SEDAR

Southeast Data, Assessment, and Review

Stock Assessment Report
of
SEDAR 8

Caribbean Spiny Lobster

SEDAR8
Assessment Report 2

2005

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SEDAR 8 Stock Assessment Report II.
Caribbean Spiny Lobster

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Stock Assessment Report 2

Caribbean Spiny Lobster

SECTION I. Introduction

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1. SEDAR Overview

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

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment workshop, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products. SEDAR workshops are organized by the SEDAR staff and the lead Council. Data and Assessment Workshops are chaired by the SEDAR coordinator. Participants are drawn from state and federal agencies, non-government organizations, Council members and advisors, and the fishing industry, with a goal of including a broad range of disciplines and perspectives. The Review Workshop is chaired by a scientist selected by the Center for Independent Experts, an organization that provides independent, expert review of stock assessments and related work. Other participants include one reviewer from the CIE, one from the SEFSC, one from NOAA fisheries, one NGO representative, one or more Council Advisory panel representatives, and one or more Council technical (SSC or other panel) representatives.

This assessment, eighth in the SEDAR series, is charged with assessing Caribbean stocks of yellowtail snapper and spiny lobster. The Review Workshop will also consider an assessment of Atlantic and Gulf of Mexico spiny lobster conducted by the State of Florida in a SEDAR workshop format and with assistance from the Councils and NOAA Fisheries.

2. Management Overview

2.1 Management Unit Definition

Each fishery management plan (FMP) defines the management unit—the species or species complexes that are relevant to the FMP’s objective. The US Caribbean Spiny Lobster is managed under the Fishery management Plan for the US Virgin Islands and Puerto Rico. Appendix A. provides a list of useful acronyms and abbreviations related to management.

2.2 Regulatory History

The Caribbean Council manages 179 fish stocks under four FMP's:

- Fishery Management Plan for the Spiny Lobster Fishery of Puerto Rico and the U.S. Virgin Islands
- Fishery Management Plan for the Queen Conch Resources of Puerto Rico and the U.S. Virgin Islands

- Fishery Management Plan for the Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands
- Fishery Management Plan for the Corals and Reef Associated Invertebrates of Puerto Rico and the U.S. Virgin Islands

The history of management measures developed and implemented under each FMP is detailed in the following sections.

2.3 Fishery Management Plan for the Spiny Lobster Fishery of Puerto Rico and the U.S. Virgin Islands

The Caribbean Council's Spiny Lobster FMP (CFMC 1981; 49 FR 50049) was implemented in January 1985, and was supported by an EIS. The FMP defined the Caribbean spiny lobster fishery management unit to include *Panulirus argus* (Caribbean spiny lobster), described objectives for the spiny lobster fishery, and established management measures to achieve those objectives. Primary management measures included:

- The definition of MSY as 830,000 lbs per year;
- The definition of OY as "all the non-[egg-bearing] spiny lobsters in the management area having a carapace length of 3.5 inches or greater that can be harvested on an annual basis," which was estimated to range from 582,000 to 830,000 lbs per year;
- A prohibition on the retention of egg-bearing (berried) lobsters (berried female lobsters may be kept in pots or traps until the eggs are shed), and on all lobsters with a carapace length of less than 3.5 inches;
- A requirement to land lobster whole;
- A requirement to include a self-destruct panel and/or self-destruct door fastenings on traps and pots;
- A requirement to identify and mark traps, pots, buoys, and boats; and
- A prohibition on the use of poisons, drugs, or other chemicals, and on the use of spears, hooks, explosives, or similar devices to take spiny lobsters.

Amendment 1 to the Spiny Lobster FMP (CFMC 1990a; 56 FR 19098), implemented in May 1991, added to the FMP definitions of overfished and overfishing, and outlined framework actions that could be taken should overfishing occur. The amendment defined "overfished" as a biomass level below 20% of the spawning potential ratio (SPR). It defined "overfishing" as a harvest rate that is not consistent with a program implemented to rebuild the stock to the 20% SPR. That amendment was supported by an Environmental Assessment (EA) and a finding of no significant impact (FONSI).

2.4 Fishery Management Plan for the Queen Conch Resources of Puerto Rico and the U.S. Virgin Islands

The Caribbean Council's Queen Conch FMP (CFMC 1996a; 61 FR 65481) was implemented in January 1997, and was supported by an EIS.

The FMP defined the queen conch fishery management unit, described objectives for the queen conch fishery, and established management measures to achieve those objectives. Primary management measures included:

- The definition of the MSY of queen conch as 738,000 lbs per year;
- The definition of the OY of queen conch as "all queen conch commercially and recreationally harvested from the EEZ landed consistent with management measure set forth in this FMP under a goal of allowing 20% of the spawning stock biomass to remain intact;
- A prohibition on the possession of queen conch that measure less than 9 inches total length or that have a shell lip thickness of less than 3/8 inches;
- A requirement that all conch species in the fishery management unit be landed in the shell;
- A prohibition on the sale of undersized queen conch and queen conch shells;
- A recreational bag limit of three queen conch per day, not to exceed 12 per boat;
- A commercial catch limit of 150 queen conch per day;
- An annual spawning season closure that extends from 1 July through 30 September; and
- A prohibition on the use of HOOKAH gear to harvest queen conch.

2.5 Fishery Management Plan for the Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands

The Caribbean Council's Reef Fish FMP (CFMC 1985; 50 FR 34850) was implemented in September 1985. The FMP, which was supported by an EIS, defined the reef fish fishery management unit to include shallow water species only, described objectives for the shallow water reef fish fishery, and established management measures to achieve those objectives. Primary management measures included:

- The definition of MSY as equal to 7.7 million lbs;
- The definition of OY as "all of the fishes in the management unit that can be harvested by U.S. fishermen under the provisions of the FMP...This amount is currently estimated at 7.7 million lbs;"
- The specification of criteria for the construction of fish traps, which included a minimum 1 1/4-inch mesh size requirement and a requirement that fish traps contain a self-destruct panel and/or self-destruct door fastening;
- A requirement to identify and mark gear and boats;
- A prohibition on the use of poisons, drugs, and other chemicals and explosives to take reef fish;
- A prohibition on the take of yellowtail snapper that measure less than 8 inches total length for the first fishing year, to be increased one inch per year until the minimum size limit reached 12 inches;

- A prohibition on the take of Nassau grouper that measure less than 12 inches total length for the first fishing year, to be increased one inch per year until the minimum size limit reached 24 inches; and

- A prohibition on the take of Nassau grouper from 1 January to 31 March each year, a period that coincides with the spawning season of this species.

Amendment 1 to the Reef fish FMP (CFMC 1990b; 55 FR 46214) was implemented in December 1990. That amendment was supported by an EA. Primary management measures included:

- An increase in the minimum mesh size for traps to 2 inches;

- A prohibition on the take or possession of Nassau grouper; and

- A prohibition on fishing in an area southwest of St. Thomas, USVI from 1 December through 28 February of each year, a period that coincides with the spawning season for red hind (this seasonal closure would later become a year-round closure with the implementation of the Hind Bank Marine Conservation District through Amendment 1 to the Coral FMP).

Amendment 1 also defined overfished and overfishing for shallow water reef fish. "Overfished" was defined as a biomass level below 20% of the spawning stock biomass per recruit (SSBR) that would occur in the absence of fishing. For stocks that are overfished, "overfishing" was defined as a rate of harvest that is not consistent with a program that has been established to rebuild a stock or stock complex to the 20% SSBR level. For stocks that are not overfished, "overfishing" was defined as "a harvesting rate that if continued would lead to a state of the stock or stock complex that would not at least allow a harvest of OY on a continuing basis."

A regulatory amendment to the Reef Fish FMP (CFMC 1991; 56 FR 48755) was implemented October 1991. The primary management measures contained in this amendment, which was supported by an EA, included:

- A modification to the mesh size increase implemented through Amendment 1 to allow a mesh size of 1.5 inches for hexagonal mesh, and a change in the effective date of the 2-inch minimum mesh size requirement for square mesh to 13 September 1993; and

- A change in the specifications for degradable panels for fish traps related to the required number of panels (required two panels per trap), and their size, location, construction, and method of attachment.

Amendment 2 to the Reef Fish FMP (CFMC 1993; 58 FR 53145), implemented in November 1993, was supported by an SEIS. That amendment redefined the reef fish fishery management unit to include the major species of deep water reef fish and marine aquarium finfish. Primary management measures implemented through this amendment included:

- A prohibition on the use of any gear other than hand-held dip nets and slurp guns to collect marine aquarium fishes;

- A prohibition on the harvest or possession of Goliath grouper (formerly known as jewfish;

- A prohibition on the harvest, possession, and/or sale of certain species used in the aquarium trade, including seahorses and foureye, banded, and longsnout butterflyfish;
- A prohibition on fishing in an area off the west coast of Puerto Rico (Tourmaline Bank) from 1 December through 28 February each year, a period that coincides with the spawning season for red hind;
- A prohibition on fishing in an area off the east coast of St. Croix, USVI (Lang Bank) from 1 December through 28 February each year, a period that coincides with the spawning season for red hind; and
- A prohibition on fishing in an area off the southwest coast of St. Croix, USVI from 1 March through 30 June each year, a period that coincides with the spawning season for mutton snapper.

Existing definitions of MSY and OY were applied to all reef fish within the revised FMU, with the exception of marine aquarium finfish. The MSY and OY of marine aquarium finfish remained undefined.

A technical amendment to the Reef Fish FMP (59 FR 11560), implemented in April 1994, clarified the minimum mesh size allowed for fish traps.

Finally, an additional regulatory amendment to the Reef Fish FMP (CFMC 1996b; 61 FR 64485) was implemented in January 1997. That action, supported by an EA, reduced the size of the Tourmaline Bank closure that was originally implemented in 1993, and prohibited fishing in two areas off the west coast of Puerto Rico (Abrir La Sierra Bank (Buoy 6) and Bajo de Cico) from 1 December to 28 February of each year, a period that coincides with the spawning season of red hind.

2.6 Fishery Management Plan for the Corals and Reef Associated Invertebrates of Puerto Rico and the U.S. Virgin Islands

The Caribbean Council's Coral FMP (CFMC 1994; 60 FR 58221) was implemented in December 1995.

The FMP, which was supported by an EIS, defined the coral fishery management unit, described objectives for Caribbean coral resources, and established management measures to achieve those objectives. Primary management measures included:

- A prohibition on the take or possession of gorgonians, stony corals, and any species in the fishery management unit if attached or existing upon live rock;
- A prohibition on the sale or possession of any prohibited coral unless fully documented as to point of origin;
- A prohibition on the use of chemicals, plants, or plant-derived toxins, and explosives to take species in the coral fishery management unit; and
- A requirement that dip nets, slurp guns, hands, and other non-habitat destructive gear types be used to harvest allowable corals.

The FMP also required that harvesters of allowable corals obtain a permit from the local or Federal governments.

Amendment Number 1 to the Coral FMP (CFMC 1999; 64 FR 60132) was implemented in December 1999. Supported through SEIS, that amendment established a closed area in the U.S. EEZ southwest of St. Thomas, USVI. That area is known as the Hind Bank Marine Conservation District (MCD). Fishing for any species, and anchoring by all fishing vessels, are prohibited in the Hind Bank MCD year round.

2.7 Generic FMP amendments

The Caribbean Council submitted the *Generic Essential Fish Habitat Amendment to the Spiny Lobster, Queen Conch, Reef Fish, and Coral Fishery Management Plans* (Generic EFH Amendment) to NOAA Fisheries in 1998 to comply with the EFH provisions of the MSFCMA. NOAA Fisheries partially disapproved that amendment on 29 March 1999, finding that it did not evaluate all managed species or all fishing gears with the potential to damage fish habitat (64 FR 14884). The document was subsequently challenged by a coalition of environmental groups and fishing associations on the grounds that it did not comply with the requirements of the MSFCMA and NEPA (*American Oceans Campaign et al. v. Daley et al.*, Civ. No. 99-982 [D.D.C.]). The Federal Court opinion upheld the plaintiffs' claim that the Generic EFH Amendment was in violation of NEPA, but determined that the amendment was in accordance with the MSFCMA. The Caribbean Council is currently preparing an EIS for the Generic EFH Amendment to comply with the 14 September 2000 court order. The notice of availability of the draft EIS, which could lead the Caribbean Council to further amend one or more of its FMPs, was published in the *Federal Register* on August 1, 2003 (68 FR 45237). The comment period on that document ended October 30, 2003.

The draft *Comprehensive Sustainable Fisheries Act Amendment to the Spiny Lobster, Queen Conch, Reef Fish, and Coral Fishery Management Plans* (Comprehensive SFA Amendment) prepared by the Caribbean Council and noticed in the *Federal Register* on 25 January 2002 (67 FR 3679) was intended to amend all four council plans to meet additional requirements added to the MSFCMA in 1996 through a Congressional amendment known as the Sustainable Fisheries Act (SFA). But a Federal review determined that the Comprehensive SFA Amendment was inconsistent with the requirements of the SFA and NEPA. The lack of an adequate range of alternatives for defining biological reference points, rebuilding schedules, and bycatch reporting standards was the primary deficiency cited in the notice of agency action to disapprove the document. That notice was published in the *Federal Register* on 1 May 2002 (67 FR 21598).

3. Assessment History

Research efforts in the Caribbean region have provided significant insight into much of the life history, growth and biology of fish and shellfish species, and into the effects of fishing pressure on some exploited stocks. In particular, fishery independent surveys have provided information on size-structure, density, abundance and community structure of coral reef fishes and invertebrates of commercial importance. Many studies have concentrated on spiny lobster and queen conch

An assessment history of the spiny lobster fisheries of the U.S. Caribbean is provided in Morris et al. (1994) and is summarized in this section. These fisheries have been assessed six times since 1990. Through these assessments, the status of the spiny lobster was determined, and this information was used to amend the FMP.

In 1990, Bohnsack et al. (1991) conducted a stock assessment based on landings and catch per unit of effort for the lobster fishery of the U.S. Caribbean. Their analysis showed that Puerto Rico's lobster landings over the past 23 years had fluctuated but averaged approximately 317,451 lbs., while the Virgin Islands lobster landings appeared relatively stable since the 1980's. The difference between island landings, such as that found between St. Thomas and St. Croix, was assumed to be due to differences in the abundance of lobsters. St. Thomas was shown to support a larger resident lobster population than St. Croix, and thus supported more fishermen. The assessment also showed that the Virgin Islands had complied with the minimum size regulations more stringently than Puerto Rico. Between 1985 and 1989, undersized lobsters that were caught in the Virgin Islands represented roughly 2.9% of the total catch, while in Puerto Rico undersized lobsters accounted for 40% of the total catch. With the available data, the review team was unable to determine why this was occurring, but recommended that more effort be used to enforce and increase compliance with the minimum size restrictions, especially in Puerto Rico. The panel also recommended that the lobster stock continue to be defined as overfished while SPR remained below 20% and total landings remained above the level where the fishery was first considered to be overfished (Bohnsack et al. 1991).

Matos-Caraballo (1999) looked at the status of Puerto Rico's spiny lobster fishery from 1992 to 1998 and found significant signs of overfishing. In 1951, a total of 446,000 pounds of spiny lobster were harvested by 466 fishermen. By 1991, only 211,941 pounds of lobster were harvested by 576 fishermen, thus showing an overall decrease in the lobster abundance. Matos-Caraballo also saw a decrease in the mean carapace length of harvested lobster over that period, from 117 mm in 1951 to 91 mm in 1991. During his study, he found that the mean carapace length remained relatively close to the 1991 measured size. Between 1989 and 1991, approximately 59% of spiny lobster caught were below the legal size restriction. Matos-Caraballo linked that to poor enforcement efforts by the Department of Natural and Environmental Resources (DNER). Between 1991 and 1998, an increase in enforcement efforts by DNER did lead to an apparent decline the catch of undersized lobsters. By 1998, only 24% of the total lobster catch was below sub-legal size. Matos-Caraballo concluded that increased DNER enforcement would lead to a further decrease in overfishing; helping local fishermen become more educated about the threats of overfishing would help increase support for, and compliance with the spiny lobster FMP.

An assessment of the St. Croix lobster fishery by Mateo and Tobias (2000) found that there had been a steady increase in spiny lobster landings from 1978 to 1998, with landings increasing from 3,400 kg to 17,700 kg. Using the Schaeffer and Fox models to calculate the maximum sustainable yield (15,500 kg per year), these authors found that St. Croix landings had exceeded MSY in the 1990-1991, 1993-1994, 1997-1998, and 1998-1999 fishing seasons. The exploitation ratios ranged from 0.73-0.82 for males and 0.58-0.76 for females; above the optimum exploitation rate ratio of 0.5. Though landings data were incomplete, Mateo and Tobias were still able to conclude that the St. Croix spiny lobster fishery was fully exploited. They recommended that fishing pressure be decreased considerably through implementation of catch quotas, seasonal closures or limitations on the numbers of traps or fishermen. They believed that the spiny lobster population would benefit most from seasonal closures, given that current enforcement of size and sex regulations have had little impact on fishing pressure. They further concluded that increased biological research of spiny lobster and more complete data compiling would lead to better stock assessments and improved management decisions (Mateo and Tobias, 2000).

Bolden (2001) evaluated the status of spiny lobster in the U.S Caribbean from 1980 to 1999. Her conclusions were based upon data gathered from commercial landings reports provided by fishermen and data from the NOAA Fisheries Trip Interview Program (TIP), which includes the collection of bio-statistical data on spiny lobsters. Bolden found that the annual landings of spiny lobster in Puerto Rico had decreased steadily between 1984 and 1988 and had fluctuated since then. In the U.S. Virgin Islands there was an increase in the total pounds of spiny lobster landed between 1986 and 1988, but began to decline in 1996. Though there had been a steady decline in the spiny lobster fisheries of both Puerto Rico and the Virgin Islands, the commercial value for spiny lobster had increased. The commercial value of the total catch increased by nearly 60% between 1994 and 1995(from $802,959 to $1,373,497). Mean annual carapace length in the U.S. Virgin Island fishery had declined since 1992, while the mean annual carapace length for Puerto Rican spiny lobster remained relatively stable over the same period. Bolden (2001) did find the spiny lobster landed in Puerto Rico to be significantly smaller in size compared with those landed in the U.S Virgin Islands, and the TIP data revealed that 20% of spiny lobsters landed in Puerto Rico and 0.5% landed in the Virgin Islands were below legal regulation size. Sub-legal sized lobster comprised close to 40% of landed lobster in Puerto Rico and only 4.4% in the U.S Virgin Islands. Bolden concluded that minimum size enforcement needed to be increased in Puerto Rico and should become a priority throughout the U.S. Caribbean. This report concluded that a negative mean annual change in carapace length, sex ratios and trap Catch Per Unit Effort (the predominant gear used in the U.S Virgin Islands) indicates a declining fishery. Bolden recommended that validating and converting all U.S. Caribbean TIP and Landings data should become a priority, recommending that all data be compiled into a single data set, allowing for more direct comparison between fisheries in future studies. Further, she recommended that landings should be evaluated more carefully since the fishery showed signs of decline (Bolden, 2001).¶A current assessment (Mateo and Die, 2004) found that lobster landings in Puerto Rico increased throughout the 1990s and have remained stable since 1995, averaging roughly 285,000 pounds. Mateo and Die found that a current stock status could not be accurately assessed with a dynamic production model due to fact that the data analyzed corresponded to a period without large differences in relative abundance. These authors recommended that there be a continued improvement in data collection focusing on extending the historic catch per unit effort data (CPUE) and obtaining landings data from recreational fishermen. They recommend that a "single trip" database be developed in order to facilitate CPUE analysis and that size and relative abundance data be used together in future assessment modeling. Lastly, Mateo and Die recommended the development of a more accurate definition of overfishing in spiny lobster, to be used in lieu of the current SPR definition (Mateo and Die, 2004).¶The final and most recent assessment, Mateo (2004), estimated current exploitation rates of spiny lobster by analyzing TIP data for the period 1999 to 2000 and using a yield per recruit analysis. Exploitation rates were estimated to be 0.66 for males and between 0.68 and 0.71 for females; above the optimum exploitation rate of 0.5. Mateo concluded that spiny lobster in the U.S. Caribbean is fully exploited. He believes that overfishing is due to three factors: management failure to enforce size regulations, a lack of basic biological and ecological knowledge of spiny lobster and a lack of management oriented research. Mateo recommends the need for fully coordinated spiny lobster research involving government, fishermen and industry research, which in turn can be used to develop a sound management plan (Mateo, 2004).

In general, each assessment conducted over the past 14 years has yielded results indicating that the spiny lobster fishery in the U.S. Caribbean have shown signs of overfishing, and that landings, catch rates and relative abundance has declined significantly since the beginning of the fishery. The general consensus is that increased enforcement of the current spiny lobster FMP should lead to a healthier fishery, while the standardization of available fishery data and the collection of data more applicable to the assessment process should allow for a more accurate determination of its status. Further, management of spiny lobster by means other than by relying on minimum carapace length regulations may prove more effective at maintaining a sustainable and profitable fishery.

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SEDAR 8. Caribbean yellowtail snapper and spiny lobster
MASTER DOCUMENT LIST

I. Data Workshop Working Papers

NUMBER	TITLE	Author
SEDAR8-DW1	Fishery Management Plan Summary for the Spiny Lobster Fishery of Puerto Rico and the U.S. Virgin Islands	Kimmel, J.
SEDAR8-DW2	A History of Yellowtail Snapper (*Ocyurus chrysurus*) Assessments from the US Caribbean and Florida	Sladek Nowlis, J
SEDAR8-DW3	Lobster assessment history	Chormanski, S, D Die
SEDAR8-DW4	The biology of yellowtail snapper, *Ocyurus chrysurus*, with emphasis on populations in the Caribbean	Cummings, NJ
SEDAR8-DW5	A Review of the Literature and Life History Study of the Caribbean Spiny Lobster, *Panulirus argus*	Saul, S
SEDAR8-DW6	Status of NOAA Fisheries Commercial Landings and Biostatistical Data - Puerto Rico, 1983-Present	Bennett, J
SEDAR8-DW7	Status of NOAA Fisheries Commercial Landings and Biostatistical Data - USVI, 1973- Present.	Bennett, J
SEDAR8-DW8	The commercial reeffish fishery in Puerto Rico with emphasis on yellowtail snapper, *Ocyurus chrysurus* : landings, nominal effort, and catch per unit of effort from 1983 through 2003	Cummings, NJ
SEDAR8-DW9	An update on the reported landings, expansion factors, and expanded landings for the commercial fisheries of the United States Virgin Islands (with emphasis on spiny lobster and the snapper complex)	M. Valle-Esquivel, and Diaz, G. M
SEDAR8-DW10	Observations on yellowtail snapper caught in US Virgin Islands' commercial fisheries from 1983 through 2003	Sladek Nowlis, J
SEDAR8-DW11	The commercial lobster fishery on Puerto Rico and US Virgin Islands	Chormanski, S, D Die
SEDAR8-DW12	Puerto Rico recreational yellowtail snapper	Cummings, N.J.

SEDAR8-DW13	Preliminary Analysis of Fishery Independent Data Collected in the U.S. Caribbean for two commercially important species: Yellowtail Snapper and Red Hind	Saul, S
SEDAR8-DW14	<<<< BLANK >>>>	
SEDAR8-DW15	The Effects of Trap Fishing in Coral reefs and reef-associated habitats (submitted to GCFI proceedings?)	Hill, R, P Sheridan, G Matthews, R Appeldoorn
SEDAR8-DW16	A very brief description of the cost and earnings of the US Caribbean fish trap fishery	Agar, J
SEDAR8-DW17	Temporal Analysis of Monitoring Data on Reef Fish Assemblages inside Virgin Islands National Park and around St. John, US Virgin Islands, 1988-2000	Beets, J, A Friedlander
SEDAR8-DW18	Effects of artisinal fishing on Caribbean coral reefs	Hawkins, J. P. and C. M. Roberts
SEDAR8-DW19	Effects of fishing on sex-changing Caribbean parrotfishes	Hawkins, J. P. and C. M. Roberts
SEDAR8-DW20	Yellowtail snapper landings maps, Puerto Rico, 2000-2003	
SEDAR8-DW21	Spiny Lobster Landings Maps, Puerto Rico, 2000-2003	

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NUMBER	TITLE	Author
SEDAR8-AW1	US Virgin Islands Commercial Landings and Biostatistical data recovery project	Saul, S
SEDAR8-AW2	Preliminary Analysis and Standardized Catch Per Unit Effort Indices for Yellowtail Snapper Fishery Independent Data in Puerto	Saul, S., G. Diaz, and A. Rosario
SEDAR8-AW3	Standardized Catch Rates of Spiny Lobster (*Panulirus argus*) estimated from the U.S. Virgin Islands Commercial Landings (1974-2003)	Valle-Esquivel, M.
SEDAR8-AW4	Standardized Catch Rates of Spiny Lobster (*Panulirus argus*) estimated from the U.S. Virgin Islands Commercial Trip Interview Program (1983-2003)	Valle-Esquivel, M.
SEDAR8-AW5	Standardized Catch Rates of Spiny Lobster (*Panulirus argus*) estimated from the Puerto Rico Commercial Trip Interview Program (1980-2003)	Valle-Esquivel, M.
SEDAR8-AW6	A Review of Assumptions for the Application of a State-Space Age-Structured Production Model to the Spiny Lobster (*Panulirus argus*) Fishery of the U.S. Caribbean.	Valle-Esquivel, M.
SEDAR8-AW7	Preliminary information on Puerto Rico commercial size composition of yellowtail snapper, 1983-2003.	Cummings, N.
SEDAR8-AW8	Additional information on Commercial Size frequency samples: US Virgin Islands from 1983-2003	Cummings, N.
SEDAR8-AW9	Caribbean Yellowtail snapper yield per recruit summary information	Cummings, N.
SEDAR8-AW10	Catch-free assessment of Caribbean Yellowtail Snapper	Brooks, L.

III. Review Workshop Working Papers

NUMBER	TITLE	Author
SEDAR8-RW1	Further explorations of a stock production model incorporating covariates (ASPIC) for yellowtail snapper (*Ocyurus chrysurus*) in the US Caribbean	Sladek Nowlis, J
SEDAR8-RW2	Length frequency analysis of Caribbean spiny lobster (Panulirus argus) sampled by the Puerto Rico commercial Trip Interview Program (1980-2003)	Chormanski, S. D, D Die, S Saul
SEDAR8-RW3	Maturity of spiny lobsters in the US Caribbean	Die, D

IV. SEDAR Final Assessment Reports

NUMBER	TITLE	Editor
SEDAR8-SAR1	Stock assessment report for Caribbean yellowtail snapper	Cummings, Nancie Nowlis, Josh
SEDAR8-SAR2	Stock assessment report for Caribbean spiny lobster	Die, David Nowlis, Josh
SEDAR8-SAR3	Stock assessment report for South Atlantic – Gulf of Mexico spiny lobster	Muller, Bob Hunt, John

V. SEDAR 8 Reference Documents List

NUMBER	TITLE	Author
SEDAR8-RD1	USVI Caribbean spiny lobster assessment. 2004. USVI DFW	Gordon, S. and J. Vasques.
SEDAR8-RD2	Compilation and summary of ex-vessel fish prices in the U.S. Virgin Islands, 1974/75 to 2003/04.	Holt, M. and K. R. Uwate.
SEDAR8- RD3	Estimates of the number of licensed commercial fishers per year in the U.S. Virgin Islands, 1974/75 to 2003/04. 2004; USVI DFW	Holt, M. and K. R. Uwate.
SEDAR8-RD4	Nearshore habitats as nursery grounds for recreationally important fishers, St. Croix, U.S. Virgin Islands, October 1, 2000 to September 30 2001. 2002; USVI DFW	Mateo, I.
SEDAR8-RD5	Nearshore habitats as nursery grounds for recreational important fishes, October 12, 1995 to September 30 2002 2001; USVI DFW	Mateo, I.
SEDAR8-RD6	Activity and harvest patterns in the U. S. Virgin Islands recreational fisheries, October 1, 1995 to September 30, 2002. 2000; USVI DFW	Mateo, I. et alt.
SEDAR8-RD7	Compilation and summary of commercial catch report forms used in the U.S. Virgin Islands, 1974/75 to 2004/05. 2004; USVI DFW	Messineo, J.
SEDAR8-RD8	Coral reef monitoring in St. Croix and St. Thomas, United States Virgin Islands. Year four final report submitted to Dept. of Planning and Nat. Res. 2004. USVI DPNR	Nemeth, R. S., et al
SEDAR8-RD9	The determination of mangrove habitat for nursery ground of recreational fisheries in St. Croix, October 1 1991 to September 30., 1995. 1996; USVI DFW	Tobias, W. J.
SEDAR8-RD10	Quantitative estimates of species composition and abundance of fishes, and fish species/habitat associations in St. Croix, U.S. Virgin Islands. 2002; USVI DFW	Toller, W.
SEDAR8-RD11	Artificial reef development, nourishment, and monitoring, October 1 1996 to September 30, 2002. 2001. USVI DFW	Uwate, R. and W. Tobias
SEDAR8-RD12	Recreational fisheries habitat assessment for St. Thomas /St. John, October 1, 1996 to September 30, 2000. 2001; USVI DFW	Voulson, B.

SEDAR8-RD13	Recruitment of postlarval spiny lobster (*Panulirus argus)* in Southwestern Puerto Rico. PR DNR	Rosario, A. and M. Figuerola
SEDAR8-RD14	Overview of the spiny lobster , *Panulirus argus*, commercial fishery in Puerto Rico during 1992-1998. 1999; 52nd GCFI	Matos-Caraballo, D.
SEDAR8-RD15	Puerto Rico Fishery Census 1995-96. 1998; PR DNR	Matos-Caraballo, D.
SEDAR8-RD16	Comparison of size of capture using hook and line, fish traps, and gill nets of five species of commercial fish in Puerto Rico during 1988-90. ; GCFI	Matos-Caraballo, D.
SEDAR8-RD17	Comparison of size capture by gear and by sex of spiny lobster (*Panulirus argus)* I Puerto Rico during 1989-91. 1992; 45th GCFI	Matos-Caraballo, D.
SEDAR8-RD18	Overview of Puerto Rico's small-scale fisheries statistics 1998-2001. 2002; 55th GCFI	Matos-Caraballo, D.
SEDAR8-RD19	Comprehensive census of the marine fishery of Puerto Rico, 2002. 2004; PR DNR	Matos-Caraballo, D.
SEDAR8-RD20	CATCH-FREE STOCK ASSESSMENTS WITH APPLICATION TO GOLIATH GROUPER (*EPINEPHELUS ITAJARA*) OFF SOUTHERN FLORIDA	Porch, C. E., A.M. Eklund and G. P. Scott
SEDAR8-RD21	Maximum reproductive rate of fish at low population sizes	Myers, R.A. , K. G. Bowen, and N. J. Barrowman
SEDAR8-RD22	Compensatory density dependence in fish populations: importance, controversy, understanding, and prognosis.	Rose, K. A.et aln
SEDAR8-RD23	A preliminary assessment of Atlantic white marlin using a state-space implementation of an age-structured production model. DRAFT NOT TO BE CITED	Porch, C. E.
SEDAR8-RD24	Preliminary estimations of growth, mortality and yield per recruit for the spiny lobster *Panulirus argus* in St. Croix, USVI. *Proc. Gulf Carib. Fish. Inst.* 53: 59-75	Mateo, I, WJ Tobias
SEDAR8-RD25	Population dynamics for spiny lobster *Panulirus argus* in Puerto Rico: Progress report. *Proc. Gulf Carib. Fish. Inst.* 55: 506-520	Mateo, I

SEDAR 8

Stock Assessment Report 2

Caribbean Spiny Lobster

SECTION II. Data Workshop

SEDAR
1 Southpark Circle # 306
Charleston, SC 29414

Caribbean Spiny Lobster (*Panulirus* argus)

March 2005

Edited by Nancie Cummings, SEFSC

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1. Introduction

Scientists from the DNER, Puerto Rico, the DFW, US Virgin Islands, the University of Puerto Rico, the Caribbean Fishery Management Council, the NOAA, SEFSC, Miami Office, the NOAA, NMFS, SEFSC Regional Office (SERO), and the University of Miami convened in St. Thomas, US Virgin Islands from December 6th to 10th 2004. A list of participants and contact information is provided in section 1.3. The main purpose of the meeting was to focus on the feasibility of using various data sets for developing information for use in stock assessments of Caribbean yellowtail snapper and spiny lobster. Appendix B provides a general reference as to the spatial area involved for these two stocks. Many of the basic data sets considered at the SEDAR8 Data Workshop were also addressed, at the 2003 SEDAR4 Deepwater Caribbean Snapper Data Workshop. Recommendations were made, during the 2003 SEDAR4 Data Workshop, regarding the quality and reliability of many of the basic data for use in determining total harvest and stock abundance. In addition, during the 2003 SEDAR4 Data Workshop, recommendations regarding improvements needed for several of the data sets were made. In particular, landings and bio-statistical samples for the US Virgin Islands were of a concern. The findings from the SEDAR4 Data Workshop were provided in the SEDAR4 Assessment Report

Because of the uncertainty about some components of the data, the workshop participants chose to provide broad summaries of the information available on the U.S. Caribbean fisheries, to indicate areas where further research is needed, and to consider which available information sets could be useful for conducting stock assessments in the near future.

Prior to the SEDAR8 Data Workshop, participants were requested to prepare initial summarizations of some of the basic data to be examined during the workshop. These findings were provided in the form of working group papers and a complete list of the documents considered at the Data Workshop is provided in section 1.5. During the Data Workshop, several working groups were formed by the participants to address compilation of necessary data to conduct a stock assessment evaluation of yellowtail snapper. These groups were: 1) Life History, 2) Commercial Fisheries (US Virgin Islands and Puerto Rico), 3) Recreational Fisheries, 4) Fishery Independent Abundance Indices, and 5) Fishery Dependent Abundance Indices. In addition, during the Data Workshop additional analyses were conducted of some of the data as well, as recommendations of analyses needed prior to the Stock Assessment Workshop.

This report is organized by section and addresses each of the working group deliberations. Structure within each section generally follows that followed by previous SEDAR workshops. Figures and Tables are retained in separate units and follow the main text of the document and numbering is sequential. List of references to the general literature (i.e., papers other than the working documents submitted to this Workshop) follow the text of the main document. Citations to papers submitted to this Workshop as 'working documents' are made in the text using the identifying numbers assigned by the SEDAR Coordinator and follow the form of SEDAR8-DW-xx.

This report is a complete and final documentation of the activities, decisions, and recommendations of the SEDAR8 Data Workshop. The content will also provide as input, one of the four components of the final SEDAR8 Assessment report for Yellowtail Snapper. The final SEDAR Assessment report will be completed subsequent to the last workshop in the SEDAR cycle, the Review Workshop. The SEDAR8 Assessment Report will contain the following sections: I) Introduction, II) Data Workshop Report, III) Assessment Workshop Report and IV) Review Workshop Report.

1.1 Workshop Time and Place

The SEDAR8 Yellowtail Snapper and Spiny Lobster Data Workshop met in St. Thomas, US Virgin Islands, at the Frenchman's Reef Hotel, December 6 through December 10, 2004.

1.2 Terms of Reference

1. Characterize stock structure and develop a unit stock definition.
2. Evaluate the quality and reliability of life-history information (Age, growth, natural mortality, reproductive characteristics, etc.); provide models to describe growth, maturation, and fecundity by age, sex, or length as appropriate.
3. Evaluate the quality and reliability of fishery-independent measures of abundance; provide indices of population abundance by appropriate strata (e.g., age, size, and fishery); provide measures of precision.
4. Evaluate the quality and reliability of fishery-dependent measures of abundance; develop indices of population abundance by appropriate strata; provide measures of precision.
5. Evaluate the quality and reliability fishery-dependent data for determining harvest and discard by species and fishery sector; tabulate total annual catch (including both landings and discard removals) in weight and number.
6. Evaluate the quality and reliability of data available for characterizing the size and age distribution of the catch (landings and discard); provide length and age distributions; tabulate landings and discards by size, age, and fishery sector.
7. Evaluate the quality and reliability of available data for estimating the impacts of management actions.
8. Recommend assessment methods and models that are appropriate given the quality and scope of the data sets reviewed and management requirements.
9. Provide recommendations for future research (research, sampling, monitoring, and assessment).
10. Prepare complete documentation of workshop actions and decisions; generate a data workshop report (Section II. of the SEDAR assessment report).

1.3 List of Participants, Affiliation, and Corresponding Email Addresses:

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1.4 List of SEDAR8 Data Workshop Working Papers

Document Number	Manuscript Title	Author(s)
SEDAR8-DW1	Fishery Management Plan Summary for the Spiny Lobster Fishery of Puerto Rico and the US Virgin Islands	Kimmel, J.
SEDAR8-DW2	A History of Yellowtail Snapper (Ocyurus chrysurus) Assessments from the US Caribbean and Florida	Sladek Nowlis, J
SEDAR8-DW3	Lobster assessment history	Chormanski, S, D Die
SEDAR8-DW4	The biology of yellowtail snapper, Ocyurus chrysurus, with emphasis on populations in the Caribbean	Cummings, NJ
SEDAR8-DW5	A Review of the Literature and Life History Study of the Caribbean Spiny Lobster, Panulirus argus	Saul, S
SEDAR8-DW6	Status of NOAA Fisheries Commercial Landings and Biostatistical Data - Puerto Rico, 1983-Present	Bennett, J
SEDAR8-DW7	Status of NOAA Fisheries Commercial Landings and Biostatistical Data - USVI, 1973- Present.	Bennett, J
SEDAR8-DW8	The commercial reef fish fishery in Puerto Rico with emphasis on yellowtail snapper, Ocyurus chrysurus : landings, nominal effort, and catch per unit of effort from 1983 through 2003	Cummings, NJ
SEDAR8-DW9	An update on the reported landings, expansion factors, and expanded landings for the commercial fisheries of the United States Virgin Islands (with emphasis on spiny lobster and the snapper complex)	Valle-Esquivel, M. and G. M. Diaz
SEDAR8-DW10	Observations on yellowtail snapper caught in US Virgin Islands' commercial fisheries from 1983 through 2003	Sladek Nowlis, J
SEDAR8-DW11	The commercial lobster fishery on Puerto Rico and US Virgin Islands	Chormanski, S, D Die
SEDAR8-DW12	Puerto Rico recreational yellowtail snapper	Cummings, N.J.
SEDAR8-DW13	Preliminary Analysis of Fishery Independent Data Collected in the U.S. Caribbean for two commercially important species: Yellowtail Snapper and Red Hind	Saul, S
SEDAR8-DW14	<<<< BLANK >>>>	
SEDAR8-DW15	The Effects of Trap Fishing in Coral reefs and reef-associated habitats (submitted to GCFI proceedings?)	Hill, R, P Sheridan, G Matthews, R Appeldoorn
SEDAR8-DW16	A very brief description of the cost and earnings of the US Caribbean fish trap fishery	Agar, J
SEDAR8-DW17	Temporal Analysis of Monitoring Data on Reef Fish Assemblages inside Virgin Islands National Park and around St. John, US Virgin Islands, 1988-2000	Beets, J, A Friedlander
SEDAR8-DW18	Effects of artisanal fishing on Caribbean coral reefs	Hawkins, J. P. and C. M. Roberts
SEDAR8-DW19	Effects of fishing on sex-changing Caribbean parrotfishes	Hawkins, J. P. and C. M. Roberts
SEDAR8-DW20	Yellowtail snapper landings maps, Puerto Rico, 2000-2003	Stone, Holly
SEDAR8-DW21	Spiny Lobster Landings Maps, Puerto Rico, 2000-2003	Stone, Holly

2. Life History

The Caribbean spiny lobster (*Panulirus argus*) supports a primarily artisanal and semi-industrial fishery, second in economic importance only to penaeid shrimp in the Caribbean as a whole (Ehrhardt, 2001).

2.1 Distribution

The Caribbean spiny lobster populates the Western Atlantic Ocean, Caribbean Sea, and Gulf of Mexico, ranging from North Carolina (USA) and Bermuda in the north, to Brazil in the south (Hernkind, 1980; Arce & de León, 2001; Cruz et al., 2001).

2.2 Habitat and Trophic Requirements

P. argus changes habitats several times during its ontogenetic development, moving from planktonic phyllosoma larvae to pelagic swimming puerulus larvae to adults, which may utilize a variety of benthic habitats (Arce & de León, 2001; Cruz et al., 2001). *P. argus* begins life as a fertilized egg, carried under the abdomen of a female lobster (Bliss, 1982). Females may migrate several kilometers toward the edges of reefs or coastal shelves in order to incubate and release larvae (Buesa, 1965). Pelagic phyllosoma larvae hatch from the eggs and may spend 6 to 10 months in the plankton, during which time they undergo 11 larval stages and are dispersed throughout the Caribbean (Alfonso et al., 1991). The phyllosoma metamorphose into puerulus larvae, which swim to shallow, near-shore environments to settle and develop (Marx & Hernkind, 1985). Settlement peaks in September-December (Cruz et al., 1995). Young post-pueruli, or algal phase lobsters (Arce & de León, 2001), typically inhabit branched clumps of red algae (*Laurencia sp.*), submerged mangrove roots, seagrass banks, or sponges, which provide refuge from predation and easy access to food sources (Marx and Hernkind 1994). Post-pueruli lobsters grow to the juvenile stage 10-15 months post settlement (Cruz et al., 1995) and begin to move from vegetated habitats to unvegetated patches of reefs as the grow, seeking refuge in caves, coral reefs, sponges or soft corals (Herrnkind 1980). Older juveniles and sub-adults migrate offshore and recruit to the fishery when they attain minimum carapace length (89mm in the U.S. Caribbean), at about two years of age (Herrnkind, 1980). Adult lobsters are thigmotactic and tend to enter social living arrangements aggregating in enclosed dens. Shelter environments may include natural holes in a reef, rocky outcrops, or artificially created environments (Lipcius & Cobb, 1994).

2.3 **Migration**.

In higher latitudes, the shallow waters that *P. argus* occupies during the summer become turbid and cold, initiating the diurnal migration of thousands of lobsters. *P. argus* is highly susceptible to severe winter cooling and will exhibit reduced feeding and locomotion at temperatures below 14ºC; molting individuals usually perish under these conditions. Caribbean spiny lobsters migrate in single-file queues to deeper water in order to evade the stresses of the cold and turbid waters. *P. argus* may migrate for periods of six hours to five days and cover distances as far as 30-50km (Herrnkind, 1985).

