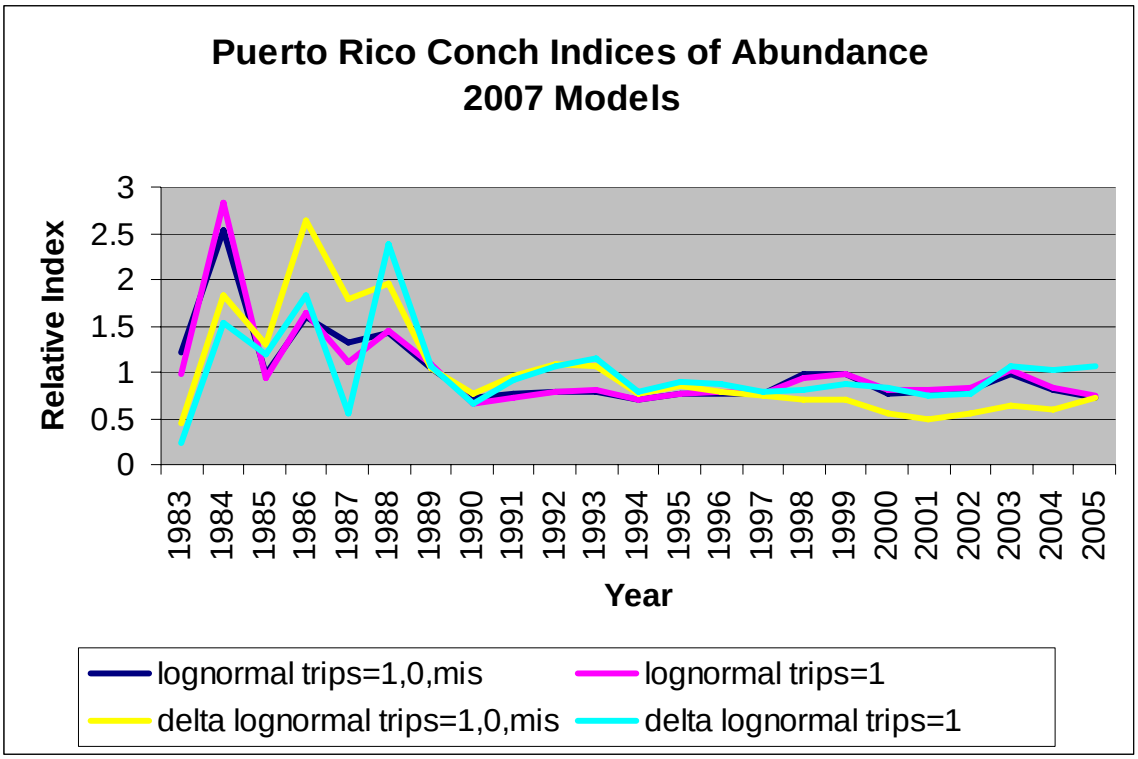


Figure 5-1 Puerto Rico queen conch indices of abundance.



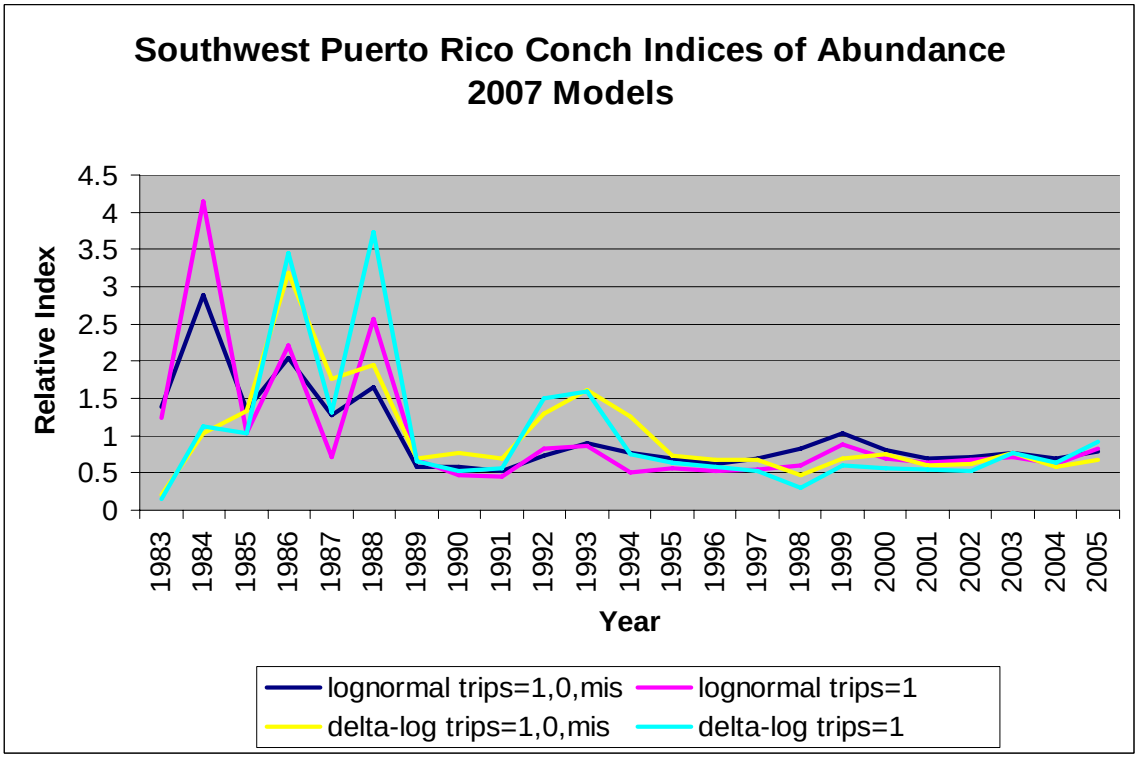


Figure5-1 Puerto Rico queen conch indices of abundance, continued.

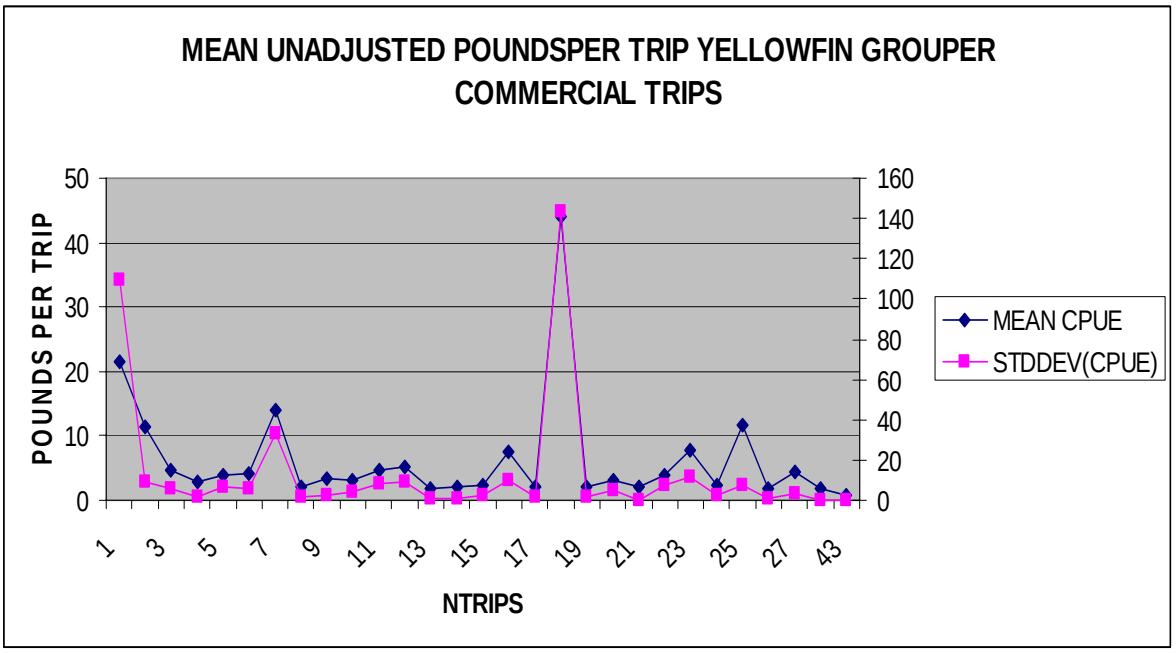


Figure 5-2. Mean CPUE (landed weight per trip) and standard deviation of the mean CPUE of Puerto Rico commercial landings.

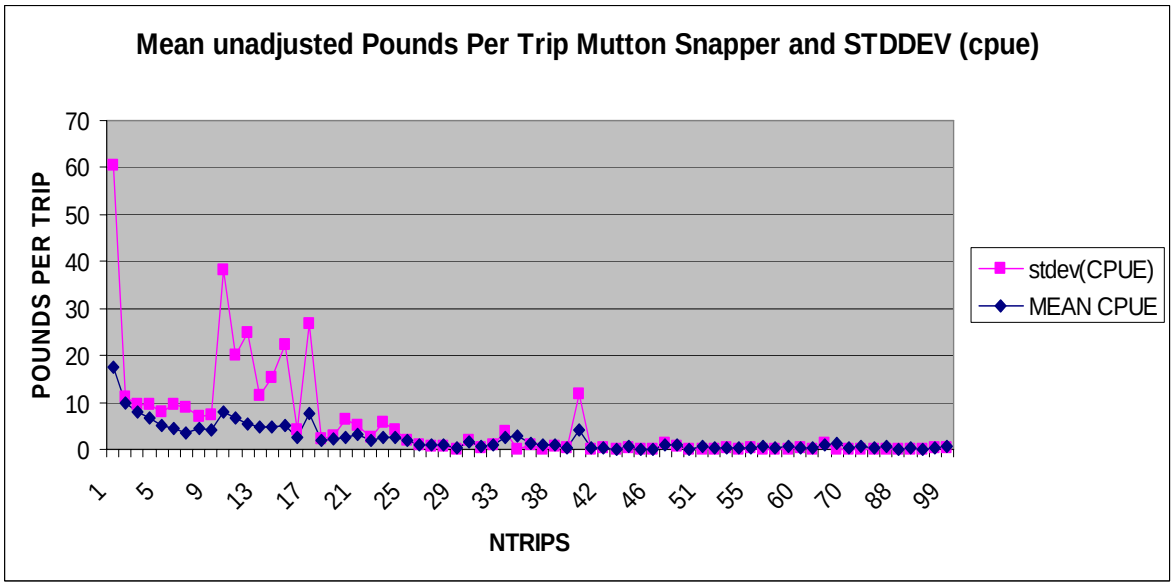
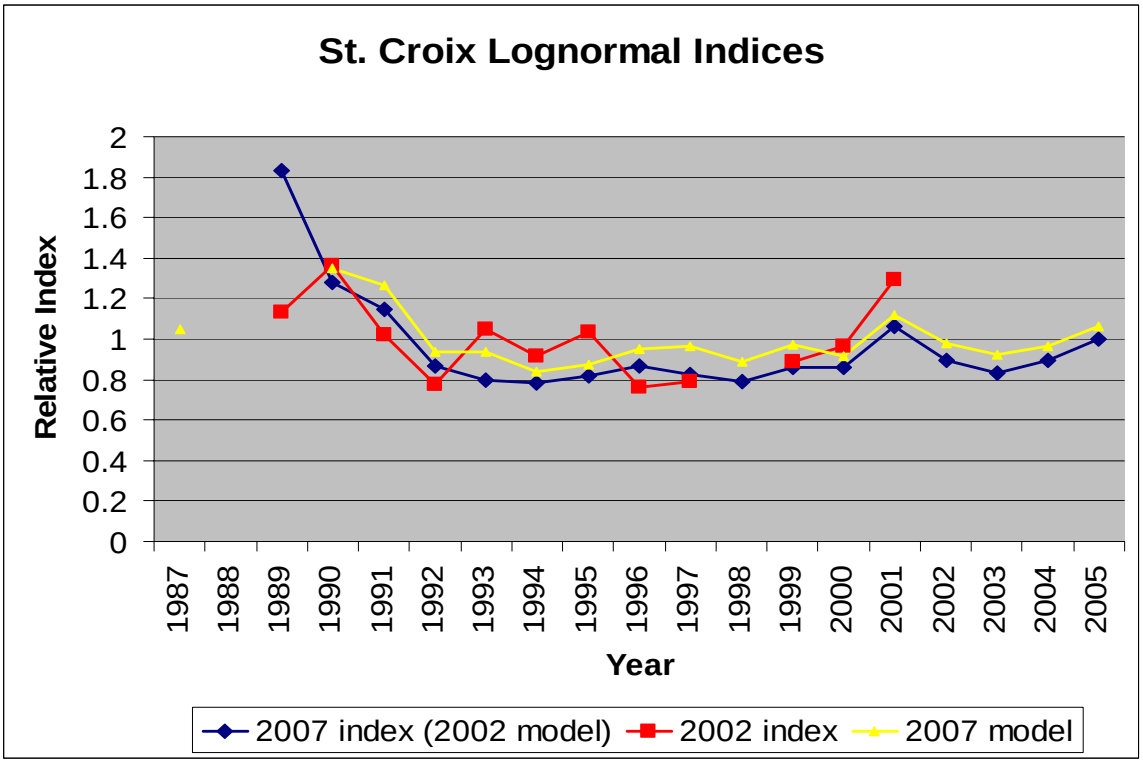


Figure 5-3. Mean CPUE (landed weight per trip) and standard deviation of the mean CPUE of Puerto Rico commercial landings.



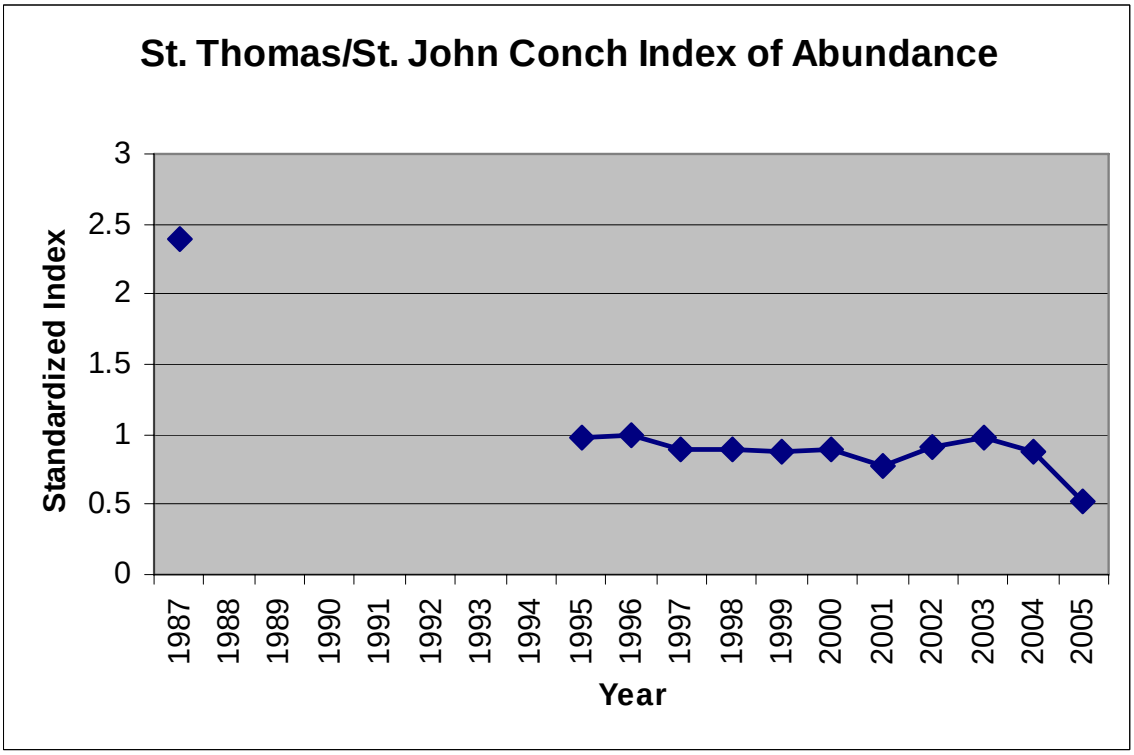


Figure 5-4. US Virgin Islands queen conch indices of abundance.

