SEDAR

Southeast Data, Assessment, and Review

SEDAR 30

Stock Assessment Report

U.S. Caribbean Blue Tang

June 2013

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

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SECTION I: Introduction

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1. SEDAR PROCESS DESCRIPTION

SouthEast Data, Assessment, and Review (**SEDAR**) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. SEDAR seeks improvements in the scientific quality of stock assessments and the relevance of information available to address fishery management issues. SEDAR emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments.

SEDAR is managed by the Caribbean, Gulf of Mexico, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commission representatives: Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is normally organized around three workshops and a series of webinars. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. The second stage is the Assessment Process, which is conducted via a workshop and a series of webinars, 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. The completed assessment, including the reports of all 3 workshops and all supporting documentation, is then forwarded to the Council SSC for certification as 'appropriate for management' and development of specific management recommendations.

SEDAR workshops are public meetings organized by SEDAR staff and the lead Cooperator. Workshop 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 30 was organized differently from the normal SEDAR process, due to the unique data and cultural issues for the U.S. Caribbean. Given the limited amount of data available for use in the assessment, and the assessment approach being used, a formal Data Workshop was not conducted. Instead a series of public meetings was held (one each on Puerto Rico, Saint Thomas, and Saint Croix) in which the data was discussed with local scientists and fisherman.

An Assessment Workshop was held, as per standard SEDAR procedures, but an in-person Review Workshop was not conducted and replaced by several CIE Desk Reviews. This modification of the Review Process was also related to the limited data availability and assessment methods used during this process.

2. MANAGEMENT OVERVIEW ((*Prepared by Graciela García-Moliner and Bill Arnold)*

2.1. *Fishery Management Plan, Plan Amendments, and Local Regulations*

Blue tang (*Acanthurus coeruleus*) is one of several species of surgeonfish within the surgeonfish fishery management unit (CFMC 2005). The regulatory overview describes the management measures that directly or indirectly impact blue tang. There are no regulations specific to any of the species of surgeonfish in the US Caribbean at this time.

The U.S. Caribbean includes the islands of Puerto Rico and the U.S. Virgin Islands (USVI) including St. Thomas, St. John, and St. Croix. The state waters of Puerto Rico extend 9 nm from the shore and the state waters of the USVI extend 3 nm from shore. The following summary applies to these jurisdictions separately.

The following is a summary of the management measures that directly or indirectly have impacted the blue tang (surgeonfish) fishery in the U.S. Caribbean. The Fishery Management Plan for the Shallow-water Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands (1985) included 3 species of surgeonfish (Acanthuridae) in the FMU, blue tang, ocean surgeonfish, and doctorfish (*Acanthurus coeruleus*, *A. bahianus*, *A. chirurgus*), and did not include size limits, seasonal closures or other management measures directed at the surgeonfish fishery in the EEZ. However, regulations on the mesh size of traps that were implemented at the time had a direct impact on the surgeonfish fishery. No other species were incorporated into Reef Fish Fishery Management Plan in 1993. The 1993 Amendment changes the name of the FMP formerly known as the Fishery Management Plan for the Shallow-water Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands; Federal Register, Vol. 50, No. 167: 34850-34855). .

Measures in the original FMP, and in the follow-on amendments, that affect surgeonfish include changes to requirements for the constructions of traps (in both the Spiny Lobster and Shallow-water Reef Fish FMPs) as well as seasonal and/or area closures established through amendments to the Reef Fish FMP and the Coral FMP:

Description of Action	FMP/Amendment	Effective Date
Traps: construction and requirement for degradable panel	Spiny Lobster FMP	1985
Traps: construction and requirement for degradable panel; changes to mesh size.	Reef Fish FMP/Amen. 1/ Reg. Amen./Amen. 2/SFA	1985; 1990;1993;2005
Seasonal area closure	Reef Fish FMP/Amen. 2; Amen. 3/Interim Rule/ SFA	1993,1996, 1999,2005
Closed area	Coral FMP Amen. 1	1999
Seasonal closure for reef fish	SFA	2005

In 2005, the Council ratified the Sustainable Fisheries Act (SFA) Amendment, which categorized surgeonfish (along with groupers and other species) into fishery management units (FMUs). Surgeonfish were all included in the Surgeonfish FMU (species included are: blue tang (in the USVI is known as blue doctor) (*Acanthurus coeruleus*), ocean surgeonfish (*A. bahianus*) and doctorfish *(A. chirurgus*). Measures were included in the SFA Amendment to institute a total ban on the use of nets in the EEZ and a prohibition on the bottom tending gear in all seasonally closed areas (HAPCs). A number of closed seasons for various FMUs during the peak spawning months of each species were also implemented and indirectly impact surgeonfish. The implementation took place on November 28, 2005, and continues to the present. At the time of implementation these measures applied only to U.S. Caribbean EEZ waters.

Compatible regulations on the ban of nets were implemented by the Government of the Territory of the USVI for their local water on July 5, 2006. Also, the prohibition on the use of bottom tending gear (including traps) from the HAPCs was implemented by the USVI Government at the time.

Puerto Rico followed a slightly different strategy by implementing a ban on the use of SCUBA and nets fished together in 2004 (Regulation 6768 with an implementation date of March 12, 2004), establishing a mesh size for gillnets of more than 2 inches (51 mm) (as it was since 1936) and various restrictions on the construction of beach seines (beach seines were subsequently banned and re-established since 2004 to present). Although, as noted above, the implementation of Regulation 6768 was to begin in March 2004, a subsequent Administrative Order (Number 2004-12) delayed enforcement until January 1, 2005, in an effort to provide adequate opportunity to educate fishers on the new regulations. The Administrative Order included a 2-year grace period for these restrictions to be implemented.

Regulation 6768 included a quota for the species collected for the aquarium trade. A total of 724 blue tangs (also known as barbero, *Acanthurus coeruleus*) were allowed to be harvest per year. All other surgeonfish not included in the list of species permitted for capture and exportation were prohibited for the aquarium trade industry. In 2010, the amendment to the regulations (Reglamento de Pesca de Puerto Rico -2010 Número 7949) listed the species permitted in the aquarium trade (capture and exportation) but did not set any quotas. Reglamento 7949 also allowed importation off the species in the family Acanthuridae.

Note that the closed seasons in all three island groups, were designed to benefit other species but not surgeonfish (i.e., SU1 including silk snapper (October – December), Grouper Unit 4 (February-April, SU3 (mutton and lane snapper April-June), GU3 (red hind, December-February) and might have limited impact on surgeonfish. However, the seasonal area closures described in Tables 2.1.1, 2.1.2, and 2.1.3 although not designed specifically for the protection of surgeonfish could indirectly benefit surgeonfish because the closure areas encompass habitats occupied by surgeonfish species including blue tang. The SFA Amendment also prohibited placement of bottom tending gear (e.g., traps, bottom longlines, nets) within Habitat Areas of Particular Concern (HAPCs).

The changes in trap construction and mesh size, the ban on bottom tending gear from HAPCs, the regulations on mesh and length of nets, the prohibition of nets in the EEZ and the USVI are all regulations that impact blue tang (mostly caught by traps, but also with nets and spear) and the other species of surgeonfish.

Table 2.1.1. Annual Commercial/Recreational Surgeonfish Regulatory Summary: St. Croix

		Minimum size limit			Trip limit			Closed season		Closed Area		
Year	Fishing Year	Size	Start date	End date	Amount	Start date	End date	Start date	End date	Area/Seasonal[4]	Start date	End date
1993										Lang Bank[1]	11/15	12/31
1994										Lang Bank[1] Mutton Snapper[3]	1/1; 12/1 3/1	2/28[2]; 12/31 6/30
1995										Lang Bank[1] Mutton Snapper[3]	1/1; 12/1 3/1	2/28; 12/31 6/30
1996										Lang Bank[1] Mutton Snapper[3]	1/1; 12/1 3/1	2/28; 12/31 6/30
1997										Lang Bank[1] Mutton Snapper[3]	1/1; 12/1 3/1	2/28; 12/31 6/30
1998										Lang Bank[1] Mutton Snapper[3]	1/1; 12/1 3/1	2/28; 12/31 6/30
1999										Lang Bank[1] Mutton Snapper[3]	1/1; 12/1 3/1	2/28; 12/31 6/30
2000										Lang Bank[1] Mutton Snapper[3]	1/1; 12/1 3/1	2/28; 12/31 6/30
2001										Lang Bank[1] Mutton Snapper[3]	1/1; 12/1 3/1	2/28; 12/31 6/30
2002										Lang Bank[1] Mutton Snapper[3]	1/1; 12/1 3/1	2/28; 12/31 6/30
2003										Lang Bank[1]	1/1; 12/1	2/28; 12/31

										Mutton Snapper[3]	3/1	6/30
2004										Lang Bank[1]	1/1; 12/1	2/28; 12/31
										Mutton Snapper[3]	3/1	6/30
2005										Lang Bank[1]	1/1; 12/1	2/28; 12/31
										Mutton Snapper[3]	3/1	6/30
2006										Lang Bank[1]	1/1; 12/1	2/28; 12/31
										Mutton Snapper[3]	3/1	6/30
2007										Lang Bank[1]	1/1; 12/1	2/28; 12/31
										Mutton Snapper[3]	3/1	6/30
2008										Lang Bank[1]	1/1; 12/1	2/28; 12/31
										Mutton Snapper[3]	3/1	6/30
2009										Lang Bank[1]	1/1; 12/1	2/28; 12/31
										Mutton Snapper[3]	3/1	6/30
2010										Lang Bank[1]	1/1; 12/1	2/28; 12/31
										Mutton Snapper[3]	3/1	6/30

[1]EEZ waters only; [2]2/29 during leap years;[3]1993 territorial area closure; 1994 EEZ and territorial area closure; 1996 boundary change to make EEZ compatible with state; [4]Bottom tending gear (e.g., traps, nets, bottom longlines) prohibited from seasonally closed areas (i.e., HAPCs); [5]Boundary change to Tourmaline Bank closed area; [6]Closure extended to six months (October 1 through March 31) beginning with 2011 calendar year.

Table 2.1.2. Annual Commercial/Recreational Surgeonfish Regulatory Summary: St. Thomas

		Minimum size limit			Trip limit			Closed season		Closed Area		
Year	Fishing Year	Size	Start date	End date	Amount (lbs)	Start date	End date	Start date	End date	Area/Seasonal[4]	Start date	End date
1990										Hind Bank(MCD)	12/1	12/31
1991										Hind Bank(MCD)	1/1; 12/1	2/28; 12/31
1992										Hind Bank(MCD)	1/1; 12/1	2/28; 12/31
1993										Hind Bank(MCD)	1/1; 12/1	2/28; 12/31
1994										Hind Bank(MCD)	1/1; 12/1	2/28; 12/31
1995										Hind Bank(MCD)	1/1; 12/1	2/28; 12/31
1996										Hind Bank(MCD)	1/1; 12/1	2/28; 12/31
1997										Hind Bank(MCD)	1/1; 12/1	2/28; 12/31
1998										Hind Bank(MCD)	1/1; 12/1	2/28; 12/31
1999										Hind Bank(MCD)	1/1; 12/1	2/28; 12/31
2000										Hind Bank(MCD)	1/1	12/31
2001										Hind Bank(MCD)	1/1	12/31
2002										Hind Bank(MCD)	1/1	12/31
2003										Hind Bank(MCD)	1/1	12/31
2004										Hind Bank(MCD)	1/1	12/31
2005										Hind Bank(MCD) Grammanik Bank	1/1 2/1	12/31 4/30
2006										Hind Bank(MCD) Grammanik Bank	1/1 2/1	12/31 4/30
2007										Hind Bank(MCD) Grammanik Bank	1/1 2/1	12/31 4/30

2008										Hind Bank(MCD) Grammanik Bank	1/1 2/1	12/31 4/30
2009										Hind Bank(MCD) Grammanik Bank	1/1 2/1	12/31 4/30
2010										Hind Bank(MCD) Grammanik Bank	1/1 2/1	12/31 4/30

[1]EEZ waters only; [2]1993 territorial area closure; 1994 EEZ and territorial area closure; 1996 boundary change to make EEZ compatible with state; [3]2/29 during leap years; [4]Bottom tending gear (e.g., traps, nets, bottom longlines) prohibited from seasonally closed areas (i.e., HAPCs); [5]Boundary change to Tourmaline Bank closed area; [6]Closure extended to six months (October 1 through March 31) beginning with 2011 calendar year.

Table 2.1.3. Annual Commercial/Recreational Surgeonfish Regulatory Summary: Puerto Rico

		Minimum size limit			Trip limit			Closed season		Closed Area		
Year	Fishing Year	Size	Start date	End date	Amount (lbs)	Start date	End date	Start date	End date	Area/Seasonal[4]	Start date	End date
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991												
1992												
1993										Tourmaline Bank	11/15	12/31
1994										Tourmaline Bank	1/1; 12/1	2/28; 12/31
1995										Tourmaline Bank	1/1; 12/1	2/28; 12/31
1996										Tourmaline Bank[5]	1/1; 12/1	2/28; 12/31
1997										Tourmaline Bank Abrir La Sierra Bajo de Sico	1/1; 12/1 1/1; 12/1 1/1; 12/1	2/28; 12/31 2/28; 12/31 2/28; 12/31
1998										Tourmaline Bank Abrir La Sierra Bajo de Sico	1/1; 12/1 1/1; 12/1 1/1; 12/1	2/28; 12/31 2/28; 12/31 2/28; 12/31
1999										Tourmaline Bank	1/1;	2/28;

											12/1	12/31
										Abrir La Sierra	1/1; 12/1	2/28; 12/31
										Bajo de Sico	1/1; 12/1	2/28; 12/31
2000										Tourmaline Bank	1/1; 12/1	2/28; 12/31
										Abrir La Sierra	1/1; 12/1	2/28; 12/31
										Bajo de Sico	1/1; 12/1	2/28; 12/31
2001										Tourmaline Bank	1/1; 12/1	2/28; 12/31
										Abrir La Sierra	1/1; 12/1	2/28; 12/31
										Bajo de Sico	1/1; 12/1	2/28; 12/31
2002										Tourmaline Bank	1/1; 12/1	2/28; 12/31
										Abrir La Sierra	1/1; 12/1	2/28; 12/31
										Bajo de Sico	1/1; 12/1	2/28; 12/31
2003										Tourmaline Bank	1/1; 12/1	2/28; 12/31
										Abrir La Sierra	1/1; 12/1	2/28; 12/31
										Bajo de Sico	1/1; 12/1	2/28; 12/31
2004										Tourmaline Bank	1/1; 12/1	2/28; 12/31
										Abrir La Sierra	1/1; 12/1	2/28; 12/31
										Bajo de Sico	1/1; 12/1	2/28; 12/31

2005										Tourmaline Bank Abrir La Sierra Bajo de Sico	1/1; 12/1 1/1; 12/1 1/1; 12/1	2/28; 12/31 2/28; 12/31 2/28; 12/31
2006										Tourmaline Bank Abrir La Sierra Bajo de Sico	1/1; 12/1 1/1; 12/1 1/1; 12/1	2/28; 12/31 2/28; 12/31 2/28; 12/31
2007										Tourmaline Bank Abrir La Sierra Bajo de Sico	1/1; 12/1 1/1; 12/1 1/1; 12/1	2/28; 12/31 2/28; 12/31 2/28; 12/31
2008										Tourmaline Bank Abrir La Sierra Bajo de Sico	1/1; 12/1 1/1; 12/1 1/1; 12/1	2/28; 12/31 2/28; 12/31 2/28; 12/31
2009										Tourmaline Bank Abrir La Sierra Bajo de Sico	1/1; 12/1 1/1; 12/1 1/1; 12/1	2/28; 12/31 2/28; 12/31 2/28; 12/31
2010										Tourmaline Bank Abrir La Sierra Bajo de Sico	1/1; 12/1 1/1; 12/1 1/1;	2/28; 12/31 2/28; 12/31 2/28;

											12/1	12/31
2011										Tourmaline Bank Abrir La Sierra Bajo de Sico[6]	1/1; 12/1 1/1; 12/1 1/1; 12/1	2/28; 12/31 2/28; 12/31 2/28; 12/31

[1]EEZ waters only; [2]1993 territorial area closure; 1994 EEZ and territorial area closure; 1996 boundary change to make EEZ compatible with state; [3]2/29 during leap years; [4]Bottom tending gear (e.g., traps, nets, bottom longlines) prohibited from seasonally closed areas (i.e., HAPCs); [5]Boundary change to Tourmaline Bank closed area; [6]Closure extended to six months (October 1 through March 31) beginning with 2011 calendar year.

2.2. Control Date Notices

The CFMC at its 130th meeting on March 24-26, 2009, established a control date of March 24, 2009, for every fishery managed by the Council, including SU1.

2.3. Management Program Specifications

The following is a summary of general information regarding management of silk snapper in the U.S. Caribbean:

Species	Blue tang
Management Unit	Surgeonfishes
Management Unit Definition	Includes blue tang (*Acanthurus coeruleus*), ocean surgeonfish (*A. bahianus*) and doctorfish *(A. chirurgus*)
Management Entity	Caribbean Fishery Management Council
Management Contacts SERO / Council	William Arnold - SERO Graciela García-Moliner - CFMC
Current stock exploitation status	Unknown (Not overfished)
Current stock biomass status	Unknown

As described in the following table, the 2005 SFA Amendment established reference points for surgeonfishes. This fishery unit includes 3 species of surgeonfish. The 2011 ACL Amendment established ACLs for the surgeonfish for the commercial and recreational sectors separate for Puerto Rico and the commercial and recreational sectors together in the USVI. No additional measures such as bag limits for the recreational catch or size limits were implemented. This ACL 2011 Amendment also redefine management reference points based on average current catch for each geographically distinct area (i.e., Puerto Rico, St. Thomas/St. John (STT/STJ), and St. Croix (STX).

Note that reference points were based upon commercial and recreational landings only. Although discards may occur in these fisheries, there has been no available method for estimating the extent of those discards.

Criteria	Current		Proposed	
	Definition	Value	Definition	Value
MSST	MSST = [(1-M) or 0.5 whichever is greater]*B_{MSY}	104,000	MSST = [(1-M) or 0.5 whichever is greater]*B_{MSY}	SEDAR
MFMT	F_{MSY} Proxy	0.32	F_{MSY}	SEDAR
MSY	Yield at F_{MSY} Proxy	36,000	Yield at F_{MSY}	SEDAR
F_{MSY}	M	0.32	F_{MAX}	SEDAR
OY	Yield at F_{OY}	34,000	Yield at F_{OY}	SEDAR
F_{OY}	F_{OY} = 0.75 * F_{MSY} Proxy	Not specified	F_{OY} = 50%,75%, 85% F_{MSY}	SEDAR
M		0.32		SEDAR

Stock Rebuilding Information

According to NOAA's Fish Stock Sustainability Index (http://www.nmfs.noaa.gov/sfa/statusoffisheries/2011/first/FSSInonFSSIstockstatusQ1_2011.pdf), the surgeonfish FMU is not considered to be undergoing overfishing and not overfished. Thus, no rebuilding plan is required.

Stock Projection Information

The 2011 ACL Amendment to the FMPs proposes the following criteria for applying AMs in the management of surgeonfishes:

Requested Information	Value
First Year of Management	2012
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	Commercial + Recreational Landings in Puerto Rico, Commercial Landings in the USVI
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	2011 landings for 2012; average of 2011-2012 landings for 2013, and average 3 years of landings for 2014 and forward

The 2011 Caribbean ACL Amendment was approved and established ACL for Surgeonfish in Puerto Rico (commercial and recreational) and in the USVI:

Current Quota Value ACL (pounds)	10,769 (PR); 29,249 (STT/STJ) 33,603 (STX)
Next Scheduled Quota Change	TBD

Annual or averaged quota	Averaged
If averaged, number of years to average	6-7 years[1]
Does the quota include bycatch/discard ?	No

[1]6 years for PR recreational and STT commercial; 7 years for PR and STX commercial.

How is the quota calculated - conditioned upon exploitation or average landings?

Average landings.

Does the quota include bycatch/discard estimates? If so, what is the source of the bycatch/discard values? What are the bycatch/discard allowances?

No.

Are there additional details of which the analysts should be aware to properly determine quotas for this stock?

The CFMC recognizes the limitations of the data. Improvements in data collection are anticipated resulting from more fisherman-friendly reporting forms and enhanced data collection and effort monitoring. For most effective management of the fisheries, the CFMC will need timely in-season data which is currently lacking for the U.S. Caribbean.

2.4. Management and Regulatory Timeline

Tables 2.1.1, 2.1.2, and 2.1.3 provide event timelines of State and federal EEZ management actions by island group. Additional details regarding regulatory history for Puerto Rico, USVI, and EEZ waters follow.

The principal gears used in targeting surgeonfish are traps and nets (including herding with SCUBA gear) and spear. Trap and pots configurations have been regulated since 1936 in Puerto Rico, since 1972 in the USVI, and since 1985 in the EEZ. Nets (beach seines) have been regulated in Puerto Rico since 1936 and not until 2005 in the EEZ and in 2006 in the USVI.

<u>Trap Regulations</u>

Puerto Rico’s Fishing Law of 1936 required that all traps have a self-destruct panel but made no mention of mesh size. In 1972, Act 3330 of the USVI regulated the mesh size of traps, establishing a minimum size of 1.25” in the smallest dimension. By convention rather than regulation, trap construction was of wood and hexagonal (i.e., chicken wire) wire mesh.

Starting in 1985 regulations associated with spiny lobster management established that, in all three jurisdictions, self-destruct panels must be configured into traps. Also in 1985, traps to be deployed in the EEZ had to have a minimum mesh size of 1.25” in the smallest dimension, resulting in compatible regulations between the USVI and the EEZ. However, the regulations were not implemented in federal waters until 1988. These regulations were established under the Fishery Management Plan for the Shallow-water Reef Fish Fishery of Puerto Rico and the USVI (i.e., Reef Fish FMP).

In the 1990's, amendments to the Reef Fish FMP (1990, 1991, 1993) increased the minimum mesh size for traps to 1.5" hexagonal or 1.5" square until September 13, 1993, and to 2" square thereafter. These regulations also required that the degradable panel be fastened with degradable material and established specifications for the composition of the degradable material. The intention of the CFMC was to have only one panel but as the regulations were written there was a requirement for two degradable panels plus a degradable door. This regulation was revised through a technical amendment, resulting in a requirement for only a single biodegradable panel.

In the EEZ by 1994, regulations for traps required that traps have a minimum mesh size of 1.5" hexagonal or 2" square mesh. The documentation for this requirement is available at the Council's office.

Act 3330 of the USVI regulates fishing and fishing gear. This 1972 regulation required that a minimum mesh size in traps be of 1.25" hexagonal in the smallest dimension and that an escape panel with degradable material also be incorporated into the traps.

In the USVI, each District imposes different requirements for trap construction but all traps have to be inspected and certified. In STT/STX beginning in 1996, all new traps must have a minimum mesh size identical to that required for the EEZ: 1.5" hexagonal or 2" square in the smallest dimension. The requirement for an escape panel with degradable fasteners is compatible in all jurisdictions.

However, in STX beginning in 1996, the minimum mesh size required for new traps was 1.5" hexagonal or 1.5" square in the smallest dimension.

Beginning in1998, the EEZ, STT/STJ, and STX required the same mesh size of 1.5" hexagonal (but not for the square mesh) for all new traps. Also beginning in 1998, all traps in the USVI had to comply with the 1.5" minimum hexagonal mesh size. The difference between the Districts remained with STT/STJ continuing to allow a square mesh of 2" whereas STX still required a 1.5" minimum mesh.

Beginning in 2000, STT/STJ required that all traps had a minimum mesh size of 2" hexagonal or 2" square. All traps had to be inspected and tagged. This is the most restrictive minimum mesh size requirement in the U.S. Caribbean.

Beginning in 2004, Puerto Rico regulated the construction of traps and required, but did not implement, a minimum mesh size of 1.5" hexagonal or 2" square. Implementation of these mesh size requirements did not occur until 2007.

In summary, the time periods during which mesh size regulations were stable are as follows:

1) For the EEZ, (a) 1.25" minimum mesh from 1988 to 1993 (total of 6 years), and (b) 1.5" hexagonal or 2" square from 1994 to present (total of 17 years through 2010).

2) For STT/STJ, (a) 1.25" minimum mesh from 1972 to 1996 (total of 25 years), (b) 1.5" hexagonal or 2" square from 1997 to 2000 (total of 4 years), and (c) 2" square or 2" hexagonal from 2001 to present (total of 10 years through 2010).

3) For STX, (a) 1.25” minimum mesh from 1972 to 1996 (total of 25 years), (b) 1.5” hexagonal or 1.5” square from 1996 (new traps) to 2009 (total of 14 years) or from 1998 (all traps) to 2009 (total of 12 years), (c) 1.5” hexagonal during 2009 (total of 1 year), and (d) 1.5” hexagonal or 2” square beginning in 2010 (total of 1 year to present).

Compatibility in the mesh size regulation was achieved as follows:

(a) 1.25” mesh in both USVI and EEZ waters between 1985 and 1988 (total of 4 years), (b) 1.5” hexagonal in both STT/STJ and EEZ waters between 1996 and 2000 (total of 5 years), and (c) 2” square from 1996 to present for both STT/STJ and EEZ waters (total of 16 years through 2010).

The missing years correspond to periods when the regulations included a mix of 1.25” minimum mesh, 1.5” hexagonal or square mesh, and 2” square mesh.

Compatibility of EEZ and STX regulations included (a) 1.25” between 1988 and 1994 (total of 7 years), (b) 1.5” hexagonal between 1996 and present (total of 16 years through 2010), and (c) for 2” square in 2010 (total of 1 year through 2010).

Tables 2.4.1, 2.4.2, and 2.4.3 summarize the number of years during which the mesh size was the same for the EEZ and each of the islands or island groups. Figure 2.4.1 provides a visual timeline for changes in regulations, clearly showing the predominance of regulations regarding mesh size.

Table 2.4.1. EEZ and STT/STJ years of compatible mesh size for traps.

			EEZ			
			1.25"	1.5"	2" square	2" hex
			1988	1994	1994	NO
STT	1.25"	1972	7 (1988-1996)			
	1.5"	1996		5 (1996-2000)		
	2" square	1996			5 (1996-2010)	
	2" hex	2000				

Table 2.4.2. EEZ and STX years of compatible mesh size in traps.

			EEZ			
			1.25"	1.5"	2" square	2" hex
			1988	1994	1994	NO
STX	1.25"	1972	7 (1988-1994)			
	1.5"	1996		5 (1996-2010)		
	2" square	2010			1 (2010)	
	2" hex					

Table 2.4.3. EEZ and Puerto Rico (this table needs to be reviewed).

			EEZ			
			1.25"	1.5"	2" square	2" hex
			1988	1994	1994	NO
PR	1.25"					
	1.5"	2007		4 (2007-2010)		
	2" square	2007		4 (2007-2010)		
	2" hex					

Table 2.4.4. Periods of time during which the same regulation of mesh size was maintained in each of the areas or jurisdictions.

Years during which the same mesh size was maintain in each jurisdiction				
Mesh/Area	EEZ	USVI	STT	STX
1.25"	1988-1993	1972-1996	1972-1998	1972-1998
1.5"hex/square	1993-1994			1996-1998
1.5" hex	1994-2010		1996-2000	1996-2010
2"square	1994-2010		1996-2010	2010
2" hex			2000-2010	

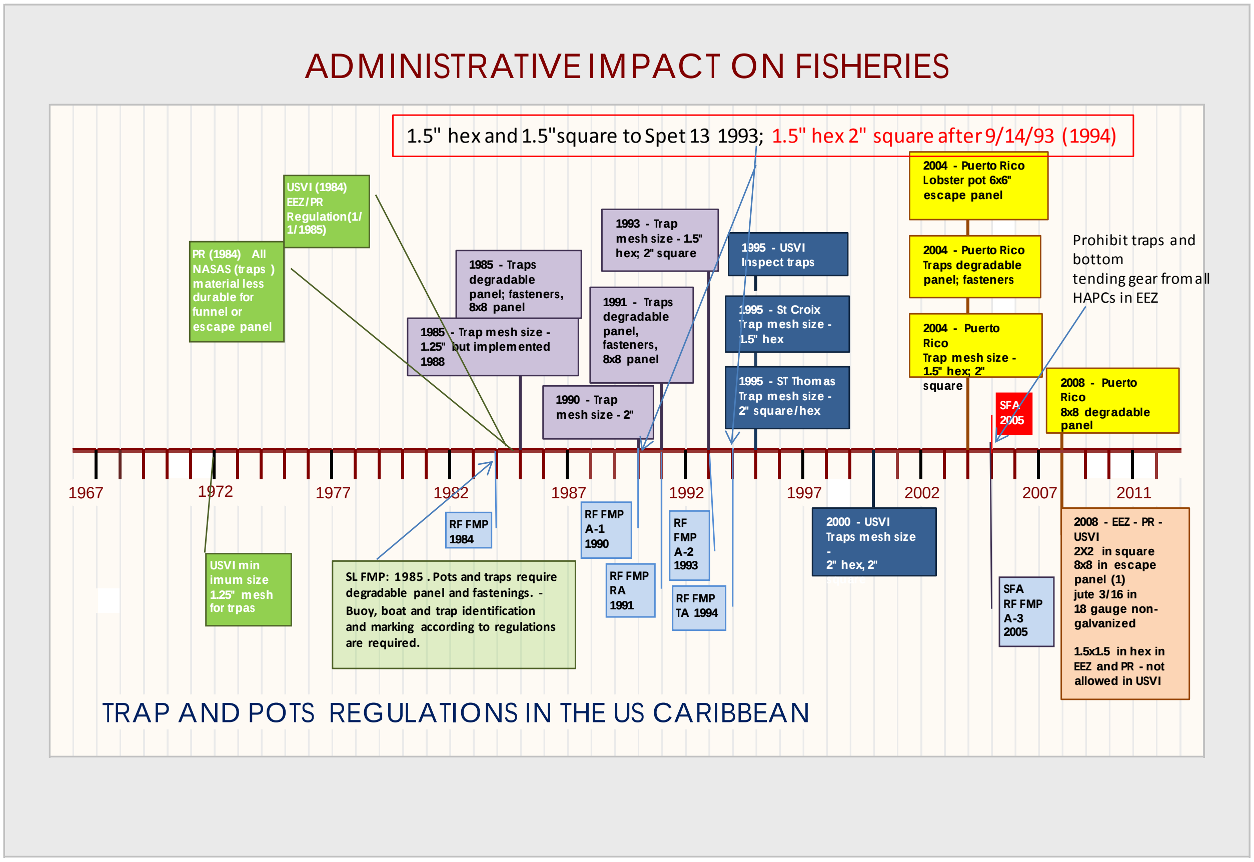

Figure 2.4.1. Schematic representation of the various FMPs and regulations that changed the way in which traps were constructed. The most significant changes are for mesh size.

2.5 *References*

Caribbean Fishery Management Council (CFMC). 1981. Fishery management plan, final environmental impact statement, and regulatory impact review for the spiny lobster fishery of Puerto Rico and the U.S. Virgin Islands. Caribbean Fishery Management Council, San Juan, Puerto Rico. 43 pp. + Appendices.

Caribbean Fishery Management Council (CFMC). 1985. Fishery management plan, final environmental impact statement, and draft regulatory impact review for the shallow-water reef fish fishery of Puerto Rico and the U.S. Virgin Islands. Caribbean Fishery Management Council, San Juan, Puerto Rico. 69 pp. + Appendices.

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Caribbean Fishery Management Council (CFMC). 2004. Final environmental impact statement for the generic essential fish habitat amendment to: Spiny lobster fishery management plan (FMP), queen conch FMP, reef fish FMP, and coral FMP for the U.S. Caribbean, Vol. I and II. Caribbean Fishery Management Council, San Juan, Puerto Rico.

Caribbean Fishery Management Council (CFMC). 2005. Comprehensive amendment to the fishery management plans (FMPs) of the U.S. Caribbean to address required provisions of the Magnuson-Stevens Fishery Conservation and Management Act: Amendment 2 to the FMP for the spiny lobster fishery of Puerto Rico and the U.S. Virgin Islands; Amendment 1 to the FMP for queen conch resources of Puerto Rico and the U.S. Virgin Islands; Amendment 3 to the FMP for the reef fish fishery of Puerto Rico and the U.S. Virgin Islands; Amendment 2 to the FMP for the corals and reef associated invertebrates of Puerto Rico and the U.S. Virgin Islands. Caribbean Fishery Management Council, San Juan, Puerto Rico. 533 pp. + Appendices. Obtained online at: http://www.caribbeanfmc.com/SCANNED%20FMPS/06%20FINAL%20SFA%20-%20MAY%2003,2005/SFA-FMP.htm

Matos, D. 1992. Annual report to the National Marine Fisheries Service Interjurisdictional Fisheries Program. P.R. Dept. Nat. Res. Fish. Res. Lab. 55 pp

3. ASSESSMENT HISTORY AND REVIEW

Caribbean blue tang have not been formally assessed prior to SEDAR 30.

4. REGIONAL MAPS

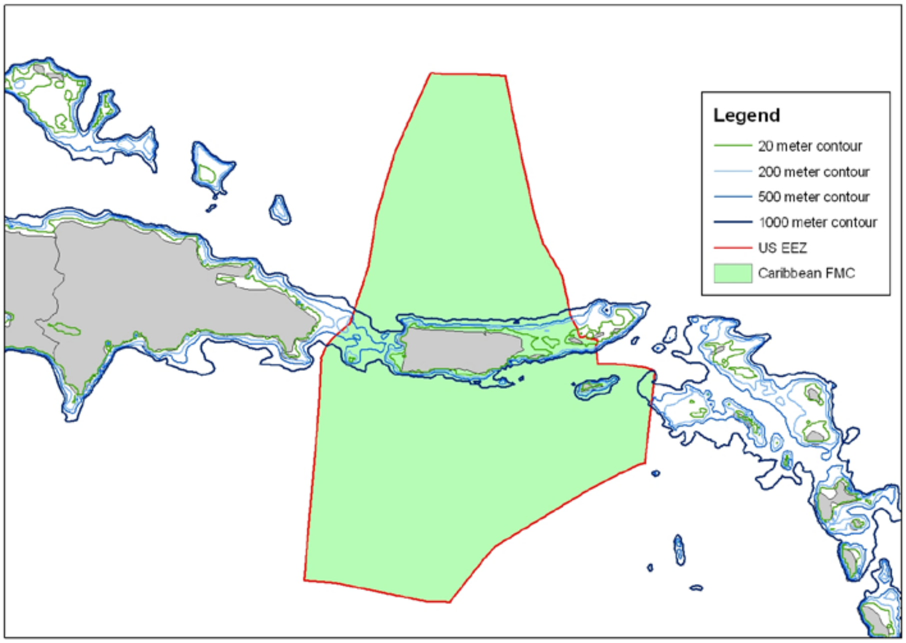

Figure 4.1. Caribbean management region including Council and EEZ Boundaries.

5. ASSESSMENT SUMMARY

The Summary Report provides a broad but concise view of the salient aspects of the stock assessment. It recapitulates: (a) the information available to and prepared by the Data Workshop; (b) the application of those data, development and execution of one or more assessment models, and identification of the most reliable model configuration as the base run by the Assessment Process (AP); and (c) the findings and advice determined during the Review Workshop.

Executive Summary

The SEDAR 30 Caribbean blue tang assessment process consisted of a data scoping process, with one public data scoping meeting held on Puerto Rico, St. Thomas, and St. Croix, and an assessment process which consisted of an in-person workshop held in Miami, FL and a series of webinars. The SEDAR 30

Peer Review Process was conducted via a CIE (Center for Independent Experts) Desk Review in lieu of a Panel Review Workshop. Three reviewers were selected by the CIE and provided with the assessment report and background materials. Each reviewer conducted a review of the material and produced an independent review report.

No clear status determination can be made from the assessment as the independent reviewers differed on the appropriateness of the assessment for making such determinations.

Stock Status and Determination Criteria

Data limitations in the US Caribbean preclude the use of advanced quantitative analyses that provide measures of uncertainty. However, the following conclusions can be drawn based on the data-poor methods employed in this assessment, the fundamental principles of population dynamics, and an overall interpretation of the raw data.

Given the available information for this assessment, it is difficult to interpret the sustainability of the estimated current exploitation rates; therefore the overfishing status for blue tang in the U.S. Caribbean is unknown. The overfished status is also unknown.

Stock Identification and Management Unit

- Blue tang occur in the western Atlantic Ocean from New York to Rio de Janeiro (including Bermuda, the Gulf of Mexico, the Bahamas, the Caribbean, and the Central American coast), and have been reported as far southeast as Ascension (Carpenter 2002). They are shallow-water fish that are commonly on coral reefs and rocky habitats (Carpenter 2002; Reeson 1975). Occasionally seen in multi-species feeding aggregations, adult blue tang are herbivorous fish that graze diurnally on a wide variety of benthic algae (Carpenter 2002).The blue tang management areas within the U.S. Caribbean include the islands of Puerto Rico and the U.S. Virgin Islands (USVI) including St. Thomas, St. John, and St. Croix. The state waters of Puerto Rico extend 9 nm from the shore and the state waters of the USVI extend 3 nm from shore.

Assessment Data

- Species-specific self-reported commercial landings are available from 1983 – 2011 for Puerto Rico
- Commercial landings in St. Croix could only be provided for surgeonfishes (all species combined) due to a lack of species-species specific reporting by commercial fishers. In St. Croix, landings data were available for the years 1998-2011.
- Commercial landings of blue tang in St. Thomas and St. John were the self-reported logbook records from 2000-2011. Landings could only be provided for surgeonfishes (all species combined) due to a lack of species-specific reporting by commercial fishers.
- Recreational landings and discard estimates are available for Puerto Rico for the years 2000-2011 via MRFSS/MRIP however data were not used in quantitative or qualitative analyses to

determine overfishing status, due to the paucity of intercepted blue tang. No recreational information was available for the USVI.