2.4 Stock Structure

Spiny lobsters are widely distributed thought the Caribbean, the southern US and in northern South America.

2.5 Maturation/Reproduction, Fecundity/ Recruitment

Reproduction in *P. argus* occurs almost exclusively in the deep reef environment once mature individuals have made the permanent transition from the shallow seagrass nursery to the ocean coral reef system. Choice of mate is determined by the female as well as by inter-male aggression, where larger males will prevent smaller males from courting females (Lipcius & Cobb, 1994). Male and females locate each other via chemical attractants released with the urine. Females mate only once during a season and are only receptive after molting, before their new shell hardens. Males may fertilize multiple females (Bliss, 1982; Atema & Cobb, 1980). During mating, the male flicks his antennules over the anterior of the female and scrape at her with the third walking legs. The male follows the female around continually trying to lift the female up and embrace her. This pattern continues until the female acquiesces and they stand on their walking legs while the male deposits the spermatophore mass on the female sternum using specially modified pleopods (Atema & Cobb, 1980; Bliss, 1982). Egg-bearing females usually seek refuge in solitary dens and infrequently forage for food (Lyons et al., 1981). Eggs gestate in about one month and change color from orange when freshly spawned to brown prior to hatching (Lyons et al., 1981).

Spawning is seasonal in some areas of the Caribbean, in Cuba it peaks in the spring and summer (March-July) with a subsidiary peak in early autumn (September), though berried females may be found year round (Kanciruk and Hernkind, 1976; Arce and de León). More southern areas of the Caribbean may show spawning peaks that extend into October or November (Castano & Cadima, 1993; Gallo et al. 1998). Spawning has been correlated with water temperature, with an optimal temperature of 24°C in the Florida Keys. In the US Caribbean, spawning occurs throughout the year without a strong seasonal pattern (Bohnsack et al 1992).

Maturity at length estimates vary between Caribbean areas. Bohnsack (1992) examined the percent mature (tar and egg bearing females) as a function of size. Analysis of this data suggests that in the US Caribbean 50% of females are mature at 3.6" (Figure 1).

2.6 Age and Growth

Temperature, maturation state, season, and sex have all been shown to affect the growth of the spiny lobster, *P. argus* (Arce & de León, 2001). Adult females have been shown to grow at 2/3 the rate of adult males (Hunt and Lyons, 1986). Physical growth of lobsters occurs through molting. The molt cycle begins with the intermolt period, the time when a new cuticle is formed, tissue growth is rapid, and the lobster actively forages. This period culminates in ecdysis, the shedding of the old cuticle (Lipcius and Herrnkind, 1982). Molting occurs primarily at night as a means of decreasing the risk of cannibalism and predation during day light. For adult lobsters, molts occur at an average rate of 2.5 year^{-1}, with each molting event requiring about 12 days for the new exoskeleton to harden and a full 28 days to completely form (Lipcius and Herrnkind, 1982; Williams, 1984).

Despite the wide body of literature on this species, limited information is available on the growth and aging of the Caribbean spiny lobster due, in part, to molting habits interfering with tagging efforts. Consequently, length data, which is substantially easier and less costly to attain, has been the dominant source of information used to estimate growth in *P. argus*. Gonzalez-Cano (1991) and Arce & de León (2001) have compiled some of this growth data from the Caribbean (Figure 2). According to Arce & de León (2001), the de León et al.

(1995) estimates for Cuba, which used large sample sizes and were obtained using the SLCA method, were considered the most reliable. SEDAR8 recommends that the estimates from Olsen and Kublic (1975) are used for the US Caribbean (Table 1)

2.7 Natural Mortality

Caribbean spiny lobster populations have been affected by such high fishing pressure for such a significant period of time that natural mortality rates have been difficult to isolate from fished mortality rates. Larger animals such as sharks and finfish are known to prey on adult lobsters (Herrnkind, 1980). Arce & de León, 2001 suggest using a range of estimates between 0.3-0.4 year^{-1} for regional studies (Table 2). SEDAR8 suggest to use mortality estimates obtained from direct estimations in either the US Caribbean (Olsen and Kublic 1975 in US VI) or areas close by (Turk and Caicos, Medley and Ninnes 1997). The chosen estimates were the median estimate of 0.46 from as the estimates of mortality for sub adults and young lobsters (up to the size at 50% maturity) and the estimate from Medley and Ninnes (1997) of 0.36 for adult lobsters. The first estimate was obtained from tagging of immature and sub adult lobsters whereas the second estimate was obtained from depletion models applied to data from the commercial fishery that targets adults.

2.8 Life History Research Recommendations

3. Fishery Descriptions and Data Sources General

The SEDAR8 commercial sub-group discussed and reviewed the available commercial landings data in addition to the available bio-statistical data. Several major issues with the data identified and discussed in detail. These issues along with recommendations appropriate to rectify the problems with the basic data were considered by the main group for further discussion. Several of the issues identified for the US Virgin Islands data in particular, were of such a nature that postponement of the subsequent SEDAR 8 Assessment Workshop was mentioned, as a recommendation by some of the workshop participants (SEDAR8 DW-23).

It was noted however, that in the context of total landings and species composition for the US Virgin Islands finfish, while the as yet incomplete data from the US Virgin Islands would likely provide an improved basis for monitoring the resources from waters surrounding the US Virgin Islands. It was also noted, that current information suggests the volume of yellowtail snapper landings from US Virgin Islands is small relative to the quantity of removals of yellowtail snapper from Puerto Rico. As such, the addition of more precise data from the US Virgin Islands for yellowtail snapper may be of a substantially smaller impact considering a stock-wide (Puerto Rican Platform) form of stock assessment. Sensitivity of the assessment model outcomes to ranges of assumed uncertainty in the US Virgin Islands data could be used to test this condition.

3.1 Commercial Puerto Rico

3.1.1 Overview Puerto Rico Spiny Lobster Commercial Fisheries

As documented in Mateo and Die (2004), the Caribbean spiny lobster (*Panulirus argus*) is a valuable exploited marine crustacean inhabiting shallow shelf waters off the Caribbean region, the southern United States and Bermuda. In Puerto Rico, spiny lobster is principally harvested by traps and diving. About 15% of Puerto Rico catch comes from the east coast, 45% from the south coast and 35% from the from the West Coast. The spiny lobster has consistently ranked as the most economically important marine shellfish species landed in Puerto Rico. Based on data from the Puerto Rico Department of Natural and Environmental Resources Fisheries Laboratory, for the period 1992 through 1998, spiny lobster value per pound ranged from $4.50 to $9.00 US (Matos-Caraballo 1999).

Spiny lobster management in Puerto Rico has been conducted under territorial and federal jurisdictions with a fishery management plan (FMP) administered by the Caribbean Fishery Management Council (CFMC). Indications of overfishing were observed in the US Caribbean during the early 1980's (CMFC, 1985). The established regulations are: (1) a minimum size of 89 mm in carapace length; (2) a prohibition against retaining egg-bearing lobsters; (3) a requirement to land lobster whole; and (4) gear restrictions prohibiting the use of poisons, drugs or other chemicals as well as spears, hooks explosives, or similar devices in harvesting spiny lobsters.

Due to concern of a perceived intense exploitation of the resource, the Puerto Rico spiny lobster fishery and biological data have been periodically re-examined by the NOAA-Fisheries (see previous section). However, problems with data collection and database management procedures, have limited the types of analyses that were possible to provide sound stock assessment of this species. Some of the problems are that the commercial landings database has been considered inappropriate for catch per unit of effort estimation, that it was difficult to distinguish between targeted and non-targeted trips and between catch coming from lobster traps and fish traps; that numerous gears are recorded for a single trip.

The CFMC is developing an amendment to the Caribbean SFA. To support this development, SEFCS/NMFS is currently compiling and reviewing data on fisheries resources for the US Caribbean. Mateo and Die's (2004) report contributed to this review of information and provided analyses that evaluate the appropriateness of US Caribbean landing reports as a source of data for stock assessment of one of the most important resources in the area, the Spiny lobster in Puerto Rico.

Mateo and Die (2004) emphasized the need for better data collection procedures, entry and storage. They suggested that analyses be attempted with the available data to identify weaknesses in present data collection systems. Standardized catch rates and effort monitoring programs would greatly improve the ability to monitor changes in the fishery resources across time. This is extremely important in a multi-species fishery such as Puerto Rico. Changes in total catch as well as species composition can be identified. Available data collection efforts for different species must follow a comparable format to avoid combination of observations by number of trips by family groups or species groups which makes detailed analyses difficult. Their preliminary results from the standardized catch rates suggest that the Puerto Rico spiny lobster fishery have been stable from 1988 to present. However the average landings from 1983 to 2001 was 228,000; this represent almost 50% of the average landings from the peak years (1979-1982) of Puerto Rico spiny lobster landings (Matos 1999) suggesting a decrease in landings. Further research assessment studies should be done utilizing other sources such as length frequency distribution and catch and effort data.

3.1.2 Commercial Landings

Die and Morris (SEDAR 8-DW-11) updated the commercial landings of spiny lobster in Puerto Rico using the same methodology as in Mateo and Die (2004). The former document is reproduced in this section. Data were obtained through the National Marine Fisheries Service (NMFS) Cooperative Statistics Program at Miami Southeast Fisheries Science Center on June 8, 2004. The data contained in the landings database used in the current analysis was therefore different to that used by Mateo and Die, not only because of the addition of two years of data but also because of some of the historic data had been modified and corrected. Most notable revisions are the much lower estimate of landing for 1985 and the new estimates for 2002 and 2003. Importantly, since 2003 most landing records correspond to single trips (Table3), all other values are very similar to those reported by Mateo and Die (2004). Landings extend through the year with little seasonal signal (Table 4), with the exception of trammel net landings that are clearly seasonal and are much greater from September to December (Fig. 3). Evolution of landings by gear type shows that the reported gear mix has not changed much since 1990, however, it was much more variable in the 1980s (Fig. 4, Table 5).

3.1.3 Status of Puerto Rico Landings Data

During the SEDAR8 Data Workshop review, Puerto Rican commercial landings data were reviewed and the information from 1998-2003 verified to examine the database for possible duplication. The results of these verification steps are summarized below for yellowtail snapper

Duplicate re-checks were re-run by the NMFS, SEFSC and Puerto Rico, DNER database coordinators to identify and remove duplicate landings records. The results of the data checks were:

YEAR	TOTAL-LBS	YTS-LBS	SPINY-LBS	# Data Records
1998	3452976.00	252010	298431	97823
1999	3326457.42	279101	326800	105923
2000	3252941.65	360518	256612	111419
2001	3390740.00	317055	281387	104661
2002	3271960.21	291024	300441	123378
2003	2387974.09	176567	241910	131283

YTS = Yellowtail snapper

SPINY = Spiny Lobster

Based on the review, the commercial subgroup found the Puerto Rican commercial landings data complete through year 2003; and

It was recommended that in the future, the price information be more closely examined in the database

3.1.4 Discards

At the present time there is no information available on discards in Puerto Rico's commercial fisheries. Data analyzed by Matos-Caraballo ( ) and reported on the various Puerto Rico, DNER Annual Cooperative Reports indicate that about 20 to 30% of the total harvest per year is below the minimum size at maturity. The size at maturity reported by Figuerola et al. (1998) is below the minimum size requirement in federal waters. The minimum size at maturity however was incorporated into the recently implemented Puerto Rico Fishing Regulation. The minimum size for yellowtail snapper is 12 inches for federal waters and 10.5 inches (FL or TL) for State Waters. Nonetheless, it is believed that no undersized fish harvested with the major gears are returned to the water. There are no studies on the yellowtail snapper discarded from beach seines.

Recently a study was funded through the NMFS, MARFIN program aimed at providing some information on this topic in the near future. The MARFIN bycatch study aims to provide some information on bycatch in Puerto Rico. The MARFIN study began in the summer of 2004 and is being conducted by the Puerto Rico, DNER.

3.1.5 Sampling Intensity

Sampling intensity calculations are given for Puerto rico Spiny lobster fishery in Table 6 and Figure 5.

3.1.6 Catch at age/length

At the current time information on the size composition of lobster has not been addressed. It is recommended that after corrections to the TIP Biostatistical samples have been completed that analyses of the sample data be carried out.

3.1.7 Status of Puerto Rico Bio-Statistical Data

For the Puerto Rico bio-statistical data, the TIP data for 1992 needs to be replaced with the PRBIO92 data file submitted by Puerto Rico DNER staff at the SEDAR8 Data Workshop and this should correct most of the outliers identified during the workshop. This task has been completed since the SEDAR8 Data Workshop however, duplicate record checks remain to be performed before analyses of the data can begin; and

In addition, for calendar years 1988 and 1989, the TIP sample data can be updated with the PRBIO88 and PRBIO89 data files, currently missing from the NMFS, TIP database. Following this addition, a check for duplicate trips in TIP will then need to be performed in advance of the SEDAR8 Stock Assessment Workshop. This task has been completed since the SEDAR8 Data Workshop however duplicate checks remain to be performed prior to data analysis; and

For the future, it is recommended that an updated data entry program be written for Puerto Rico bio-statistical data. An additional recommendation was made that the data entry program consist of multiple-screen entry as opposed to the current one screen-entry system in use. It is recommended that the revised bio-statistical data entry program for Puerto Rico samples include a feature which screens the data for duplicate samples.

3.1.8 Spiny Lobster CPUE from Puerto Rico

3.2 Commercial Fishery US Virgin Islands

3.2.1 Overview US Virgin Islands

A review of the history and characteristics of the commercial fisheries of the United States Virgin Islands was presented in SEDAR4-DW-Caribbean (2004) and Valle-Esquivel and Diaz (2003) and is updated in Valle-Esquivel and Diaz (SEDAR8-DW-09, 2004). The status of the commercial landings and bio-statistical data available in NOAA Fisheries is given in Bennett (2004) (SEDAR8-DW-06/07). Excerpts from those documents are presented in the following sections.

Before describing the details of the fishery and the information available to date, it is important to note that due to the format and content of the catch report forms from the U.S. Virgin Islands, and to the multiple changes they have undergone since the data collection program was initiated, landings by species cannot be disaggregated. Over most of period covered by the time-series (1974-1996), landings have been reported by gear type, and later on (1996-2004) by groups of species. This situation applies mostly to fish landings, so fish species can not be directly partititioned from the bulk landings by gear (pots, nets, diving, hooks, etc.) at the present time, without complementary information (i.e., from the Trip Interview Program, TIP). In the case of **Spiny Lobster** (and Queen Conch), landings have been reported in a separate field (or column) in the catch forms since the program's inception, thus facilitating analysis. In addition, landings have largely been reported by gear (diving, lobster traps, fish traps, etc), allowing for further resolution of the analysis. Landings in the U.S. Virgin Islands are given The historical information content recorded for the US Virgin Islands commercial landings was given in SEDAR4-Carib. Table 12 and is reproduced here as Appendix C. in weight (pounds), and no size or age-structure is provided for directly in the landings records.

3.2.2 Commercial US Virgin Islands Spiny Lobster Landings

The working group papers by Bennett (2004) and Valle-Esquivel and Diaz (2003, 2004) (SEDAR8-DW-07/-09) document the data currently available at NOAA-SEFSC and the development of a comprehensive commercial landings database for the US Virgin Islands, from 57 annual files covering the period 1974 to 2003. Since the inception of the mandatory reporting system in 1974, the DFW has modified their monthly (trip level) reporting form several times to collect more detailed gear, effort and species composition information. Because of incompatible information fields, a comprehensive database made up of 3 data sets was assembled:

1. Data from Old Report Form 1 (1974-1986).
2. Data from Old Report Forms 2, 3, and 4 (1986-1999).
3. Data from New Report Form (1994-2003).

In addition, to summarize the reported landings, two expansion factors were developed to account for underreporting. The first expansion factor was calculated as the ratio between the number of licensed fishermen and the number of licensed fishermen who turned in their catch reports. The expanded landings were calculated by multiplying this ratio by the reported landings. A second expansion factor was estimated as the ratio between the maximum number of monthly reports (i.e., 12 monthly reports times the number of licensed fishermen) and the number of submitted landing reports. This last ratio can be multiplied by the expanded landings to obtain the total estimated landings.

EF1 = No. of Licensed Fishermen/ Number of Reporting Fishermen.

Expanded Landings = EF1 * Reported Landings

EF2 = Max Number Reports/ Number of submitted reports

Estimated Landings = EF2 * Expanded Landings

Expansion factors will be recalculated based on new licensing and reporting information provided by the DFW at the SEDAR8-DW workshop (Holt and Uwate, 2004), and will be used to calculate the total estimated landings. The expanded landings presented in Valle and Diaz (2004) and reproduced in this document are thus preliminary, and may be underestimations of the true landings, as only incomplete information for the first expansion factor was available.

It is important to note that DFW has recently been conducting an extensive review and re-entry of the landings reports. Approximately 75% of the catch reports encompassing years 1974-1985 and 1993-2003 have been verified and error-proofed. Data pertaining to years 1986-1992 are currently under review, and shall be completed within a two to three month period (Uwate, pers. comm..). Thus, the summary information presented in Valle-Esquivel and Diaz (2004) and reproduced below is preliminary, as the data for the middle years is incomplete. Corrections to the raw data included the removal of outliers and duplicates from all the analyses.

Tables 7 and 8 and Figures 7 and 8 summarize the reported and expanded landings for the overall finfish-shellfish fishery and also for the spiny lobster fishery. Landings for spiny lobster for the whole period (1974-2003) could be assembled despite differences in report formats, however, landings for years 1986-2002 remain incomplete and should be used with caution. The difference between the reported and expanded landings was estimated at 34% for the overall multi-species fishery, and at 39% for spiny lobster. The proportion of spiny lobster landings by gear type obtained from the new catch report forms (years 1994-2003, with better resolution than older forms) are illustrated in Figures 9 and 10.

3.2.3 <u>Status of US Virgin Islands Landings Data Reviewed at the SEDAR8 Data Workshop:</u>

- US Virgin Islands landings data before reporting years 1985/1986 are viewed as complete.
- US Virgin Islands landings data from reporting years 1986/1987 through 1992/1993 are currently being re-entered by US Virgin Islands Department of Fisheries and Wildlife staff who estimate 2-3 months will be required to complete the task. This task was required because electronic data file for those years indicated several fields in the data records were missing.
- US Virgin Islands landings data from reporting years 1993/1994 forward are considered complete.
- A recommendation was made that, a new data collection form and a new data entry program be developed in order to provide species-level information. Species level landings data would add more certainty to individual species based evaluations. Historically, the NMFS, SEFSC has provided guidance and data management help with bio-statistical field sampling forms (i.e., the NMFS, SEFSC, TIP data entry system) in the US Virgin Islands and with landings data entry programs in Puerto Rico. It is recommended that the US Virgin Islands DFW coordinate revision of landings data entry program with the NMFS, SEFSC.

3.2.4 <u>Discards</u>

There is currently no information available on discards from the U.S. Caribbean commercial reef fish fisheries. Recently two studies have been funded through the NOAA, NMFS, Cooperative Research Program (CRP) aimed to provide some information on this topic in the near future. The focus of the NMFS, CRP bycatch study is to determine the feasibility of deploying observers in the US Virgin Islands to quantify bycatch. The NMFS, CRP project is being conducted by the Marine Resources Assessment Group (MRAG) in cooperation with the NMFS, SEFSC and the US Virgin Islands, DFW. The NMFS, CRP bycatch study began in 2004 off St. Croix and is expected to be implemented in St. Thomas in 2005. In addition to collection of bycatch information the NOAA, NMFS, CRP project off St. Thomas also aims to provide biological samples.

3.2.5 <u>Commercial Sampling Intensity</u>

Sampling intensity calculations are given in SEDAR8-

DW-Tables 9 and 10 and Figures 11 and 12.

3.2.6 Commercial Catch-at-Age/Length

The size composition of lobster in the US Virgin Islands commercial fisheries was not addressed in analyses for the SEDAR8 data workshop. When the missing TIP data have been computerized and all corrections have been made to the data it is recommended that analyses begin.

3.2.7 Status of US Virgin Islands Biostatistical Data

- USVI Department of Fisheries and Wildlife (DFW) staff estimated that 40% of the NMFS, TIP data that have been collected, has not yet been entered into an electronic database. DFW staff estimated the entry of bio-statistical data into an electronic database will take between one and two person-years (R. Uwate, Pers. Comm.). All bio-statistical data have been cataloged by date and by island. DFW holds the view that the NMFS, SEFSC currently does not have the best available data for stock assessment purposes. DFW and NOAA, SEFSC staff have been involved in a rigorous data clean-up process since 2000. Following the estimates from DFW, several more years could be required to fully clean-up the existing US Virgin Islands commercial bio-statistical data. DFW requested additional resources and support to computerize the bio-statistical data. In response to the request for additional support, during and immediately subsequent to the SEDAR8 Data Workshop, NOAA, SEFSC provided personnel, materials, and supplies to photocopy, transport to the SEFSC in Miami, Florida and keypunch some of the data identified by DFW staff as not yet incorporated into the TIP database. This work is on going, with an objective of updating the US Virgin Islands bio-statistical database available for analysis in time for the SEDAR8 Stock Assessment Workshop scheduled for March 2005.
- Outliers of lengths and weights need to be verified and corrected, if necessary, in the data set. This task should be completed prior to making computations of catch at length composition. This task has not yet begun.
- Efforts should be scheduled to identify incorrect length and/or weight type units in the TIP samples and correct these. This task is required before accurate estimates of catch at length can be made. This information is needed for management. This task is required in order to compute accurate estimates of sampling intensity. Sampling intensity information is needed in order to carry out informative allocation of sampling resources and funds. This task has not yet begun.
- After the missing bio-statistical data have been entered and all other needed edits of the data performed then analyses should be initiated to develop catch at size composition.

3.2.8 Research and Analytical Recommendations

Complete data entry and clean-up task of landings (catch) reports (reporting years 1986/1987 to reporting years 1992/1993) within 2-3 months, prior to the SEDAR8-

Assessment Workshop. This task is currently being carried out by the US Virgin Islands, DFW.

- Estimate landings based on complete catch report database after corrections to landings database are made and after reporting years 1986/1987 to 1992/1993 are entered.
- Recalculate expanded landings based on new lists of licensed fishers.
- Table final analyses of commercial bio-statistical data (size-frequency, catch-composition, CPUE) until all the field sampling data has been completely entered and checked for errors and both US, Virgin Island and NMFS, SEFSC staff have signed off on corrections.
- Avoid repetitive analyses on incomplete information. Use only complete data sets in stock assessment analysis. A solid foundation will then be established for the analysis of other species to be included in future assessments.
- If the assessment proceeds, assumptions about the data should be clearly identified.
- Immediate changes in the catch report forms are not recommended. The fishing community in the U.S.Virgin Island is reluctant to provide any additional information, unless they see their data of approximately 30 years reflected in the management decisions.
- Provide feedback to the fishing community after stock assessment analyses are performed, in order to reassure them that the information they provide is valuable and necessary to manage their resources.
- Caribbean Fishery Management Council staff present at the SEDAR8 Data workshop, recommended to conduct stock assessments with the information available at the moment to support management decisions. Proper consideration of uncertainty and acknowledgment of missing data was recommended.

3.1.1 CPUE From Commercial fisher Landings Data

Nominal catch rates for neither yellowtail snapper nor spiny lobster from the fisher reported landing data, were not estimated prior to the SEDAR8-DW workshop because the available information does not yet include any reliable effort data that could be used as a proxy to calculate CPUEs. However, the workshop participants made some progress regarding future CPUE analysis of the commercial landings data regarding nominal effort. Some participants suggested that the effort unit that is most consistent throughout the database was that of a fisher report. Some participants noted however that the reporting time period for a ‘fisher report’ was not always consistent throughout the entire time period, 1974-2003. The key assumption when using the ‘fisher report’ is that a single landing record represents one fishing trip, and that one trip is identified by a name/date combination. However, during some years fishers were required only monthly to report their landings while in later years fishers were required to report weekly and then later daily landings. Landings of Spiny lobster are retained separately on the landings data form so disaggregating of bulk landings will not be necessary as for reef fish species.

- Landings for years 1975-1985 and 1993-2003 have been revised and are available for analysis; data for the middle years (1986-1992) is in progress and will be available in early 2005.
- If and when TIP data becomes available, it will be used to complement the commercial landings CPUE, particularly with regard to gear composition, size composition, and the amount of effort exerted.
- Catch rates for Yellowtail Snapper will be calculated for the most representative gears (pots, lines, diving).
- Preliminary standardizations of catch rates will include the factors: year, location, time of the year, and area.
- For the area stratification, different boundaries across catch report forms will be unified.
- For spiny lobster, temporal stratification will consider the last quarter of the year, when most intense fishing occurs.
- Catch rates will be calculated by island (STT/STJ and STX) and by the most representative gears.

Preliminary analyses were performed at the SEDAR 8-DW workshop to estimate nominal CPUEs for spiny lobsters harvested with all gears from1974-2003. Preliminary CPUEs by district (Table 11) were calculated from the effort (number of lobster records=number of lobster trips) and expanded landings presented in Table 8. Effort, landings and CPUE trends by district are illustrated in Figure 13 Similar analysis will be performed by Gear and District and standardized catch rates will be calculated based on the approach outlined above.

3.2 Recreational Fisheries for Spiny Lobster in the US Caribbean

SEDAR8-DW-12 (Cummings 2004) summarized the recent “recreational” (which likely includes subsistence style fishing as well as recreational fishing activities) catch data for yellowtail snapper in US Caribbean waters. This information was also reviewed at SEDAR4 (November 2003). Recreational fishing in the U.S. Caribbean can be a significant source of fishing mortality, and consists of activities by both locals and tourists. The new Puerto Rico fisheries law requires charter and other recreational operators to have a license. In the Virgin Islands, recreational fishers are also moving toward a recreational license system. In the Virgin Islands, approximately half of charter operators also have a commercial fishing license. However, information on recreational fishing activities in the region is generally lacking.

There are few available estimates of recreational or subsistence harvests of spiny lobster from US Caribbean waters. Available information is summarized in the Caribbean Council’s SFA Amendment for the Caribbean Lobster Fishery Management Plan, and this information suggests that these removals may be on the order of 30% of commercial landings from Puerto Rico. These removals could be substantial, but at present are not quantified.

The Marine Recreational Fisheries Sampling Survey (MRFSS) surveys “recreational” fishers to provide information on the number and attributes of non-marketed fish, both those retained and released. This survey protocol has only been implemented in the U.S. Virgin

Islands in 2000. Jennings (1992) performed a telephone survey of U.S.V.I. recreational fishers in 1986. The Eastern Caribbean Center (2002) performed a smaller survey in 2000. These studies should be examined further, but have not yet been considered.

The MRFSS has been conducted in Puerto Rico since 2000. This survey provides estimates of total fish landed, the variance of the total, and auxiliary information on the sizes of fish caught and their fate—retained or released. Consequently, the focus of this report is on recreational fishing activity in Puerto Rico.

It is apparent that recreational and other forms of fishing not accounted for through commercial markets could be a substantial and potentially growing component of the overall fishing mortality for a number of US Caribbean fishery resources, as evidenced by the available information summarized in the recent Caribbean Council SFA Amendment to the Reef Resources Fisheries Management Plan (see Table z). It is recommended that sampling surveys to estimate and monitor these catches in the US Caribbean be expanded to US Virgin Islands and maintained for Puerto Rico.

3.3 Stock-wide Total Landings Estimates

4. Fishery-Independent Survey Data

Fishery-independent surveys are conducted in the U.S. Caribbean by local and Federal resource agencies and academic researchers, covering various parts of Puerto Rico and the U.S. Virgin Islands. With the noted exceptions, these programs are designed to sample reef fish and do not effectively survey *Panulirus argus* (Caribbean spiny lobster). Projects that collect lobster data specifically and may collect lobster data opportunistically are shown in the table below. While data from these efforts may contribute to the assessment of spiny lobster, they are neither truly comprehensive spatially, nor do they provide a long time series with which to identify fishery-induced changes. Programs that collect data specifically on spiny lobster are highlighted in the following sections in order to document these efforts, their findings, and their limitations. These data should serve as a foundation for research recommendations to improve our capabilities to assess Caribbean reef fish stocks.

4.1 NMFS, Southeast Area Monitoring Program (NMFS, Caribbean, SEAMAP)

The NMFS Southeast Area Monitoring and Assessment Program (SEAMAP) collects and manages fishery independent data in the southeastern United States to assess the status of marine resources within U.S. federal jurisdiction. In the US Caribbean, the Puerto Rico Department of Natural and Environmental Resources (PR DNER) administers the program in Puerto Rico, while US Virgin Islands, Division of Fish and Wildlife (DFW) administers the program in the US Virgin Islands. In both Puerto Rico and the US Virgin Islands, regular studies are conducted to assess the spatial and temporal variations in spiny lobster puerili settlement and relative abundance in selected areas.

4.1.1 <u>Methods, Gears, and Coverage</u>

Both Puerto Rico (DNER) and USVI (DFW) have looked at settlers on collectors within the SEAMAP program. Methods are similar between both areas of the US Caribbean. Modified Witham collectors are used, targeting the same sampling locations each survey period. In Puerto Rico, 20 survey sites off the west coast (2 collectors per site) are sampled. In the US Virgin Islands, 5 sites off the southeastern quadrant of St. Thomas are targeted with 2 collectors per site. Collectors are sampled at least once every two weeks. An age index is used to record post larvae and juveniles. During the most recent sampling in the USVI, small artificial shelters were also deployed to test whether they could be used as indices of settlement abundance.

4.1.2 <u>Sampling Intensity – Time Series</u>

Sampling is usually conducted during 1 of 5 years for Puerto Rico and 2 (back-to-back) out of 5 for US the Virgin Islands. The most recent sampling in Puerto Rico was done from January 2003 to February 2004. Comparisons were made to the previous 1998 study (Rosaria and Figuerola 1998). Most recent sampling in the USVI occurred from June 2002 to June 2003. Previous sample period cited were from 1992-93 and 1997-98.

4.1.3 <u>Catch Rates – Number and Biomass</u>

In the 2003 study in Puerto Rico, a total of 183 post larvae and 43 juveniles were collected. Mean collection rates were 1.1 puerili per collector per sampling event however the majority of puerili were highly concentrated both temporally and spatially. Forty eight percent (48%) were collected from three collectors close to shore. Fifty four percent (54%) were collected between August and October. The most productive collectors were set in areas with a combination of habitats - mixes of soft sediment, hard-ground, and *Thalassia*. Mean catch rate 1.1/collector/event was the same in 1998.

In the 2002-03 Virgin Islands study, 202 post larvae were collected. A maximum of 40 settlers were found across all collectors in one sample period. Settlement at a single site (Nazareth Bay with 127 total) was considerably higher that the other four sites. Peaks of settlement occurred in March to June and in October. The lower settlement sites demonstrated CPUEs less than 0.15 puerili per day per collector. Settlement in May 2003 at Nazareth Bay peaked at 1.54 puerili per day per collector, primarily attributed to a single sample event. CPUE was generally greater in 1992-93 than in either 1997-98 or 2002-03 although only 2 sites were sampled during that time period. From 1997-98 to 2002-03, CPUE declined at all sites except St. James, where mean annual CPUE increased slightly from 0.02 to 0.03 puerili per day per collector.

In the juvenile surveys using artificial shelters to assess recruitment rates only 2 juvenile lobsters were recorded. No analysis was possible.

4.1.4 Uncertainty and Measures of Precision

In both programs, the sites studied are limited. The numbers of stations are low owing to the manpower required to service them, and they are, of necessity, located close to the laboratory for easy access. That being said, they can still provide valuable information for resource assessment and management. The Florida Fish and Wildlife Commission (FWC) uses a similar method to track puerili settlement. From experimental surveys throughout the Florida Keys they have found that in areas of poor or limited juvenile habitat, there is little or no correlation between puerili settlement rates and juvenile recruitment. However, in areas of good or abundant habitat, they find very good correlation between the two rates. Just coincidentally, they have found that their regular monitoring sites are good indicator sites for population predictions. From their work they have expect the puerili settlement rates to be most appropriate as long-term trend indicators. They are also highly useful as tuning indices in their lobster stock assessments.

4.2 Virgin Islands National Park (VINP)

The Virgin Islands National Park has conducted or funded a number of assessments of marine resources within the parks boundaries and in areas near the park. Lobster were surveyed as part of this effort and highlights of that study are detailed below (Beets et al. 1996, Boulon 1987, Wolff 1998).

4.1.5 Methods, Gears, and Coverage

Earlier visual census surveys were conducted at Yawzi Point and Tektite reef on the south coast of St. John. In 1996 complete-reef surveys were repeated at these sites. Divers surveyed the entire reef from the reef edge to mean low water mark. Abundance and estimated carapace length for both spiny and spotted lobster were recorded during these visual surveys. In addition, in 1985-86, Boulon (1987) reported surveys of three bays within VINP waters. These bays were re-sampled in 1996. Similar methods, thorough searches, visual estimation of sizes and abundance were used.

4.1.6 Sampling Intensity – Time Series

The Tektite and Yawzi Reef surveys were originally conducted in 1970. A second survey of three sites within the VINP were surveyed from 1985-86 (Boulon 1987). Surveys in 1996 compare findings with the earlier surveys.

4.1.7 Catch Rates – Number and Biomass

The 1996 sampling found only 43% of the number of lobster counted at Tektite Reef in 1970. At Yawzi Reef, 31 lobsters were found in 1996 compared to 10 in 1970, however, most (18) were juveniles and were in the same hole. Mean length of lobster at Tektite and Yawzi in 1970 was 11.4 cm (CL) with approximately 20 % measuring over 14 cm. In 1996, mean length was only 8.0 cm, with only 6 % over 14 cm. In 1996 63% of all lobsters observed were less than 7 cm, while in 1970 only 12% were that small. Maximum size found in 1970 was 20 cm; in 1996 it was 16 cm.

The survey of Fish Bay and Reef Bay within the VINP showed similar abundances and similar sizes.

4.1.8 Uncertainty and Measures of Precision

Surveys are of specific locations within the VINP and it is not known if these results are representative of other parts of the USVI or PR. The park has regulations different from other parts of the USVI. The sample size is small although the time series makes interesting comparisons. Samples were taken visually, making reproducibility highly dependent on level of training and competence of observers.

5. Overall Data Workshop Research Recommendations for Spiny Lobster

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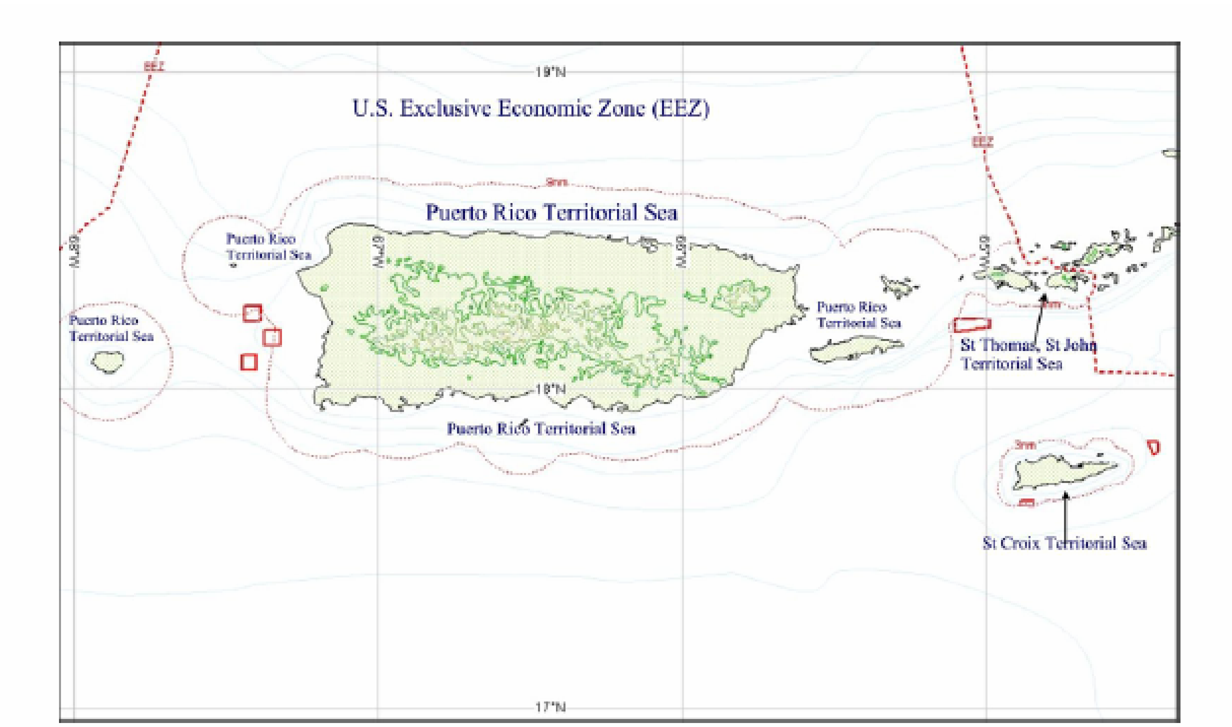
7. Appendices

7.1 Appendix A. Abbreviations and Acronyms

allowable biological catch (ABC)
advisory panel (AP)
biological opinion (BO)
biomass (B)
carapace length (CL)
catch (C)
catch per unit effort (CPUE)
Caribbean Fishery Management Council (CFMC)
Code of Federal Regulations (CFR)
draft environmental impact statement (DEIS)
Division of Fish and Wildlife – U.S. Virgin Islands (DFW)
Department of Natural and Environmental Resources–Puerto Rico (DNER)
Endangered Species Act (ESA)
environmental impact statement (EIS)
essential fish habitat (EFH)
exclusive economic zone (EEZ)
Federal Register (FR)
final environmental impact statement (FEIS)
fishery management plan (FMP)
fishery management unit (FMU)
fishing mortality (F)
fork length (FL)
habitat area of particular concern (HAPC)
highly migratory species (HMS)
Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA)
Marine Mammal Protection Act (MMPA)
Marine Recreational Fisheries Statistical Survey (MRFSS)
maximum fishing mortality threshold (MFMT)
maximum sustainable yield (MSY)
minimum stock size threshold (MSST)
National Environmental Policy Act (NEPA
National Marine Fisheries Service (NOAA Fisheries)
National Marine Fisheries Service Southea Regional Office (SERO)
National Oceanic and Atmospheric Administration (NOAA)
national standard (NS)
national standard guideline (NSG)
natural mortality rate (M)
optimum yield (OY)
Paperwork Reduction Act (PRA)
Puerto Rico (PR)
Regulatory Flexibility Act (RFA)
regulatory impact review (RIR)
spawning potential ratio (SPR)
spawning stock biomass (SSB)
supplemental environmental impact statem (SEIS)
Sustainable Fisheries Act (SFA)
submerged aquatic vegetation (SAV)
total allowable catch (TAC)
total length (TL)
U.S. Virgin Islands (USVI)

7.2 Appendix B. Map of SEDAR8 Reference Area.

Source Graph: SEDAR4 DW Report, Carib-Figure 1. Map of Puerto Rico and the U.S. Virgin Islands, pg. 138.



7.3 Appendix C. Catch Report Fields, USVI

The following table lists fields contained in the different catch report forms used in the U.S. Virgin Islands between years 1974-2003. Source of Table: Taken from SEDAR4- Data Workshop Report (Carib-Table 12, pg 52.).

1	2	3	4	5
OLD FORM (1) (1974-1985)	OLD FORM (2) (1986-1999)	OLD FORM (3) (Short) (1988-1992)	OLD FORM (4) (1992-1999)	NEW FORM (Revised) (1994-2003)
1. ID#	1. LOCATION	1. ID CODE	1. ID CODE	1. GEAR TYPE
2. LAST NAME	2. FISHERMEN #	2. CLASS	2. FISHED (yes/no)	2. GEAR NO.
3. FIRST NAME	3. VESSEL #	3. ISLE: St. Croix	3. TRIP DATE	3. AREA FISHED
4. BOAT LICENSE	4. DATE	St. Thomas/ St. John	4. POT FISH	4. HOURS FISHED
5. FISHING LICENSE	5. POTFISH	4. TRIP DATE	5. POTS	5. GROUPED
6. DATE	6. NETFISH	5. FISH CODE:	6. HOOK FISH	6. SNAPPER
7. # OF HELPERS	7. HOOKFISH	Bait (B), Conch (C)	7. NET FISH	7. GRUNT
8. POT FISH SNAPPER GROUPER	8. SPEAR GUN	Finfish (S), Lobster (L),	8. SPEARGUN	8. JACK
9. POT FISH ALL OTHERS	9. POT LOBSTER	Whelk (W), Other(Z)	9. POT LOBSTER	9. SURGEON
10. NET FISH SNAPPER GROUPER	10. DIVED LOBSTER	6. GEAR CODE:	10. DIVED LOBSTER	10. PARROT
11. NET FISH ALL OTHERS	11. CONCH	Diving (D), Hook& Line (H)	11. CONCH	11. SHELLFISH
12. HOOK FISH SNAPPER GROUPER	12. WHELK	Net (N), Pot or trap (P).	12. WHELK	12. TRIGGER
13. HOOK FISH ALL OTHERS		7.NO. POTS	13. BAITFISH	13. BARRA
14. SPEAR/GUN FISH SNAPPER GROUPER		8. NO. SPEAR GUNS (S_G)	14. FISH AREA	14. GOAT
15. SPEAR/GUN FISH ALL OTHERS		9. NO. OTHER GEAR	15. DISTANCE FROM SHORE (> 3 miles)	15. MACKEREL
16. LOBSTER BY POT		10. FISH AREA	16. TUNA	16. OFFSHORE (D/T/W)
17. LOBSTER BY HAND			17. DORADO	17. FAD
18.OTHER KINDS CONCH, WHELK, OCTOPUS, SQUID, CLAM, OYSTERS			18. WAHOO	18. BAITFISH
19.AREA				19. LOBSTER
20. NOTES				20. CONCH MEAT
				21. WHELK MEAT
				22. DISTANCE FR LAND

8. Tables

Table 1 Von Bertalanffy estimates for spiny lobster from Olsen and Kublic (1975)

Sex	Linfinity	K	tzero	Method	Source
Male	185 mm	0.23			
female	155 mm	0.19			

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Table 2Values of Natural Mortality for Spiny Lobster from the literature.