SEDAR 14

Stock Assessment Report 2

Caribbean Mutton Snapper

SECTION III. Assessment Workshop

SEDAR
4055 Faber Place #201
Charleston, SC 29405

SEDAR 14. Caribbean Mutton Snapper
Assessment Workshop Report

Table of Contents

1. Introduction

1.1. Workshop Time and Place

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

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.

1.3. 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

1.4. 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, 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 Recommendations Regarding Data Modifications

The Puerto Rico commercial landings data for mutton snapper were examined at the DW. The data indicated that the majority of the landings are from the trap and/or pots and hook and line fishery (SEDAR14 AW-01, Table 1). Historically throughout the 23 year time series, 1983-2005, removals from hook and line gear have accounted for some 46% of the removals across all years while pots or traps have accounted for about 28.5% (SEDAR14 AW-01, Table 2). Although landings were reported form the diving and net fisheries, there were insufficient data to carry out CPUE standardization analysis. The numbers of observations of CPUE were insufficient temporarily and spatially for these minor gears to develop a time series of standardized CPUE ((SEDAR14 AW-01, Table 1). SEDAR14 DW7 provided information on the nominal CPUE trends for both the minor and major gears (Table 2) There were no separate mutton snapper landings reported for the USVI. The very limited information available for mutton snapper from the USVI is specifically from the spawning aggregation. Species composition samples were insufficient to partition the aggregate samples. The SEDAR14 DW catch report provides information on the available samples from the USVI reef fish fisheries. Therefore, no CPUE models were attempted for the US Virgin Islands mutton snapper population due to the lack of species specific landings information.

At the SEDAR14 Data Workshop the Panel reviewed preliminary information on mutton snapper nominal catch per unit of effort (CPUE) in Puerto Rico. SEDAR14 DW-07 was provided as a background document describing data available for characterizing CPUE. Previous CPUE analyses from SEDAR8 for yellowtail snapper evaluated the Puerto Rico landings records for yellowtail snapper (SEDAR8) including only included successful catches in the analyses and included all landings areas into the analyses. The SEDAR14 DW Panel recommended that the SEDAR14 mutton snapper CPUE analysis include trips that also could possibly have landed mutton snapper but did not, in addition to successful or positive trips. The Panel recommended that the Stevens-MacCall (2004) approach be evaluated to select 0 trips. SEDAR14 AW1 document provided the background and Stephens McCall results indicated that of over 200 unique species indicated as being landed in Puerto Rico's reef fish fishery, 69 species were landed in 75% of all trips, and of these 32 were found to be significant with the mutton snapper.

The group also identified the principal landings areas for mutton snapper to determine the potential trips for harvesting mutton snapper. In addition to selection of zero trips for inclusion into the CPUE dataset, the Panel discussed the quality of the early years of the landings data. A recommendation was made to only consider the landings data from 1988 on for CPUE analysis. The data from the years 1983 to 1988 were not used because these were the years of the implementation of the sampling protocol and thus not considered reliable.

2.2. Discussion and Critique of Each Model Considered

2.2.1. *CPUE Models*

SEDAR14 AW01 describes the CPUE standardization analysis for the Puerto Rico mutton snapper landings and summarized data availability (Table 2). General linear models were applied to each separate set of CPUE observations for the hook and line and the trap fishery. The measure of CPUE was the landed weight (round pounds) for each unique trip. SEDAR14 DW07 described the procedure used to identify unique fishing trips. The approach used to derive the standardized

index utilized the Lo et al. (1992) delta-lognormal model which fits a log-normal model to the positive CPUE data and a binomial model to the proportion of positive data with the resulting index being a combination of the two. A normal error distribution was assumed for the positive log(CPUE) data and a binomial distribution was assumed for the proportion of errors. The estimated probability of the proportion of positives was a linear function of the fixed main effects (e.g., year, area, and month). Municipality identification code was a proxy of area in the mutton CPUE analyses. The model evaluations were made using the generalized linear modeling Glimmix and the Mixed procedure (Version 8.02 of the SAS System for Windows © 2000, SAS Institute Inc., Cary, NC, USA).

SEDAR14 AW-01 described the steps for the mutton snapper CPUE model fitting. Several CPUE models were attempted for each gear based fishery. These models explored the effect of several independent variables to explain CPUE. The independent variables available for these data were very few including year, area and month. The analyses were carried out separately for each of the major gear based fisheries (i.e., traps and hook and line) because of the operational differences in the two fisheries. The procedures and methods used to select the final model were included in the SEDAR14 AW01 document. The model selected as best characterizing the mutton snapper CPUE was based on the analysis of the deviance and diagnostic results from each fit after evaluating the input of each main effect (e.g., year, area, month) and in some cases one or more interaction terms (e.g., Year*Area, Year*Month, Area*Month). The diagnostic results included evaluation of the residual distributions of the fits, the AICC statistic, and the overdispersion statistic.

2.2.2. *Length Based Mortality Estimator*

Document SEDAR14-AW-05 presented the results of a length based total mortality (Z) estimator. Due to data insufficiencies, the method could only be applied to the mutton snapper trap fishery in Puerto Rico (Table 3). Although it was felt that there were adequate sample sizes to consider application of the length model to the Puerto Rican samples it was noted that the sampling intensity was very variable in Puerto Rico. Mutton snapper sampling intensity ranged from 0 % to 3.6 % for both the hook and line and trap fishery between 1983 and 2005, averaging 0.97% and 0.60% respectively. It was also noted that in some years, mutton snapper sampling intensity was disproportionate to the level of landings for some gears. There were insufficient samples collected for St. Thomas and/or St, Croix fisheries to consider application of this model (Tables 5 and 6). The length based mortality method applied here is based on the Beverton and Holt length-based mortality estimator (Beverton and Holt, 1956, 1957) which was modified by Gedamke and Hoenig (2006) to accommodate non-equilibrium situations.

2.2.3. *Production Models*

The panel also discussed the possibility of using a surplus production model (ASPIC) to assess the status of mutton snapper in Puerto Rico. A production model requires a series of total landings and an index of abundance or total effort as inputs. Commercial landings removals exist back to 1983 however recreational landings are unknown for the island of Puerto Rico before 2000. The panel discussed the possibility of using either total human population or number of registered recreational boats as a proxy for fishing effort to estimate recreational landings back in time using MRFSS estimated landings for 2000-2005. MRFFS landings are estimated as number of fish. In addition, the estimates of recreational catches of mutton snapper were characterized by high CV's. Because a production model requires landings in biomass, any estimated landings using MRFSS estimates required a conversion from numbers to biomass. Size samples from MRFSS 2000-2005 ranged only from 8 to 34 per year (SEDAR-DW-03). Given the small number of fish sampled by MRFSS and the change of mutton snapper mean length through time as a result of fishing pressure (SEDAR-AW-05), it was agreed by the panel not to estimate recreational landings for the years prior to 2000 because of the large number of uncertainties (i.e., lack of recreational catch, inadequate samples of size to convert numbers to biomass, large CV's in estimates); therefore,

precluding the use of a surplus production model (ASPIC) to assess the mutton snapper fishery in Puerto Rico.

2.2.4. Habitat Based Model

SEDAR14 AW02 provided estimates of mutton snapper abundance based on visual census surveys conducted in the nearshore mapped hard and soft bottom habitats off the southwest coast of Puerto Rico (La Parguera) and off the northeast coast of St. Croix (Buck Island) and St. John between 2001 and 2006. Observed frequencies of mutton snapper were expanded to totals based on benthic map spatial extent. The group noted felt that the unexpanded estimates provided information on relative levels over the combined six year period, 2001-2006 from the areas surveyed.

2.3. Preferred Model, Configuration, and Summary of Model Issues Discussed

2.3.1. *CPUE Models-*

Hook and Line Fishery CPUE

The annual standardized mutton snapper CPUE indices for Puerto Rico hook and line fishery are provided in Table 7 and Figure 1. Models were calculated for the hook and line fishery CPUE data from 1989 through 2005. The final model structure fitted to the positives log(CPUE) observations from the hook and line fishery was:

log(CPUE)=Year + Municipality + Month + Year * Municipality

The final model structure fitted to the proportion of positives observations from the hook and line fishery was:

Proportion Positives = Year + Municipality + Month + Year*Municipality.

Trap Fishery CPUE

The annual standardized mutton snapper CPUE indices for Puerto Rico trap are provided in Table 8 and Figure 2. Models were calculated for the pot fishery CPUE data from 1990 through 2005. When data from 1989 was incorporated into the model the models did not achieve convergence. The final model structure fitted to the positive log(CPUE) observations from the trap fishery was:

log(CPUE) = Year + Municipality + Month + Municipality*Month.

The final model structure fitted to the proportion of positives observations from the trap fishery was:

Proportion Positives = Year + Municipality + Year*Municipality

Discussion of the model fitting characteristics occurred. The mutton snapper Puerto Rico CPUE standardization models did not include many variables. This is an artifact of the way in which the landings data were recorded as few attributes are requested on the landings sales record form. In addition, the amount of the total variance explained by the models was low suggesting the models were uninformative. This result could be due to the lack of information available regarding the CPUE data to characterize the model. The diagnostic results for the lognormal fits to the positive log CPUE observations for both the trap and the hook and line fishery did not suggest any major violation of assuming the lognormal model for the mutton CPUE data (Figures 3 and 4). Also, the distribution of the residuals did not suggest strong tendencies in the patterns. It was noted that the number of successful trips landing mutton snapper over the period of the analysis time series was

very low for both the hook and line and the trap fishery (Figures 5 and 6). The proportion of positives for the hook and line fishery ranged from about 6.2% to 14.2% averaging 10% across all years but was very low particularly between 1993 and 1997.

The proportion of positive for the trap fishery ranged from about 3.8 % to 21.2 % averaging 10.3% (Figures 7 and 8). The diagnostic results from the fits of the individual CPUE models suggested that overdispersion was present in the proportion of positives observations in both the hook and line and the pot fishery data. This could suggest the binomial model did not adequately fit the proportion of positives data or also that the model structure (i.e., information contained in the model description) was not adequate for explaining the variability in the proportion of positives. Figures 9 and 10 illustrate the residual distribution for the proportion positives fitted from the final delta lognormal model by year, for mutton snapper from the Puerto Rico line fishery, 1989-2005. The lognormal model fit to the positive log CPUE data did not suggest overdispersion in the data for either the hook and line or the trap fishery.

The SEDAR14 AW group reviewed the mutton snapper final standardized CPUE trends presented in SEDAR14 AW-01 and also results from the hook and line fishery sensitivity run. It was noted that for the hook and line fishery that the pattern of standardized CPUE suggested little trend in CPUE over the period, 1989-2003. Only the last two years of the series indicated a slight increase. The mutton snapper pot fishery standardized CPUE indicated an increase in CPUE occurring between 1990 and 1998 and again from 2000-2002. The group discussed if the Puerto Rico CPUE indices can be considered reflective of stock abundance. The group noted that no information had been presented to indicate that the indices were not reflective of abundance.

During the AW the Panel recommended to explore a sensitivity model for the hook and line fishery that excluded the observations for the spawning closure months of April and May for 2004 and 2005. The model structure was the model that resulted from the best fit hook and line CPUE model from the above description. The resulting trends in estimated standardized CPUE from this sensitivity trial were unchanged (Figure 11) thus the selection of the final standardized indices were unchanged changed from the base case scenario (Tables 7 and 8).

The group also recommended updating the mutton snapper CPUE indices to include new data from 2006 as that was made available during the AW. This task will be evaluated after the AW and any updated or new indices made available for the SEDAR RW workshop.

2.3.2. *Length Based Mortality Estimator*

Length of full vulnerability, L_c, was estimated to be 300 mm FL. Three different cases or scenarios were developed by creating separate time series for: 1) mean lengths calculated for each separate or unique interview day, 2) mean lengths calculated by month strata and 3) mean length calculated by year strata.

The chosen base case was the times series estimated using average length by interview day and runs were performed with and without weighting the data by the sample size of each estimated mean length. The aggregation of data over the larger time scales had little effect on the weighted functions (Table 9) which appeared to be driven by a few samples with unusually high sample number and large fish (see years 2001 and 2002).

During the SEDAR14 AW, it was discussed with the Puerto Rico DNER Port Agent supervisor (D. Matos-Caraballo, SEDAR14 AW07) the validity of those samples containing high numbers of observed large fish. It was agreed that it was unlikely to have caught that many large mutton snappers in a single trap trip. The port agents believed that those records were miscoded and they most probably correspond to catches made by hook-and-line gear fishing on the spawning aggregations. It was therefore agreed to exclude those observations and rerun the length based model.

2.3.3. *Production Model*

Production models were not explored for mutton snapper at the SEDAR 14 due to the large uncertainty regarding total removals. Data exists since 1983 to describe commercial removals however, the level of uncertainty around estimating the recreational component from lack of catch information, short time series, and inadequate samples to convert estimates of catch in numbers to biomass would substantial uncertainty to the analysis.

2.3.4. *Habitat based Model*

Estimates of total abundance of mutton snapper from 2001-2006 from the habitat based estimator are given in Table 10. The areas surveyed are shown in Figure 12. In Puerto Rico, the estimate ranged from 4,979 to 32,750 individuals with a mean of 18,865 sexually immature fish and zero adult fish. It is important to note that the estimate in Puerto Rico is based only on the occurrence of three juvenile fish. In St. Croix, total mutton snapper abundance ranged from 41,487 to 136,943 individuals with a mean of 106,678 individuals. In St. John, total mutton snapper abundance ranged from 3,698 to 28,986 individuals with a mean of 16,342 fish. The large range in these estimates result from the high variability in occurrence of mutton snapper among different habitats as noted by SEDAR14 AW02. Juvenile and adult mutton snapper varied somewhat in their distribution among habitats, with juveniles being more common in mud, sand and seagrass habitats and adults being more frequently observed in hard bottom habitats (SEDAR14 AW02-Figure 2).

The panel noted that the expansions were based on the benthic map spatial extent and thus the resolution of the estimates was dependent on the accuracy and resolution of the habitat maps. The group felt that the frequency of occurrence information could be considered as relative information for the period of study, 2001-2006. It was recommended that the estimates be validated through estimates from other habitat studies if available. The group noted that the surveys were from localized areas off Puerto Rico, St. Thomas and St. Croix and whether the estimates reflected total island population sizes could not be determined.

2.4. Recommended Parameter Estimates

A full stock evaluation could not be performed for the US Caribbean mutton snapper stock due to inadequate data therefore recommendation for stock status parameters (stock biomass, fishing mortality, selectivity) were not determined. Some information was derived on relative abundance levels from CPUE observations.

2.5. Evaluation of uncertainty and model precision

2.5.1. *CPUE Indices*

The group discussed the results of the mutton CPUE analyses and noted that for the hook and line fishery there was little trend in CPUE, if any only a slight increase in CPUE, until the rather sharp increase predicted for the last two years around 2003 (Table 7, Figure 1). In the trap fishery, the trend of CPUE showed a relatively flat CPUE through 1998, then a sharp increase in 1999 followed by another increase in 2003 (Table 8, Figure 2). It was noted that the increase in CPUE predicted in 2003 coincided with changes in regulations of a seasonal closure during April and May. There was some discussion by the Panel as to effects of climate changes in the 1990's, in

particular drought conditions that may have impacted mutton snapper population sizes. Evaluating this environmental impact on CPUE was not possible with the current data set as information on species landings is not available before 1989.