- Commercial length data were available from the Trip Interview Program:
  - Pots and Traps data from St. Croix for years 1985-2011
  - Pots and Traps data from St. Thomas/St. John for years 1983-1988, 1991-1996, 2002-2006, 2008-2010
- The reported ranges for age and growth parameters were:
  - L_{inf} : 188mm-246mm FL
  - K: 0.39-1.03 per year
- The following life history parameter inputs were used in the length-frequency analysis:
  - Lower and upper values for K= 0.39 and 1.03 per year used in sensitivity.
  - Lower and upper values (in mm) used in sensitivity analyses for L_{inf} were 188mm and 231mm.

Release Mortality

No data on release mortality for blue tang in the U.S. Caribbean exists. Release mortality information is not required for the length-based approach attempted in this assessment.

Assessment Methods

Puerto Rico

Mean-length analyses were not conducted for the fisheries of Puerto Rico because the available length samples were considered insufficient by the AW panel. Therefore, the available length data from Puerto Rico were not analyzed.

USVI

- The length frequency analysis for blue tang pot and trap fishery focused on time series analyses and relative differences in total mortality estimates rather than on absolute values of total mortality due to considerable uncertainty in age-growth parameters.
- Total mortality (Z) estimates and the ability to detect changes in mortality were explored using a variant of the Beverton-Holt length-based mortality estimator.

Fishing Mortality Trends

Estimates of total mortality can be translated to fishing mortality (F) by subtracting natural mortality (M). Lacking direct estimates of natural mortality, life history invariant relationships were used and given the uncertainty in total mortality estimates this was not pursued.

Stock Abundance and Biomass Trends

Given the data limitations, accurate estimates of stock abundance or biomass could not be developed.

Key Sources of Scientific Uncertainty

- The calculation of traditional benchmarks based on MSY theory using the mean length mortality estimation method were not derived due to considerable uncertainty in the available life-history parameters. Lack of current, species-specific life history information greatly hindered the assessment.
- Small sample size for the length data in in the 1980s and in recent years (2006 to present) complicated the interpretation of the results.
- Blue tang are a seemingly fast growing fish species with a long life-span. Beyond the age of five, length information is not informative about the age-structure of blue tang populations. A better understanding about how fishing mortality influences population structure will come from collection of catch-at-age data.

Projections:

Given the data limitations, projections for future status could not be constructed. Furthermore, the AW panel acknowledged that projections were not appropriate for the blue tang stocks due to concerns about life history parameters.

Figures

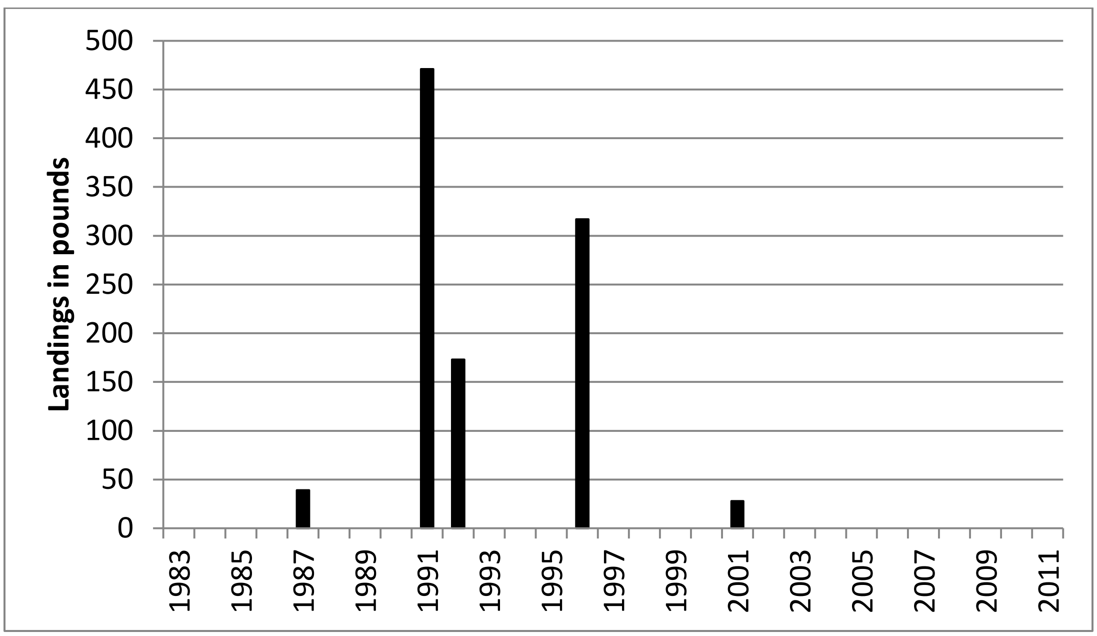

Figure 1. Puerto Rico yearly commercial fishery expanded landings of surgeonfishes reported for all gears, 1983-2011. Note: data from all gears were combined due to small sample sizes and confidentiality constraints. (*Figure 1 in the Assessment Workshop Report*)

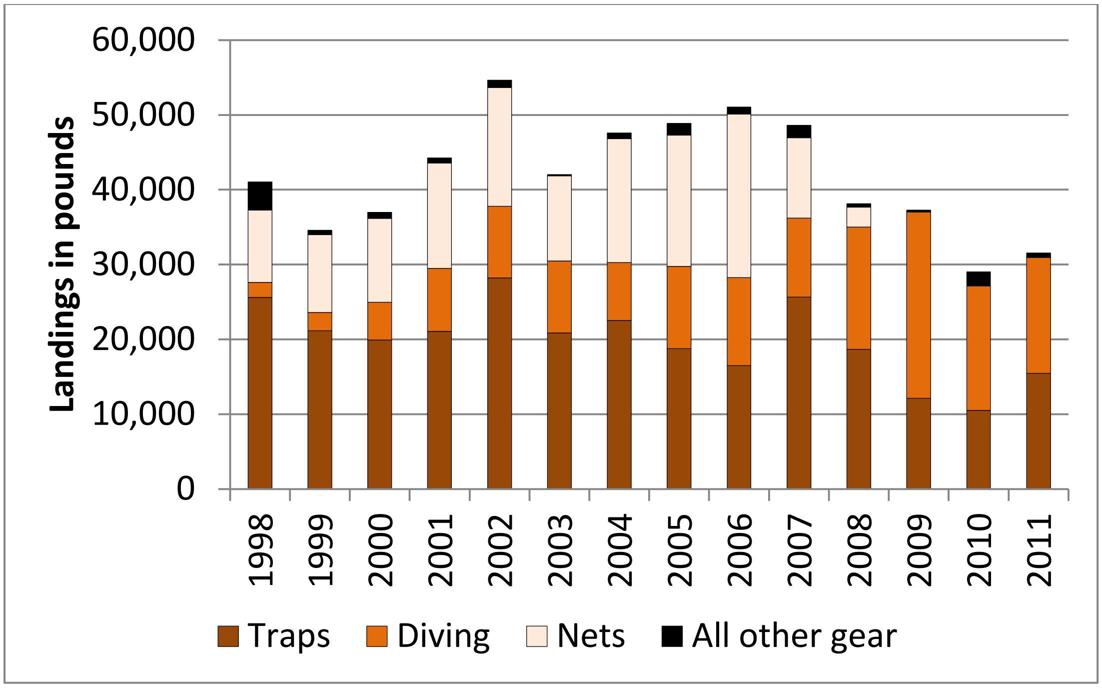

Figure 2. Yearly commercial landings of surgeonfishes as reported (no expansion factors applied) on fisher logbooks from St. Croix by gear and year. *(Figure 6 from the Assessment Workshop Report*)

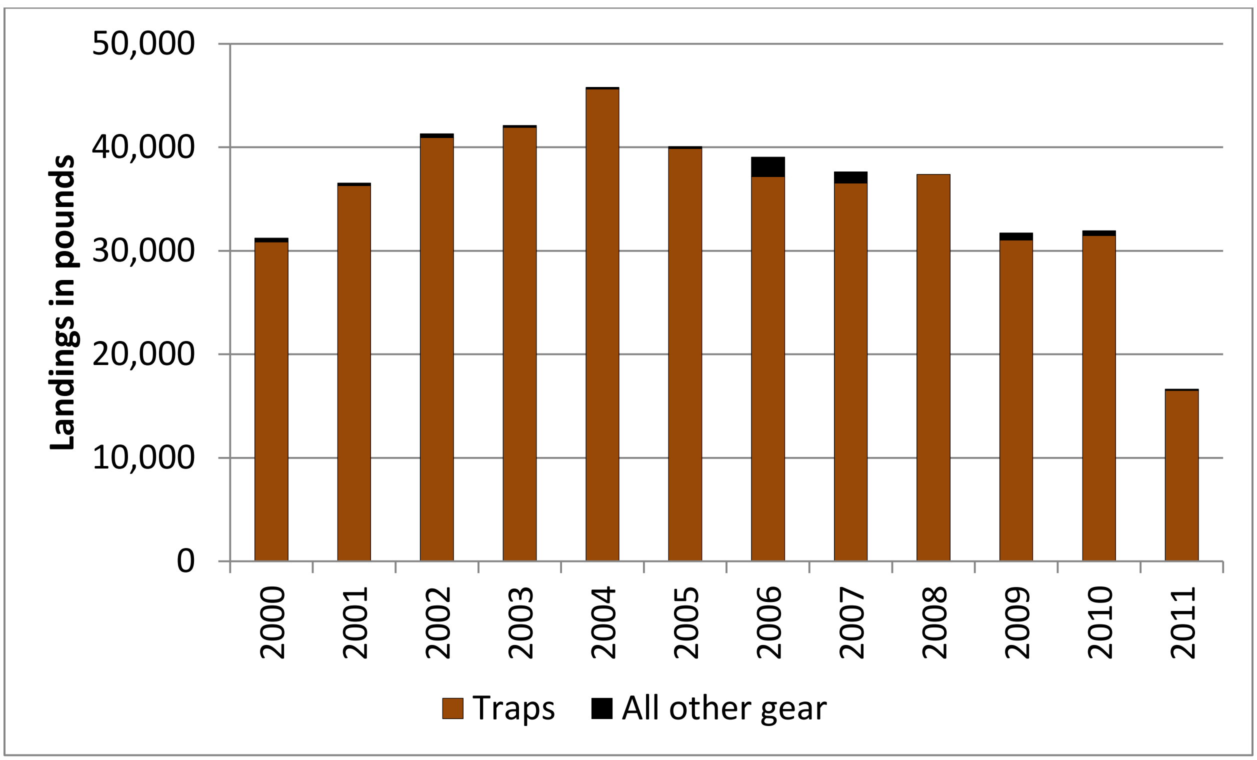

Figure 3. Yearly commercial landings of surgeonfishes as reported (no expansion factors applied) on fisher logbooks from St. Thomas and St. John by gear and year. *(Figure 4 from the Assessment Workshop Report*)

6. SEDAR ABBREVIATIONS

ABC	Allowable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BMSY	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort
F	fishing mortality (instantaneous)
F_{MAX}	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F_{MSY}	fishing mortality to produce MSY under equilibrium conditions
F_{OY}	fishing mortality rate to produce Optimum Yield under equilibrium
$F_{XX\%\ SPR}$	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
F_0	a fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fisheries and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	general linear model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MFMT	maximum fishing mortality threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MRIP	Marine Recreational Information Program
MSST	minimum stock size threshold, a value of B below which the stock is deemed to be overfished

MSY	maximum sustainable yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	optimum yield
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS Corporation
SC DNR	South Carolina Department of Natural Resources
SEDAR	Southeast Data, Assessment and Review
SEFSC	Fisheries Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Fisheries Southeast Regional Office, National Marine Fisheries Service
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 30

U.S. Caribbean Blue Tang

SECTION II: Assessment Process Report

January 2013

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

Table of Contents

1. WORKSHOP PROCEEDINGS

1.1. INTRODUCTION

1.1.1 Workshop time and Place

The SEDAR 30 Assessment Workshop was held October 16-18, 2012 in Miami, Florida.

1.1.2 Terms of Reference

1. Review any changes in data following the data scoping and any analyses suggested by the data scoping. Summarize data as used in each assessment model.
2. Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered.
3. Provide estimates of stock population parameters, if feasible
    - When available, include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as necessary to describe the population
    - Include appropriate and representative measures of precision for parameter estimates.
4. Characterize uncertainty in the assessment and estimated values.
    - Consider uncertainty in input data, modeling approach, and model configuration.
    - Consider other sources as appropriate for this assessment
    - Provide appropriate measures of model performance, reliability, and 'goodness of fit'
    - Provide measures of uncertainty for estimated parameters
5. Provide evaluations of yield and productivity
    - Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models
6. Provide estimates of population benchmarks or management criteria consistent with the available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.
    - Evaluating existing or proposed management criteria as specified in the management summary
    - Recommend proxy values when necessary
7. Provide declarations of stock status relative to benchmarks or alternative data-poor approaches if necessary.
8. Perform a probabilistic analysis of proposed reference points, stock status, and yield.
    - Provide the probability of overfishing at various harvest or exploitation levels
    - Provide a probability density function for biological reference point estimates.
    - If the stock is overfished, provide the probability of rebuilding within mandated time periods as described in the management summary or applicable federal regulations.

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:

   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)

   D) If data-limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice.

10. Provide recommendations for future research and data collection.
    - Be as specific as practicable in describing sampling design and sampling intensity
    - Emphasize items which will improve future assessment capabilities and reliability
    - Consider data, monitoring, and assessment needs

11. Complete the Assessment Workshop Report for Review (Section III of the SEDAR Stock Assessment Report).

1.1.3. List of Participants

Assessment Workshop Panel

Adyan Rios..NMFS SEFSC Miami
Daniel Matos..PR DNER
Francisco Pagãn..Caribbean Coral Reef Institute
Kevin McCarthy..NMFS/SEFSC/Miami
Meaghan Bryan..NMFS/SEFSC
Nancie Cummings..NMFS/SEFSC/Miami
Richard Appeldoorn..SSC Representative/University of Puerto Rico

Council Representation

Carlos Farchette..CFMC

Appointed Observers

Carlos Velazquez..Industry Representative/Puerto Rico
Daryl Bryan..Industry Representative/St. Thomas
Gerson Martinez..Industry Representative/St. Croix
Gregory Ledee..Industry Representative/St. Thomas

Attendees

Shannon Cass-Calay..NMFS/SEFSC/Miami
Clay Porch..NMFS/SEFSC/Miami

Staff

Andrea Grabman..SEDAR
Bill Arnold..SERO
Graciela García-Moliner..CFMC Staff
Julia Byrd..SEDAR
Julie A. Neer..SEDAR
Michael Larkin..SERO

1.1.4. List of Assessment Process Working and Reference Papers

Document #	Title	Authors
Documents Prepared for the Assessment Workshop		
SEDAR30-AW-01	Summary of recreational catch and effort for blue tang and queen triggerfish caught in Puerto Rico since 2000	Meaghan Bryan
SEDAR30-AW-02	Evaluation of the available length-frequency information in the US Caribbean Trip	Meaghan Bryan

	Interview Program (TIP) data	
SEDAR30-AW-03	A review of the life history characteristics of blue tang and queen triggerfish	Adyan B. Rios
SEDAR30-AW-04	Commercial fishery landings of queen triggerfish and blue tang in the United States Caribbean, 1983-2011	Kevin J. McCarthy
	Reference Documents	
SEDAR30-RD01	A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of St. Thomas, U.S. Caribbean	MRAG Americas
SEDAR30-RD02	A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of U.S. Caribbean (Saint Croix)	MRAG Americas

1.2. PANEL RECOMMENDATIONS AND COMMENT

1.2.1. Term of Reference 1

Review any changes in data following the data scoping and any analyses suggested by the data scoping. Summarize data as used in each assessment model.

Commercial landings were presented for Puerto Rico, St. Thomas/St. John, and St. Croix. The recreational intercept data and the length-frequency data from the Trip Interview Program (TIP) were also reviewed. Basic data inputs for this assessment, such as length-frequency data by island and gear, and life history information from published literature, were reviewed in detail.

1.2.2. Term of Reference 2

Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered.

The AW panel recognized that the length-frequency data from TIP were the most consistent species-specific data available for blue tang. As such, the length based total mortality estimator (Gedamke and Hoenig 2006) was applied to the available length data. This approach was only applied to the St. Thomas/ St. John and St. Croix pot and trap fisheries data. The approach was not applied to the data from Puerto Rico due to very limited sample size.

1.2.3. Term of Reference 3

Provide estimates of stock population parameters, if feasible

- *When available, include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as necessary to describe the population*
- *Include appropriate and representative measures of precision for parameter estimates.*

Fishing mortality estimates were derived from total mortality estimates from the Gedamke-Hoenig length-based mortality estimator and natural mortality estimates from several published equations. The AW panel expressed concerns regarding the life history parameters, their influence on the model results, and whether the estimates were meaningful. Sensitivity analyses were conducted to illustrate the influence of the input parameters on the estimates of fishing mortality and the potential uncertainty in the fishing mortality estimates.

1.2.4. Term of Reference 4

Characterize uncertainty in the assessment and estimated values.

- *Consider uncertainty in input data, modeling approach, and model configuration.*
- *Consider other sources as appropriate for this assessment*
- *Provide appropriate measures of model performance, reliability, and 'goodness of fit'*
- *Provide measures of uncertainty for estimated parameters*

Since considerable uncertainty exists in the absolute estimates of total mortality from the mean length analysis, a comprehensive sensitivity analysis was conducted.

1.2.5. Term of Reference 5

Provide evaluations of yield and productivity

- *Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models*

Due to limited data and concerns regarding life history parameters, the AW panel did not recommend calculations of yield-per-recruit, spawner-per-recruit, and stock-recruitment estimations. The data limitations are discussed throughout the model results and discussion sections.

1.2.6. Term of Reference 6

Provide estimates of population benchmarks or management criteria consistent with the available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.

- *Evaluating existing or proposed management criteria as specified in the management summary*
- *Recommend proxy values when necessary*

Derived fishing mortality estimates are discussed with regard to natural mortality, which can be used as a proxy for F_{MSY}. However, due to data limitations, concerns regarding the life history parameters and the resulting uncertainty in the model results, the AW panel concluded that useful population benchmarks could not be developed during this assessment.

1.2.7. Term of Reference 7

Provide declarations of stock status relative to benchmarks or alternative data-poor approaches if necessary.

The AW Panel concluded that this was not applicable to this assessment given the data limitations.

1.2.8. Term of Reference 8

Perform a probabilistic analysis of proposed reference points, stock status, and yield.

- *Provide the probability of overfishing at various harvest or exploitation levels*
- *Provide a probability density function for biological reference point estimates.*
- *If the stock is overfished, provide the probability of rebuilding within mandated time periods as described in the management summary or applicable federal regulations.*

The AW Panel concluded that a probabilistic analysis of proposed reference points was not possible given data limitations.

1.2.9. Term of Reference 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:

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)
D) If data-limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice.

Due to the limited data available, a data poor methodology was attempted that does not include projections of stock dynamics. Therefore, projections were not conducted for this analysis. Furthermore, the AW panel acknowledged that projections were not appropriate for the blue tang stocks due to incomplete data and concerns about life history parameters.

1.2.10. Term of Reference 10

Provide recommendations for future research and data collection.

- *Be as specific as practicable in describing sampling design and sampling intensity*
- *Emphasize items which will improve future assessment capabilities and reliability*
- *Consider data, monitoring, and assessment needs*

The ability to utilize length-frequency data is contingent upon having reliable estimates of life history parameters (von Bertalanffy parameters in particular). Studies on basic life history (e.g. age-growth relationships and estimating natural mortality) in the US Caribbean will greatly enhance the utility of the existing length-frequency data and should provide the greatest benefit to providing management advice in the short term. Studies should be carefully planned to ensure a representative sample of individuals by age/size, region, season etc. This type of research should be placed as a top priority for key species.

Blue tang are a seemingly fast growing fish species with a long life-span. Beyond the age of five, length information is not informative about the age-structure of blue tang populations. A better understanding about how fishing mortality influences population structure will come from collection of catch-at-age data. Sampling efforts should be carefully planned to ensure representative sampling of individuals by fishing gear, mode, region, season etc.

Fishery-independent surveys should be considered as a top research priority for additional data collection. Fishery-independent surveys designed using a rigorous statistical framework will allow for the collection of species-specific catch and effort data that can be used to develop indices of abundance. Indices of abundance are used in stock assessments to inform models about how a population may be changing over time. Fishery-independent surveys can also be used to supplement existing programs by collecting age, length, weight, and reproductive data.

It is essential that continued efforts to improve the data collection of fishery-dependent catch and effort statistics be made. More specifically, continued efforts to collect species-specific catch statistics will be important for future assessments.

2. DATA REVIEW

2.1. Commercial landings

A detailed description of the methods and results of the commercial landings calculations can be found in working paper SEDAR30-AW-04.

Puerto Rico

Commercial fishery landings data for Puerto Rico were available from self-reported fisher logbooks/sales receipts for the years 1983-2011. Data were reported by species, fishing gear, and fishing center where the catch was landed. Puerto Rico commercial landings have been incompletely reported (Caribbean Fisheries Data Evaluation Final Report, 2009) and required expansion factors to estimate total landings. For the years 2003 to 2011, expansion factors have been coast-specific (north, south, east, and west). Estimation of commercial fishery landings of earlier years used a single, island-wide, expansion factor.

Puerto Rico landings were estimated as: year-specific reported landings * year-specific expansion factor. Estimation of landings for the most recent years (2003-2011) included year and coast-specific expansion factors. Reported landings were assigned to coast based upon the fishing center reported for a trip. Blue tang landings from Puerto Rico had been reported within the species group surgeonfishes; but not by species. The proportion of blue tang within the surgeonfishes species group is unknown. Yearly total expanded surgeonfish landings for Puerto Rico are provided in Table 1 and Figure 1. The numbers of trips with reported surgeonfishes landings are plotted in Figure 2 (by coast) and Figure 3 (by gear).

St. Thomas and St. John

In the US Virgin Islands logbook landings data from the islands of St. Thomas and St. John were compiled separately from St. Croix. Logbook reporting began in 1974; however, landings were initially reported by gear type (e.g., net fish, hook fish, pot fish, and spear fish) and as either snapper/grouper or as other fin fish during the period 1974-1995. Beginning in 1997 in St. Thomas/St. John, some landings data were reported by species group; (e.g., snappers, groupers, parrotfishes, surgeonfishes, etc.) and by gear (hook and line, gill net, SCUBA, trap, etc.). All commercial fishery data reports began including species group in 2000. Species-specific data were reported in the US Virgin Islands during the 2011-2012 fishing year.

The data available for calculating commercial landings of blue tang were the self-reported logbook records from commercial fishers. Landings could only be provided as surgeonfishes (all species combined) due to the lack of species-specific reporting by commercial fishers. Yearly landings data, as reported, were summed by species group and fishing gear and are provided in Table 2 and Figure 4. The numbers of commercial fishing trips with landings of surgeonfishes in St. Thomas and St. John are shown in Figure 5 by gear and year. The landings and number of trips decline in 2011 and are a little more than half those in 2010. This drop in blue tang landings and trips in 2011 may be due to changes in reporting with the commencement of reporting forms. Changes in reporting should be more fully investigated in the future.

St. Croix

The section above (St. Thomas and St. John) contains a brief description of the available landings data which also pertains to St. Croix. Landings could only be provided for surgeonfishes (all species combined) due to the lack of species-specific reporting by commercial fishers. In St. Croix, landings data were available for the years 1998-2011. Yearly landings data, as reported, are provided in Table 3 and Figure 6 (by gear and year). The numbers of commercial fishing trips with landings of surgeonfishes in St. Croix are shown in Figure 7 by gear and year.

2.2. Recreational data

A detailed summary of the available recreational fishery data collected by the Marine Recreational Fisheries Statistics Survey (MRFSS) can be found in working paper SEDAR30-AW-01. During the assessment workshop (AW) the recreational data from MRFSS were evaluated to determine 1) whether the intercept data could be used to develop a relative index of abundance for blue tang and 2) whether the length data was sufficient to use for length-based analyses. In the US Caribbean, MRFSS only collects data in Puerto Rico. Tables 4 and 5 show that the number of intercepted trips that caught blue tang was small and the number of length measurements was negligible. The AW panel determined that at the current time, these data are not useful for the assessment of blue tang given the paucity of intercepted recreational fishing trips catching this species.

2.3. Life history

A detailed summary of the life history of blue tang can be found in working paper SEDAR-AW-03. Table 6 summarizes the defined age-length relationships found in the literature. Two studies, Choat and Robertson (2002) and Mutz (2006) provided estimates of the von Bertalanffy growth parameters from various locations in the Caribbean for blue tang. Figure 8 illustrates the von Bertalanffy growth curves derived from the parameters summarized in Table 6. The differences among the von Bertalanffy growth coefficients cause the curves to approach the asymptotic lengths at different rates, but in general the asymptotic length is reached by age five (Figure 8). Beyond the age of five, length is not informative about blue tang age.

Table 9 illustrates the relationship between the von Bertalanffy growth coefficient and the asymptotic length for blue tang. These parameters are generally negatively correlated, which seems true for many of the parameter pairs obtained from the literature (Figure 9). The estimates of the von Bertalanffy growth coefficient and the asymptotic length for Los Roques (Mutz, 2006) are exceptions (Figure 9). The estimated growth coefficients also separated into two groups, K~0.4 and between K~ 0.82 and 1, which describe considerably different growth rates (Figure 9). Given the uncertainty in the growth parameters, a sensitivity analysis was carried out to evaluate the full range of available estimates for these parameters.

2.4. Length-frequency data

Working paper SEDAR30-AW-02 provides a detailed description of the available length-frequency data from the NMFS Trip Interview Program (TIP). A summary of the annual blue tang length measurements can be found in Appendix A in SEDAR30-AW-02.

Table 7 provides a general summary of the total number of blue tang lengths measured, the number of years in which blue tang were measured, and the average number of measured lengths per year. The total number of blue tang length measurements from Puerto Rico was small compared to St. Thomas/St. John or St. Croix. The greatest number of blue tang length measurements were associated with the pot and trap fisheries in St. Thomas/St. John and St. Croix (Table 7). The AW panel agreed that the data available from the pot and trap fisheries in St. Thomas/St. John and St. Croix had sufficient annual sample sizes for length-based analyses. Concerns were raised about the relationship between the observed lengths and the published age-length information. This will be discussed in more detail during the discussion of the model results. In this section, the length frequency data for the pot and trap fisheries in St. Thomas/St. John and St. Croix will be summarized.

Figure 10 shows the annual length-frequency data for blue tang from the St. Thomas/St. John pot and trap fishery available in the TIP database. Annual sample size varied throughout the time-series with an overall size range between 5cm and 40cm. Early in the time-series, especially in 1986, the right tail of the distribution was a prominent feature with many lengths greater than 25cm (Figure 10). The range of the length-frequency distributions varied over time, as did the mode of the respective distributions (Figure 10, Table 8). Although blue tang lengths greater than or equal to 25cm were observed later in the time-series, they were not consistent observations (Figure 10). The mode of each annual length-frequency distribution was identified to determine the length at which blue tang were fully vulnerable to fishing. The range of the annual mode estimates varied considerably and between 15cm and 21cm (Table 8).

Figure 11 shows the annual length-frequency data from the St. Croix pot and trap fishery available in the TIP database. Annual sample size varied throughout the time-series with an overall size range between 10cm and 40cm. The length-frequency distributions were stable over time and the annual modes were also stable (Figure 11, Table 9). The range of the annual mode estimates was between 17cm and 19cm (Table 9).

3. Length-Based Mortality Estimator Methods

3.1. Overview

A review of the length frequency data available from the NMFS TIP database indicated that sample sizes were sufficient to conduct a time-series length analysis for a limited number of island and gear combinations (Table 7). Total mortality (Z) estimates and the ability to detect changes in mortality were explored using a variant of the Beverton-Holt length-based mortality estimator (Beverton and Holt 1956, 1957).

3.2. Data sources

The AW panel reviewed the only available source of information regarding length composition, the TIP database, and recommended that these data be used for the analysis. The input values for other parameters populating the model were gathered from the available literature. Preliminary analyses were performed using the values summarized in Table 10. The input values for the von Bertalanffy growth parameters were gathered from Mutz (2006) and represent the age-length relationships for three areas found in the Caribbean. The SEDAR 30 AW panel noted considerable uncertainty about the existing values of von Bertalanffy growth parameters in relation to available lengths data from TIP. This will be discussed along with the model results in a later section of this report.

3.3. Model configuration and equations

The Beverton-Holt mortality estimator has received widespread use, especially in data-limited situations, owing mainly to the minimal parameter inputs, namely the von Bertalanffy growth parameters K and L_∞, the length of first capture (smallest size at which animals are fully vulnerable to the fishery and to the sampling gear), L_c, and the mean length of the animals ($\bar{L}$) above the length L_c:

$$Z = \frac{K(L_\infty - \bar{L})}{\bar{L} - L_c}$$

There are six assumptions behind this method:

1. Asymptotic growth with known parameters K and L_∞ which are constant over time.

2. No individual variability in growth.

3. Constant and continuous recruitment over time.

4. Mortality rate is constant with age for all ages $t > t_c$, where t_c is the age at first capture.

5. Mortality rate is constant over time.

6. Population is in equilibrium (i.e., enough time has passed following any change in mortality that mean length now reflects the new mortality level).

A criticism of this method is that the assumption of equilibrium (6) is very difficult to meet in the real world situations where any change in fishing pressure disrupts the equilibrium age distribution. For example, with increased fishing pressure, there is a delay before larger/older animals are removed from the population and before the mean length decreases in accordance with the current mortality rate. Likewise, when fishing pressure is decreased, equilibrium can only be reestablished once the smaller/younger animals have grown, and the mean length increases in accordance with the reduced mortality rate.

Gedamke and Hoenig (2006) developed an extension of the Beverton-Holt length-based mortality estimator for use in non-equilibrium situations. This method is quantitatively attractive because it requires minimal and commonly available data, and it does not require the assumption that catch rate is proportional to abundance. The method also allows for a broader application of the mean length approach as it does not require an assumption of equilibrium, which is not often met in real world situations. In addition, the transitional form of the model allows mortality estimates to be made within a few years of a change, rather than having to wait for the mean lengths to stabilize at their new equilibrium level. In other words, as soon as a decline in mean lengths is detected, this model can be applied and the trajectory of decline can be used to estimate the new *Z* and how mean lengths will change over time.

The method is described in detail in Gedamke and Hoenig (2006) and is summarized below. Like the Beverton and Holt estimator, this extension only requires a series of mean length above a user defined minimum size and von Bertalanffy growth parameters. Therefore, it can be applied in many data poor situations. Gedamke and Hoenig (2006) demonstrated the utility of this approach using both simulated data and an application to data for goosefish caught in the NEFSC fall groundfish survey.

The mean length in a population can be calculated *d* years after a single permanent change in total mortality from Z_1 to Z_2 yr^{-1} by the following equation:

$$\bar{L} = L_\infty - \frac{Z_1 Z_2 (L_\infty - L_c)\{Z_1 + K + (Z_2 - Z_1)\exp(-(Z_2 + K)d)\}}{(Z_1 + K)(Z_2 + K)(Z_1 + (Z_2 - Z_1)\exp(-Z_2 d))}$$

This equation has been generalized to allow for multiple changes in mortality rate over time (e.g. one change, two changes, three changes etc.). The algorithm was programmed in AD Model Builder in a maximum likelihood framework and used to estimate mortality rates from the observed mean lengths. A shell program was written in R to conduct a grid search of potential year(s) of change and also to conduct a sensitivity analysis to input parameters.

Models were run starting with the simplest (i.e. no change in mortality) and then with increasing complexity by sequentially adding the number of change years (Note: each year of change adds two parameters). The Akaike Information Criterion with a correction for small sample size (AIC_c) was calculated for each scenario and will be referred to simply as AIC throughout the remainder of this document. To compare models, the change in AIC (ΔAIC, the difference between AIC and the minimum AIC) was also calculated. When comparing models, a ΔAIC value less that 2 indicated strong support for the model and a ΔAIC value between 3 and 5 indicated moderate support for the model (Burnham and Anderson, 2002).

The first step in the application of this mean-length approach is to determine the length at which animals become fully vulnerable to the gear, L_c. Annual length-frequency plots were constructed for island gear combinations for which sufficient sample sizes were available. L_c was selected visually (Thorson and Prager, 2011) and estimates of central tendency were also calculated to inform the selection. The highest L_c value over the time series was chosen as the input for preliminary runs and the central value from which to develop a sensitivity range. Using the highest L_c value avoids violating model assumptions and the confounding of selectivity and mortality in the calculation of annual mean lengths. The three values of L_c that were identified from the St. Thomas/St. John pot and trap fishery were 19cm, 20cm, and 21cm for use in the preliminary analyses (Table 10, Figure 10). The three values of L_c that were identified from the St. Croix pot and trap fishery for use in the preliminary analyses were 18cm, 19cm, and 20cm (Table 10, Figure 11). The lower value was chosen to avoid confounding between changes in selectivity and total mortality.

3.4. Estimated parameters

The parameters estimated by the non-equilibrium length method, as described above, are the total mortality rates (*Z*) and the year(s) of change. The total mortality in the most recent time periods is referred to $Z_{current}$ for the remainder of the document.

3.5. Uncertainty and measures of precision

Considerable uncertainty in the von Bertalanffy growth parameters was acknowledged by the SEDAR 26 AW panel. As such, a comprehensive sensitivity analysis was conducted to determine the impact this uncertainty on estimates of total mortality.

The range of the von Bertalanffy growth parameter (*K*) explored was 0.39-1.03 in increments of 0.1. The range of the asymptotic growth parameter (L_∞) explored was 18.8cm – 24 cm. These ranges were developed from the estimates available in the published literature from the Caribbean (Table 6).

4. Model Results

4.1. Puerto Rico

Mean-length analyses were not conducted for the fisheries of Puerto Rico because the available length samples were considered insufficient by the AW panel. Therefore, the available length data from Puerto Rico were not analyzed.

4.2. St. Thomas and St. John

Preliminary model runs

The AIC results for the preliminary analyses are summarized in Table 11 and Table 12. For illustrative purposes, Table 11 includes parameter combinations that were not biologically plausible. For example, there were some parameter combinations where the L_c was greater than the L_∞, which is the theoretical maximum length of the population. This is a biologically unreasonable assumption and the results from these model runs are not meaningful. In all model runs where L_c was greater than L_∞, the total mortality estimate reached the upper bound that was placed on this parameter. The lower bound imposed on the total mortality parameter was reached when L_c and L_∞ were within one centimeter of one another. Similar L_c and L_∞ values led to mean lengths that were similar to the L_∞ over time. In these situations, the mean length data indicated that the population had experienced minimal mortality over time and the model estimates of total mortality were constrained at zero (Table 11, Table 12).

The model converged for two input parameter combinations that used 0.49 and 23.1cm as the values for K and L_∞, and L_c values equal to 19cm and 20cm (Table 11). The model with the lowest AIC value and also the strongest support from AIC criteria predicted one change in total mortality in either 1983 or 2000 (Table 11, see the results highlighted in gray). The model run using 19cm as the input value for L_c predicted that total mortality increased from 0.09 to 0.4 after 1983, a 300% increase. The year 1983 is the first year for which data were available and there was a subtle decline in the annual mean length after 1983 (Figure 12). There was not sufficient evidence that any other model was strongly supported by AIC criteria (i.e., ΔAIC was not less than 2). The model run using 20cm as the input value for L_c predicted that total mortality increased from 0.05 to 0.42 after 2000, a 740% increase. Figure 13 shows the model fit to the mean length data. After 2000, mean length declines. Prior to 2000, the mean lengths are quite variable as compared to the mean lengths after 2000.

Sensitivity analysis

Models predicting no change or one change in blue tang total mortality were strongly supported by AIC criteria for the majority of sensitivity runs, irrespective of the input parameter values (Table 13, gray highlighted cells). The runs were almost evenly split between the model predicting no change in total mortality and the model predicting one change. The sensitivity runs predicting no change resulted in very low estimates of total mortality, which was due to similar L_c and L_∞ values. An L_c value similar to the asymptotic lengths resulted in mean lengths that were also similar to the L_∞, informing the model that the blue tang population experienced very little mortality. For those sensitivity runs that strongly supported a single year of change in total mortality, the predicted year of change was ambiguous (Table 14). Almost all years were selected for a number of sensitivity runs; however, the highest number of sensitivity runs (14) predicted 2001 as the year of change in blue tang total mortality (Table 14).

Figure 14 shows the absolute estimates of current total mortality and also shows the obvious sensitivity to the input values. The current total mortality estimates for blue tang ranged between ~0 and 1.25 (Figure 14). In general, higher values of the von Bertalanffy growth coefficient and higher values of the asymptotic length led to higher values of total mortality. The only exceptions were for those parameter combinations where the L_c was less than, but within, 2cm of the L_∞. In these cases, total mortality was estimated to be close to zero, and was associated with those sensitivity runs that did not support a change in total mortality. In this situation the resulting mean length was similar to the asymptotic length, informing the model that mean size remained close the theoretical maximum and the blue tang population has experienced very little mortality.

Table 15 summarizes the percent change in total mortality for the sensitivity runs that resulted in strong support for the model predicting a single change in total mortality. In all cases a decrease in mean length was observed, which caused the model to predict that total mortality had increased. The magnitude of change was greater than 100% in all cases (Table 15). There were several sensitivity runs that resulted in a percent increases that was questionable (e.g., an increase in total mortality that was 10,000 times greater than the previous time period). In all of these cases, the total mortality estimated for the first time period was close to zero.