Country	Sex	Method	M	Author
Bahamas	♂+♀	?	0.36	Ehrhardt
Brazil	♂+♀	Pauly (1980)[3]	0.30	Ivo (1996)
Colombia	♂	Empirical formula[2]	0.54	Gallo *et al.* (1998)
	♀		0.51	
	♂+♀		0.62	
Cuba	♂+♀	Tagging	0.26	Buesa (1972)
	♂+♀	Tagging	0.44	Cruz *et al.*, (1986a)
	♂+♀	Empirical formula[2]	0.34	Cruz *et al.* (1981)
Florida, USA	♂+♀	Pauly (1980)[3]	0.42	Powers and Sutherland (1989)
Florida, USA	♂+♀	Longevity	0.30	Muller *et al.* (1997)
Jamaica	♂	Pauly (1980)[3]	0.59	Haughton (1988)
	♀		0.67	
	♂+♀		0.62	
Nicaragua	♂	Empirical formula[2]	0.41	Estimated during the 1998 working group session
	♀		0.50	
	♂+♀		0.45	
Virgin Is.	♂	Tagging	0.46	Olsen and Koblic (1975)
	♂		0.43	
	♀		0.52	
Turks & Caicos	♂+♀	Depletion model[4]	0.36	Medley and Ninnes (1997)

[1]The working group used as an average value for longevity of 13.9 years from Ivo (1996), in conjunction with the model for natural mortality of Hoenig (1983) where the relation between Z and longevity (T_m) is: $Z = 1.46 - 1.01\ T_m^{1.01}$.

[2]Cruz *et al* (1981) developed an empirical equation to estimate crustacean natural mortality based on mortality and growth parameters and mean water temperature from a number of data sets, similar to Pauly's equation used for finfish:

$$M = 0.0277 - 0.0004 * L_\infty + 0.5397 * K + 0.0119 * T$$

Where L_∞ = CL (mm), K = Growth rate (year^{-1}) and T = Temperature (°C). Using this equation, M values for the region range between 0.3 and 0.35 year^{-1}.

[3]Pauly's (1980) method was developed for finfish and is unreliable for crustaceans, which may explain the generally higher values obtained through this method. Where possible, these values should be re-estimated using Cruz *et al.* (1981) method.

[4]The depletion model provides an estimate independent of growth models and size data.

Table 3 Annual landings (1,000 lbs) of spiny lobster from the Puerto Rico Commercial fishery for 1983-2003 (values shaded are those that have changed from those reported by Mateo and Die 2004).

	All records	Only records where trip number equal 1		
	Total landings	Landings	% of landings	Number records
1983	273.7	32.8	12.0%	2620
1984	248.0	6.5	2.6%	484
1985	211.1	10.3	4.9%	670
1986	210.1	5.7	2.7%	257
1987	153.4	1.7	1.1%	90
1988	141.2	92.7	65.6%	4420
1989	185.8	111.0	59.8%	5039
1990	168.7	79.8	47.3%	4618
1991	211.6	100.3	47.4%	5643
1992	160.5	59.3	37.0%	2802
1993	168.9	78.4	46.4%	4196
1994	192.1	110.0	57.3%	5611
1995	279.2	195.5	70.0%	9021
1996	280.6	145.1	51.7%	7270
1997	283.3	139.4	49.2%	6692
1998	298.5	122.3	41.0%	4842
1999	327.1	186.8	57.1%	7427
2000	258.4	178.6	69.1%	8928
2001	280.6	214.5	76.4%	10130
2002	300.4	230.2	76.6%	9129
2003	241.9	239.2	98.9%	11990

Table 4Average monthly landings (1000 lbs) of spiny lobster from the Puerto Rico Commercial fishery for the period 1983-2001, for all records. (values shaded are those that have changed from those reported by Mateo and Die 2004).

Month	Landing
1	22.3
2	20.7
3	21.2
4	18.1
5	18.9
6	17.2
7	18.2
8	20.5
9	18.4
10	19.2
11	19.3
12	18.1

Table 5 Landings of spiny lobster by gear type from the Puerto Rico Commercial fishery for the period 1983-2001, for all records (values shaded are those that have changed from those reported by Mateo and Die 2004).

Gear type	Landings (1000 lbs)	Percent
Scuba Diving	2110.4	43.3%
Fish Pot	1859.0	38.1%
Lobster Pot	442.7	9.1%
Trammel Net	162.2	3.3%
Bottom Line	78.7	1.6%
Spear Fishing	77.4	1.6%
Skin Diving	58.3	1.2%
Gill Net	52.6	1.1%
Other	34.0	0.7%

Table 6 Sampling Intensity of Spiny Lobster for the Puerto Rico commercial Landings.

YEAR	# Samples	# SL	TOTAL NUMBER	SL weight sampled	Catch Raise Factor	SL Landings	Raised SL Landings	# SL / Raised SL Landings	SL Weight / Raised SL Landingsgs
1980	34	0	621	0					
1981	0	0	0	0					
1982	0	0	0	0					
1983	193	0	6644	0	0.61	273700	448688.5246	**0**	**0**
1984	703	1333	22292	2033.106	0.59	248000	420338.9831	**0.00317125**	**0.004836826**
1985	387	743	19075	2184.56	0.56	211100	376964.2857	**0.001971009**	**0.005795137**
1986	555	879	35126	1238.856	0.75	210100	280133.3333	**0.003137792**	**0.004422378**
1987	408	777	19171	44770.97	0.75	153400	204533.3333	**0.003798892**	**0.218893287**
1988	397	54	18882	119.408	0.56	141200	252142.8571	**0.000214164**	**0.000473573**
1989	560	1244	20496	26774.63	0.51	185800	364313.7255	**0.003414639**	**0.073493337**
1990	575	951	19830	1413.232	0.51	168700	330784.3137	**0.002874985**	**0.004272366**
1991	958	1766	37523	2751.539	0.51	211600	414901.9608	**0.004256427**	**0.006631781**
1992	977	1381	31500	2431.917	0.60	160500	267500	**0.005162617**	**0.00909128**
1993	616	936	19825	4595.785	0.60	168900	281500	**0.003325044**	**0.016326057**
1994	270	330	8528	619.0514	0.64	192100	300156.25	**0.001099427**	**0.00206243**
1995	465	913	10670	1882.484	0.71	279200	393239.4366	**0.002321741**	**0.004787118**
1996	334	818	5443	1468.932	0.71	280600	395211.2676	**0.002069779**	**0.003716827**
1997	289	376	4768	549.1594	0.78	283300	363205.1282	**0.001035228**	**0.001511981**
1998	464	908	13266	1479.234	0.78	298500	382692.3077	**0.002372663**	**0.003865335**
1999	565	1360	23187	2957.261	0.78	327100	419358.9744	**0.003243045**	**0.007051861**
2000	491	984	20174	1882.954	0.57	258400	453333.3333	**0.002170588**	**0.004153574**
2001	531	1493	21578	2654.562	0.68	280600	412647.0588	**0.003618104**	**0.00643301**
2002	530	758	21815	9450.295	0.86	300400	349302.3256	**0.00217004**	**0.027054774**
2003	571	1779	20707	733.678	0.56	241900	431964.2857	**0.004118396**	**0.001698469**

Table 7 Estimated reported and expanded total landings for St. Thomas/St. John and St. Croix, U.S. Virgin Islands years 1974-2003.

Reported Total Landings

Year	STT/STJ	STX	TOTAL
1974	57,656	0	57,656
1975	264,787	38,208	302,995
1976	224,631	59,850	284,481
1977	266,236	66,511	332,747
1978	478,023	77,859	555,883
1979	500,965	78,047	579,012
1980	506,347	53,040	559,387
1981	518,385	110,360	628,744
1982	499,814	170,358	670,171
1983	606,387	245,296	851,682
1984	606,540	317,770	924,311
1985	616,324	175,621	791,945
1986	513,556	115,654	629,210
1987	199,833	105,676	305,509
1988	6,237	51,708	57,945
1989	64,675	202,256	266,931
1990	434,857	346,061	780,917
1991	1,788,133	1,308,703	3,096,836
1992	997,031	954,964	1,951,995
1993	606,918	503,474	1,110,391
1994	544,124	466,129	1,010,253
1995	705,718	373,039	1,078,757
1996	718,405	390,387	1,108,792
1997	571,810	522,681	1,094,491
1998	449,827	521,902	971,729
1999	437,302	543,270	980,572
2000	457,195	636,076	1,093,270
2001	556,771	817,513	1,374,283
2002	569,813	945,292	1,515,105
2003	300,683	452,881	753,564

Expanded Total Landings

Year	STT/STJ	STX	TOTAL
1974	135,492	0	135,492
1975	622,248	119,591	741,839
1976	527,883	187,329	715,212
1977	625,653	208,180	833,834
1978	1,123,355	243,700	1,367,055
1979	1,177,267	244,287	1,421,554
1980	1,189,916	166,015	1,355,931
1981	1,163,691	367,105	1,530,796
1982	1,013,348	471,329	1,484,677
1983	1,111,520	403,117	1,514,637
1984	1,005,335	389,577	1,394,912
1985	1,246,974	200,208	1,447,182
1986	1,244,541	261,839	1,506,380
1987	485,452	238,099	723,551
1988	14,494	85,372	99,866
1989	93,295	365,309	458,604
1990	642,035	741,819	1,383,854
1991	2,510,782	2,370,346	4,881,128
1992	1,339,125	1,510,968	2,850,093
1993	819,999	618,048	1,438,048
1994	764,931	545,021	1,309,952
1995	870,341	384,230	1,254,571
1996	835,634	397,550	1,233,184
1997	620,863	536,798	1,157,660
1998	487,615	540,633	1,028,249
1999	463,263	559,568	1,022,832
2000	489,198	655,158	1,144,356
2001	595,745	842,038	1,437,783
2002	609,700	973,651	1,583,351
2003	321,731	466,468	788,199

Table 8 Number of landing records reporting Spiny Lobster (i.e., proxy for number of Lobster trips); reported and expanded Spiny Lobster landings for St. Thomas/St. John and St. Croix, U.S. Virgin Islands years 1974-2003.

Number of Landing Records Reporting Spiny Lobster

Year	STT/STJ	STX	TOTAL
1974	85	0	85
1975	268	154	422
1976	201	152	353
1977	491	157	648
1978	753	170	923
1979	568	87	655
1980	601	65	666
1981	637	91	728
1982	647	148	795
1983	702	248	950
1984	621	347	968
1985	720	195	915
1986	676	65	741
1987	288	74	362
1988	26	214	240
1989	2	176	178
1990	1,452	126	1,578
1991	5,083	491	5,574
1992	706	663	1,369
1993	1,228	1,140	2,368
1994	1,073	882	1,955
1995	1,408	1,434	2,842
1996	1,646	4,125	5,771
1997	1,635	8,371	10,006
1998	2,650	8,623	11,273
1999	4,216	8,507	12,723
2000	4,947	9,822	14,769
2001	5,623	12,243	17,866
2002	5,398	13,703	19,101
2003	2,726	6,486	9,212

Reported Spiny Lobster Landings (1974-2003)

Year	STT/STJ	STX	TOTAL
1974	2,743	0	2,743
1975	6,796	5,213	12,009
1976	6,742	3,623	10,364
1977	19,957	8,166	28,123
1978	58,681	4,981	63,661
1979	25,762	3,078	28,840
1980	39,796	1,276	41,072
1981	38,059	2,116	40,175
1982	38,626	2,692	41,317
1983	40,825	4,480	45,305
1984	35,979	7,564	43,543
1985	29,314	4,426	33,739
1986	24,103	1,573	25,676
1987	12,102	1,546	13,648
1988	561	7,083	7,644
1989	18	6,480	6,498
1990	70,038	11,893	81,931
1991	204,533	15,348	219,881
1992	32,189	34,399	66,588
1993	64,689	33,333	98,021
1994	47,894	26,319	74,212
1995	76,941	21,600	98,541
1996	106,405	26,487	132,892
1997	77,086	33,842	110,928
1998	53,758	41,919	95,677
1999	49,975	50,884	100,859
2000	46,208	84,496	130,704
2001	50,592	112,297	162,889
2002	61,504	115,370	176,873
2003	36,754	50,617	87,371

Expanded Spiny Lobster Landings (1974-2003)

Year	STT/STJ	STX	TOTAL
1974	6,446	0	6,446
1975	15,969	16,317	32,286
1976	15,843	11,338	27,181
1977	46,898	25,560	72,457
1978	137,899	15,590	153,489
1979	60,541	9,634	70,176
1980	93,520	3,994	97,514
1981	83,777	6,916	90,693
1982	78,754	8,462	87,216
1983	75,231	7,188	82,419
1984	60,504	9,372	69,876
1985	60,769	5,045	65,814
1986	58,378	3,571	61,948
1987	29,181	3,373	32,554
1988	1,313	11,570	12,883
1989	34	11,378	11,412
1990	95,952	25,282	121,233
1991	285,717	29,444	315,162
1992	36,695	53,188	89,883
1993	87,045	41,344	128,389
1994	68,127	30,658	98,785
1995	94,738	22,248	116,986
1996	124,068	26,912	150,980
1997	83,734	34,842	118,576
1998	58,488	43,381	101,868
1999	52,921	52,411	105,332
2000	49,442	87,031	136,473
2001	54,134	115,666	169,799
2002	65,809	118,831	184,640
2003	39,327	52,136	91,462

Table 9 Sampling intensity for Spiny Lobster in St. Croix, US Virgin Islands commercial fisheries.

YEAR	# Samples	# SL	TOTAL NUMBER	SL weight sampled	Catch Raise Factor	SL Landings	Raised SL Landings	# SL / Raised SL Landings	SL Weight / Raised SL Landingsg
1983	237	0	14116	0	0.6084973	4480	7362.398802	0	0
1984	393	0	35781	0	0.8156812	7564	9273.231017	0	0
1985	540	1346	17280	0	0.8771932	4426	5045.638992	0.266765023	0
1986	431	1092	11201	0	0.4416982	1573	3561.254917	0.306633483	0
1987	435	1150	33365	2506.495	0.4438331	1546	3483.291201	0.330147534	0.719576703
1988	487	496	36343	1037.007	0.6056702	7083	11694.48333	0.042413161	0.088674922
1989	424	59	21396	129.8726	0.5536579	6480	11703.97777	0.005041021	0.01109645
1990	525	602	10076	1341.505	0.4665026	11893	25493.96238	0.023613434	0.052620498
1991	912	396	12699	927.3902	0.5521148	15348	27798.56882	0.014245338	0.033361077
1992	3	0	173	0	0.6320211	34399	54426.97794	0	0
1993	99	0	3670	0	0.8146182	33333	40918.55344	0	0
1994	118	630	8890	1584.719	0.8552494	26319	30773.47836	0.020472174	0.051496272
1995	99	545	6123	1330.802	0.9708738	21600	22247.99919	0.024496585	0.059816705
1996	75	406	4515	1014.592	0.9819831	26487	26972.9685	0.015052107	0.037615126
1997	95	659	4943	1546.824	0.9737027	33842	34755.99015	0.01896076	0.044505261
1998	86	525	5958	1246.685	0.9653527	41919	43423.50832	0.012090225	0.02870991
1999	70	589	3940	1248.667	0.9708737	50884	52410.52398	0.011238201	0.023824742
2000	41	339	1741	724.174	0.9708738	84496	87030.87781	0.003895169	0.008320886
2001	47	308	2852	652.52	0.9708738	112297	115665.9059	0.002662842	0.00564142
2002	92	619	7822	1413.673	0.9708737	115370	118831.106	0.005209074	0.011896487
2003	61	564	3314	1250.59	0.9708738	50617	52135.5114	0.010817962	0.023987297

Table 10 Sampling Intensity for Spiny Lobster in the St. Thomas/St. John commercial fisheries.

YEAR	# Samples	# SL	TOTAL NUMBER	SL wt sampled	Catch Raise Factor	SL Landings	Raised SL Landings	# SL / Raised SL Landings	SL Weight / Raised SL Landingsgs
1980	0	0	0	0	NA	39796	NA	NA	NA
1981	0	0	0	0	NA	38059	NA	NA	NA
1982	0	0	0	0	NA	38626	NA	NA	NA
1983	0	0	0	0	0.5455471	40825	74833.13695	0	0
1984	3	9	9	31.3	0.6033216	35979	59634.86345	0.000150918	0.000524861
1985	287	503	8299	30698.42	0.4942557	29314	59309.38246	0.008480952	0.517598038
1986	54	3	2255	8.02	0.412647	24103	58410.69814	5.13605E-05	0.000137304
1987	35	0	1899	0	0.4116426	12102	29399.29043	0	0
1988	0	0	0	0	0.4303225	561	1303.673333	0	0
1989	0	0	0	0	0.6932282	18	25.96547661	0	0
1990	0	0	0	0	0.6773098	70038	103406.152	0	0
1991	0	0	0	0	0.7121817	204533	287192.1579	0	0
1992	52	210	2252	550.8408	0.7445394	32189	43233.44174	0.004857351	0.012741081
1993	81	141	3067	427.812	0.7401442	64689	87400.53309	0.001613262	0.004894844
1994	41	91	1751	182.376	0.7113374	47894	67329.51197	0.001351562	0.002708708
1995	20	37	1338	52.1654	0.810853	76941	94888.95826	0.000389929	0.000549752
1996	16	133	1355	0	0.8597129	106405	123768.0652	0.001074591	0
1997	0	0	0	0	0.920993	77086	83698.78811	0	0
1998	0	0	0	0	0.9225037	53758	58274.0234	0	0
1999	0	0	0	0	0.9439587	49975	52941.93655	0	0
2000	0	0	0	0	0.9345794	46208	49442.56177	0	0
2001	0	0	0	0	0.9345795	50592	54133.43831	0	0
2002	31	351	2649	931.3211	0.9345794	61504	65809.28509	0.005333594	0.014151819
2003	11	392	688	1071.9	0.9345795	36754	39326.77707	0.009967763	0.027256238

• Table 11 Preliminary CPUEs (in lb/trip) for spiny lobster harvested with all gears in the U.S. Virgin Islands. Expanded landings and number of lobster records (=

Spiny Lobster CPUE (lb/trip) (1974-2003)

Year	STT/STJ	STX	TOTAL
1974	76		76
1975	60	106	77
1976	79	75	77
1977	96	163	112
1978	183	92	166
1979	107	111	107
1980	156	61	146
1981	132	76	125
1982	122	57	110
1983	107	29	87
1984	97	27	72
1985	84	26	72
1986	86	55	84
1987	101	46	90
1988	50	54	54
1989	17	65	64
1990	66	201	77
1991	56	60	57
1992	52	80	66
1993	71	36	54
1994	63	35	51
1995	67	16	41
1996	75	7	26
1997	51	4	12
1998	22	5	9
1999	13	6	8
2000	10	9	9
2001	10	9	10
2002	12	9	10
2003	14	8	10

Table 12 Fishery Independent sampling in the US Caribbean relevant to Spiny Lobster poupulations

<table>
<tr><td colspan="3">Sampling Programs that Encounter Spiny Lobster in the US Caribbean</td></tr>
<tr><td colspan="3">SEAMAP – Caribbean (NOAA Fisheries SEFSC)</td></tr>
<tr><td>Target:</td><td>Lobster puerili and juveniles</td><td rowspan="4">Note: Multiyear data set</td></tr>
<tr><td>Coverage:</td><td>western PR, southeastern St. Thomas</td></tr>
<tr><td>Duration:</td><td>1992-3 to present</td></tr>
<tr><td>Contact:</td><td>Aida Rosario (lipdrna@coqui.net)
Barbara Kojis (bkojis@vitelcom.net)</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Monitoring Reef Fish Populations in the VI National Park (DOI, National Park Service, Virgins Island National Park)</td></tr>
<tr><td>Target:</td><td>Reef fish, conch, lobster</td><td rowspan="4">Note: Resource monitoring by the park is most comprehensive</td></tr>
<tr><td>Coverage:</td><td>St. John; Buck Island, St. Croix</td></tr>
<tr><td>Duration:</td><td>1989 to present</td></tr>
<tr><td>Contact:</td><td>Alan Friedlander (Alan.Friedlander@noaa.gov)</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Trap Impacts on Coral Reefs and Associated Habitats (NOAA Fisheries SEFSC)</td></tr>
<tr><td>Target:</td><td>Fish and lobster traps</td><td rowspan="4">Note: Studying impacts to habitat but also collecting catch composition from traps sampled</td></tr>
<tr><td>Coverage:</td><td>All US Caribbean</td></tr>
<tr><td>Duration:</td><td>2001 to present</td></tr>
<tr><td>Contact:</td><td>Ron Hill (ron.hill@noaa.gov)</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Coral Reef Ecosystem Studies (University of Puerto Rico-Mayagüez)</td></tr>
<tr><td>Target:</td><td>Reef fish, corals, urchins, sedimentation</td><td rowspan="4">Note: NOAA grant funded partnership studying causes of reef degradation</td></tr>
<tr><td>Coverage:</td><td>La Parguera, Culebra, St. John</td></tr>
<tr><td>Duration:</td><td>2001 to present</td></tr>
<tr><td>Contact:</td><td>Richard Appeldoorn (rappeldo@uprm.edu)</td></tr>
</table>

Table 12 continued.		
Caribbean Reef Fish Surveys (NOAA Oceans Biogeography Program)		
Target:	Reef fish and benthos	Note: In four years program has surveyed almost 2000 samples, only 4 lobster recorded
Coverage:	La Parguera; Buck Island, St. Croix; St. John	
Duration:	2001 to present	
Contact:	Chris Caldow (Chris.Caldow@noaa.gov)	
Shallow water surveys of adjacent habitats (NOAA Fisheries SEFSC)		
Target:	Reef fish, conch, and lobster	Note: Surveys in shallow habitats comparing sampling methods and use; mainly juveniles
Coverage:	Shallow water bays of St. John	
Duration:	2001-2003; 2005	
Contact:	Jennifer Doerr (Jennifer.Doerr@noaa.gov)	
Monitoring Reef Ecology, Coral Disease, and the Fortuna Reefer Coral Restoration in western and southwestern Puerto Rico (SEFSC, NMFS OHC, University of Puerto Rico-Mayagüez),		
Target:	Reef fish, corals, coral disease	Note: western Puerto Rico islands, lobster recorded when observed, rarely.
Coverage:	La Parguera, Desecheo, Mona Island, PR	
Duration:	1999 to present	
Contact:	Ron Hill (ron.hill@noaa.gov)	
Coral Reef Monitoring in St. Croix and St. Thomas, United States Virgin Islands (Univ. of the Virgin Islands, USVI Fish and Wildlife Div.)		
Target:	Reef fish and benthos	Note: Surveys of reef fish and benthos (coral), expected to continue long-term
Coverage:	USVI	
Duration:	2001 to present	
Contact:	Rick Nemeth (rnemeth@uvi.edu)	
Modeling the Effectiveness of Marine Reserves (SEFSC-Galveston)		
Target:	Coral reef ecosystems	Note: Not data collection but data management project that may provide future useful summaries.
Coverage:		
Duration:		
Contact:	Ron Hill (ron.hill@noaa.gov)	

9. Figures

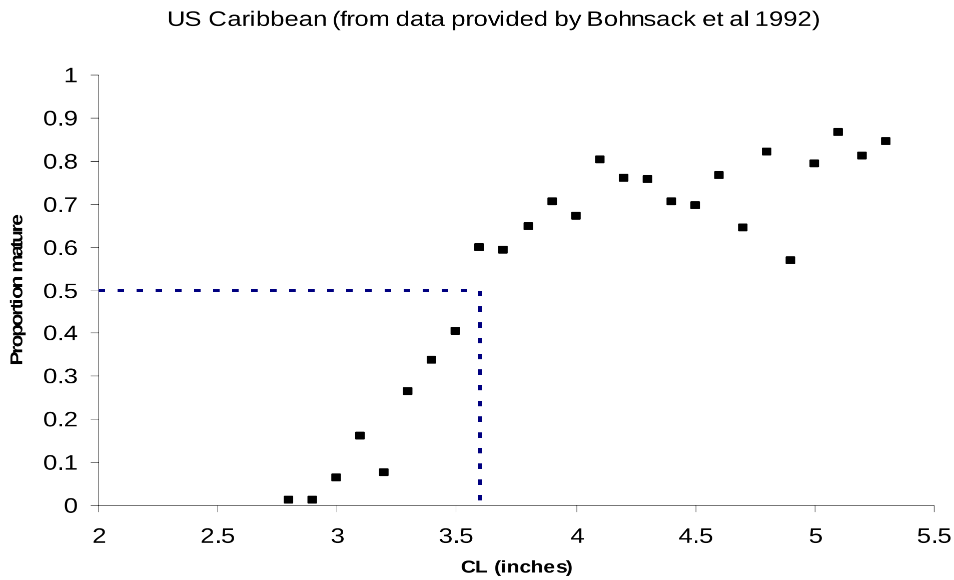


Figure 1 Information on maturation of spiny lobster

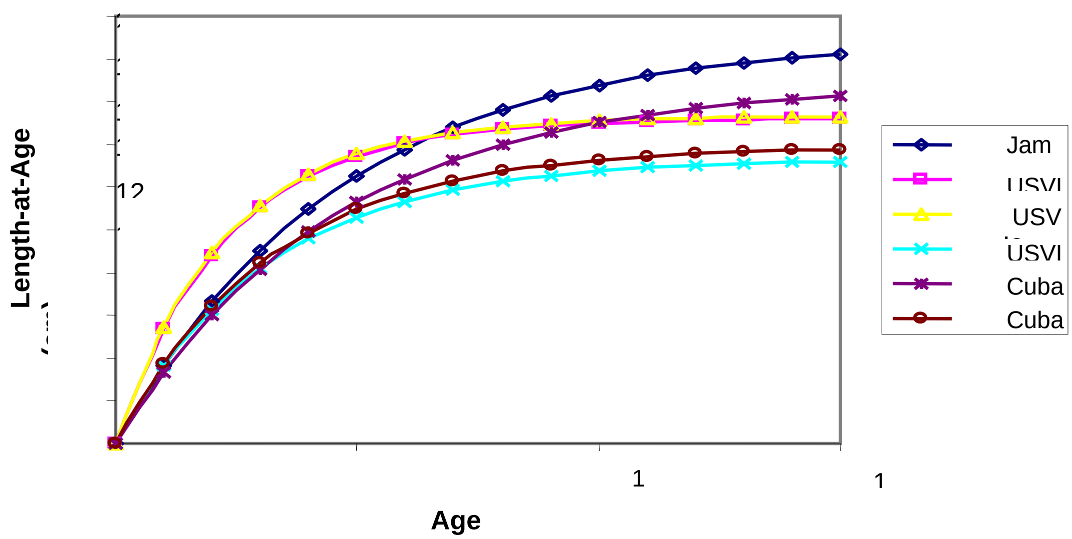


Figure 2 Von Bertalanffy Growth Curves for Panulirus argus in the Caribbean. (Gonzalez-Cano, 1991)

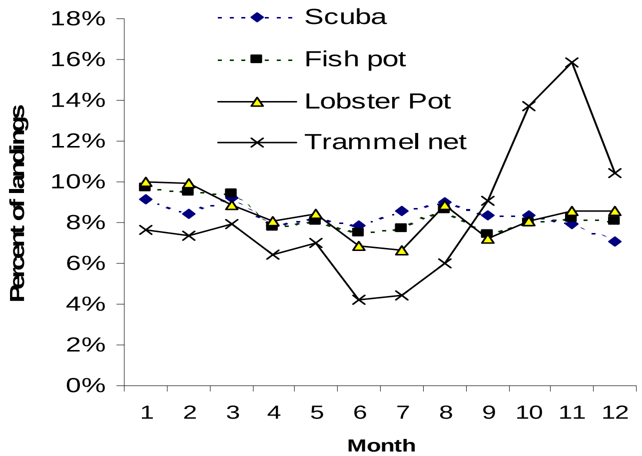


Figure 3 Monthly pattern of Reported landings for major gear types

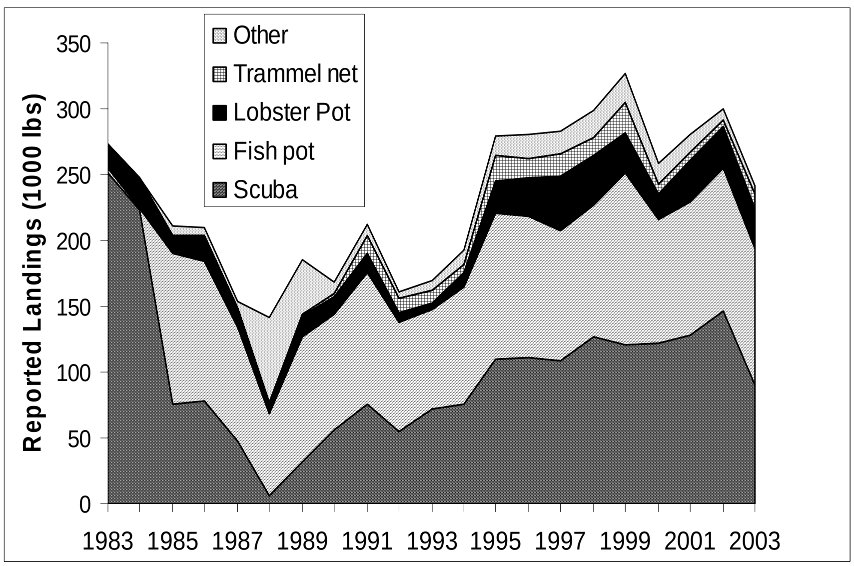


Figure 4 Reported landings of lobsters in Puerto Rico by major gear type

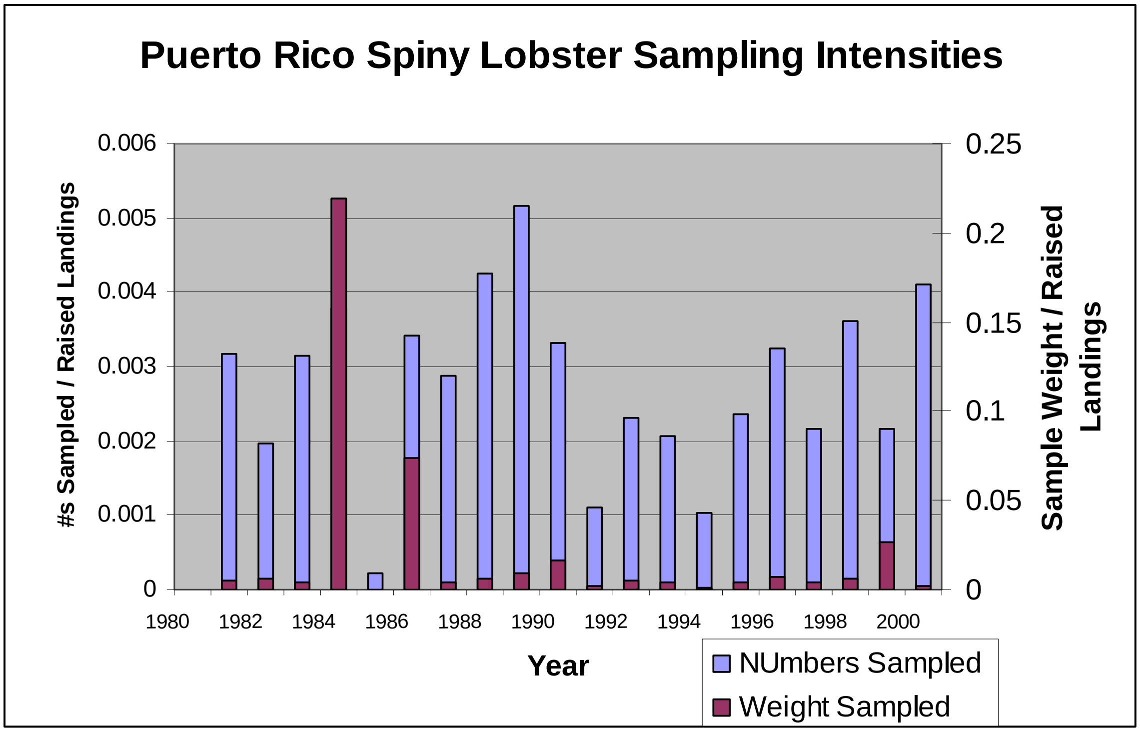
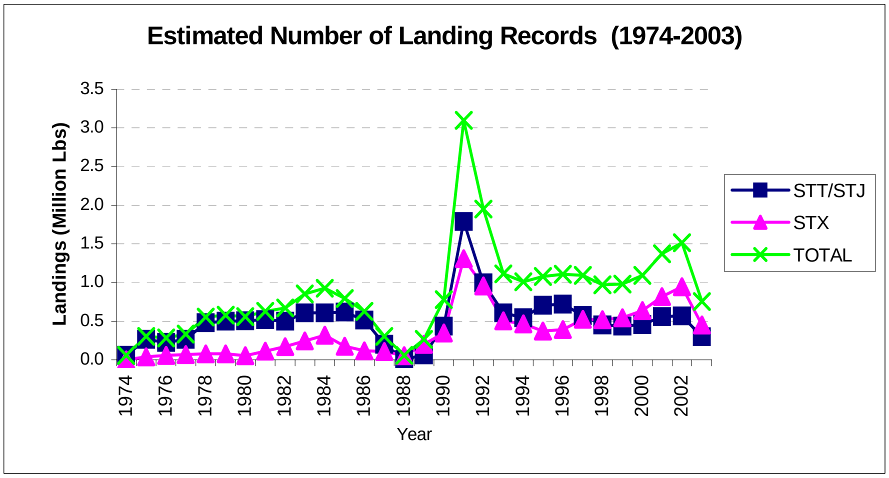
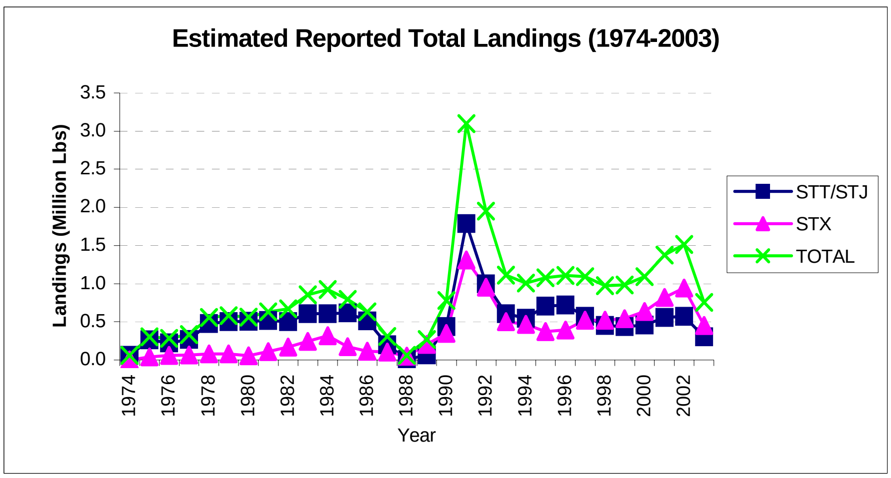


Figure 5 Sampling intensity for Spiny Lobster in the Puerto Rico commercial fishery.





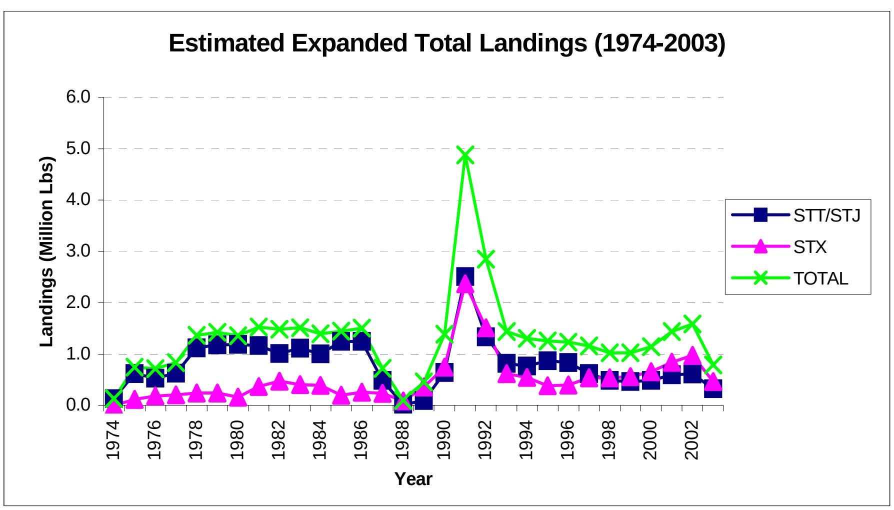


Figure 6 Estimated number of landing records, reported and expanded total landings for St. Thomas/St. John and St. Croix, years 1974-2003

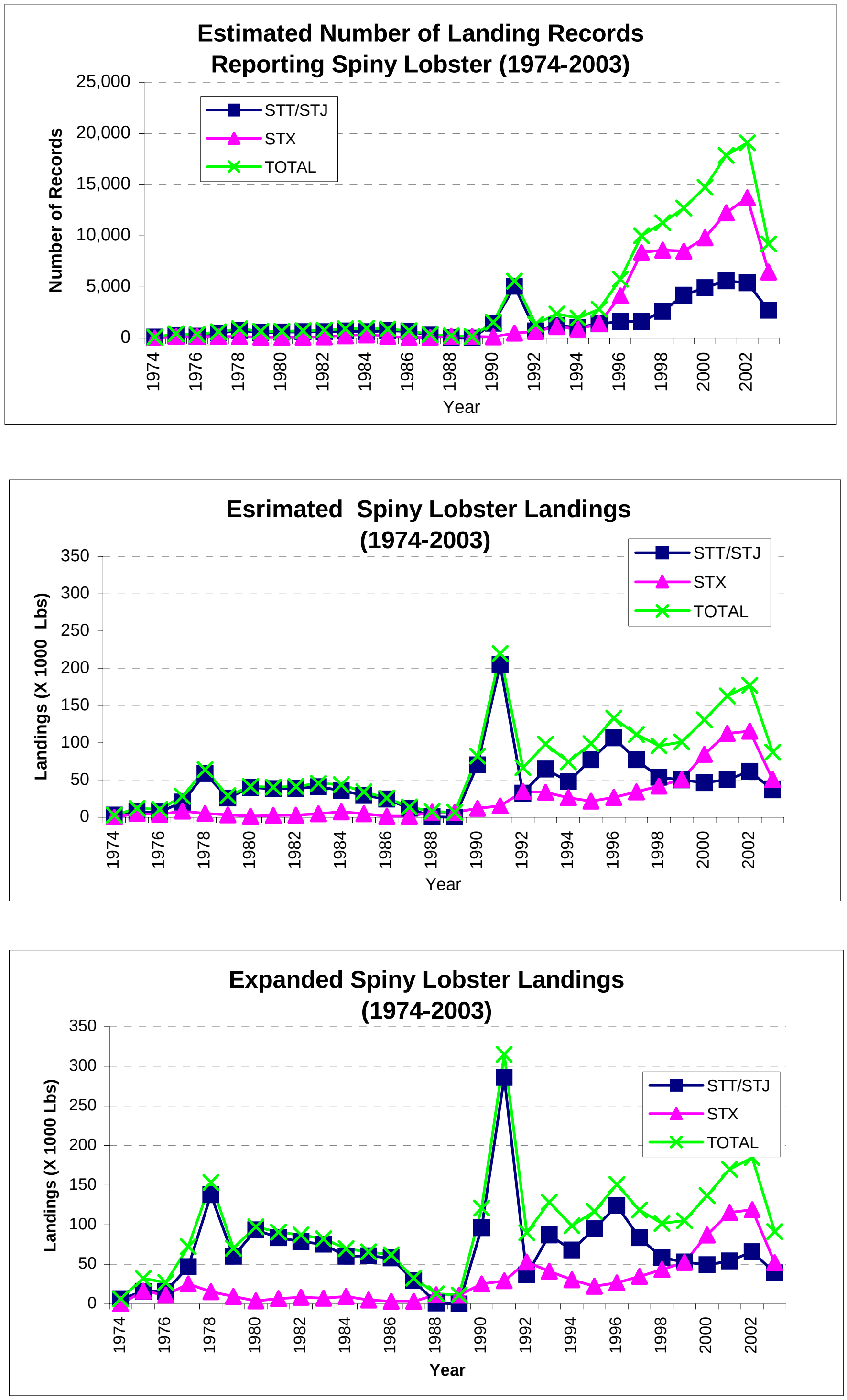


Figure 7 Estimated number of landing records reporting Spiny Lobster, estimated and expanded landings from 1974-2003**.**

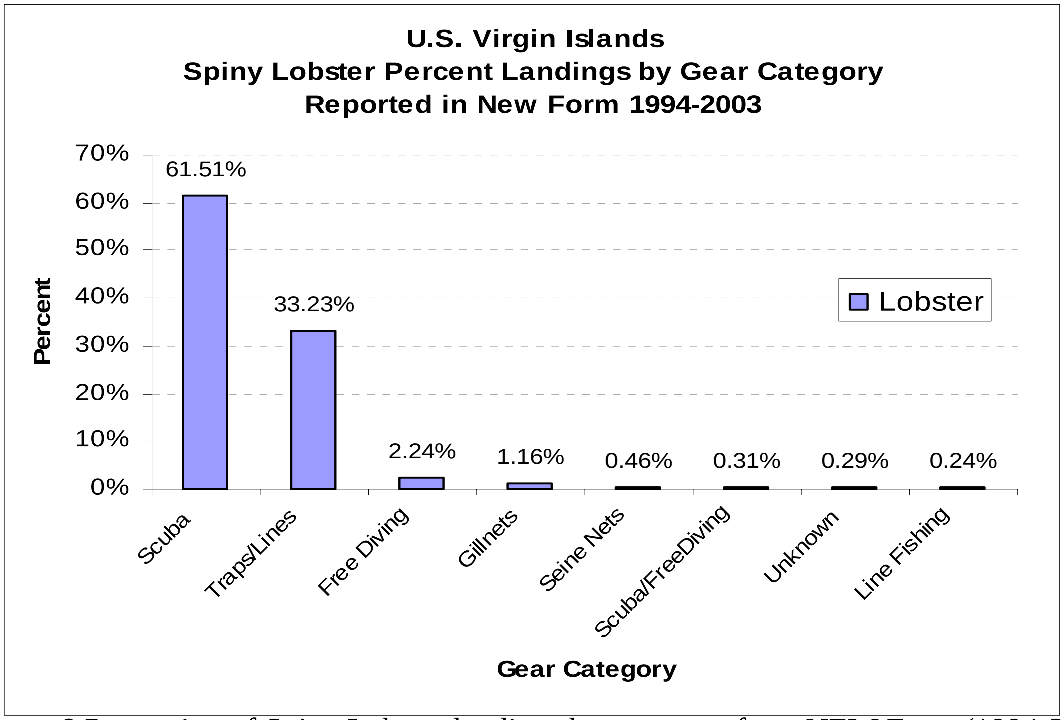


Figure 8 Proportion of Spiny Lobster landings by gear type from NEW Form (1994-2003) for the whole U.S. Virgin Islands.