Estimated CV's around the standardized CPUE indices were reasonably low. CV's for the hook and line fishery ranged from 14-22% while the pot fishery CPUE's were somewhat more variable with CV's ranging from 18-32% (Tables 7 and 8). The panel discussed whether the standardized CPUE mutton indices were reflective of stock abundance. It was agreed that there was no reason identified to either doubt or discard the indices.

2.5.2. *Length Based Mortality Estimator*

The panel noted that the Puerto Rico trap length data showed evidence of clear length truncation (Figure 13). In addition sample sizes ranged from very low to some very high (Table 3). In a few cases with large numbers of observations, there were clear outliers of larger mean length. There was additional discussion on the use of the procedure to derive estimates of population parameters (e.g. mortality). It was noted that this gear does not usually target mutton snapper, but apparently that mutton may have an affinity for this gear. It was also noted that traps caught a wide range of available sizes. It was also noted that fishers can keep what they catch, so landings length composition is probably reflective of catch length composition and also length samples are taken randomly by the Puerto Rican port agents. One concern noted was that the very largest mutton may not be able to get in the trap. This may or may not be a major bias. The group felt therefore that the trap length composition may be reasonable reflection of the population length composition. It was emphasized however that the key output from the length data should be considered in terms of trends in mortality over time, not so much as an absolute estimate.

This type of analysis shows promise for this type of data limited situation. Unfortunately, data were even too limited in regionally specific fisheries to apply the model (e.g., St. Thomas, St. Croix). In the one case (Puerto Rico trap fishery) where sufficient samples were taken, the high variability of the data leads to significant uncertainty surrounding the absolute values presented in this analysis. It is also important to note that there is an apparent discrepancy between the conclusions of the length-based analysis (i.e., indicating increased mortality around 1990) and the trend in the indices (i.e., indicating increasing abundances by the late 1990's). There are two aspects of the length-based analysis to consider. First, given the high variability in the length data that were analyzed, any reduction in fishing mortality that may have occurred after the estimated increase in 1990 would be difficult to detect. Secondly, the model assumes constant recruitment and a violation of this assumption, in the form of an increase in recruitment, would make the mean length smaller (i.e. overestimate mortality) while at the same time explain the increase in catch rates. Generally, the assumption of constant recruitment is not unreasonable for most teleost fish over relatively small changes in stock sizes, but results should be used with caution until information on recruitment is available. Simulations of the length based analysis to the constant recruitment assumption violation demonstrate that the magnitude of trend in recruitment will reflect the magnitude of bias in the total mortality estimate (i.e. a 10% trend of increase in recruitment will result in a 10% overestimation of total mortality).

The panel requested further evaluation of the length model to include the CPUE indices possibly as weighting factors for consideration by the review Panel. The evaluation would apply to the Puerto Rico samples only as sufficient length statistics were not available for the USVI fisheries.

2.5.3. *Habitat Model*

Relative abundance information was provided through expansions of frequency of occurrence information from visual census information (SEDAR14-AW02). SEDAR14 AW02 noted that that large variability in frequency of occurrence existed among the different habitats, resulting in a large range of estimated population levels.

2.6. Discussion of YPR, SPR, Stock-Recruitment

The Panel discussed whether a yield per recruit analysis (YPR) was appropriate for the mutton snapper population. It was noted that such analysis would require input of necessary life history growth parameters from outside the study area. It was noted that although such assumptions could be made that in addition these parameters would be based on observations from commercial fisheries. In addition information on recreational selectivity was not available from any source for mutton snapper in the US Caribbean. Additional uncertainty concerned lack of information on current fishing mortality to evaluate what current YPR was.

2.7. Recommended SFA parameters and Management Criteria

The US Caribbean mutton snapper population is currently managed under criteria adopted for Management Unit 3. Table 12 provides the current SFA parameters and criteria.

2.8. Status of Stock Declarations

A full evaluation of stock status was not possible for the mutton snapper stocks in the US Caribbean due to the insufficiency of information regarding population levels. Some information was derived yielding information on trends in CPUE since 1983 for the two dominant fisheries exploiting the mutton snapper in Puerto Rico. CPUE information was not available for the remaining islands (St. Thomas/ST. John or St. Croix). In addition application of a length based model provided information on general trends in total mortality since 1983.

2.9. Recommended ABC

Calculations of ABC were not possible for mutton snapper because status of stock could not be determined.

2.10. Discussion of Stock Projection

Population projections were not possible for the US Caribbean mutton snapper stocks.

2.11. Management Evaluation

2.11.1. Effectiveness/impacts of past management actions

Mutton snapper populations in the US Caribbean have been subject to a seasonal area closure in St. Croix since 1993 (in the EEZ) and 1994 in the state waters of St. Croix (Figure 14). The SFA Amendment to the FMPs (2005) established a seasonal closure for mutton snapper for all of the EEZ during the months of April through June. The US VI established a seasonal closure in 2006 during the same months, April through June. Puerto Rico established a seasonal closure in 2004 for the month of April, in 2007 amended the closure to cover April and Month.

- Have size, bag, harvest limits etc. affected the stock? achieved objectives?
- evaluation of rebuilding strategy (if implemented)

Effects of management strategies such as recreational bag limit and/or commercial harvests guidelines for mutton snapper cannot be evaluated as there is no history of these actions on the resource. The fishery is not under quota management. The current status of the mutton snapper populations in the US Caribbean is not known thus overfishing status has not been determined and therefore no rebuilding strategy is in effect. Impacts from federal and/or state seasonal closures have not yet been evaluated.

2.12. Research Recommendation Research Recommendations

Table 12 provides a comprehensive overview of the availability of information for U.S. Caribbean mutton snapper populations, This table in addition to the following discussion provides a synthesis of the groups thoughts regarding sufficiency and quality of the data available for use in evaluating the stock status of the mutton snapper population in this region. Due to the current categorization of mutton snapper as undergoing overfishing, this species should be prioritized in all data collection efforts in the US Caribbean both in dependent and fishery independent programs. Obtaining information required to assess the impact of regulations on management measures is needed. Targeted research efforts are needed to determine relative abundance, CPUE, length and age structure of catch for all commercial and recreational gears used to harvest mutton snapper. The group noted the need to monitor population densities at seasonal closed areas to open areas to determine effects of management and to monitor compliance. The only area closure for mutton snapper is off St. Croix and the closure has been in place since 1993. There has been no monitoring in this area since the closure took effect. In addition there is no current mechanism of enforcing the spawning seasonal closure.

2.12.1. Dependent Data Collections

At the SEDAR14 AW the group discussed the importance of accurate and reliable information regarding the catch. Fishery dependent data collection (i.e., commercial fishery) should be continued and improved with emphasis on priority species (in this case mutton snapper). The group noted that a review of the field methods and protocols of the fishery data collection systems in the U.S. Caribbean needs to be conducted to evaluate what relevant attributes need to be collected to characterized trip specific catch. Such a review should be conducted in collaboration with all the primary agencies responsible for management of these species to assess appropriate sampling levels and priority species (or groups of species) and prioritize fisheries. Species landings information should be collected at a resolution so CPUE can be determined for each gear used to harvest this species. Accurate information must be recorded to identify each individual fisher, location and date of catch and where possible depth of catch. For all primary harvest gears, optimum CPUE should be in terms of number of individuals, biomass, and the amount of effort in hook-hours (i.e., time hooks are in the water) or trap soak-time in hours. The group also emphasized the need to review the catch sampling intensity protocols prescribed by the NMFS, SEFSC, Trip Interview Program for sampling catches as a guideline for setting catch length frequency sampling needs. As a starting point the current TIP target of taking 25-30 individual lengths and weights per trip should be considered as a guideline for sampling of individual catches. When sub-sampling occurs the sampling fraction must be recorded. In addition, information should be collected to determine whether fish were captured in a spawning aggregation or otherwise. Where appropriate, information on directed fishery discards should be collected and, the fate (i.e., dead, alive) and size of individuals of the discards characterized. The group also noted the importance of monitoring the fishery accurately as relates to the intra-day variability. The group emphasized that the MRFSS sampling program should add additional

survey attributes to draw out information on mutton snapper throughout the U.S. Caribbean. The group emphasized the need to continuous recreational fishery data collection in the US. VI. In addition, the sampling effort of the MRFSS intercepts should be increased to a level that would result in adequate sample sizes for biological characterization. The use of research initiatives such as CRP, MARFIN and Sea Grant were encouraged as funding mechanisms for the collection of such critically needed data.

2.12.2. Fishery Independent

The group emphasized the need to continue and enhance the current fishery independent program(s) to better evaluate abundance indices for mutton snapper populations cross insular platforms in habitats where these fish are known to occur as well as for known spawning aggregations. During such monitoring length of individuals, location, depth, time of day of sample collection, and habitat should be noted. Visual counts or directed gear sampling (i.e., hook-and-line, traps, spear fishing, nets, etc.) are possible monitoring gear as well as possible camera devices. Life history information to determine age, size, growth, reproduction (size of maturity, fecundity, spawning behavior, stock identification) is needed. The group encouraged the use of already existing research funding opportunities including CRP, MARFIN, and Dingell Johnson (Johnson) programs for the collection of such critically needed data. The group emphasized the need to coordinate life history studies between key agencies to collect and assemble time series of information on life history attributes including age, growth, and maturation. In addition, individuals conducting basic life history studies are encouraged to collaborate with other external groups including NMFS, SEFSC Panama City and Beaufort Laboratories, with existing protocols and methods for similar species.

The group encouraged reference to supporting efforts by SEAMAP-C committee and also the other ongoing fishery independent sampling initiatives. The group noted that the SEDAR14 DW discussed a recent proposal submitted to the SEAMAP-C committee, the objective which was to evaluate the current reef fish sampling methods and protocols of the SEAMAP-C and to develop pilot studies for enhancing the spatial and temporal coverage of the study. The group noted that the SEMAP-C committee has recently submitted a letter of support regarding that study (SEDAR14 AW RW-49). Research efforts such as these are encouraged.

A research need exists for evaluating impacts from management measures. In particular monitoring of closed areas should be conducted through carefully conducted scientific experiments in such no take areas. Researchers are encouraged to collaborate with fishers in the areas to utilize their knowledge in planning these experiments and to seek funding through such initiatives as NOAA, CRP process.

SEDAR14 AW Table 1. Annual distribution of commercial landings (N=number of sales tickets) of mutton snapper**,** *Lutjanus analis,* in Puerto Rico by major gear category from 1983-2005. 2005 Preliminary data. Data available beginning in 1983.
Table taken from Table 3c. SEDAR14 DW-07. No spatial exclusions performed.

	Gear Category																	
	Cast Net		Dive, Spear, Scuba		Net		Other		Pot		Rod and Reel		Seine		Verticcal Line		All Gears	
	pounds		pounds		pounds		pounds		pounds		pounds		pounds		pounds		pounds	
	N	RowPc-tN	N	RowPc-tN	N	RowPc-tN	N	RowPc-tN	N	RowPc-tN	N	RowPc-tN	N	RowPc-tN	N	RowPc-tN	N	RowPc-tN
cyear																		
1983	3	0	84	4	109	6	.	.	1086	56	534	27	108	6	28	1	1952	100
1984	2	0	29	2	92	7	.	.	760	54	395	28	106	8	14	1	1398	100
1985	.	.	42	3	197	15	.	.	606	45	446	33	44	3	19	1	1354	100
1986	4	0	124	10	268	21	.	.	449	35	359	28	61	5	11	1	1276	100
1987	9	1	72	6	186	16	.	.	374	32	402	34	98	8	26	2	1167	100
1988	2	0	118	10	163	14	2	0	333	29	466	40	30	3	41	4	1155	100
1989	6	0	166	12	183	13	2	0	425	30	587	41	42	3	27	2	1438	100
1990	1	0	202	15	145	11	.	.	418	31	535	40	13	1	18	1	1332	100
1991	9	0	233	11	280	13	.	.	641	30	907	42	33	2	36	2	2139	100
1992	1	0	120	8	163	11	.	.	480	32	643	43	50	3	38	3	1495	100
1993	10	1	201	12	152	9	.	.	466	29	732	45	54	3	19	1	1634	100
1994	21	1	130	8	200	12	.	.	502	30	699	42	34	2	66	4	1652	100
1995	32	1	176	6	285	10	.	.	879	30	1379	47	89	3	92	3	2932	100
1996	14	0	235	6	631	17	.	.	1119	30	1438	39	84	2	173	5	3694	100
1997	44	1	251	7	710	18	.	.	1270	33	1366	36	66	2	134	3	3841	100
1998	12	0	310	9	509	14	.	.	1121	31	1453	41	28	1	144	4	3577	100
1999	6	0	301	8	631	16	.	.	1278	32	1567	40	22	1	138	3	3943	100
2000	9	0	327	8	683	17	.	.	1320	32	1609	39	18	0	135	3	4101	100
2001	10	0	343	8	711	17	.	.	1294	30	1739	41	44	1	120	3	4261	100
2002	4	0	397	9	753	17	.	.	1376	31	1757	39	60	1	154	3	4501	100
2003	.	.	386	9	673	15	.	.	1657	37	1516	34	61	1	129	3	4422	100
2004	.	.	689	20	410	12	.	.	1217	35	991	29	40	1	84	2	3431	100
2005	.	.	536	21	234	9	.	.	801	31	906	35	12	0	73	3	2562	100
All	199	0	5472	9	8368	14	4	0	19872	34	22426	38	1197	2	1719	3	59257	100

[1]Prior to 1987 mutton snapper was classified in the Puerto Rico commercial landings as “first class fish” (Matos-Caraballo, 2004).
. = No Reported Sales this cell. N= number observations, RowPctN= percentage of observations within a year.

SEDAR14 AW Table 2. Nominal unadjusted catch per unit of effort (CPUE) for mutton snapper commercial catches in Puerto Rico, 1983-2005, by gear and year for fisher sales where the 'ntrips' variable was coded as ntrips=1 trip. Nominal CPUE calculated as pounds per landed trip. Table reprinted from Table 12a SEDAR14 DW-07. Nominal CPUE is based on excluding trips where 'NTrips variable >1.