The highest value of the range examined for the length-at-full vulnerability (L_c) is probably unrealistic. It was included because in two years, 2008 and 2009, the mode of the length-frequency histogram was approximately 21cm (Table 8, Figure 10). The sample sizes were fairly low in both years, more realistic length-at-full vulnerability values for the St. Thomas/St. John pot and trap fishery were between 19cm and 20cm. For these values, the corresponding current total mortality estimates ranged between 0.25 and 1.25 over the range of the von Bertalanffy growth parameters.

Fishing mortality was derived from the minimum and maximum total mortality estimates from the sensitivity analysis and compared to estimates of natural mortality. A rule of thumb that is sometimes adopted in data poor situations is that the fishing mortality to achieve maximum sustainable yield (F_{MSY}) is approximately equal to natural mortality. Fishing mortality estimates greater than natural mortality indicate a fishery is experiencing overfishing while fishing mortality estimates less than natural mortality indicate that a fishery is not experiencing overfishing. Our ability to derive appropriate estimates of fishing mortality is also dependent on having a reliable estimate of natural mortality.

Natural mortality estimates derived from several published equations are presented in Table 16. The natural mortality estimates varied greatly among the natural mortality equations with a range of 0.01 to 2.03. The AW panel suggested that the Pauly equation (Pauly 1980) be used since the von Bertalanffy growth coefficient and the asymptotic length are both included in the equation, and may be robust to their negative correlation. The natural mortality estimates from the Pauly equation ranged between 1.01 and 2.03 (Table 16). The corresponding fishing mortality rates were quite small, and in many cases negative, indicating that the current fishing mortality for blue tang in St. Thomas/St. John is low. These fishing mortality estimates were also less than the Pauly natural mortality estimate. Similar estimates of fishing mortality were obtained when using estimators reliant on the von Bertalanffy growth parameter alone or with the asymptotic length (Table 16, see values not highlighted in gray). Age based natural mortality estimators resulted in much lower estimates of natural mortality (Table 16, highlighted in gray). The fishing mortality estimates for blue tang derived from the age-based natural mortality estimates and the lowest total mortality estimate from the sensitivity analysis were generally less than the estimate of natural mortality. The fishing mortality estimates derived from the age-based natural mortality estimates and the highest total mortality estimate from the sensitivity analysis were all greater than the corresponding estimates of natural mortality (Table 16, values highlighted in gray).

4.3. St. Croix

Preliminary model runs

The AIC results from the preliminary analyses are summarized in Table 17 and Table 18. Only four parameter combinations resulted in a model that met convergence criteria, these are highlighted in gray in Table 17. AIC criteria strongly supported (i.e., ΔAIC = 1.484 and 1.54) a model that did not predict a change in total mortality for two of the parameter combinations (input values: L_c=18cm, L_∞=19.9cm, and K = 0.39 y^{-1}; L_c=20cm, L_∞=23.1, and K = 0.49 y^{-1}). The corresponding estimates of total mortality were 0.14 and 0.6. Alternatively, AIC criteria also strongly supported the model that predicted one change in total mortality for the two other sets of parameter combinations (input values: L_c=18cm, L_∞=23.1cm, and K = 0.49 y^{-1}; L_c=19cm, L_∞=23.1cm, and K = 0.49 y^{-1}). The corresponding total mortality estimates were 0.69 and 1.42, and 0.5 and 1.15. The predicted year of change for both model runs was 1983.

Figure 15, Figure 16, Figure 17, and Figure 18 illustrate the model fit to the mean length data for the four model runs. In each, the mean length in 1983 is approximately one to two centimeters larger than other mean lengths throughout the time series, however, only two model runs strongly support a single change in total mortality in 1983, where mean length declines and total mortality was predicted to increase after 1983 (Figure 16, Figure 17). The other two model runs indicate that mean length and total mortality did not change over time (Figure 15, 18).

Sensitivity analysis

Overall, a similar number of sensitivity runs strongly supported either the model predicting constant total mortality, the model predicting a single change in total mortality, or the model predicting two changes in total mortality (Table 19). For those sensitivity runs that resulted in strong support for a model that predicted a change in total mortality, the year of change or the first year of change was in 1983 (Table 20). For those sensitivity runs that resulted in strong support for a model predicting more than one change in total mortality, the second year of change was either 1985 or 1999 (Table 21).

Figure 19 illustrates the estimates of current total mortality and shows the sensitivity of the mortality estimates to the input parameters. In general, higher values of the von Bertalanffy growth coefficient and higher values of the asymptotic length led to higher values of total mortality. The only exceptions were for those parameter combinations where the length-at-full vulnerability was less than, but within, 1cm of the asymptotic length. In these cases, total mortality was estimated to be close to zero and was associated with those sensitivity runs that did not support a change in total mortality. In this situation the resulting mean length was similar to the asymptotic length, informing the model that mean size remained close the theoretical maximum and the blue tang population has experienced very little mortality.

The range of the current total mortality estimates from the sensitivity analysis, not including the estimates approximately equal to zero, was between 0.016 and 3.6 (Figure 19). A narrowed range of total mortality estimates between 0.25 and 2 was also developed, considering only the published age-length parameters and length-full-vulnerability (i.e. 19 cm) deemed most reliable by the AW panel (Table 9, Figure 11).

Percent change in total mortality was calculated for those sensitivity runs that strongly supported a single change in total mortality (Table 22, Table 23). All sensitivity runs predicted an increase in total mortality when a single change in total mortality was strongly supported (Table 22). The corresponding percent change in total mortality ranged between 100% and 345%. Focusing on the estimates corresponding to the published von Bertalanffy growth parameters, the range of percent change narrows to between 100% and 250% (Table 22). The increase in total mortality was predicted to occur after 1983 for the majority of sensitivity runs (Table 20). The sensitivity runs equally provided strong support for the model predicting two changes in total mortality. Total mortality was predicted to increase after the first change and percent change ranged between 70% and 1000% (Table 23). The majority of sensitivity runs predicted the first change occurred in 1983, similar to the model predicting one change in total mortality (Table 20). Considering only the published von Bertalanffy values, the range of percent change narrowed to an increase of total mortality between 70% and 600% (Table 23). The second change in total mortality was predicted to occur in either 1985 or 1999 and total mortality was predicted to decline (Table 20, Table 23). The percent decline was estimated to be between 31% and 100% (Table 23).

Fishing mortality was derived from the minimum and maximum total mortality estimates from the sensitivity analyses and compared to estimates of natural mortality. A rule of thumb that is sometimes adopted in data poor situations is that the fishing mortality to achieve maximum sustainable yield (F_{MSY}) is approximately equal to natural mortality. Fishing mortality estimates greater than natural mortality suggest a fishery is experiencing overfishing while fishing mortality estimates less than natural mortality indicate that a fishery is not experiencing overfishing. Our ability to derive appropriate estimates of fishing mortality is also dependent on having a reliable estimate of natural mortality.

Natural mortality estimates were derived to calculate fishing mortality estimates from total mortality (Table 24). The natural mortality estimates are the same as those derived for St. Thomas/St. John and will not be described here. The fishing mortality rates were then compared to the natural mortality rates, which were considered proxies for F_{MSY}. The fishing mortality estimates derived from the lowest total mortality estimates of the various sensitivity runs were less than natural mortality for most of the natural mortality estimators, except Alverson and Carney when the von Bertalanffy growth coefficient was approximately greater than or equal to 0.8 (Table 24). The fishing mortality estimates derived from the highest total mortality estimate were greater than natural mortality for all natural mortality estimators, except Pauly, when the von Bertalanffy growth coefficient was approximately equal to 0.4 (Table 24). All fishing mortality estimates derived from the Pauly natural mortality estimator were less than natural mortality (Table 24). These results confirm that our interpretation of fishing mortality status is highly dependent on the life history parameters and the natural mortality estimators.

5. Discussion

Although it is possible to identify overfishing if natural mortality can be considered a proxy for F_{MSY}, and natural mortality is well known, it is not possible to determine stock status relative to biomass based metrics using length-based analytic methods alone. Given the inherent data limitations, the AW panel concluded that the length-based approach should be applied to the blue tang length data from the TIP database to ascertain whether mortality has changed over time, to identify the direction of change and the relative magnitude of change, and to derive fishing mortality estimates from total mortality and estimates of natural mortality. The implications of these analyses are discussed below.

5.1. St. Thomas/St. John

The results from the sensitivity analysis using the length data from the St. Thomas/St. John pot and trap fishery indicates a change in total mortality may have occurred. Total mortality was predicted to increase for those sensitivity runs strongly supporting a change in total mortality. The year of change, however, was ambiguous. The magnitude of this proportional increase in total mortality was highly variable and strongly related to the von Bertalanffy growth coefficient, larger growth coefficient led to a greater predicted proportional increase in total mortality.

Natural mortality was used as a proxy for F_{MSY}. In data poor situations, this proxy is used to evaluate whether a fishery is experiencing overfishing. Natural mortality was estimated using a number of published equations that were reliant on either the von Bertalanffy growth parameters or maximum age. The comparisons of fishing mortality and natural mortality indicated that fishing mortality may or may not be greater than natural mortality. The fishing mortality estimates derived from the low estimate of total mortality that was associated with a von Bertalanffy growth coefficient equal to 0.4 was generally less than the natural mortality estimates, irrespective of the natural mortality estimator. The fishing mortality estimates derived from the high estimate of total mortality that was associated with a von Bertalanffy growth coefficient approximately equal to 0.8 were greater than natural mortality when natural mortality was derived from age-based estimators and less than natural mortality when natural mortality was derived from growth parameter-based estimators.

The length-frequency data indicate that since 1983, the length distributions have remained relatively stable. However, in the 1980s and from 2006 to the present, there were more frequent length measurements of blue tang from the St. Thomas/ St. John pot and trap fishery. The number of length measurements between these two time periods was quite small, making it difficult to determine whether the lack of larger blue tang is due to a sampling issue or fishing effects. This points to the need for more comprehensive and consistent sampling by the Trip Interview Program in St. Thomas.

The relative stability of the blue tang length-frequency data indicates that current fishing mortality experienced by blue tang in St. Thomas/St. John may be sustainable. It is difficult to definitively make this conclusion given that length data are not available prior to 1983. It is therefore unknown whether the annual length-frequency data from the St. Thomas/St. John pot and trap fishery observed between 1983 and 2011 reflect a shift in size from relatively unexploited times.

5.2. St. Croix

The results from the analysis of the blue tang length data from the St. Croix pot and trap fishery indicate that an increase in total mortality may have occurred in 1983. This increase in total mortality is due to a decrease in mean length after 1983, which remains fairly stable through the rest of the time series.

Fishing mortality was derived from the lower and upper total mortality estimates from the sensitivity analysis and natural mortality, which was estimated using various published equations. Comparisons of fishing mortality relative to natural mortality indicated that fishing mortality may or may not be greater than natural mortality. The fishing mortality estimates derived from the low estimate of total mortality that was associated with a von Bertalanffy growth coefficient equal to 0.4 was generally less than natural mortality, irrespective of the natural mortality estimator.

Examination of the annual length-frequency data for the time period when data were available (1983-2011), the annual length-frequency distributions for St. Croix have remained relatively stable over time. This indicates that the exploitation rates over this time period may be sustainable. It is difficult to definitely conclude that the exploitation rates have been sustainable since length data from years prior to 1983 are not available. It is, therefore, unknown whether this stable size distribution represents a new stable reduction in size or if this size distribution has been stable since fishing for blue tang began in St. Croix.

6. General conclusions

The absolute total mortality estimates, as well as the fishing and natural mortality estimates, from this analysis should be considered with caution. The techniques used are sound; however, the information contained in the available data makes it difficult to interpret the predicted mortality rates. Several published studies that described the von Bertalanffy growth relationship for blue tang and provided estimates of the von Bertalanffy growth parameters were available for this analysis. During the AW, the panel evaluated the published parameter sets and determined that there were two possible explanations for the growth of blue tang. The first was described by slower growth, K ~0.4, and the second was described by faster growth, K~0.8-1. The von Bertalanffy growth coefficient is an important input parameter that influences the estimate of total mortality, as was shown in the sensitivity analyses. It also served as the underpinning of the natural mortality estimates that were used to derive fishing mortality and evaluate the status of the fishery. The disparate estimates of growth led to considerable uncertainty in the mortality estimates. They also made it difficult to meaningfully interpret stock status in terms of fishing mortality, in the absence of a weighting system giving credence to one life-history strategy over another. The AW panel discussed the limitations of the available studies. Both suffered from small sample sizes and the size range from which they sampled was quite small. These concerns point to the need for well-designed growth studies for this species (and many other species in the US Caribbean).

Another cause for concern that weakens confidence in the absolute estimates of mortality, as was discussed by the AW panel, is that the blue tang age-length relationship erodes at a very early age relative to its lifespan. The foundation of length-based analytical tools is that changes in the size structure of the population reflect changes in the age structure of the population. Given that blue tang appear to reach their asymptotic length rather quickly, and larger fish may represent several age groups, the AW panel suggested that a length-based approach may not be appropriate for this species. It is strongly recommended that future data collection efforts focus on collecting catch-at-age data that will more adequately describe changes in the population structure of blue tang over time.

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8. Tables

Table 1. Puerto Rico expanded commercial landings of surgeonfishes, 1983-2011. Note, blue tang have not been reported by species; the species group surgeonfishes includes blue tang and other species. Surgeonfishes landings for certain years may not be presented due to confidentiality constraints. * indicates years in which data are available

Year	Surgeonfishes
1983	
1984	
1985	
1986	
1987	39
1988	
1989	
1990	
1991	471
1992	173
1993	
1994	
1995*	
1996	317
1997	
1998*	
1999*	
2000	
2001	28
2002*	
2003*	
2004	
2005	
2006	
2007	
2008	
2009	
2010	
2011	
Total	**1,106**

Table 2. St. Thomas and St. John reported commercial landings of surgeonfishes (no expansion factors applied), 2000-2011.

Year	Surgeonfishes
2000	31,215
2001	36,550
2002	41,305
2003	42,121
2004	45,806
2005	40,076
2006	39,040
2007	37,633
2008	37,385
2009	31,718
2010	31,927
2011	16,640
Total	**431,415**

Table 3. St. Croix reported commercial landings of surgeonfishes (no expansion factors applied), 1998-2011.

Year	Surgeonfishes
1998	41,040
1999	34,596
2000	36,992
2001	44,249
2002	54,632
2003	42,039
2004	47,570
2005	48,853
2006	51,062
2007	48,625
2008	38,127
2009	37,274
2010	29,035
2011	31,556
Total	**585,649**

Table 4. Summary of the MRFSS intercept data for blue tang by year. The summary includes the number of AB1 catch, which refers to the number of observed landed blue tang and blue tang reported as dead, number of B2 catch, which refers to the number of blue tang released alive, the number of trips catching blue tang; total number of intercepted trips catching any recreationally caught species in Puerto Rico, the proportion of trips catching blue tang, and the number of angler hours.

Year	AB1	B2	# of positive trips	Total # of trips	Proportion positive	Angler Hours
2000	0	0	0	737	0	3658
2001	1	1	2	768	0.003	4349
2002	0	0	0	517	0	3098.5
2003	1	0	1	812	0.001	5022
2004	0	0	0	621	0	3643.5
2005	0	0	0	426	0	2329
2006	0	0	0	366	0	2118.5
2007	0	1	1	572	0.002	2953.5
2008	0	0	0	623	0	3393.5
2009	0	1	1	581	0.002	3148.5
2010	0	0	0	588	0	3054.5
2011	0	0	0	774	0	3530.5
Total	2	3	5	7385	0.0006	40299

Table 5. The number of length measurements in the MRFSS database for blue tang.

Platform	Mode	Gear	Year	Number of observations
PR	Shore	Hook and line	2001	1
			2003	1

Table 6. Life history parameters for blue tang in the western Atlantic including: maximum age and length (FL: fork length; SL: Standard length; TL: total length), and the age-length relationship.

			Length -age $L_t = L_\infty(1-e^{K(t-to)})$				
Location	t_{max} (years)	L_{max} (mm)	L_∞	K	t_o	n	Source
San Blas	16	-	183 SL	0.477	-0.310	110	Choat and Robertson (2002)
Belize	15	242 FL	188 FL	1.030	-0.150	92	Mutz (2006)
Los Roques	20	285 FL	199 FL	0.390	-0.112	81	Mutz (2006)
Margarita	20	335 FL	-	-	-	74	Mutz (2006)
San Blas	16	261 FL	231 FL	0.490	-0.251	110	Mutz (2006)
Asencion	37	-	193 FL	0.403	-	-	Choat and Robertson (2002)
Lee Stocking	27	-	174 FL	0.817	-	-	Choat and Robertson (2002)
Asencion	37	304 FL	244 FL	0.420	-0.092	112	Mutz (2006)
Bermuda	43	250 FL	203 FL	1.010	-0.412	105	Mutz (2006)
Lee Stocking	27	256 FL	219 FL	0.880	-0.419	77	Mutz (2006)

Table 7. Summary of Trip Interview Program (TIP) data for blue tang including: the number of length measurements, the number of years samples, the average number of lengths per year, and the analysis type by island and gear type. TS indicates a length-based time-series analysis was done and ID indicates insufficient data for analysis.

Island	Gear type	Number of lengths	Number of years sampled	Average number of lengths $year^{-1}$	Analysis
-	Pots & traps	62	1	-	-
Puerto Rico	Hook & line	1	1	1	ID
Puerto Rico	Nets	121	6	20.2	ID
Puerto Rico	Pots & traps	19	6	3.2	ID
St. Thomas/ St John	Hook & line	21	2	10.5	ID
St. Thomas/ St John	Nets	22	3	7.33	ID
St. Thomas/ St John	Pots & traps	2996	21	142.6	TS
St. Croix	Hook & line	90	3	30	ID
St. Croix	Nets	1462	15	97.5	ID
St. Croix	Pots & traps	32220	29	1111	TS

Table 8. Measures of central tendency and skewness for the blue tang length frequency data from the St. Thomas and St. John pot and trap fishery. Estimates correspond to the annual length frequency plots shown in Figure 10.

Species	Gear	Island	Year	Mean	Median	Mode	Skewness
Blue tang	Pots and traps	St. Thomas and St. John	1983	19.80	16.50	15.75	0.77
			1984	19.40	19.50	17.25	0.69
			1985	21.60	21.00	17.25	0.78
			1986	21.10	21.00	20.25	-0.68
			1987	19.70	19.50	17.25	0.43
			1988	17.23	18.00	18.75	-0.74
			1991	20.45	19.50	18.75	0.75
			1992	18.58	18.00	17.25	1.20
			1993	20.03	19.50	17.25	1.10
			1994	20.02	19.50	18.75	0.79
			1995	19.60	19.50	18.75	0.40
			1996	22.26	21.00	20.25	0.90
			2002	21.84	21.00	18.75	0.96
			2003	22.50	22.50	20.25	0.36
			2004	21.58	21.00	20.25	1.32
			2005	19.47	19.50	18.75	1.56
			2006	18.32	18.00	17.25	0.36
			2008	21.00	21.00	21.75	0.00
			2009	21.55	21.00	21.75	0.53
			2010	21.01	21.00	20.25	1.16

Table 9. Measures of central tendency and skewness for the blue tang length frequency data from the St. Croix pot and trap fishery. Estimates correspond to the annual length frequency plots shown in Figure 11.

Species	Gear	Island	Year	Mean	Median	Mode	Skewness
Blue tang	Pots and traps	St. Croix	1985	19.13	19.50	17.25	0.94
			1986	19.31	18.00	17.25	1.36
			1987	18.88	18.00	17.25	1.31
			1988	18.84	18.00	17.25	1.42
			1989	18.34	18.00	17.25	0.86
			1990	17.76	18.00	17.25	1.44
			1991	18.38	18.00	17.25	7.37
			1992	18.57	18.00	17.25	1.26
			1993	18.40	18.00	17.25	1.09
			1994	18.44	18.00	17.25	1.36
			1995	18.45	18.00	17.25	1.15
			1996	18.52	18.00	17.25	0.94
			1997	18.31	18.00	17.25	0.60
			1998	18.70	18.00	17.25	1.33
			1999	18.60	18.00	17.25	0.69
			2000	18.63	18.00	17.25	1.59
			2001	19.04	18.00	17.25	0.57
			2002	19.16	19.50	17.25	0.92
			2003	19.50	18.75	17.25	0.63
			2004	20.00	19.50	18.75	0.46
			2005	20.08	19.50	18.75	0.39
			2006	17.40	18.00	17.25	-0.59
			2007	18.88	18.00	17.25	1.04
			2008	19.32	19.50	18.75	1.31
			2009	19.09	19.50	18.75	0.21
			2010	18.94	18.00	17.25	0.76
			2011	19.55	19.50	18.75	1.09

Table 10. Input parameters used for the analysis of the blue tang length data, L_c: length at full vulnerability, K: von Bertalanffy growth coefficient, and L_∞: asymptotic length used for the preliminary model run. The von Bertalanffy growth parameters were obtained from Mutz (2006).

Species name	Island	Gear type	L_c (cm)	K	L_∞ (cm)
Blue tang	St. Thomas/St. John	Pots and traps	19, 20, 21	1.03	18.8
			19, 20, 21	0.39	19.9
			19, 20, 21	0.49	23.1
Blue tang	St. Croix	Pots and traps	18, 19, 20	1.03	18.8
			18, 19, 20	0.39	19.9
			18, 19, 20	0.49	23.1

Table 11. The results from preliminary length-based analyses that used the blue tang length data from the St. Thomas/St. John pot and trap fishery. The summarized results represent the models with the lowest AIC value for a given set of input parameters. Results highlighted in gray met convergence criteria.

Gear	Island	L_c (FL mm)	Estimates	L_∞ = 18.8 K = 1.03	19.9 0.39	23.1 0.49
Pots and traps	St. Thomas & St. John	19	Nchanges	0	1	1
			Change year	-	1983	1983
			Z	4.99	0.001, 0.00101	0.09, 0.4
		20	Nchanges	0	0	1
			Change year	-	-	2000
			Z	5	4.99	0.05, 0.42
		21	Nchanges	0	0	0
			Change year	-	-	-
			Z	5	5	0.001

Table 12. The full AIC results from the preliminary analyses using the blue tang length data from the St. Thomas/St. John pot and trap fishery. The rows highlighted in gray have the lowest AIC values. Parameter combinations where L_c was greater than L_∞ were excluded from this summary. Total mortality values that are equal to 0.001 or are greater than or equal to 4.99 indicate the model did not converge and parameter bounds were reached.

L_c	K	L_∞	Npar	Nobs	Nchange	AIC	ΔAIC	LLIKE	Z	$Z1$	Change Year1	$Z2$	Change Year2	$Z3$	Change Year3	$Z4$
19	0.39	19.9	2	21	0	118.252	10.371	56.79	4.99	-	-	-	-	-	-	-
			4	21	1	107.881	0	48.69	-	0.001	1983	0.001	-	-	-	-
			6	21	2	115.381	7.5	48.69	-	0.001	1983	0.001	1985	0.001	-	-
			8	21	3	125.381	17.5	48.69	-	0.001	1983	0.001	1985	0.001	1987	0.001
19	0.49	23.1	2	21	0	64.84	4.01	30.08	0.28	-	-	-	-	-	-	-
			4	21	1	60.82	0	25.16	-	0.09	1983	0.40	-	-	-	-
			6	21	2	63.31	2.48	22.65	-	0.09	1986	4.20	1988	0.38	-	-
			8	21	3	67.88	7.05	19.94	-	0.09	1986	4.24	1988	0.14	2001	0.49
20	0.49	23.1	2	20	0	58.00	6.71	26.65	0.14	-	-	-	-	-	-	-
			4	20	1	51.30	0	20.31	-	0.05	2000	0.43	-	-	-	-
			6	20	2	58.58	7.28	20.06	-	0.03	1983	0.12	2001	0.41	-	-
			8	20	3	64.38	13.09	17.65	-	0.00	1985	3.47	1987	0.00	2001	0.43
21	0.49	23.1	2	20	0	59.87	0	27.58	0.001	-	-	-	-	-	-	-
			4	20	1	64.40	4.53	26.87	-	0.001	1996	0.38	-	-	-	-
			6	20	2	71.88	12.01	26.71	-	0.001	2003	2.61	2005	0.001	-	-
			8	20	3	82.51	22.64	26.71	-	0.001	1983	0.001	2003	2.61	2005	0.001

Table 13. The frequency of sensitivity runs predicting zero, one, or two changes in blue tang total mortality (*Z*). Four length-at-full vulnerability (L_c) values and the length data from the St. Thomas/St. John pot and trap fishery were used as inputs. Results highlighted in gray represent the majority of sensitivity runs.

	Number of changes in total mortality (*Z*)		
L_c	0 change	1 change	2 changes
19	24	13	11
20	8	24	0
20.5	16	16	0
21	16	8	0
Total	64	61	11

Table 14. The frequency of sensitivity runs predicting one or two changes in blue tang total mortality (*Z*) and the associated predicted first year of change. These results represent all parameter combinations used for the sensitivity analysis. The length data from the St. Thomas/St. John pot and trap fishery were used for this analysis.

	Number of changes in total mortality (*Z*)	
Year of first change	1 change	2 changes
1983	4	0
1984	2	0
1985	7	6
1986	0	5
1992	2	0
1993	3	0
1994	8	0
1995	3	0
1999	2	0
2000	5	0
2001	14	0
2002	8	0
2003	3	0
Total	61	11

Table 15. The percent change in total mortality for the sensitivity runs strongly supporting the model predicting a single year of change. The data used for these sensitivity runs were the blue tang length data from the St. Thomas/St. John pot and trap fishery.

		K							
L_c	L_∞	0.39	0.49	0.59	0.69	0.79	0.89	0.99	1.03
19	22.5	563.88	650.88						
	23.1	299.24	341.63						268.15
	24	162.34	179.01	150.26	157.81	164.77	170.79	175.76	177.46
20	22.5	36017.10	40008.90	41743.88	43457.56	45175.15	46912.23	51333.27	52073.36
	23.1	861.93	771.24	750.67	688.10	690.10	698.67	709.69	714.20
	24	213.76	206.84	199.99	195.20	191.52	194.19	191.98	191.15
20.5	23.1	36358.30	38413.70	42586.27	44706.05	49340.70	51636.88	53916.90	52492.11
	24	402.45	378.83	366.04	358.23	349.86	346.35	343.28	342.15
21	24	707.04	645.14	627.74	587.63	587.01	589.51	592.69	593.89

Table 16. Natural and fishing mortality estimates for blue tang caught by the St. Thomas/St. John pot and trap fishery. Input parameters include: asymptotic length (L_∞, FL mm), the von Bertalanffy growth coefficient (*K*), maximum age (*tmax*), the proportion of population at the maximum age (*P*), and temperature (the average for Puerto Rico: www.nodc.noaa.gov/dsdt/cwtg/oatl.html. Footnotes indicate the equation associated with each publication. Fishing mortality estimates (*F*= *Z*-*M*) result from two estimates of total mortality from the sensitivity analysis and the natural mortality estimates. Cells highlighted in gray indicate *F* is greater than *M*.

Input parameters					Source of natural mortality equation							
L_∞	*K*	*tmax*	*P*	Temp	Alverson and Carney 1975[1]	Pauly 1980[2]	Hoenig 1983[3] (regression)	Hoenig 1983[4]	Ralston 1987[5]	Jensen 1996[6] (theoretical)	Jensen 1996[7] (derived from Pauly 1980)	Hewitt and Hoenig 2005[8]
244	0.42	14	0.05	26.6	0.15	1.05	0.22	0.15	0.88	0.63	0.67	0.21
231	0.49	14			0.12	1.18			1.03	0.74	0.78	
219	0.88	14			0.02	1.75			1.83	1.32	1.41	
203	1.01	14			0.01	1.96			2.10	1.52	1.62	
199	0.39	14			0.17	1.06			0.82	0.59	0.62	
188	1.03	14			0.01	2.03			2.14	1.55	1.65	
					Total mortality assumed equal to 0.25 (lower estimate from sensitivity analysis)							
L_∞	*K*	*tmax*	*P*	Temp	Fishing mortality estimates							
244	0.42	14	0.05	26.6	0.10	-0.80	0.03	0.10	-0.63	-0.38	-0.42	0.04
231	0.49	14			0.13	-0.93			-0.78	-0.49	-0.53	
219	0.88	14			0.23	-1.50			-1.58	-1.07	-1.16	
203	1.01	14			0.24	-1.71			-1.85	-1.27	-1.37	
199	0.39	14			0.08	-0.81			-0.57	-0.34	-0.37	
188	1.03	14			0.24	-1.78			-1.89	-1.30	-1.40	

Figure 16. continued.

					Source of natural mortality equation							
					Alverson and Carney 1975[1]	Pauly 1980[2]	Hoenig 1983[3] (regression)	Hoenig 1983[4]	Ralston 1987[5]	Jensen 1996[6] (theoretical)	Jensen 1996[7] (derived from Pauly 1980)	Hewitt and Hoenig 2005[8]
					Total mortality assumed equal to 2 (upper estimate from sensitivity analysis)							
L_∞	*K*	*tmax*	*P*	Temp	Fishing mortality estimates							
244	0.42	14	0.05	26.6	1.10	0.20	1.03	1.10	0.37	0.62	0.58	1.04
231	0.49	14			1.13	0.07			0.22	0.52	0.47	
219	0.88	14			1.23	-0.50			-0.58	-0.07	-0.16	
203	1.01	14			1.24	-0.71			-0.85	-0.27	-0.37	
199	0.39	14			1.08	0.19			0.43	0.67	0.63	
188	1.03	14			1.24	-0.78			-0.89	-0.30	-0.40	

[1] $M = 3K/(\exp[0.38*K*tmax) - 1]$

[2] $M = \exp[-0.0152 + 0.6543*\ln(K) - 0.279*\ln(L\infty/10) + 0.4634*\ln(\text{Temp})]$

[3] $M = \exp[1.44 - 0.982*\ln(tmax)]$

[4] $M = -\ln(P)/tmax$

[5] $M = 0.0189 + 2.06K$

[6] $M=1.5K$

[7] $M=1.6K$

[8] $M=4.22/tmax$

Table 17. The results from the preliminary length-based analyses that used the blue tang length data from the St. Croix pot and trap fishery. The summarized results represent the models with the lowest AIC value for a given set of input parameters or is strongly supported by AIC criteria (i.e., ΔAIC≤2). Results highlighted in gray met convergence criteria.

				L_∞ = 18.8	19.9	23.1
Gear	Island	Lc (FL mm)	Estimates	*K* = 1.03	0.39	0.49
Pots and traps	St. Croix	18	Nchanges	0	0	1
			Change year	-	-	1983
			Z	0.001	0.14	0.69, 1.42
		19	Nchanges	0	0	1
			Change year	-	-	1983
			Z	5	0.001	0.5, 1.15
		20	Nchanges	0	0	0
			Change year	-	-	-
			Z	5	4.99	0.6

Table 18. The full AIC results from the preliminary analyses using the blue tang length data from the St. Croix pot and trap fishery. The rows highlighted in gray have the lowest AIC values. In most cases, no other model is supported by AIC criteria. Total mortality values that are equal to 0.001 or are greater than or equal to 4.99 indicate the model did not converge and parameter bounds were reached.

L_c	K	L_∞	Npar	Nobs	Nchange	AIC	ΔAIC	LLIKE	*Z*	*Z1*	Change Year1	*Z2*	Change Year2	*Z3*	Change Year3	*Z4*
18	1.03	18.8	2	29	0	92.96	0	44.25	0.001	-	-	-	-	-	-	-
			4	29	1	98.16	5.21	44.25	-	0.001	1983	0.001	-	-	-	-
			6	29	2	104.31	11.36	44.25	-	0.001	1983	0.001	1985	0.001	-	-
			8	29	3	111.69	18.74	44.25	-	0.001	1983	0.001	1985	0.001	1987	0.001
18	0.39	19.9	2	29	0	55.46	1.484	25.52	0.144	-	-	-	-	-	-	-
			4	29	1	59.05	5.042	24.69	-	0.157	1995	0.001	-	-	-	-
			6	29	2	54.01	0	19.09	-	0.054	1985	1.006	1988	0.021	-	-
			8	29	3	60.46	6.447	18.63	-	0.054	1985	1.016	1988	0.001	2007	0.714
18	0.49	23.1	2	29	0	55.49	2.41	25.52	1.31	-	-	-	-	-	-	-
			4	29	1	53.09	0	21.71	-	0.69	1983	1.42	-	-	-	-
			6	29	2	54.35	1.26	19.26	-	0.67	1983	1.49	1999	0.99	-	-
			8	29	3	59.02	5.94	17.91	-	0.67	1983	1.48	2001	0.43	2005	1.25
19	0.39	19.9	2	29	0	84.53	0	40.04	0.001	-	-	-	-	-	-	-
			4	29	1	89.74	5.21	40.04	-	0.001	1983	0.001	-	-	-	-
			6	29	2	95.89	11.36	40.04	-	0.001	1983	0.001	1985	0.001	-	-
			8	29	3	103.26	18.73	40.03	-	0.001	1983	0.001	1988	0.001	2009	3.46
19	0.49	23.1	2	29	0	62.69	2.81	29.12	1.01	-	-	-	-	-	-	-
			4	29	1	59.89	0	25.11	-	0.50	1983	1.15	-	-	-	-
			6	29	2	64.46	4.57	24.32	-	0.47	1983	1.25	1989	1.00	-	-
			8	29	3	68.08	8.19	22.44	-	0.49	1983	1.20	2001	0.19	2005	1.30
20	0.49	23.1	2	28	0	59.50	1.54	27.51	0.60	-	-	-	-	-	-	-
			4	28	1	59.46	1.51	24.86	-	0.34	1983	0.74	-	-	-	-
			6	28	2	57.96	0	20.98	-	0.18	1983	1.65	1985	0.59	-	-
			8	28	3	63.64	5.68	20.03	-	0.17	1983	1.79	1985	0.44	0.70	1991

Table 19. The frequency of sensitivity runs predicting no change, one change, or multiple changes in blue tang total mortality (*Z*). Four length-at-full vulnerability (L_c) values and the length data from the St. Croix pot and trap fishery were used as inputs.

	Number of changes in total mortality (*Z*)			
L_c	No change	1 change	2 changes	3changes
18	14	8	26	0
19	7	25	0	0
19.5	14	8	10	0
20.5	15	1	8	0
21	9	0	1	6
Total	59	42	45	6

Table 20. The frequency of sensitivity runs predicting one, two, or three changes in blue tang total mortality (Z) and the associated predicted first year of change. These results represent all parameter combinations used for the sensitivity analysis. The length data from the St. Croix pot and trap fishery were used for this analysis. Results highlighted in gray show the year with support from the majority of sensitivity runs.

	Number of changes in total mortality (Z)		
First year of change	1	2	3
1983	42	33	6
1985	0	3	0
1986	0	9	0
Total	42	45	6

Table 21. The frequency of sensitivity runs predicting two or three changes in blue tang total mortality (*Z*) and the associated predicted second year of change. These results represent all parameter combinations used for the sensitivity analysis. The lengths from the St. Croix pot and trap fishery were used as the input data. Results highlighted in gray show the year with support from the majority of sensitivity runs.

	Number of changes in total mortality (*Z*)	
Year of second change	2	3
1985	19	6
1988	3	0
1989	3	0
1996	6	0
1999	14	0
Total	45	6

Table 22. The percent change in total mortality for the sensitivity runs strongly supporting the model predicting a single change in total mortality. The data used for these sensitivity runs were the blue tang length data from the St. Croix pot and trap fishery

		K							
L_c	L_∞	0.39	0.49	0.59	0.69	0.79	0.89	0.99	1.03
18	21		107.96	119.92					
	23.1							245.52	259.57
	24					212.74	247.09	278.16	289.16
19	21					205.60	234.96	263.18	274.14
	22.5			143.91	164.46	187.52	213.26	241.84	254.12
	23.1		128.76	151.68	178.20	208.50	242.76	281.13	297.64
	24	115.57	142.25	174.14	211.16	252.83	298.10	345.45	364.59
19.5	22.5		106.06	125.75			183.75	205.02	213.91
	23.1	91.92			153.21	176.59			
20.5	24			106.00					

Table 23. The percent change in total mortality for the sensitivity runs strongly supporting the model predicting two years of change. The data used for these sensitivity runs were the blue tang length data from the St. Croix pot and trap fishery. ‡ indicates that the total mortality estimate prior to the first change was approximately equal to 0.001 causing an impressive percent increase in total mortality.

		K															
		0.39		0.49		0.59		0.69		0.79		0.89		0.99		1.03	
L_c	L_∞	1st Δ	2nd Δ	1st Δ	2nd Δ	1st Δ	2nd Δ	1st Δ	2nd Δ	1st Δ	2nd Δ	1st Δ	2nd Δ	1st Δ	2nd Δ	1st Δ	2nd Δ
18	19.5											144744‡	-99.9	209299‡	-99.9	238502‡	-99.9
	21							177.8	-51.0	165.0	-47.2	115.8	-51.5	114.9	-49.8	114.4	-49.1
	22.5	125.8	-44.6	82.1	-43.6	137.2	-34.9	159.2	-34.5	185.6	-34.4	216.2	-34.3	250.6	-34.1	265.3	-34.1
	23.1	77.4	-43.0	123.7	-33.4	147.1	-33.1	175.7	-32.9	209.0	-32.8	245.8	-32.6				
	24	70.3	-38.5	136.6	-31.5	168.9	-31.4	205.9	-31.2								
19.5	23.1											656.3	-42.3	747.0	-41.5	784.9	-41.1
	24			415.9	-44.4	480.9	-42.5	558.9	-40.9	625.7	-38.8	673.5	-35.9	707.4	-32.9	718.2	-31.7
20.5	23.1									1229.6	-70.6	1284.5	-69.0				
	24	525.7	-64.4					665.9	-58.2	710.5	-56.1	762.3	-54.2	820.3	-52.6	844.6	-51.9
21	24									1285.1	-66.9						

Table 24. Natural and fishing mortality estimates for blue tang caught by the St. Croix pot and trap fishery. Input parameters include: asymptotic length (L_∞, FL mm), the von Bertalanffy growth coefficient (*K*), maximum age (*tmax*), the proportion of population at the maximum age (*P*), and temperature (the average for Puerto Rico: www.nodc.noaa.gov/dsdt/cwtg/oatl.html. Footnotes indicate the equation associated with each publication. Fishing mortality estimates (*F*= *Z*-*M*) result from two estimates of total mortality from the sensitivity analysis and the natural mortality estimates. Cells highlighted in gray indicate *F* is greater than *M*.