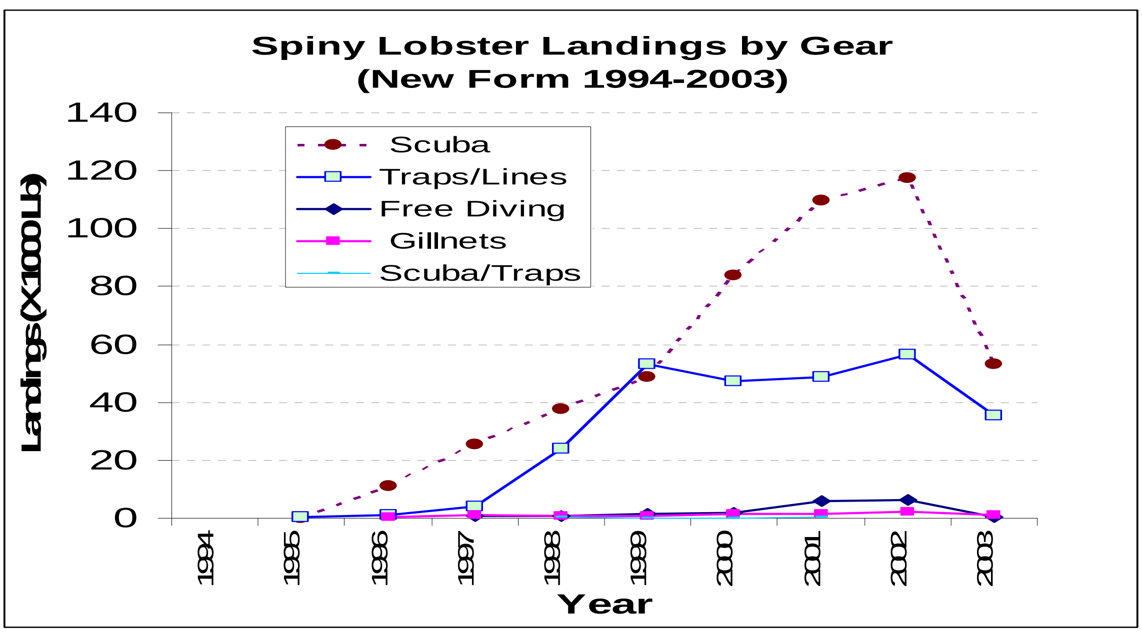


Figure 9 Spiny Lobster landings by year and gear from New Form (1995-2003).

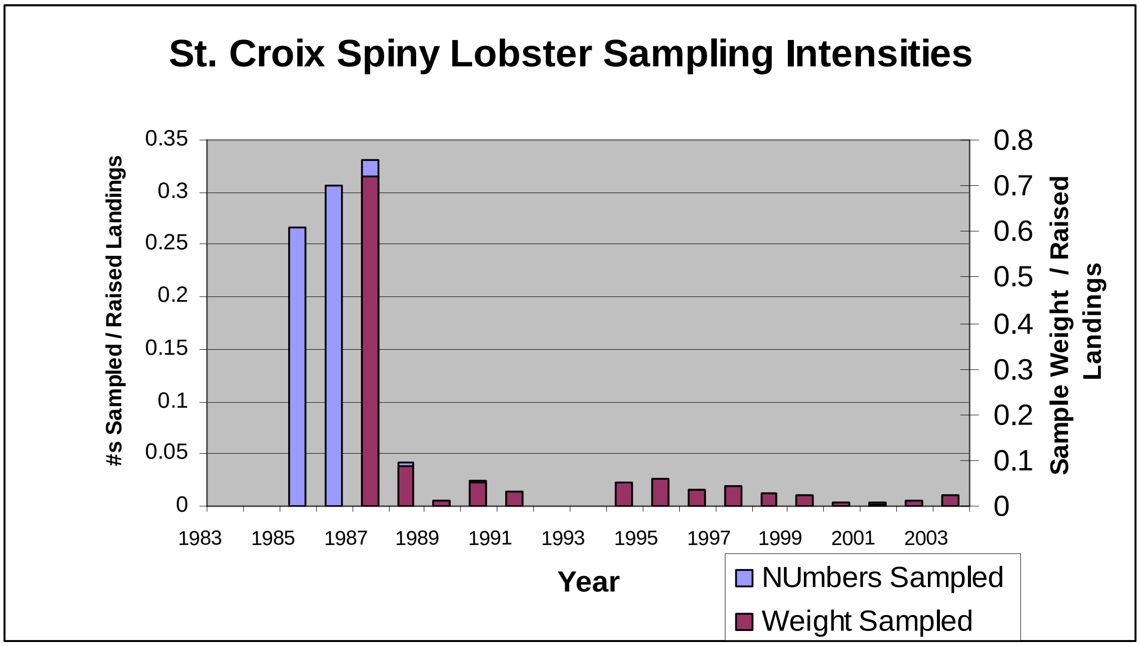


Figure 10 Sampling intensity for Spiny Lobster in the St. Croix commercial fishery.

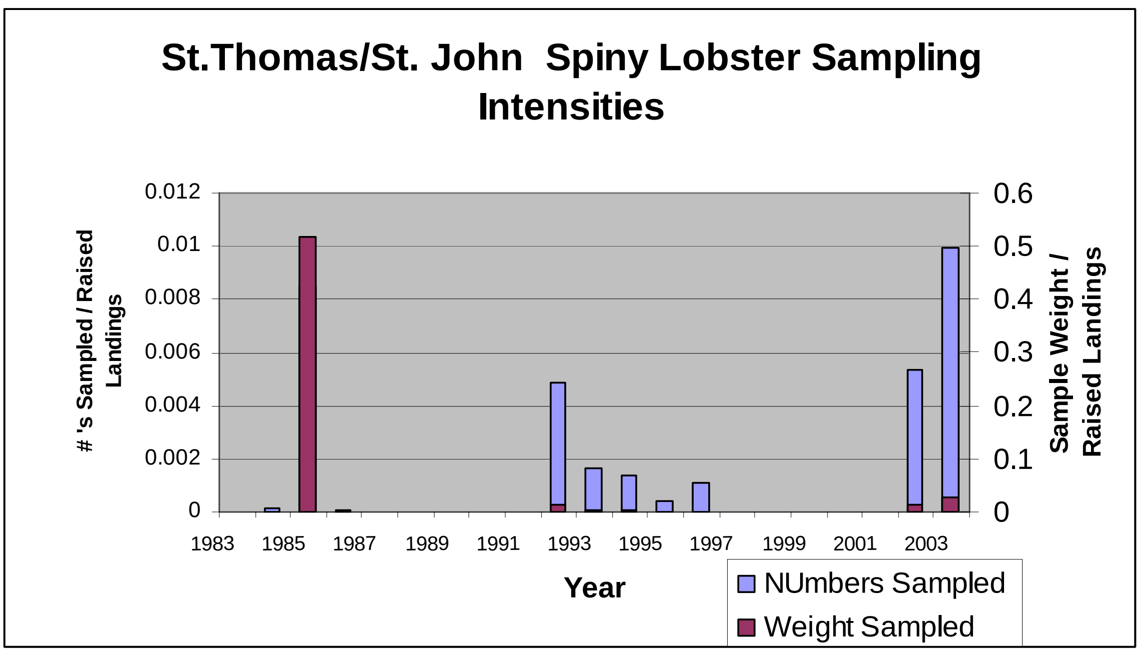


Figure 11 Sampling intensity for Spiny Lobster in the St. Thomas/St John commercial fishery.

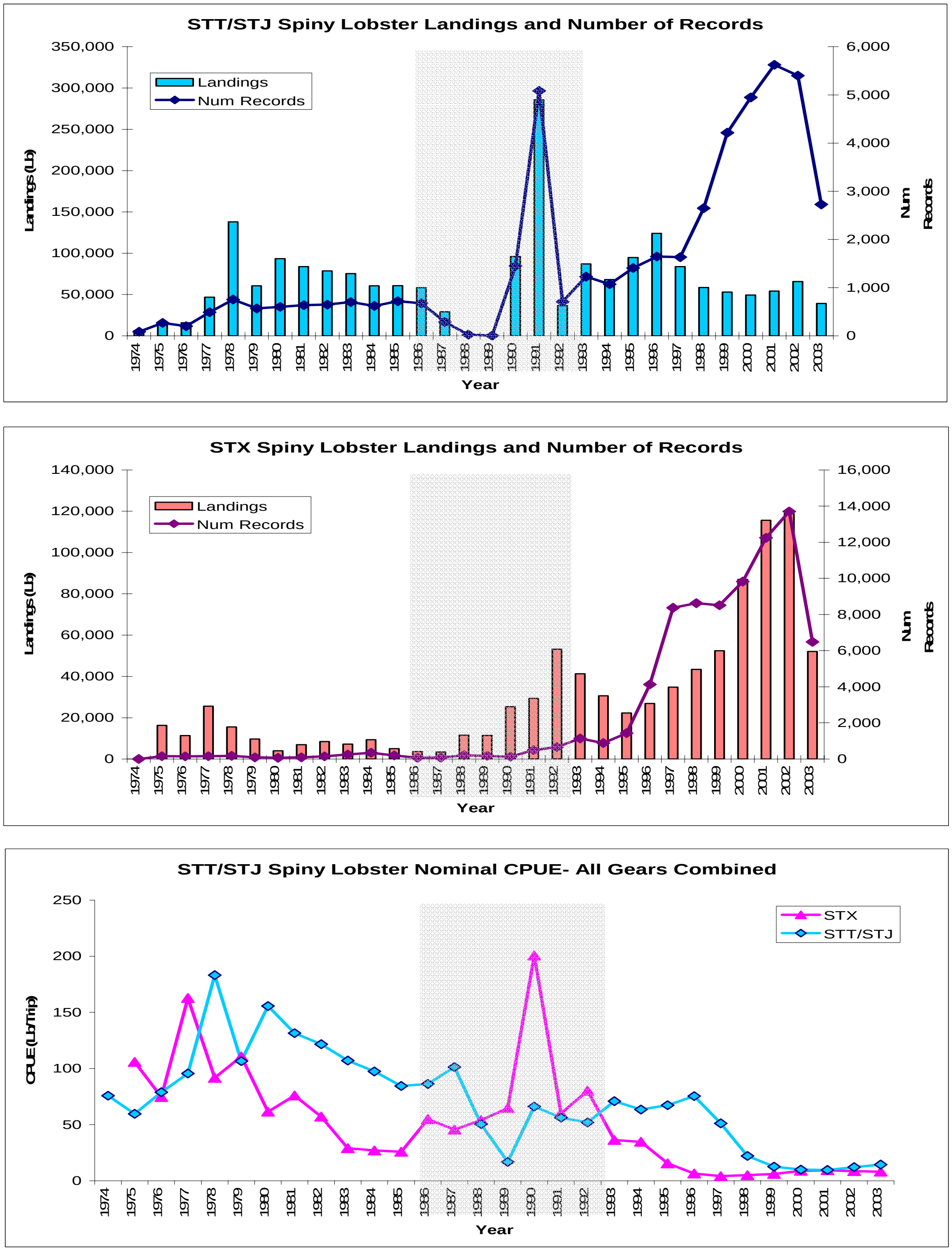


Figure 12 Preliminary estimation of Spiny Lobster Effort (number of trips), Landings (lb) and nominal CPUE (lb/trip) for St. Thomas/St. John (STT/STJ) and St. Croix (STX), U.S.V.I.

Note: All gears are aggregated in this analysis. Shaded areas represent years of incomplete data.

SEDAR 8

Stock Assessment Report 2

Caribbean Spiny Lobster

SECTION III. Assessment Workshop

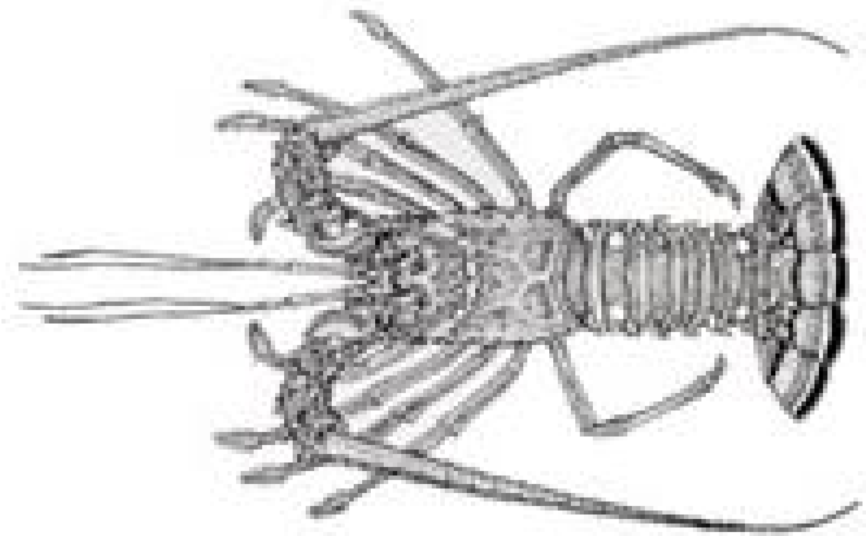
SEDAR
1 Southpark Circle # 306
Charleston, SC 29414

Southeast Data, Assessment, and Review

SEDAR 8

Caribbean Spiny Lobster

Panulirus argus



SECTION III. Stock Assessment Workshop Report

Developed by the Assessment Workshop Panel

Edited by Joshua Sladek Nowlis, Southeast Fisheries Science Center, Miami, FL

March 2005

SEDAR

1 Southpark Circle #306

Charleston, SC 29414

Table of Contents

1 Introduction

1.1 Workshop Time and Place

The SEDAR 8 Assessment Workshop convened March 14 – 18, 2005, at the Divi Carina Bay Resort in St. Croix, USVI.

1.2 Terms of Reference

1. Select several appropriate modeling approaches, based on available data sources, parameters and values required to manage the stock, and recommendations of the Data Workshop.

2. Develop and solve the chosen population models, incorporating data that are the best available, the most recent and up-to-date, and scientifically sound.

3. Provide measures of model performance, reliability, and goodness of fit.

4. Estimate values and provide tables of relevant stock parameters (abundance, biomass, fishery selectivity, stock-recruitment relationship, etc; by age and year; weights to be presented in pounds).

5. Consider sources of uncertainty related to input data, modeling approach, and model configuration. Provide appropriate and representative measures of precision for stock parameter estimates.

6. Provide Yield-per-Recruit and Stock-Recruitment analyses.

7. Provide complete SFA criteria: evaluate existing SFA benchmarks; estimate alternative SFA benchmarks if appropriate; estimate SFA benchmarks (MSY, Fmsy, Bmsy, MSST, and MFMT) if not previously estimated; develop stock control rules.

8. Provide declarations of stock status relative to SFA benchmarks: MSY, Fmsy, Bmsy, MSST, MFMT.

9. Estimate the Allowable Biological Catch (ABC) for each stock.

10. Estimate probable future stock conditions and develop rebuilding schedules if warranted; include estimates of generation time. Stock projections are to be prepared as follows:

    A) If stock is overfished:
       i. F=0, F=current, F=Fmsy, Ftarget (OY),
       ii. F=Frebuild (max that rebuild in allowed time)

    B) If stock is overfishing
       i. F=Fcurrent, F=Fmsy, F= Ftarget (OY)

C) If stock is neither overfished nor overfishing
   i. F=Fcurrent, F=Fmsy, F=Ftarget (OY)

11. Evaluate the impacts of current management actions, with emphasis on determining progress toward stated management goals.

12. Provide recommendations for future research and data collection (field and assessment); be as specific as possible in describing sampling design and sampling intensity.

13. Provide thorough justification for any deviations from recommendations of the Data Workshop or subsequent modification of data sources provided by the Data Workshop.

14. Fully document all activities: Draft Section III of the SEDAR Stock Assessment Report; Provide tables of estimated values; Prepare a first draft of the Advisory Report based on the Assessment Workshop's recommended base assessment run for consideration by the Review Panel. Reports are to be finalized within 5 weeks of the conclusion of the Assessment Workshop (Provided to Council and SEDAR Staff on April 22, 2005 for distribution to the Review Panel.)

1.3 List of Participants

SEDAR 8 Assessment Workshop Panel Members:

Juan Agar	SEFSC
Liz Brooks	SEFSC
Scott Chormanski	Univ. Miami, RSMAS/CUFER
Nancie Cummings	SEFSC
David Die	Univ. Miami, RSMAS/CUFER
Ron Hill	SEFSC
Walter Keithley	CFMC SSC/LSU
Daniel Matos	PR DNR
Jimmy Magner	CFMC Advisory Panel, St. Thomas
Josh Sladek Nowlis	SEFSC
David Olsen	St. Thomas Fishermen's Assoc.
Francisco Pagán	Univ. Puerto Rico
Steven Saul	Univ. Miami, RSMAS/CUFER
Jerry Scott	SEFSC
William Tobias	USVI DFW
Roger Uwate	USVI DFW
Mónica Valle-Esquivel	Univ. Miami, RSMAS/CUFER

Observers

Tom Daly	St. Thomas Fishermen's Assoc.
Winston Ledee	St. Thomas Fishermen's Assoc.
Bob McAulffe	CFMC Advisory Panel, St. Croix
Julian Magras	St. Thomas Fishermen's Assoc.

Council Members

Barbara Kojis	CFMC

Support Staff

John Carmichael	SEDAR Coordinator
Tyree Davis	SEFSC IT
Graciela Garcia-Moliner	CFMC Staff
Cynthia Morant	SAFMC Administrative Assistant

1.4 List of Assessment Workshop Working Papers

Document Number	Manuscript Title	Author(s)
SEDAR8-AW-03	Standardized catch rates of spiny lobster (*Panulirus argus*) estimated from the U.S. Virgin Islands commercial landings (1974-2003)	Valle-Esquivel, M.
SEDAR8-AW-04	Standardized catch rates of spiny lobster (*Panulirus argus*) estimated from the United States Virgin Islands commercial Trip Interview Program (1983-2002)	Valle-Esquivel, M.
SEDAR8-AW-05	Standardized catch rates of spiny lobster (*Panulirus argus*) estimated from the Puerto Rico commercial Trip Interview Program (1980-2003)	Valle-Esquivel, M.
SEDAR8-AW-06	Preliminary application of a state-space age-structured production model to the spiny lobster (*Panulirus argus*) fishery of the U.S. Caribbean	Brooks, E.N., M. Valle-Esquivel
SEDAR8-AW-11	US Virgin Islands commercial landings and biostatistical data recovery project	S. Saul

2 Data Issues and Deviations from Data Workshop Recommendations

Four new analyses were conducted, three of which were available for the 2005 US Caribbean lobster SEDAR 8 Assessment Workshop. These analyses developed three new sets of abundance indices for spiny lobster using US Virgin Islands commercial landings, US Virgin Islands biostatistical sampling (Trip Interview Program, or TIP), and Puerto Rico TIP. The fourth analysis, which was performed during the assessment workshop and therefore was not available for the assessment, examined US Virgin Islands commercial landings for patterns that might distinguish lobster targeting from incidental catches. Additional effort was made to recover previously unavailable TIP data from the US Virgin Islands, which would be available for the next assessment (Saul, SEDAR8-AW-11).

Some concern was raised about the use of catch rates as a surrogate for abundance. Stock assessment experts at the meeting indicated this was not a new concern but that catch rates usually were accepted as a measure of relative abundance unless some confounding factor was identified and that none have been for Caribbean spiny lobster.

2.1 CPUE from US Virgin Islands Commercial Landings

The commercial landing statistics from the United States Virgin Islands (1974-2003) were used to construct standardized indices of abundance for spiny lobster, *Panulirus argus*, based on effort and expanded landings (Table 1, Figs. 1, 2) discussed in detail in Valle-Esquivel (SEDAR8-AW-03). US Virgin Islands commercial lobster catch data through mid-2004 were made available at the Assessment Workshop, along with some missing commercial landings reports from the late 1980s and early 1990s. Unfortunately, it was too late to incorporate these data into the models, most of which had already progressed substantially prior to the workshop. A Generalized Linear Model Approach (GLM) was used to standardize the catch rates from the positive lobster trips. St. Thomas and St. John lay on a different geological platform than St. Croix and the lobster fisheries operate differently. Analyses were made for the entire fishery and by island complex for the two main gears used to harvest lobster: dive and fish traps. No obvious trends in relative abundance were identified for the trap fishery of St. Thomas/St. John during the first period, but a slight decline was observed toward the later years. The dive fishery of St. Croix showed a clear signal, suggesting that relative abundance has decreased over the period studied.

A step-wise regression procedure was used to determine the set of factors and interactions that significantly explained the observed variability. Factors were added sequentially to the model based on the percentage reduction in deviance (>1.0%) using a χ^2 (Chi-square) statistic (McCullagh and Nelder, 1989). Deviance analysis tables for catch rates in pounds are presented only for the first index developed (entire US Virgin Islands) to illustrate the process. Once a set of fixed factors was selected, possible interactions were evaluated, in particular interactions between the *year* effect and other factors. Selection of interactions followed the same criteria.

GLM models were applied to estimate relative indices of abundance for spiny lobster from the commercial landings. Only positive trips were analyzed because the configuration of this database does not allow the estimation of effective effort from the identification of zero trips. Landings for other gear groups, species groups or species have been reported differently over the years, so no attempts were made to construct indices of species association or to otherwise select trips associated to lobster. Then, only trips that caught lobster in any amount were used for CPUE estimation. Years 1974, 1986-1992 and 2003 were excluded from analysis given that they are incomplete, missing, or currently undergoing review.

Six relative indices of abundance were estimated. They had geographic and gear focuses due to differences in geomorphology and data collection procedures. The six indices included:

1) US Virgin Islands: all islands and gears (diving and traps) combined

2) US Virgin Islands TRAPS, all islands combined

3) St. Thomas/St. John TRAPS

4) US Virgin Islands DIVE, all islands combined

5) St. Croix DIVE

6) St. Thomas/St. John DIVE

2.1.1 US Virgin Islands, Islands and Gear Combined

Examination of the entire US Virgin Islands lobster landings showed a number of trends. Lobster landings have showed a marked increase over time, but do not show seasonal patterns. Both island platforms (St. Thomas/St. John and St. Croix) contribute substantially to the lobster landings. In 60 percent of the trips that reported lobster, this species made up over half the total weight landed. Diving and traps contributed about the same lobster landings and both far exceeded other gears, which were excluded from these analyses.

The following restrictions were imposed on the data for CPUE analysis. Years with incomplete or missing information were removed. The analysis was constrained to two periods, before 1987 (years 1976-1986) and after 1992 (1993-2002). Trips were only examined if lobster were present (>1 lb), but excluded if lobster made up more than 250 lbs because of the likelihood that such trips were misentered or misreported.

Explanatory variables considered for GLM model: year, season, district, gear, and target. Interactions with year are considered random interactions. The final model was:

LNCPUE= YEAR+ DISTRICT+ TARGET+ YEAR*DISTRICT+ YEAR*TARGET

The standardized CPUE index is provided in Table 2 and the GLM model results are illustrated in Fig. 3.

2.1.2 US Virgin Islands TRAPS, All Islands Combined

The same process applied above was used, except that in this case only the trips that harvested lobster with TRAPS were used for analysis. Although trap trips in St. Croix only represented 7.5% of the (trap) trips, they were considered in the analysis; then the TRAP index was formulated for all islands combined.

The explanatory variables considered for the GLM model were: year, season, district, and target. A table with the selection of factors is not included, but the final model was:

LNCPUE= YEAR+ DISTRICT+ TARGET+ YEAR*DISTRICT+ YEAR*TARGET

US Virgin Islands trap index estimates are provided in Table 3 and illustrated in Fig. 4.

2.1.3 St. Thomas/St. John TRAPS

A similar index was calculated including only the St. Thomas/St. John trap fishery, because this fishery puts forth 80% of lobster effort and showed greater consistency in landings over time (Table 1, Fig. 2).

The explanatory variables considered for the GLM model formulation were: year, season, and target. The final model was:

LNCPUE= YEAR+ TARGET+YEAR*TARGET

GLM model estimates are provided in Table 4 and illustrated in Fig. 5.

A comparison of the TRAP indices between the whole US Virgin Islands and St. Thomas/St. John indicates that catch rates are greater when St. Thomas/St. John is isolated from St. Croix (Fig. 6). Apparently, the St. Croix component depresses the index values and creates larger fluctuations over time. It is recommended to use the St. Thomas/St. John index, as it is more representative of the trap fishery.

2.1.4 US Virgin Islands DIVE, All Islands Combined

Only the trips that harvested lobster with DIVE gear were used for this analysis. Although St. Croix represents an 85% of the DIVE fishery, this index was formulated for all the islands combined. Though low, dive landings in St. Thomas/St. John have been fairly consistent over the time series, whereas the data for St. Croix is mainly constrained to years 1992-2003 (Table 1, Fig. 2).

The explanatory variables considered for the GLM model were: year, season, district, and target. A table with the selection of factors is not included, but the final model was:

LNCPUE=YEAR+TARGET+YEAR*TARGET

Index statistics are given in Table 5 and illustrated in Fig. 7.

2.1.5 St. Croix DIVE

A relative index of abundance was estimated for the St. Croix dive fishery because 85% of the total DIVE fishery takes place there. The explanatory variables considered for the GLM model were: year, season, and target. Using the stepwise procedure, only the following were selected for the final model:

LNCPUE=YEAR+TARGET+YEAR*TARGET

Index estimates are provided in Table 6 and Fig. 8.

2.1.6 St. Thomas/St. John DIVE

A final index was estimated for the St. Thomas/St. John dive fishery, even though it only represents a 15% of this sector in the US Virgin Islands. The same assumptions as above were considered, and the test for significant factors resulted in the same model. Estimates are given in Table 7 and Fig. 9.

A comparison of the DIVE indices between districts (Fig. 10) shows slightly larger values but a sharper decline for St. Croix during the first period (1976-1986). Differences are insignificant between 1993-2003. It is important to note that the St. Thomas/St. John fishery represents only a small proportion of the dive fishery (15%) but has been consistent over time, while in St. Croix there was either underreporting during the first period or this sector developed rapidly after 1992 (see Table 1, Fig. 2).

2.2 CPUE from VI Commercial Trip Interview Program (TIP)

Biostatistical Trip Interview Program (TIP) data from the US Virgin Islands (1983-2003) were used to construct standardized indices of abundance for spiny lobster, *Panulirus argus*. This effort is described in greater detail in Valle-Esquivel (SEDAR8-AW-04). However, it should be noted that the TIP database is the subject of ongoing data recovery efforts (SEDAR8-AW-11). Separate indices were estimated for each main gear type used to harvest this species: dive, fish traps, and lobster traps, using the Delta-Lognormal approach. This method combines two general linear models, a binomial model fit to the proportion of positive trips, and a lognormal fit to catch rates on positive trips. Effective effort was approximated by considering zero trips through the construction of species assemblages by gear. No clear trends in relative abundance were noted in any of the fisheries examined. It appears that abundance has been fairly stable over the period studied, although with some inter-annual fluctuation and a large variability within each year. Index values suggest that fish traps may be a more effective method to harvest spiny lobster than diving gear.

2.2.1 Methods

TIP data were utilized to estimate CPUE as the mean weight (in pounds) of spiny lobster per fishing trip by gear type. Indices were estimated for the three main gear types used to harvest lobster: DIVE (Hand/Spear/Diving), FISH TRAPS (Fish Pots/Traps), and LOBSTER TRAPS, either for the whole U.S. Virgin Islands or per island complex (or District), depending on where each fishery occurs. Islands were grouped by geological platform: 1) St. Thomas and St. John (STT/STJ) and St. Croix (STX). Only those records with a single gear type recorded were used.

Defining effort from the TIP data set is not straightforward, given the multi-specific nature of the US Virgin Islands fisheries. The data sets contained information about species caught, but not regarding the species targeted. Effective fishing effort (i.e., including trips that landed lobster and trips that may have targeted this species but did not catch it—zero trips) was estimated using the species assemblage method developed by D. Heinemann and described in Cass-Calay and Bahnick, (2002) and in the Valle-Esquivel (SEDAR8-AW-04).

A generalized linear mixed model approach was used to estimate relative indices of abundance. Two different methods were used, depending on the characteristics of the data by gear and island: 1) a conventional GLM model to describe only the positive lobster CPUE observations, and 2) a Delta-Lognormal model that combines the proportion of positive trips (trips that landed spiny lobster over total trips) and positive catch rates on successful trips to construct a single index (Lo et al., 1992).

The influences of the following categorical variables on relative abundance were investigated: year, season (Winter, Spring, Summer, Fall), island (STT/STJ and STX), gear (dive, fish traps, lobster traps), number of gear (number of traps, number of dives), hours or days fished (soak time from trap set to haul, hours diving), and the average depth of fishing (for dive trips).

2.2.2 Results

Based on the gear used to harvest spiny lobsters, the location fished, and the sample size by island, it was only possible to pursue CPUE analysis for St. Croix, for all gears combined (traps and dive), and separately for DIVING and TRAPS. The proportion of spiny lobster trips by gear were Fish Traps (42.6%), Dive (29%), Lobster Traps (2.25%), Unknown Gear (26%) Only 22 trips with Lobster Traps were identified. Due to small sample size, a separate analysis was not performed for this gear. Lobster traps were grouped with Fish Traps for CPUE analysis.

In the selection of explanatory variables, only interactions that contained significant fixed factors were included in the model. Inclusion of other significant interactions (fixed and random) did not improve model fit, and caused larger deviations from the observed CPUE values.

Although a variety of species are harvested with Dive gear in the U.S. Virgin Islands, none showed association with lobster. This may indicate that species such as queen conch, which is likely to be caught with lobster, are not sampled in TIP, that dive trips target lobster exclusively and all other catch is incidental, or some combination of both. For Fish Traps, all the trips that harvested the species from this assemblage were considered in the CPUE index estimation.

Diagnostics for the US Virgin Islands TIP database indicated that a number of restrictions must be imposed on the data for further analysis. Some outliers were apparent in positive catch data, and the use of 95% quantiles was recommended. Some years had very small sample sizes, and gear usage was heavily skewed by island. St. Croix, where almost 80 percent of lobster sampling occurred, used dive gear as well as traps, while St. Thomas/St. John used only traps. The number of traps ranged from 0 to 130, with an average of 26 traps per trip. In St. Croix, 40% of the trips deploy more than 40 traps; in STT/STJ, 57% of the trips deploy less than 20 traps. The mean soak time for trap trips is 142 hr in STT/STJ and 93 hr in STX. Lobster is harvested year-round, with fairly even catches among seasons, perhaps peaking in the Spring, with 32% of the total lobster landings. Given these observations, the explanatory variables that can be considered for analysis are: year, season, island/district/area fished, number of gear, soak time, depth.

In order to develop a well balanced design, these variables were classified into the following categories:

YEAR = 1983-2003
SEASON = 1. Winter (Dec, Jan, Feb)
2. Spring (Mar, Apr, May)
3. Summer (Jun, Jul, Aug)
4. Autumn (Sep, Oct, Nov)
DISTRICT = 1. St. Thomas/St. John (STT/STJ)
2. St. Croix (STX)
3. Unknown
AREA FISHED[1] (within STX) = 1. South-Southeast (XS_XSE).
2. Southwest (XSW)
3. Northeast (XNE)
4. Northwest (XNW)
5. Unknown (XXX)

[1] Note that area designations were updated in 2005. Therefore, future assessments will follow a different categorization

NUMBER OF GEAR
Num. TRAPS= 1. 1-20 traps
2. 21-40 traps
3. More than 40 traps
4. Unknown

TIME FISHED
TRAPS=> Soak Days (time between trap set and haul):
1. 1-6 days
2. More than 7 days

DIVE=> Hours diving per trip:
1. 1-5 hr
2. More than 5 hr.
3. Unknown

AVERAGE DEPTH (Average of start and end depth):
1. < 10 Fathoms
2. 10-12 Fathoms
3. > 12 Fathoms

Three indices of relative abundance were developed:

1) US Virgin Islands Traps

2) St. Croix- Traps

3) St. Croix- Dive.

2.2.2.1 US Virgin Islands TRAPS TIP Index

For the development of this index, we used data from fish and lobster traps from all US Virgin Islands covering the years 1986-2002. We developed a Delta-Lognormal model limited to trips that landed lobster and associated species. Of these trips, 31 percent landed lobster.

The final model selected was:

LNCPUE = YEAR + SEASON + NUM_GEAR + SOAK_DAYS + YEAR*NUM_GEAR + YEAR*SOAK_DAYS

SUCCESS = YEAR + NUM_GEAR + DISTRICT + SEASON + SOAK_DAYS

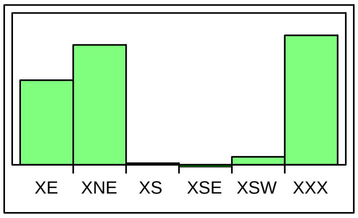
The binomial model did not converge with any interactions, so only main factors were selected. The observed, standardized, and scaled index is given in Table 8 and illustrated Fig. 11.

2.2.2.2 St. Croix TRAPS TIP Index

For the development of this index, we used data from fish traps from St. Croix during the years 1986-2000, excluding 1993 due to small sample size (and note that there were no trap samples taken in 1992). Records were removed if lobster landings exceeded 130 lbs or were positive but less than 1 lb (95% quantiles). Additionally, records were removed if the soak time or island of origin were unknown. Data were assigned to one of three regions—North East (XNE), East (XE), South (XS, XSE, XSW)—or an unknown (XXX) category.

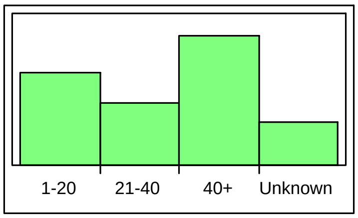
- Only St. Croix Island.

Distributions STX



Level	Count	Prob
XE	168	0.24348
XNE	239	0.34638
XS	5	0.00725
XSE	3	0.00435
XSW	17	0.02464
XXX	258	0.37391
Total	690	1.00000

Trips were classified into four categories based on the number of fish traps deployed: 1-20, 21-40, over 40, or unknown; distributed as follows.



Level	Count	Prob
1-20	265	0.28312
21-40	179	0.19124
40+	369	0.39423
Unknown	123	0.13141
Total	936	1.00000

Finally, trips were classified based on the soak time of the traps into three categories: 1-6 days, 7 or more days (60% of trips fell into this category), and unknown.

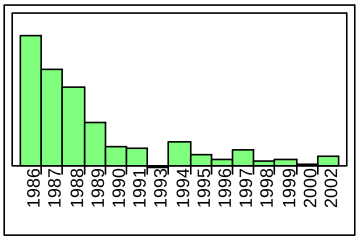
Explanatory variables considered included Year, Season, Region, Num_Gear, and Soak_days

The final Delta-Lognormal model was:

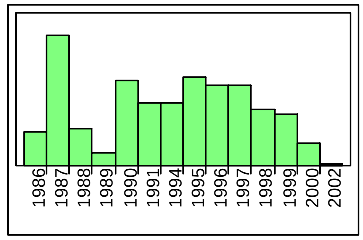
```
LNCPUE =  YEAR + SOAK_days + NUM_GEAR + YEAR*NUM_GEAR +
          YEAR*SOAK_DAYS

SUCCESS = YEAR + NUM_GEAR + SOAK_DAYS + SEASON
```

The Delta-Lognormal model did not provide a good fit to the data and standardized index values were therefore not estimated. The lack of fit was due to a highly unbalanced number of observations by year in the success model (see below), and to marked differences in the distribution of explanatory variables between the Binomial and the Lognormal models. In particular, the area fished (region) was distributed differently for positive and zero trips, and caused problems with convergence. This factor was removed from analysis. The positive observations have a more balanced design for all the factors considered (except Area), so a GLM model was used to estimate the relative index.

SUCCESS=0 (Proportion)



SUCCESS=1 (Positive Catch)



The final GLM Model for Positive trips was:

```
LNCPUE =  YEAR + SOAK_days + NUM_GEAR + YEAR*NUM_GEAR +
          YEAR*SOAK_DAYS
```

The observed, standardized, and scaled index is given in Table 9 and illustrated in Fig. 12.

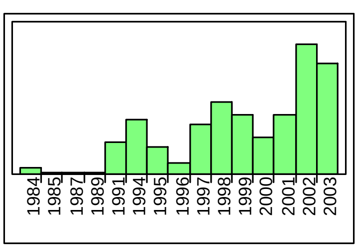
2.2.2.3 St. Croix DIVE TIP Index

A close examination of the DIVE trips for STX was conducted to select plausible explanatory variables for index estimation. These included the area fished, the gear number (number of dives per trip), the dive time in hours (SOAK), the season of the year, and the average depth.

Even when a clear imbalance in the number of observations by year and by variable was observed, or that the range of observations was quite constrained, an attempt was made to test some variables as factors for the CPUE model. Variables Depth and Area fished were not tested, as a common classification into meaningful levels for both the positive and zero trips could not be made. As for the TRAP index, the success model did not converge, so a GLM approach was used to explain trends in the positive trips.

A number of observations were made. Before 1991, few dive trips occurred or were sampled.

YEAR



Of the sampled trips, 50 percent took place on the NE coast, 28% in the SW, and the remaining were distributed across the S and SE. Almost no trips occurred in the NW. Sampled trips averaged five dives totaling 5 hours, all occurring between the narrow depth range of 8-14 fathoms. No major seasonal patterns in sampling/effort were observed.

Thus, a GLM model was constructed for data from 1991-2003. The model used four regions: S-SE, SW, NE, and E. The NW and unknown areas were removed due to small sample size. Trips were classified as to the number of dives (<5 and ≥5) and the number of hours diving (≤5 and >5). The final GLM model was:

```
LNCPUE =  YEAR + REGION + NUM_GEAR + YEAR*REGION +
          YEAR*NUM_GEAR
```

The observed, standardized, and scaled index is given in Table 10 and illustrated in Fig. 13. For comparative purposes, all the standardized and scaled indices are illustrated in Fig. 14.

2.3 CPUE from PR Commercial Trip Interview Program (TIP)

Trip Interview Program (TIP) data from Puerto Rico (1983-2003) were used to construct standardized indices of abundance for spiny lobster, *Panulirus argus*, as described more fully in Valle-Esquivel (SEDAR8-AW-05). Separate indices were estimated for each main gear type: dive, fish traps and lobster traps, using a Delta-Lognormal approach. This method combines two general linear models, a binomial model fit to the proportion of positive trips, and a lognormal model fit to catch rates on positive trips. Effective effort was approximated by considering zero trips through the construction of species assemblages by gear. The lobster fishery in Puerto Rico is concentrated around the Southwest shelf, with Diving being the most important fishing method. The fishery operates year-round, but a peak in relative abundance was observed during the Winter and early Spring months. Consistent trends were not observed across the fisheries examined, but for the overall fishery, a slight increase in abundance was suggested. CPUE rates from the Puerto Rico TIP program may be underestimated due to incomplete trip samples.

2.3.1 <u>Methods</u>

TIP data were utilized to estimate CPUE as the mean weight (in pounds) of spiny lobster per fishing trip by gear type. Indices were estimated for the three main gear types used to harvest lobster: DIVE (Hand/Spear/Diving), FISH TRAPS (Fish Pots/Traps), and LOBSTER TRAPS. Only those records with a single gear type recorded were used.

It is important to note that the TIP data from Puerto Rico does not contain any information to calculate the proportion of the catch sampled by trip, so it is impossible to expand the samples to the total landings. In order to conduct this study, it was assumed that the whole catch is sampled on any particular interview, so the sum of all individual weights should serve as a proxy to calculate the trip landings. If all the catch is sampled, then also the catch composition—and species assemblages—could be drawn from the information available in TIP.

Defining effort from the TIP data set is not straightforward, given the multi-specific nature of the Puerto Rico –and other U.S. Caribbean- fisheries. The data sets contained information about species caught, but not regarding the species targeted. Effective fishing effort (i.e., including trips that landed lobster and trips that may have targeted this species but did not catch it—zero trips) was estimated using the species assemblage method developed by D. Heinemann and described in Cass-Calay and Bahnick, (2002) and Valle-Esquivel (SEDAR8-AW-04).

Effort was quantified based on gear type. We considered the number of traps set or the number of dives conducted (including how many divers there were). We also considered how long the traps soaked or the duration of diving activity on a trip, and the depth at which fishing occurred.

Many records were missing this information. Generally half of the dive and lobster trap records lacked the desired effort information, while 80 percent of the fish trap records suffered this limitation.

A Generalized Linear Mixed Model Approach (GLMM) was used to estimate relative indices of abundance. Two different methods were used, depending on the characteristics of the data for each gear: a conventional GLM model and a Delta-Lognormal model (Lo et al. 1992). The GLM model uses a linear model to describe only the positive CPUE observations of the target species. The delta-lognormal model combines the proportion of positive trips (trips that landed spiny lobster) and positive catch rates on successful trips to construct a single index.

The influences of the following categorical variables on relative abundance were investigated: year, season (Winter, Spring, Summer, Fall), coast (N, S, E, W), gear (dive, fish traps, lobster traps), number of gear (number of traps, number of dives), hours or days fished (soak time from trap set to haul, hours diving), and the average depth of fishing (for dive trips).

2.3.2 Results

Of the 10,821 interviewed trips, 2,268 reported spiny using 3 main gears: DIVING (spears, scuba, free diving, hand), FISH TRAPS (or 'pots') and LOBSTER TRAPS. Lobster was landed in approximately 81% of the sampled dive trips, 65% of the sampled lobster trap trips, and 19% of the sampled fish trap trips. Of the lobster trips by gear, 68%, 26% and 2% of the trips use fish traps, diving, and lobster traps, respectively. Based on this information, four standardized CPUE indices were developed, one for the overall fishery and one for each of these main gears.