	Cast Net		Dive, Spear, Scuba		Net		Pot		Rod and Reel		Seine		Verticcal Line		All Gears	
	cpue		cpue		cpue		cpue		cpue		cpue		cpue		cpue	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean		
1983	*	10	41	26.4	19	14.7	306	13.1	210	15.2	18	11.8	12	9.4	607	14.7
1984	*	60	3	11.7	6	89.7	85	44.8	18	63.3	7	152	*	179	122	57.4
1985	.	.	3	8.3	36	19.1	69	16.6	68	17.7	4	23.3	*	35	182	17.7
1986	*	10	*	7	10	38.7	10	19.2	12	22.1	*	6	.	.	35	24.8
1987	.	.	*	12	*	72	8	11.5	9	13.2	*	30	.	.	20	16.3
1988	*	7.5	97	17.7	135	21.1	237	13.9	366	19.5	28	23.1	36	22.4	903	18.3
1989	4	73	138	23.1	120	15.4	303	18.9	376	21.2	25	30.6	19	21	986	20.4
1990	*	15	147	13.5	78	17	125	17.1	267	15.4	*	85	3	9.7	623	15.7
1991	4	34	149	11.7	156	13.9	215	16.6	399	17.3	3	15.7	26	12.4	952	15.6
1992	*	9	64	16.1	107	13.4	130	12.4	275	19.1	9	29.7	21	17.4	607	16.4
1993	3	11.7	93	12.1	83	10	132	13.7	297	15.2	50	35.5	18	7.1	676	15.1
1994	11	76.6	81	14.3	122	19.6	229	13.4	421	27	26	76.8	23	19.7	913	23.3
1995	26	23.3	109	12.2	163	17.9	488	11.6	798	27.5	59	18.6	39	13.3	1682	20.3
1996	4	18	149	10.1	260	16.9	431	12.1	807	26.2	38	18.7	45	13.1	1734	19.4
1997	26	21.8	171	12.1	281	13.7	323	12	778	29.5	12	30.3	10	23.3	1601	21.2
1998	5	16	130	14.1	160	18	413	12.1	649	23.4	8	39.2	66	6.9	1431	18
1999	*	30	197	12	366	16.7	736	13.6	833	23.7	5	70	61	9.6	2199	17.8
2000	4	9.6	246	16.5	380	18.1	758	15.1	940	18.9	10	28.4	85	12.9	2423	17.2
2001	10	21.6	290	15	488	17.9	781	12.6	1238	22.8	30	73.7	66	9.9	2903	18.7
2002	*	18.6	279	21.2	513	15.2	861	12.5	1202	17.9	52	56	107	9.9	3016	16.6
2003	.	.	385	10.7	661	11.2	1641	11.7	1484	29.2	61	40.3	129	12.6	4361	17.9
2004	.	.	689	8.8	410	12.8	1214	11.4	990	19.3	39	33.1	84	16.5	3426	13.7
2005	.	.	536	9.4	234	10.4	801	11	903	17.7	12	19.3	73	13.1	2559	13.1
All	107	28.7	3999	12.9	4789	15.3	10296	13	13340	22.5	500	38.6	927	13.2	33961	17.5

[1]Prior to 1987 mutton snapper was classified in the Puerto Rico commercial landings as "first class fish" (Matos-Caraballo, 2004).
.- No reported sales this cell. There were 3 positive landings observations from gear=unknown that were excluded.

SEDAR14 AW Table 3. Number of mutton snapper with accepted length measurements from Puerto Rico by gear. Reprinted from SEDAR14 DW Catch Report Table 13.

	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

SEDAR14 AW Table 4. Mutton snapper sampling fractions from Puerto Rico. Reprinted from SEDAR14 DW Catch Report Table 15.

	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					
Range %	0.1 - 2.3	0.0-2.9	0.0-3.6	0.1-9.8	0.0-3.6
Average %	0.59	0.36	0.97	4.13	0.60

SEDAR14 AW Table 5. Number of mutton snapper with accepted length measurements from St. Thomas / St. John by gear. Reprinted from SEDAR14 DW Catch Report Table 16.

	mutton snapper		
	traps	**other**	**total**
1983	-	-	-
1984	38	2	40
1985	87	17	104
1986	13	-	13
1987	7	-	7
1988	-	-	-
1989	-	-	-
1990	-	-	-
1991	6	-	6
1992	2	-	2
1993	4	-	4
1994	4	-	4
1995	-	2	2
1996	-	-	-
1997	-	-	-
1998	-	-	-
1999	-	-	-
2000	-	-	-
2001	-	-	-
2002	13	5	18
2003	3	-	3
2004	2	-	2
2005	39	-	39
2006	22	-	22

SEDAR14 AW Table 6. Number of mutton snapper grouper with accepted length measurements from St. Croix by gear. Reprinted from SEDAR14 DW Catch Report Table 17.

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

SEDAR14 AW Table 7. Standardized CPUE indices for the Puerto Rico Mutton Snapper Commercial Line fishery, 1989-2005. Year = Calendar Year, STDCPUE=Index, LCI and UCI are 0.95 Upper and Lower Confidence Intervals. Obcpue=Nominal log(CPUE), obppos=proportion of positives log(CPUE), Cv_i=CV(Index).

YEAR	StdErr	obcpue	obppos	nobs	cv_i	MEANINDEX	STDCPUE	LCI	UCI	estcpue	obscpue
1989	0.292628	1.714655	0.077873	3968	0.188838	1.773522	0.873755	0.600899	1.270509	1.549624	0.73912
1990	0.377138	1.767548	0.115385	2080	0.215449	1.773522	0.987007	0.644619	1.511256	1.75048	0.76192
1991	0.282804	1.831079	0.106236	3031	0.207242	1.773522	0.769434	0.510567	1.159552	1.364609	0.789305
1992	0.330374	1.553954	0.078642	2238	0.217456	1.773522	0.856639	0.557308	1.316742	1.519269	0.669848
1993	0.220312	1.017553	0.06167	3616	0.205163	1.773522	0.605483	0.403397	0.908805	1.073837	0.438627
1994	0.262045	2.38644	0.075202	4202	0.190618	1.773522	0.775134	0.531231	1.13102	1.374717	1.028699
1995	0.268009	2.468328	0.080045	7146	0.157635	1.773522	0.958651	0.700777	1.311418	1.700189	1.063998
1996	0.255867	2.41838	0.085992	7617	0.154661	1.773522	0.932816	0.685886	1.268645	1.65437	1.042468
1997	0.229098	2.402755	0.079456	7652	0.158894	1.773522	0.812976	0.59282	1.114889	1.44183	1.035732
1998	0.315793	2.59266	0.108292	5282	0.156429	1.773522	1.138282	0.834061	1.553466	2.018768	1.117593
1999	0.382245	3.197473	0.121942	5232	0.150392	1.773522	1.433115	1.062631	1.932769	2.541662	1.378304
2000	0.290912	2.287454	0.113383	7188	0.145433	1.773522	1.127877	0.844502	1.506341	2.000315	0.986031
2001	0.284187	2.791383	0.117675	8379	0.143431	1.773522	1.11718	0.839796	1.486183	1.981343	1.203255
2002	0.2903	2.576073	0.138847	7303	0.139527	1.773522	1.173149	0.888681	1.548677	2.080606	1.110443
2003	0.365874	4.277426	0.141862	8896	0.135173	1.773522	1.526175	1.166072	1.997484	2.706705	1.843829
2004	0.296472	2.343065	0.114152	7490	0.146974	1.773522	1.137381	0.849039	1.523648	2.017171	1.010003
2005	0.21456	1.811411	0.099516	7235	0.156114	1.773522	0.774944	0.568181	1.056949	1.37438	0.780827

SEDAR14 AW Table 8. Standardized CPUE indices for the Puerto Rico Mutton Snapper Commercial Pot fishery, 1990-2005. Year =Calendar Year, STDCPUE=Index, LCI and UCI are 0.95 Upper and Lower Confidence Intervals. Obcpue=Nominal log(CPUE), obppos=proportion of positives log(CPUE), Cv_i=CV(Index)

YEAR	StdErr	obcpue	obppos	nobs	cv_i	MEANINDEX	STDCPUE	LCI	UCI	estcpue	obscpue
1990	0.125186	0.650032	0.038313	3106	0.322323	1.031664	0.376467	0.200748	0.705999	0.388388	0.49338
1991	0.162922	0.964225	0.056442	3508	0.270954	1.031664	0.582835	0.342258	0.992517	0.60129	0.731855
1992	0.202722	0.8682	0.070602	1728	0.290394	1.031664	0.676667	0.383027	1.19542	0.698093	0.658972
1993	0.132162	0.617265	0.044142	2424	0.304648	1.031664	0.420502	0.231741	0.763016	0.433817	0.468509
1994	0.170779	0.788712	0.055948	3539	0.255858	1.031664	0.646989	0.390998	1.070579	0.667475	0.598639
1995	0.135566	0.903051	0.076181	5802	0.23001	1.031664	0.571303	0.362787	0.899666	0.589393	0.685423
1996	0.141726	0.895432	0.072647	5451	0.233232	1.031664	0.58901	0.37172	0.933315	0.60766	0.679641
1997	0.106332	0.660293	0.055086	5319	0.251449	1.031664	0.409898	0.249809	0.672578	0.422877	0.501168
1998	0.161944	0.93067	0.080611	4255	0.234569	1.031664	0.669198	0.421243	1.063106	0.690388	0.706387
1999	0.304025	1.695057	0.124463	5351	0.213734	1.031664	1.378786	0.903481	2.10414	1.422444	1.286563
2000	0.303261	2.208763	0.141431	4907	0.205922	1.031664	1.427498	0.949659	2.14577	1.472699	1.67647
2001	0.235089	1.499756	0.118145	6145	0.198333	1.031664	1.148944	0.775689	1.701806	1.185325	1.138328
2002	0.303509	1.677623	0.134262	6100	0.187594	1.031664	1.568241	1.081128	2.274827	1.617898	1.273331
2003	0.387158	2.619283	0.211946	6931	0.169789	1.031664	2.210244	1.577648	3.096496	2.28023	1.988059
2004	0.351781	2.278151	0.200209	5744	0.187866	1.031664	1.815037	1.250605	2.634213	1.872509	1.729137
2005	0.306549	1.823613	0.162856	4636	0.196993	1.031664	1.508381	1.021013	2.228389	1.556143	1.384138

SEDAR14 AW Table 9. Fit Diagnostics from the mean length mortality based estimator model evaluations to the Puerto Rico trap fishery length data.

Mean Lengths computed by:	Weighted (n) Likelihood	Estimated First Mortality Rate (Z_{ONE})	Estimated Second Mortality Rate (Z_{TWO})	Estimated Year of Change
Year	**No**	**0.458**	**0.832**	**1992.42**
Year	**Yes**	**0.478**	**0.647**	**1991.80**
Month	**No**	**0.435**	**0.801**	**1987.81**
Month	**Yes**	**0.478**	**0.645**	**1992.24**
Interview Day	**No**	**0.391**	**0.810**	**1988.36**
Interview Day	**Yes**	**0.478**	**0.645**	**1992.23**

SEDAR14 AW Table 10. Shows estimates of total mutton snapper abundance (number of individuals) by life stage for three US Caribbean Islands. Reprinted from SEDAR14 AW02 Table 4 and added column identifying #individuals observed in survey.

Size of study Island area (ha)	% of study area sampled	# of surveys	# mutton observed	Life stage	Estimated abundance	Range of estimate
Puerto Rico 157,285	< 0.1	1013	3	Juvenile	18,865	4,979 -32,750
			0	Adult	-	---
			3	**Total**	**18,865**	**4,979 -32,750**
St. Croix 32,014	0.1	1275	49	Juvenile	78,592	30,860 -126,325
			13	Adult	28,085	10,618 -10,618
			49	**Total**	**106,678**	**41,478 -136,943**
St. John 4,684	0.2	845	18	Juvenile	8,896	2,146 -15,645
			20	Adult	7,447	1,553 -13,340
			38	**Total**	**16,342**	**3,698 -28,986**

Table 11. Current Management Criteria. Values in Table 2 are for Snapper Unit 3 (Mutton Snapper, 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.	1,682,000 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})].	542,000 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} = $0.75F_{MSY}$.	508,000 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 Specified)		(Not Specified)

SEDAR14 AW Table 12. SEDAR14 Assessment Workshop: Data and Analytical Status overview. PR=Puerto Rico, STT= St. Thomas, STX=St. Croix. Conch=Conch (Stromgbias gigas*)* YFG=Yellwowfin Grouper (*Mycterperca venenosa*), MTS=Mutton Snapper (*Lutjanus analis*).

	MTS		
Attribute	PR	STT	STX
Commercial Landings	Fair, 1983+ adj. conc improving	No Species information	No Species information
Commercial Lengths	Fair, some gears, 1983+, improving. Need to increase sampling fraction, need to insure representative sampling	very un- comnon 200 fish sampled in 20 years , Need to increase sampling fraction, need to insure representative sampling	fair 1983-1988, then none; Need to increase sampling fraction, need to insure representative sampling
Commercial Discard	No info	No info	No Info
Recreational Landings	MRFSS 2000-05 numbers, weight smples poor	No info	no Info
Recreational Landings	CHK	No Info	no Info
Recreational Discards	CHK	No Info	no Info
AGE Observations	None	None	None
Independent Indices	Possibility NOS Habitat CMP lowN	NOS Habitat	NOS habitat
Dependent Indices	Com CPUE 1989+	No Info	No Info
Life History	No ages here maybe other areas		
Stock ID	UNK	UNK	UNK
To DO, AW	relative efforts		
Analytical Options	Length , Prod models-short time series, recreational yield not known		
Comments			
Recommendations			
Future Discussions:	Com vs. recreational catch compare CPUE reflect abundance? YPR using other area growth model, backcast recreational-but would introduce additional uncertainty to do prod mod?		

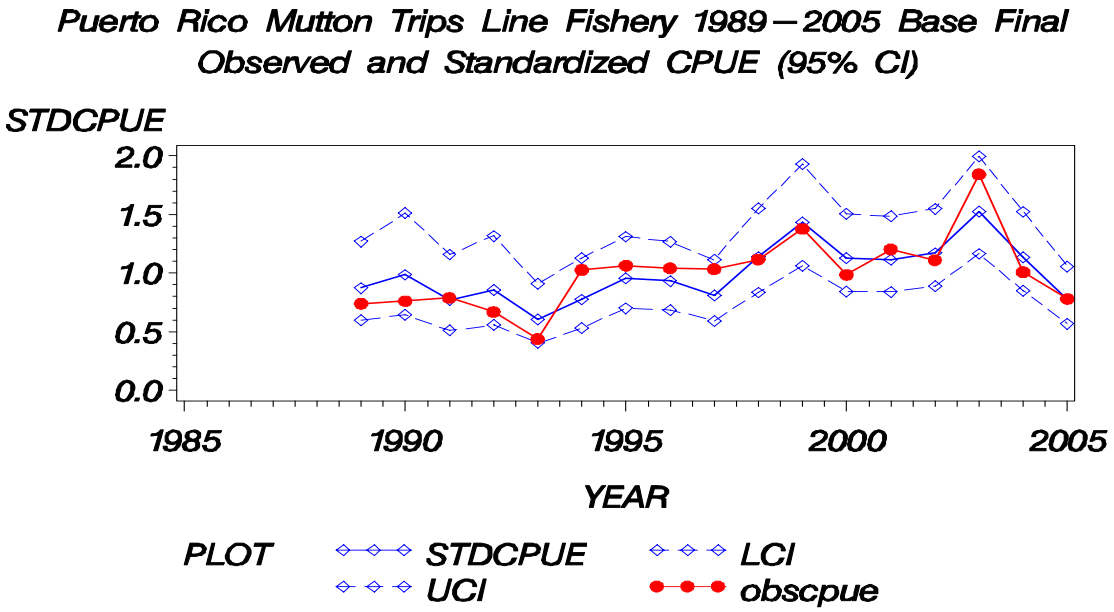


Figure 1. Standardized mutton snapper CPUE, 95% confidence interval and, nominal CPUE of mutton snapper from the Puerto Rico line fishery, 1989-2005. CPUE is measured in Lbs per trip

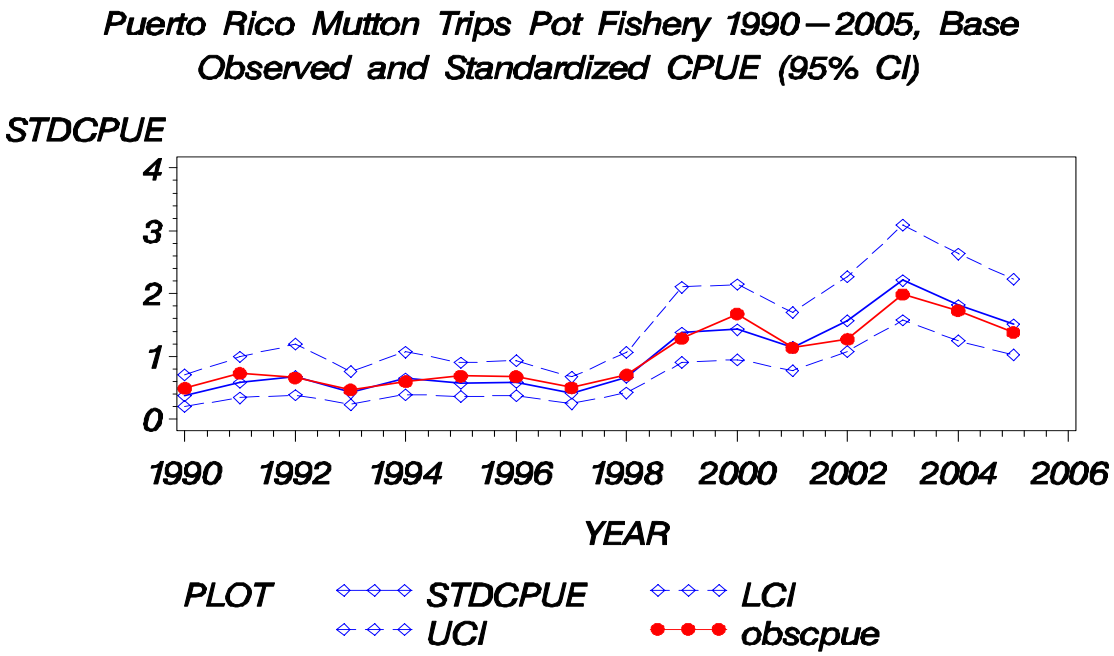


Figure 2. Standardized mutton snapper CPUE, 95% confidence interval, and nominal CPUE from the Puerto Rico commercial pot fishery, 1990-2005. CPUE is measured in Lbs per Trip.