Input parameters					Source of natural mortality equation							
L_∞	*K*	*tmax*	*P*	Temp	Alverson and Carney 1975[1]	Pauly 1980[2]	Hoenig 1983[3] (regression)	Hoenig 1983[4]	Ralston 1987[5]	Jensen 1996[6] (theoretical)	Jensen 1996[7] (derived from Pauly 1980)	Hewitt and Hoenig 2005[8]
244	0.42	14	0.05	26.6	0.15	1.05	0.22	0.15	0.88	0.63	0.67	0.21
231	0.49	14			0.12	1.18			1.03	0.74	0.78	
219	0.88	14			0.02	1.75			1.83	1.32	1.41	
203	1.01	14			0.01	1.96			2.10	1.52	1.62	
199	0.39	14			0.17	1.06			0.82	0.59	0.62	
188	1.03	14			0.01	2.03			2.14	1.55	1.65	
					Total mortality assumed equal to 0.25 (lower estimate from sensitivity analysis)							
L_∞	*K*	*tmax*	*P*	Temp	Fishing mortality estimates							
244	0.42	14	0.05	26.6	0.10	-0.80	0.03	0.10	-0.63	-0.38	-0.42	0.04
231	0.49	14			0.13	-0.93			-0.78	-0.49	-0.53	
219	0.88	14			0.23	-1.50			-1.58	-1.07	-1.16	
203	1.01	14			0.24	-1.71			-1.85	-1.27	-1.37	
199	0.39	14			0.08	-0.81			-0.57	-0.34	-0.37	
188	1.03	14			0.24	-1.78			-1.89	-1.30	-1.40	

Table 24. continued.

					Source of natural mortality equation							
					Alverson and Carney 1975[1]	Pauly 1980[2]	Hoenig 1983[3] (regression)	Hoenig 1983[4]	Ralston 1987[5]	Jensen 1996[6] (theoretical)	Jensen 1996[7] (derived from Pauly 1980)	Hewitt and Hoenig 2005[8]
					Total mortality assumed equal to 2 (upper estimate from sensitivity analysis)							
L_∞	*K*	*tmax*	*P*	Temp	Fishing mortality estimates							
244	0.42	14	0.05	26.6	1.85	0.95	1.78	1.85	1.12	1.37	1.33	1.79
231	0.49	14			1.88	0.82			0.97	1.27	1.22	
219	0.88	14			1.98	0.25			0.17	0.68	0.59	
203	1.01	14			1.99	0.04			-0.10	0.49	0.38	
199	0.39	14			1.83	0.94			1.18	1.42	1.38	
188	1.03	14			1.99	-0.03			-0.14	0.46	0.35	

[1] $M = 3K/(\exp[0.38*K*tmax) - 1]$

[2] $M = \exp[-0.0152 + 0.6543*\ln(K) - 0.279*\ln(L_\infty/10) + 0.4634*\ln(Temp)]$

[3] $M = \exp[1.44 - 0.982*\ln(tmax)]$

[4] $M = -\ln(P)/tmax$

[5] $M = 0.0189 + 2.06K$

[6] $M=1.5K$

[7] $M=1.6K$

[8] $M=4.22/tmax$

9. Figures

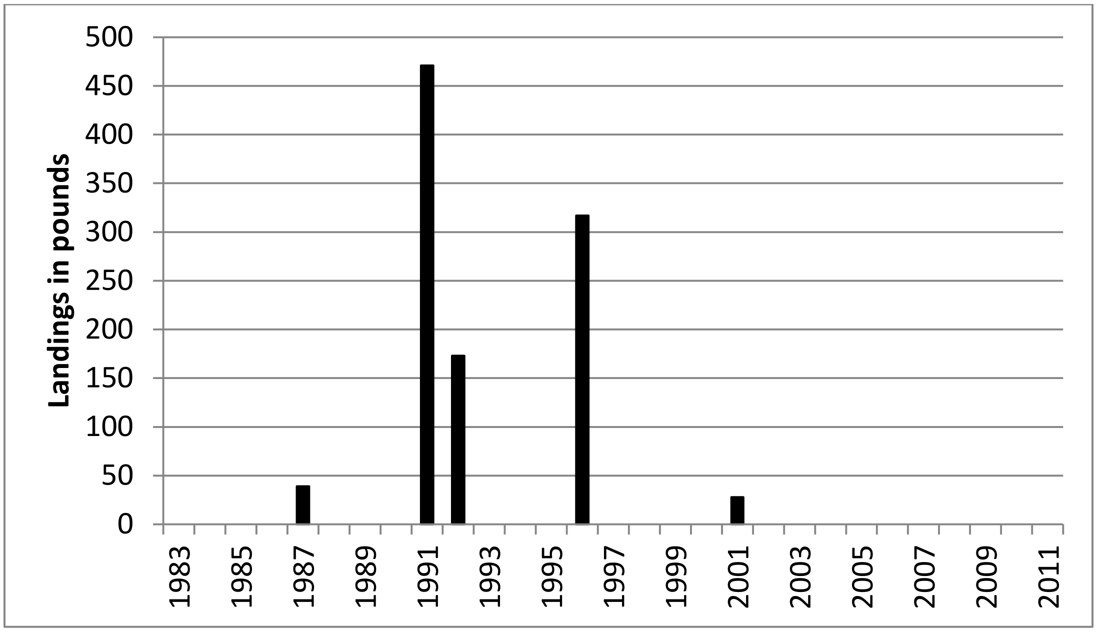

Figure 1. Puerto Rico yearly commercial fishery expanded landings of surgeonfishes reported for all gears, 1983-2011. Note: data from all gears were combined due to small sample sizes and confidentiality constraints.

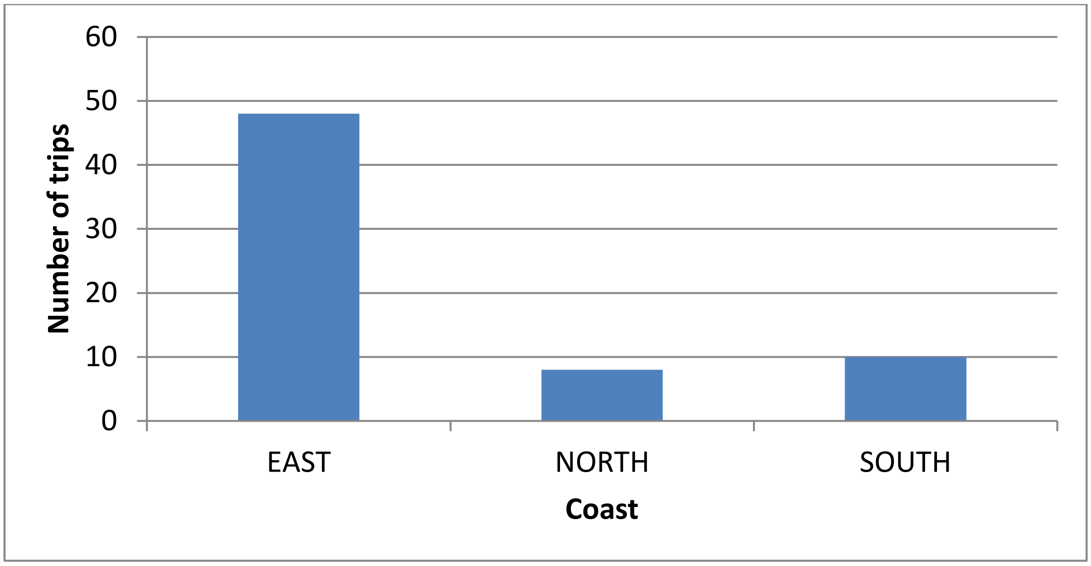

Figure 2. Puerto Rico reported commercial fishing trips with surgeonfish landings, 1983-2011, by coast. Note: trips reporting surgeonfishes from the west coast of Puerto Rico could not be presented due to confidentiality constraints. Data were combined across years due to small sample sizes.

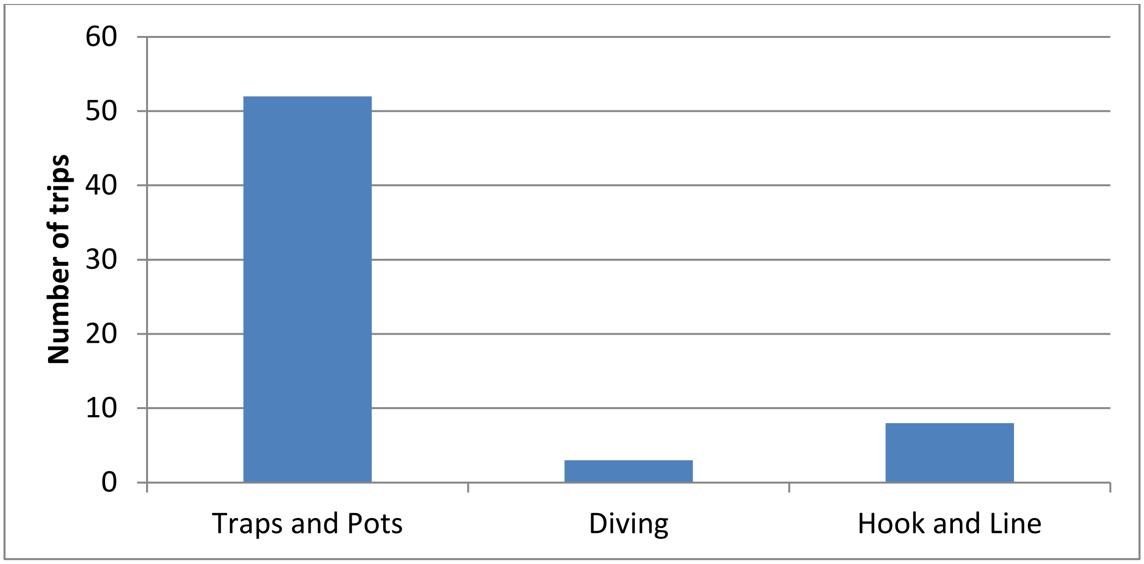

Figure 3. Puerto Rico reported commercial fishing trips with surgeonfish landings, 1983-2011, by gear. Data were combined across years due to small sample sizes.

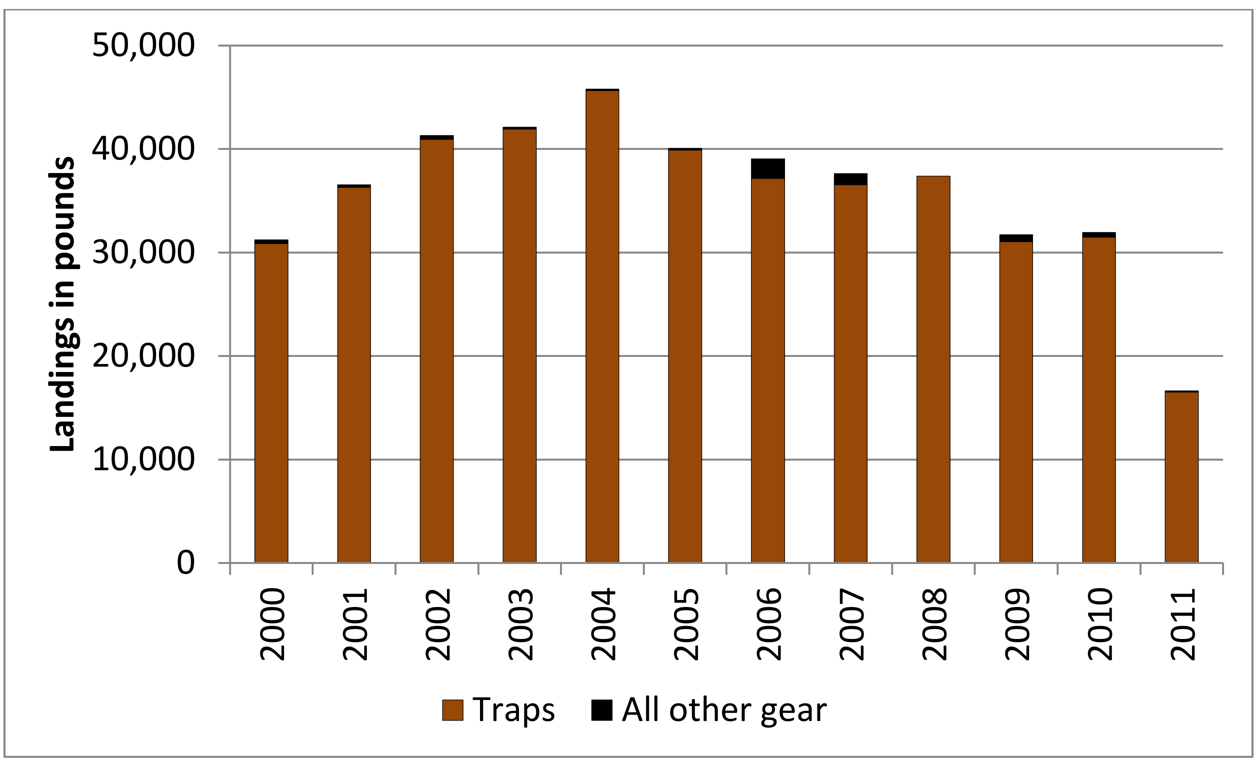

Figure 4. Yearly commercial landings of surgeonfishes as reported (no expansion factors applied) on fisher logbooks from St. Thomas and St. John by gear and year.

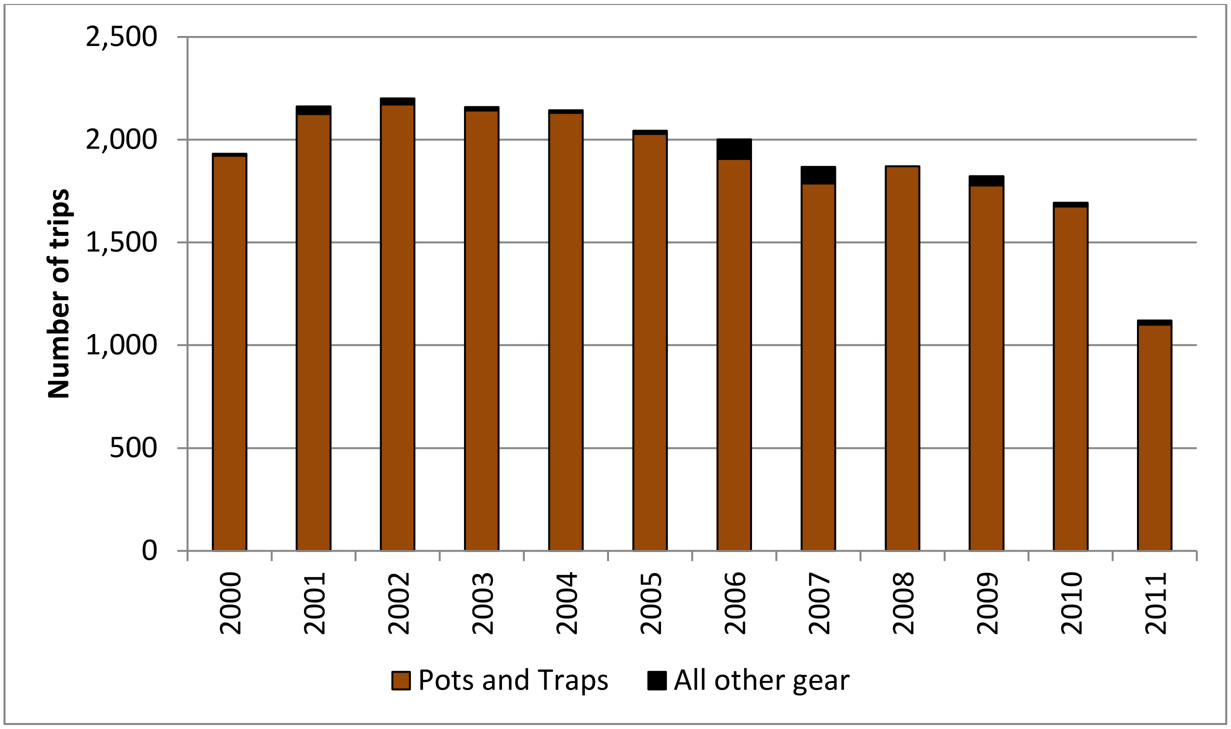

Figure 5. St. Thomas and St. John reported commercial fishing trips with surgeonfish landings by gear and year.

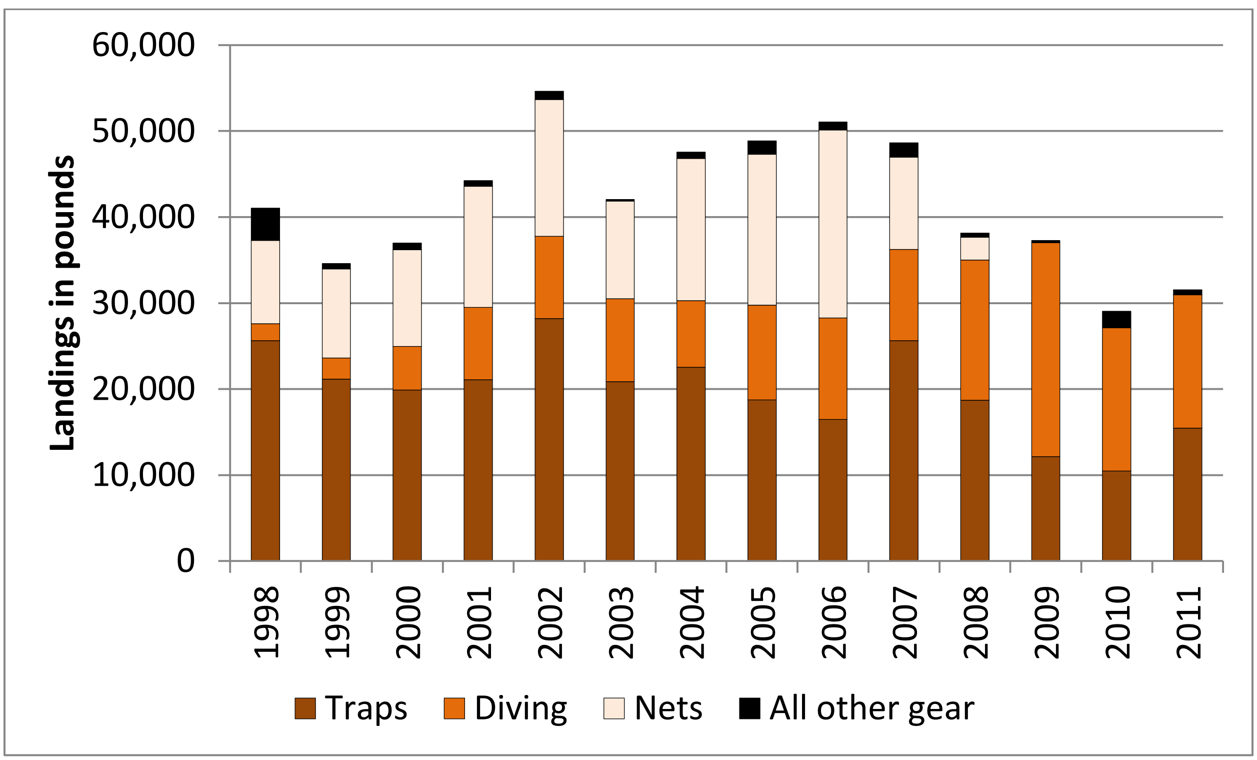

Figure 6. Yearly commercial landings of surgeonfishes as reported (no expansion factors applied) on fisher logbooks from St. Croix by gear and year.

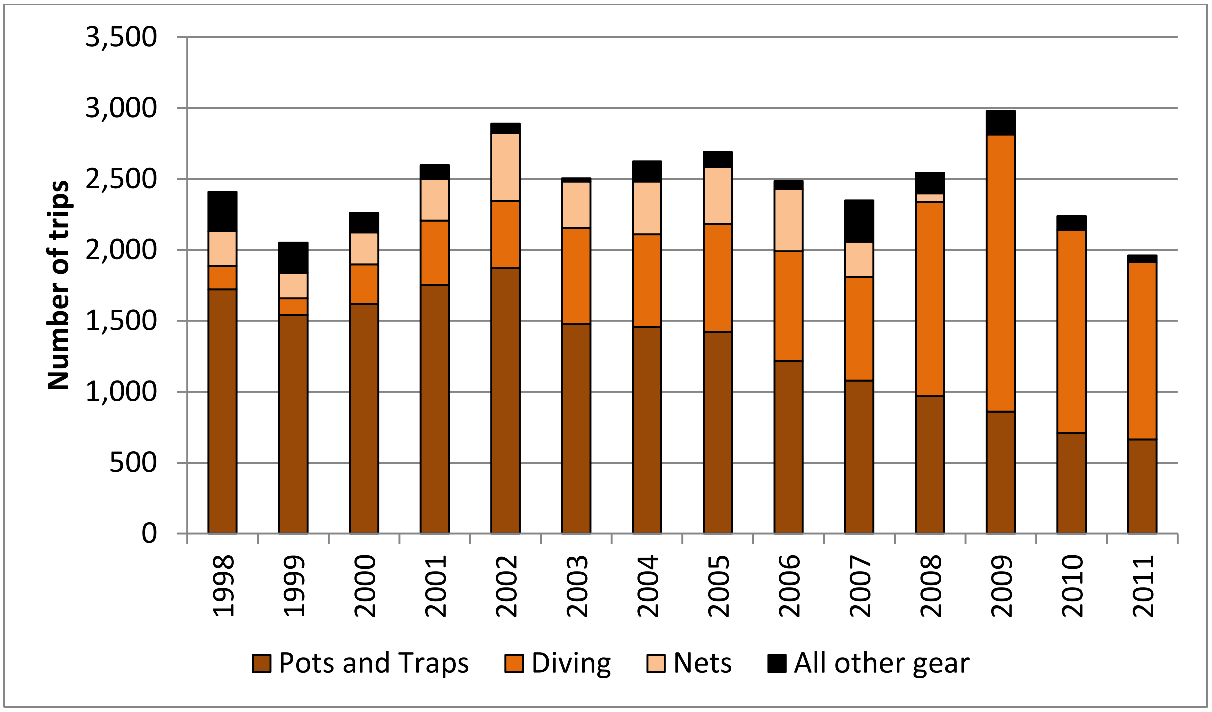

Figure 7. St. Croix reported commercial fishing trips with surgeonfish landings by gear and year.

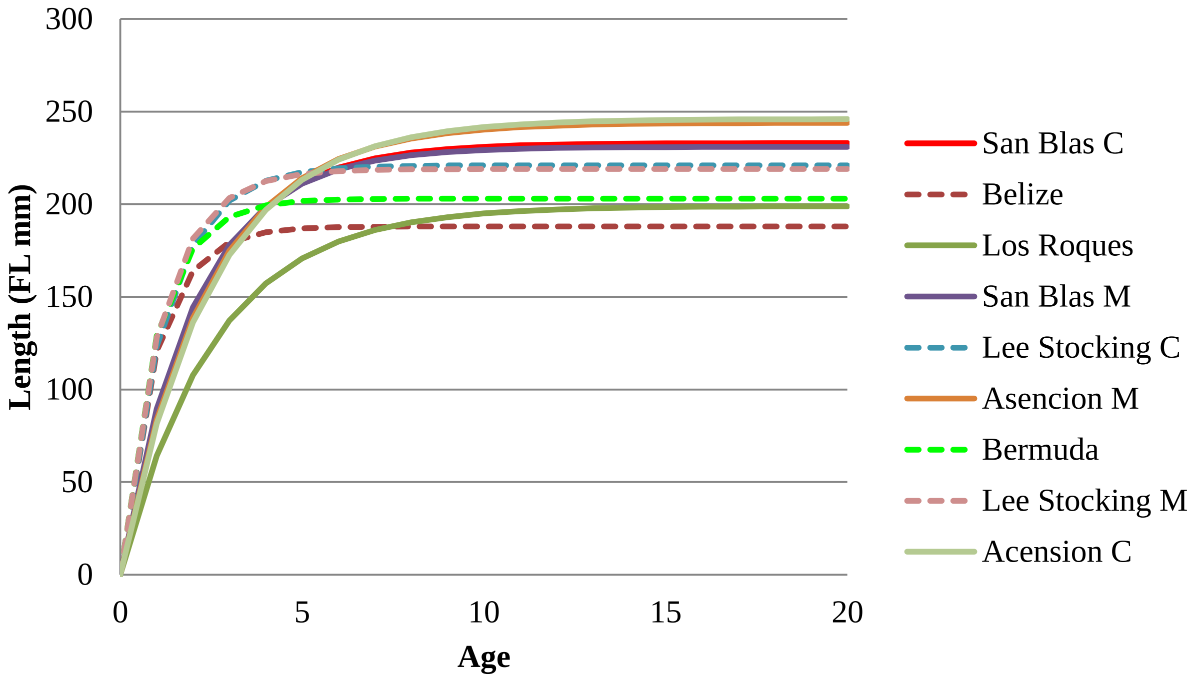

Figure 8. von Bertlanffy growth curves for blue tang. This figure corresponds with Table 6. In the figure legend, the letter C following the location indicates the input values were from Choat and Robertson (2002) and the letter M indicates the input values were from Mutz (2006).

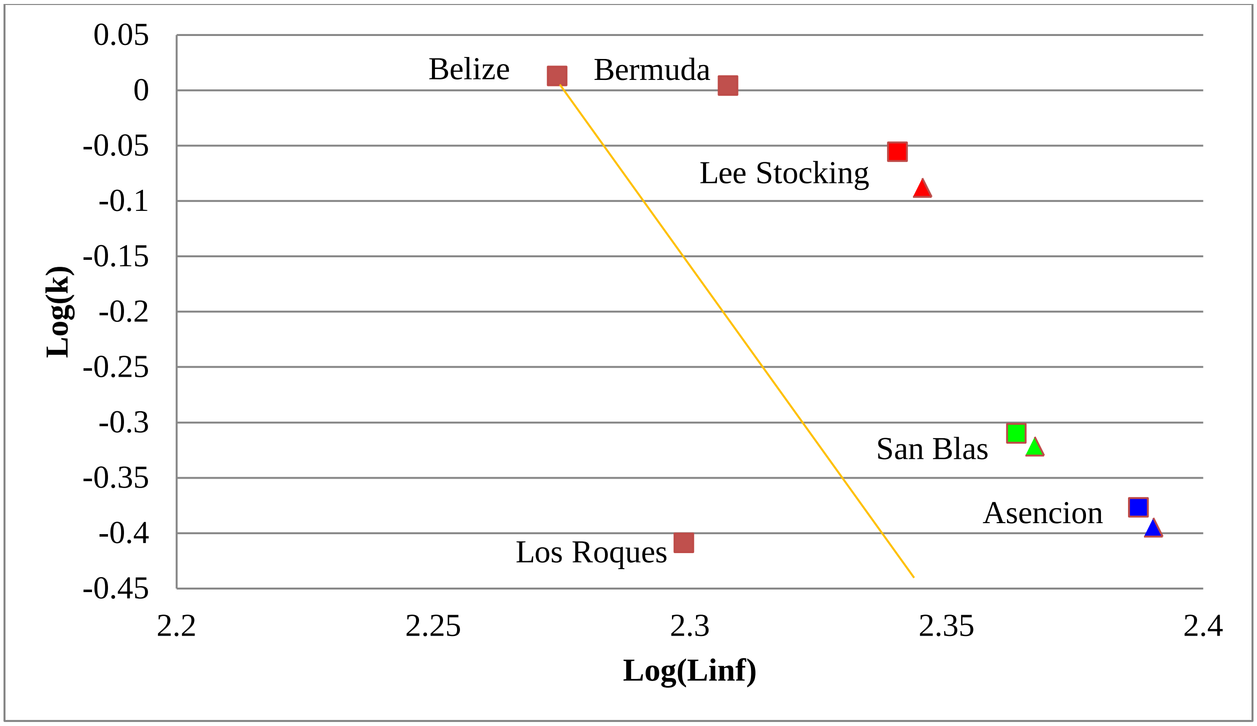

Figure 9. The relationship between the von Bertalanffy growth coefficient (k) and the asymptotic length (Linf) for blue tang. The squares represent values from Choat and Robertson (2002) and the triangles represent values from Mutz (2006). Each point represents a different location in the Caribbean. The yellow line has a slope of -2.

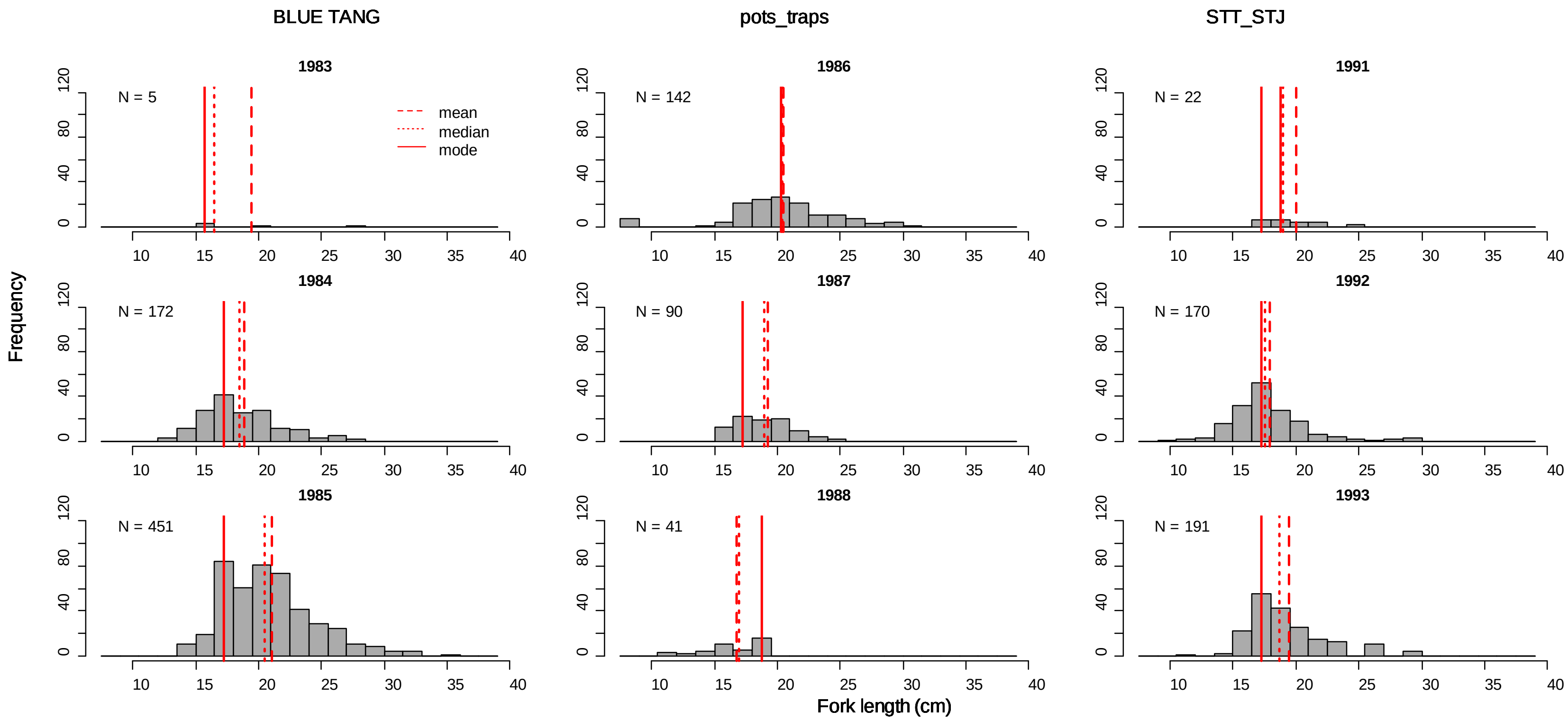

Figure 10. Length frequency plots of blue tang from the St. Thomas/St. John pot and trap fishery. The bin size is 1.5cm. The solid red line is the mode, the dashed red line is the mean, and the dotted line is the median. In some instances there is more than one mode because the frequency of more than one length bin is equal.