Although target species is specified in the TIP data, this information is suspect given that in nearly two-thirds of the sampled trips, the target species does not match the species that were sampled. Therefore assumptions have to be made to conduct CPUE analysis. The total trip landings and the total sample weight are frequently missing, so there is no way to estimate the proportion of the catch that the sample of each species represents or to expand the sampled proportions to total landings. The same applies in the analysis of species composition or to the identification of species assemblages. Moreover, many outliers were identified, most likely coming from errors in individual weights of other species. As a result, estimations of the proportion of the sampled catch composed of spiny lobster were problematic.

The location fished was generally not provided in the TIP database, but could be inferred from the reporting or sampling ZIP codes. With these, the fishing center, the municipality, and the coast where catch is landed may be known. To simplify assumptions, ZIP code locations were assigned to 4 coasts: North, South, East, and West.

2.3.2.1 Combined Gears

A number of restrictions were required to achieve a balanced sampling design for the models. Data were examined for years 1984-2003. We included all diving and lobster trap trips but filtered fish trap trips based on species associations. Records were removed if they had no information on landing or reporting area and if they fell beyond the 90% quantiles for landed lobster weight (over 100 lbs or less than 1 lb). Remaining records were categorized for coast (NE, S, W), season (Winter, Spring, Summer, Fall), and approximately half of these trips landed lobster. Preliminary runs used two approaches to estimate relative indices of abundance: Delta-Lognormal Index including zero trips; and Generalized Linear Model Index, using only positive lobster trips. Explanatory variables considered: year, season, gear, coast, from which the following models were selected:

LNCPUE = YEAR + COAST + YEAR*COAST

SUCCESS = YEAR + GEAR + YEAR*GEAR

For comparative purposes, a Delta-Lognormal (Table 11, Fig. 15) and a GLM (Table 12, Fig. 16) model were applied. An increasing trend in relative abundance was observed, from approximately 5 lb/trip in 1984 to 12 lb/trip in 2003, with large annual fluctuations over the whole period (coefficient of variation averaging 30%). It is worth examining the sources of this variation, which may be attributed to large differences among gears. This upward slope disappeared when only the positive trips were examined under the GLM model: fluctuations were smaller around a mean value of 13 lb/trip, and variability was reduced to approximately 20%. This comparison indicated that the proportion of lobster trips has increased (i.e., increased targeting), whereas the actual CPUEs from positive trips have remained stable.

In addition, significance of the Gear factor suggested that each fishery should be analyzed separately, as each gear is likely to produce differences in catch rates. Thus, standardized CPUEs were developed for the Dive gear, Fish Traps, and Lobster Traps.

2.3.2.2 Dive Gear

For this index, sampled trips were kept if they used dive gear from 1989-2003 and if coast information was available. Due to small sample sizes, trips that were conducted on the North or East coasts were grouped. Of these records, 84 percent landed lobster. These data were analyzed with and without Depth as a factor. In the analyses that used Depth, records were excluded if they lacked depth information. For the remaining trips, Depth was classified into four categories: less than 6 Fathoms, 6 to 7¼ Fathoms, 7¼ to 12½ Fathoms, and greater than 12½ Fathoms.

In the Dive model without Depth as a factor, year, season, and coast were considered as explanatory variables. The final model selected was:

LNCPUE = YEAR + COAST + YEAR*COAST

SUCCESS = YEAR + COAST

No clear trends in relative abundance were observed, index values have fluctuated around 11 lb/trip since 1989, with an average variation of 18% (Table 13, Fig. 17).

In the Dive model with Depth as a factor, year, season, coast, and depth were considered as explanatory variables. Depth was a significant factor, and the final model selected was:

LNCPUE = YEAR + COAST + DEPTH + YEAR*DEPTH + YEAR*COAST

SUCCESS = YEAR + COAST + YEAR*COAST

The Delta-Lognormal index statistics for the Dive-Depth method is provided in Table 14 and illustrated in Fig. 18. No clear trends in relative abundance were observed, index values have fluctuated around 11 lb/trip since 1990. The gap observed in 1996 is due to incomplete data.

2.3.2.3 Fish Traps

For this index, records were included if they used fish traps from 1984-2003, landed lobster or associated species, and identified a coast. When lobster was landed, records were excluded if the weight was less than 1 lb or 100 lbs or more. Twenty-three percent of the remaining records indicated lobster was landed. Year, season, and coast were considered as explanatory variables, and the final model was:

LNCPUE = YEAR

SUCCESS = YEAR + COAST + SEASON

The positive trips were only explained with the year factor, which suggests that the methods, location, and time of fishing for the species in the fish trap assemblage may differ significantly from the trips that truly target spiny lobster. Standardized index statistics for this fishery are given Table 15 and depicted Fig. 19. An upward trend in relative abundance was observed, from 3 lb/trip in 1984 to 12 lb/trip in 2003, with large fluctuations between years. Variability within each year also increased significantly toward the later years, to approximately 40% coefficient of variation.

2.3.2.4 Lobster Traps

For this index, records were included if lobster traps were used between 1991-2001 (no records for 1995 or 1996) and where the weight of landed lobster was 50 lbs or less. Nearly two-thirds of these trips landed lobster. Overall sample size was small (68 observations), in particular for the North and West coasts which were grouped as a result. The low sample size was also likely responsible for the binomial model’s failure to converge, which necessitated using a GLM on only those trips that landed lobster. Year, coast, and season were considered as possible explanatory variables, and the model selected was:

LNCPUE = YEAR + COAST +YEAR*COAST

GLM index values for the Lobster Trap fishery are presented Table 16 and Fig. 20. The data available for this index were sparse and inconsistent, but a close examination of the statistics suggest smaller values before 1995 (averaging 15 lb/trip) than after 1997 (averaging 20 lb/trip). During both periods, relative abundance declined and variance was high (approx CVs of 40%).

2.3.3 <u>Conclusions</u>

Summaries of all the indices developed in this study are presented in Fig. 21. A comprehensive examination of the results suggests that the lobster fishery in Puerto Rico is concentrated around the Southwest shelf, with Diving being the most important method used to harvest lobster. The fishery operates year-round, but some seasonality was observed, with higher relative abundance around the Winter and early Spring months. This coincides with the Winter migration that has been reported in this region.

Examination of the overall Puerto Rico lobster fishery indicates that the catch rates from positive trips have remained fairly constant over the period 1984-2003, at around 13 lb/trip, but that targeting of this species has increased significantly, as suggested by the Delta-Lognormal index. Clear differences were observed among gears, with increasing rates in the fish trap fishery, compared to flat rates in the dive fishery and declining rates in the lobster trap fishery. These contrasting, and often contradicting results suggest that each fishery may operate with distinct efficiencies, selectivities, and catchabilities. The least efficient gear in capturing lobsters was the fish traps, but this was expected, as this gear targets mostly fish species and therefore a large proportion of zero (lobster) trips occur. It is possible that the species assemblage method used to identify fish trap trips was rather subjective or arbitrary, so estimation of effective fishing effort for lobster may have been over or under-estimated.

The largest catch rates were observed with lobster traps, but this method is not very common in Puerto Rico. The preferred method is diving, which showed very stable (and flat) rates over time, suggesting that relative abundance has remained constant over the twenty-year period examined. However, if trend lines were added to all the indices developed in this study, the general trend would be toward an increase in abundance.

It is important to note that the major assumptions of this study may have been violated by irregular sampling in space and time and incomplete sampling of the catch. The low catch rates observed, even in the targeted lobster fisheries (dive and lobster traps) indicate that this database may be unreliable for catch rate analysis, unless targeting information and the proportion sampled start being recorded regularly.

2.4 Other Data Explorations for Future Assessments

Typically, stock assessment models rely primarily on abundance indices and age structure to gauge status and trends, with age structure often inferred by size structure. The US Caribbean stock of spiny lobster provides a challenge on both fronts. Spiny lobsters are not easily aged because they molt all hard parts as they grow, and their growth pattern makes size an unreliable indicator of age. These challenges require us to place additional emphasis on abundance indices.

Yet spiny lobsters are not sampled well by fishery independent methods currently in place. As such, we have to rely on data obtained from fishers. These data provide their own challenges. Typically, we use catch per unit effort as an indicator of abundance. Yet changes in fishing behavior may make such a relationship less direct than it would be from stratified random sampling, as is done in fishery independent methods. Consequently, it is crucial that we make every effort to understand fishing behavior and to account for it when calculating catch per unit effort indices.

At the SEDAR8 Assessment Workshop, held on St. Croix, US Virgin Islands, from March 14-18, 2005, fishermen from St. Thomas/St. John indicated that effort patterns had changed markedly in recent years. They suggested that lobster was primarily an opportunistic fishery on these islands while pursuing fish with pots. However, they suggested that in recent years there had been a growing number of fishers who primarily targeted lobster, at least on certain days. Such targeting should be visible in biostatistical sampling programs (e.g., TIP) and catch reports. Since TIP sampling had relatively few samples for the Virgin Islands, we focused our exploration on catch reports. We analyzed these reports for evidence of lobster targeting with an aim to determine whether we should distinguish targeted effort from incidental effort on this species.

2.4.1.1 Methods

US Virgin Islands commercial catch reports were examined for qualitative patterns of lobster landings. Only trips that caught lobster were examined for now, since methods for identifying trips that had the potential to catch lobster, but did not catch any, have been explored elsewhere by Valle-Esquivel (SEDAR8-AW-04; SEDAR8-AW-05). Two types of data were examined: the weight of lobster landings per trip, and the proportion of total landings by weight that were lobster. In both cases, all trips were examined together through frequency histograms. The goal was to determine whether there were natural breaks in these distributions that might differentiate targeted lobster trips from those that took lobster incidentally and, if so, identify criteria for the differentiation. Our focus was on the St Thomas/St. John trap fishery since it is the primary gear for catching lobster on those islands but is also used for other species. In contrast, diving is the major mode for targeting lobster on St. Croix but is not likely to target many other species, conch being the primary exception.

2.4.1.2 Results

There were no obvious natural breaks in the weight of lobster landed per trip for the US Virgin Islands as a whole (Fig. 22). Similarly, no clear breaks were evident for St. Thomas/St. John, neither in aggregate, by gear (Fig. 23), or by year for the trap fishery (Fig. 24). St. Croix showed a similar lack of break in weight of lobster landed per trip in aggregate or by any gear (Fig. 25).

In contrast, there were clear natural breaks in the proportion of total landings that were lobster, both for the US Virgin Islands as a whole (Fig. 26) and most subsets (Figs. 27-29) where a surprising number of trips landed lobster exclusively. This result demonstrates that examining landings for the proportion lobster contained in them is a better indicator of lobster targeting than examining them for the total weight of lobster.

Both data sets provide additional information about patterns of effort in lobster fishing. They show that diving is more targeted than traps or other categories. This fact is evidenced in the flatter distributions for lobster catches on St. Thomas/St. John (Fig. 23) and St. Croix (Fig. 25), and the especially high proportion of trips that landed lobster exclusively (Figs. 27, 29). Traps are also clearly used to target lobster on St. Thomas/St. John (Figs. 23, 27), although only on occasion. This pattern is not as apparent on St. Croix in landing weights (Fig. 25) but does find some support in landing proportions (Fig. 29). Among St. Thomas/St. John trap trips, targeting apparently increased from 1974/75-1996/97 as is apparent by the increasing frequency of high lobster landings (Fig. 24) and decreasing frequency of trips that caught anything other than lobster (Fig. 28). This increasing pattern may not have held in 2002/03, where fewer high weight trips were observed (Fig. 24) and more trips caught species other than lobster (Fig. 29).

2.4.1.3 Conclusions

These results suggest that we may be able to distinguish commercial fishing trips in the US Virgin Islands that target lobster from those that catch lobster incidentally. A large proportion of trips landed exclusively lobster, particularly from gears that are known to target lobster. It is recommended that future assessments consider separating trips that land lobster exclusively as directed and other trips as incidental lobster take. The incidental trips might be further subdivided into those that had any potential for catching lobster and those that had no such potential using techniques as described by Valle-Esquivel (SEDAR8-AW-04; SEDAR8-AW-05). In this manner, we might obtain distinct abundance indices from directed fishing efforts and from incidental efforts where lobster had any potential of being caught.

3 Stock Assessment Models and Results

3.1 A Stock-Production Model Incorporating Covariates (ASPIC)

3.1.1 <u>Methods</u>

3.1.1.1 Model Overview

Non-equilibrium production models were fitted to data for Caribbean spiny lobster with version 3.94 of the ASPIC software (Prager 1994) and assuming a logistic production function. All ASPIC fits were made by assuming that population removals (total catch) were known without error even though there is great uncertainty in these values, as explained in a previous section.

In addition to the ASPIC fits that aggregated all data for Puerto Rico and the Virgin Islands, sensitivity runs were performed by treating each of the island platforms as a separate stock. Mateo and Die (2002) had already done such fit for Puerto Rico alone, so this time, fits to the catch and catch per unit effort (CPUE) indices for the combined platform of St Thomas/St. John were conducted and also some fits for St Croix alone. Because of the short time series available for these island some of the fits were constrained by fixing $r = 0.4$ to improve convergence.

3.1.1.2 Catches

To illustrate the possible effects if this uncertainty sensitivity runs were made with different scenarios of total catch. Prior to the assessment workshop, landings estimates for spiny lobster were available for: Puerto Rico from 1969 to 2003 for all commercial gears, and a single estimate for 1951; for the US Virgin Islands trap fishery from 1975-2002 excluding 1988-1991, the data for which were not available prior to the assessment workshop; and for the US Virgin Islands dive fishery from 1975-2002 excluding 1988-1991, the data for which were not available prior to the assessment workshop. Data were missing for the following components of the total removals: sport fishery for both Puerto Rico and US Virgin Islands; commercial fisheries for the US Virgin Islands prior to 1974 and Puerto Rico prior to 1969; and dead discards for all fisheries. Since spiny lobster is a live specimen fishery, it was assumed that dead discards were negligible.

The following scenarios were used for total harvest:

I. *No under-reporting*. Catch statistics are complete; no catch existed when data is not available.

II. *Recent commercial fishery*. Assumes that the only significant harvest comes from commercial fishing, it ignores recreational catches. Furthermore it assumes that catches prior to data being available (1969 in Puerto Rico and 1975 in Virgin Islands) were negligible. This scenario is like scenario I but with filling the gaps of data for the USVI through interpolation. Landings for 1988 to 1991 for USVI were replaced by the average of landings from 1987 and 1992 and landings of 2003 replaced by the average of landings for 2000-2002.

III. *Slow evolving commercial fisheries*. Assumes the commercial fishery started slowly after World War II in Puerto Rico and post 1970 in USVI. This scenario is like II but for both USVI and Puerto Rico it was assumed that catches slowly increased linearly. For Puerto Rico catches started increasing in 1945 until they reached the estimated level reported in 1969. For US VI catches started in 1970 linearly increasing to the level reported in 1975.

IV. *Fast evolving commercial fisheries* . Like III for USVI but for Puerto Rico it was assumed that catches increased rapidly and linearly from 1945 to 1951 and stayed at the average between 1951 and 1969 during the period 1952-1968.

V. *Fast evolving commercial fisheries and recent recreational fishery*. Like IV but assuming a recreational fishery started in 1970 evolving exponentially to a level of 30% of the commercial fishery by 2003.

VI. *Fast evolving commercial fisheries and recreational fishery.* Like IV but assuming a recreational fishery started at the same time as the commercial fishery and always landed quantities equivalent to 30% of the commercial fishery landings.

The above scenarios imply different cumulative removals, the total removals over the entire history of the fishery (Table 17). In fact removals increase significantly from scenario I to scenario VI so that the last scenario removed more than twice as many lobsters than scenario I. From the perspective of cumulative removals, scenarios I and II are similar and so are scenarios IV and V. Given that, scenarios II and V were not consider further in the ASPIC fits

3.1.1.3 Abundance Indices

All indices of abundance used in ASPIC fits were based on fishery dependent data. Three of these indices were obtained from standardized catch per unit of fishing effort data that were presented elsewhere in this report: St Thomas/St John Traps (1976-1986, 1993-2003); St Croix Dive (1976-1986, 1993-2003); and Puerto Rico commercial fishery (1983-2001). A fourth index, based on historical nominal catch per unit of fishing effort for Puerto Rico, that extends much earlier in time (1969-1976, 1980, 1982, 1985, 1988) was also used in a subset of sensitivity runs.

There are no estimates of biomass independent of fishery data, therefore several scenarios had to be contemplated regarding the possible state of the biomass at the start of the modeling period: virgin (B_1 = K, B_1/B_{MSY} = 2); lightly exploited (B_1 = 0.75 K, B_1/B_{MSY} = 1.5); fully exploited (B_1 = 0.5 K, B_1/B_{MSY} = 1); and unknown (B_1 to be estimated).

It is clear that some of the catch and biomass scenarios combinations are more plausible than others and that some combination of scenarios are not plausible. Table 18 presents the combination of scenarios fitted to the data.

3.1.2 Results

Many of the ASPIC fits failed to converge before they hit one of the constraints established for r (0.1 - 2.0), and some converged at r values close to the constraint indicating that the data has not a lot of information regarding stock productivity. This was especially true for fits to the St. Croix data alone, which only converged to plausible solutions when both r and B_1/B_{MSY} were fixed, indicating that the data for this island are not informative enough to be fitted to a surplus production model.

Fits to the aggregated data for all islands did converge to plausible solutions (Table 19, Fig. 30a). However, the solutions implied very different productivity and/or current stock status. Fits that used only the recent catch (post 1969 in Puerto Rico and post 1974 in the US Virgin islands) and assumed no substantial recreational fishery only converged when the nominal catch rate from Puerto Rico was added to the list of abundance indices. These fits suggested a low productivity stock ($r < 0.2$) that ranged from MSY to somewhat lower abundance levels ($1.0 > B_{2003}/B_{MSY} > 0.6$) and was experiencing fishing pressure ranging from MSY levels to more than twice those levels ($1.0 > F_{2003}/F_{MSY} > 2.3$). Fits that assumed substantial catches from Puerto Rico prior to 1969 suggested a more productive stock (r 0.4~0.5), which is neither overfished nor experiencing overfishing, with current fishing mortality at around half of F_{MSY} levels.

Runs were also conducted looking at two island platforms in the US Virgin Islands alone (Table 19, Fig. 30b). Fits to the St. Thomas/St. John data suggested that the current stock is overfished and overfishing is taking place, regardless of which assumption was made about initial biomass. Fits to the St Croix data alone did not converge most of the time unless r and B_1/B_{msy} were fixed, in such cases the fit suggested the current stock was not overfished but was suffering overfishing.

3.1.3 Conclusions

The ASPIC lobster model had significant challenges associated with it. A number of formulations of this model resulted in estimates that hit constraints for key parameters. Even for those runs that converged on more reasonable values, the conclusions one might draw from the model changed dramatically with the formulation. As a result, the Assessment Workshop Panel was unable to identify a reasonable base model.

3.2 State-Space Age-Structured Production Model

A state-space age-structured production model (Porch, 2002) was applied to Caribbean spiny lobster (see Brooks and Valle-Esquivel SEDAR8-AW-06). As fishery data for spiny lobster in the U.S. Caribbean are sparse, variable among islands, and relative abundance indices do not show consistent trends, it was difficult to fit the model without placing a suite of constraints on initial parameter values. Even with constraints, reasonable fits to the indices and the catch series could not be obtained simultaneously, and in all cases results appeared to be unrealistic. Under all the scenarios tested, the model tended to overestimate SSB and underestimate F. At this time, it is not possible to draw a conclusion about the stock status from this age-structured production model.

3.2.1 Methods

3.2.1.1 Commercial Landings

Annual landings of spiny lobster from the US Virgin Islands, including St. Thomas, St. John, and St. Croix are available since 1974-75, and since 1983 from Puerto Rico. In the present study, expanded landings from the Virgin Islands were used, but only reported landings (without expansion) were available from Puerto Rico (Table 20, Fig. 31). Initial model applications attempted to use landings by sector and island with their corresponding index; final trials used the combined landings for the whole US Caribbean (i.e., total reported) and only one of the abundance indices.

3.2.1.2 Commercial Catch Rates

Selected standardized CPUE indices developed by Valle-Esquivel (2005) for the Virgin Islands and by Mateo and Die (2004) from Puerto Rico were used to calibrate an age structured production model (Table 21, Fig. 32). To facilitate comparison, relative indices of abundance were scaled to the mean of the overlapping years in each series. Scaled standard index values were incorporated as inputs of the assessment model. The indices selected were those that had a corresponding, fairly complete catch series, that encompassed a sufficient period of time, and that were deemed representative of trends in the respective fisheries. Under these premises, trap and dive CPUE indices from the U.S. Virgin Islands and an overall (multi-gear) index from Puerto Rico were used in all trials, either simultaneously or one at a time.

3.2.1.3 Population Model

A state-space, age-structured production model was used to evaluate the status of spiny lobster in the US Caribbean. A state-space model can facilitate parameter estimation by separately estimating observation and process error. The present formulation can accommodate Bayesian priors, and allows for interannual variations in parameters such as recruitment and catchability. An age-structured production model is advantageous because it allows fecundity and vulnerability of the fishery to vary with age. The theory and implementation of the model is described in detail in Porch (2002).

Required inputs to run this age structured production model include: a time series of catch and effort (or CPUE) for each fishery, a length-weight relationship, a length-at-age equation, and a maturity schedule. In addition, parameters for the stock-recruitment function are specified in terms of virgin recruitment and α, the maximum rate of reproduction at low stock sizes (Myers et al. 1999). Parameters estimated by the model include a catchability coefficient for each fishery, annual effort, historical average fishing mortality, abundance, spawning biomass, and equilibrium statistics corresponding to MSY, F_{MAX} and various other benchmark statistics (Porch 2002).

3.2.1.4 Population Parameters

3.2.1.4.1 Length-Weight Relationship

A morphometric relationship was estimated from Puerto Rico TIP data (1986-2003), after a thorough examination of outliers and after performing a conversion of units into millimeters (carapace length) and grams (weight) (Chormanski, SEDAR8-RW-02). The estimated equation is:

$$W_T = 0.00921\, L_C^{\,2.4804}$$

where W_T is total weight in grams and L_C is carapace length in millimeters.

3.2.1.4.2 Natural Mortality

The mortality estimates used were obtained from literature values for the Virgin Islands and the Turks and Caicos Islands (Olsen and Koblic 1975; Medley and Ninnes 1996; FAO 2001). The median value of 0.36 for adult lobsters was used for all ages.

3.2.1.4.3 Growth

Growth in carapace length (CL) was assumed to follow a von Bertalanffy growth model, with parameters taken from León and colleagues (1994) for Cuba. The estimates for males were used for all age calculations,

$$L_t = 185\ mm\ (1-e^{-0.23(t-0.44)})$$

and mean parameter values for both sexes combined were used to estimate a maturity schedule.

$$L_t = 170\ mm\ (1-e^{-0.21(t-0.405)})$$

The SEDAR8 group decided to use the parameters for the U.S. Virgin Islands, estimated by Olsen and Koblic (1975) as an alternative.

3.2.1.4.4 Maturity

A logistic maturity schedule for spiny lobsters in the U.S. Caribbean was estimated by Die at the Assessment Workshop (Die, SEDAR8-RW-03) based on a re-examination on data from Bohnsack and co-workers (1991).

Model A is:

$$m = 1/(1+e^{-kL-\gamma})$$

$$L_{50\%m} = (\gamma - \mathrm{Ln}(1))/k$$

3.2.1.4.5 Fecundity

A fecundity schedule was calculated from a relationship between carapace length and fecundity from Cuba (FAO 2001):

$$E = 0.5911 * L_C^{2.9866}$$

where E = number of eggs and L_C = carapace length (mm). Length was converted to age and fecundity values were scaled to the maximum value. Some trials used weight as a surrogate of fecundity, but this did not alter results.

3.2.1.4.6 Stock-Recruitment Relationship

The stock-recruitment function was parameterized using a maximum reproduction rate (α) and virgin recruitment level (R_0). A starting point was derived from a steepness value 0.8. This corresponds to α = 16. A fairly flat prior was put on α (lognormal with mean 16 and CV of 70%) to reflect our uncertainty in this parameter. A starting point for virgin recruitment (R_0 in numbers) was obtained by assuming that it was approximately 10 times the largest catch observed (e.g., 4 million pounds). An additional assumption was that each lobster weighs on average one pound, making the initial value for R_0 equal to 4 million fish.

3.2.1.4.7 Number of Age Classes and Selectivity

Based on the spiny lobster length distribution from Puerto Rico TIP data (1983-2003), the range 20.9 to 180 mm corresponds to an age distribution between 1 and 16 years of age. This age was used as the longevity estimate for the ASPM model. However, this distribution includes data from years prior to the implementation of the minimum size (CL=75 mm) regulation. Therefore the main size classes targeted in the fishery can be considered those within this length limit and the upper 99.5% quantile of the distribution (75-150mm). This range corresponds approximately to ages 2.7 to 7.68. This indicates that the fishery is centered on five main age classes (3 to 8). Ages 1-10 are included in the model; age 10 is a plus group.

Initial trials used distinct selectivities for Puerto Rico and the US Virgin Islands. The Puerto Rico selectivity was modeled with a logistic function, with 3.6 as the age of 50% recruitment and the curve was essentially knife-edged. Knife-edge selectivity at 4 years was assumed for the U.S.V.I. dive and trap fisheries, as size and age of entry to the fishery has been consistent over time, even before the size regulations were introduced. Final trials used only the Puerto Rico value (50% selectivity at 3.6 years) because Puerto Rico takes the largest proportion of the catch.

3.2.1.5 Model Setup

For initial ASPM model runs, the total Caribbean spiny lobster landings were divided into three catch series: Puerto Rico, USVI-Dive and USVI-Traps. Each fishery was linked to an appropriate abundance index (Puerto Rico commercial index, Dive index from St. Croix, and a Trap index from St. Thomas/St. John) and was assigned different selectivity, catchability and effort patterns, with their respective variance parameters.

Initial trials at fitting the age-structured production model with all three indices were unsuccessful. In general, the model tended to fit the catch very well while the fits to the indices showed great bias. Subsequent trials were constrained to one catch series (overall U.S. Caribbean lobster landings) and focused on fitting the models to only one index, and these results are discussed below. In the three base models constructed, effort was allowed to vary interannually, the catchability coefficients were estimated as constant (time-independent), and the catch and effort series were allowed to have a lognormal error distribution. Even fitting one index at a time, the model still tended to favor greatly a fit to catch rather than the index, so constraints were imposed to force the model to fit the indices better, typically 2.0-3.5 times better than the catch series.

Natural mortality was given a lognormal prior with a mode of 0.36. A very tight distribution was imposed (CV=0.10) as the model tended to go to the upper bound of 0.8 without this constraint. In contrast, very wide bounds and flatter distributions were specified for R0 and α (virgin recruitment in numbers and the maximum reproductive rate, respectively): R0 was in the range [2.00E+03, 6.50E+09] and α was in the range [2,90]. Initial parameter starting values were 4.00E+07 for R0 and 16 for α (this value for α corresponds to a steepness of 0.8). Point estimates for R0, α, and M for each model are given in Table 22.

3.2.2 Results

3.2.2.1 Puerto Rico Index

The index constructed from Puerto Rico commercial landings (Mateo and Die, 2004) was fairly flat overall, and the model fit a trend through the middle of the observations; catch was fit very well (Fig. 33). Given the lack of trend in the index, and the lack of information prior to 1975, estimated fluctuations in F and SSB were driven by the catch series. A plot of the relative management benchmarks F/F_{MSY} and SSB/SSB_{MSY} suggest that the stock is not overfished and there is no overfishing occurring. In fact, it suggests that fishing mortality has been, on average, about 400 times less than the level that would achieve MSY, while SSB is close to 4 times greater than the level that would produce MSY. F in 2002 (last year of data) is estimated to be 8.42E-04 while SSB is estimated to be 4.47E+08 (20% greater than the estimate of virgin SSB). These results are very unrealistic.

3.2.2.2 St. Croix Dive Index

This index had no observations for the period 1987-1992 (the data for which were provided at the Assessment Workshop but too late for these analyses), and attempts to fit both catch and CPUE led to a very poor fit to the second half of the time series (generally the bias was positive). In an attempt to force the model to fit the entire index, it was split into two time periods, and a separate catchability parameter was estimated for each period. This successfully eliminated the bias, although the estimated fit was flat (Fig. 34). It was also necessary to constrain the model to fit the index 2 times better than the catch index, which still provided a decent fit to catch (Fig. 34). A plot of the relative management benchmarks F/F_{MSY} and SSB/SSB_{MSY} suggest that the stock is not overfished and there is no overfishing occurring. On average, the level of fishing mortality has been 10% of the rate that would achieve MSY, while SSB has been about 3.7 times the level that would yield MSY (Fig. 34). F in 2002 (last year of data) is estimated to be 0.035

while SSB is estimated to be 9.4E+6 (about 95% of virgin SSB). These results seem intuitively unrealistic. Forcing the model to fit the index trend (which gave a really poor fit to catch in some years) suggested that the stock is at 80% of virgin levels in 2002, but overall there is no overfishing and the stock is not overfished (Fig. 35).

3.2.2.3 St. John Trap Index

The Trap index has a trend which is very similar to the Dive index, so the results from this model exercise were not very different from the results described for the previous model runs.

3.2.3 Conclusions

Although the results across all model runs were consistent in their estimate of stock status (i.e., no overfishing and not overfished), their resemblance to reality was questionable, mainly because they estimated that the stock was currently at or above virgin levels and that impacts from fishing were practically nil. A possible explanation for these results is the lack of contrast in the data. The Puerto Rico index in particular is flat, and while the Trap and Dive indices show some trend (downward overall), there are no index values for the years 1987-1992 when the catches were lowest.

At this time, it is not possible to draw a conclusion about the stock status from this age-structured production model.

4 Model Comparisons

Although a number of scenarios were explored with two quite different models, no definitive conclusions could be reached about the status of US Caribbean spiny lobster. The ASPIC non-equilibrium surplus production model showed the widest range of results, with the estimated biomass ranging from half to almost twice MSY levels and fishing mortality rates ranging from 6 percent to well over three times MSY levels. Though they showed a more limited range, the age-structured model results were similarly unbelievable, with biomass ranging from three to four times MSY levels and fishing mortality rates from one-quarter to two percent of MSY levels. When limited to runs that seemed more reasonable, the ASPIC model estimated biomass levels ranging from half to 1.5 times MSY levels and fishing mortality rates from half to a bit over twice MSY levels. The age-structured did not produce any results that fell within a reasonable range. Meanwhile the yield-per-recruit modeling (discussed in the following section) suggested that the lobster fishery is experiencing fishing mortality rates that are close to but have not yet exceeded MSY levels.

Given these wide disparities, the Assessment Workshop Panel felt the assessment of US Caribbean spiny lobster was inconclusive and that it is not possible to determine its status at present.

5 Population Modeling

5.1 Length-Based Methods

5.1.1 Previous Length-Based Assessments

Estimates of growth and mortality parameters for Caribbean spiny lobster have been calculated using length frequency data collected from the St. Croix (1995-1999) and Puerto Rico (1999-2000) commercial biostatistical programs using the FISAT software package (Mateo and Tobias 2002, Mateo 2004).

5.1.1.1 St. Croix

Mateo and Tobias (2002) reported the St. Croix length-converted catch curve and Beverton and Holt total mortality (Z) estimates ranging from 1.24 to 1.91 for males and 0.8 to 1.58 for females. Their estimate of Z from Jones length cohort analysis ranged from 0.83 to 1.15 for males and 0.65 to 0.83 for females. The exploitation ratios (E, equal to the fishing mortality rate, F, divided by the natural mortality rate, M) from length catch curve ranged from 0.73 to 0.82 for males and 0.58 to 0.76 for females. Meanwhile, exploitation ratios from Jones length cohort analysis ranged from 0.59 to 0.70 for males and 0.47 to 0.64 for females. These results indicated that the levels of fishing pressure up to 1999 had not exceeded the maximum sustainable levels. The E_{MSY} (exploitation ratio at maximum sustainable year) estimates for males and females (0.71 and 0.72, respectively) had not yet been surpassed by the exploitation ratios at the time (0.66 and 0.58).

The Beverton relative yield per recruit model analysis for male lobsters in St. Croix waters implied that with values of E=0.66 and length at first capture (Lc)=95.4 mm the lobster fishery was harvesting approximately 98% of the potential yield (Fig. 36a). Likewise, the analysis for females showed that with a value of E=0.58 and Lc= 89.36 mm the fishery was harvesting 95% of the potential yield in females (Fig. 36b).

Mateo and Tobias' (2002) estimates of MSY from the Schaeffer and Fox model varied from 15,300 to 15,500 kg within the two models. The number of trips required to achieve MSY levels ranged from 5,688 to 7,644 trips.

These authors suggested that lobster populations in St. Croix were experiencing overfishing using a threshold of E=0.5, which is more conservative than the MSY-based exploitation ratio. They further observed a decline in mean CL in males from 1995 to 1999 and suggested that compliance with minimum length regulation decreased over time. In terms of MSY, they pointed out that the estimated value of 15,500 kg had been exceeded in several fishing seasons over the period 1990-1999, with the implication that the fishery is fully exploited. Nevertheless, their analysis did not indicate that spiny lobster was currently experiencing overfishing according to the criteria used under federal management.

5.1.1.2 Puerto Rico

The length-converted catch curve analysis of the Puerto Rico spiny lobster during the period 1999-2000 conducted by Mateo (2004) yielded total mortality estimates (Z) ranging from 1.32 to 1.35 for males and 1.25 to 1.85 for females. Length at first capture (Lc) for males was around 88 mm and for females it ranged between 86.3 and 87.4 mm. The Z estimated from Jones length cohort analysis ranged from 1.01 to 1.02 for males and 1.05 to 1.11 for females. The exploitation ratios from length converted catch curve were between 0.74-0.75 for males and 0.73-0.82 for females; whereas, exploitation rates from Jones length cohort analysis were around 0.66 for males and 0.68 to 0.71 for females. The results indicated that the levels of fishing pressure in 2000 had not exceeded the maximum sustainable yield. The E_{MSY} (exploitation ratio at maximum sustainable yield) estimates for males and females (0.69 and 0.72, respectively) were not surpassed by the exploitation ratios (0.66 and 0.68) during that year.

The mean fishing mortalities obtained with Jones' length cohort analysis for fully recruited length groups were around 0.67-0.68 for males and 0.71-0.94 for females, respectively. Mortality estimates from Jones length cohort analysis were used for the yield per recruit analysis.

The Beverton relative yield per recruit model for males in 2000 implied that with values of E=0.66 and Lc=88.05 mm the lobster fishery was harvesting approximately 95.6% of the potential yield (Fig. 37a). Likewise, the analysis for females showed that with a value of E=0.68 and Lc=86.2 mm the fishery was harvesting 94% of the potential yield in females (Fig. 37b).

Mateo (2004) acknowledged uncertainty in his analysis and concluded that the fishery was overfished. The Beverton relative yield per recruit model analysis for 2000 for males and females implies the Puerto Rico lobster fishery is operating very close to its maximum sustainable yield (MSY) level and that no further increase in fishing effort is advisable. However, the fishery has not exceeded MSY-based overfishing thresholds according to his analysis.

5.1.2 Length-Frequency Analysis

Length data for Caribbean spiny lobster from Puerto Rico was further analyzed by Chormanski and colleagues (SEDAR8-RW-02) to identify trends in size composition in time and space and to assess compliance with minimum size regulations over the years sampled by the Trip Interview Program (TIP). In particular, they examined trends relative to the year caught, the season (quarter) caught, the region of Puerto Rico where they were landed, and the gear used for capture. The data were cleaned by removing outliers and by standardizing the length units to carapace length and the weight units to total weight.

A multi-way ANOVA conducted on the length data for year, region, and the gear types most frequently used indicated a significant effect of year and region on mean lobster length, though all interaction terms were also significant, indicating that gear may also represent a significant factor (Table 23).

An analysis was also conducted on the percentage of undersized spiny lobsters sampled in Puerto Rico by TIP. Percent undersize was found to vary by gear and region but not by season (quarter) (Fig. 38). Further, the initial analysis showed a decreasing trend in percent undersize over the years sampled by TIP, from a level of around 40-50 percent in the 1980's to near 15 percent between 2000 and 2003 (Fig. 39). It is possible that sampling had shifted from fishing centers with relatively high percentages of undersized catch to others with relatively low percentages of undersized catch. To test this hypothesis, the data on percentage of undersized lobsters reported were analyzed spatially.

To accomplish this, municipalities were placed into three groups: (a) municipalities not sampled in the first five years of TIP (1983-1987); (b) municipalities with a high initial percentage of undersized lobsters for the first five years of TIP; and (c) municipalities with a low percentage of undersized lobsters for the first five years of TIP.

This stratification revealed the percentage of undersized lobsters sampled by year for each municipality (Fig. 40) and showed the number of municipalities sampled for each municipality group as defined above (Fig. 41). The number of municipalities sampled each year was then stratified by municipality group, which revealed that no sampling bias appeared to be present (Fig. 42). This allowed for the expansion of the percent undersize trends to the total landings of spiny lobster in Puerto Rico by year available from NOAA landings data (Fig. 43). The percent undersize trends were expanded only to the landings represented in those municipalities sampled by TIP for any given year. The results of both of these analyses confirm a decreasing trend in percent undersize catch of spiny lobster in Puerto Rico over the time period sampled by TIP (Figs. 44).

6 Biological Reference Points (SFA Parameters)

Given the large uncertainties surrounding this assessment, neither current status nor biological reference points could be determined with any confidence.

6.1 Status of Stock Declarations

The Assessment Workshop Panel recommended that the US Caribbean spiny lobster stock be considered unknown with respect to both overfishing and overfished status.

7 Projections and Management Impacts

Because of our inability to define a base model, we were unable to derive meaningful projection scenarios.

8 Management Outcomes and Risk Analysis

Similarly, our agreement on the large uncertainties surrounding the US Caribbean spiny lobster stock precluded an extensive analysis of management outcomes. It might be possible to perform a more detailed risk analysis, and such an exercise is recommended for the future.

9 Research Recommendations

Various sources of fishery independent data have been collected through the NMFS SEAMAP Caribbean sampling program for the Puerto Rico and US Virgin Islands reef fish fishery. It was established at the SEDAR 8 Data workshop that at the time, the most complete data set available for Puerto Rico was collected through the Puerto Rico Department of Natural and Environmental Resources, while the most complete data set available for the US Virgin Islands was collected by the Department of Fish and Wildlife. However, spiny lobster is not well represented in these data.

The following recommendations were made regarding fishery-independent sampling in general:

- Increase the fishery independent sampling effort in the US Caribbean. Further diversify the regions that are sampled to include equal coverage of areas frequently fished. Inquiry among the fishing community should provide appropriate information on the location, habitats and best fishing methods appropriate to acquire the most complete set of information on all species in the region. Cooperative sampling design and implementation between the fishermen and scientists is strongly encouraged. If every species captured cannot be completely sampled, then those species deemed to be or to have been important to the local fishing economy should be given sampling priority. A list of commercially important species to the region can be obtained from the Caribbean Fishery Management Council.
- The ideal survey would utilize hook and line and traps as the primary sampling gears in order to maintain consistency with those surveys that have been completed in the past. The number of gear fished and the hours fished each sampling period should be standardized and strictly adhered to from one sampling period to the next. When determining the appropriate amount and allocation of standard effort, one should consider how fishery independent effort was employed in previous years so that consistency can be achieved over a substantial time period. Sampling should be done such that it is temporally distributed in an even manner with the same number of hours fished from season to season, and within a season.
- Due to the lack of adequate and consistent historical data in the Caribbean, it is difficult to determine stock status using many of the traditional quantitative methods. However, the relatively good knowledge of habitat distributions and of habitat usage by various species/life stages provides a valuable opportunity to explore the power of habitat-based spatial models in this region.

Recommendations were also made specific to fishery-independent monitoring of spiny lobster:

- Development and implementation of a fishery independent sampling program specific to Caribbean spiny lobster. One of the challenges was the inability to determine a reliable and robust measure of abundance and size for the population, using fishery dependent or fishery independent data. Consequently, a program is needed to go beyond the present attempts to determine larval dispersal and should attempt to sample lobsters in the same capacity that the SEAMAP Caribbean sampling program samples reef fish or queen conch. These improvements would also provide a better understanding of directed versus incidental fishing effort on spiny lobster, of gear selectivity, and of the fishing process as a whole. Local fisherman participation (cooperative research) should be used to assist in the sampling and information gathering process. The SEAMAP Caribbean sampling group is aware that the puerulus sampling program is insufficient and is presently considering alternatives.
- Visual surveys could be used in the Virgin Islands and in Puerto Rico to collect additional size and abundance information on the spiny lobster resource. This may be the fastest way to obtain a large quantity of information (although targeted lobster fishing may prove more efficient), and data collected can be paired with size distributions.

Lobsters can be temporarily captured and carapace length measured while in the water. Such data would be useful in calculating yield per recruit.

- Mark recapture techniques could be attempted to estimate abundance and learn more about the movements and habitat preferences of spiny lobster. One problem with this is that for lobsters, growth is achieved through molting. Each time a lobster molts, the tag is removed from the individual along with the molt. New tagging technologies however may enable more success with spiny lobster. This is a good opportunity to do cooperative research between scientists and the local fishing association. Important components would include communicating and educating the fishermen such that they are encouraged to return the tags.

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11 Tables

Table 1—Expanded US Virgin Islands Commercial Lobster Landings by Gear, Year, and District

Data for years 1974 includes only St. Thomas/St. John and only January-June of 2003 for both districts is represented. Data is filtered to upper 97.5% quantile (records with lobster catch> 250 lb/trip were removed). Data from 1986-87 to 1991-92 (highlighted) is incomplete, missing or contained only outliers, and is currently under review. Data organized into fishing years, which begin July 1 and end June 30, for this and subsequent commercial landings tables.