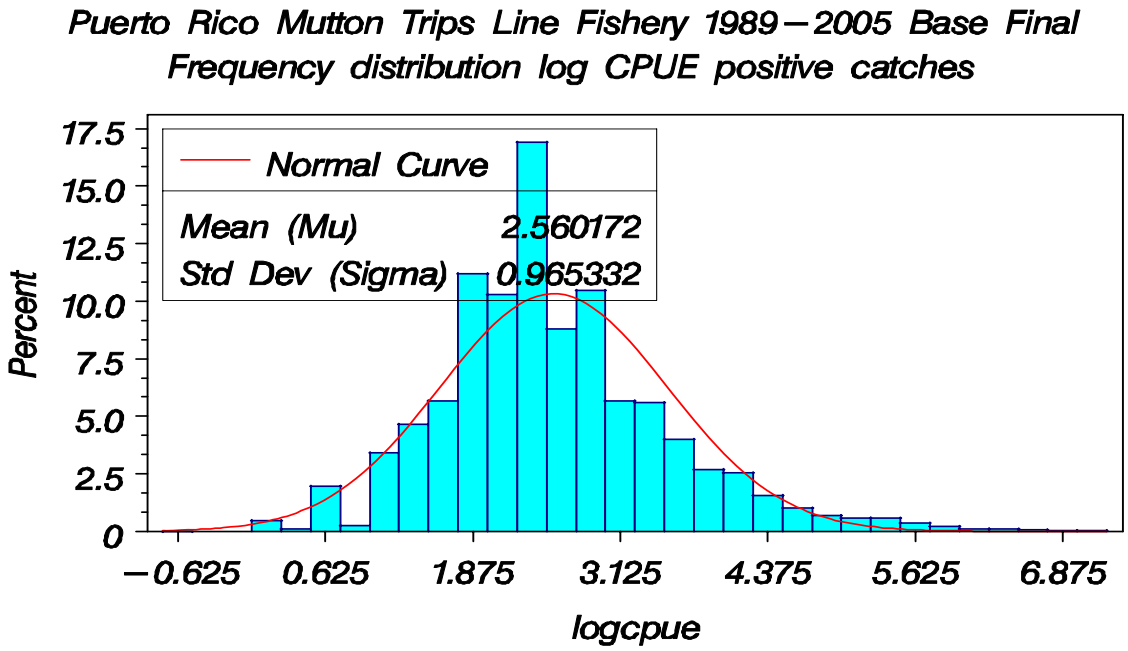


Figure 3. Frequency distribution of log(CPUE) of mutton snapper successful trips from the Puerto Rico commercial line fishery, 1989-2005. CPUE is measured in Lbs per Trip.

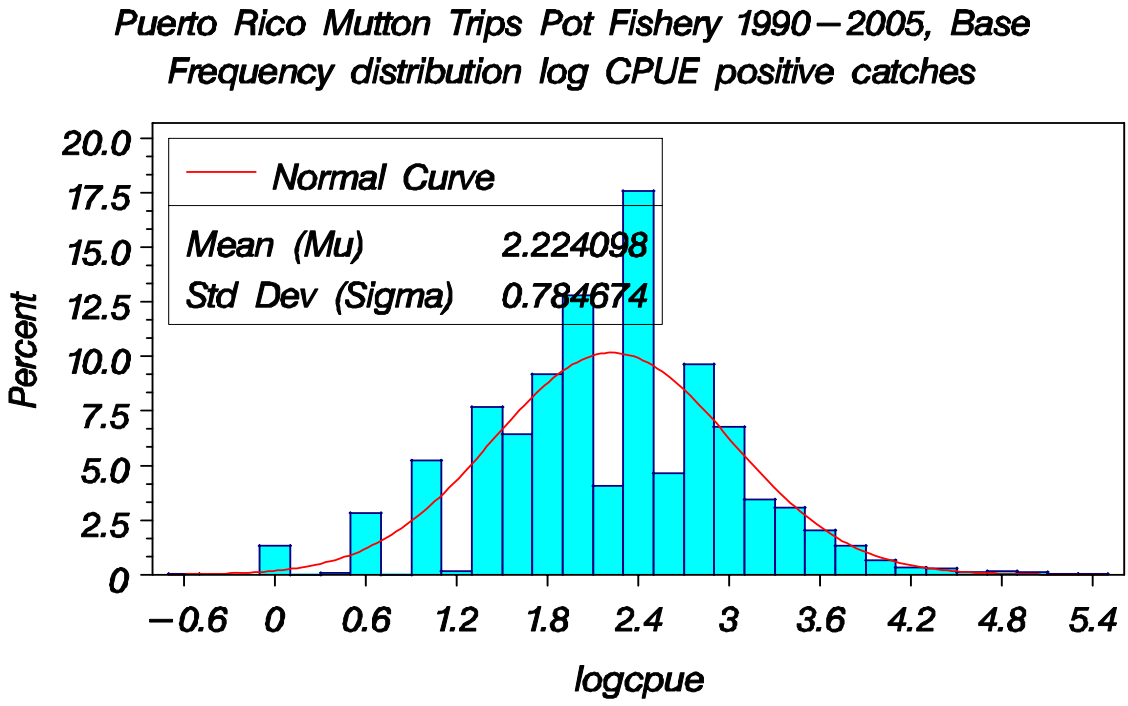


Figure 4. Frequency distribution of log(CPUE) of mutton snapper positive (successful) trips from the Puerto Rico commercial pot fishery, 1990-2005.

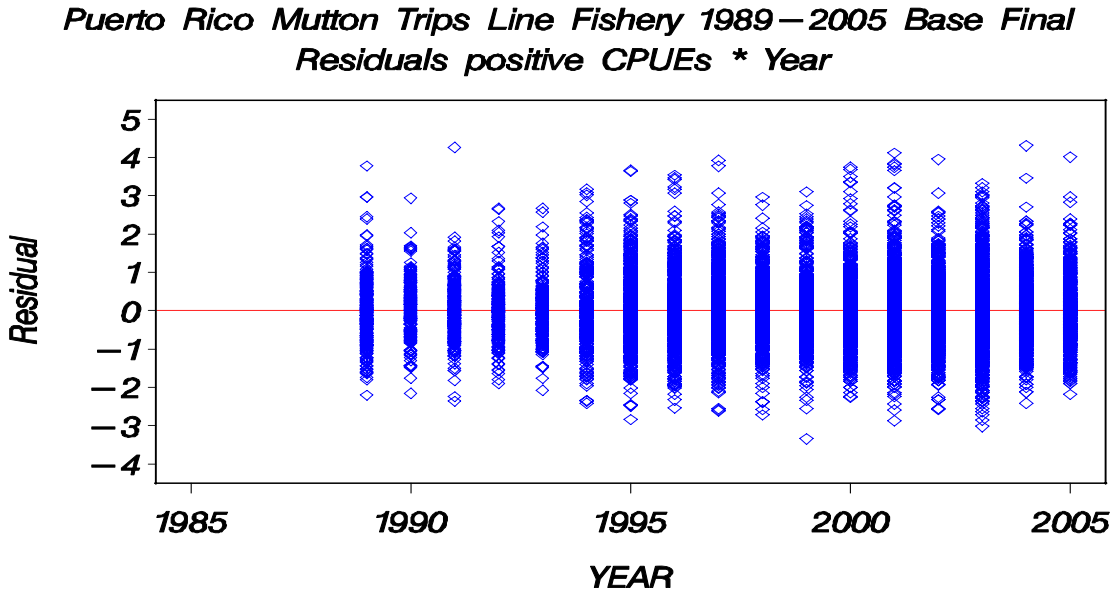


Figure 5. Residual distribution of the final delta lognormal model for the positive (successful) observations for mutton snapper from the Puerto Rico commercial line fishery, 1989-2005..

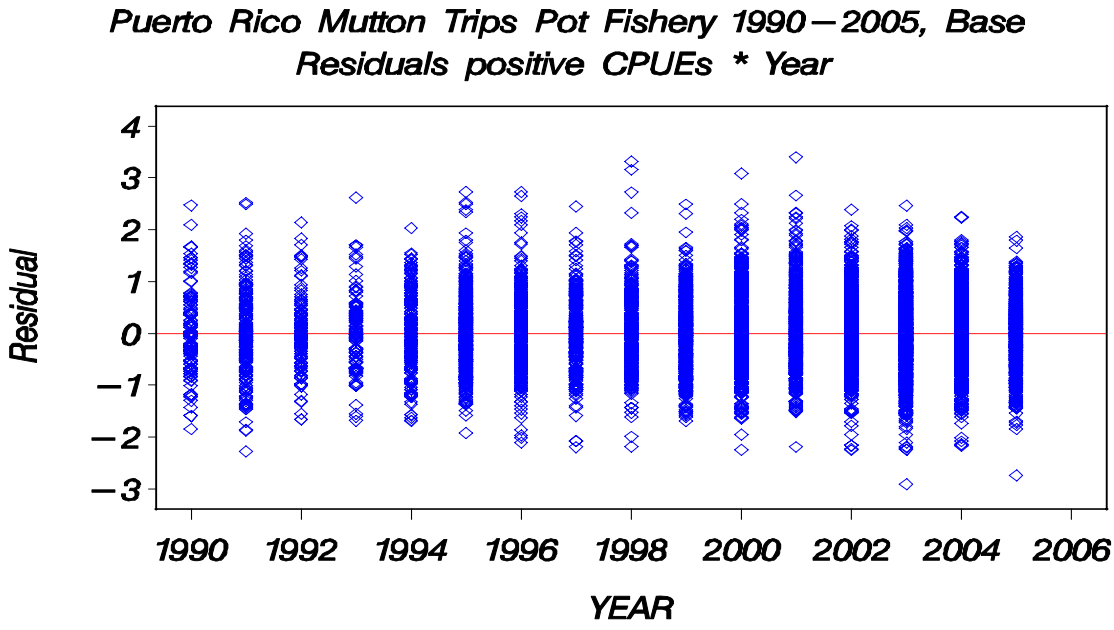


Figure 6. Residual distribution of the final delta lognormal model for the positive (successful) observations for mutton snapper from the Puerto Rico commercial line fishery, 1989-2005

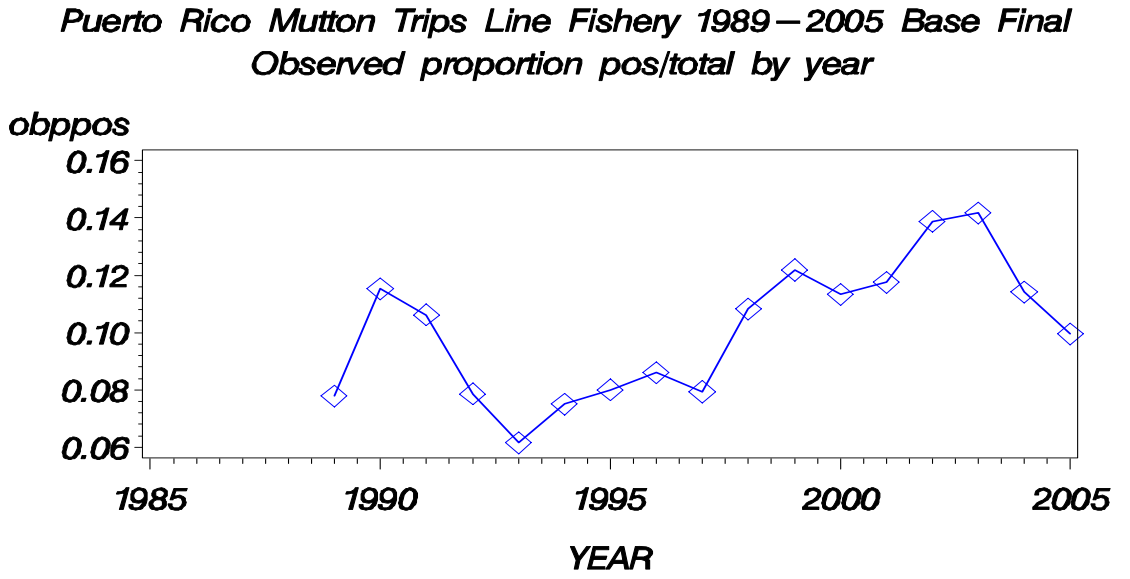


Figure 7. Observed average annual proportion of positive (successful) trips for mutton snapper from the commercial line fishery in Puerto Rico, 1989-2005

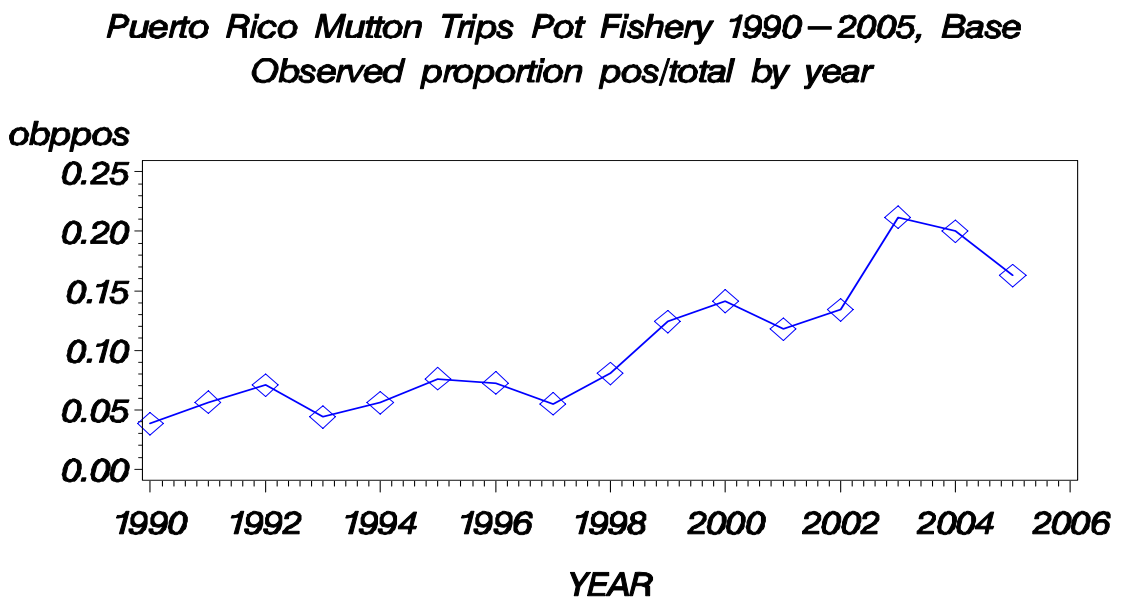


Figure 8. Observed average proportion of positive (successful) trips for mutton snapper from the Puerto Rico commercial pot fishery, 1990-2005.