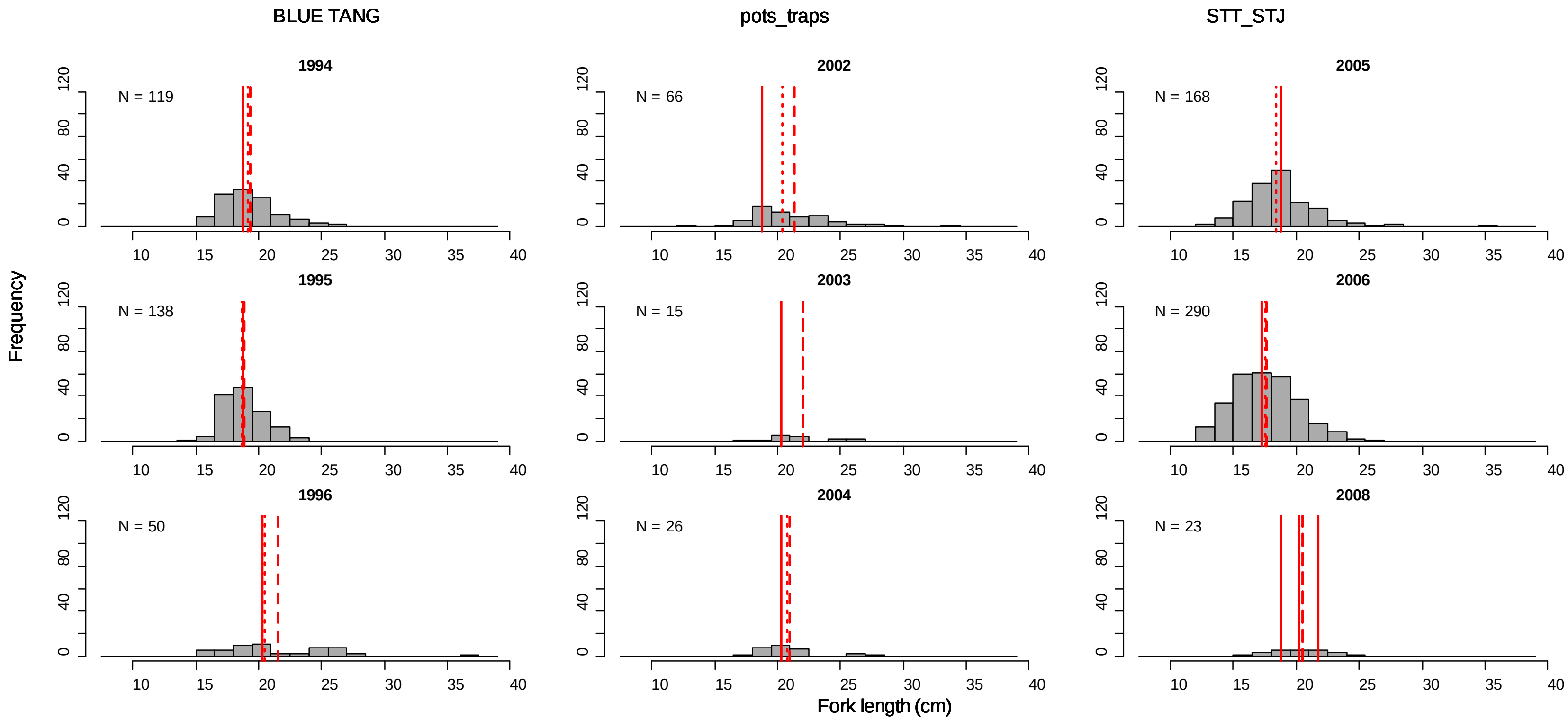

Figure 10. continued

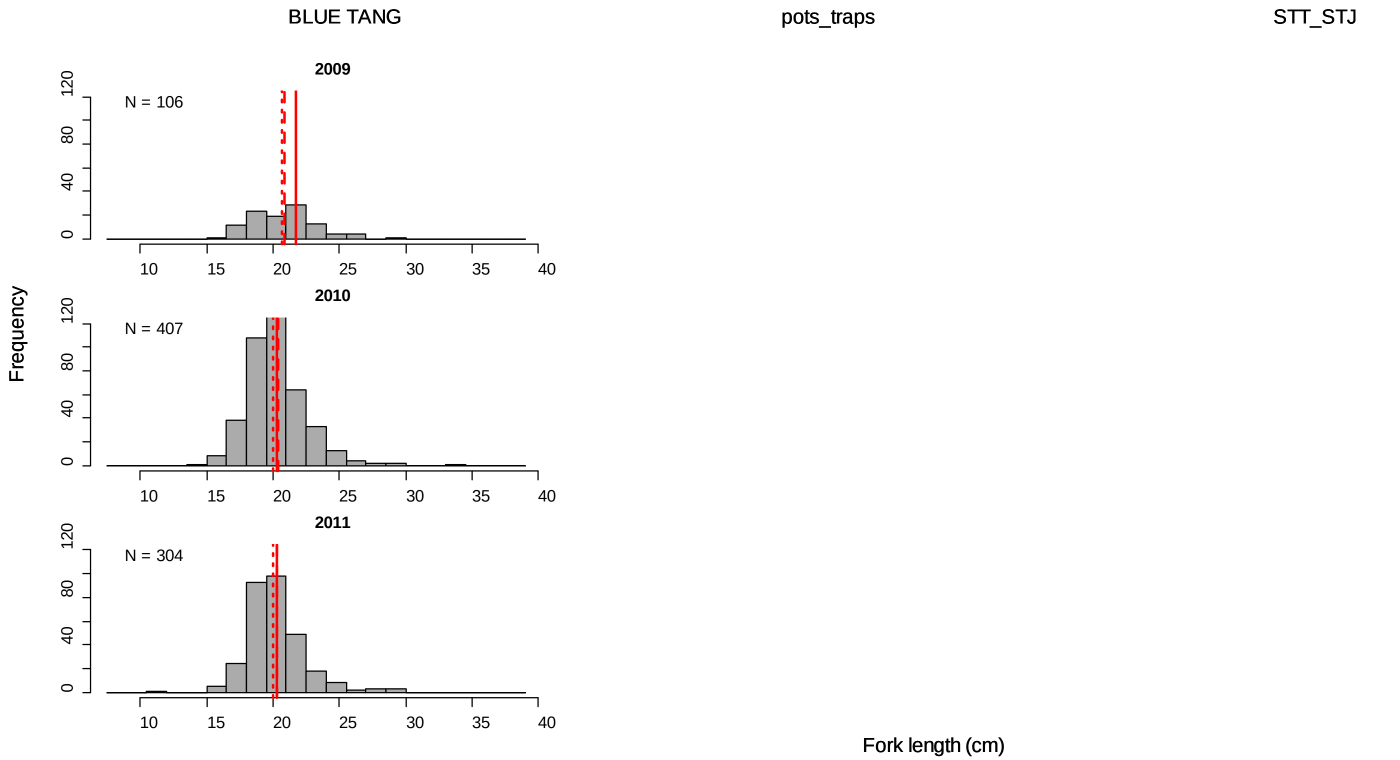

Figure 10. continued

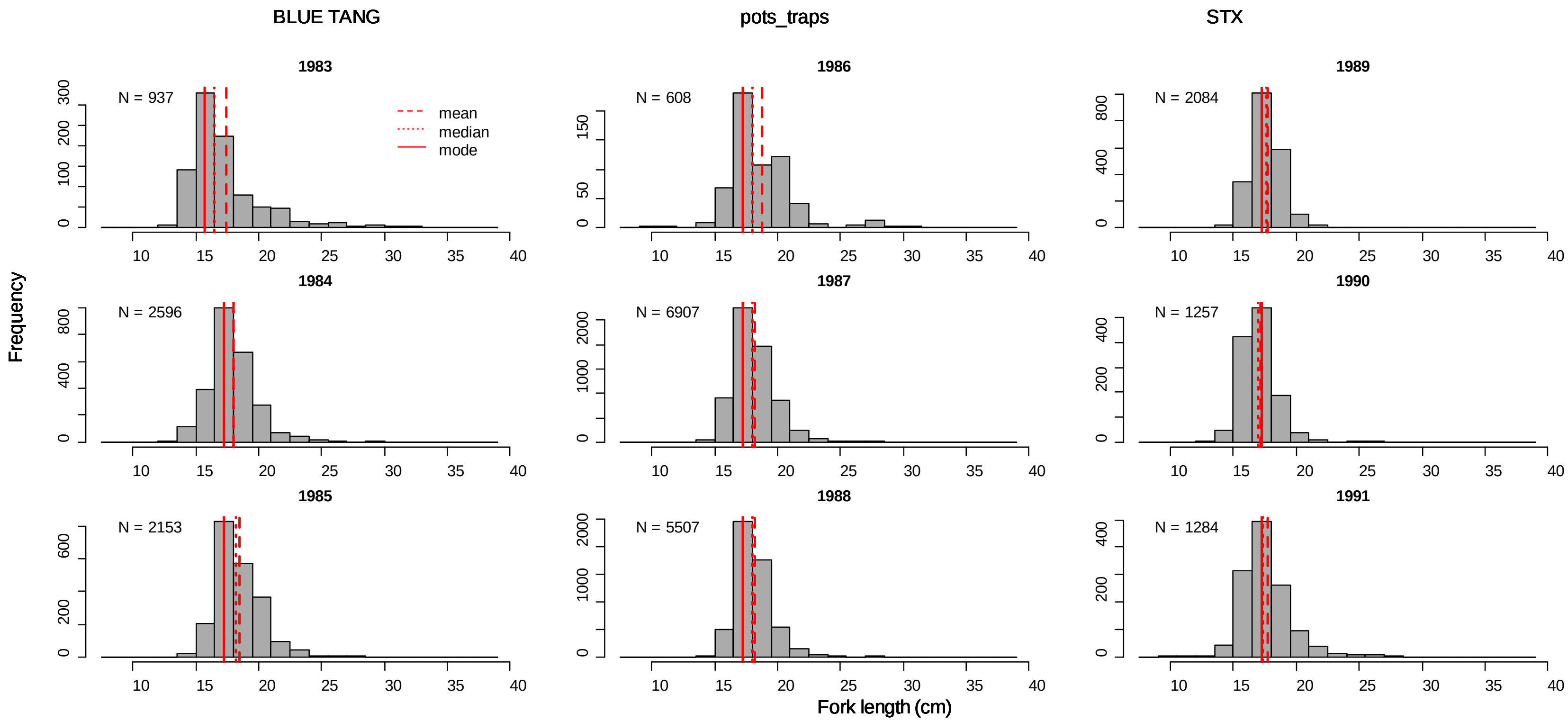

Figure 11. Length frequency plot of blue tang from the St. Croix pot and trap fishery. The bin size is 1.5cm. The solid red line is the mode, the dashed red line is the mean, and the dotted line is the median. In some instances there is more than one mode because the frequency of more than one length bin is equal. Note: The Y-axis scale varies year to year.

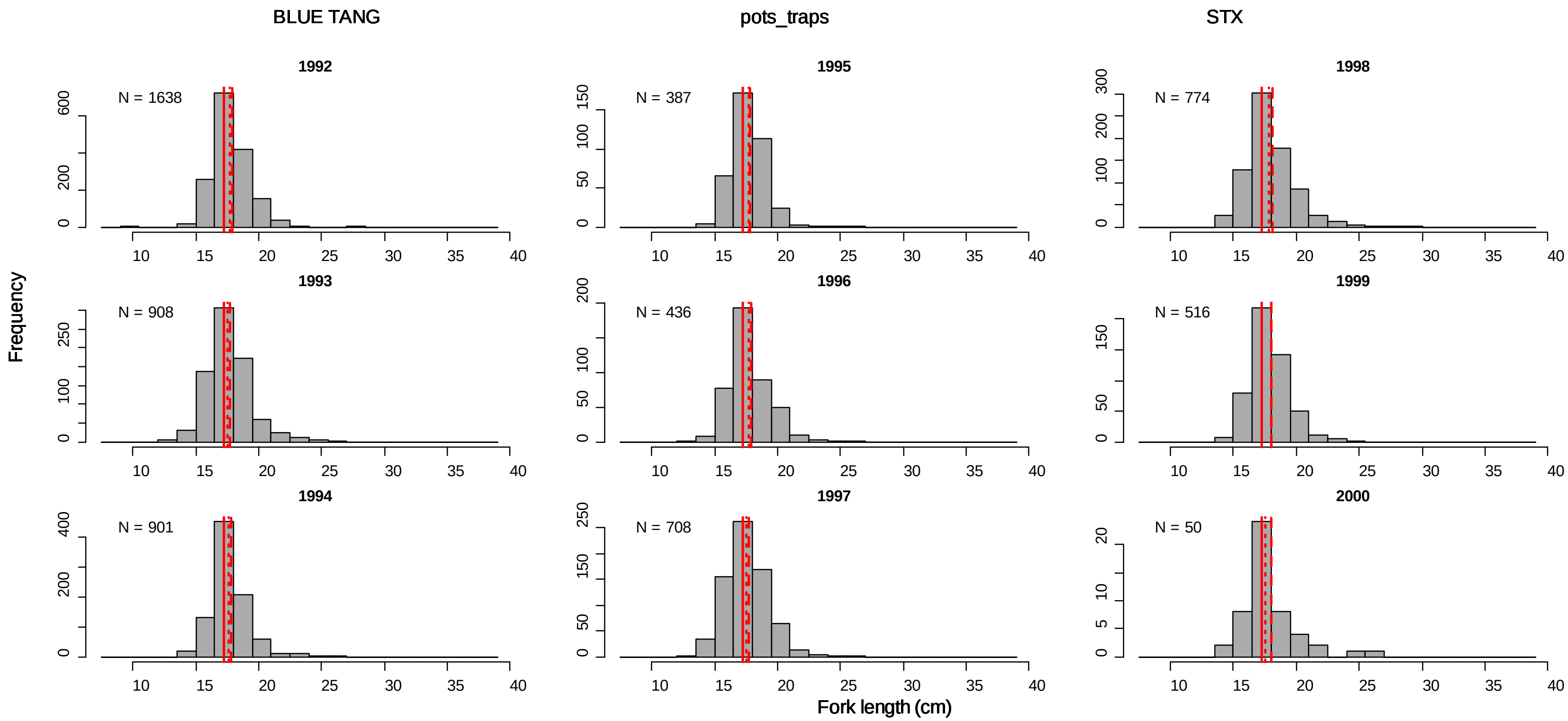

Figure 11. continued

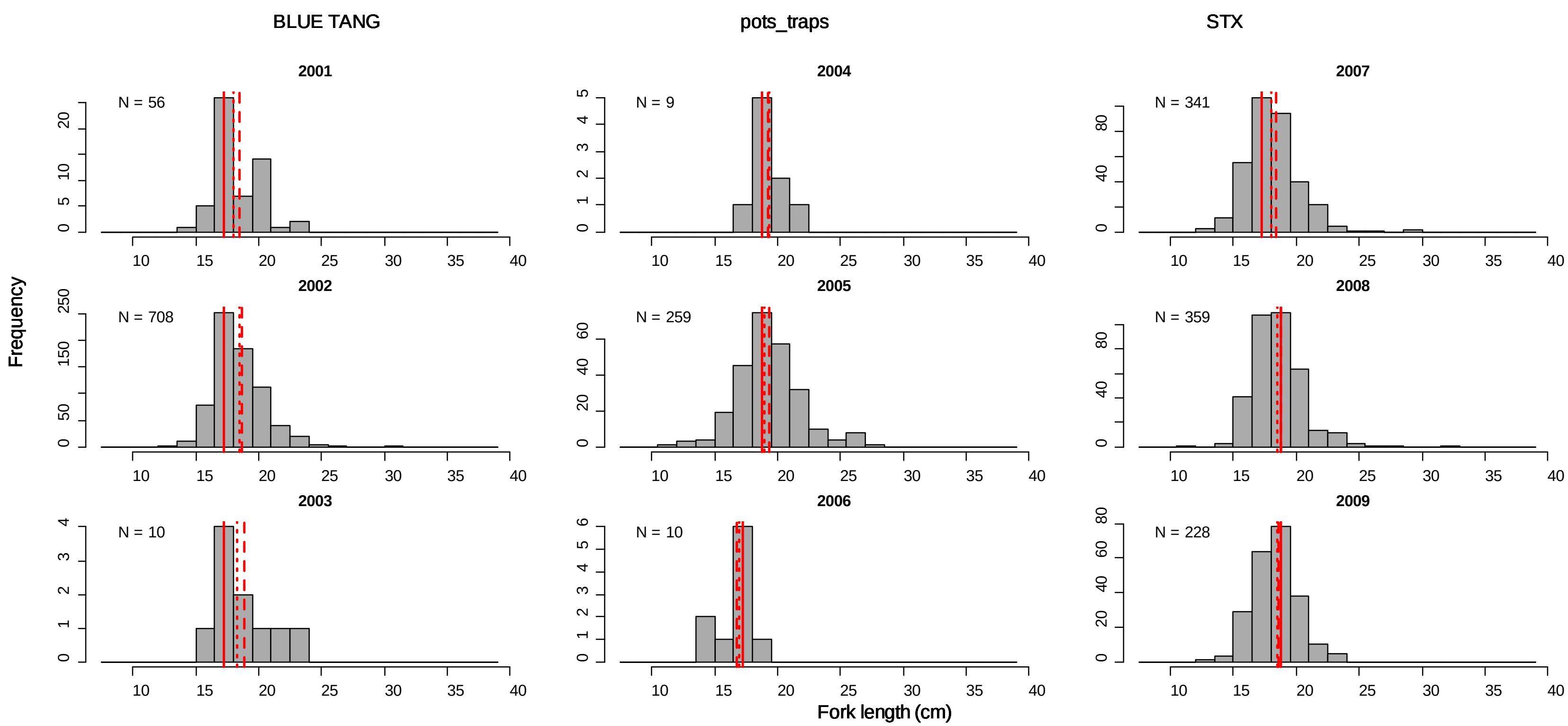

Figure 11. continued

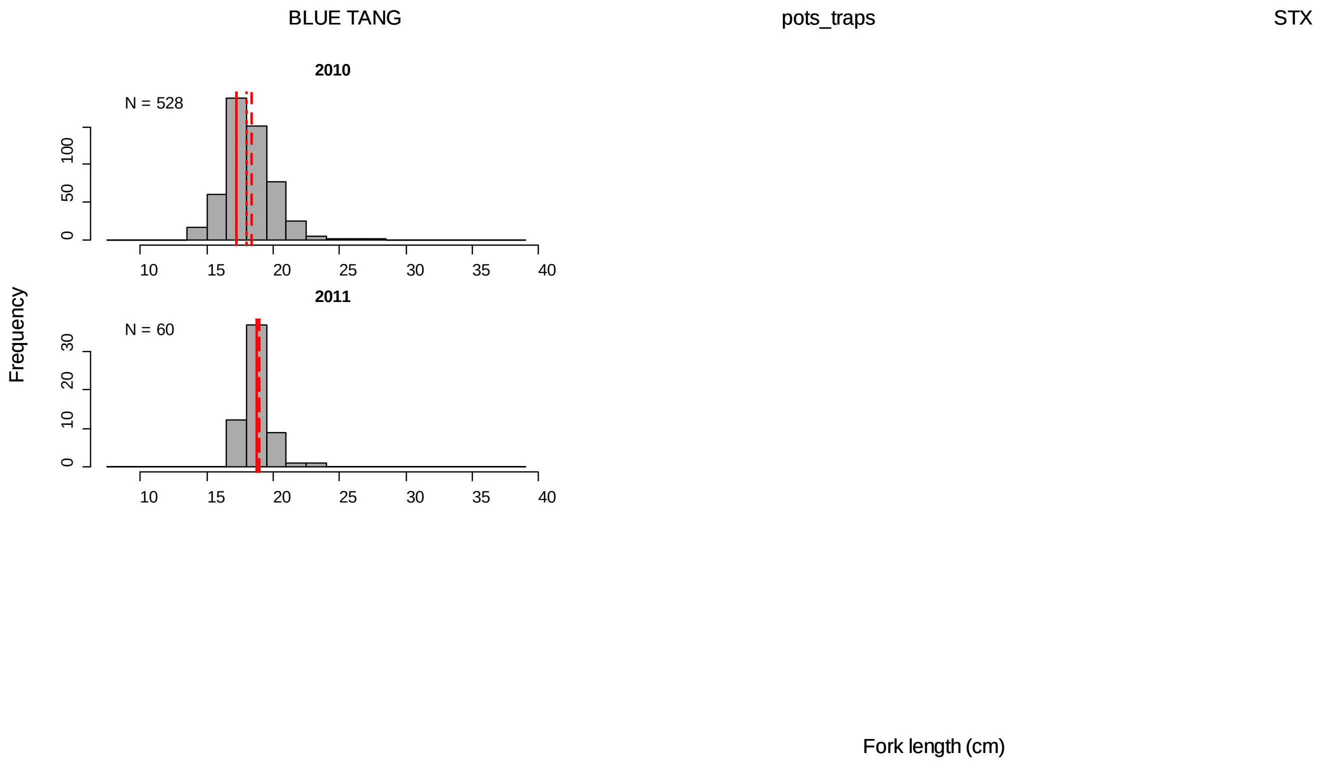

Figure 11. continued

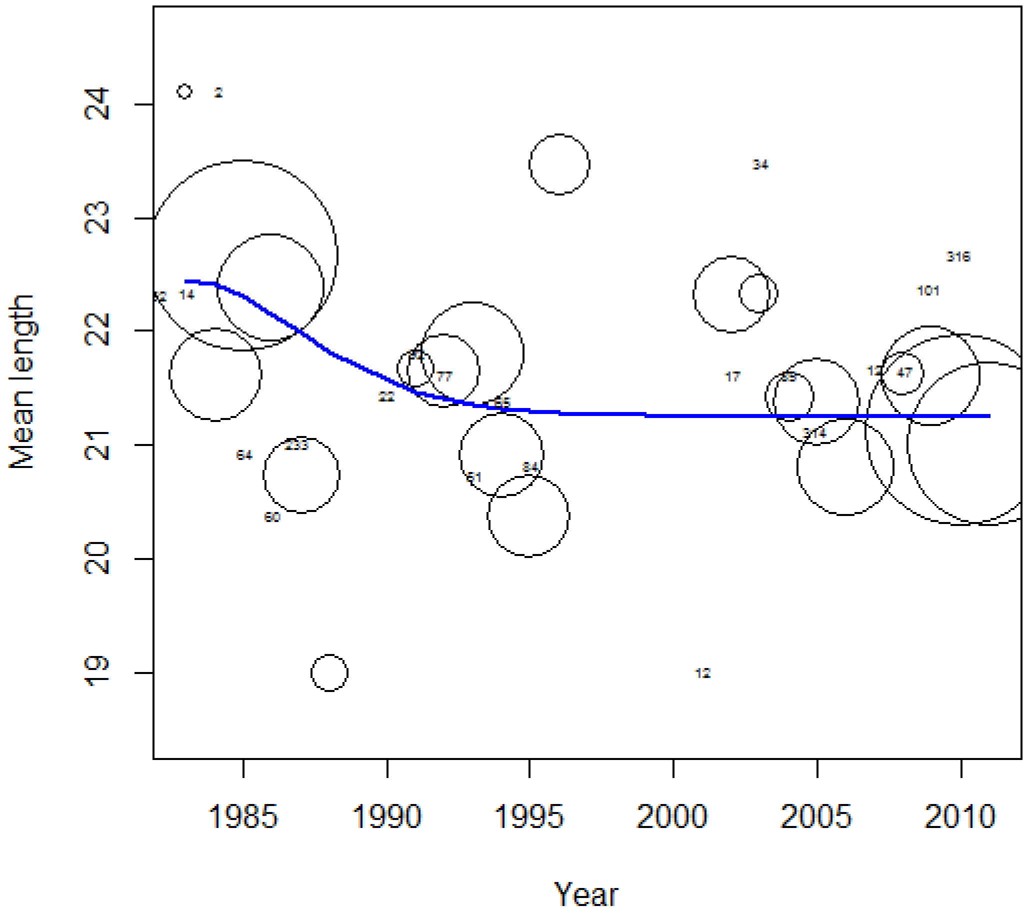

Figure 12. The model fit to the blue tang length data from the St. Thomas/St. John pot and trap fishery. The model fit shown predicts one change in total mortality and had the lowest AIC value. The input parameter values used were L_c = 19cm, L_∞ = 23.1cm, and K = 0.49. Bubble size represents the annual sample size scaled with respect to other years.

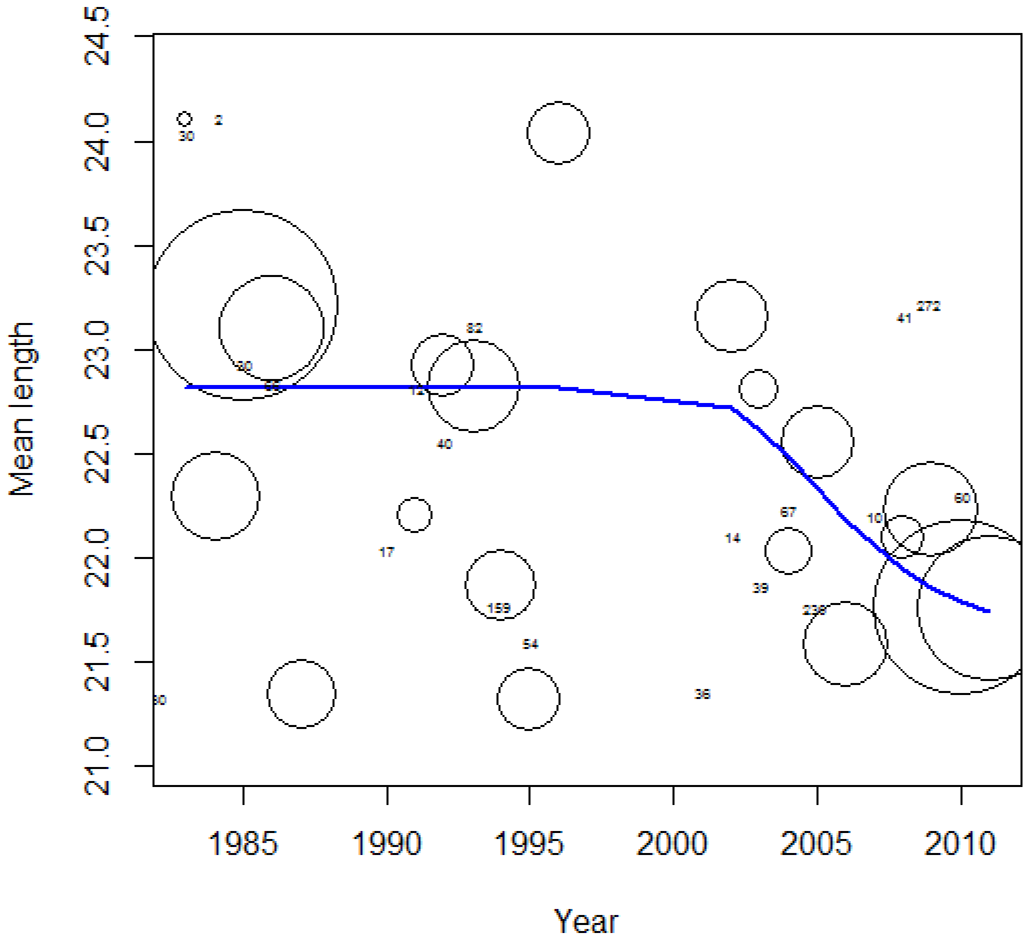

Figure 13. The model fit to the blue tang length data from the St. Thomas/St. John pot and trap fishery. The model fit shown predicts one change in total mortality and had the lowest AIC value. The input parameter values were: L_c = 20 cm, L_∞ = 23.1cm, and K = 0.49. Bubble size represents the annual sample size scaled with respect to other years.

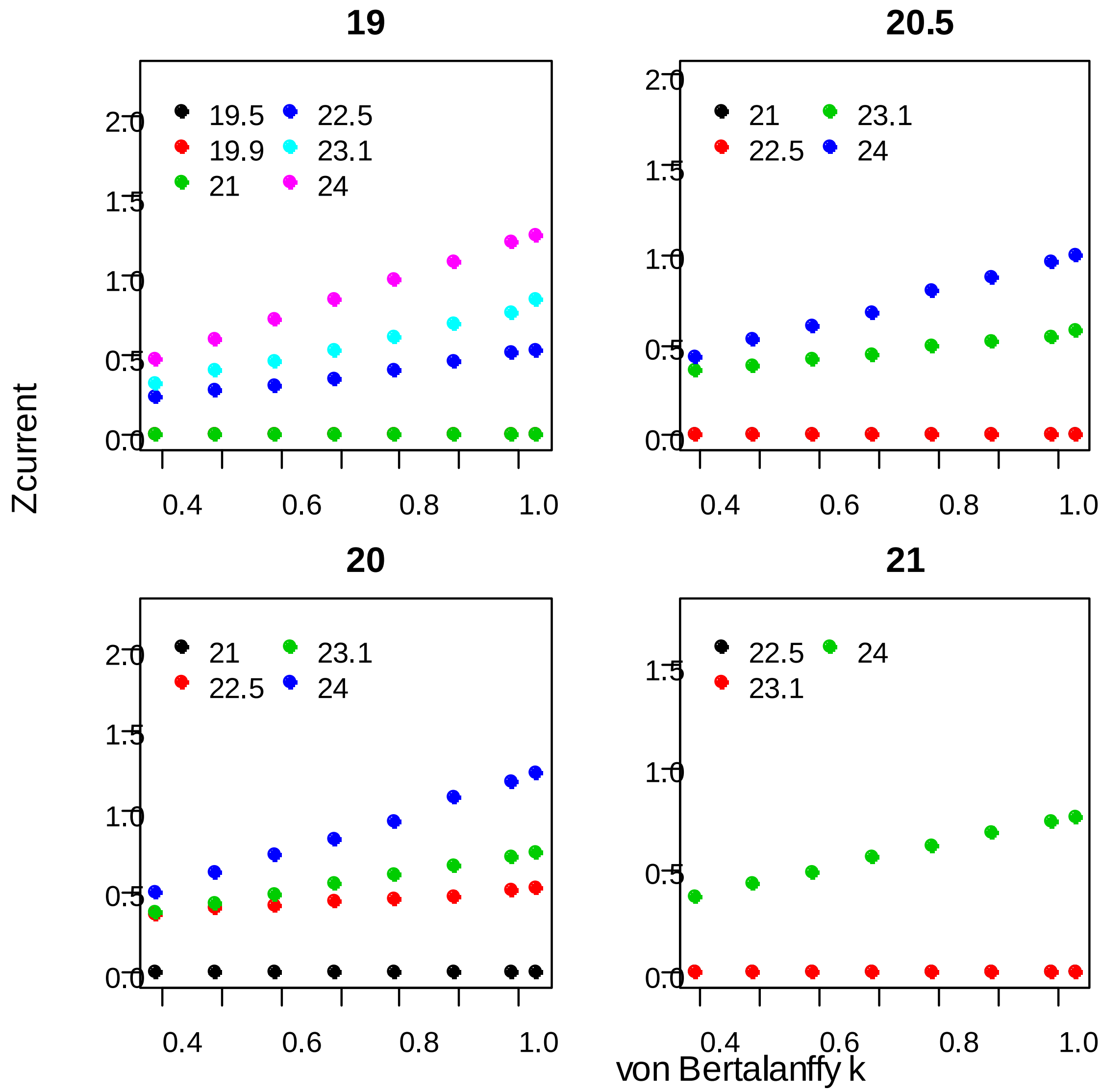

Figure 14. The estimates of the current total mortality, Zcurrent, from the sensitivity analysis carried out on the blue tang length data from the St. Thomas/St. John pot and trap fishery. Each panel represents a different length-at-full vulnerability value, L_c, and is indicated above each panel. The colored points represent different values of L_∞, which are indicated in the figure legend.

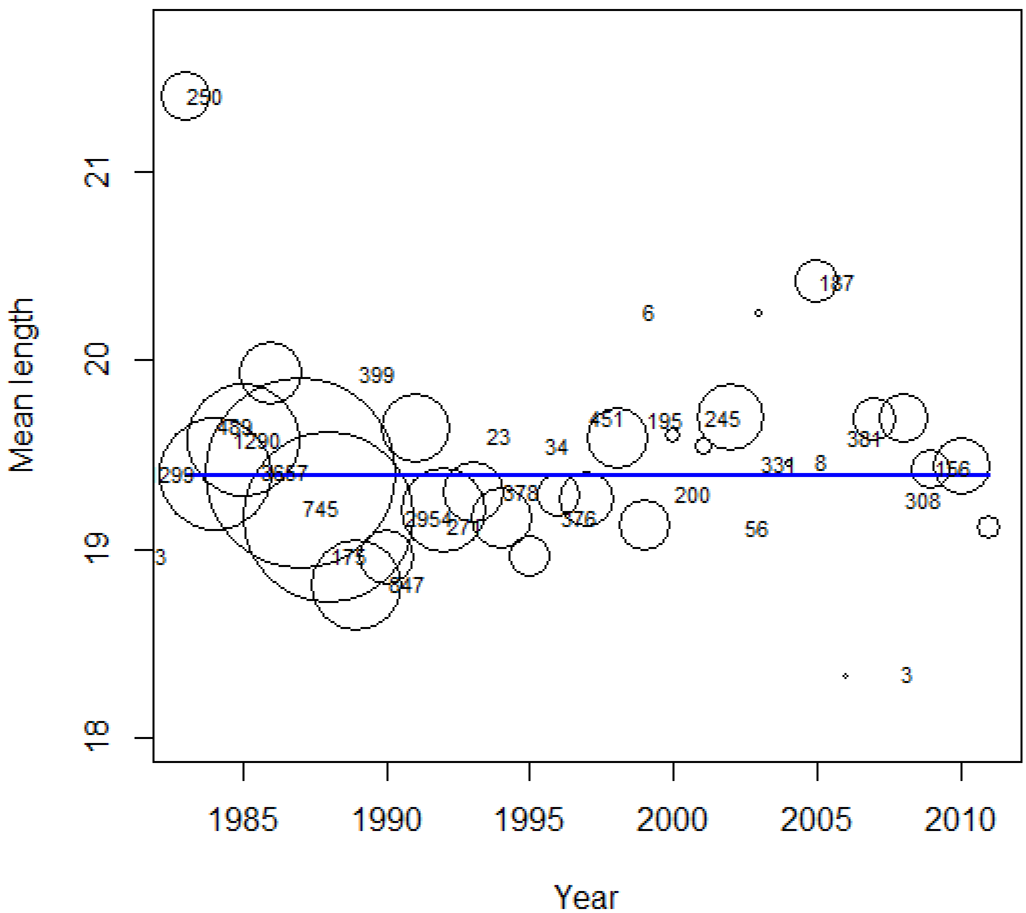

Figure 15. The model fit to the blue tang length data from the St. Croix pot and trap fishery. The model fit shown predicts no change in total mortality and had the lowest AIC value. The input parameter values used were L_c = 18cm, L_∞ = 19.9cm, and K = 0.39, the L_c input value differs from Figures 16-18. Bubble size represents the annual sample size scaled with respect to other years.

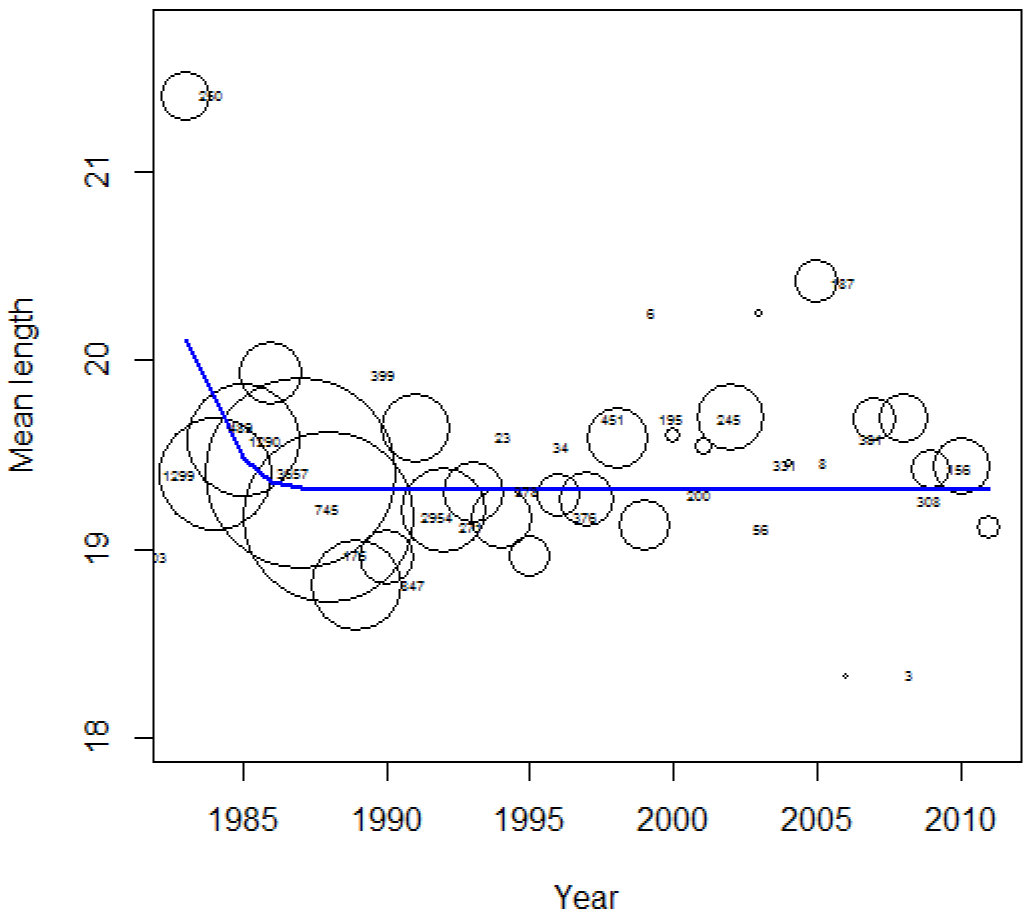

Figure 16. The model fit to the blue tang length data from the St. Croix pot and trap fishery. The model fit shown predicts one change in total mortality and had the lowest AIC value. The input parameter values used were L_c = 18cm, L_∞ = 23.1cm, and K = 0.49, the L_c input value differs from Figures 15, 17, and 18. Bubble size represents the annual sample size scaled with respect to other years.

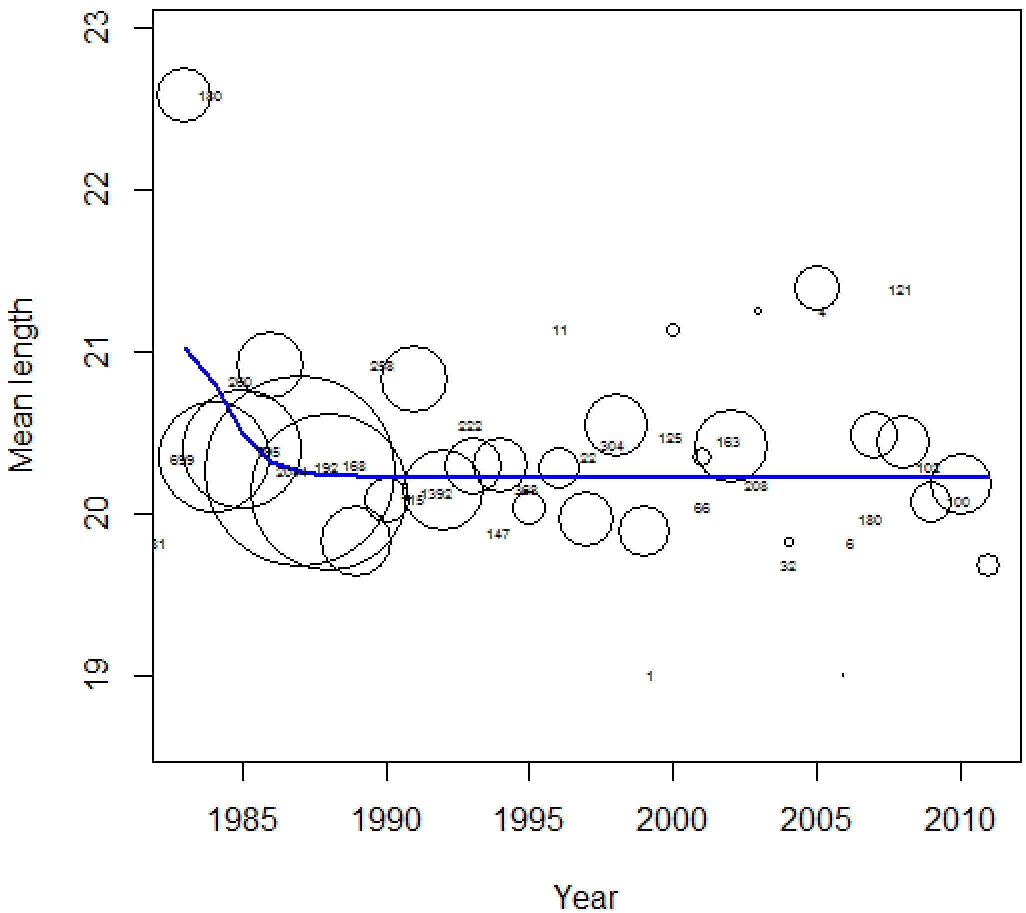

Figure 17. The model fit to the blue tang length data from the St. Croix pot and trap fishery. The model fit shown predicts one change in total mortality and had the lowest AIC value. The input parameter values used were L_c = 19cm, L_∞ = 23.1cm, and K = 0.49, the L_c input value differs from Figures 15, 16, and 18.. Bubble size represents the annual sample size scaled with respect to other years.