DISTRICT= STT/STJ

	N Trips	DIVE	TRAPS	OTHER	ALL GEAR
1974	83	2442	3370		5812
1975	267	4434	11182		15617
1976	186	1779	11890		13669
1977	465	10493	25522		36015
1978	630	14850	45048		59898
1979	535	6716	38360		45076
1980	532	6256	47651		53907
1981	559	6719	47697		54416
1982	566	5681	38650		44331
1983	619	6060	36161		42221
1984	553	8251	23495		31746
1985	678	7266	34652		41918
1986	653	16195	32659		48853
1987	181	4075	10804		14879
1988					
1989					
1990					
1991					
1992	706	1028	35667		36695
1993	1213	6720	76219		82939
1994	1068	4837	61993		66830
1995	1408	7060	87678		94738
1996	1623	7650	110446		118096
1997	1261	4607	79096	31	83734
1998	1025	3411	54911	166	58488
1999	1090	5512	47265	143	52921
2000	1054	5964	43286	192	49442
2001	1200	8126	45866	142	54134
2002	1323	12734	52900	174	65809
2003	697	5372	33888	66	39327

DISTRICT= STX

YEAR	N Trips	DIVE	TRAPS	OTHER	ALL GEAR
1974					
1975	141	157	7349		7506
1976	140	753	6764		7517
1977	139	5847	4720		10567
1978	150	9768	2526		12294
1979	80	1107	3550		4658
1980	64	2404	1277		3681
1981	86	2828	2312		5140
1982	123	4223	3676		7899
1983	244	2043	4883		6926
1984	345	7395	1977		9372
1985	193	4166	879		5045
1986	65	2724	847		3571
1987	50	2118	449		2567
1988					
1989					
1990					
1991					
1992	345	8288	3076		11365
1993	1140	30574	10770		41344
1994	882	24536	6122		30658
1995	938	17011	5185	52	22248
1996	1102	22883	3327	702	26912
1997	1356	29044	4242	1557	34842
1998	1512	36785	4178	2418	43381
1999	1620	45212	6229	970	52411
2000	2531	80443	3912	2676	87031
2001	3208	109833	3047	2786	115666
2002	3428	111487	3686	3658	118831
2003	1625	48447	1605	2083	52136

Table 2—US Virgin Islands DIVE and TRAPS Combined Commercial Lobster Index
Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster in the U.S. Virigin Islands, years 1976-1986 and 1993-2003.

				Scaled Index			
Year	Nominal	Estimated	CV Index	Obscpue	StdIndex	Upper 95% CI	Lower 95% CI
1976	63.633	54.593	18.5%	0.659	0.707	1.020	0.489
1977	77.122	72.163	18.2%	0.798	0.934	1.339	0.651
1978	92.554	77.264	18.1%	0.958	1.000	1.432	0.698
1979	80.789	65.894	18.4%	0.836	0.853	1.227	0.592
1980	96.623	69.137	18.4%	1.000	0.894	1.289	0.620
1981	92.334	71.487	18.3%	0.956	0.925	1.330	0.643
1982	75.773	59.315	18.3%	0.784	0.768	1.103	0.535
1983	56.970	32.905	18.3%	0.590	0.427	0.613	0.297
1984	45.777	27.528	18.3%	0.474	0.357	0.514	0.248
1985	53.964	32.643	18.3%	0.559	0.423	0.609	0.294
1986	73.014	54.891	18.4%	0.756	0.710	1.024	0.493
1993	52.536	41.860	18.0%	0.544	0.543	0.776	0.379
1994	49.993	38.179	18.1%	0.517	0.495	0.709	0.346
1995	49.908	35.662	18.1%	0.517	0.462	0.662	0.323
1996	54.209	39.939	18.1%	0.561	0.518	0.741	0.362
1997	47.263	36.806	18.1%	0.489	0.477	0.683	0.333
1998	42.069	37.968	18.1%	0.435	0.492	0.705	0.344
1999	39.642	37.128	18.1%	0.410	0.481	0.689	0.336
2000	39.123	37.493	18.1%	0.405	0.486	0.696	0.340
2001	39.421	38.144	18.1%	0.408	0.495	0.708	0.346
2002	40.011	39.006	18.0%	0.414	0.506	0.724	0.354
2003	40.249	39.607	18.1%	0.417	0.513	0.735	0.359

Table 3—US Virgin Islands TRAPS Commercial Lobster Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for the spiny lobster trap fishery, all islands included, years 1976-1986 and 1993-2003.

				Scaled Index			
Year	Nominal	Estimated	CV Index	Obscpue	StdIndex	Upper 95% CI	Lower 95% CI
1976	60.942	68.838	25.6%	0.604	0.675	1.117	0.407
1977	63.534	75.724	25.5%	0.630	0.742	1.226	0.450
1978	85.719	88.210	25.6%	0.850	0.864	1.431	0.522
1979	81.356	87.302	25.5%	0.806	0.855	1.414	0.518
1980	100.882	82.687	25.9%	1.000	0.809	1.348	0.486
1981	98.441	102.145	25.7%	0.976	1.000	1.659	0.603
1982	75.665	64.777	25.6%	0.750	0.635	1.051	0.383
1983	61.502	47.711	25.4%	0.610	0.468	0.772	0.284
1984	53.672	36.175	25.6%	0.532	0.355	0.588	0.214
1985	62.542	37.219	25.8%	0.620	0.365	0.607	0.220
1986	73.638	63.892	26.3%	0.730	0.625	1.048	0.373
1993	63.664	53.470	25.2%	0.631	0.525	0.863	0.319
1994	64.169	49.854	25.3%	0.636	0.489	0.806	0.297
1995	67.526	49.758	25.3%	0.669	0.488	0.804	0.297
1996	73.260	48.033	25.4%	0.726	0.471	0.777	0.286
1997	66.760	47.394	25.3%	0.662	0.465	0.766	0.282
1998	53.522	46.877	25.4%	0.531	0.460	0.758	0.279
1999	45.839	48.955	25.3%	0.454	0.481	0.791	0.292
2000	44.695	41.373	25.5%	0.443	0.406	0.670	0.246
2001	46.013	49.818	25.5%	0.456	0.489	0.807	0.296
2002	49.988	51.680	25.5%	0.496	0.507	0.837	0.307
2003	58.666	55.782	25.8%	0.582	0.547	0.908	0.329

Table 4—St. Thomas/St. John TRAPS Commercial Lobster Index
Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for the St. Thomas/St. John spiny lobster trap fishery, years 1976-1986 and 1993-2003.

				Scaled Index			
Year	Nominal	Estimated	CV Index	Obscpue	StdIndex	Upper 95% CI	Lower 95% CI
1976	69.930	63.863	20.3%	0.668	0.629	0.940	0.421
1977	64.613	64.468	19.8%	0.617	0.636	0.941	0.429
1978	88.330	77.288	19.4%	0.843	0.762	1.120	0.519
1979	85.029	74.743	19.5%	0.812	0.737	1.084	0.501
1980	104.727	92.893	19.5%	1.000	0.916	1.348	0.622
1981	102.353	101.460	19.6%	0.977	1.000	1.474	0.678
1982	79.960	64.509	19.6%	0.764	0.636	0.939	0.431
1983	77.886	64.637	19.5%	0.744	0.638	0.939	0.433
1984	71.753	59.954	19.7%	0.685	0.591	0.874	0.400
1985	68.212	55.920	19.5%	0.651	0.552	0.812	0.375
1986	75.424	68.600	19.6%	0.720	0.677	0.997	0.459
1993	75.521	64.508	19.3%	0.721	0.637	0.933	0.434
1994	69.970	55.697	19.4%	0.668	0.550	0.807	0.375
1995	74.237	61.116	19.3%	0.709	0.603	0.884	0.412
1996	78.890	64.674	19.3%	0.753	0.638	0.935	0.436
1997	74.195	65.907	19.3%	0.708	0.650	0.953	0.444
1998	60.541	57.769	19.4%	0.578	0.570	0.837	0.388
1999	50.933	55.158	19.4%	0.486	0.544	0.800	0.371
2000	49.869	53.360	19.4%	0.476	0.527	0.774	0.358
2001	48.027	49.964	19.4%	0.459	0.493	0.725	0.336
2002	51.863	52.985	19.4%	0.495	0.523	0.769	0.356
2003	60.406	57.016	19.5%	0.577	0.563	0.828	0.382

Table 5—US Virgin Islands DIVE Commercial Lobster Index
Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for the spiny lobster dive fishery, all islands combined, years 1976-1986 and 1993-2003.

				Scaled Index			
Year	Nominal	Estimated	CV Index	Obscpue	StdIndex	Upper 95% CI	Lower 95% CI
1976	103.993	86.762	24.3%	0.815	0.975	1.574	0.603
1977	127.653	88.344	21.1%	1.000	1.000	1.518	0.659
1978	109.412	84.361	20.8%	0.857	0.956	1.442	0.634
1979	77.840	50.122	21.5%	0.610	0.568	0.867	0.371
1980	78.014	62.201	21.1%	0.611	0.704	1.070	0.464
1981	69.687	54.390	21.1%	0.546	0.616	0.935	0.406
1982	76.242	52.301	21.1%	0.597	0.593	0.899	0.390
1983	41.467	15.498	21.9%	0.325	0.176	0.272	0.114
1984	36.930	19.840	21.2%	0.289	0.226	0.343	0.148
1985	37.831	23.583	21.2%	0.296	0.268	0.407	0.176
1986	71.935	54.635	20.8%	0.564	0.619	0.934	0.411
1993	37.249	33.212	20.7%	0.292	0.377	0.568	0.250
1994	33.057	28.744	20.8%	0.259	0.327	0.493	0.216
1995	24.856	23.522	20.9%	0.195	0.267	0.404	0.177
1996	27.532	27.388	20.8%	0.216	0.311	0.470	0.206
1997	27.416	24.191	20.9%	0.215	0.275	0.416	0.182
1998	32.003	28.378	20.8%	0.251	0.322	0.486	0.214
1999	34.695	31.229	20.7%	0.272	0.355	0.534	0.236
2000	36.629	32.609	20.6%	0.287	0.370	0.557	0.246
2001	37.211	34.561	20.6%	0.292	0.393	0.590	0.261
2002	36.676	35.151	20.6%	0.287	0.399	0.600	0.266
2003	33.345	31.714	20.7%	0.261	0.360	0.542	0.239

Table 6—St. Croix DIVE Commercial Lobster Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for the St. Croix spiny lobster dive fishery, years 1976-1986 and 1993-2003.

				Scaled Index			
Year	Nominal	Estimated	CV Index	Obscpue	StdIndex	Upper 95% CI	Lower 95% CI
1976	103.993	86.762	24.3%	0.815	0.975	1.574	0.603
1977	127.653	88.344	21.1%	1.000	1.000	1.518	0.659
1978	109.412	84.361	20.8%	0.857	0.956	1.442	0.634
1979	77.840	50.122	21.5%	0.610	0.568	0.867	0.371
1980	78.014	62.201	21.1%	0.611	0.704	1.070	0.464
1981	69.687	54.390	21.1%	0.546	0.616	0.935	0.406
1982	76.242	52.301	21.1%	0.597	0.593	0.899	0.390
1983	41.467	15.498	21.9%	0.325	0.176	0.272	0.114
1984	36.930	19.840	21.2%	0.289	0.226	0.343	0.148
1985	37.831	23.583	21.2%	0.296	0.268	0.407	0.176
1986	71.935	54.635	20.8%	0.564	0.619	0.934	0.411
1993	37.249	33.212	20.7%	0.292	0.377	0.568	0.250
1994	33.057	28.744	20.8%	0.259	0.327	0.493	0.216
1995	24.856	23.522	20.9%	0.195	0.267	0.404	0.177
1996	27.532	27.388	20.8%	0.216	0.311	0.470	0.206
1997	27.416	24.191	20.9%	0.215	0.275	0.416	0.182
1998	32.003	28.378	20.8%	0.251	0.322	0.486	0.214
1999	34.695	31.229	20.7%	0.272	0.355	0.534	0.236
2000	36.629	32.609	20.6%	0.287	0.370	0.557	0.246
2001	37.211	34.561	20.6%	0.292	0.393	0.590	0.261
2002	36.676	35.151	20.6%	0.287	0.399	0.600	0.266
2003	33.345	31.714	20.7%	0.261	0.360	0.542	0.239

Table 7—St. Thomas/St. John DIVE Commercial Lobster Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for the St. Thomas/St. John spiny lobster dive fishery, years 1976-1986 and 1993-2003.

				Scaled Index			
Year	Nominal	Estimated	CV Index	Obscpue	StdIndex	Upper 95% CI	Lower 95% CI
1976	62.040	43.936	39.7%	0.811	0.553	1.189	0.257
1977	72.232	51.230	32.9%	0.944	0.663	1.258	0.349
1978	76.543	76.770	30.7%	1.000	1.000	1.822	0.549
1979	66.727	41.782	30.3%	0.872	0.546	0.988	0.302
1980	64.498	53.260	30.1%	0.843	0.696	1.253	0.386
1981	64.705	53.716	29.8%	0.845	0.702	1.260	0.392
1982	56.967	47.367	29.6%	0.744	0.620	1.107	0.347
1983	32.048	13.121	30.6%	0.419	0.173	0.314	0.095
1984	27.433	11.790	30.7%	0.358	0.155	0.283	0.085
1985	30.277	22.249	30.2%	0.396	0.292	0.527	0.162
1986	47.859	43.993	28.9%	0.625	0.577	1.018	0.327
1993	33.048	27.485	29.2%	0.432	0.361	0.640	0.204
1994	26.578	22.003	29.5%	0.347	0.289	0.515	0.162
1995	31.356	32.738	29.0%	0.410	0.430	0.759	0.244
1996	34.305	35.625	29.0%	0.448	0.468	0.826	0.265
1997	23.458	23.151	29.4%	0.306	0.304	0.541	0.171
1998	31.877	32.628	29.5%	0.416	0.428	0.762	0.240
1999	34.926	33.950	29.3%	0.456	0.445	0.790	0.251
2000	32.773	30.945	29.1%	0.428	0.406	0.719	0.230
2001	35.024	36.276	28.9%	0.458	0.476	0.839	0.271
2002	42.823	41.905	28.7%	0.559	0.550	0.966	0.313
2003	38.544	40.503	29.1%	0.504	0.531	0.939	0.301

Table 8—US Virgin Islands TRAPS Delta-Lognormal TIP Lobster Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for the spiny lobster trap fishery, all islands included, calendar years 1986-2002. Data presented by calendar year for this and subsequent TIP-based tables. Note that US Virgin Islands TIP data are subject to ongoing data recovery efforts (SEDAR8-AW-11). These results should be viewed as preliminary.

					Scaled Index		
Year	**Nominal**	**Estimated**	**C.V.**	**Obscpue**	**StdIndex**	**U95% CI**	**L95% CI**
1986	4.544	0.583	87.5%	0.280	0.040	0.009	0.180
1987	16.276	1.633	82.4%	1.003	0.112	0.026	0.471
1988	12.725	5.472	62.2%	0.784	0.374	0.119	1.175
1989	3.612	1.836	87.2%	0.223	0.126	0.028	0.565
1990	25.413	29.818	45.9%	1.566	2.039	0.851	4.887
1991	14.141	7.654	52.0%	0.871	0.523	0.197	1.392
1992	12.338	13.355	60.6%	0.760	0.913	0.299	2.793
1993	12.586	5.426	88.7%	0.776	0.371	0.081	1.703
1994	14.322	11.965	48.2%	0.883	0.818	0.328	2.040
1995	19.676	19.307	42.9%	1.212	1.320	0.580	3.005
1996	20.514	26.257	45.2%	1.264	1.795	0.759	4.249
1997	21.966	22.295	48.9%	1.354	1.524	0.604	3.850
1998	19.839	16.616	52.6%	1.223	1.136	0.423	3.053
1999	21.450	24.414	49.4%	1.322	1.669	0.656	4.250
2000	20.553	22.825	64.4%	1.267	1.561	0.481	5.065
2001							
2002	19.693	24.545	57.6%	1.213	1.678	0.575	4.899

Table 9—St. Croix TRAPS GLM TIP Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for the spiny lobster Trap fishery of St. Croix, calendar years 1986-2002. Note that US Virgin Islands TIP data are subject to ongoing data recovery efforts (SEDAR8-AW-11). These results should be viewed as preliminary.

					Scaled Index		
Year	**Nominal**	**Estimated**	**C.V.**	**Obscpue**	**StdIndex**	**U95% CI**	**L95% CI**
1986	4.544	0.583	87.5%	0.280	0.040	0.009	0.180
1987	16.276	1.633	82.4%	1.003	0.112	0.026	0.471
1988	12.725	5.472	62.2%	0.784	0.374	0.119	1.175
1989	3.612	1.836	87.2%	0.223	0.126	0.028	0.565
1990	25.413	29.818	45.9%	1.566	2.039	0.851	4.887
1991	14.141	7.654	52.0%	0.871	0.523	0.197	1.392
1992	12.338	13.355	60.6%	0.760	0.913	0.299	2.793
1993	12.586	5.426	88.7%	0.776	0.371	0.081	1.703
1994	14.322	11.965	48.2%	0.883	0.818	0.328	2.040
1995	19.676	19.307	42.9%	1.212	1.320	0.580	3.005
1996	20.514	26.257	45.2%	1.264	1.795	0.759	4.249
1997	21.966	22.295	48.9%	1.354	1.524	0.604	3.850
1998	19.839	16.616	52.6%	1.223	1.136	0.423	3.053
1999	21.450	24.414	49.4%	1.322	1.669	0.656	4.250
2000	20.553	22.825	64.4%	1.267	1.561	0.481	5.065
2001							
2002	19.693	24.545	57.6%	1.213	1.678	0.575	4.899

Table 10—St. Croix DIVE GLM TIP Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for the spiny lobster Dive fishery of St. Croix, calendar years 1991-2003. Note that US Virgin Islands TIP data are subject to ongoing data recovery efforts (SEDAR8-AW-11). These results should be viewed as preliminary.

					Scaled Index		
Year	**Nominal**	**Estimated**	**Coeff Var**	**Obscpue**	**StdIndex**	**U95% CI**	**L95% CI**
1991	30.630	24.015	41.0%	1.419	1.092	2.401	0.497
1992							
1993							
1994	30.033	32.530	24.4%	1.392	1.565	2.534	0.967
1995	21.993	24.307	32.4%	1.019	1.143	2.152	0.607
1996	11.087	13.192	37.1%	0.514	0.613	1.257	0.299
1997	23.904	19.964	26.3%	1.108	0.958	1.606	0.572
1998	18.394	16.253	26.3%	0.852	0.781	1.310	0.466
1999	24.502	17.374	26.8%	1.135	0.834	1.412	0.492
2000	31.226	29.436	27.1%	1.447	1.407	2.394	0.826
2001	16.722	14.943	27.4%	0.775	0.717	1.228	0.418
2002	23.278	17.947	22.7%	1.079	0.870	1.362	0.556
2003	27.219	21.077	23.5%	1.261	1.019	1.620	0.641

Table 11—Puerto Rico Combined Gear Delta-Lognormal TIP Lobster Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, calendar years 1984-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interva	
1984	2.758	5.361	30.3%	0.355	0.679	0.375	1.229
1985	4.282	8.267	31.3%	0.551	1.047	0.568	1.930
1986	4.187	8.770	36.5%	0.538	1.111	0.548	2.253
1987	5.067	7.035	30.6%	0.651	0.891	0.490	1.621
1988	0.621	0.489	123.3%	0.080	0.062	0.009	0.424
1989	6.108	5.388	31.2%	0.785	0.683	0.371	1.256
1990	7.030	5.546	32.2%	0.904	0.703	0.375	1.316
1991	9.461	8.949	27.5%	1.216	1.134	0.660	1.946
1992	8.184	7.101	25.4%	1.052	0.900	0.546	1.482
1993	8.701	8.108	25.7%	1.119	1.027	0.620	1.703
1994	7.664	7.973	27.8%	0.985	1.010	0.585	1.743
1995	9.728	9.205	27.4%	1.251	1.166	0.681	1.997
1996	10.272	10.076	27.9%	1.321	1.276	0.738	2.208
1997	6.864	6.701	32.6%	0.883	0.849	0.449	1.604
1998	9.577	8.571	29.2%	1.231	1.086	0.613	1.923
1999	12.071	11.301	26.2%	1.552	1.432	0.855	2.397
2000	10.330	9.499	28.5%	1.328	1.203	0.688	2.106
2001	13.154	10.879	26.8%	1.691	1.378	0.814	2.332
2002	8.735	7.956	30.1%	1.123	1.008	0.559	1.817
2003	10.748	10.691	27.8%	1.382	1.354	0.784	2.338

Table 12—Puerto Rico Combined Gear GLM TIP Lobster Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, calendar years 1984-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence intervals	
1984	15.897	13.465	20.0%	1.064	1.040	1.546	0.699
1985	18.398	16.480	20.9%	1.232	1.268	1.919	0.838
1986	27.470	23.829	20.5%	1.839	1.831	2.747	1.221
1987	17.090	13.137	20.3%	1.144	1.014	1.516	0.679
1988	12.627	9.014	42.1%	0.845	0.654	1.466	0.291
1989	13.225	10.061	22.2%	0.885	0.776	1.204	0.500
1990	11.796	9.752	23.8%	0.790	0.750	1.199	0.469
1991	15.409	12.486	23.3%	1.032	0.959	1.517	0.606
1992	13.292	10.418	20.0%	0.890	0.807	1.199	0.543
1993	12.610	10.779	20.1%	0.844	0.834	1.243	0.560
1994	10.346	9.261	21.6%	0.693	0.716	1.097	0.468
1995	12.944	12.213	19.9%	0.867	0.945	1.401	0.637
1996	13.599	13.095	20.0%	0.910	1.012	1.504	0.681
1997	10.015	9.066	22.7%	0.671	0.700	1.095	0.447
1998	14.058	12.875	19.5%	0.941	0.996	1.466	0.677
1999	17.389	15.882	19.1%	1.164	1.227	1.791	0.841
2000	15.279	14.394	19.4%	1.023	1.113	1.633	0.758
2001	18.876	16.322	18.9%	1.264	1.261	1.836	0.866
2002	13.637	12.547	19.9%	0.913	0.970	1.439	0.654
2003	14.778	14.587	19.6%	0.989	1.127	1.662	0.764

Table 13—Puerto Rico DIVE Delta-Lognormal TIP Lobster Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, calendar years 1989-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interva	
1989	9.101	7.924	21.7%	0.803	0.743	0.483	1.141
1990	10.147	10.269	19.4%	0.895	0.962	0.655	1.413
1991	14.062	11.959	20.1%	1.240	1.121	0.753	1.668
1992	12.214	11.721	17.1%	1.077	1.098	0.783	1.541
1993	11.772	11.833	16.8%	1.038	1.109	0.795	1.547
1994	9.958	8.974	19.7%	0.878	0.841	0.569	1.243
1995	11.663	13.080	16.5%	1.029	1.226	0.884	1.700
1996	11.091	9.733	17.2%	0.978	0.912	0.648	1.283
1997	7.881	9.547	22.5%	0.695	0.895	0.574	1.395
1998	9.792	8.465	17.0%	0.864	0.793	0.566	1.113
1999	13.670	12.183	16.2%	1.206	1.142	0.828	1.574
2000	12.409	11.216	16.4%	1.094	1.051	0.759	1.455
2001	15.746	13.346	15.4%	1.389	1.251	0.922	1.697
2002	9.064	8.606	18.0%	0.799	0.806	0.565	1.152
2003	11.521	11.218	17.2%	1.016	1.051	0.748	1.478

Table 14—Puerto Rico DIVE Delta-Lognormal with Depth TIP Lobster Index

Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, calendar years 1990-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interva	
1989	9.101	7.924	21.7%	0.803	0.743	0.483	1.141
1990	10.147	10.269	19.4%	0.895	0.962	0.655	1.413
1991	14.062	11.959	20.1%	1.240	1.121	0.753	1.668
1992	12.214	11.721	17.1%	1.077	1.098	0.783	1.541
1993	11.772	11.833	16.8%	1.038	1.109	0.795	1.547
1994	9.958	8.974	19.7%	0.878	0.841	0.569	1.243
1995	11.663	13.080	16.5%	1.029	1.226	0.884	1.700
1996	11.091	9.733	17.2%	0.978	0.912	0.648	1.283
1997	7.881	9.547	22.5%	0.695	0.895	0.574	1.395
1998	9.792	8.465	17.0%	0.864	0.793	0.566	1.113
1999	13.670	12.183	16.2%	1.206	1.142	0.828	1.574
2000	12.409	11.216	16.4%	1.094	1.051	0.759	1.455
2001	15.746	13.346	15.4%	1.389	1.251	0.922	1.697
2002	9.064	8.606	18.0%	0.799	0.806	0.565	1.152
2003	11.521	11.218	17.2%	1.016	1.051	0.748	1.478

Table 15—Puerto Rico FISH TRAPS Delta-Lognormal TIP Lobster Index
Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, calendar years 1989-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interva	
1984	2.869	3.030	17.1%	0.688	0.615	0.438	0.862
1985	4.366	4.415	19.9%	1.047	0.896	0.604	1.328
1986	4.134	5.679	22.9%	0.991	1.152	0.733	1.811
1987	4.116	5.104	21.9%	0.987	1.035	0.672	1.595
1988	0.881	0.865	65.4%	0.211	0.175	0.053	0.579
1989	3.631	4.642	26.4%	0.871	0.942	0.560	1.583
1990	0.935	1.057	54.1%	0.224	0.214	0.078	0.591
1991	4.071	4.193	27.0%	0.976	0.850	0.500	1.446
1992	2.519	3.019	28.5%	0.604	0.612	0.351	1.070
1993	2.239	2.884	36.0%	0.537	0.585	0.291	1.175
1994	4.515	6.027	28.3%	1.083	1.223	0.702	2.131
1995	3.244	4.016	41.5%	0.778	0.815	0.367	1.806
1996	7.745	9.991	30.1%	1.857	2.027	1.125	3.652
1997	3.786	4.304	37.4%	0.908	0.873	0.423	1.801
1998	4.212	4.761	49.3%	1.010	0.966	0.380	2.454
1999	7.612	7.420	27.5%	1.825	1.505	0.878	2.581
2000	2.744	3.070	44.4%	0.658	0.623	0.267	1.455
2001	2.989	3.908	39.9%	0.717	0.793	0.368	1.709
2002	7.294	8.120	36.5%	1.749	1.647	0.812	3.340
2003	9.494	12.092	31.8%	2.277	2.453	1.318	4.567

Table 16—Puerto Rico Lobster Traps GLM TIP Lobster Index
Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, calendar years 1991-2001.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interva	
1991	16.528	16.614	30.8%	0.867	0.944	1.725	0.517
1992	17.353	18.788	36.4%	0.911	1.047	2.119	0.517
1993	25.061	14.781	44.2%	1.315	0.800	1.861	0.344
1994	14.626	11.662	60.7%	0.768	0.581	1.780	0.190
1995							
1996							
1997	18.680	24.148	44.5%	0.980	1.298	3.040	0.554
1998	26.439	25.323	28.5%	1.387	1.446	2.530	0.826
1999	18.680	20.872	33.5%	0.980	1.174	2.254	0.612
2000	20.432	18.661	33.9%	1.072	1.049	2.028	0.543
2001	13.705	11.817	36.5%	0.719	0.661	1.342	0.326

Table 17—Cumulative Lobster Catches Under Various Scenarios

Cumulative removals (millions of pounds caught over the entire time history) from all fisheries considered in each catch scenario (defined in the text).

Scenario	Million pounds
I	12.3
II	12.7
III	16.2
IV	21.4
V	21.9
VI	27.8

Table 18—Summary of Lobster Scenarios Explored with ASPIC

Summary of input data used in ASPIC runs. Runs 111 to 621 use data for all islands, runs st1 to st7 only data for St Thomas St John and stc1 to stc7 data for St Croix only.

Run code	Years of catch data included (values in italics are calculated rather than reported)				Years of CPUE indices used				Assumption about initial biomass
	Commercial fisheries			Sport	Standardized indices			Nominal cpue	
	Puerto Rico	St Thomas St John	St Croix		Puerto Rico commercial	St Thomas St John Trap	St Croix Dive	Puerto Rico commercial	
111	1969-2003	1975-87, ’92-2002	1975-87, ’92-2002	None	1983-2003	1975-86, ’93-2002	1975-86, ’93-2002	None	$B_{1969} = K$
114	1969-2003	1975-87, ’92-2002	1975-87, ’92-2002	None	1983-2003	1975-86, ’93-2002	1975-86, ’93-2002	None	B_{1969} = estimated
121	1969-2003	1975-87, ’92-2002, *2003*	1975-87, ’92-2002, *2003*	None	1983-2003	1975-86, ’93-2002	1975-86, ’93-2002	1969-76, ’80, ’82, ’85, ’88	$B_{1969} = K$
124	1969-2003	1975-87, ’92-2002, *2003*	1975-87, ’92-2002, *2003*	None	1983-2003	1975-86, ’93-2002	1975-86, ’93-2002	1969-76, ’80, ’82, ’85, ’88	B_{1969} = estimated
321[2]	*1945-68*, ’69-2003	1975-87, ’92-2002, *2003*	1975-87, ’92-2002, *2003*	None	1983-2003	1975-86, ’93-2002	1975-86, ’93-2002	1969-76, ’80, ’82, ’85, ’88	$B_{1945} = K$
324	*1945-51,* ’52, *’53-68*, ’69-2003	1975-87, ’92-2002, *2003*	1975-87, ’92-2002, *2003*	None	1983-2003	1975-86, ’93-2002	1975-86, ’93-2002	1969-76, ’80, ’82, ’85, ’88	B_{1945} = estimated
421	*1945-51,* ’52, *’53-68*, ’69-2003	1975-87, ’92-2002, *2003*	1975-87, ’92-2002, *2003*	None	1983-2003	1975-86, ’93-2002	1975-86, ’93-2002	1969-76, ’80, ’82, ’85, ’88	$B_{1945} = K$
621	*1945-51,* ’52, *’53-68*, ’69-2003	1975-87, ’92-2002, *2003*	1975-87, ’92-2002, *2003*	*1945-2003*	1983-2003	1975-86, ’93-2002	1975-86, ’93-2002	1969-76, ’80, ’82, ’85, ’88	$B_{1945} = K$
624	*1945-51,* ’52, *’53-68*, ’69-2003	1975-87, ’92-2002	1975-87, ’92-2002	*1945-2003*	1983-2003	1975-86, ’93-2002	1975-86, ’93-2002	1969-76, ’80, ’82, ’85, ’88	B_{1945} = estimated

[2] Runs 321 and 421 only differ in the calculated catches for Puerto Rico in the years prior to 1969. 321 assumes a slow increase in catch from 1945 to 1969. 421 assumes a fast increase in catches to the levels reported in 1952 and then a constant catch between 1953 to 1968.

st1	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	None	1975-86, ’93-2002	None	None	B_{1975} = K
st2	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	None	1975-86, ’93-2002	None	None	B_{1975} = 0.75 K
st3	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	None	1975-86, ’93-2002	None	None	B_{1975} = 0.5 K
st4	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	None	1975-86, ’93-2002	None	None	B_{1975} = estimated
st5	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	None	1975-86, ’93-2002	None	None	B_{1975} = estimated r = 0.4
st6	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	None	1975-86, ’93-2002	None	None	B_{1975} = K r = 0.4
st7	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	None	1975-86, ’93-2002	None	None	B_{1975} = 0.75 K r = 0.4
stc1	None	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	1975-86, ’93-2002	None	None	B_{1975} = K
stc2	None	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	1975-86, ’93-2002	None	None	B_{1975} = 0.75 K
stc3	None	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	1975-86, ’93-2002	None	None	B_{1975} = 0.5 K
stc4	None	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	1975-86, ’93-2002	None	None	B_{1975} = estimated
stc5	None	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	1975-86, ’93-2002	None	None	B_{1975} = estimated r = 0.4
stc6	None	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	1975-86, ’93-2002	None	None	B_{1975} = K r = 0.4
stc7	None	None	1975-87, *’88-91*, ’92-2002, *2003*	None	None	1975-86, ’93-2002	None	None	B_{1975} = 0.75 K r = 0.4

Table 19—Summary Results from Lobster Scenarios Explored with ASPIC

Results from fits to spiny lobster data with ASPIC. Details of parameters used in each run are presented in Table 18. Values in bold were not estimated because they were fixed for that run to facilitate convergence. Values in italics and underlined correspond to limits of constraint for that parameter indicating that the fit did not converge but rather stopped at a constraint.

Run code	MSY	K	B_1/B_{msy}	r	B_{2003}/B_{msy}	F_{2003}/F_{msy}	Notes
111	225,000	8,894,000	**2.0**	*0.1*	0.65	2.38	did not converge before r hit constraint
114	3,142,000	6,944,000	1.26	1.81	1.94	0.06	Very high r - very unlikely
121	301,600	10,920,000	**2.0**	0.11	1.16	1.01	
124	250,000	6,847,000	2.2	0.14	0.6	2.28	
321	287,600	6,689,000	**2.0**	0.17	0.51	2.31	
324	4,038,000	1,841,000	2.00	1.82	1.89	0.1	Very high r - very unlikely
421	2,183,000	9,208,000	**2.0**	0.94	1.91	0.08	High r - unlikely
621	595,400	5,738,000	**2.0**	0.41	1.42	0.53	
624	626,300	4,826,666	2.27	0.52	1.46	0.5	
st1	48,980	886,700	**2.0**	0.21	0.82	1.4	
st2	51,500	760,400	**1.5**	0.27	0.79	1.37	
st3	55,350	592,800	**1.0**	0.37	0.81	1.25	
st4	47,860	946,400	2.3	0.2	0.83	1.4	
st5	57,610	576,100	2.97	**0.4**	0.97	1.01	Very high initial biomass very unlikely
st6	56,400	564,000	**2.0**	**0.4**	0.85	1.17	
st7	56,020	560,200	**1.5**	**0.4**	0.74	1.34	
stc1	28,970	1,159,000	**2.0**	*0.1*	0.97	3.64	did not converge before r hit constraint
stc2	131,800	263,600	**1.5**	*2.0*	1.39	0.6	did not converge before r hit constraint
stc3	131,500	263,000	**1.0**	*2.0*	1.39	0.6	did not converge before r hit constraint
stc4	58,070	2,021,000	4.2	0.11	1.53	0.75	Very high initial biomass very unlikely
stc5	79,250	792,500	3.59	**0.4**	1.23	1.08	Very high initial biomass very unlikely
stc6	72,240	722,400	**2.0**	**0.4**	1.13	1.28	
stc7	68,880	688,800	**1.5**	**0.4**	1.08	1.4	

Table 20—Commercial Lobster Landings Used in the Age-Structured Model

Reported commercial landings (in pounds) from the U.S. Caribbean. Puerto Rico (calendar years 1983-2002) are reported landings, U.S. Virgin Islands (1975-2002) are expanded reported landings. Landings from historic documents (1969-1982) are included.

Year	Puerto Rico Historic	Puerto Rico	USVI-Dive (Expanded)	USVI-Traps (Expanded)	TOTAL Reported
1969	354000				
1970	417000				
1971	258000				
1972	237000				
1973	250000				
1974	244000				
1975	311000		5233	27054	32286
1976	384000		4145	23036	27181
1977	421000		17672	54785	72457
1978	451000		30293	123196	153489
1979	512000		7824	62352	70176
1980	474000		16211	81303	97514
1981	481000		11575	79118	90693
1982	359000		10802	76414	87216
1983		273700	8104	74315	356119
1984		248000	15987	53889	317876
1985		211100	11981	53833	276914
1986		210100	18919	42837	271856
1987		153400	6193	18317	177910
1988		141200			141200
1989		185800			185800
1990		168700			168700
1991		211600			211600
1992		160500	9316	38744	208560
1993		168900	37294	91095	297289
1994		192100	29374	69411	290885
1995		279200	24072	92863	396134
1996		280600	30533	119744	430878
1997		283300	33651	83338	400289
1998		298500	40196	59089	397784
1999		327100	50724	53494	431318
2000		258400	86407	47198	392005
2001		280600	117959	48912	447471
2002		300400	124221	56587	481208

Table 21—Lobster Abundance Indices Used in Age-Structured Model

Scaled relative indices of abundance selected for use in the ASPM assessment model. The Puerto Rico index is from a Delta-Lognormal standardized index estimated by Mateo and Die (2004) from the commercial landings. The St. Croix (STX) and St. Thomas/St. John (STT/STJ) are standardized indices from the commercial landings calculated with a GLM approach by Valle-Esquivel (SEDAR8-AW-03).

Year	PR	STX-DIVE	STT/STJ-TRAPS
1969			
1970			
1971			
1972			
1973			
1974			
1975			
1976		1.000	0.629
1977		0.619	0.636
1978		0.515	0.762
1979		0.322	0.737
1980		0.399	0.916
1981		0.381	1.000
1982		0.407	0.636
1983	0.496	0.273	0.638
1984	0.529	0.204	0.591
1985	0.606	0.189	0.552
1986	0.885	0.404	0.677
1987	0.732		
1988	0.830		
1989	0.872		
1990	0.684		
1991	0.704		
1992	0.839		
1993	0.740	0.267	0.637
1994	0.777	0.241	0.550
1995	0.858	0.164	0.603
1996	0.790	0.195	0.638
1997	0.825	0.187	0.650
1998	1.000	0.211	0.570
1999	0.996	0.227	0.544
2000	0.792	0.245	0.527
2001	0.843	0.259	0.493
2002		0.259	0.523
2003		0.233	0.563

Table 22—Parameter Estimates from Various Age-Structured Lobster Model Configurations
Point estimates (standard deviation) for natural mortality (M), virgin recruitment (R0) and maximum reproductive rate (α) for models which attempted to fit an index derived from Puerto Rico TIP data, St. Croix Dive data, or St. John Trap data.

Parameter	Puerto Rico	STX Dive	STJ Trap
M	0.44 (0.04)	0.54 (0.05)	0.52 (0.05)
R0	6.2E+5 (3.5E+5)	2.6E+4 (1.2E+4)	6.1E+4 (2.5E+4)
α	14.8 (6.5)	15.9 (6.2)	15.9 (6.2)

Table 23—Statistical Examination of Factors on Mean Lobster Lengths
Multiple way analyses of variance for spiny lobster for year, gear and region on Puerto Rico biostatistical TIP data.

MANOVA Model CL by YEAR GEAR and REGION

Test	Value	Exact F	NumDF	DenDF	Prob>F
MODEL	0.1638712	42.9288	30	7859	<.0001
YEAR	0.0217382	28.4735	6	7859	<.0001
REGION	0.0005476	4.3036	1	7859	0.0381
GEAR	0.0003798	2.9845	1	7859	0.0841
YEAR*REGION	0.0167755	11.9853	11	7859	<.0001
YEAR*GEAR	0.0159545	17.9124	7	7859	<.0001
REGION*GEAR	0.0057412	22.5602	2	7859	<.0001

12 Figures

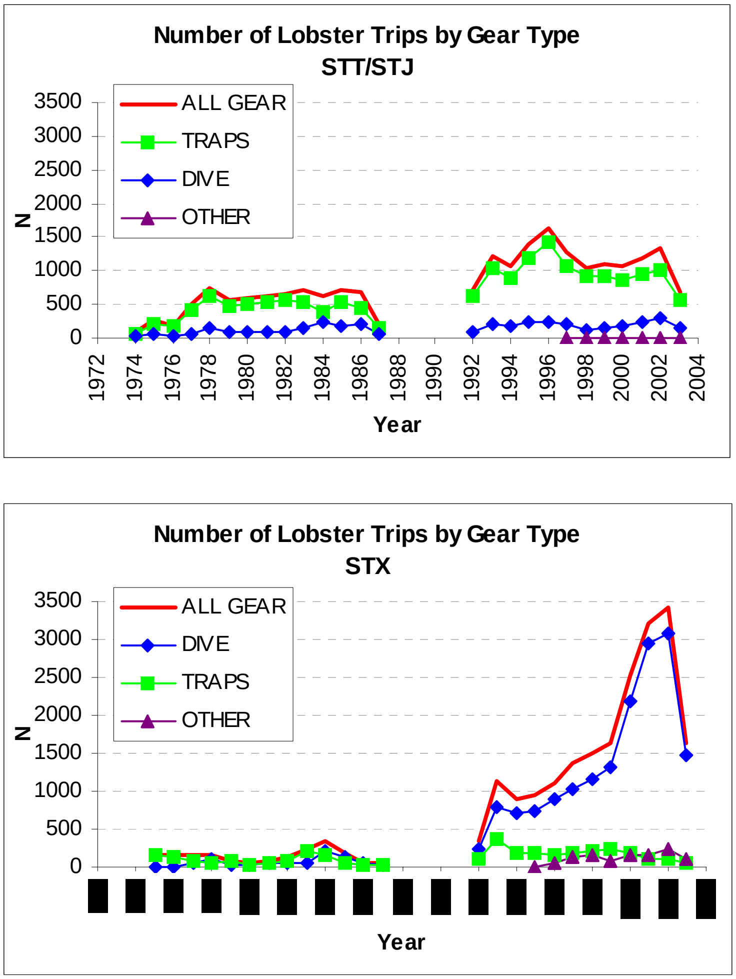
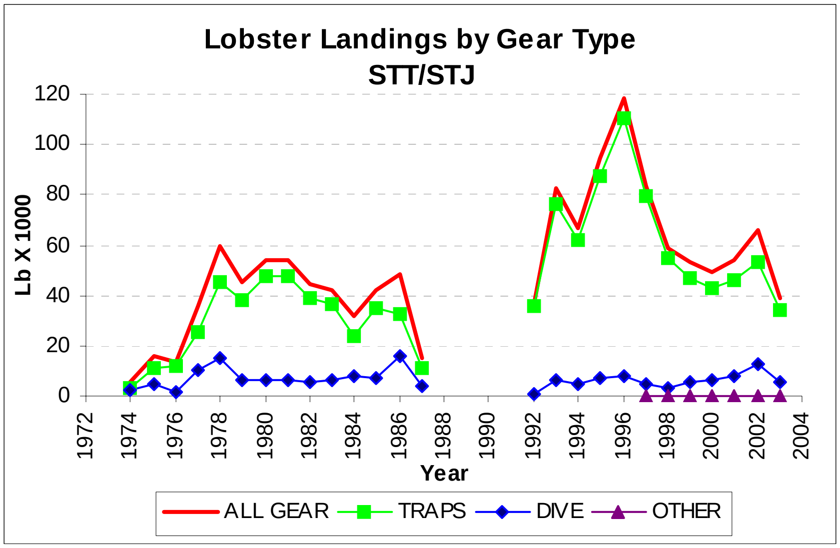


Figure 1—Number of US Virgin Islands Lobster Commercial Trips by District, Gear, and Year

Data for years 1974 includes only St. Thomas/St. John and only January-June of 2003 for both districts is represented. Lobster landings are filtered for outliers (>250 lb/trip removed). Data from 1986-87 to 1991-92 (highlighted) is incomplete, missing or contained outliers and is currently under review. Data organized into fishing years, which begin July 1 and end June 30, for this and subsequent commercial landings figures.