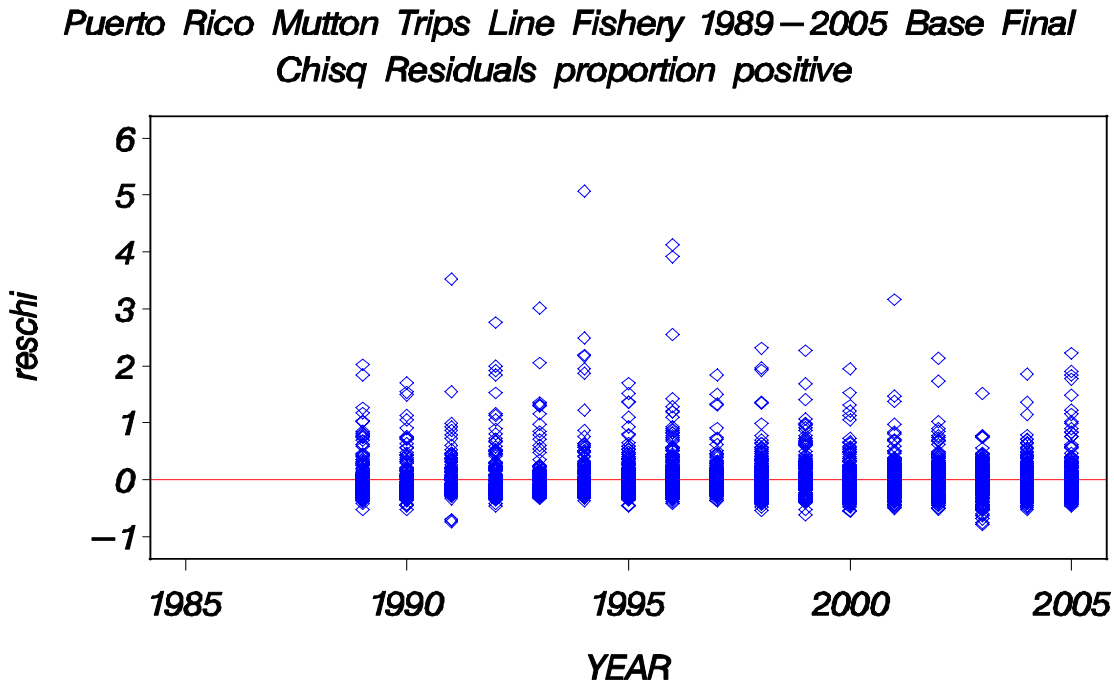


Figure 9. Residual distribution of proportion positives from the final delta lognormal model by year, for mutton snapper from the Puerto Rico line fishery, 1989-2005

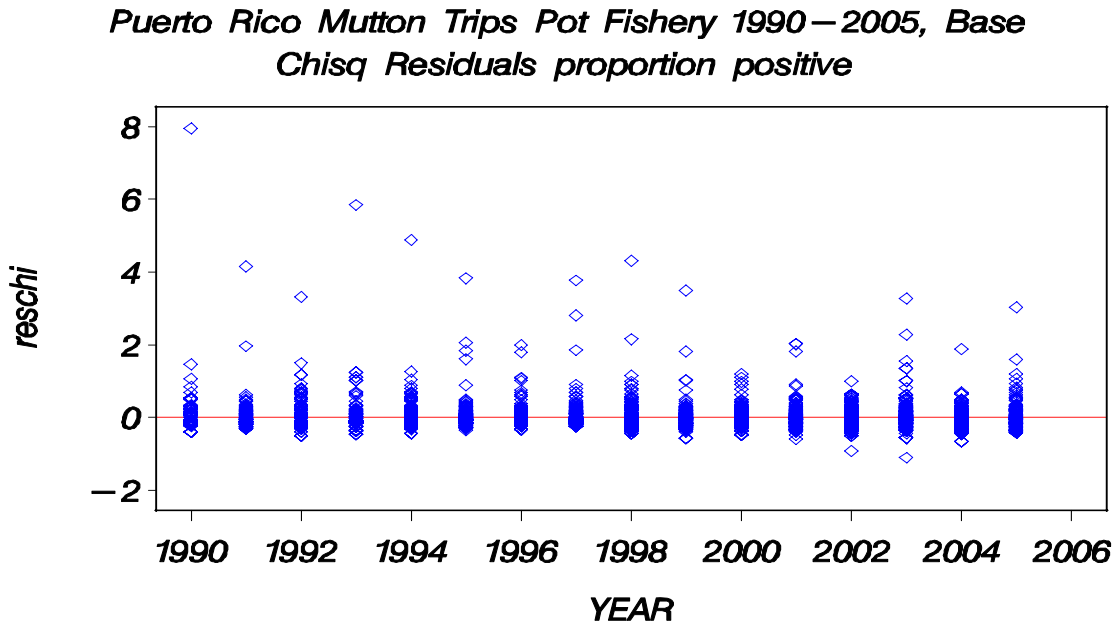


Figure 10. Residual distribution from the final delta lognormal model by year, of the proportion positives (successful) for mutton snapper from the Puerto Rico pot fishery, 1990-2005.

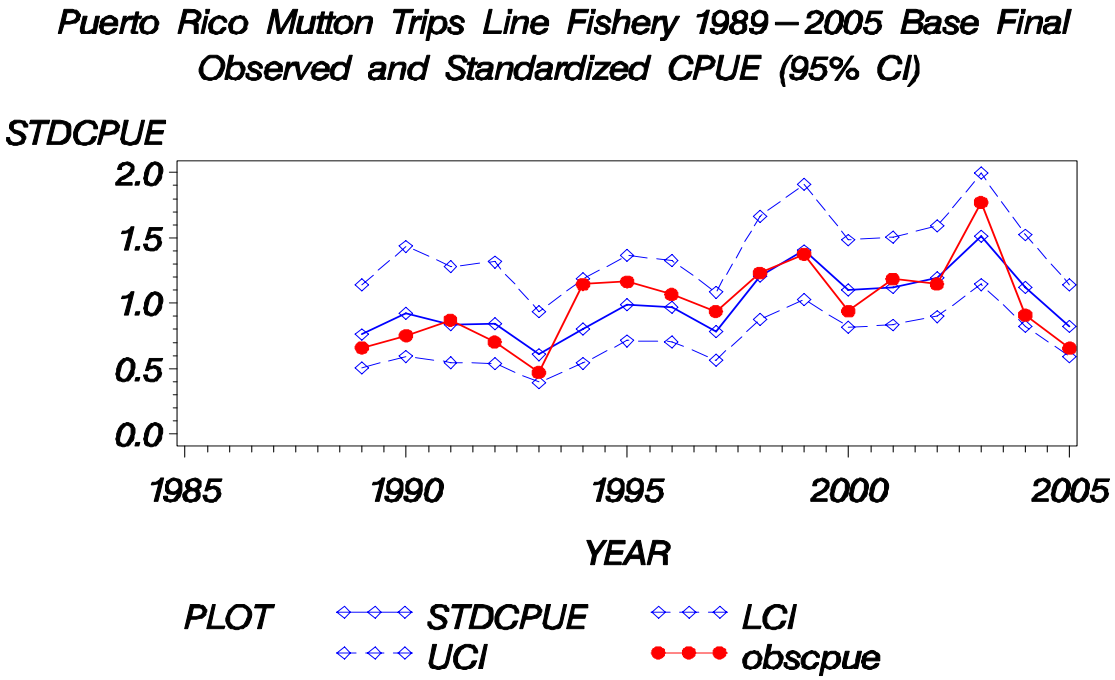
Figure 11. SEDAR14 AW sensitivity trial for hook and line fishery standardized CPUE of mutton snapper in Puerto Rico. Sensitivity trial data set excluded observations from the months of April and May 2004-2005 from the analysis.

Model Input: Same as Best Model from Line Fishery Base:

Positive log (CPUE)=Year + Municipality + Month + Year * Municipality

Proportion Positives = Year + Municipality + Month + Year*Municipality.

Deviance: 6456.3 AICC 23,280.3, Year term p=.0455, Month and Area effects p<0.0001
Over Dispersin =1.7 for binomial model and 0.72 for lognormal



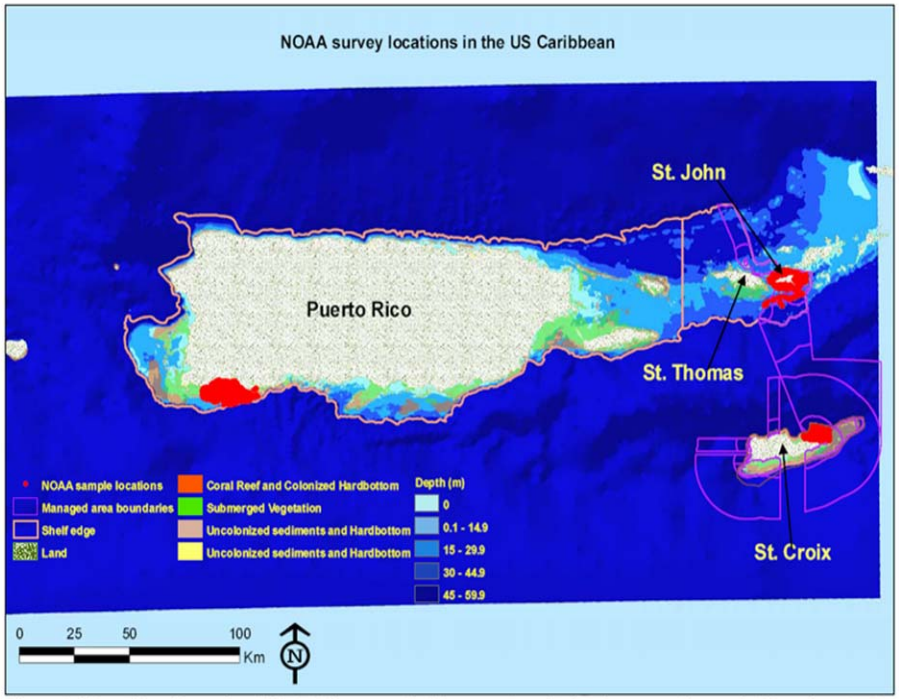


Figure 1. Map of locations where NOAA Biogeography Team conducted visual censuses for conch (*Strombus gigas*) and mutton snapper (*Lutjanus analis*) between 2001 and 2006.

Figure 12. Mutton snapper habitat model study area. Reprinted from SEDAR14 AW02, Figure 1.

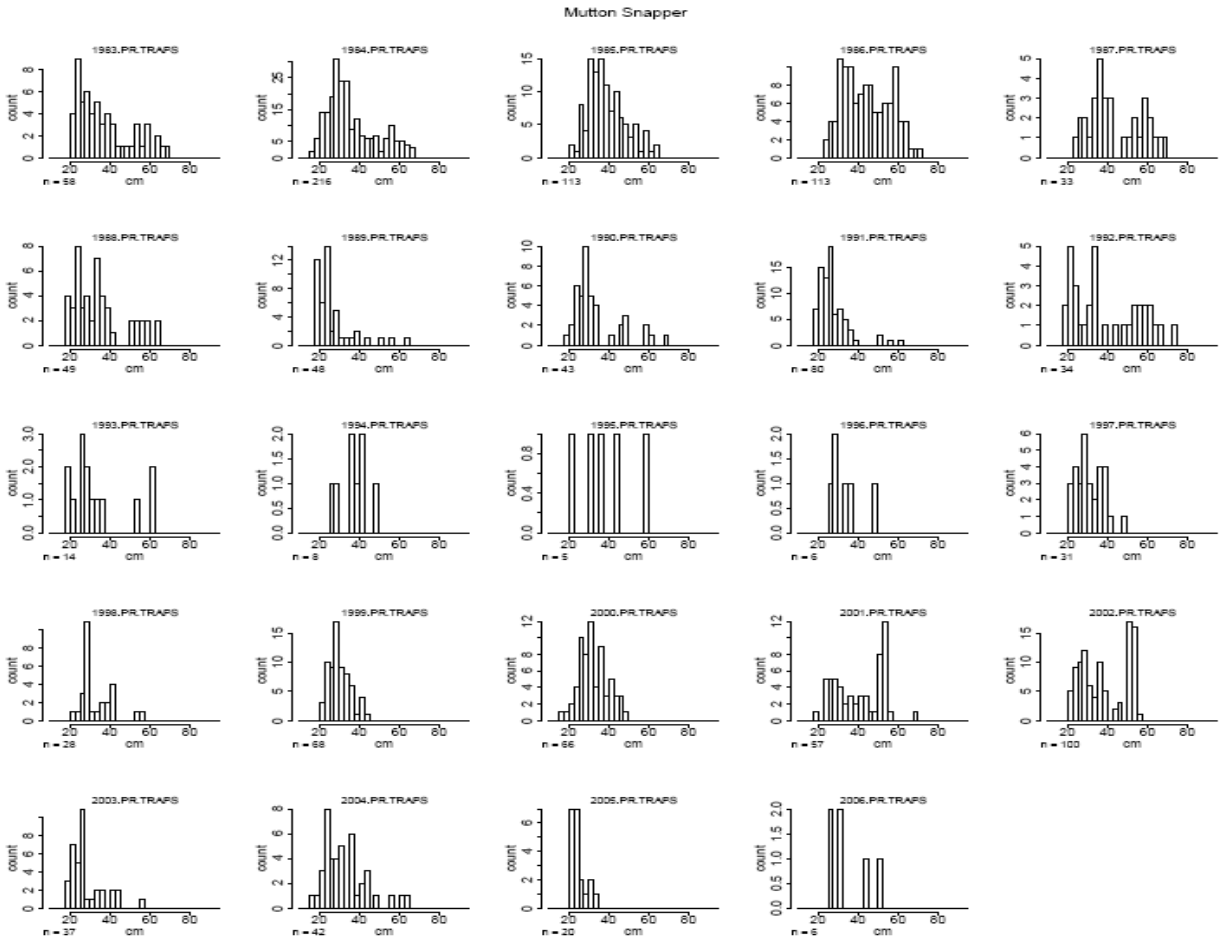


Figure 13. Number of mutton snapper at length (cm) from Puerto Rican landings by trap fisheries from 1983 through 2006. Note that the vertical axes vary in scale.