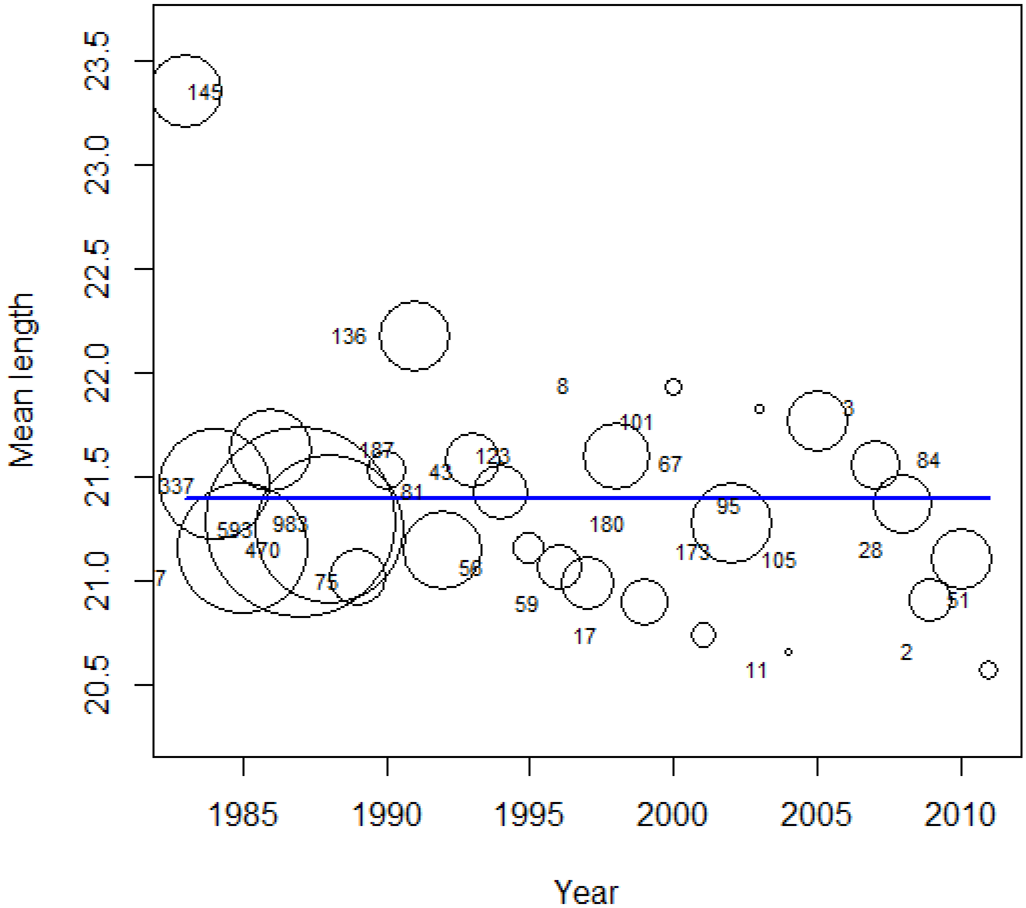

Figure 18. The model fit to the blue tang length data from the St. Croix pot and trap fishery. The model fit shown predicts one change in total mortality and had the lowest AIC value. The input parameter values used were L_c = 20cm, L_∞ = 23.1cm, and K = 0.49, the L_c input value differs from Figures 15 - 17. Bubble size represents the annual sample size scaled with respect to other years.

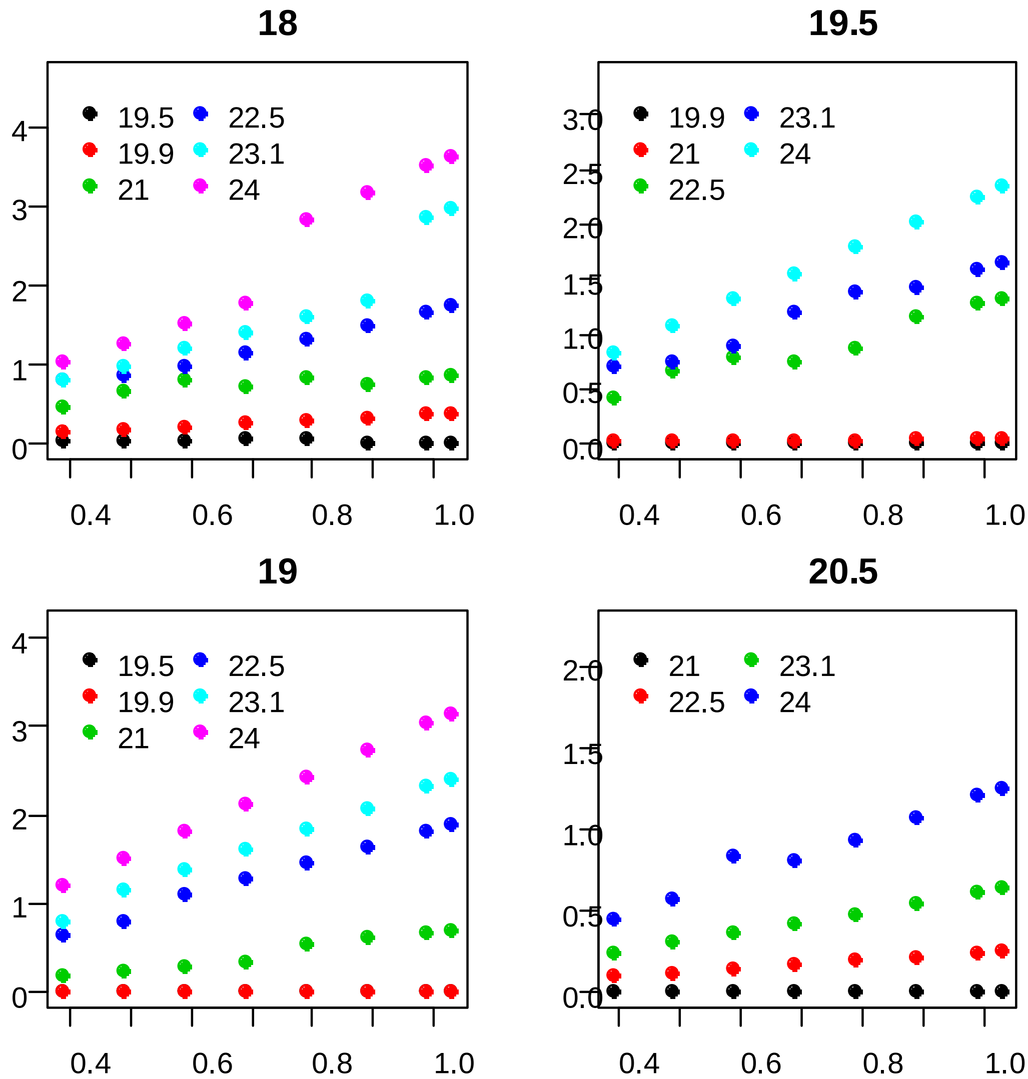

Figure 19. The estimates of the current total mortality, Zcurrent, for blue tang from the sensitivity analysis carried out on the data from the St. Croix pot and trap fishery. Each panel represents a different length-at-full vulnerability value, L_c, and is indicated above the panel. The colored points represent different values of L_∞, the values are indicated in the figure legend.

SEDAR
Southeast Data, Assessment, and Review

SEDAR 30

U.S. Caribbean Blue Tang

SECTION III: Review Report

March 2013

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

Table of Contents

1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 30 Peer Review Process was conducted via a CIE (Center for Independent Experts) Desk Review in lieu of a Panel Review Workshop. Three reviewers were selected by provided the CIE and provided with the assessment report and background materials. Each reviewer conducted a review of the material and produced an independent review report. Those reports are included below.

1.2 TERMS OF REFERENCE

1. Evaluate the data used in the assessment, addressing the following:
   a) Are data decisions made by the Assessment Workshop sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are data applied properly within the assessment model?
   d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   a) Are methods scientifically sound and robust?
   b) Are assessment models configured properly and used consistent with standard practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   b) Is the stock overfished? What information helps you reach this conclusion?

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

4. Evaluate the stock projections, addressing the following:

   a) Are the methods consistent with accepted practices and available data?

   b) Are the methods appropriate for the assessment model and outputs?

   c) Are the results informative and robust, and useful to support inferences of probable future conditions?

   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

   - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
   - Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.

7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

1.3 LIST OF PARTICIPANTS

CIE Reviewers

Massimiliano Cardinale ....CIE Reviewer
Yong Chen ....CIE Reviewer
M. Kurtis Trzcinski...CIE Reviewer

2. CIE REVIEWER REPORTS

Center for Independent Experts (CIE) Independent Peer Review Report of the SEDAR 30 Caribbean Blue Tang and Queen Triggerfish assessment review

Dr. Massimiliano Cardinale

March 2013

Executive Summary

• This document is the individual Center for Independent Experts (CIE) review report of the SEDAR 30 Caribbean blue tang and queen triggerfish assessments conducted during February 2013 and provided at the request of the CIE (see Attachment A).

• This report solely represents the views of the independent reviewer (Dr. Massimiliano Cardinale).

• This reviewer does not completely agree with all of the findings reported in the SEDAR 30 Caribbean queen triggerfish assessment report, while the reviewer is in general agreement concerning the blue tang assessment report. Findings that are reported in the SEDAR 30 Caribbean blue tang and queen triggerfish assessments reports are not necessarily fully repeated in this individual report. This report focuses on clarifications of elements contained in the Summary Report and some additional views of the individual reviewer about how data for queen triggerfish could have been better explored to derive more robust estimates of exploitation rates and thus stock status.

• The assessment team tackled all of the review terms of reference (TORs).

• This reviewer believes that the SEDAR 30 has done a good job in carrying out the assessment, analysing all available source of data, modelling uncertainty and providing a full sensitivity analysis of both the data and the models. However, the reviewer is of the opinion that data for queen triggerfish are underutilised and that the reader is left with the doubt that more could have been done in terms of data analysis to derive estimates of exploitation rates and thus stock status for this species.

• For Caribbean blue tang, the report gives the impression that stability in average length is taken as an indication of a low level of F. The reviewer disagrees with this idea, and considers that given the available information the status of the stock should be considered as unknown.

• Further recommendations aimed at improving the data source used in the Caribbean queen triggerfish and blue tang assessment were made. These are based on additional future research and further re-analysis and modelling of the original data set.

Introduction

SEDAR 30 Caribbean blue tang and queen triggerfish assessments reports and associated background documents containing detailed information on the data used in the assessment were provided to the independent reviewer (Dr. Massimiliano Cardinale) well in advance of the deadline scheduled for the 28th of February 2013. The reports were reviewed at the request of the CIE (see Attachment A).

Description of review activities

This review was undertaken by Dr. Massimiliano Cardinale as desk work during February 2013 at the request of the CIE (see Attachment A).

Relevant documents (see bibliography, Attachment B) were made available four weeks prior to the deadline through email and via a link to an ftp or SEDAR 30 website (https://grunt.sefsc.noaa.gov/sedar/Sedar_Documents.jsp?WorkshopNum=30&FolderType=Assessment). The documentation was reviewed prior to the deadline and the deadline was met. The background information and assessments of Caribbean blue tang and queen triggerfish was presented through two documents (see Attachment A). Background information relevant to this review are presented in a series of appendices, including: CIE Statement of Work (Attachment A); a bibliography (Attachment B), report format (Annex 1); Terms of Reference (Annex 2); Comments included here are provided following the terms of reference (TORs) (Annex 2) and are those of this independent reviewer only. The list of main documents provided as background material is included in Attachment B. Additional presentations and documentations were made available during the meeting and were continuously updated under the ftp or SEDAR 30 website (https://grunt.sefsc.noaa.gov/sedar/Sedar_Documents.jsp?WorkshopNum=30&FolderType=Assessment).

Summary of findings

Recommendations

1. Estimate time series of landings per unit of effort (LPUE) for Puerto Rico queen triggerfish and investigate the possibility to derive the proportion of queen triggerfish within triggerfish and blue tang within surgeonfish from the Trip Interview Program (TIP) data. This would allow estimating the total number of fish landed by size class for the main gear (i.e. traps and pots) for both species, combining landings information with the size frequency data from the TIP (see also comments under ToR2).

2. Explore also the quality of the effort data for both species from the TIP, with the aim to produce an effort standardized time series of length frequency distribution (LFD) for queen triggerfish and blue tang.

3. **Queen triggerfish catch data from Puerto Rico traps and pots:** Estimate the total number of fish landed by size class for the main gear (i.e. traps and pots), combining the landings information with the size frequency data from the TIP; Statistical slicing of the total number of fish landed by size class by the main gear (i.e. traps and pots) to estimate the number of fish landed per age class for years with sufficient length measurements (i.e. for years from 1983 to 1988; a general rule of thumb would be to use years with more than 150 or 200 individuals); Estimation of Z from the catch curve or using a pseudocohort analysis (i.e. VIT when only one or few years of data are available); Conducting a yield-per-recruit (YPR) analysis to estimate F_{01} as proxy for F_{MSY} to be compared against estimate of M

4. **TIP data of queen triggerfish:** Explore the use of effort data from the TIP survey to produce an effort standardized time series of LFD for years with sufficient length measurements (a general rule of thumb would be to use years with more than 150 or 200 individuals); statistical slicing of the total number of fish caught by size class by the main gear (i.e. traps and pots) to estimate the total number of fish per age class; estimation of Z from the catch curve or using a pseudocohort analysis (i.e. VIT when only one or few years of data is available)

5. The reviewer considers that ProdBiom method (see Abella et al.,1997) might be more appropriate for the estimation of M as it combines in a single framework the growth parameters, the length weight relationship and information on the longevity of the species. Or at least it should be used along with the other methodologies presented in the reports.
6. The reviewer is of the opinion that the combination of large L_{inf} and low k are the most plausible set of VBF parameters for queen triggerfish, given what has been presented in SEDAR 30 AW 03 and according to information available in the literature, and therefore they should have been given more weight in the evaluation of the stock status.
7. The reviewer considers F_{MSY}=M as a large oversimplification, which ignores selectivity that has a large impact on F_{MSY}. The assessment team should try to estimate catch at age data from LFD (which is possible for certain combinations of years and gear type) and conduct a VIT and an YPR analysis for queen triggerfish based on selected yearly data to verify how realistic is the F_{MSY}=M assumption.
8. For Caribbean blue tang, there is some implication in the report that stability in average length is taken as an indication of a low level of F. The reviewer disagrees with this idea, and considers that given the available information the status of the stock should be considered as unknown.
9. Selectivity studies should be conducted to estimate the effect of the mesh size of the traps on the amount and size distribution of the catches of Caribbean queen triggerfish and blue tang.

Terms of Reference (ToR)

ToR1: Evaluate the data used in the assessment, addressing the following:

a) Are data decisions made by the Assessment Workshop sound and robust?

b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

c) Are data applied properly within the assessment model?

d) Are input data series reliable and sufficient to support the assessment approach

Puerto Rico reported landings of Caribbean queen triggerfish and Caribbean blue tang have been adjusted for incomplete reporting using so-called expansion factors to estimate the total real landings. It is however unclear, both from the assessment report and from the background documents, how the expansion factor has been estimated (which is the source of the factors), how large the factors are, and if they vary between years for the different areas.

In general, I feel that the landings and effort data are underutilised, especially for Puerto Rico queen triggerfish, for which landings are reported to the level of species. Even the simple estimation of a LPUE time series for Puerto Rico, would have been an useful addition, especially for evaluating estimated time-changes in mortality derived from the Gedamke and Hoenig (2006) method. Also, simple production models might have been tested as an attempt to validate or corroborate the results from the Gedamke and Hoenig (2006) method.

I accept that it is difficult to utilise landings data for Caribbean blue tang as they are reported within the species-group surgeonfish, but especially for short times series such as St. Thomas and St. John, an assumption of constant proportion of landings of blue tang within the species-group surgeonfish could be made. This would allow building CPUE time series also for the other areas and species. In general, I wonder if the TIP data could provide an estimate of the proportion of both species in the landings, when landings data are provided as a species group instead that at the species level. In other words, it would be a useful addition to know if an estimate of the proportion of queen triggerfish within triggerfish and blue tang within surgeonfish might be derived from the TIP data from which the LFD are also derived.

Although it is reasonable to assume that some form of effort data has been collected during the TIP, it is not clear from the assessment reports if such information exists. This has been specified neither in the assessment reports nor in the background information document (i.e. SEDAR 30 AW 02). Effort data from TIP would give a rather different dimension to the LFD as they could provide information more similar to a survey and thus could be useful for estimating stock parameters such as Z and relative changes in population size, especially for queen triggerfish.

Again, considering the large uncertainty associated with the estimate of Z from the Gedamke and Hoenig (2006) method (i.e. violation of constant selectivity assumption, and uncertainty in the VBF parameters), the assessment team should have tried to produce another source of information concerning the exploitation status of the queen triggerfish stock.

I agree instead with the way the assessment team dealt with the available data for Caribbean blue tang. The large uncertainty in the reported Von Bertalanffy (VBF) parameters and, given the fact that this species presents an initial fast growth but a very high longevity, makes the length data uninformative regarding individual ages after age 5. With such large uncertainty in the basic growth parameters, to which both M and F (and F_{MSY}) depend and, due to the peculiar growth characteristics of the species, I agree with the assessment team that it is not possible to use length data to define the stock status of the species. A further difficulty with the use of length data for Caribbean blue tang is the fact that L_c is almost as large as L_{inf}, which makes most of the age classes for which the age could be in theory derived from length information not fully exploited. In this situation, age data are crucial for a robust assessment of this species.

Recreational data for both species are also presented but they are too sparse for allowing any kind of analysis. In this context, the reviewer agrees with the evaluation made by the assessment team.

Recommendations: Estimate time series of CPUE for Puerto Rico queen triggerfish and investigate the possibility of deriving the proportions of queen triggerfish within triggerfish and blue tang within surgeonfish from the TIP data. This would allow estimating the total number of fish landed by size class for the main gear (i.e. traps and pots) for both species, combining landings information with the size frequency data from the TIP (see also comments under ToR2).

Explore also the quality of the effort data for both species from the TIP, with the aim to produce an effort standardized time series of LFD for queen triggerfish and blue tang.

ToR2: Evaluate the methods used to assess the stock, taking into account the available data.

a) Are methods scientifically sound and robust?

b) Are assessment models configured properly and used consistent with standard practices?

The methodology (i.e Gedamke and Hoenig (2006) method) used to estimate Z has been applied correctly and I consider it as one that is robust and is an appropriate alternative for deriving estimates of exploitation given the available data. However, as for the landings data, and considering the uncertainty associated with the method used, I consider that the length data for queen triggerfish have been underutilised. Thus, other methods should have been used in conjunction with the Gedamke and Hoenig (2006) method to derive estimate of exploitation rates for this species.

For queen triggerfish from Puerto Rico, length frequency data (LFD) from the trap and pot fisheries between 1983 and 1988 are sufficient to estimate the total number of fish caught by the main gear (i.e. traps and pots) by age class, at least for the first 4-6 age classes, which constitutes the main bulk of the catches (compare for example Figures 9 and 10). A recent method has been developed (statistical slicing; see Kell and Kell 2011; Scott et al., 2011) to generate age-structured data for stock assessment from length frequency data and VBF growth curve parameters. The method is very flexible and offers a sophisticated framework for converting numbers at length to numbers at age as well as estimating the mean length at age assuming different distributions of the length data (i.e. Gaussian, gamma and lognormal).

This would allow the assessment team to obtain another and possibly more robust estimate of Z and F (assuming that M is known) from the same length data and to compare them with those derived from the Gedamke and Hoenig (2006) method. In theory, this would also allow for conducting a yield per recruit (YPR) analysis (at least based on the historical part of the times series) and derive estimates of F_{MSY} (using F_{01} as a proxy), which are independent from the estimates of M and take into account selectivity at size/age. Historical estimates of F would be crucial to evaluate the results from the Gedamke and Hoenig (2006) method as well as YPR would be important to define a more robust estimate of F_{MSY}.

However, I also realise that this is conditional on the standardization of the LFD by fishing effort to make them comparable between years and to allow for the catch curve analysis and estimates of Z. For example, the yearly number of trips from which the LFD are derived would be a reasonable index of the effort and sufficient to make the LFD comparable between years. This would allow the use of the statistical slicing method and the catch curve analysis (see also comments and recommendations under ToR2).

Another method that can be used to derive estimates of mortality is the VIT (Lleonart and Salat, 2000), which is even more flexible because it can be used also when a single year of LFD and growth parameters are available, thus no effort standardization of the LDF is needed. The method is extensively used in similar data situations with several Mediterranean stocks (e.g. STECF 2012). VIT conducts a virtual population analysis (VPA) assuming a steady state. This is a rather strong assumption for species such as small pelagic fish species, with highly fluctuating abundance due to both variable recruitment and relatively low number of age classes, but it is a much more likely assumption for demersal fish species such as triggerfish for which the population is made up of several age classes. As it requires knowledge of the catches over one year only (Lleonart and Salat, 2000) it might be used for years, areas and species for which the data allow for such an analysis. In addition to the above mentioned data, VIT requires a number of biological parameters as growth, length-weight relationship, natural mortalities and percentage mature by size or age, and proportions caught by each fishing gear (when available, but these parameters are not necessary). These parameters are all available for queen triggerfish and reported in SEDAR 30 AW 02 and thus they might be used.

For several years, the sample size of queen triggerfish from Puerto Rico is too low to conduct such kinds of analyses. However, this also applies to the estimation of average length used in the Gedamke and Hoenig (2006) method and constitutes a further argument why the assessment team should have combined different approaches to estimate Z and tried a more thorough utilisation of the available data, especially for those years with large sample size of individual length data.

The situation is different for blue tang due to the large uncertainty in the reported Von Bertalanffy (VBF) parameters and, given the fact that the species presents an initial fast growth but a very high longevity, it makes the length data uninformative regarding individual ages after age 5. Therefore, for blue tang, the exploration of the slicing method and the VIT are not feasible and the reviewer agrees with the assessment team concerning the methodology used for assessing this species.

Another method to estimate M is ProdBiom (Abella et al., 1997). The main advantage of this method is that it combines in a single framework the growth parameters, the length weight relationship and information on the longevity of the species. Also, it is able to derive estimates of M by age class, which are very useful in VIT models. It generally gives values of M which are slightly smaller than other methods, thus also avoiding failure to detect overfishing because of unrealistically high values of M. The reviewer considers that Prodbiom might be more appropriate for the estimate of M or it should be used along with the other methodologies presented.

In general, the reviewer considers that the reader is left with the doubt that much more could have been done if there had been a few more assumptions for the queen triggerfish, or at least the assessment team should have explored the possibility of using different methodologies than the Gedamke and Hoenig (2006) method to derive estimates of exploitation rates and F_{MSY}.

Recommendations:

Queen triggerfish catch data from Puerto Rico trap and pots

- Estimate the total number of fish caught by size class for the main gear (i.e. traps and pots), combining the landings information with the size frequency data from the TIP.

- Statistical slicing of the total number of fish landed by size class by the main gear (i.e. traps and pots) to estimate the number of fish landed per age class for years with sufficient length measurements (i.e. for years from 1983 to 1988; a general rule of thumb would be to use years with more than 150 or 200 individuals).

- Estimation of Z from the catch curve or using a pseudocohort analysis (i.e. VIT when only one or few years of data are available).

- Conducting an YPR analysis to estimate F_{01} as a proxy for F_{MSY} to be compared against using M as a proxy for F_{MSY}.

TIP data of queen triggerfish

- Explore the use of effort data from the TIP survey to produce an effort standardized time series of LFD for years with sufficient length measurements (a general rule of thumb would be to use years with more than 150 or 200 individuals).

- Statistical slicing of the total number of fish caught by size class by the main gear (i.e. traps and pots) to estimate the total number of fish per age class.

- Estimation of Z from the catch curve or using a pseudocohort analysis (i.e. VIT) when only one or few years of data is available.

Use the ProdBiom method (Abella et al., 1997) to estimate M along with the other methodologies presented here.

ToR3: Evaluate the assessment findings with respect to the following:

a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
b) Is the stock overfished? What information helps you reach this conclusion?
c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

Generally, a lot of emphasis is given in estimating the uncertainty, which is obviously fine, but with little critical considerations of the likelihood of each of the tested scenarios. This will automatically overestimate the uncertainty and make the evaluation of the stock status even more complicated. This is a more prominent issue for Caribbean queen triggerfish compared to blue tang. As the assessment team correctly pointed out, the key items here are the VBF parameters, which are used to estimate Z, M and F (and F_{MSY}) for both species. It is clear from Table 7 in the assessment report and Table 2 in SEDAR30 AW 03 that the L_{inf} of queen triggerfish estimated by Manooch and Drennon (1987) is generally lower or much lower than L_{max} estimated by other studies in the same area, although no details are given on the number of individuals analysed in these studies. L_{inf} is assumed to range from 37.3 to 45.6, which is in the lower range of the reported L_{max}. The impression I have is that L_{inf} is likely larger than 46.5 and thus the sensitivity analysis should have included also larger L_{inf} and lower k as L_{inf} and k are generally negatively correlated. This has direct consequences on the estimation of M and F, which are likely to be over- and underestimated, respectively. Moreover, L_{inf} and k are negatively correlated, which makes several of the scenarios tested and presented in figure 17, 19 and 21 unrealistic and also inflates the level of uncertainty in the Z estimates. Interestingly, figure 17, 19 and 21 showed that Z estimated for the combination of extreme range of L_{inf} and k are very similar, again corroborating the idea that uncertainty is largely overestimated by the way the sensitivity analysis is set up.

The reviewer is of the opinion that the combination of large L_{inf} and low k are the most plausible set of VBF parameters, given what has been presented in SEDAR30 AW 03 and therefore they should have been given more weight in the evaluation of stock status.

The situation is different for blue tang due to the large uncertainty in the reported VBF parameters, which, together with the fact that the species presents an initial fast growth but a very high longevity, makes the length data uninformative of individual age after age 5. Thus, the reviewer agrees with the assessment team that it is not possible to precisely define the stock status for the Caribbean blue tang and that age-based data are crucial in the future. Stability in mean length is difficult to interpret in this case, and without a robust estimate of the absolute vale of Z it cannot be interpreted as an indication of sustainable fishing. Thus, I consider that the stock status is unknown and age data are needed in the future as also pointed out by the assessment team in their general conclusions.

A lot of emphasis has been given to test the effect of L_c on the Z estimates, which was then revealed by the sensitivity analysis to be very small, instead of critically assigning different likelihood to the different scenarios. The authors correctly stress that the estimates are dependent on the parameters but they fail to give critical support to one or fewer scenario over the others to reduce the number of scenarios and help with the evaluation of the stock status.

The impression is that the assessment team is more prone to consider queen triggerfish as being not subject to overexploitation although they correctly stress the fact that the data are not enough to make firm conclusions on the stock's status. However, from Tables 19 and 21, several scenarios indicated that F was in excess of F_{MSY}, which I would interpret as an indication of overfishing being highly likely but this does not emerge from the text of the report. The reviewer also considers F_{MSY}=M as a large oversimplification, which ignores selectivity that has a large impact on F_{MSY}. I would try to estimate catch at age data from LFD and conduct an YPR analysis based on selected yearly data to have an idea of how realistic is this assumption.

For Caribbean blue tang, there is some implication in the report that stability in average length is viewed as an indication of a low level of F. The reviewer disagrees with this view, and considers that given the available information the status of the stock should be considered as unknown.

Recommendations

The reviewer is of the opinion that the combination of large L_{inf} and low k are the most plausible set of VBF parameters, given what has been presented in SEDAR30 AW 03 and therefore they should have been given more weight in the evaluation of the stock's status.

The reviewer considers F_{MSY}=M as a large oversimplification, which ignores selectivity that has a large impact on F_{MSY}. The assessment team should try to estimate catch at age data from LFD and conduct a VIT and an YPR analysis for queen triggerfish based on selected yearly data to have an idea of how realistic is this assumption.

For Caribbean blue tang, the report gives the impression that stability in average length is taken as an indication of low level of F. The reviewer disagrees with this view, and considers that given the available information the status of the stock should be considered as unknown.

ToR 4. Evaluate the stock projections, addressing the following:
a) Are the methods consistent with accepted practices and available data?
b) Are the methods appropriate for the assessment model and outputs?
c) Are the results informative and robust, and useful to support inferences of probable future conditions?
d) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?...........................

The ToR could not be conducted due to data restrictions.

Recommendations

None.

ToR 5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
• Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.
• Ensure that the implications of uncertainty in technical conclusions are clearly stated.

See comments under ToR3.

Recommendations

None.

ToR 6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

• Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
• Provide recommendations on possible ways to improve the SEDAR process.

The assessment team do provide an exhaustive shopping list for future data to be collected, which would greatly improve the capability of assessing the status of the Caribbean queen triggerfish and blue tang stock. However, I also suggest that effort should be devoted to selectivity experiments aimed to evaluate the theoretical changes in selectivity linked with the historical changes in the mesh size of the traps.

Recommendations

Conduct selectivity studies on the effect of the mesh size of the traps on the amount and size distribution of the catches of queen triggerfish and blue tang.

ToR 7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

See comments under ToR 2 and 3.

Recommendations

None

The key information contained in the introduction of both the assessment for U.S. Caribbean queen triggerfish and the one for blue tang is the management table and the table with the changes in management regulations. The management table should indicate the unit for the value of MSST, MSY and OY, which are now missing. On the other hand, the table with the changes in management regulations is very detailed but without any information about the selectivity of the different mesh size for the traps. Therefore, the reported information is rather uninformative and it is basically impossible to evaluate how these changes might have affected the selectivity of the fisheries. This is crucial information as violating the assumption of time invariant selectivity would affect directly the model output in this case and makes the utilisation of the landings data more complicated. I suggest that effort should be devoted to selectivity experiments aimed to evaluate the theoretical changes in selectivity linked with the historical changes in the mesh size of the traps (see also recommendations in ToR6).

Conclusions

The assessment team should be commended for their effort, timing and clarity in presenting the results. However, I consider that data are underutilised and the uncertainty overestimated by the sensitivity set up used. Also, the lack of alternative estimates of Z beside those coming from the Gedamke and Hoenig (2006) method makes it difficult to evaluate the results and assess the status of the Caribbean queen triggerfish stock. A series of recommendations on how to improve the data utilisation and provide alternative estimates of the exploitation rates have been given under the specific ToRs.

For Caribbean blue tang, the report gives the impression that stability in average length is an indication of a low level of F. The reviewer disagrees with this view, and considers that given the available information the status of the stock should be considered as unknown.

The basic data and model framework were adequately presented through documents and were circulated well in advance of the review. A possible improvement for the presentation of the result in the report could be the creation of a *Glossary* and an *Acronyms* list at the end of the document. This will greatly facilitate the reading of the report for the public.

Reference list

Abella A., Caddy J., Serena F., 1997. Do natural mortality and availability decline with age? An alternative yield paradigm for juvenile fisheries, illustrated by the hake *Merluccius merluccius* in the Mediterranean. Aquat. Liv. Res., 10: 257-269.

Laurence T. Kell and Alexander Kell. A comparison of age slicing and statistical age estimation for mediterranean sword_sh (xiphias gladious). Collect. Vol. Sci. Pap. ICCAT, 66(4):1522{1534, 2011.

Lleonart, J. & Salat, J., 2000. VIT (version 1. 1): Software for fishery analysis. User's manual. On ligne: http//www.faocopemed.org/es/activ/infodif/vit.htm.

Scientific, Technical and Economic Committee for Fisheries (STECF) – Assessment of Mediterranean Sea stocks – part 1 (STECF 12-19). (eds. Cardinale M. (Chairman) Osio C. & Charef A.). 2012. Publications Office of the European Union, Luxembourg, EUR 25602 EN, JRC 76735, 502 pp.

Scott F, Osio G, Cardinale M 2011. Comparison of age slicing methods - Working Document in support to the STECF Expert Working Group 11-12 Assessment of Mediterranean Sea stocks - part II. EUR 25054 EN. Luxembourg.

Attachment A: Statement of Work for Dr. Massimiliano Cardinale

External Independent Peer Review by the Center for Independent Experts

SEDAR 30 Caribbean blue tang and queen triggerfish assessment review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description SEDAR 30 will be a compilation of data, an assessment of the stock, and an assessment review conducted for Caribbean blue tang and queen triggerfish. The CIE peer review is ultimately responsible for ensuring that the best possible assessment has been provided through the SEDAR process. The stocks assessed through SEDAR 30 are within the jurisdiction of the Caribbean Fisheries Management Council and the territorial waters of Puerto Rico and the U.S. Virgin Islands. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall have the necessary qualifications to complete an impartial and independent peer review in accordance with the tasks and ToRs described in the SoW herein. The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the scientific peer-review described herein. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct the desk review during 4-7 February 2013, therefore no travel will be required.
Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other information pertinent to the desk review arrangements. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.

2) During February 4-7, 2013 as specified herein, conduct an independent desk peer review in accordance with the ToRs (**Annex 2**).

3) No later than February 21, 2013, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Sampson david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

14 January 2013	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
18 January 2013	NMFS Project Contact sends the stock assessment report and background documents to the CIE reviewers.
4-13 February 2013	Each reviewer conducts an independent desk peer review
19 February 2013	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
7 March 2013	CIE submits CIE independent peer review reports to the COR
14 March 2013	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on changes. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed. The CIE independent report shall be an independent peer review of each ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

SEDAR 30 Caribbean blue tang and queen triggerfish assessment review

1. Evaluate the data used in the assessment, addressing the following:
    a) Are data decisions made by the Assessment Workshop sound and robust?
    b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
    c) Are data applied properly within the assessment model?
    d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
    a) Are methods scientifically sound and robust?
    b) Are assessment models configured properly and used consistent with standard practices?
    c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
    a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
    b) Is the stock overfished? What information helps you reach this conclusion?
    c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
    d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
    e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
    a) Are the methods consistent with accepted practices and available data?
    b) Are the methods appropriate for the assessment model and outputs?
    c) Are the results informative and robust, and useful to support inferences of probable future conditions?
    d) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
    - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods

- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.

7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

Attachment B: List of main documents provided as background material

Draft Stock Assessment:
Section1_blue tang_v1.pdf
SectionII_S30_Blue_tang_AW_report_complete_w_watermark.pdf
Section1_queen_triggerfish_v1.pdf
SectionII_S30_Queen_triggerfish_AW_report_w_watermark.pdf

Background Materials:
S30 Doc List.pdf
S30_FTP site instructions.pdf
S30_AW_01_SummaryRecreationalBlueTangQueenTriggerfish.pdf.
S30_AW_02_SummaryTIP.pdf
S30_AW_03_Rios_Life History Review.pdf
S30_AW_04_Caribbean queen triggerfish and blue tang landings.pdf

CIE Independent Peer Review Report

on

SEDAR 30

Caribbean blue tang and queen triggerfish assessment review

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Contents

I. Executive Summary

Queen triggerfish (*Balistes vetula*) and blue tang (*Acanthurus coeruleus*) are reef dwelling and widely distributed in the Atlantic Ocean. They are common in the Caribbean Sea and support two important fisheries in the Puerto Rico and U.S. Virgin Islands. Commercial landing data of the U.S. Caribbean queen triggerfish and blue tang were included in snapper/grouper landings in the 1970s -1990s and then in species groups in the 2000s, and species-specific landing data were only available in recent years. Limited life history parameters such as von Bertalanffy growth parameters are available. Length-composition data are also available for all locations except for the Puerto Rico blue tang. No fishery-independent and fishery-dependent abundance index data were available for the assessment. Because limited data are available for their stock assessment, they are considered data-poor fisheries and a formal stock assessment model is not applicable to these two fish stocks.

An estimator, which uses length-frequency data and requires no assumption of equilibrium population, was used in the assessment for estimating total mortality rate. The natural mortality was estimated from various methods. The fishing mortality was then estimated as the difference between the total and natural mortality rates. No biological reference points such as F_{MSY} and B_{MSY} were estimated. The natural mortality was used as a proxy of F_{MSY}. The estimated fishing mortality was compared with the natural mortality to determine if the fishery was in the status of "overfishing". Because no biomass could be estimated, it is impossible to determine if the queen triggerfish and blue tang stocks were "overfished" and no stock projection under different management strategies could be done. A comprehensive sensitivity analysis was conducted to evaluate impacts of uncertainty associated with the key life history parameters. The stock assessment suggests that the choice of growth parameters and estimators of natural mortality influenced the determination of status of the U.S. Caribbean queen triggerfish and blue tang. For certain combinations of growth parameters and natural mortality estimators, the fisheries could be defined as experiencing "overfishing", but for the other combinations, the fisheries were considered not in the status of "overfishing". Although large uncertainty existed in the status of the fisheries, it appears that these two fish stocks were *less likely* to be in the status of "overfishing". *Overall, I conclude this assessment is the best the AW panel could do given the restriction of data availability; however I cannot conclude that the assessment is "sound" and "robust" as the assessment quality and results are affected greatly by large uncertainty in the data quality and estimators of natural mortality.*

I have made the following recommendations for improving the assessment: (1) the expert and background knowledge on species of similar life history patterns be used to exclude biologically unrealistic values of K, L_∞, natural mortality, and total mortality; (2) uncertainty associated with K, L_∞, natural mortality, total mortality, and subsequently fishing mortality be quantified using a Monte Carlo simulation; (3) a program be developed to interview fishermen to collect the information on temporal and spatial variability of the fishing grounds, target species and sizes, and fishing efforts; (4) the information on the species composition of current landings be used to decompose the historical landings of species group into the species-specific landings; (5) a fishery-independent survey program be developed for the queen triggerfish, blue tang and other reef-dependent species sharing similar habitat to collect samples for estimating basic life history parameters and for driving reliable abundance indices; (6) a simulation study be conducted to evaluate the performance of the length-based estimator and identify factors that are critical in influencing the performance of the estimator; (7) a yield-per-recruit analysis be conducted with the incorporation of uncertainty in life history parameters to estimate biological reference points such as F_{max} and $F_{0.1}$; and (8) a spawning stock biomass-per-recruit analysis be done with the incorporation of uncertainty associated with life history parameters to estimate reference points such as $F_{20\%}$ and $F_{40\%}$.

II. Background

Queen triggerfish (*Balistes vetula*) is a reef dwelling triggerfish mainly distributed in the Atlantic Ocean. In the West Atlantic, they are distributed from Canada to southern Brazil and are common in the US Caribbean. They are reef-dependent and typically occur at coral and rocky reefs in shallow waters. However, they sometimes also can be found in relatively deep water (up to 275 m) and in areas with sand or seagrass. Adult queen triggerfish are opportunistic feeders. The species is subject to diurnal movement and tends to be either solitary or aggregate in small groups (Randall 1968; Aiken 1975). The maximum length was observed at 572 mm fork length in the U.S. Virgin Islands (Randall 1968). The oldest age recorded in the U.S. Caribbean was 7 years old (Manooch and Drennon 1987).