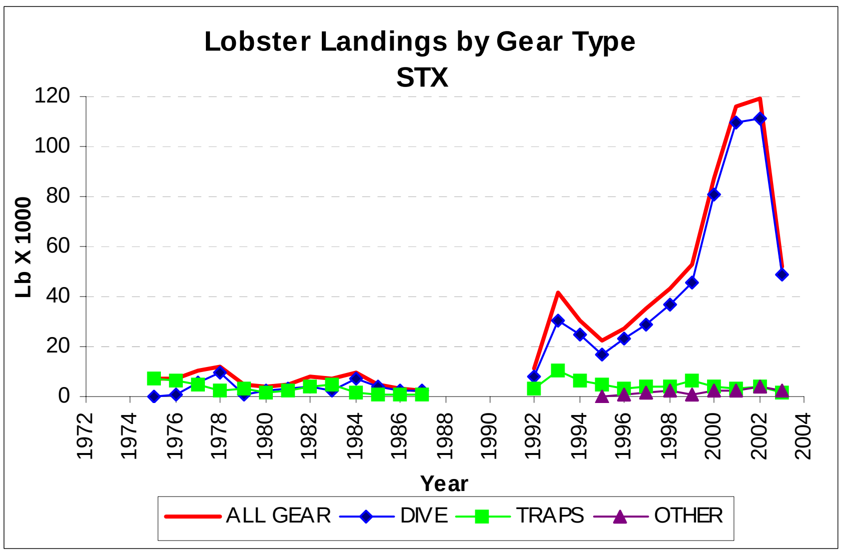


Figure 2—Expanded US Virgin Islands Commercial Lobster Landings by District, Year, and Gear

Landings estimated using a single expansion factor (Valle-Esquivel, SEDAR-AW-03). Data for 1974 only available for second half of the year from St. Thomas/St. John, and data for 2003 was available for all islands but only for the first half of the year. Lobster landings are filtered for outliers (>250 lb/trip removed). Data from 1986-87 to 1991-92 (highlighted) is incomplete, missing or contained outliers and is currently under review.

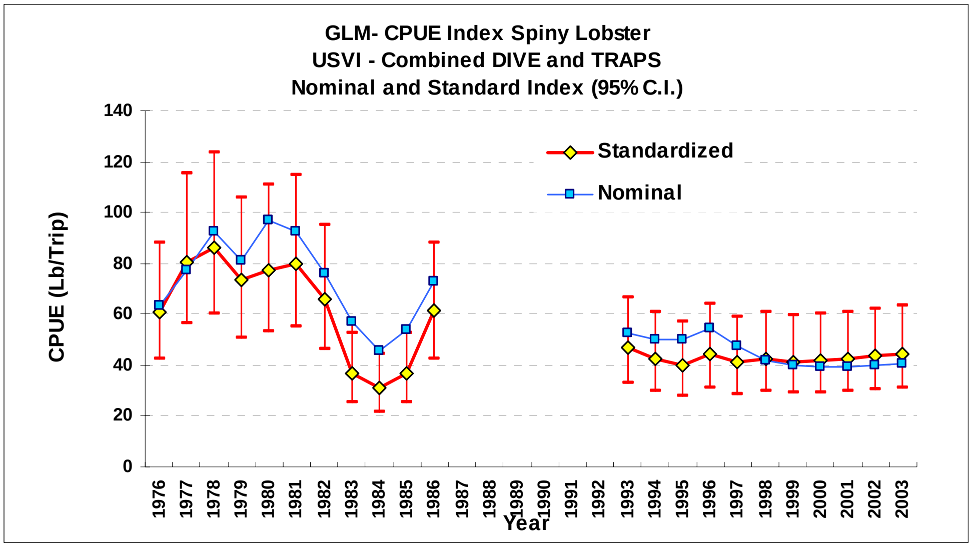


Figure 3—US Virgin Islands DIVE and TRAPS Combined Commercial Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for the U.S. Virgin Islands spiny lobster, all islands included, DIVE and TRAPS combined, years 1976-1986 and 1993-2003.

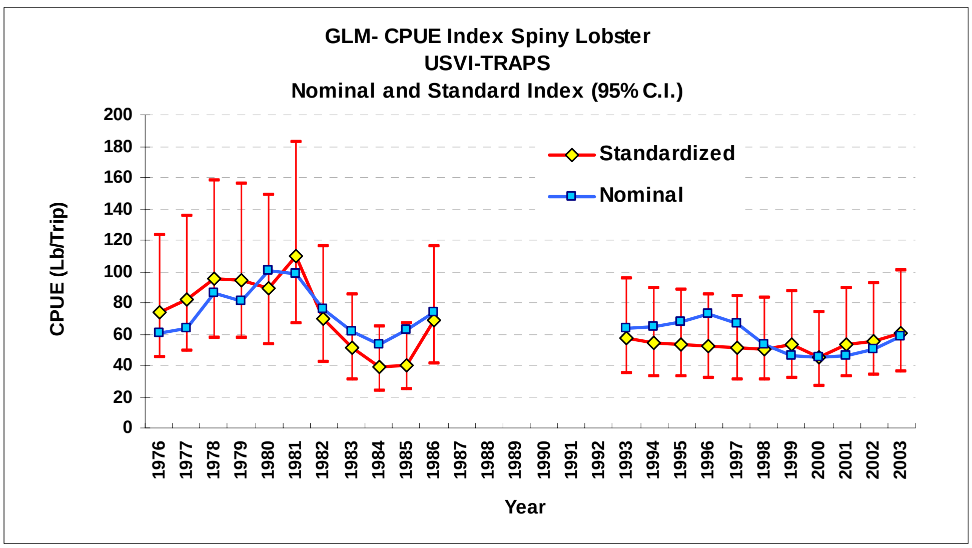


Figure 4—US Virgin Islands TRAPS Commercial Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for the U.S. Virgin Islands spiny lobster trap fishery, all islands included, years 1976-1986 and 1993-2003.

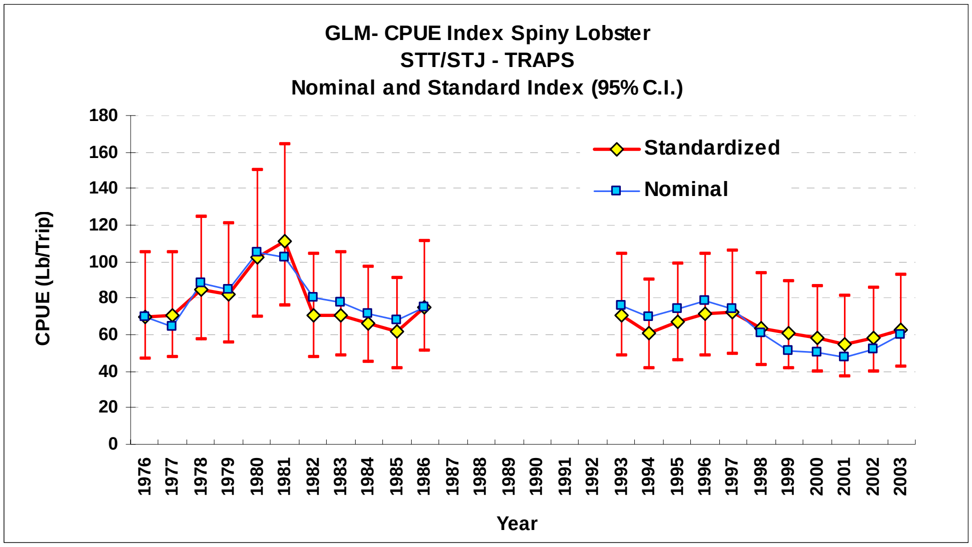


Figure 5—St. Thomas/St. John TRAPS Commercial Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for the St. Thomas/St. John spiny lobster trap fishery, years 1976-1986 and 1993-2003.

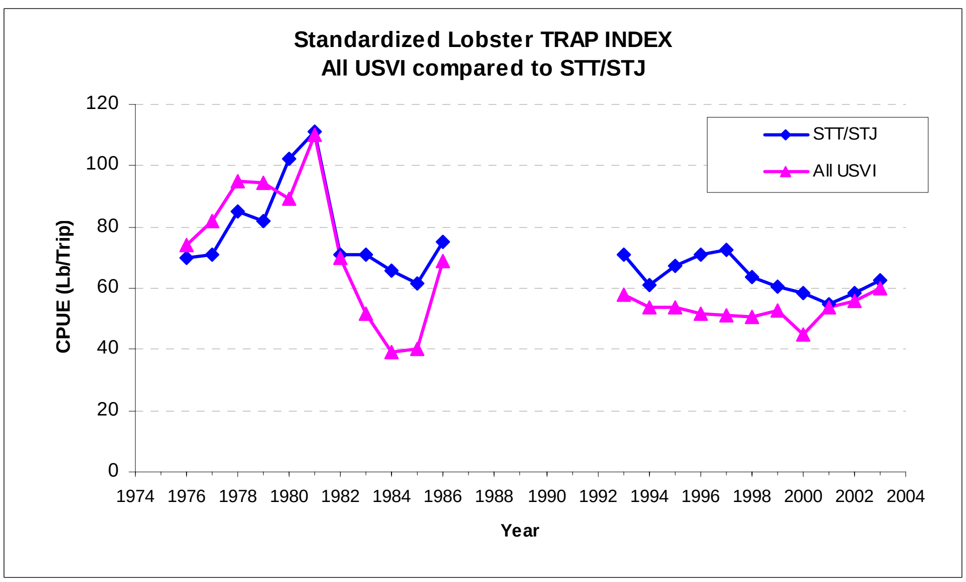


Figure 6—US Virgin Islands Vs. St. Thomas/St. John TRAPS Commercial Lobster Indices
Comparison of standardized lobster TRAP indices for the whole US Virgin Islands and only for St.Thomas/St. John, where this gear represents 80% of the lobster effort.

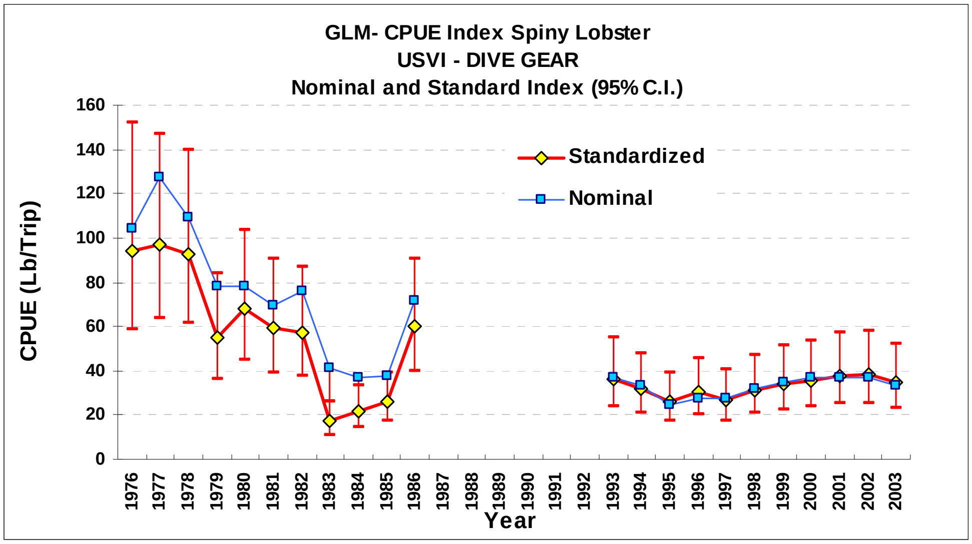


Figure 7—US Virgin Islands DIVE Commercial Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for the U.S. Virgin Islands spiny lobster dive fishery, all islands included, years 1976-1986 and 1993-2003.

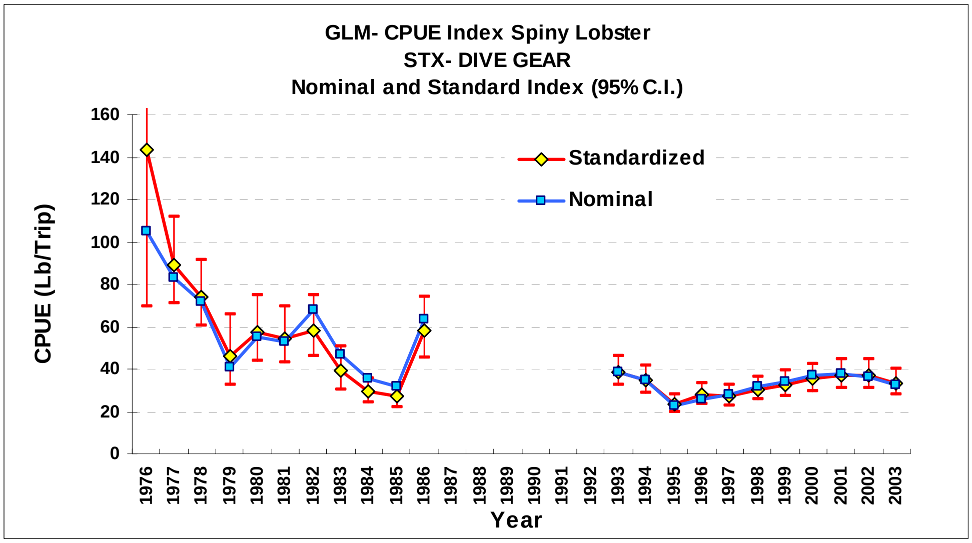


Figure 8—St. Croix DIVE Commercial Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for the STX spiny lobster dive fishery, years 1976-1986 and 1993-2003.

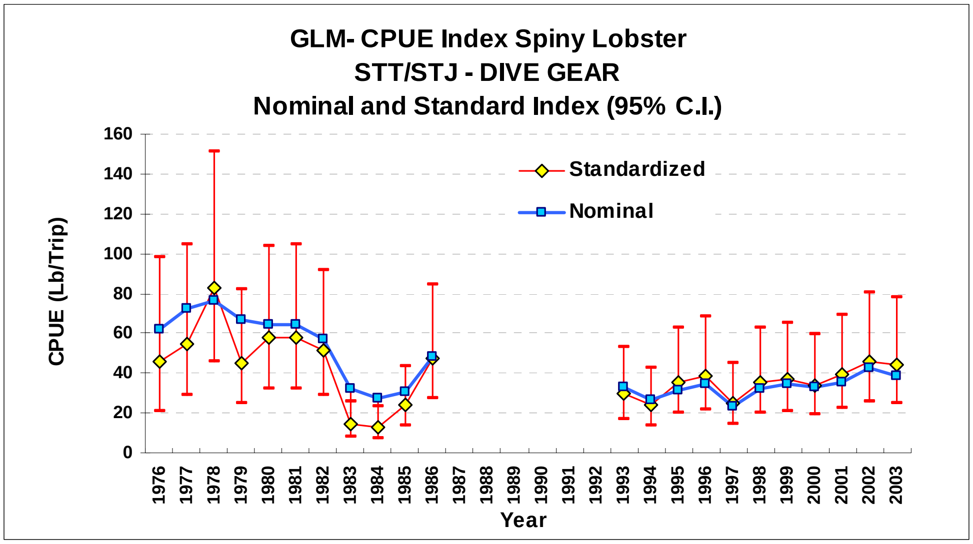


Figure 9—St. Thomas/St. John DIVE Commercial Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for the St. Thomas/St. John spiny lobster dive fishery, years 1976-1986 and 1993-2003.

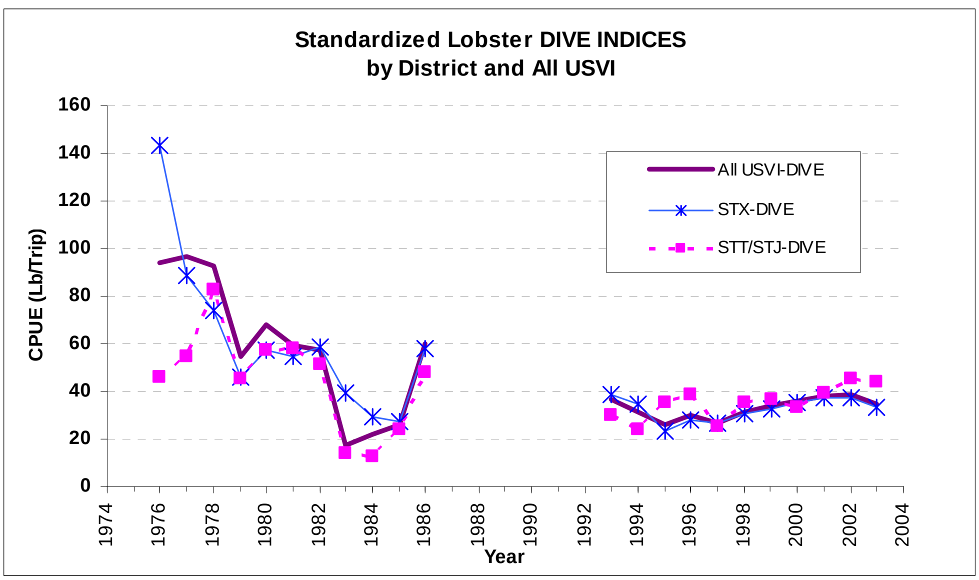


Figure 10—US Virgin Islands Vs. St. Croix Vs. St. Thomas/St. John DIVE Commercial Lobster Indices
Comparison of standardized lobster DIVE indices among districts and for the whole US Virgin Islands.

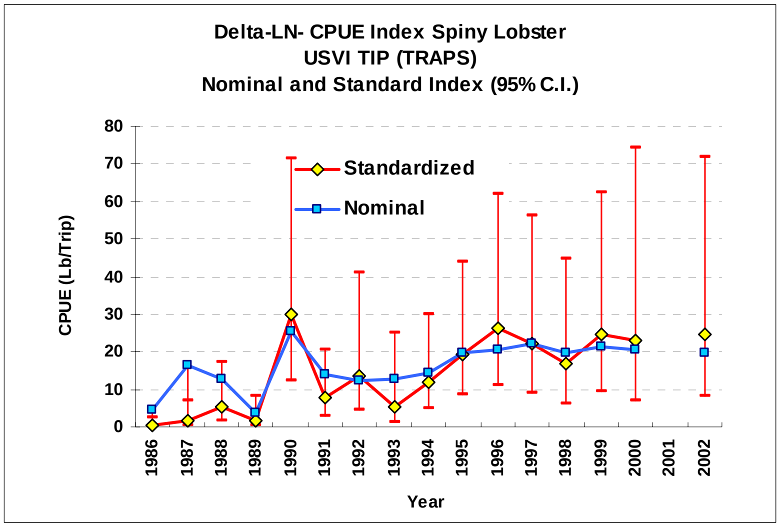


Figure 11—US Virgin Islands TRAPS Delta-Lognormal TIP Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for the U.S. Virgin Islands spiny lobster, all islands included, DIVE and TRAPS combined, calendar years 1986-2002.

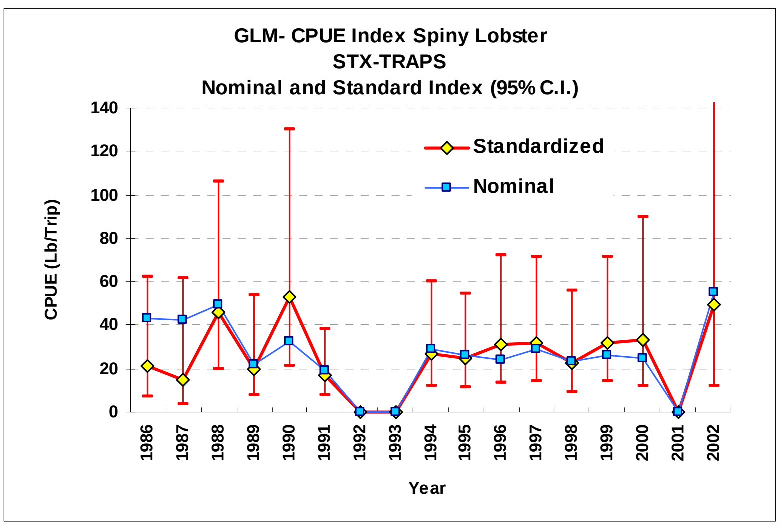


Figure 12—St. Croix TRAPS GLM TIP Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for the St. Croix spiny lobster Trap fishery, calendar years 1986-2002.

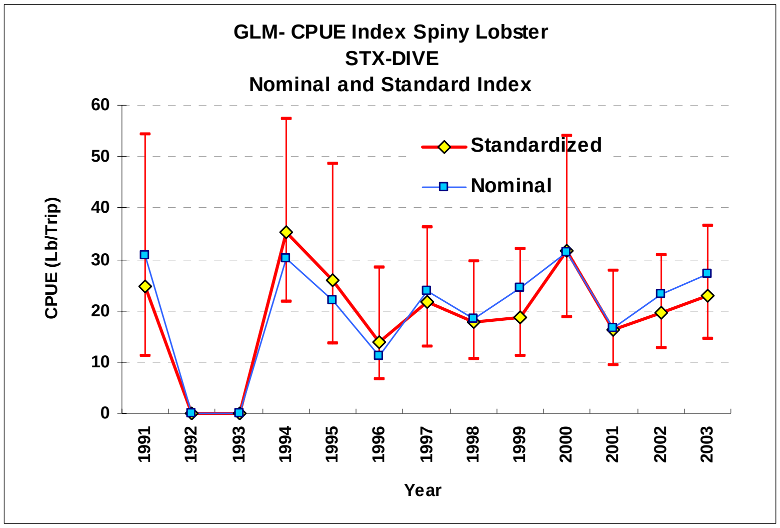


Figure 13—St. Croix DIVE GLM TIP Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for the St. Croix spiny lobster Dive fishery, calendar years 1991-2003.

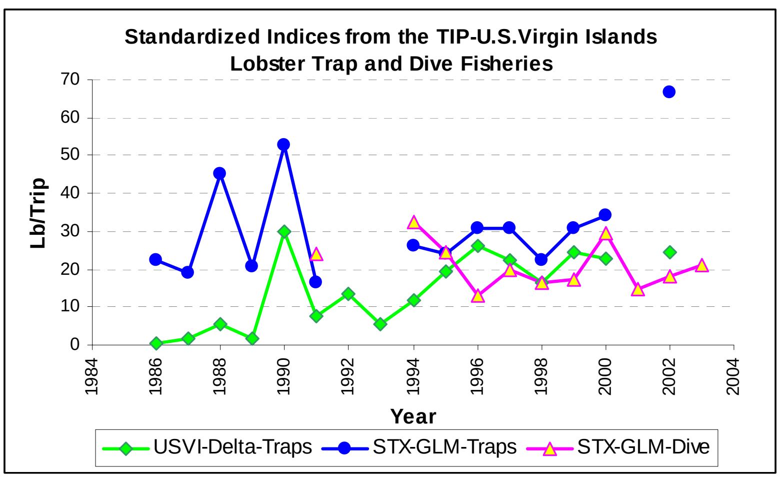


Figure 14—Comparison of US Virgin Islands TIP Lobster Index
A summary of the standardized CPUE indices (in lb/trip) estimated in this study for lobster trap and dive fisheries; the model used is specified.

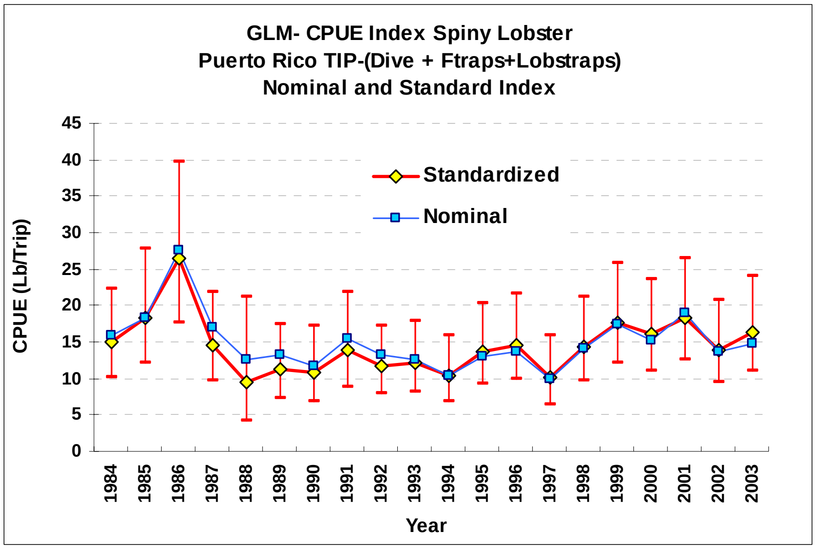


Figure 15—Puerto Rico Combined Gears GLM TIP Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, calendar years 1984-2003.

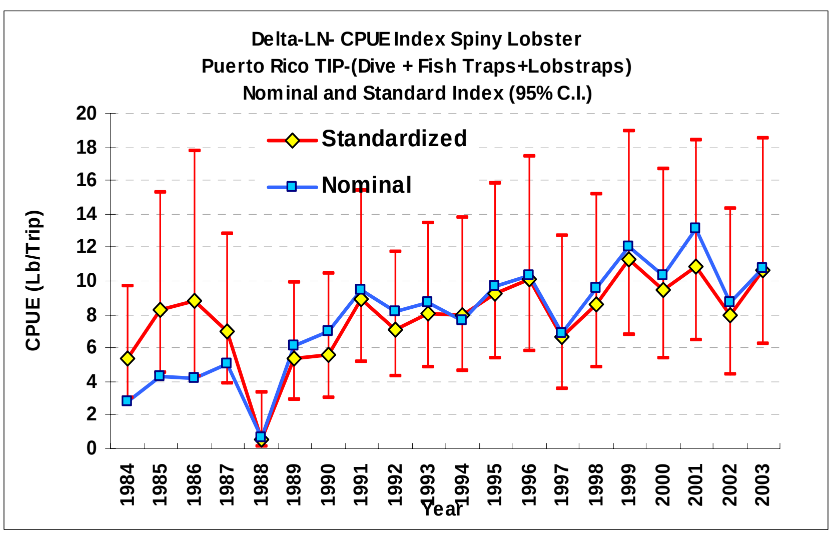


Figure 16—Puerto Rico Combined Gears Delta-Lognormal TIP Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, calendar years 1984-2003.

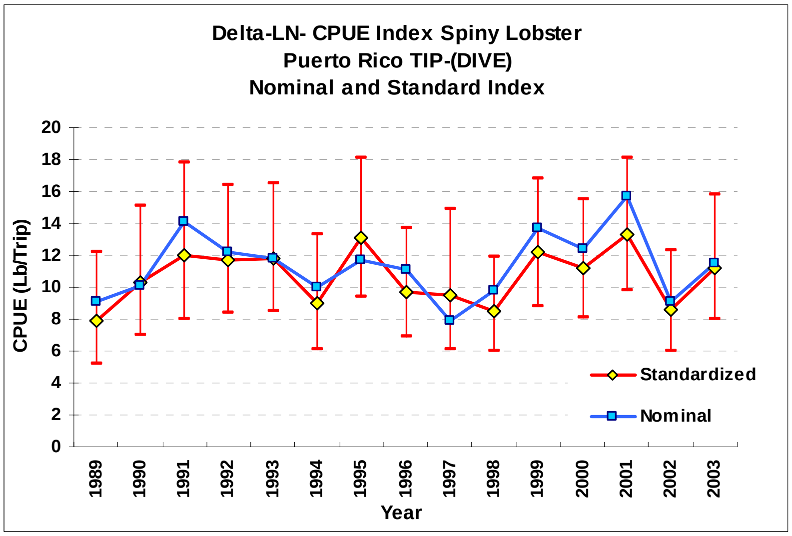


Figure 17—Puerto Rico DIVE Delta-Lognormal TIP Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, calendar years 1989-2003.

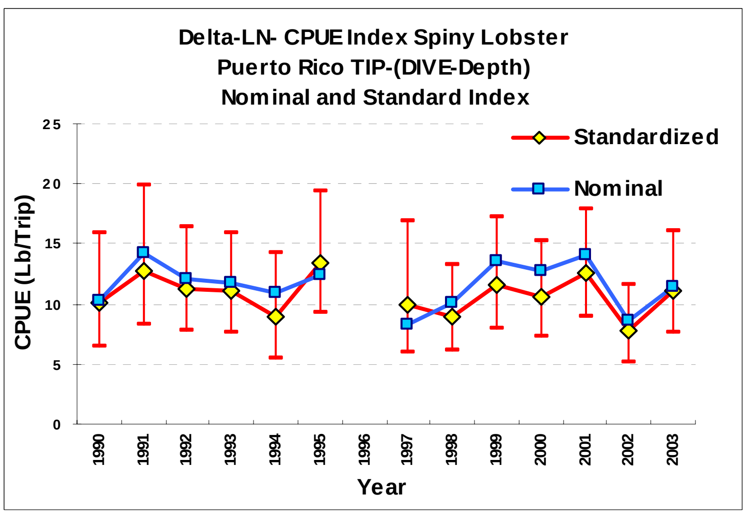


Figure 18—Puerto Rico Combined Gears Delta-Lognormal with Depth TIP Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, calendar years 1989-2003.

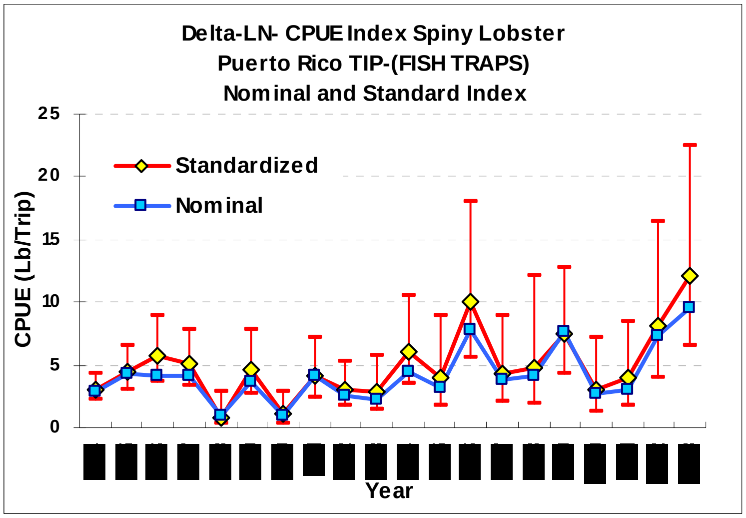


Figure 19—Puerto Rico FISH TRAPS Delta-Lognormal TIP Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, calendar years 1984-2003.

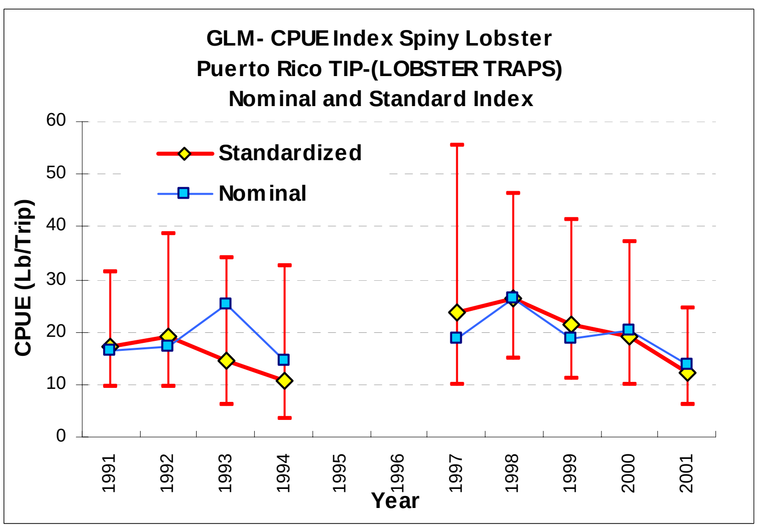


Figure 20—Puerto Rico LOBSTER TRAPS Delta-Lognormal TIP Lobster Index
Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, calendar years 1991-2001.

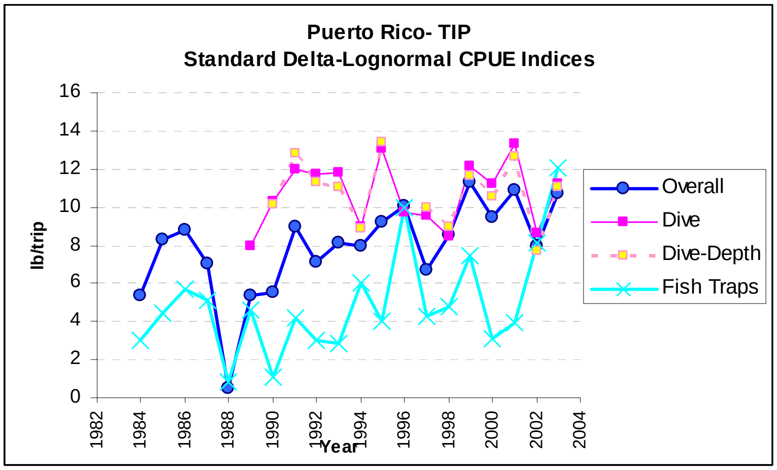


Figure 21—Comparison of Puerto Rican TIP Lobster Indices
A summary of the standardized Delta-Lognormal indices (in lb/trip) estimated for the overall combined fishery, and the dive and fish trap fisheries.

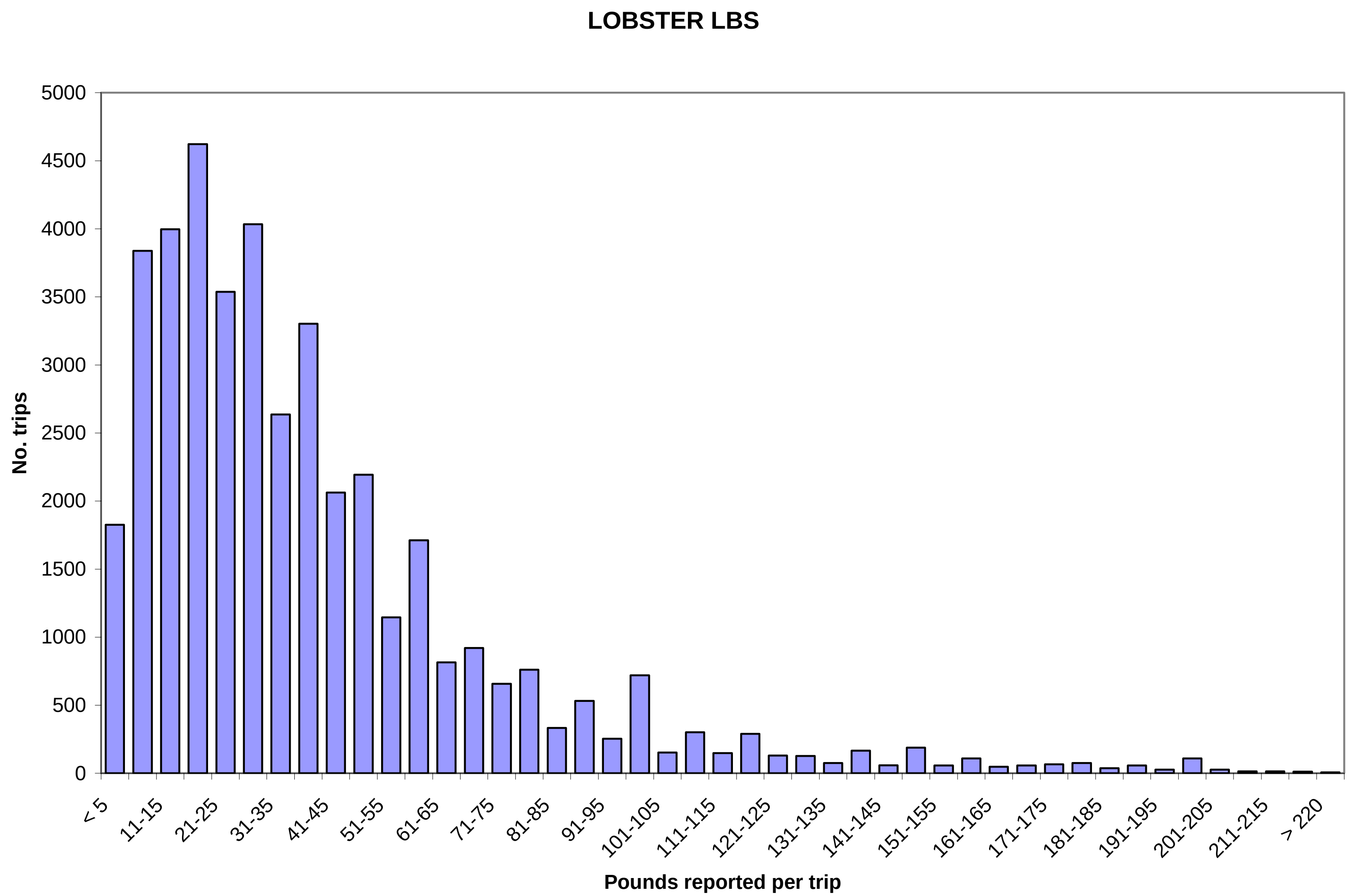


Figure 22—Lobster Landings Weight Reported Per Trip for All US Virgin Islands
Data from commercial catch records from 1974 to mid-2003 used for this and subsequent frequency histograms, with bars representing number of trips that fall into each weight category.

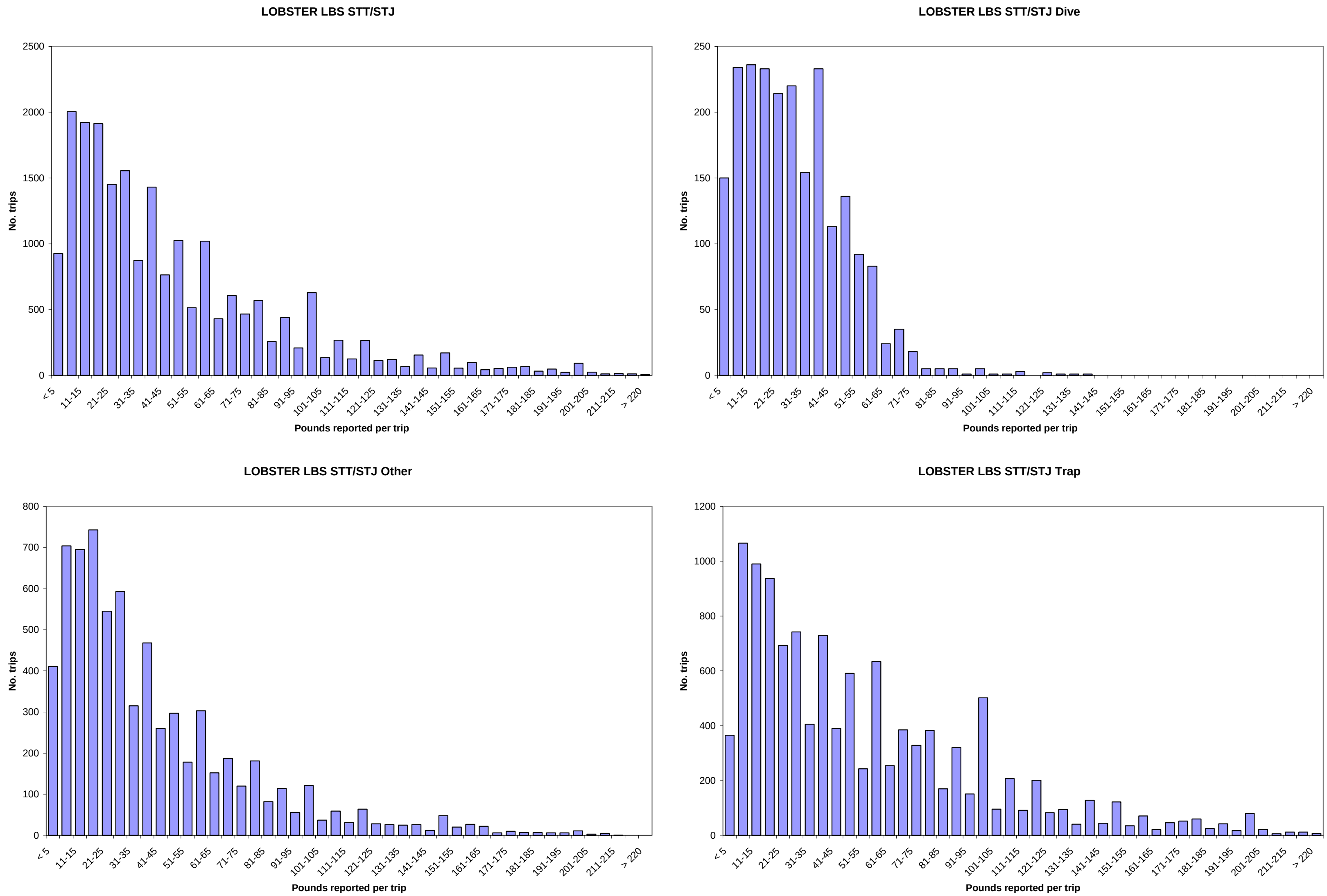


Figure 23—Lobster Landings Weight Reported Per Trip for St. Thomas/St. John by Gear
Data from commercial catch records, with bars representing number of trips that fall into each weight category.