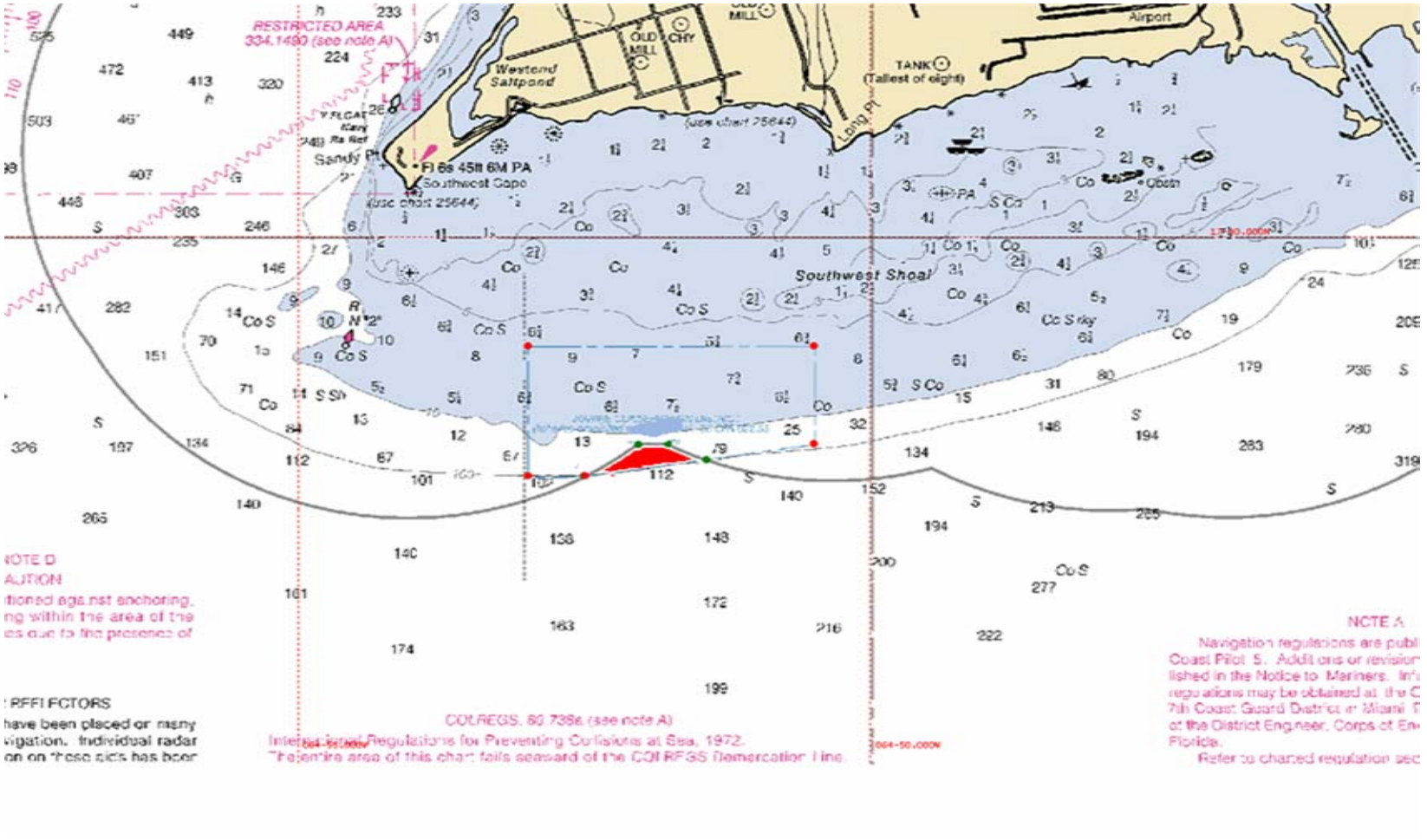


Figure 14. Mutton snapper seasonal closure location off St. Croix. Figure provided by Graciela Garcia-Moliner CFMC.

SEDAR 14

Stock Assessment Report 2

Caribbean Mutton Snapper

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 CIE. The workshop was also attended by five US technical experts, the SEDAR facilitator, one representative from CFMC, one representative from Puerto Rico DNR, two representatives from UPR and one representative from NMFS HQ. All documentation, including background documentation provided to earlier Data and Assessment Workshops, was provided to the Panel in good time for prior review, and was comprehensive for the job in hand.

The data on the Puerto Rican stock of mutton snapper are not sufficient to identify stock status relative to any possible reference points for exploitation and are sufficient only for indicating trends in abundance and mortality. No suitable data were available from the US Virgin Islands for inclusion in the assessment of the Puerto Rican shelf stock. Data on mutton snapper are available primarily from commercial fishery landings, CPUE and length frequency sampling although individual data series have deficiencies making interpretation of trends difficult. Data on recreational catches are also very deficient although this is an important source of mortality. The trap and line CPUE indicate an increase in abundance in the last decade, whilst changes in mean length in the trap and line fisheries indicate an increase in mortality around 1990 and a possible decline around the late 1990s. Fishing effort data are very uncertain due to incomplete reporting, but an apparent decline in the 2000s may support indications of reducing mortality in this period. However it is not possible to confidently assess the magnitude of any trends in abundance or mortality due to data deficiencies and poor knowledge of changes in fishing practices or other processes that may be affecting the data. A commitment to long-term research and data collection to address the deficiencies in data and knowledge is essential for effective management supported by robust assessments. The Review Panel strongly endorses the need to develop partnerships with local fishermen to conduct research and to collect needed data, as well as development of appropriately designed fishery-independent surveys. Mutton snapper are harvested as part of a diverse community of reef and coastal fish, and it is unlikely that such species could be successfully managed independently of co-occurring species. The Review Panel recommends a mixed fishery approach involving the development of indicators of fishery impacts on coastal and reef fish communities with associated benchmarks, together with single-species assessments for indicator species with data that are likely to be adequate for providing reliable assessments and benchmarks. The Review Panel recommends that a workshop to develop such an approach is convened within the next 12-18 months.

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. Survey., 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 non-equilibrium 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 on the Puerto Rican stock of mutton snapper were collected using appropriate methods, but are not sufficient to identify stock status relative to any possible reference points for exploitation and are sufficient only for indicating trends in abundance and mortality. No suitable data were available from the US Virgin Islands for inclusion in the assessment of the Puerto Rican shelf stock.

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

The methods used to estimate trends in relative abundance and fishing mortality were compatible with the limited type of data available, and in principle should be capable of detecting temporal trends if used with adequate data and understanding of the factors causing trends in the data. The methods were applied correctly.

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

It is not possible to recommend appropriate estimates of stock abundance, biomass, and exploitation, and information is only available on indicative trends as described in Section 2.3.

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 Allowable Biological Catch (ABC), and declarations of stock status.

The data were not adequate for providing estimates of population benchmarks and management parameters.

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).

No population projections were possible.

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.

The General Linear Model (GLM) method used to estimate trends in abundance from Catch Per Unit Effort (CPUE data) appropriately characterized the precision of model estimates, but it was not possible to evaluate potential biases due to changes in fishing practices and technology. Similarly, the length-based method for estimating changes in total mortality provided model-based estimates of variance, but the potential for bias due to changes in recruitment, fishing practices and fishing gear design could not be evaluated.

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 results were clearly and accurately presented in the AW final report and in supporting documents provided to the Review Panel (RP). The reported results, and the results of sensitivity analyses requested by the RP, are consistent with the RP 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.

The Data Workshop (DW) and Assessment Workshop (AW) addressed each of their Terms of Reference, as far as was possible given the availability and quality of data, and a wide range of useful data on mutton snapper were provided. Interpretation of trends in fishery data was however hampered by the absence of a sufficiently detailed description of changes in fishing operations, fishing gear, and fishing effort and how these may influence catchability and size composition of mutton snapper over time. Maps of reported fishing effort (where available) and landings by gear would have been useful to help characterize the spatial patterns in the fishery.

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.

The RP recommends that the assessment and management of inshore and reef fish in the Caribbean should follow a multi-species, mixed fishery approach appropriate to the conditions of coastal tropical fisheries. It is therefore recommended that the scope and timing of the next AW is established following an intersessional workshop within the next 12 – 18 months to evaluate the information available to support such an approach. Specifically, the workshop should identify the relative abundance, potential vulnerability to exploitation and type and quality of data available for each species, potential indicator species for which it may be possible to provide reliable single-species assessments and benchmarks, and procedures and data-needs for deriving indicators and benchmarks at the fish community level.

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.)

2.2. Analyses and Evaluations

The RP requested a number of sensitivity analyses to clarify aspects of the mutton snapper assessments. These are given below together with a summary of the results. Detailed results are included with the relevant documents provided by the DW and AW.

An evaluation of the potential effect that the closure of three areas off western Puerto Rico in December-January, introduced during 1996 to protect red hind, may have had on mutton snapper CPUE and length structure.
Examination of mutton snapper landings by area indicated a roughly 10% reduction in the proportional contribution of the three areas to the annual landings from 1997 onwards compared to the years prior to 1997. However the statistical significance of this decline was not evaluated. The assessment scientists considered that there was unlikely to be a strong bias in the CPUE data caused by the closures. The three areas do not appear to have spawning aggregations of mutton snapper during the spawning season for mutton. Traps were excluded from the closures in 2005; and were displaced to areas between the closures.

Examine the sensitivity of the length-based mortality estimator to the use of data for the spawning season and the non-spawning season.
For the hook and line fishery, the length frequency distributions differed significantly between spawning and non-spawning periods and sample sizes were high enough to allow a separate analysis for each season. A combined analysis was not deemed necessary because results from both spawning and non spawning seasons provided almost identical estimates of the most recent total mortality and the estimated time of change. The overall results and interpretation of the pattern of mortality would not change significantly from a combined analysis.

Apply the length-based mortality estimator to hook-and-line length frequency data using a range of values for length at full selectivity (L_c) and also applying possible selection curves.
The AW had not pursued the method for the hook-an-line fishery due to difficulties in determining L_c. The analyses requested by the RP indicated trends in mean length (calculated for L_c values close to the largest modal length) that were similar to the temporal trends observed for the trap fisheries. This result provided corroborating evidence for changes in total mortality causing trends in mean length.

Collate data on fishing effort.
Data were collated on total numbers of trips for trap and line fishermen, amount of gear deployed per trip, mean hours fished per trip and numbers of registered fishermen. The main difficulties of interpretation are in the variable expansion factors, and the variable numbers of trips with "zero trips" recorded in the years prior to 2001. These records could comprise large numbers of trips, causing potentially substantial underestimation of effort. Data subsequent to 2001 may be more reliable, although the problem of expansion factors remains. An increase in numbers of traps per trip has been observed, but not sufficient to compensate for the apparent decline in number of trips since 2000. Commercial hook-and-line effort also appears to have declined in recent years. MRFSS data on recreational fishing effort also shows a decline since 2000 off Puerto Rico. Overall, there is some evidence for a decline in fishing effort in the 2000s that could possibly explain the recent increase in mean length of fully-selected mutton snapper in the trap and line fisheries which the length-based model interprets as a reduction in mortality since the late 1990s.

Investigate the possibility of mutton snapper being attracted into traps containing lobster, by examining trends in lobster and mutton snapper CPUE.
Nominal CPUE of lobsters in the trap fishery exhibits a small trend of increase since the late 1990s, whilst mutton snapper CPUE has shown a much larger increase. Hence there is no evidence that the mutton snapper trend is due to increasing catch rates of lobster leading to a greater probability of mutton snapper entering traps. An investigation at the trip or haul level would be needed to investigate this further. The CPUE of lobsters taken by divers has shown a slight decrease since the late 1990s, and the difference with trap CPUE trends could possibly indicate an effect of ignoring soak time and numbers of traps per trip in the calculation of trap effort. This may explain part of the increase in mutton snapper CPUE, but clearly there will be species-specific differences in the effect of soak time on catch rates.

2.3. Additional Comments

2.3.1. General comments on the assessments

1. The analysis of CPUE data indicate an increase in mutton snapper abundance off Puerto Rico in the last decade, whilst changes in mean length in the trap and line fisheries indicate an increase in mortality around 1990 and a possible decline around the late 1990s. The mortality trends are consistent with crude estimates of recent trends in trap, line and recreational fishing effort. The inclusion of trap CPUE in the model for this fishing gear does not change the perception of recent changes in mortality, although there is some

inconsistency in the changes indicated by the CPUE and length data. Although the analyses provide indicative trends in abundance and mortality, it is not possible to confidently assess the magnitude of the trends due to data deficiencies and poor knowledge of changes in fishing practices or other processes that may be affecting the data.

2. The ability to provide robust advice on the status of mutton snapper is undermined by data deficiencies including incomplete reporting of fishery catches and effort, absence of species-specific data in some areas, limited information on changes in fishing practices and gears and how these affect CPUE and size composition, low rates of sampling for length, absence of data from recreational fisheries, lack of adequate fishery-independent indices of abundance for recruits and older fish, and lack of data on biological parameters such as growth and maturity for the local stocks. 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 mutton snapper and associated species in the region.

3. 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 in the region. The RP's recommendations for future research are offered as improvements or additions to the current data collection, not as replacements.

4. The RP strongly endorses the need to continue to develop partnerships with local fishermen to conduct research and to collect needed data. Partnerships with the fishing community and other stakeholders are a cost-effective way to collect components of the data necessary for the assessment process, particularly in areas such as the Caribbean where existing data and research funding are limited. Partnerships facilitate ongoing cooperation and participation by fishermen in the management process, leading to a higher probability of successful management outcomes.

5. Mutton snapper are harvested as part of a diverse community of reef and coastal fish, and it is unlikely that such species could be successfully managed independently of co-occurring species. For example, mutton snapper represent only 2-4% of the fish landings in the Puerto Rican trap fishery that is a major source of CPUE data. Furthermore, in a data-poor situation, improvements in statistical power and interpretation of trends may be obtained by evaluating the effects of fishing on all stocks taken together in the mixed-species fisheries. The Review Panel therefore recommends a mixed fishery approach involving the development of indicators of fishery impacts on coastal and reef fish communities with associated benchmarks, together with single-species assessments for indicator species with data that are likely to be adequate for to providing reliable assessments and benchmarks. An analysis of longer term changes in species compositions and size compositions may provide information on broader ecosystem impacts of fishing on stocks of different vulnerability to over-fishing. Future ecosystem management will likely dictate such a course of action.

6. The data provided by the DW cover a relatively recent period and do not reflect earlier periods when much lower exploitation was occurring and the reef populations may have more closely approached the unexploited state. Attempts should be made to collate all available information on earlier states of the reef fish populations, even if qualitative, to try and counter the problems of inappropriate and shifting baselines.

2.3.2. Review Panel research recommendations:

The DW and AW reports provided a wide range of research recommendations related to biology, fishery data, fishery-independent data and assessment methods for mutton snapper. The recommendations were scattered throughout the reports, but without any prioritization according to short-term and longer-term needs or any indication of the extent to which the results could improve the assessment and management of the stocks. The RP recommends that future DW and AW reports provide a single section collating all recommendations, with priorities and expected contribution of the results clearly identified.

The following sections give the combined DW and AW recommendations for different research areas. In each case these are followed by RP evaluations and consolidated recommendations for data collection and research that is needed to address the deficiencies in data and understanding that are impeding the evaluation of stock status and development of appropriate management measures. In some cases similar recommendations appear in different guises in different parts of the DW and AW reports and the RP has taken the liberty of merging and rewording these as appropriate, and summarizing some of the other recommendations.

2.3.2.1. DW & AW Workshop recommendations on fishery-dependent data

- Biological sampling at USVI to characterize size and age composition.
- 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; resolve other problems with data through extensive meetings with port samplers and others familiar with US Caribbean fisheries.
- Targeted research efforts to determine relative abundance, CPUE, length and age structure of catch for all commercial and recreational gears;
- Collection of species landings data at resolution to allow CPUE data for each gear; need to identify each individual fisher, location/date of catch, and depth where possible.
- Estimate CPUE in terms of numbers and biomass; estimate effort as hook-hours and trap soak times;
- Where appropriate, collection of discards data and fate (dead or alive) of discards;
- Review of field methods and protocols for fishery data collection throughout Caribbean;
- Review catch sampling intensity protocols;
- Evaluate impacts of management measures, particularly closed areas

The RP considers the improvement in the accuracy and coverage of fishery data to be of very high priority for the fisheries of Puerto Rico and the U.S. Virgin Islands, and endorses the DW and AW recommendations. The RP makes the following consolidated recommendations:

i) Ensure accurate recording of data by species in all areas.
ii) Development of a random fishery sampling scheme, stratified by appropriate areas/gears/seasons, to provide valid statistical estimates of catches and size compositions by species, and fishing effort, with high spatial and temporal resolution.
iii) Continued improvement of log-book reporting schemes and improvements in methods for expanding reported landings to the total fishery, for example by stratifying by port.
iv) Evaluation of the representativeness of the reported fishery data, for example by interviewing fishermen who have submitted log sheets in recent years but did not before.
v) Identification of fishing effort units (e.g. soak time for traps; hook-hours) that are most likely to provide a linear relationship between CPUE and population abundance, and the capturing of historical TIP data on landing weight per trip for trips with soak time or other effort data
vi) Collection of covariates (e.g. depth) to help explain variability in CPUE data.
vii) Accurate documentation of changes over time in fishing effort, fishing gears and their deployment, species targeting and fish-location technology (e.g. GPS), to help interpret CPUE data and identify periods when catchability may have changed.
viii) The Panel agrees that standardized sampling protocols and systems for Quality Assurance / Quality Control of data are needed for data collection throughout the Caribbean.
ix) Involvement of fishers in data collection schemes, including investigating the potential for web-based systems for capturing fisher's data and other information.