Blue tang (*Acanthurus coeruleus*), also known as the Atlantic blue tang surgeonfish or the Atlantic blue tang, is a surgeonfish in the Atlantic Ocean. Blue tang is common in the Caribbean Sea and Gulf of Mexico. They inhabit shallow-water, coral reefs and rocky habitat (Carpenter 2002). Adult blue tang are herbivorous, feeding on various benthic algae (Carpenter 2002). The maximum length was observed at 457 mm total length in St. Thomas (Olsen 2011), and the oldest age was found to be 20 years of age (Mutz 2006). Growth parameters estimated in different studies tend to differ greatly as a result of differences in sampling locations, sample sizes, and ranges of age/size composition of sampled fish (Choat and Robertson 2002; Mutz 2006).

Both the fisheries are data-poor with a limited amount of information/data available to the stock assessment. The historical landing data were aggregated by snapper/grouper earlier in the 1970s -1990s, by species groups in the 2000s, and were only separated by species in recent years (after 2011). The recreational data tend to have few trips of positive catch. No reliable fishing effort and no fishery-independent data were available. Size composition data of commercial catch derived from relatively large sample sizes were available for all locations except for the blue tang stock in Puerto Rico (SEDAR30 2013).

Size composition data were used in the stock assessment for estimating the total mortality rate using a length-based estimator developed by Gedamke and Hoenig (2006). This method improves the traditional Beverton-Holt mortality estimator (Beverton and Holt 1957) with no requirement for the assumption of an equilibrium population. The natural mortality was estimated from various methods (Pauly 1980; Hoenig 1983; Jensen 1996). The fishing mortality was then estimated as the difference between the total and natural mortality rates. Because this is data-poor fishery, no biological reference points such as F_{MSY} and B_{MSY} were estimated. The natural mortality was used as a proxy of F_{MSY} (King 1995). Thus, the estimated fishing mortality was compared with the natural mortality to determine if the fishery was in the status of "overfishing". Because no biomass could be estimated, it is impossible to determine if the queen triggerfish and blue tang stocks are "overfished" and no stock projection can be done to evaluate impacts of various management strategies on the stocks. A comprehensive sensitivity analysis was conducted to evaluate impacts of uncertainty associated with the estimates of key life history parameters. The stock assessment suggests that the choice of growth parameters and estimators of natural mortality influenced the determination of status of the U.S. Caribbean queen triggerfish and blue tang. For certain combinations of growth parameters and natural mortality estimators, the fisheries could be defined as experiencing "overfishing", but for the other combinations, the fisheries were considered not in the status of "overfishing" (SEDAR30 2013).

III. Description of the Individual Reviewer's Role in the Review Activities

As the SoW states that "*Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs*", my role as a CIE independent reviewer is to conduct an impartial and independent peer review of SEDAR 30 "Caribbean blue tang and queen triggerfish assessment" with respect to the pre-defined Terms of Reference.

This is a desk review. Thus, I have no opportunity for face-to-face discussion and questioning. I read the "SEDAR30-SAR1: Final Stock Assessment Report for Caribbean Blue Tang" and "SEDAR30-SAR2: Final Stock Assessment Report for Caribbean Queen Triggerfish" and all other background documents that were sent to me (see the list in the Appendix I). I also read references relevant to the topics covered in the reports and the SoW. I addressed each topic covered in the ToRs, evaluated the strengths and weaknesses of what was done in this assessment, and provided recommendations to improve future assessment. Based on these evaluations and analyses, I made research recommendations for future assessment of Caribbean blue tang and queen triggerfish.

IV: Summary of Findings

IV-1. Queen triggerfish

The following summary of my findings is provided with respect to a set of pre-defined TORs for the U.S. Caribbean queen triggerfish.

IV-1-1. Evaluate the data used in the assessment, addressing the following:

Data available to the assessment include commercial landings, recreational intercept data and length frequency data estimated separately for St. Thomas/St. John, St. Croix, and Puerto Rico.

For Puerto Rico, the commercial landing data of queen triggerfish by gear and fishing center were estimated from self-reported fisher logbooks/sale receipts for the time period from 1983 to 2011. Because the report was incomplete, the total landings were adjusted (SEDAR30, 2013). The number of trips with reported queen triggerfish landings was also estimated by gear and year.

For St.Thomas and St. John, although logbook reporting started in 1974, landings were reported by gear and by either snapper/grouper or other finfish prior to 1997. Landings were reported by species group and gear from 1997 to 1999, all commercial landings were reported by species group from 2000 to 2010, and the landing data have been reported by species since 2011. For the years included in this assessment, queen triggerfish-specific landing data are not available prior to 2011, and landing data are only available for the triggerfish species group.

For St. Croix, similar to St. Thomas and St. John, landing data were only available for the triggerfish species group, not for queen triggerfish. Commercial landing data were only available from 1998 to 2011.

Marine Recreational Fisheries Sampling Survey (MRFSS) collects data from Puerto Rico, but not the US Virgin Islands. The sampling design consists of two complementary components, an angler-site intercept survey for estimating catch and length frequency data and a fishing effort telephone survey to estimate fishing effort. However, the positive intercepted trips (i.e., presence of queen triggerfish) were less than 1% in almost all the years. Only 60 queen triggerfish were measured from 2000-2011.

The VBGF parameters were estimated in two studies, but K differs greatly (Manooch and Drennon 1987; de Albuquerque et al. 2011). The maximum age in the sample is 7 (Manooch and Drennon 1987) and 14 years of age (de Albuquerque et al. 2011), and the growth curves in neither study reached the asymptotic lengths. The VBGF parameters estimated in Manooch and Drennon (1987) were used because the samples were taken in Puerto Rico and the US Virgin Islands.

Length frequency data were estimated from samples taken in pot and trap fisheries in Puerto Rico, St. Thomas and St. John, and St. Croix. However, the temporal changes in length frequency data might be influenced by changes in market demand for large sizes of queen triggerfish and/or possible expansion of the fishery into new areas.

IV-1-1-a. Are data decisions made by the Assessment Workshop sound and robust?

The AW panel decided to use the von Bertalanffy growth parameters estimated in Manooch and Drennon (1987) because the samples were taken in Puerto Rico and the US Virgin Islands. The AW panel also decided to use length-frequency data estimated in the pot and trap fisheries for estimating the total mortality using a length-based mortality estimator. The AW decided not to use the intercepted catch, effort, and length data from MRFSS because of the low proportion of positive trips and sample sizes of length data.

Based on the data available, these decisions are the best the AW panel could make. However, based on the information available I do not have evidence to conclude if the data decisions are "sound and robust".

IV-1-1-b. Are data uncertainties acknowledged, reported, and within normal or expected levels?

The AW panel did acknowledge potential issues which might influence the quality of the data. The MRFSS data were excluded because of small sample sizes, and good discussions were made on potential causes resulting in large shifts in length compositions over time. However, I do not see distributional quantification of uncertainty associated with the estimates of the von Bertalanffy growth parameters. I think the estimation of these parameters should come with estimates of uncertainty (e.g., bootstrap-estimated confidence intervals). Given there are only 7 age groups available in Manooch and Drennon (1987), the uncertainty associated with the estimated L_∞ and K could be large. It is also unclear if the variation in size within an age group was considered and if the fitting of the VBGF was weighted by the sample sizes of the different age groups.

IV-1-1-c.Are data applied properly within the assessment model?

This is a data-poor fishery, and there is no enough information for a formal stock assessment. Given the data available, I consider the data are properly applied in the estimation of total, natural and fishing mortality rates in the assessment.

However, I believe the sensitivity analysis could be better designed and justified if the uncertainty associated with K and L_∞ could be better quantified and if expert and background knowledge could be used to exclude biologically unrealistic combinations of values for the growth parameters and natural mortality.

IV-1-1-d.Are input data series reliable and sufficient to support the assessment approach and findings?

Estimation of the length-frequency data might be influenced by temporal variability in the shifted preference of market demand for large queen triggerfish, which might change the selectivity of the fishery over the time. Thus, the temporal variability in length composition might not reflect changes in fish mortality; rather reflect changes in selectivity. Although potential changes in the total mortality could be incorporated in Gedamke and Hoenig (2006), I did not see how possible changes in selectivity could be incorporated. This may yield biases in the assessment results.

IV-1-2. Evaluate the methods used to assess the stock, taking into account the available data.

Given the limitation of data availability, the Beverton-Holt length-based mortality estimator (Beverton and Holt 1957) is a good option for the assessment of this fishery. However, as the AW panel explicitly described in the assessment report, this method, explicitly and implicitly, requires six assumptions: (1) growth is constant over time and space; (2) there is no variability in growth among individuals; (3) there is constant and continuous recruitment over time; (4) the mortality rate is the same for fish older than the age at recruitment; (5) the mortality rate is constant over time and space; and (6) the population is in equilibrium. Apparently none of these assumptions can be satisfied in the U.S. Caribbean queen triggerfish fishery. Instead of using this traditional approach, the AW panel used a modified Beverton-Holt length-based mortality estimator which requires no assumption of an equilibrium population. However, the other assumptions are still required. There were a number of years when mortality rate changes were identified using the Akaike Information Criterion (AIC) as the model selection measure. A systematic sensitivity analysis was done to evaluate impacts of uncertainty in the growth parameters on the estimation of fish mortality rates.

IV-1-2-a. Are methods scientifically sound and robust?

Given the limitation of data availability, this approach may be the best choice the AW panel can have for the assessment of the U.S. Caribbean queen triggerfish. However, based on what has been reported in the AW report, I cannot conclude that this is scientifically sound and robust because it is difficult to evaluate whether this approach can capture the real fishing mortality rate without knowing the true value. A simulation study, similar to the one in

Gedamke and Hoenig (2006) but based on the queen triggerfish data, should be conducted to evaluate the performance and robustness of this mortality estimator for the queen triggerfish with respect to different assumptions associated with the fishery.

IV-1-2-b. Are assessment models configured properly and used consistent with standard practices?

Given what is available, I believe that the configuration of the assessment models is consistent with standard practices. However, the uncertainty in growth parameters was not estimated and the sensitivity analysis could be better designed if the uncertainty associated with K and L_∞ was explicitly estimated. The values of K and L_∞ are usually strongly and negatively correlated, and such negative correlations should be considered in the sensitivity analysis. The sensitivity analysis should focus on one parameter (either K or L_∞) with the value of the other parameter drawn from a joint probability distribution with a defined covariance structure for K and L_∞. A bootstrap approach can be used to define the joint probability distribution of K and L_∞.

The AW panel considered different approaches for estimating natural mortality, and recommended that the M estimated using the Pauly's equation (Pauly 1980) be used because the growth parameters were also used in the estimation. I agree with the AW panel and believe this perhaps is the most robust approach to reduce potential biases in the estimated fishing mortality rate (because F = Z-M). However, I think a more appropriate approach for estimating M may be the use of a subset of fish species with similar habitat and life history characteristics (e.g., reef-associated species) to modify Pauly's equation to make the estimation of M more consistent with the life history and habitat characteristics of the Caribbean queen triggerfish.

The use of M as a proxy for F_{MSY} is a common practice for a data-poor fishery (King 1995). This *ad hoc* limit reference point appears to be the best choice given the available data.

IV-1-2-c. Are the methods appropriate for the available data?

Overall, I believe that the method is appropriate for the available data. However, I believe a simulation study should be conducted to evaluate the performance of the method.

IV-1-3. Evaluate the assessment findings with respect to the following:

IV-1-3-a. Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

Because of data limitations, neither abundance nor biomass was estimated. Fishing mortality was derived from the difference between the total mortality estimated from length-composition data and natural mortality estimated from Pauly's model (Pauly 1980). Uncertainty associated with the fishing mortality was evaluated by considering possible ranges of the total mortality estimated using different growth parameters and natural mortality estimated using different estimators.

I believe that the lack of abundance/biomass estimates is consistent with the limitation of data availability. Large uncertainty associated with fishing mortality estimates is consistent with possible issues related to the estimates of life history parameters used in estimating the total and natural mortality rates.

IV-1-3-b. Is the stock overfished? What information helps you reach this conclusion?

The stock biomass/abundance and biomass-based limit reference points cannot be estimated reliably in this assessment based on the data available. The AW panel concluded that this assessment did not have enough information to determine if the stock was overfished. Given the available data, I agree with the AW panel.

IV-1-3-c. Is the stock undergoing overfishing? What information helps you reach this conclusion?

Puerto Rico

Large uncertainty is associated with the estimation of fishing mortality as a result of the varying choices of estimators for estimating natural mortality and different growth parameters used in estimating the total mortality. However, for most scenarios tested, the estimated fishing mortality tended to be much lower than natural mortality, suggesting that the queen triggerfish experienced low fishing mortality. If the natural mortality is used as a limit reference point in determining if the fishery is in the status of overfishing, we may conclude that the Puerto Rico queen triggerfish fishery is not in the status of overfishing. The analysis of length composition data from the pot and trap fishery shows that fishing mortality has a declining trend in the late 1990s; however large uncertainty as a result of lack of understanding of possible temporal changes in selectivity and fishing grounds complicates the interpretation of this result.

St. Thomas and St. John

The results of comparing fishing mortality and natural mortality depend on the choices of (1) growth parameters used in the estimation of the total mortality; (2) estimators of natural mortality; and (3) maximum age (i.e., 7 in Manooch and Drennon (1987) or 14 in de Albuquerque et al. 2011). Given such large uncertainty and lack of strong evidence to justify the use of one set of life history parameters over the other, it is difficult to conclude if the fishery is in the status of overfishing.

St. Croix

The results of comparing fishing mortality and natural mortality depend on the choice of growth parameters, which determine the estimates of the total mortality. For the set of life history parameters resulting in a high level for the total mortality estimate, the fishing mortality is higher than natural mortality, suggesting that fishing mortality may be too high. However, for the set of life history parameters resulting in a low level for the total mortality estimate, the estimated fishing mortality is lower than natural mortality, suggesting that the fishing mortality is not too high. We do not have strong evidence favoring one set of the life history parameters over the other, and hence it is difficult to decide if the fishery is in the status of overfishing.

IV-1-3-d. Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

No stock-recruitment relationship can be developed based on the available data.

IV-1-3-e. Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

Like many data-poor fisheries, natural mortality was used as a proxy for F_{MSY} in the assessment (King 1995). This effectively treats natural mortality as a limit biological reference point to determine if the fishery is in the status of overfishing. The AW panel explored and evaluated different methods in quantifying the natural mortality and found large uncertainty associated with the natural mortality estimates. Given the information available, I believe that yield-per-recruit (and maybe egg-per-recruit) analysis can be conducted, which can produce estimates of F0.1 and Fmax. The AW panel did mention that they did not do per-recruit analysis because of concerns on the quality of life history parameters. However, given the same life history parameters used in estimating the total fishing mortality and natural mortality (for some methods), I do not see the logic here for not doing a per-recruit analysis. I think the uncertainty associated with life history parameters can be readily incorporated in a per-recruit analysis using a Monte Carlo approach (e.g., Chen and Wilson 2002; Chang et al. 2009).

IV-1-4. Evaluate the stock projections, addressing the following:

No formal stock projection was done in the assessment because of data limitations.

IV-1-4-a. Are the methods consistent with accepted practices and available data?

Stock projections were not done in the assessment because of lack of the information on the dynamics of the fish population.

IV-1-4-b. Are the methods appropriate for the assessment model and outputs?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-1-4-c. Are the results informative and robust, and useful to support inferences of probable future conditions?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-1-4-d. Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-1-5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The AW panel outlined several sources of uncertainty in the assessment. The uncertainty associated with the quality and quantity of fisheries data (e.g., commercial and recreational catch and size composition data, fishing efforts, and sample sizes) is well discussed to determine which data sets should be used in the assessment. Large variabilities on growth parameters among different studies were identified and their impacts on the estimation of total mortality and fishing mortality were evaluated in a sensitivity analysis. Uncertainty resulting from choices of estimators for natural mortality also was discussed.

Although the AW panel discussed the uncertainty of different sources rather thoroughly and developed sensitivity analyses to evaluate impacts of the uncertainty on the estimation of the total, natural and fishing mortality rates, I believe the uncertainty should be incorporated in the assessment in a more systematic way. I suggest using a Monte Carlo simulation approach to systematically incorporate the uncertainty in life history parameters into the estimation of the fishing mortality rate. For each parameter, a distribution (uniform, multinomial, normal, or log-normal) can be defined based on the type of the data and possible ranges of the values. For each run, the value of a given parameter can be randomly drawn from such a distribution. The correlations between L_∞ and K should be considered and their values should be drawn from a joint distribution of these two values. One hundred or more runs of Monte Carlo simulation can yield a distribution for the total, natural and fishing mortality rates. Such an approach can better capture and quantify the uncertainty, which can be used directly in comparing probability distributions of natural mortality and fishing mortality to determine the likelihood of overfishing. Before this can be done, however, the range of the growth parameters and natural mortality should be narrowed down based on the expert knowledge and background information on fish species of similar life history and habitat needs.

IV-1- 6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

- Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
- Provide recommendations on possible ways to improve the SEDAR process.

The AW panel recommends improving the quality of life history parameter estimates; developing a fishery-independent monitoring program; continuing the efforts to improve the collection of species-specific catch and effort data; and modifying the length-based total mortality estimator to account for potential changes in selectivity. I consider these research areas are important for reducing the uncertainty and improving the quality of the assessment. The AW panel probably needs to prioritize the research recommendations and separate the short-term research plan from the long-term plan.

Given the problems associated with the data, an important research goal should be to improve the data quality and quantity. Short-term and long-term plans should be developed to achieve the goal. Short term research priority may include (1) improvement of life history data estimates and the quantification of their uncertainty in the form of probably distributions; (2) identification of major fishing areas and their spatio-temporal variability via conducting interviews with fishermen involved in the fishery; and (3) identification of potential approaches that can be used to estimate species-specific landing data (e.g., based on species composition of landings that become available in recent years). The long-term research plan should include the development of a fishery-independent monitoring program and continued improvement of the sampling protocol for the collection of fishery-dependent data (catch and effort).

Given the data limitations, I believe another research priority that should be addressed soon is to evaluate the performance of the length-based estimator (Gedamke and Hoenig 2006) for the total mortality. Based on the information available and with some assumptions, a queen triggerfish fishery can be simulated, following the approach used in Gedamke and Hoenig (2006). A simulation study can be conducted with this simulated fishery to evaluate the performance of this length-based estimator for estimating the total mortality. Different scenarios can be developed to identify key factors that may have significant impacts on the performance of the estimator. This can guide the future model development and data collection.

IV-1-7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

I recommend the following key areas for the improvement when scheduling the next assessment:

- Growth parameters K and L_∞ should be estimated with uncertainty. A bootstrap approach can be used with the von Bertalanffy growth model to quantify the joint probability distribution of K and L_∞, which can be used for quantifying probability distributions for the total, natural and fishing mortality rates;

- More basic biological studies need to be conducted to improve our understanding of key life history processes and estimate key life history parameters such as growth parameters, length/age at maturity, fecundity, and their spatial variability;

- An interviewing-fishermen program should be done to identify major fishing grounds and main size classes of landed catch, and possible changes over time;

- Use the proportion of queen triggerfish in the total catch of all triggerfish species estimated in recent years to estimate the queen triggerfish catch in the past (assuming that the proportion is the same over time);

- A simulation study needs to be conducted to evaluate the performance of the length-based estimator of the total mortality rate and identify assumptions/parameters that can influence greatly the performance of the estimator, which will help us understand the quality of the estimates of the total mortality;

- Uncertainty associated with the natural mortality rate should be quantified in the form of a probability distribution, which can be done with a Monte Carlo simulation approach;

- The Pauly natural mortality estimator was derived from many species with very different life history and habitat needs (Pauly 1983), and a subset of fish species that have life history and habitat needs similar to the focal species may yield a more appropriate natural mortality estimator;

- A yield-per-recruit analysis with the consideration of uncertainty associated with life history parameters (e.g., Chen 1996; Chang et al. 2009) can be done to estimate theoretical biological reference points such as F_{max} and $F_{0.1}$; and

- A spawning stock biomass-per-recruit analysis with the incorporation of uncertainty associated with life history parameters can also be done to estimate reference points such as $F_{20\%}$ and $F_{40\%}$.

IV-2. Blue tang

The following summary of my findings is provided with respect to the set of pre-defined TORs for blue tang.

<u>IV-2-1. Evaluate the data used in the assessment, addressing the following:</u>

Data available to the assessment included commercial landings, recreational intercept data and length-frequency data estimated separately for St. Thomas/St. John, St. Croix, and Puerto Rico. Life history data obtained from published studies were also used in the assessment.

For Puerto Rico, the commercial landing data of blue tang were included in the reported catch of the species group surgeonfishes by gear and fishing center, and the proportion of blue tang within the surgeonfishes species group was unknown. Hence, no separate landing data are available for blue tang. The landing data were reported by gear and fishing center and estimated from self-reported fisher logbooks/sale receipts for the time period from 1983 to 2011. Because the report was incomplete, the total landings were adjusted (Caribbean Fisheries Data Evaluation Final Report, 2009). Length composition data were derived from small sample sizes.

For St.Thomas and St. John, although logbook reporting started in 1974, landings were reported by gear and by either snapper/grouper or other finfish prior to 1997. Some landings were reported by species group and gear from 1997 to 1999, and all reported commercial landings was reported by species group from 2000 to 2010, and the landing data have been reported by species since 2011. For the years included in this assessment, landing data were provided as surgeonfishes with all the species combined, and blue tang-specific landing data are not available.

For St. Croix, similar to St. Thomas and St. John, landing data were only available for surgeonfishes, and no blue tang-specific landing data were available. Commercial landing data were only available from 1998 to 2011.

Marine Recreational Fisheries Sampling Survey (MRFSS) collects data from Puerto Rico, but not the US Virgin Islands. The sampling design consists of two complementary components, an angler-site intercept survey for estimating catch and length frequency data and a fishing effort telephone survey to estimate fishing effort. However, the positive intercepted trips (i.e., presence of blue tang) are too small. The AW panel concluded that this data set was not useful for the blue tang assessment.

The VBGF parameters were estimated for different locations in the U.S. Caribbean in two studies (Choat and Robertson 2002; Mutz 2006). Large differences were found in the estimates between the studies. A sensitivity analysis was done to evaluate the range of possible values for K and L_∞.

Length frequency data were estimated from samples taken in the NMFS Trip Interview program for the pot and trap fisheries in Puerto Rico, St. Thomas and St. John, and St. Croix. The number of blue tang measured in Puerto Rico was small compared to St. Thomas/St John or St. Croix.

IV-2-1-a. Are data decisions made by the Assessment Workshop sound and robust?

The AW panel concluded that the sample sizes for the length-frequency data in the pot and trap fisheries in the US Virgin Islands were sufficient for length-based mortality estimation. The growth parameters used in the initial analysis were from Mutz (2006). A sensitivity analysis was conducted to evaluate alternative values and their impacts on the estimation of the total fish mortality. The AW panel decided not to use the intercepted catch, effort, and length data from MRFSS because of the low proportion of positive trips and sample sizes of length data.

The AW panel considered that the sample size for estimating length-composition data was not sufficient in Puerto Rico, and derived length-composition data were not appropriate for length-based mortality estimator.

Based on the data available and limited choices the AW panel had, these decisions were the best one could make. However, because there is no scientific evidence showing the results are robust regarding these decisions, I cannot conclude that the data decisions are "sound and robust".

IV-2-1-b. Are data uncertainties acknowledged, reported, and within normal or expected levels?

The AW did acknowledge potential issues which might influence the quality and quantity of the data. The MRFSS data were excluded because of small sample sizes, and good discussions were made on potential causes resulting in changes in length compositions over time. However, I do not see quantification of uncertainty associated with the estimates of von Bertalanffy growth parameters (although the differences in the parameters estimated in different studies were shown). I think the estimation of these parameters should come with estimates of uncertainty, which could be derived using an approach such as a bootstrap method.

IV-2-1-c.Are data applied properly within the assessment model?

This is a data-poor fishery, and there is not enough information for a formal stock assessment. Given the data available and limitation of stock assessment model choices, I consider the data are properly applied in the estimation of the fish mortality in this stock assessment.

However, I believe the sensitivity analysis could be better designed and justified if the uncertainty associated with K and L_∞ could be estimated and quantified. The values of K and L_∞ in the sensitivity analysis should be drawn from their joint distribution (Chen 1996; Chang et al. 2009) rather than varied independently. The correlation between K and L_∞ and standard errors associated with L and L_∞ can be estimated in the Nonlinear Least Squares or their joint probability distribution could be derived using the bootstrap approach.

IV-2-1-d.Are input data series reliable and sufficient to support the assessment approach and findings?

Estimation of the length-frequency data may be influenced by spatio-temporal variability in fishing selectivity. Thus, the temporal variability in length composition may not reflect changes in fish mortality; but rather reflect changes in selectivity and fishing locations. Although potential changes in the total mortality rate can be incorporated in Gedamke and Hoenig (2006), I do not see how changes in selectivity can be incorporated. This may yield biases in the assessment.

IV-2-2. Evaluate the methods used to assess the stock, taking into account the available data.

Given the limitations of data availability, the Beverton-Holt length-based mortality estimator (Beverton and Holt 1957) is a good option for the assessment of this fishery. However, as the AW panel explicitly described in the assessment report, this method, explicitly and implicitly, has six assumptions: (1) growth is constant over time and space; (2) there is no variability in growth among individuals; (3) there is constant and continuous recruitment over time; (4) the mortality rate is the same for fish older than the age at recruitment; (5) the mortality rate is constant over time and space; and (6) the population is in equilibrium. Apparently none of these assumptions can be satisfied in the US Caribbean queen triggerfish fishery. Instead of using this traditional approach, the AW panel used a modified length-based mortality estimator. This method does not need to make the equilibrium assumption, but still needs the other five assumptions. The number of years when mortality rate changes was estimated using the Akaike Information Criterion (AIC) as the performance measure. A systematic sensitivity analysis was done to evaluate impacts of uncertainty in growth parameters on the estimation of fish mortality rates.

IV-2-2-a. Are methods scientifically sound and robust?

Given the limitation of data availability, this approach may be the best the AW panel can have for the assessment of the US Caribbean blue tang. However, based on what has been reported in the AW report, I cannot conclude that this is scientifically sound and robust because there is no evidence showing that this approach can capture the real rate of fishing mortality. A simulation study, similar to the one in Gedamke and Hoenig (2006) but based on the blue tang data, should be conducted to evaluate the performance and robustness of this mortality estimator for blue tang with respect to different assumptions associated with the fishery.

IV-2-2-b. Are assessment models configured properly and used consistent with standard practices?

Given what is available, I believe that the configuration of the assessment models is consistent with standard practices to estimate mortality rates and to evaluate impacts of uncertainty in growth parameters on the mortality estimation. However, the uncertainty in the growth parameters was not estimated and the sensitivity analysis could be better designed. The values of K and L_∞ are usually strongly and negatively correlated, and such negative correlations should be considered in the sensitivity analysis. The sensitivity analysis should focus one parameter (either K or L_∞) with the value of the other parameter drawn from a joint probability distribution with defined correlations of K and L_∞. Alternatively, a bootstrap approach can be used to estimate a joint distribution of K and L_∞, which can be used to quantify the uncertainty associated with the estimates of the total and natural mortality rates.

The AW panel considered different approaches for estimating natural mortality, and recommended that the M estimated from Pauly equation (Pauly 1980) be used because the growth parameters were also used in the estimation. I agree with the AW panel and believe this perhaps is the most robust approach to reduce potential biases in estimating fishing mortality (because F = Z-M). However, I think a more appropriate approach for estimating M may be the use of a subset of fish species with similar habitat and life history (e.g., reef-associated species) to modify the Pauly equation, which can make the estimation of M more consistent with the life history and habitat of the Caribbean blue tang. Biologically unrealistic estimates of natural mortality, judged based on life history theory and knowledge on species of similar life history and habitat need, should be excluded from further consideration in the estimation of fishing mortality.

The use of M as a proxy for F_{MSY} is a common practice for a data-poor fishery (King 1995). This *ad hoc* limit reference point appears to be the best choice given the available data.

IV-2-2-c. Are the methods appropriate for the available data?

Overall, I believe the method is appropriate for the available data. However, I believe a simulation study should be conducted to evaluate the performance of the method.

IV-2-3. Evaluate the assessment findings with respect to the following:

IV-2-3-a. Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

Because of data limitations, neither abundance nor biomass was estimated. Fishing mortality was derived from the difference between the total mortality rate estimated from length-composition data and natural mortality rate estimated from Pauly's model (Pauly 1980). Uncertainty associated with the fishing mortality rate was evaluated by evaluating possible ranges of the total mortality rate estimated using different growth parameters and natural mortality estimated using different estimators.

I consider the lack of abundance/biomass estimates is consistent with the limitations of data availability. Large uncertainty associated with the fishing mortality estimates is consistent with possible issues related to the estimates of life history parameters used in the estimation of the total and natural mortality rates.

The AW panel did not estimate the total mortality rate for the Puerto Rico blue tang from the length-frequency data because they believed that the sample size was too small. I agree with the AW panel and consider this is consistent with the data available.

IV-2-3-b. Is the stock overfished? What information helps you reach this conclusion?

The stock biomass/abundance and biomass-based limit reference points cannot be estimated reliably in this assessment based on the data available. The AW panel concluded that this assessment did not have enough information to determine if the stock is overfished. Given the available data, I agree with the AW panel.

IV-2-3-c. Is the stock undergoing overfishing? What information helps you reach this conclusion?

Puerto Rico

No length-based analysis was done because the AW panel concluded that the sample size used to derive the length-composition data was too small. Thus, there were no estimates of the total, natural and fishing mortality rates for the Puerto Rico blue tang.

St. Thomas and St. John

The results of comparing the fishing mortality and natural mortality rates depend on the choices of (1) growth parameters used in the estimation of the total mortality; and (2) estimators of natural mortality. The AP panel suggested that Pauly's natural mortality estimator be used because both K and L_∞ were used, which is consistent with what is used in estimating the total mortality. Based on this approach, the fishing mortality rate, estimated as the difference between the total mortality rate estimated from the length-based estimator (Gedamke and Hoenig 2006) and natural mortality rate estimated using Pauly's equation (Pauly 1980), was much smaller than the natural mortality rate, which is commonly used as limit reference point to determining if a data-poor fishery is in the status of overfishing. This suggests that the fishery was not in the status of overfishing. However, if natural mortality was estimated from age-based data, the results would depend on the choice of growth parameters in estimating the total mortality. For the most scenarios tested in the sensitivity analysis, it appears that the fishing mortality rate was lower than the natural mortality rate, suggesting that the St. Thomas and St. John blue tang were likely not in the status of overfishing. However, given such large uncertainty and the lack of strong evidence to justify the use of one set of life history parameters over the other, it is difficult to yield a conclusive result regarding the status of the fishery.

St. Croix

Like the assessment for the St. Thomas and St. John blue tang, the results of comparing fishing mortality and natural mortality depend on the choice of growth parameters, which determine the estimates of the total and natural mortality rates. For the set of life history parameters resulting in a high level for the total mortality rate, the fishing mortality rate is higher than the natural mortality rate, suggesting that fishing mortality may be too high. However, for the set of life history parameters resulting in a low level for the total mortality rate, the estimated fishing mortality was lower than natural mortality, suggesting that the fishing mortality was not too high. We do not have strong evidence favoring one set of the life history parameters over the other, and hence it is difficult to decide if the fishery is in the status of overfishing.

IV-2-3-d. Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

No stock-recruitment relationship can be developed based on the available data.

IV-2-3-e. Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

Like many data-poor fisheries, natural mortality is used as a proxy for F_{MSY} in the assessment (King 1995). This effectively treats the natural mortality rate as a limit biological reference point to determine if the fishery is in the status of overfishing. The AW panel explored and evaluated different methods for quantifying the natural mortality rate and found large uncertainty associated with the natural mortality rate estimates. Given the information available, I believe that a yield-per-recruit (and maybe egg-per-recruit) analysis can be conducted, which can yield estimates for $F_{0.1}$ and F_{max}. The AW panel did mention that they did not do a per-recruit analysis because of concerns on the quality of life history parameters. However, given the same life history parameters used in estimating the total fishing mortality and natural mortality (for some methods), I do not see the logic for not doing a per-recruit analysis. I think the uncertainty associated with the life history parameters can be readily incorporated in a per-recruit analysis using a Monte Carlo approach (e.g., Chen and Wilson 2002; Chang et al. 2009).

IV-2-4. Evaluate the stock projections, addressing the following:

No formal stock projection was done in the assessment because of data limitations.

IV-2-4-a. Are the methods consistent with accepted practices and available data?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-2-4-b. Are the methods appropriate for the assessment model and outputs?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-2-4-c. Are the results informative and robust, and useful to support inferences of probable future conditions?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-2-4-d. Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Stock projections were not done in the assessment because of lack of information on the dynamics of the fish population.

IV-2-5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The AW panel outlined several sources of uncertainty in the assessment. The uncertainty associated with the quality and quantity of fisheries data (e.g., commercial and recreational catch and size composition data, fishing efforts, and sample sizes) is well discussed to determine which data set should be used in the assessment. Large variability in growth parameters among different studies was identified and their impact on the estimation of the total mortality rate and fishing mortality rate were evaluated in a sensitivity analysis. Uncertainty resulting from choices of estimators for the natural mortality rate also was discussed.

Although the AW panel discussed the uncertainty of different sources rather thoroughly and developed sensitivity analyses to evaluate impacts of the uncertainty on the estimation of the total, natural and fishing mortality rates, I believe the uncertainty should be incorporated in the assessment in a more systematic way. I suggest using a Monte Carlo simulation approach to systematically incorporate the uncertainty in life history parameters into the estimation of the fishing mortality rate. For each parameter, a distribution (uniform, multinomial, normal, or log-normal) can be defined based on the type of the data and possible ranges of the values. For each run, the value of a given parameter can be randomly drawn from such a distribution. The correlations between L_∞ and K should be considered and their values should be drawn from a joint distribution of these two values. One hundred or more runs of Monte Carlo simulation can yield a distribution for the total, natural and fishing mortality rates. Such an approach can better capture and quantify the uncertainty, which can be used directly in comparing probability distributions of the natural mortality rate and fishing mortality rate to determine the likelihood of overfishing. Before this can be done, however, the range of the growth parameters and natural mortality rate should be narrowed down based on expert knowledge and background information on fish species of similar life history and habitat needs.

IV-2- 6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

- Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
- Provide recommendations on possible ways to improve the SEDAR process.

The AW panel recommended improving the quality of life history parameter estimates; developing a fishery-independent monitoring program; continuing efforts to improve the collection of species-specific catch and effort data; and modifying the length-based total mortality rate estimator to account for potential changes in selectivity. I consider these research areas are important for reducing the uncertainty and improving the quality of the assessment. The AW panel probably needs to prioritize the research recommendations and separate the short-term research plan from the long-term plan.

Given the problems associated with the data, an important goal should be to improve the data quality and quantity. Short-term and long-term plans should be developed to achieve the goal. The short term research priority may include (1) improving life history data estimates and the quantification of their uncertainty in the form of probably distributions; (2) identifying major fishing areas and how the fishing areas vary with time via conducting interviews with fishermen involved in the fishery; and (3) identifying potential approaches that can be used to estimate species-specific landing data (e.g., based on species composition of landings that become available in recent years). The long-term research plan should include the development of fishery-independent monitoring program and continue improving the sampling protocol in the collection of fishery-dependent data (catch and effort).

Given the data limitations, I believe another research priority is to evaluate the performance of the length-based estimator (Gedamke and Hoenig 2006) for the total mortality. Based on the information available and with some assumptions, a queen triggerfish fishery can be simulated, following the approach used in Gedamke and Hoenig (2006). A simulation can be conducted with this simulated fishery to evaluate the performance of this length-based estimator in estimating the total mortality rate. Different scenarios can be developed to identify key factors that may have significant impacts on the performance of the estimator. This can guide the future model development and data collection.

IV-2-7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

I recommend the following key areas for the improvement when scheduling the next assessment:

- Growth parameters K and L_∞ should be estimated with uncertainty. A bootstrap approach can be used with the von Bertalanffy growth model to quantify the joint probability distribution of K and L_∞, which can be used for quantifying probability distributions for the total, natural and fishing mortality rates;

- More basic biological studies need to be conducted to improve our understanding of key life history processes and estimate key life history parameters such as growth parameters, length/age at maturity, fecundity, and their spatial variability;

- An interviewing-fishermen program should be done to identify major fishing grounds and main size classes of landed catch, and possible changes over time;

- Use the proportion of blue tang in the total catch of all surgeonfish species estimated in recent years to estimate the queen triggerfish catch in the past (assuming that the proportion is the same over time);

- A simulation study needs to be conducted to evaluate the performance of the length-based estimator of the total mortality rte and identify assumptions/parameters that can influence greatly the performance of the estimator, which will help us understand the quality of the estimates of the total mortality rate;

- Uncertainty associated with the natural mortality rate should be quantified in the form of a probability distribution, which can be done with a Monte Carlo simulation approach;

- The Pauly natural mortality rate estimator was derived from many species with very different life history and habitat needs (Pauly 1980), and a subset of fish species that have life history and habitat needs similar to the focal species may yield a more appropriate natural mortality rate estimator;

- A yield-per-recruit analysis with the consideration of uncertainty associated with life history parameters (e.g., Chen 1996; Chang et al. 2009) can be done to estimate theoretical biological reference points such as F_{max} and $F_{0.1}$; and

- A spawning stock biomass-per-recruit analysis with the incorporation of uncertainty associated with life history parameters can also be done to estimate reference points such as $F_{20\%}$ and $F_{40\%}$.

V. Conclusions and Recommendations

Given the data limitations, the assessment appears to be well-planned and structured. Uncertainties in the quality and quantity of data, fisheries (e.g., selectivity) and life history parameters (e.g., von Bertalanffy growth parameters and natural mortality rate), and model structure (different estimators used to estimate the total and natural mortality rates) were carefully evaluated. I would like to commend the efforts of the AW panel in addressing data quality and quantity issues, identifying and evaluating implicit and explicit assumptions associated with methods and data, designing and conducting a rather systematic sensitivity analysis, exploring alternative model configurations and parameterization. However, based on the information I have reviewed, I cannot conclude that this assessment is scientifically sound, and adequately addresses needs for management advice. This mainly results from the data limitations.

I do have concerns for both the Caribbean queen triggerfish and blue tang that I hope the AW panel could address to improve the assessment of the Caribbean queen triggerfish and blue tang. I made the following general comments and specific recommendations.

General comments

The Caribbean queen triggerfish and blue tang are typical data-poor fisheries with no fishery-independent data and limited fishery-dependent data of questionable quality. Their life history processes are not well understood and key life history parameters are not well quantified. The low quality and quantity of the information available makes it extremely difficult to assess the status of the Caribbean queen triggerfish and blue tang stocks. The top priority should be to develop a fishery-independent monitoring program for the reef-dependent species such as queen triggerfish and blue tang in the U.S. Caribbean. Such a program can yield a reliable abundance index and provide samples for basic biological studies to estimate key life history parameters such as von Bertalanffy growth parameters, fecundity, and length/age at maturity and their spatial variability, not only for the Caribbean queen triggerfish and blue tang; but also for other reef-dependent fish species inhabiting the same area.

The quality and quantity of fishery-dependent data should also be improved. This can be done by developing a port or sea sampling program or further improve current reporting system by including the information on spatial locations of catch and conducting some cross-validation studies of fishermen's reported data. The report of species-specific landings in recent years is certainly a good way to improve the data quality and quantity, making the landing data useful in the species-specific stock assessment. The information may be useful to decompose the historical landings of species group into species-specific landings. A program should be developed to interview fishermen on their historical and current fishing areas and the changes in their attitude towards the targeted species and size composition in the fishery (Ames 2004). I believe such an interview program is cost effective to collect some valuable historical information regarding fishing grounds and fishermen's preferences for species and size. Such information will be valuable to improve the quality of the historical data and improve the understanding of possible temporal changes in fishing effort distribution and selectivity.

Given the data limitations, the choice of stock assessment models is rather limited for the U.S. Caribbean queen triggerfish and blue tang stock assessment. Instead of using a traditional Beverton-Holt method to estimate the total mortality from length-composition data, the AW panel listed six assumptions explicitly and explicitly associated with the method and decided to use the method by Gedamke and Hoenig (2006) which does not require the assumption of an equilibrium population. Given the available data, this may be the best approach available. However, this approach also requires some assumptions in temporal variability in selectivity. Although Gedamke and Hoenig (2006) conducted a simulation study to evaluate the performance of the estimator, their simulation was based on a single species with different biology and fishing intensity. I suggest that the AW panel uses the Caribbean queen triggerfish and blue tang data to design a similar simulation study. The AW panel can design a few scenarios to evaluate the performance of the estimator in retrieving the "true" built in the simulation study and identify key factors that may greatly influence the performance of the estimator for the U.S. Caribbean queen triggerfish and blue tang fisheries.

A rather comprehensive sensitivity analysis was conducted to evaluate possible impacts of uncertainty associated with the growth parameters for the estimation of the total mortality rate in the assessment of the queen triggerfish and blue tang. Although I appreciate the AW panel's efforts, I believe a better structured Monte Carlo simulation approach may be better in quantifying the uncertainty associated with the estimation of the total mortality rate and natural mortality rate. The AW panel can use the sensitivity analysis to identify the most plausible parameterization of the Gedamke-Hoenig model (Gedamke and Hoenig 2006) and then conduct a Monte Carlo simulation approach with parameters K and L_∞ randomly drawn from their joint distribution which can be derived from bootstrapped nonlinear least squares in fitting the von Bertalanffy growth model to length-at-age data. similar approach can be used for estimating the natural mortality rate.

I also believe expert and background knowledge about the queen triggerfish and blue tang should be used to reduce the magnitude of the uncertainty on the growth parameters and natural mortality rate. Some values for M, K, and L_∞ appear to be not biologically realistic for a fish species with a life history process similar to the queen triggerfish and blue tang, and should be excluded in the assessment. Maybe a literature search for fish species of similar life history and habitat should be done to derive a range of values that are biologically realistic for the key life history parameters.

The AW panel did not do a yield-per-recruit analysis and SSB-per-recruit (or egg-per-recruit) analysis because of uncertainty associated with the growth parameters and natural mortality rate. However, these values were used in the estimation of the total mortality rate and natural mortality rate. This is a rather inconsistent argument. I would like to suggest that at least a yield-per-recruit analysis can be done to estimate F_{MAX} and $F_{0.1}$ for possible reference points. The fact that both growth parameters and natural mortality rate are used in a yield-per-recruit analysis and estimation of the current fishing mortality rate using the approach described in the assessment may reduce the impact of uncertainty associated with the growth parameters and natural mortality rate on the determination of the fishery status.

Specific recommendations

Although I have provided comments and recommendations under each TOR, I would like to re-iterate the following recommendations.

- I recommend that expert and background knowledge/information on species of similar life history patterns and habitat needs be used to exclude biologically unrealistic values of K, L_∞, natural mortality rate, and total mortality rate;

- I recommend that uncertainty associated with K, L_∞, natural mortality rate, total mortality rate, and subsequently fishing mortality rate be quantified using a Monte Carlo simulation;

- I suggest that a program be developed for interviewing fishermen to have a better understanding of temporal and spatial variability of the fishing ground, target fish species and size (i.e. selectivity), and fishing efforts;

- I recommend that information on the fish species composition of current landings be used to decompose the historical landings of species group into the species-specific landings;

- I recommend that a fishery-independent survey program be developed for the U.S. Caribbean queen triggerfish, blue tang and other reef-dependent species sharing similar habitat to collect samples for estimating basic life history parameters and for driving reliable abundance indices;

- I recommend that a simulation study be conducted to evaluate the performance of the length-based estimator of the total mortality rate and identify assumptions/parameters that can influence greatly the performance of the estimator;

- I suggest that a yield-per-recruit analysis be conducted with the incorporation of uncertainty associated with life history parameters to estimate theoretical biological reference points such as F_{max} and $F_{0.1}$; and

- I recommend that a spawning stock biomass-per-recruit analysis be done with the incorporation of uncertainty associated with life history parameters to estimate reference points such as $F_{20\%}$ and $F_{40\%}$.

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Appendix 1: Bibliography of materials provided for review for SEDAR 30 Caribbean Blue Tang and Queen Triggerfish

Documents Prepared for the Assessment Workshop

- Bryan, M. 2012. Summary of recreational catch and effort for blue tang and queen triggerfish caught in Puerto Rico since 2000. SEDAR30-AW-01.

- Bryan, M. 2012. Evaluation of the available length-frequency information in the US Caribbean Trip Interview Program (TIP) data. SEDAR30-AW-02

- Rios, A. B. 2012. A review of the life history characteristics of blue tang and queen triggerfish. SEDAR30-AW-03

- McCarthy, K. J. 2012. Commercial fishery landings of queen triggerfish and blue tang in the United States Caribbean, 1983-201. SEDAR30-AW-04

Final Stock Assessment Reports

- SEDAR30-SAR1: Blue Tang Assessment Report

- SEDAR30-SAR2: Queen Triggerfish Assessment Report

Reference Documents

- SEDAR30-RD01: A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of St. Thomas, U.S. Caribbean

- SEDAR30-RD02: A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of U.S. Caribbean (Saint Croix)

Appendix 2: A copy of the CIE Statement of Work

Attachment A: Statement of Work for Dr. Yong Chen

External Independent Peer Review by the Center for Independent Experts

SEDAR 30 Caribbean blue tang and queen triggerfish assessment review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description SEDAR 30 will be a compilation of data, an assessment of the stock, and an assessment review conducted for Caribbean blue tang and queen triggerfish. The CIE peer review is ultimately responsible for ensuring that the best possible assessment has been provided through the SEDAR process. The stocks assessed through SEDAR 30 are within the jurisdiction of the Caribbean Fisheries Management Council and the territorial waters of Puerto Rico and the U.S. Virgin Islands. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall have the necessary qualifications to complete an impartial and independent peer review in accordance with the tasks and ToRs described in the SoW herein. The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the scientific peer-review described herein. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct the desk review during 4-7 February 2013, therefore no travel will be required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COR, who forwards this information to the NMFS Project

Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other information pertinent to the desk review arrangements. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.

2) During February 4-7, 2013 as specified herein, conduct an independent desk peer review in accordance with the ToRs (**Annex 2**).

3) No later than February 21, 2013, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Sampson david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

14 January 2013	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
18 January 2013	NMFS Project Contact sends the stock assessment report and background documents to the CIE reviewers.
4-13 February 2013	Each reviewer conducts an independent desk peer review
19 February 2013	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
7 March 2013	CIE submits CIE independent peer review reports to the COR
14 March 2013	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on changes. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed. The CIE independent report shall be an independent peer review of each ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

SEDAR 30 Caribbean blue tang and queen triggerfish assessment review

1. Evaluate the data used in the assessment, addressing the following:
   a) Are data decisions made by the Assessment Workshop sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are data applied properly within the assessment model?
   d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   a) Are methods scientifically sound and robust?
   b) Are assessment models configured properly and used consistent with standard practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   b) Is the stock overfished? What information helps you reach this conclusion?
   c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
   d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
   e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
   a) Are the methods consistent with accepted practices and available data?
   b) Are the methods appropriate for the assessment model and outputs?
   c) Are the results informative and robust, and useful to support inferences of probable future conditions?
   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.
   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.
7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

30th Southeast Data, Assessment and Review (SEDAR 30)

Reviewer Report to the Center for Independent Experts on the U.S. Caribbean Blue Tang and Queen Triggerfish (SEDAR 30)

March 20, 2013

Prepared for:
Center for Independent Experts

By:
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Executive Summary

This document is an independent review of the activities and findings of the 30th Southeast Data, Assessment and Review (SEDAR 30). The review was a desktop review, that is, assessment documents and supporting material were sent out for review, but there was not a meeting or an opportunity for dialogue regarding the assessment. Two stocks were reviewed: the U.S. Caribbean blue tang and queen triggerfish. While I acknowledge that the science reviewed is the best scientific information available and that considerable effort was made to make the best use of the data available, I do not find that either assessment provides a sound basis for management advice. Several of the ToRs were met, but the most important ones regarding stock status, trends and the impact of fishing were not (ToRs 3 and 4). The failure to meet these ToRs are through no fault of the assessment team, but rather, are due to the lack of data and often the poor quality of the data they do have.

The approach to each assessment was similar. It was in fact so similar, I had trouble seeing the differences and I wonder what differences in methods, if any, are warranted given the life history of each species and any differences in the fishery. Consequently, my comments typically apply to both assessments and I only make distinctions where necessary.

My overall conclusions are that we don't know much about the status of these fish or whether overfishing has occurred. A noble effort has been made, but alas, we have tremendous uncertainty and little basis for management advice. Rather than focusing on the particulars of these assessments, which I do below, I encourage the assessment team to take a strategic approach to the problem. In particular, to formulate a medium to long-term plan to, 1) engage external scientists in a program review where an assessment framework (benchmark) can be agreed upon, and 2) make plans to collect the data to support it.

1.0 Background

This document is an independent review of the findings of the 30th Southeast Data, Assessment and Review (SEDAR 30). The review was a desktop review, that is, assessment documents and supporting material were sent out for review, but there was not a meeting or an opportunity for dialogue regarding the assessment. Two stocks were reviewed: the U.S. Caribbean blue tang and queen triggerfish. Assessment documents (Appendix 1) and background materials were provided via a website two weeks before the review. I was also provided with a Statement of Work (Appendix 2), including the Terms of Reference (ToR).

2.0 Individual Reviewer Activities

I reviewed the assessment and background documents provided for the review. This was a desktop review so there was no dialogue between the assessment team and me and all my comments only pertain to documents provided to me. As outlined in Statement of Work (Appendix 2), these reports should state in the reviewer's own words whether each ToR of the Stock Assessment Workshop was completed successfully, should state whether they accepted or rejected the work that they reviewed, and should include an explanation of their decisions (strengths, weaknesses of the analyses, etc.) and recommendations for each ToR. A key determinant of whether a ToR had been met was the extent to which it provided a scientifically credible basis for developing fishery management advice. The following section contains my review for both assessments.

3.0 Review of U.S. Caribbean Blue Tang and Queen Triggerfish

U.S. Caribbean blue tang and queen triggerfish were assessed using a length-based estimate of total mortality (Beverton and Holt 1957, Gedamke and Hoenig 2006). I presume that this is the first time these stocks have been assessed as there were no citations to previous assessments. If these are the first assessments of these stocks, I think it is important to put in the assessment report as context (as it stands now, the information is presented in section 3 of Section I; I suggest making that more prominent in the introductions to Sections I and II). I felt like a lot of the structure of the report and writing was 'cookie cutter', that is, following a particular formulae. This seems counter productive to me. In my view, what is needed in a first assessment is a review of past work and some soul searching for ways forward. This is better done in a free format. Furthermore, the assessments are chopped up into little pieces (six supporting documents). While the details should remain in the supporting documents, I think a synthesis of these documents is needed in the Assessment Process Report. Maybe that is what is lacking the most: a cohesive synthesis and vision. Blue tang and queen triggerfish have similar data and assessment problems, how can we solve them together? Or for perhaps a larger species group? Step back and take stock of the situation, so to speak. I am having trouble getting the sense of whether people care and if so exactly what they care about. Compared to some of the world's fisheries the landings of surgeonfish and triggerfish are small (~35, ~80 metric tons / year respectively) although this is a relatively small area as well. Maybe more data and analysis to support management is not needed. If it is, then a stronger case should be made for it. Similarly, if one is going to choose an assessment method, it should be defended and not simply stated that the 'AW panel decided'.

The assessment of blue tag and queen triggerfish is difficult given the quality and limited amount of data. Overall, the data have been assembled with considerable care and diligence. Some issues remain, but it is a good point in the history of these fisheries to step back and evaluate the quality of the data and the most effective means of assessing stock status and the impact of fishing. The assessment team makes good use of the data, given what they have and it is clear that progress has been made and that higher quality data are being collected. Stock status, in terms of a biomass based reference, cannot be determined given the approach used and the impact of fishing can only be estimated using strong and weakly supported assumptions about fishing and natural mortality. In my view, the current monitoring and assessment approach is inadequate and what is needed is an overall program review. I am not a manager, but if I were, I would be uncomfortable managing this fishery with such limited tools to assess stock status and the impact of fishing. So that causes me, as a reviewer, to look to the future. What is the framework or benchmark which will be used to assess these populations? Has there been adequate discussion and review of a proposed framework? Once the framework is decided upon, then the focus can be put on the most important and useful information to collect. The discussion of the assessment approach and data collection needs to proceed hand in hand. I will go so far as to suggest that this assessment team formulate a proposal for a new assessment approach along with a plan to collect the necessary data and submit that for review.

I did find the management history and context presented in Section I: Introduction useful, complicated, but important to be aware of. Actually, I would like to be slightly more complimentary of this work, as I don't see it enough and appreciate the work it takes. What I would like is for the managers and biologists to make stronger statements about if and when these management measures would be expected to affect the data used in the assessment. If a management measure was put in place and it was expected to affect mean length in the catch, did we see it? Did we even have the data to see it? Which of these management measures can be ignored, in terms of the assessment, and which should be explicitly accounted for. If you find a change in total morality, can it be attributed to a management measure and / or a change in fishing practices? This is good work, but it should be pushed to the next level, if possible (I acknowledge the difficulties, but encourage those involved to try).

I find the explanation of methods in the Section II: Assessment Process Report thin, but what is needed even more is better motivation of the general approach and methods used. The motivation is even more important because this is a desktop review. It is much easier to get a sense of why decisions about the data or methods were made when there is a presentation and reviewers are afforded the opportunity to ask questions. In the situation of a desktop review, we are left with sentences like 'The AW [assessment workshop] panel determined..., The AW panel agreed...', but I need more written explanation supporting the decision or conclusion in order to decide whether I reach the same conclusion or not.

I see at least four major data categories where you might concentrate your efforts: 1) landings data, 2) fisheries independent survey, 3) life history data, and 4) tagging. As I noted, the priority and amount of effort given to each depends on the assessment framework you plan to use. Obviously, if one wishes to assess the stock with fisheries based catch per unit effort (cpue) data, then emphasis would be placed on collecting high quality effort and landings data. If on the other hand, one wishes to assess the stock using a fisheries independent survey, or calculate yield per recruit then the priorities shift and a different investment is required. I fear I state the obvious to my fellow stock assessment scientists, but in an effort to be as helpful and constructive as possible, I elaborate on these issues below (ToR 7).

ToRs 1,2,5 and 6 were met, but ToRs 3 and 4 were not in both assessments. I provide comments on all the ToRs below.

ToR 1

1. *Evaluate the data used in the assessment, addressing the following:*

    a) Are data decisions made by the Assessment Workshop sound and robust?

    b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

    c) Are data applied properly within the assessment model?

    d) Are input data series reliable and sufficient to support the assessment approach and findings?

This ToR was met. There are limited data for this fishery. The landings are unknown for the species blue tang or queen triggerfish, but are recorded collectively as surgeonfish and triggerfish. There has been some length sampling, but they appear to be uninformative for a length-based cohort analysis as one cannot see cohorts in the length frequency plots (both species). Life history data (growth, age at maturity) for blue tang from the management unit is lacking and data are taken from other areas. The life history data for queen triggerfish is taken from Puerto Rico and the US Virgin Islands but the authors suggest that it needs to be verified by another study using otoliths rather than dorsal spines. Plots of the frequency at length by age and examining the modes and overlap among ages would be useful, to help determine if a length or age based model might be effective. Neither species has a fisheries independent survey. Overall, there is very little to go on. So, the greatest advancements in understanding the dynamics in these stocks will occur by collecting better data.

One big difficulty is not knowing the landings. The landings are aggregated into large species groups and until there is a method to estimate landings at a species level it will be hard to answer the question 'should we care'. I would like to say we should care about every fish we remove from the ocean, but the fact is that we must prioritize our efforts. Certainly some surgeonfish and triggerfish are being removed, but even a rough estimate of proportion by species would be useful. It appears that the reporting regulations have changed and that this will no longer be a problem, but I suggest you take the time to demonstrate that it is not a problem in the future with some biological sampling of the catch. It is stated that species-specific data were reported in the US Virgin Islands during the 2011 - 2012 fishing year. I think it would have been very useful to report the proportion of blue tang and queen triggerfish in your assessment. If there have not been a lot of gear changes or changes in fishing practices, these proportions can be applied with some caution to the older landings data. Do we have enough information to partition the landings in the other areas? If not, what additional data would be needed?

I am not entirely sure if blue tang and queen triggerfish are targeted in the fishery or if they are principally bycatch species. If they are only a small proportion of the surgeonfish and triggerfish maybe this assessment approach is adequate. My confusion, of course, would have been cleared up immediately if this review was done at a meeting. This small example shows how extra effort is required by the assessment team to explain the context of the situation.

In general, I would have appreciated more background on the natural history of these fish and the community and ecosystem in general. This context is important in evaluating the appropriateness of this assessment and avenues for its improvement. I would integrate all the information in SEDAR30-AW-03 'A review of the life history characteristics...' into the Assessment Process Report. One notable gap in your knowledge is the length or age at maturity.

I can appreciate the fact that improved sampling of the catch will be difficult, and I found the pilot studies examining these issues useful (SEDAR30-RD-01,SEDAR30-RD-02). Some sort of improved sampling will need to occur, but the level of investment is proportional to the assessment method. If you want to use a length-based or age-based model then this data stream will be very important and will require further study and planning. If you instead choose to use tagging as an assessment method, sampling the catch is less of a priority.

a) The decisions about how to use the data appear to be robust and sound.

b) Data uncertainties are acknowledged and reported. I find the uncertainties larger than 'normal' and these uncertainties severely limit the ability to track the population and to estimate the impact of fishing. Only the most general of statements about total mortality and whether it has changed can be made and given the uncertainties we cannot be confident in these conclusions.

c) The data appear to be applied properly within the model: the length based mortality estimator by Gedamke and Hoenig (2006).

d) This depends on what the goals are. I think the goals should be on how to move to a better assessment framework. The input data series are not reliable and sufficient to support the assessment of stock status and the impact of fishing, the typical goals of an assessment. If the goal is to estimate whether there has been a change (increase?) in the total mortality rate, then this work makes a contribution, but the conclusions must be very tentative given the quality of the data.

ToR 2

2. *Evaluate the methods used to assess the stock, taking into account the available data.*

   a) Are methods scientifically sound and robust?

   b) Are assessment models configured properly and used consistent with standard practices?

   c) Are the methods appropriate for the available data?

This ToR was met. The methods used for a length-based estimate of the total mortality rate look sound, but maybe not very robust. The methods are appropriate for the data available. As noble as these efforts are, I have trouble viewing these methods as an 'assessment'. With better life history and selectivity data we may have more confidence in an estimate of the total mortality rate and any conclusion about whether the total mortality rate has changed. The signal in any changes in length does not appear to be as strong as in the examples in Gedamke and Hoenig (2006). There is some evidence that the total mortality rate has increased for blue tang and possibly decreased for queen triggerfish, but changes in fishing practices may (probably?) make it difficult to interpret these data. In the AIC results, it is essentially profiling over different life history input parameters *and* changes in Z. The interpretation focuses on the best model for Z within a combination of life history parameters, but do these results also indicate the most likely combination of life history parameters? Can one actually put forth one or two models from Table 18 blue tang and Table 13 queen triggerfish as the best model?

a) The methods are scientifically sound and robust, but they cannot estimate stock status and the impact of fishing. I would like to have seen the profile likelihoods or the Bayesian posteriors for the estimates of total mortality and change year, similar to Figure 3 in Gedamke and Hoenig (2006), but more. These kinds of diagnostics are typically important to present.

b) The model is configured properly.

c) The methods are appropriate for the available data but do not form the basis for strong management advice (objectives 3 and 4 below). I have some trouble with the sensitivity analysis. It seems like a very wide range was chosen and that just has the effect of demonstrating that the estimates of the total mortality rate could be just about anything. How were the ranges of the life history parameters chosen? Were they the 95% credible interval (CI) from a growth study? I also have difficulty tracing back the range of total mortality rates used in the tables estimating F and M (blue tang: Tables 16 and 24, queen triggerfish: Tables 19, 21, 25). Couldn't that range be taken from the CI of Z estimated from your analysis of mean length?

ToR 3

3. *Evaluate the assessment findings with respect to the following:*

   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

   b) Is the stock overfished? What information helps you reach this conclusion?

   c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

   d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

   e) *Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?*

This ToR was not met. By and large it is not possible to reach these objectives given the lack of suitable data. The assessment does not provide abundance or biomass estimates and given the data, it currently is not possible. It does provide an estimate of total mortality (Z) from which fishing mortality (F) can be inferred. However, there are large uncertainties in both total mortality and natural mortality making it exceedingly difficult to estimate fishing mortality (Z-M=F). They did not provide a convincing argument that their estimate(s) of mortality are useful to support status inferences. The do a good job of showing the uncertainty, but could do a better job arguing which estimate has the most support. A preferred model or estimate brings focus to the discussion about whether the estimate or model is 'useful to support status inferences'. As noted by the authors in the general discussion of the blue tang assessment:

'*The disparate estimates of growth led to considerable uncertainty in the mortality estimates. They also made it difficult to meaningfully interpret stock status in terms of fishing mortality, in the absence of a weighting system giving credence to one life-history strategy over another.*'

So given these data, the status of the blue tang fishery cannot be well determined. I agree entirely with this statement. Although, I think sometime we need to stick our neck out and rely on 'expert knowledge', if for nothing else than to push things forward (I guess that is what I am doing with all these comments!).

Similarly for queen triggerfish in the section on stock status and general conclusions the authors state:

'...*it is difficult to interpret the sustainability of the estimated, current exploitation rates and that the absolute estimates of mortality should be interpreted with caution.*'

I also agree entirely with this statement. So given the data, and a good analysis of what data is available, I conclude that we can not determine if the stock is overfished or if overfishing is occurring. The current data and modeling is light-years away from estimating a stock recruitment relationship, and I don't think this should be a short or medium term goal. Stock status cannot be determined with the current data and there are very few other data, if any, that can be used to inform managers about stock trends and conditions. If there were better life history data from the management unit and better length sampling of the catch then statements about overfishing based on F relative to M potentially could be better substantiated, but it will not solve all your problems and I would not rush to this without a more thorough program review.

ToR 4

4. *Evaluate the stock projections, addressing the following:*

   a) Are the methods consistent with accepted practices and available data?

   b) Are the methods appropriate for the assessment model and outputs?

   c) Are the results informative and robust, and useful to support inferences of probable future conditions?

   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

This ToR was not met. No projections were done.

ToR 5

5. *Consider how uncertainties in the assessment, and their potential consequences, are addressed.*
   - *Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.*
   - *Ensure that the implications of uncertainty in technical conclusions are clearly stated.*

The uncertainties are well addressed, there are just so many! Most of the uncertainties are either due to the lack of data or to data of poor quality / resolution. The AIC analysis and sensitivity analyses are useful and demonstrate the need for better data, but I think that one could and should put forth (tentatively) the best model. You could work on how to better visualize the output from multiple models. The assessment team points out that the estimates from the length based total mortality estimator 'should be considered with caution', which is clearly and appropriately stated.

ToR 6

6. *Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.*

   - *Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.*

   - *Provide recommendations on possible ways to improve the SEDAR process.*

I set this out more generally below. I cannot prioritize these well because I do not know 1) the species biology, ecosystem and fishery well, 2) the long-term assessment goals or 3) the financial constraints. I think the assessment team would benefit from a meeting to discuss these issues and help set out the overall assessment framework. But if prioritizing is at all useful given my limited knowledge, I would work on getting a fisheries independent survey together, I might even do this over the life history work although that should be done as well.

Presumably some discussion occurred about whether the method used was the best given the available data. I think it is important to review and recapitulate that argument in the introduction to the assessment report.

ToR 7

7. *Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.*

I wouldn't schedule another assessment until an assessment framework is chosen and the appropriate data collected to support it. Below I briefly review the potential value of collecting better data in four areas.

Landings
I encourage to continue to try and improve sampling of the landings. Some changes have already been made. Check to see they accomplish your goals. Stratification and expansion factors will be important issues if you decide to go to a length based or age based model.

Fisheries independent survey
A fisheries independent survey can be the most useful and important piece of data indicating stock status and the impact of fishing. I am showing some of my bias, but I think many fisheries scientists believe this as well. The effectiveness of a survey, however, depends on many things including, the natural variability in the distribution and abundance of the species or community of interest, the survey design, the gear, the catchability, etc.. Designing a good survey is a big task and unless the species is extremely valuable, most surveys are used for an array of species. In your research recommendations you identify a fisheries independent survey as a 'top research priority'. If so, then this is quite an undertaking and probably deserves a suite of studies examining

1) the species which the survey would focus on monitoring, 2) the gear and fishing method, and 3) statistical design including stratification, sample size and power analysis. I would like to encourage this work, but it should be acknowledged that commitment to a survey is a high level decision and that a new survey will take a lot of work and will require some long-term planning.

Life history data

There is quite a bit of uncertainty in the basic biology of this species. In particular, there has not been a growth study done in this area for blue tang, and there is quite a bit of variability in growth when looking across other regions. The authors suggest that the growth study for queen triggerfish be redone. Natural mortality is estimated from these growth studies, but you seem to show with the different methods and your sensitivity analysis that it could be just about anything. Which estimate should go forward and why? The authors argue that the Pauly (1980) method is better because it includes the growth coefficient and asymptotic length and then state that it 'may be robust to their negative correlation', but the real question is whether the extra parameter contains new or different information. No information was presented on the length or age at maturity which I believe is used in Roff's method (1984). It is stated that beyond the age of five, length is not informative about blue tang age. While this may be true, it would be better to support it with plots of the frequency at length for each age group, so we can see how much overlap there is. If the first 4 or 5 ages show distinct modes then a length-based model may still be a good way forward.

Although it appears that the authors have some data to estimate the selectivity of the gear, this has not been done. In the analysis of the total mortality rate, the parameter measuring the length of first capture (L_c) was allowed to vary. I would think about how to better estimate the selectivity of the gear. Tagging? If one ever wanted to do a yield per recruit analysis, this parameter along with natural mortality, and maturity would have to be better estimated.

Tagging

A tagging program can be used to address many questions, as I am sure most of those involved are aware. I just think it is important to bring up because it may be useful in designing a program for assessing these fish. Conventional tags can be used to estimate movement and help determine the appropriateness of the management unit, the selectivity of the gear and fish growth. Tagging can be used to get an estimate of the fishing and natural mortality rates, and an estimate of population size, however population size is more difficult and requires more tags. In my view, an overall assessment and research program benefits from a tagging program. It has the potential to reduce the number of assumptions in an assessment and the uncertainty in some parameters. In some cases it is the best method for an assessment given the natural history of the fish and the nature of the fishery.

4.0 References

Beverton, R. J., & Holt, S. J. (1957). *On the dynamics of exploited fish populations*. Springer.

Pauly, D. (1980). A new methodology for rapidly acquiring basic information on tropical fish stocks: growth, mortality and stock-recruitment relationships. *Stock assessment for tropical small-scale fisheries*, 154-172.

Roff, D. A. (1984). The evolution of life history parameters in teleosts. *Canadian Journal of Fisheries and Aquatic Sciences*, *41*(6), 989-1000.

5.0 Appendices

Appendix 1: Bibliography of Materials Provided for Review

Appendix 2: CIE Statement of Work

Appendix 1: Bibliography of Materials Provided for Review

Documents Prepared for the Assessment Workshop

SEDAR30-AW-01. Summary of recreational catch and effort for blue tang and queen triggerfish caught in Puerto Rico since 2000. Meaghan Bryan

SEDAR30-AW-02. Evaluation of the available length-frequency information in the US Caribbean Trip Interview Program (TIP) data. Meaghan Bryan

SEDAR30-AW-03. A review of the life history characteristics of blue tang and queen triggerfish. Adyan B. Rios

SEDAR30-AW-04. Commercial fishery landings of queen triggerfish and blue tang in the United States Caribbean, 1983- 2011. Kevin J. McCarthy

Final Stock Assessment Reports

SEDAR30-SAR1. Blue tang

SEDAR30-SAR2. Queen triggerfish

Reference Documents

SEDAR30-RD01. A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of St. Thomas, U.S. Caribbean. MRAG Americas

SEDAR30-RD02. A pilot program to assess methods of collecting bycatch, discard, and biological data in the commercial fisheries of U.S. Caribbean (Saint Croix). MRAG Americas

Appendix 1: CIE Statement of Work.

Attachment A: Statement of Work for Dr. Kurtis Trzcinski

External Independent Peer Review by the Center for Independent Experts

SEDAR 30 Caribbean blue tang and queen triggerfish assessment review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description SEDAR 30 will be a compilation of data, an assessment of the stock, and an assessment review conducted for Caribbean blue tang and queen triggerfish. The CIE peer review is ultimately responsible for ensuring that the best possible assessment has been provided through the SEDAR process. The stocks assessed through SEDAR 30 are within the jurisdiction of the Caribbean Fisheries Management Council and the territorial waters of Puerto Rico and the U.S. Virgin Islands. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall have the necessary qualifications to complete an impartial and independent peer review in accordance with the tasks and ToRs described in the SoW herein. The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the scientific peer-review described herein. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct the desk review during 4-7 February 2013, therefore no travel will be required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other information pertinent to the desk review arrangements. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

(1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.

(2) During February 4-7, 2013 as specified herein, conduct an independent desk peer review in accordance with the ToRs (**Annex 2**).

(3) No later than February 21, 2013, each CIE reviewer shall submit an independent peer review report addressed to the “Center for Independent Experts,” and sent to Mr.

Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to Dr. David Sampson david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

14 January 2013	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
18 January 2013	NMFS Project Contact sends the stock assessment report and background documents to the CIE reviewers.
4-13 February 2013	Each reviewer conducts an independent desk peer review
19 February 2013	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
7 March 2013	CIE submits CIE independent peer review reports to the COR
14 March 2013	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on changes. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,

(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Program Manager, COR
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Roger W. Peretti, Executive Vice President
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Key Personnel:

NMFS Project Contact:

Julie Neer, SEDAR Coordinator
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405
julie.neer@safmc.net Phone: 843-571-4366

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed. The CIE independent report shall be an independent peer review of each ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

SEDAR 30 Caribbean blue tang and queen triggerfish assessment review

1. Evaluate the data used in the assessment, addressing the following:

   a) Are data decisions made by the Assessment Workshop sound and robust?

   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

   c) Are data applied properly within the assessment model?

   d) Are input data series reliable and sufficient to support the assessment approach and findings?

2. Evaluate the methods used to assess the stock, taking into account the available data.

   1. Are methods scientifically sound and robust?

   2. Are assessment models configured properly and used consistent with standard practices?

   3. Are the methods appropriate for the available data?

3. Evaluate the assessment findings with respect to the following:

   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

   b) Is the stock overfished? What information helps you reach this conclusion?

   c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

   d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

   e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

4. Evaluate the stock projections, addressing the following:

   a) Are the methods consistent with accepted practices and available data?

   b) Are the methods appropriate for the assessment model and outputs?

   c) Are the results informative and robust, and useful to support inferences of probable future conditions?

d) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

   - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods

   1. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.

   - Provide recommendations on possible ways to improve the SEDAR process.

7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 30

U.S. Caribbean Blue Tang

SECTION IV: Research Recommendation

May 2013

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

Recommendations from the Assessment Process

The ability to utilize length-frequency data is contingent upon having reliable estimates of life history parameters (von Bertalanffy parameters in particular). Studies on basic life history (e.g. age-growth relationships and estimating natural mortality) in the US Caribbean will greatly enhance the utility of the existing length-frequency data and should provide the greatest benefit to providing management advice in the short term. Studies should be carefully planned to ensure a representative sample of individuals by age/size, region, season etc. This type of research should be placed as a top priority for key species.

Blue tang are a seemingly fast growing fish species with a long life-span. Beyond the age of five, length information is not informative about the age-structure of blue tang populations. A better understanding about how fishing mortality influences population structure will come from collection of catch-at-age data. Sampling efforts should be carefully planned to ensure representative sampling of individuals by fishing gear, mode, region, season etc.

Fishery-independent surveys should be considered as a top research priority for additional data collection. Fishery-independent surveys designed using a rigorous statistical framework will allow for the collection of species-specific catch and effort data that can be used to develop indices of abundance. Indices of abundance are used in stock assessments to inform models about how a population may be changing over time. Fishery-independent surveys can also be used to supplement existing programs by collecting age, length, weight, and reproductive data.

It is essential that continued efforts to improve the data collection of fishery-dependent catch and effort statistics be made. More specifically, continued efforts to collect species-specific catch statistics will be important for future assessments.

Research Recommendations from the CIE Reviewer Reports (Term of Reference 6)

Cardinale Recommendations

The assessment team does provide an exhaustive shopping list for future data to be collected, which would greatly improve the capability of assessing the status of the Caribbean queen triggerfish and blue tang stock. However, I also suggest that effort should be devoted to selectivity experiments aimed to evaluate the theoretical changes in selectivity linked with the historical changes in the mesh size of the traps.

Chen Recommendations:

The AW panel recommends improving the quality of life history parameter estimates; developing a fishery-independent monitoring program; continuing the efforts to improve the collection of species-specific catch and effort data; and modifying the length-based total mortality estimator to account for potential changes in selectivity. I consider these research areas are important for reducing the uncertainty and improving the quality of the assessment. The AW panel probably needs to prioritize the research recommendations and separate the short-term research plan from the long-term plan.

Given the problems associated with the data, an important research goal should be to improve the data quality and quantity. Short-term and long-term plans should be developed to achieve the goal. Short term research priority may include (1) improvement of life history data estimates and the quantification of their uncertainty in the form of probably distributions; (2) identification of major fishing areas and their spatio-temporal variability via conducting interviews with fishermen involved in the fishery; and (3) identification of potential approaches that can be used to estimate species-specific landing data (e.g., based on species composition of landings that become available in recent years). The long-term research plan should include the development of a fishery-independent monitoring program and continued improvement of the sampling protocol for the collection of fishery-dependent data (catch and effort).

Given the data limitations, I believe another research priority that should be addressed soon is to evaluate the performance of the length-based estimator (Gedamke and Hoenig 2006) for the total mortality. Based on the information available and with some assumptions, a queen triggerfish fishery can be simulated, following the approach used in Gedamke and Hoenig (2006). A simulation study can be conducted with this simulated fishery to evaluate the performance of this length-based estimator for estimating the total mortality. Different scenarios can be developed to identify key factors that may have significant impacts on the performance of the estimator. This can guide the future model development and data collection.

Trzcinski Recommendations:

I set this out more generally below. I cannot prioritize these well because I do not know 1) the species biology, ecosystem and fishery well, 2) the long-term assessment goals or 3) the financial constraints. I think the assessment team would benefit from a meeting to discuss these issues and help set out the overall assessment framework. But if prioritizing is at all useful given my limited knowledge, I would work on getting a fisheries independent survey together, I might even do this over the life history work although that should be done as well.

Presumably some discussion occurred about whether the method used was the best given the available data. I think it is important to review and recapitulate that argument in the introduction to the assessment report.