2.3.2.2. DW & AW Workshop recommendations on the recreational fishery

- Conduct surveys to estimate magnitude of USVI recreational landings for all species (use a USVI contractor) (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 required.)
- MRFSS program should add additional survey attributes to draw out information on mutton snapper throughout US Caribbean; increase MRFSS intercepts to improve sample sizes.

The RP endorses recommendations to collect relevant data on recreational fishing. Data on recreational fishery catches of mutton snapper are limited to the recent period of the MRFSS survey (2000 onwards for Puerto Rico, 2000 only for USVI). Although the precision of estimates of fish catches is quite low (CV's = 30-50%), recreational fishing appears to be an important source of mortality (6,000 – 25,000 fish killed per year off Puerto Rico), and shore

fishermen appear to target mainly juvenile mutton snapper. Improvements in the coverage and intensity of the Puerto Rico sampling scheme and restarting the USVI scheme would contribute significantly to the accuracy of removals estimates from the stocks. Shore-angling catch rates may indicate recruitment trends. As with the commercial fishery, involvement of the angling community in data collection schemes would be beneficial, potentially making use of web-based systems.

2.3.2.3. DW & AW Workshop recommendations on fishery independent data

- Initiate surveys in deeper water, the preferred habitat of adult mutton snapper.
- Identify essential habitats according to life history stage, including critical recruitment and post-settlement (nursery) habitats.
- Monitor spawning aggregations for density (abundance indices), and collection of population parameters such as sex ratio and size of fish.
- Collection and documentation of historical information for qualitative and/or quantitative comparisons of current conditions; collation of historical indicators of spawner abundance
- Continue and enhance fishery independent programs including spawning aggregations and collection of data on size of individuals, depth, time of day, habitat; use of visual counts or directed gear sampling;

The RP encourages the development of fishery independent surveys using fishing gears or direct observation, provided the surveys adequately cover the range of the target species and are capable of providing abundance indices or raised abundance estimates with acceptable accuracy. The RP recognizes that such surveys require substantial investment to achieve the necessary spatial coverage, and will benefit from existing studies and fisher's knowledge to identify strata for visual or fishing surveys of spawning fish.

The DW listed 14 different sources of fishery independent data from different areas around Puerto Rico and the U.S. Virgin Islands, but only five appear to provide data on mutton snapper, mainly in the U.S. Virgin Islands. In general the surveys tend to be localized and observations of mutton snapper can be low. Diver surveys using volunteer divers on the REEF program indicate (other than in 2006) an increase in abundance of mutton snappers at inshore sites off the U.S. Virgin Islands, showing a similar general pattern to the Puerto Rico commercial trap fishery CPUE. The existing surveys should be reviewed to establish areas that could be targeted for systematic dive surveys, and to determine the survey effort required to achieve specified precision levels. Discussions at the Review meeting indicated that surveys at times of year when the fish are more dispersed may provide more precise abundance indices than surveys of spawning aggregations. Occupancy of spawning sites will also be strongly affected by spawning behavior and the environmental triggers for spawning. On the other hand, surveys designed to collect data on parameters such as relative size composition of mature fish, may benefit from taking place on known spawning sites at spawning time. The design of surveys therefore needs to be linked clearly to their objectives.

The RP recommends investigation of other methods for fishery-independent stock monitoring, for example beach-seine surveys to provide recruitment indices for mutton snapper and other species and tag-release programs to estimate mortality rates as well as fish movements. Desk studies are however required to establish the requirements for design, intensity and sampling to deliver the required accuracy of estimates from any such surveys.

2.3.2.4. DW & AW Workshop recommendations on biological studies

- Collect life history information (growth, maturity, fecundity etc.); coordinate between key agencies;
- Tag recapture studies to determine habitat utilization and movement.
- Identify additional past and present spawning aggregation sites and characterize migration corridors;
- Define the spatial scale of migrations by individuals participating in spawning aggregations through tag and release studies;
- Conduct studies on temporal variability of oceanographic processes in relation to larval dispersal and connectivity of platforms of currently managed stock units;
- Examine early larval dispersal patterns using genetic markers and otolith microchemistry;
- Investigate population genetic structure of mutton snapper "stocks" within US Caribbean and in relation to the wider Caribbean.
- Examine ontogenetic shifts in habitat usage and diel foraging patterns.

The RP endorses the need for estimates of biological parameters determining productivity (growth, maturity, fecundity). Growth estimates by sex are needed for length-based models, and growth and maturity data are needed for development of biological reference points for exploitation.

The RP endorses the need for better information on distribution and seasonal/ontogenetic migrations and dispersal of mutton snapper. Whilst such information may not necessarily feed directly into stock assessment models, it is important for interpreting CPUE data, evaluating the impact of effort redistribution during closures, and establishing the possibility for over-fishing of localized populations with limited dispersal and mixing.

Modeling of egg and larval drift provides further information on connections between spawning and recruitment sites and the linkages between mutton snapper populations around Puerto Rico and the US Virgin Islands, and is an important long-term area of research rather than for assessing local stock status.

2.3.2.5. DW & AW Workshop recommendations on modeling approaches

The AW did not make any specific recommendations regarding future development of assessment models for mutton snapper. The RP makes the following recommendations:

i) Simulation testing of the length-based mortality estimator and any subsequent developments of it to examine its performance under different conditions of recruitment variability; use of a bootstrapping procedure to estimate variance; testing of the method on a wide range of stocks with age-based indices and associated length frequencies.
ii) Further exploration of GLM models for CPUE; regional application of the Stephens and McCall method to identify trips that could have caught mutton snapper; comparative model runs for all co-occurring species taken by each gear.
iii) Development of community-based indicators of fishery impacts in different areas or habitats, and evaluation of how these could be used to inform management of the fisheries.
iv) Investigate future use of PARFISH (Participatory Fishery stock assessment; MRAG) to integrate fishery data and information from fisher interviews.
v) Collection of the necessary information to carry out simple yield-per-recruit and spawner-per-recruit models to evaluate reference points for fishing mortality and the potential benefits of improving the selectivity characteristics of the commercial and recreational fisheries.

2.4. 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.

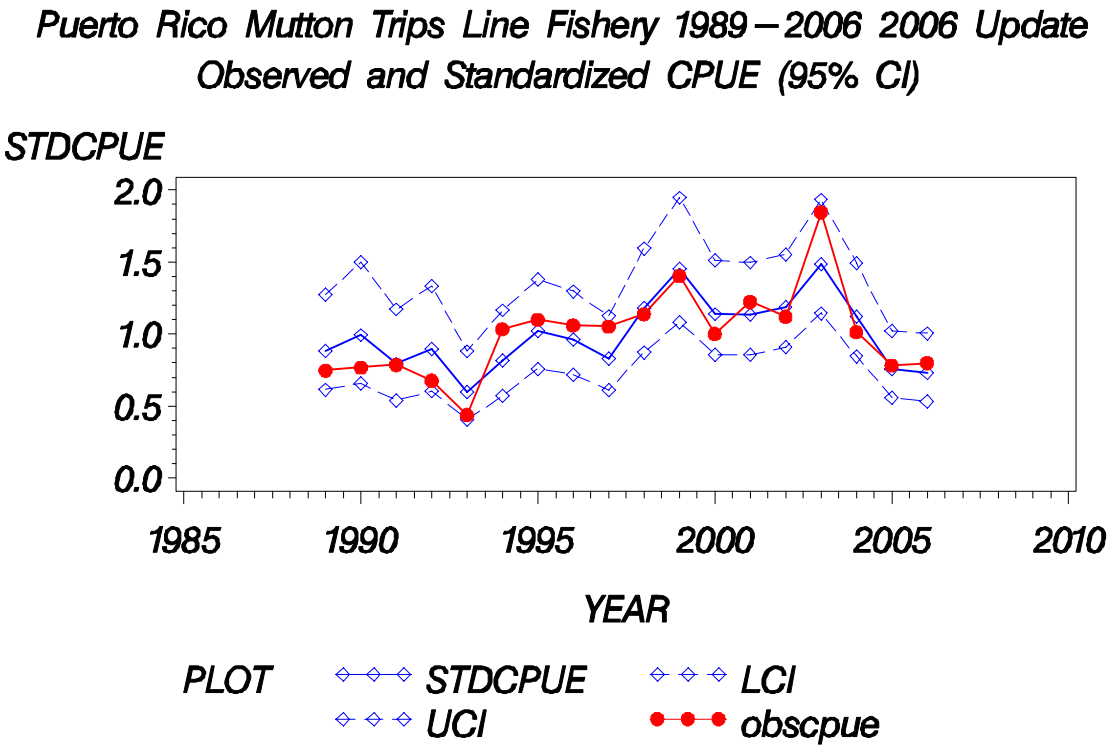
3. Written Comment submitted to the Review Panel

No written comments were submitted.

Addendum 1. Mutton Snapper Review Workshop

Mutton Snapper P. Rico **line** index updated to include 2006 data:

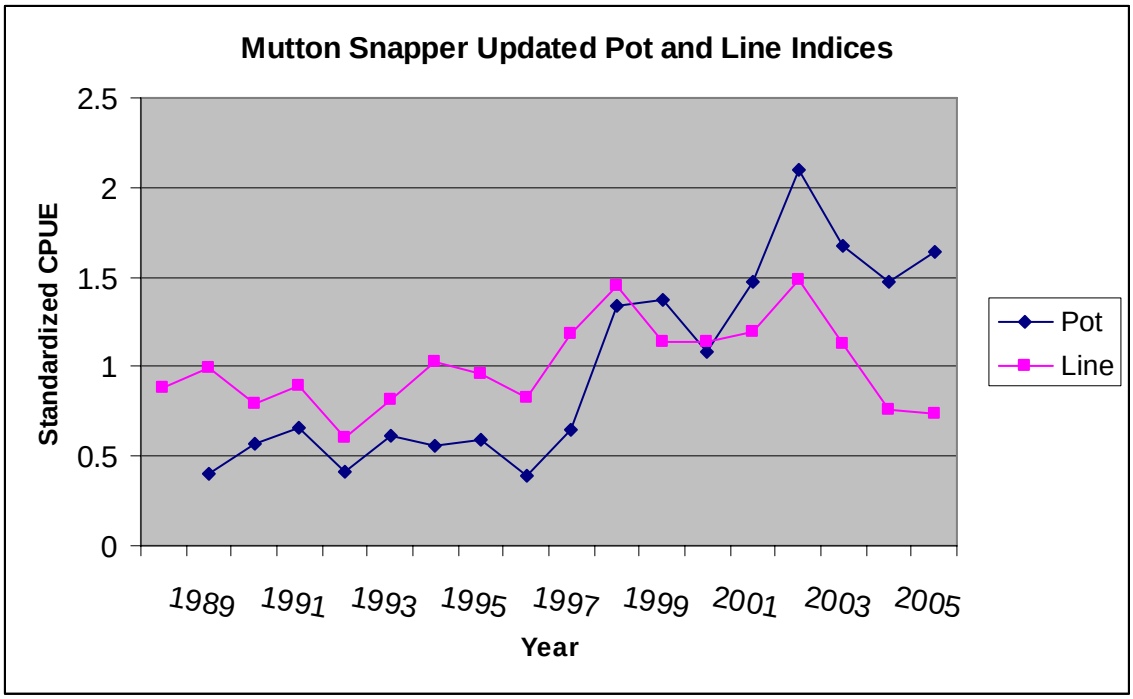
1. Sumary:
2006 Predicticted values (blue line) is slightly below that of 2005 by -3.0 %; the CV of the index is similar to that of preceeding years, around 20%



2) Estimates: Mutton P.Rico **Line** indices updated to include 2006

YEAR	StdErr	Obcpue	obppos	nobs	cv_i	MEANINDEX	STDCPUE	LCI	UCI	estcpue	obscpue
1989	0.285961	1.701207	0.07767	4017	0.183437	1.762122	0.884676	0.61485	1.272914	1.558906	0.747074
1990	0.364927	1.748358	0.113977	2132	0.208528	1.762122	0.993128	0.657361	1.500398	1.750013	0.76778
1991	0.275096	1.791757	0.104353	3239	0.196462	1.762122	0.794639	0.538442	1.172739	1.400251	0.786838
1992	0.316985	1.544228	0.087267	2521	0.200392	1.762122	0.897682	0.603636	1.334967	1.581826	0.678138
1993	0.206182	1.000326	0.062299	3740	0.195765	1.762122	0.597694	0.405541	0.880891	1.053209	0.439287
1994	0.258653	2.355384	0.077848	4406	0.179929	1.762122	0.815796	0.570875	1.165796	1.437532	1.034351
1995	0.270815	2.504961	0.083678	7493	0.150037	1.762122	1.024328	0.760053	1.380495	1.804991	1.100037
1996	0.253501	2.415159	0.086458	7761	0.149224	1.762122	0.964065	0.716481	1.297201	1.698799	1.060602
1997	0.224409	2.397481	0.079815	7768	0.153603	1.762122	0.829097	0.610892	1.125243	1.460969	1.052838
1998	0.315107	2.592208	0.108903	5335	0.151488	1.762122	1.180445	0.873396	1.59544	2.080088	1.138351
1999	0.37697	3.198248	0.121817	5262	0.147173	1.762122	1.453593	1.084662	1.948012	2.561408	1.40449
2000	0.2851	2.282937	0.113495	7225	0.141998	1.762122	1.139407	0.858927	1.511478	2.007774	1.002537
2001	0.279257	2.787153	0.117682	8438	0.139753	1.762122	1.133987	0.858632	1.497645	1.998222	1.22396
2002	0.281924	2.554426	0.139519	7447	0.134542	1.762122	1.189149	0.9097	1.554443	2.095426	1.12176
2003	0.345277	4.204726	0.139967	9095	0.131633	1.762122	1.488566	1.145312	1.934694	2.623034	1.846478
2004	0.282292	2.309678	0.113321	7642	0.142471	1.762122	1.12444	0.846854	1.493015	1.9814	1.01428
2005	0.202949	1.780703	0.098087	7371	0.152342	1.762122	0.756017	0.558428	1.023519	1.332194	0.781984
2006	0.205432	1.819937	0.09468	6485	0.158985	1.762122	0.73329	0.534618	1.00579	1.292145	0.799213

3) Comparison of line and pot Updated Indices: recall from Pot that the 2006 index was about 11% greater than the 2005 value. The 2006 predicted line index is 3% greater than the 2005 predicted value. Both indices suggest an increase in CPUE- not a dramatic increase though. Also, keep in mind that the pot fishery reflects about 25% on average of the mutton snapper commercial yield while the line fishery reflects about 50% of the removals.


Mutton Snapper Updated Pot and Line Indices
Standardized CPUE
2.5
2
1.5
1
0.5
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
Year
Pot
Line