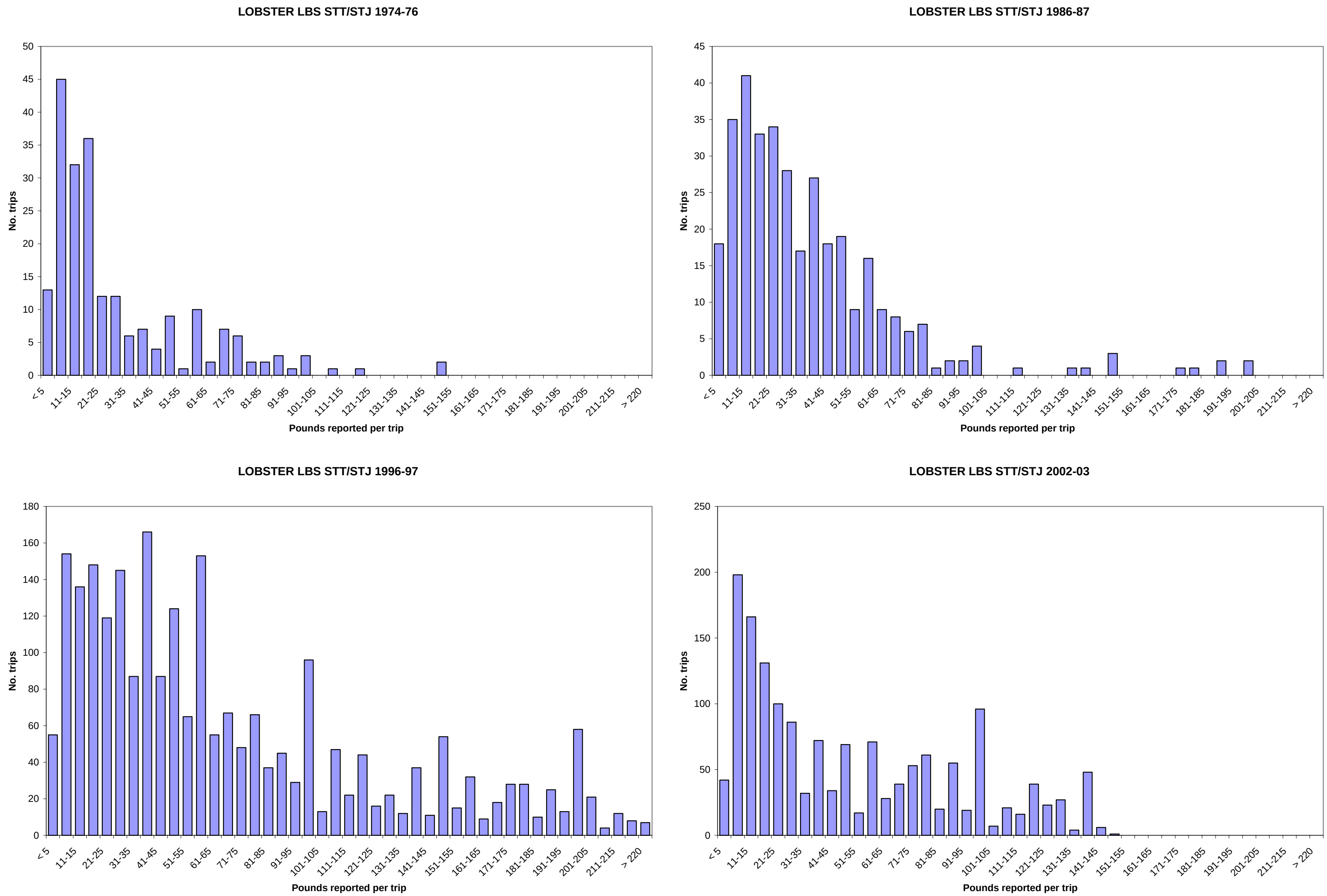


Figure 24—Lobster Landings Weight Reported Per Trip for St. Thomas/St. John Traps by Year
Data from commercial catch records, with bars representing number of trips that fall into each weight category. Calendar years used.

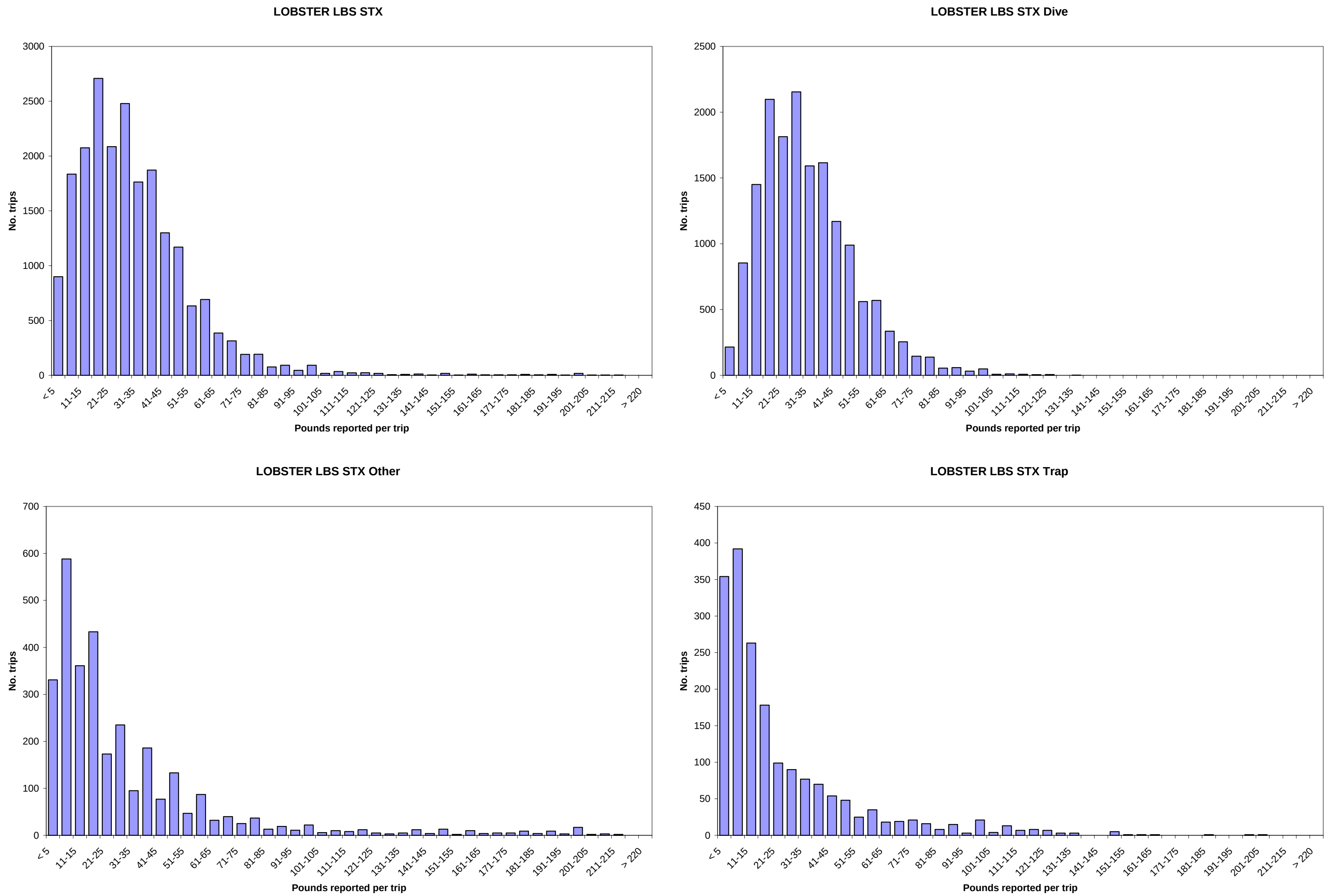


Figure 25—Lobster Landings Weight Reported Per Trip for St. Croix by Gear
Data from commercial catch records, with bars representing number of trips that fall into each weight category.

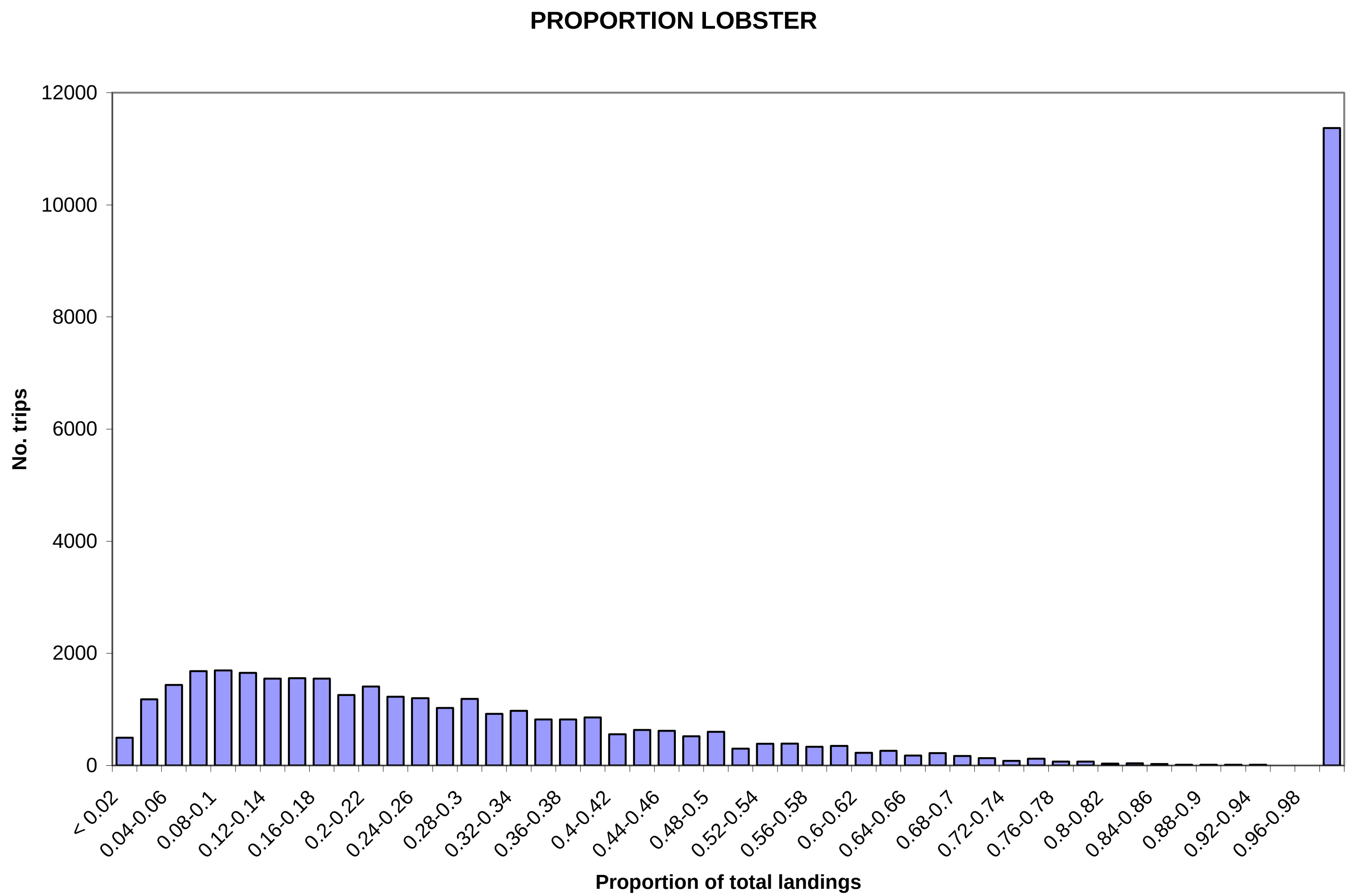


Figure 26—Lobster as a Proportion of Total Landings per Trip for All US Virgin Islands
Data from commercial catch records, with bars representing number of trips that fall into each proportion category.

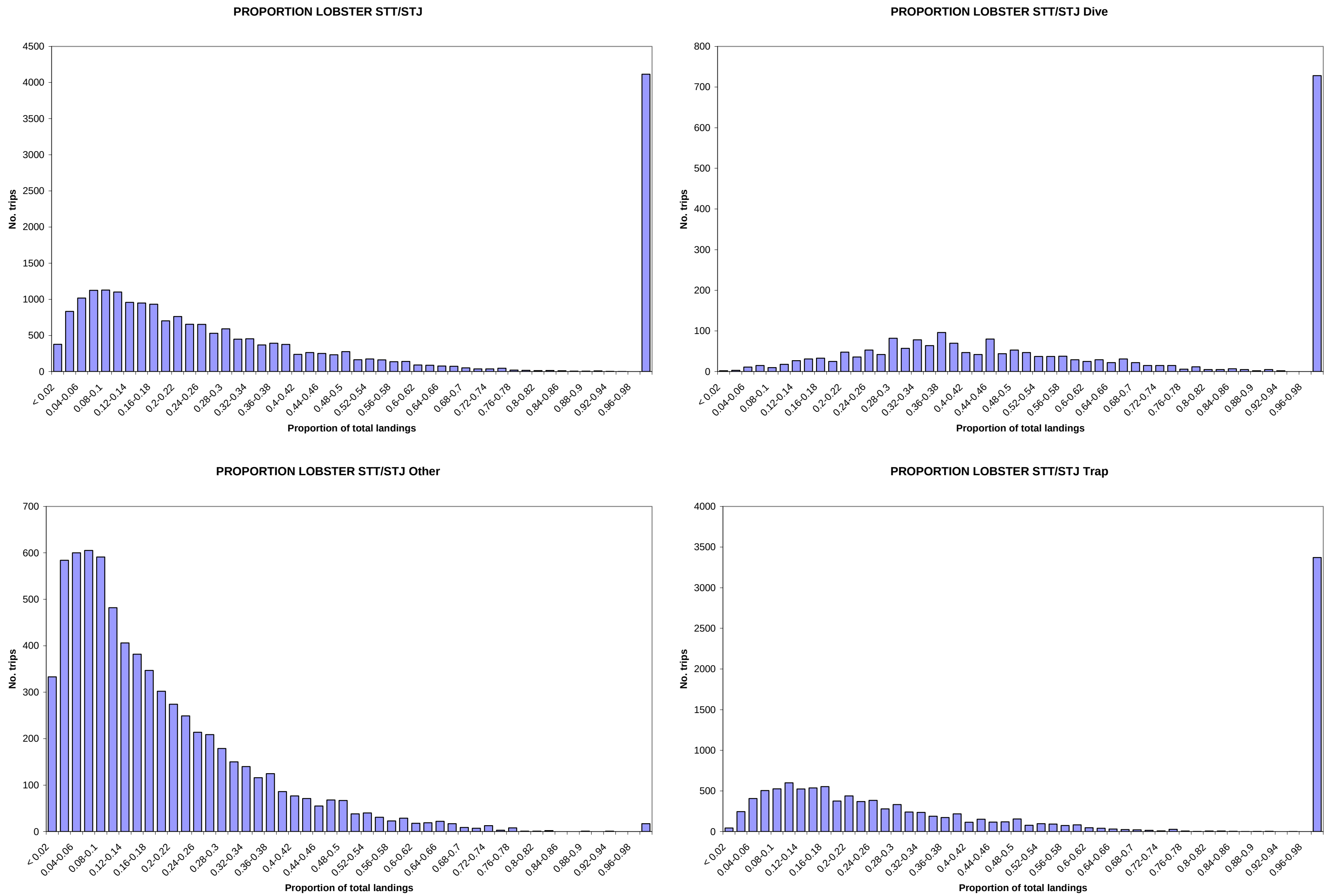


Figure 27—Lobster as a Proportion of Total Landings per Trip for St. Thomas/St. John by Gear
Data from commercial catch records, with bars representing number of trips that fall into each proportion category.

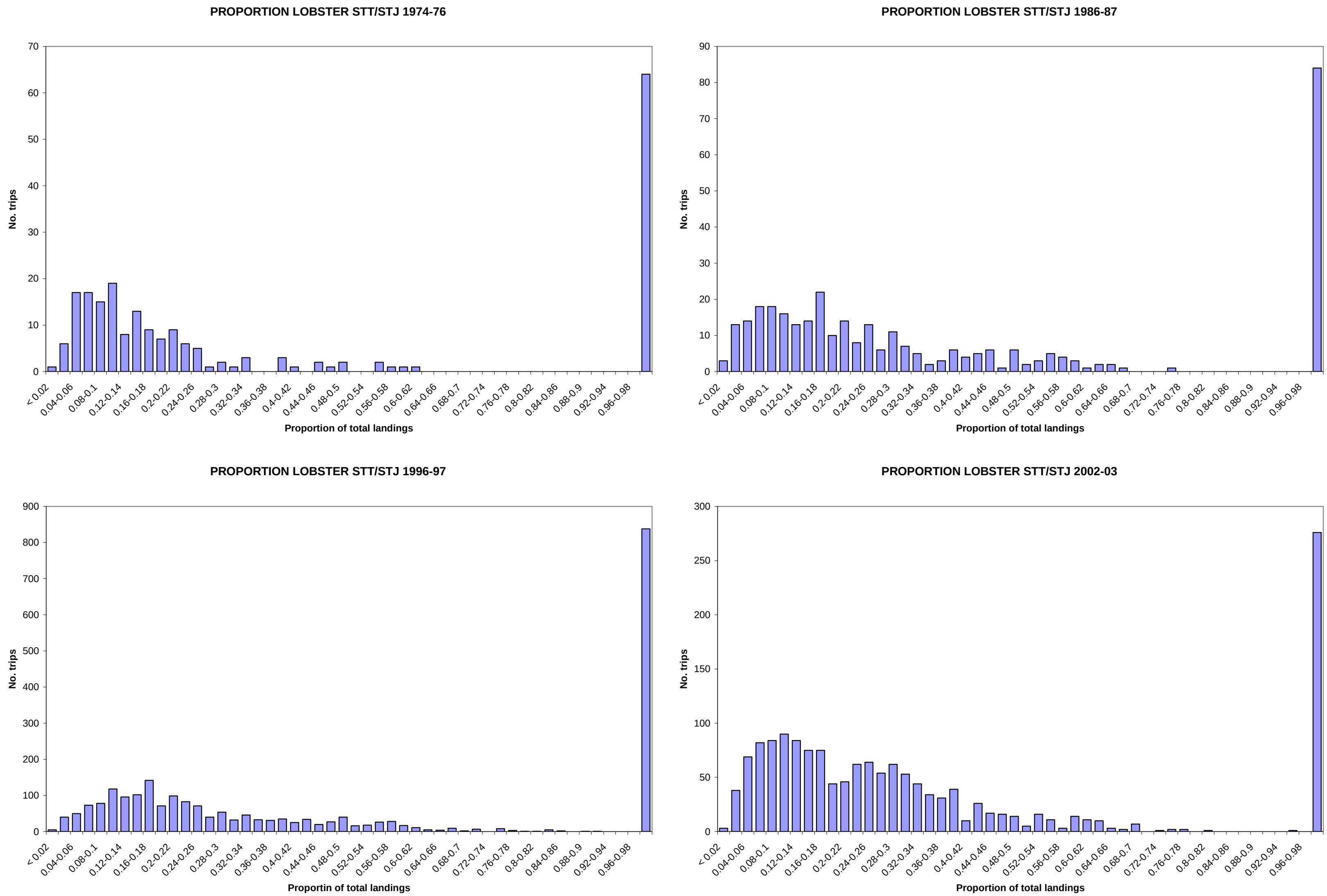


Figure 28—Lobster as a Proportion of Total Landings per Trip for St. Thomas/St. John Traps by Year
Data from commercial catch records, with bars representing number of trips that fall into each weight category. Calendar years used.

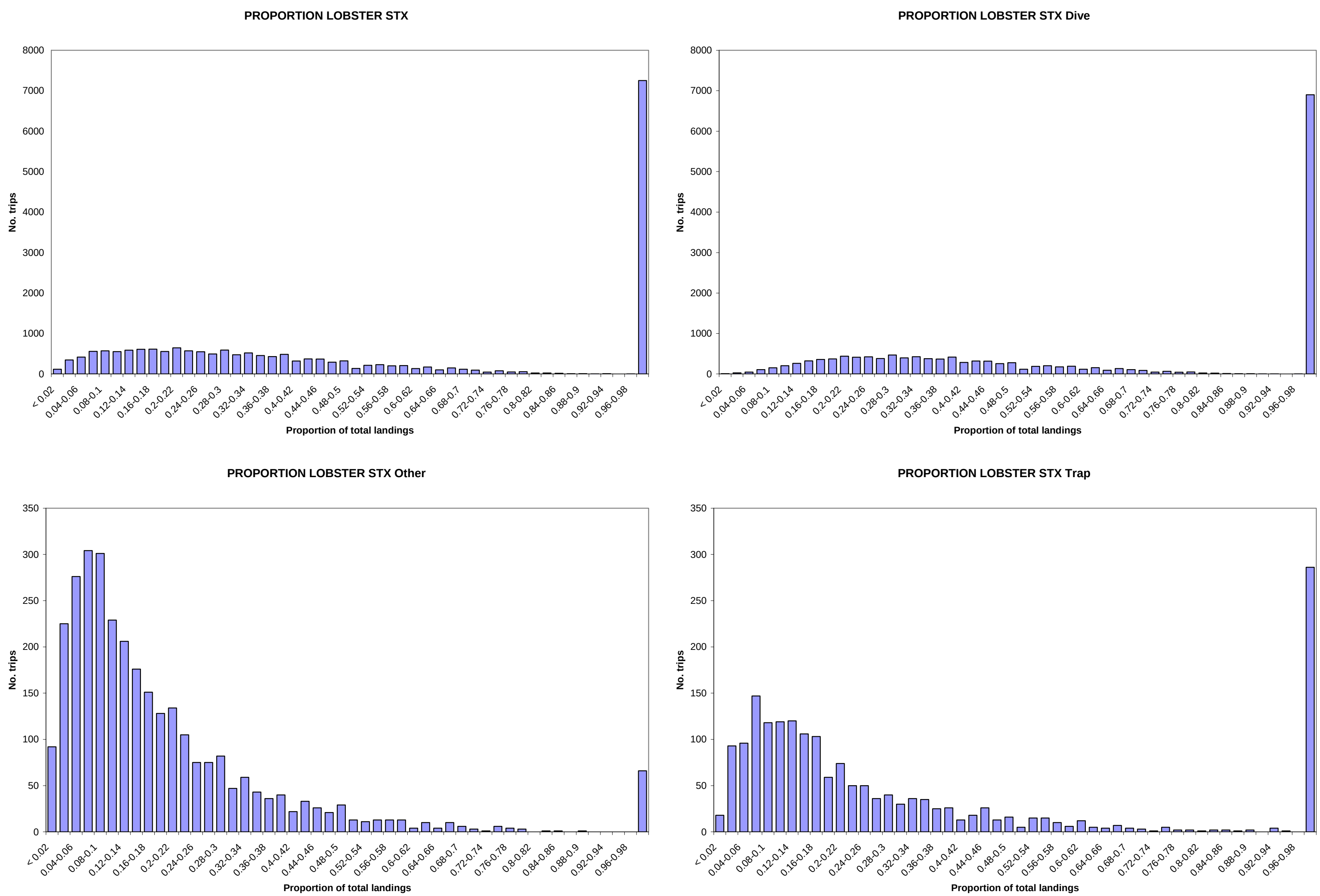


Figure 29—Lobster as a Proportion of Total Landings per Trip for St. Croix by Gear
Data from commercial catch records, with bars representing number of trips that fall into each proportion category.

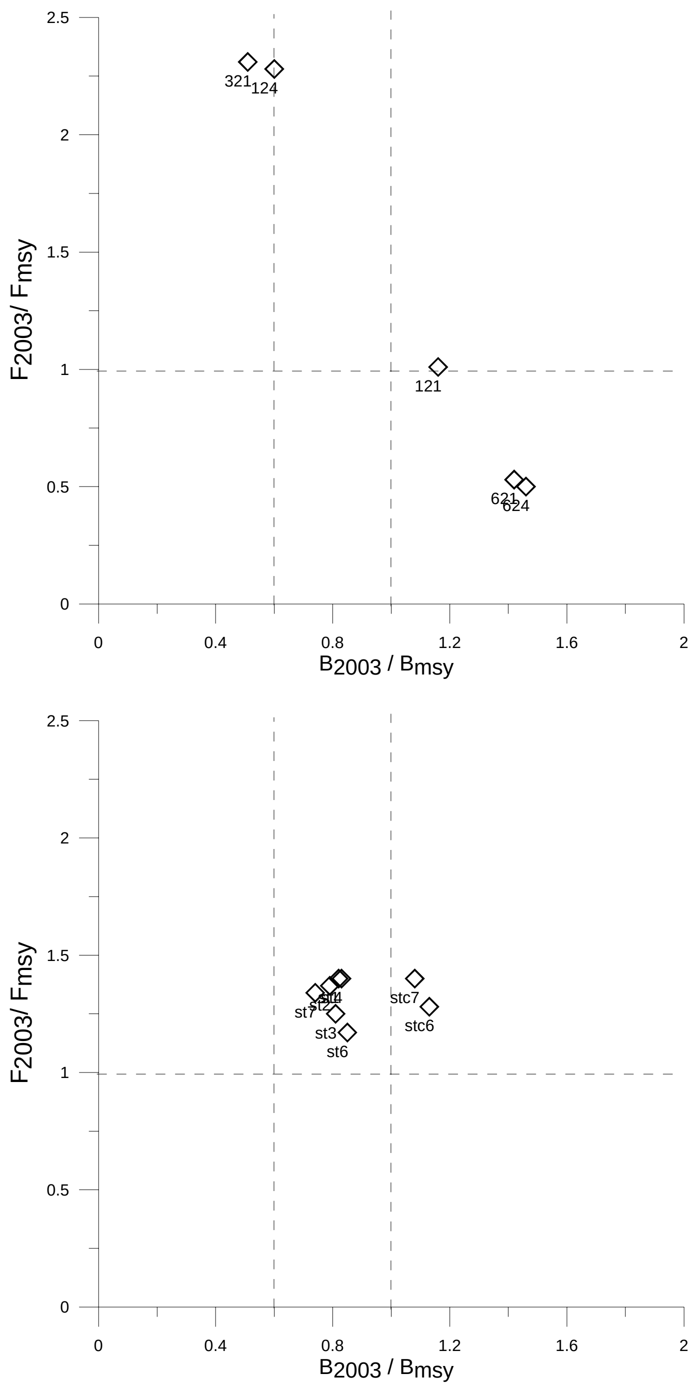


Figure 30—Commercial Lobster Landings in US Caribbean, 1969-2002
Figure b Current stock status (B_{2003}/ B_{msy}) and fishing mortality (F_{2003}/F_{msy}) from ASPIC results for fits to data using (a) all islands and (b) virgin islands only. Only runs that converged are shown. Labels correspond to codes in Table 18. Dashed lines represent the overfished and overfishing limits.

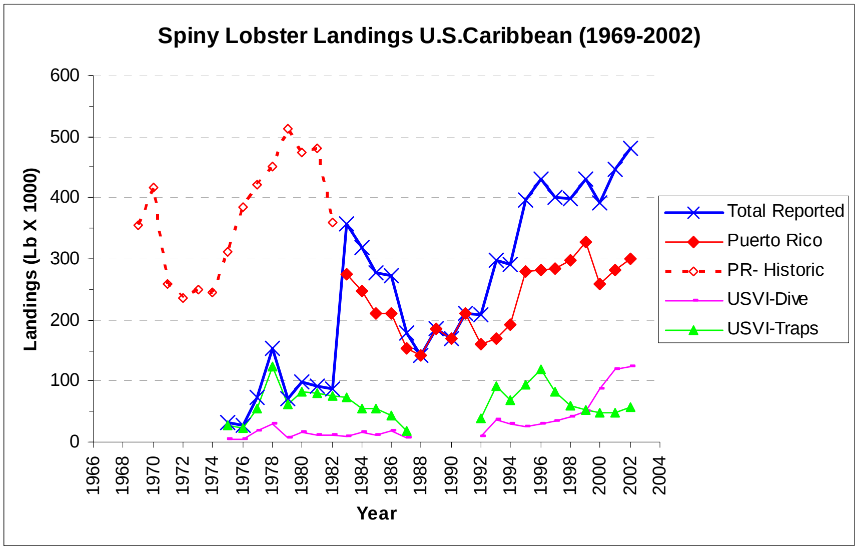


Figure 31—Commercial Lobster Landings Used in the Age-Structured Model
Reported commercial landings (in pounds) from the U.S. Caribbean. Puerto Rico (calendar years 1983-2002) are reported landings, U.S. Virgin Islands (calendar years 1975-2002) are expanded reported landings. Landings from historic documents (1969-1982) are included.

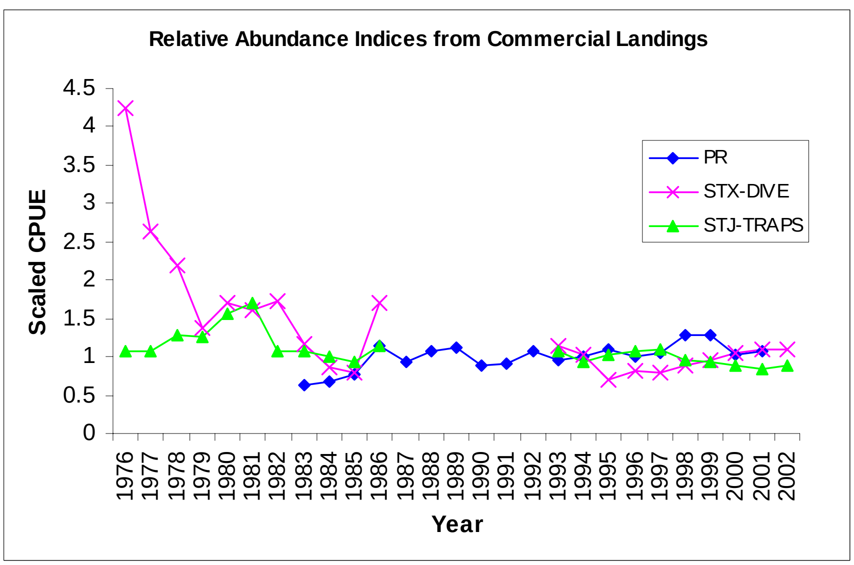


Figure 32—Lobster Abundance Indices Used in the Age-Structured Model
Scaled relative indices of abundance selected for use in the ASPM assessment model. All indices are standardized and were estimated from commercial landings. The Puerto Rico index used the Delta-Lognormal model, and was estimated by Mateo and Die (2004); the St. Croix (STX) and St. Thomas/St. John (STT/STJ) were calculated with a GLM approach by Valle (2005).

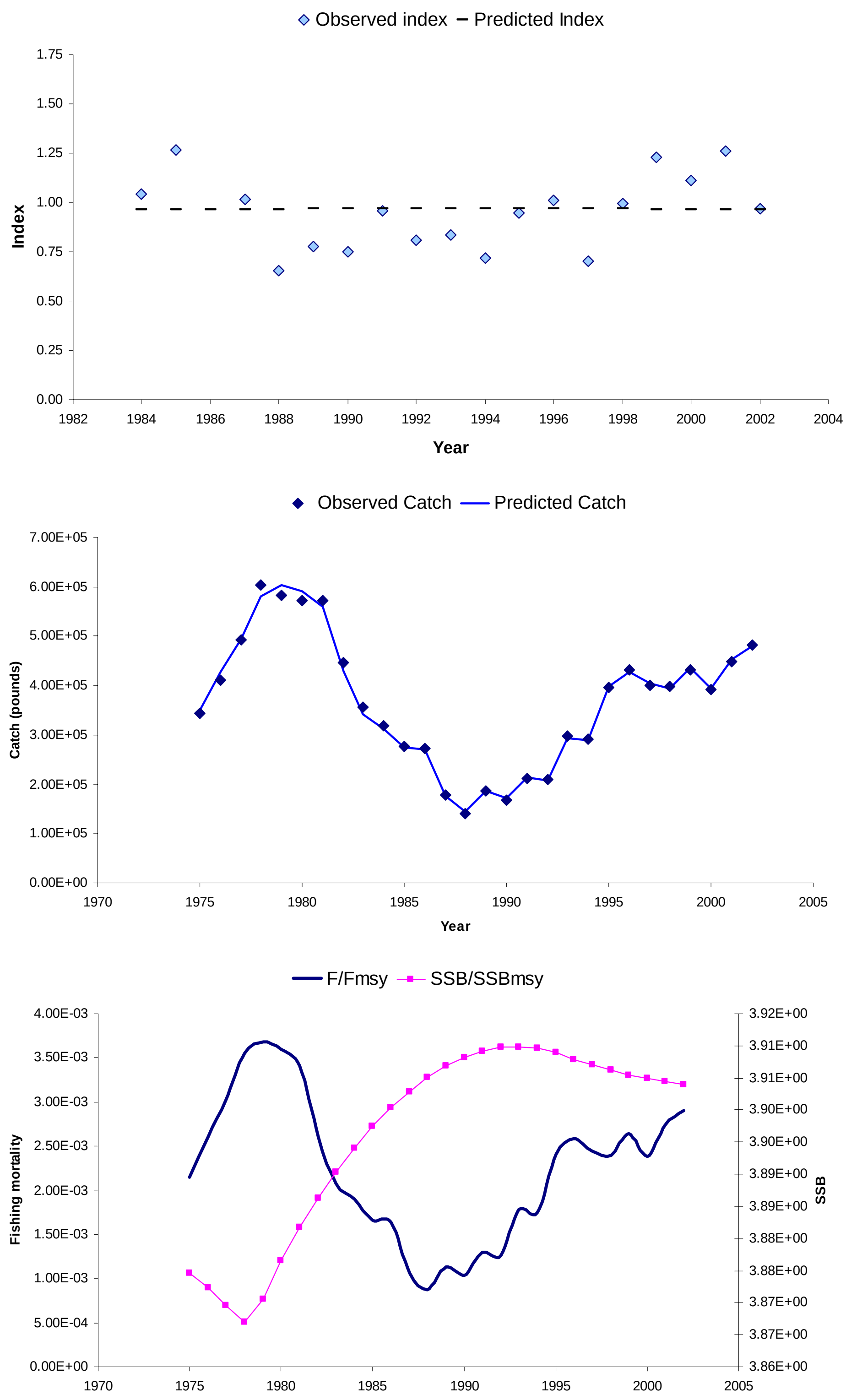


Figure 33—Lobster Age-Structured Model Fits Using Puerto Rico Index
Model fit to the Puerto Rico index (top), total reported (expanded) catch of spiny lobster (middle), and relative benchmarks (bottom).

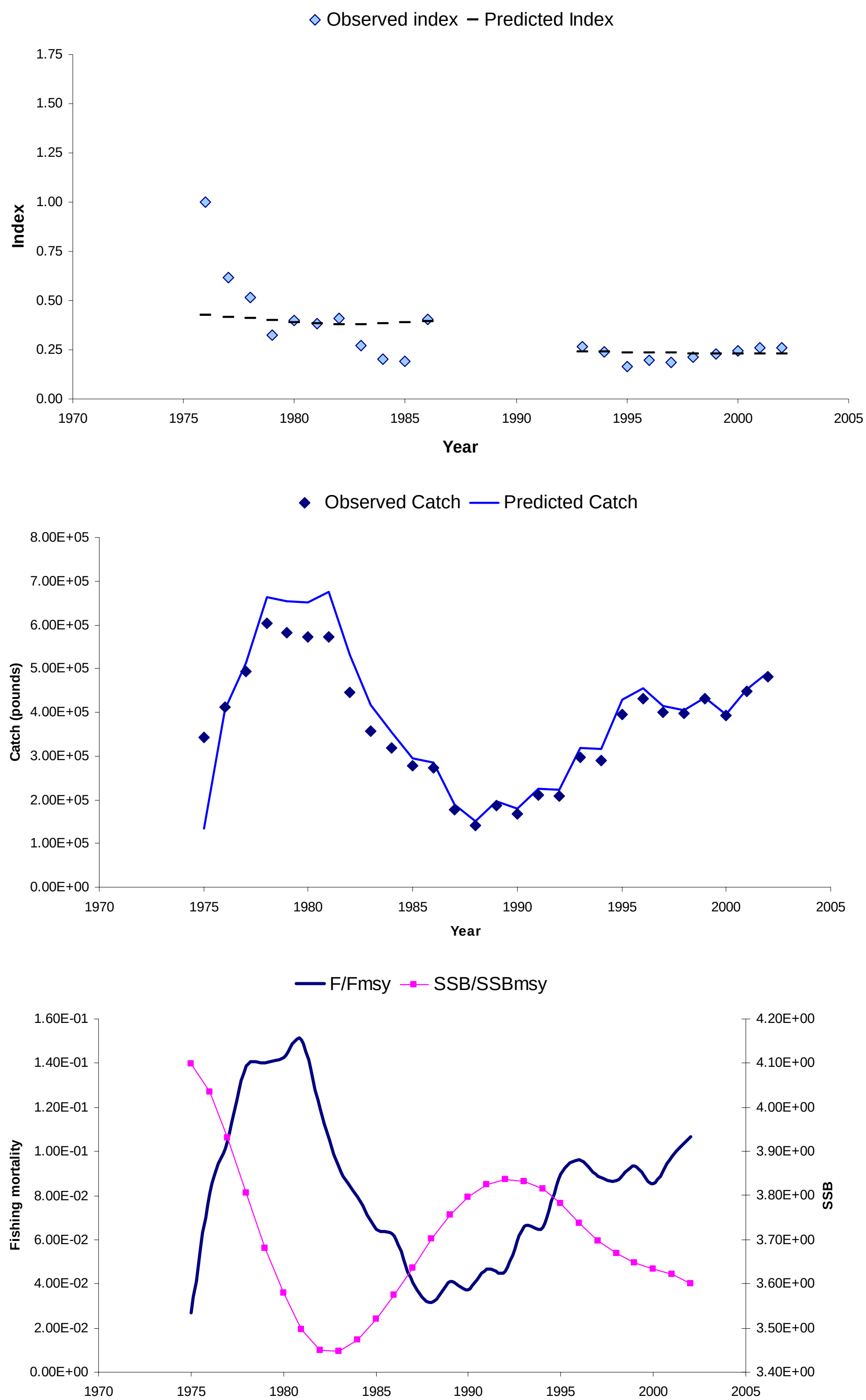
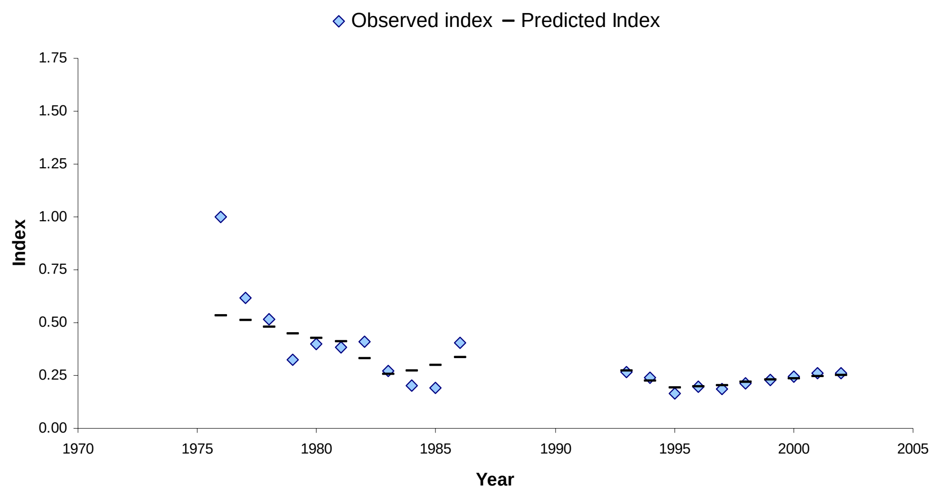
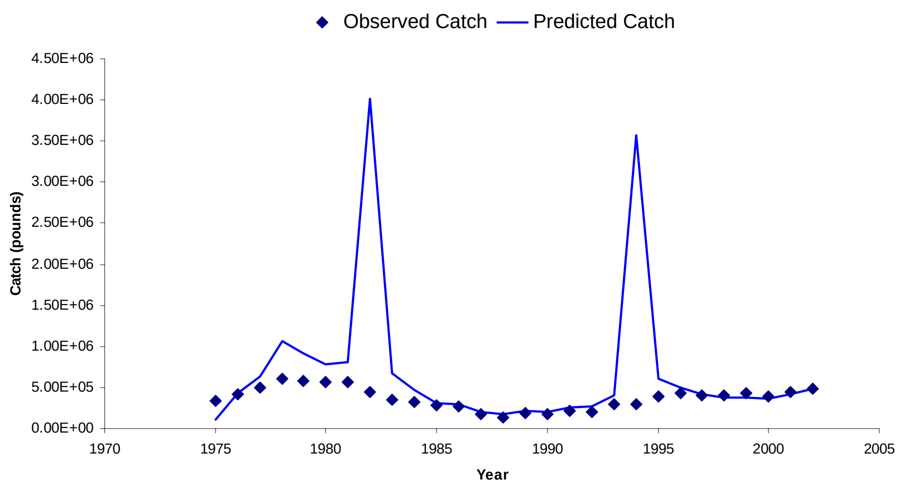


Figure 34—Lobster Age-Structured Model Fits Using St. Croix Dive Index
Model fit to the St. Croix Dive index (top), total reported (expanded) catch of spiny lobster (middle), and relative benchmarks (bottom).





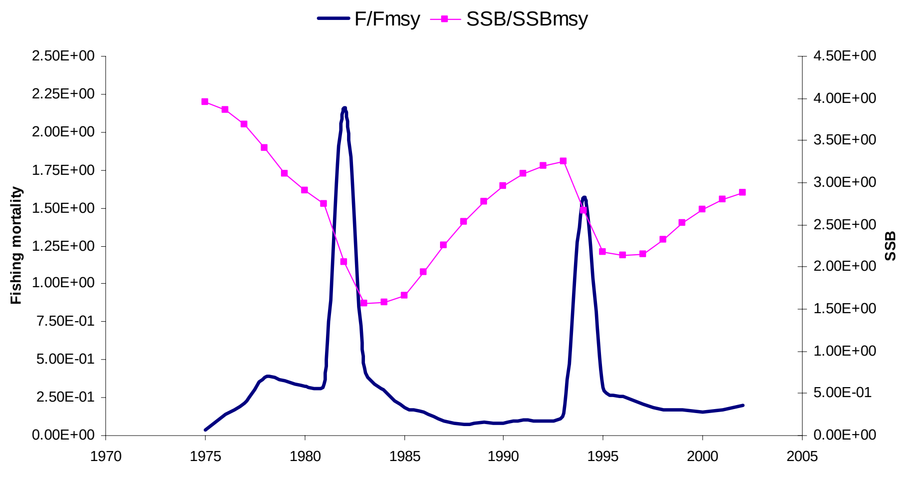


Figure 35—Lobster Age-Structured Model Fits Forcing Fit to St. Croix Dive Index
Model fit to the St. Croix Dive index (top), total reported (expanded) catch of spiny lobster (middle), and relative benchmarks (bottom) when model was constrained to fit the trend in the index.

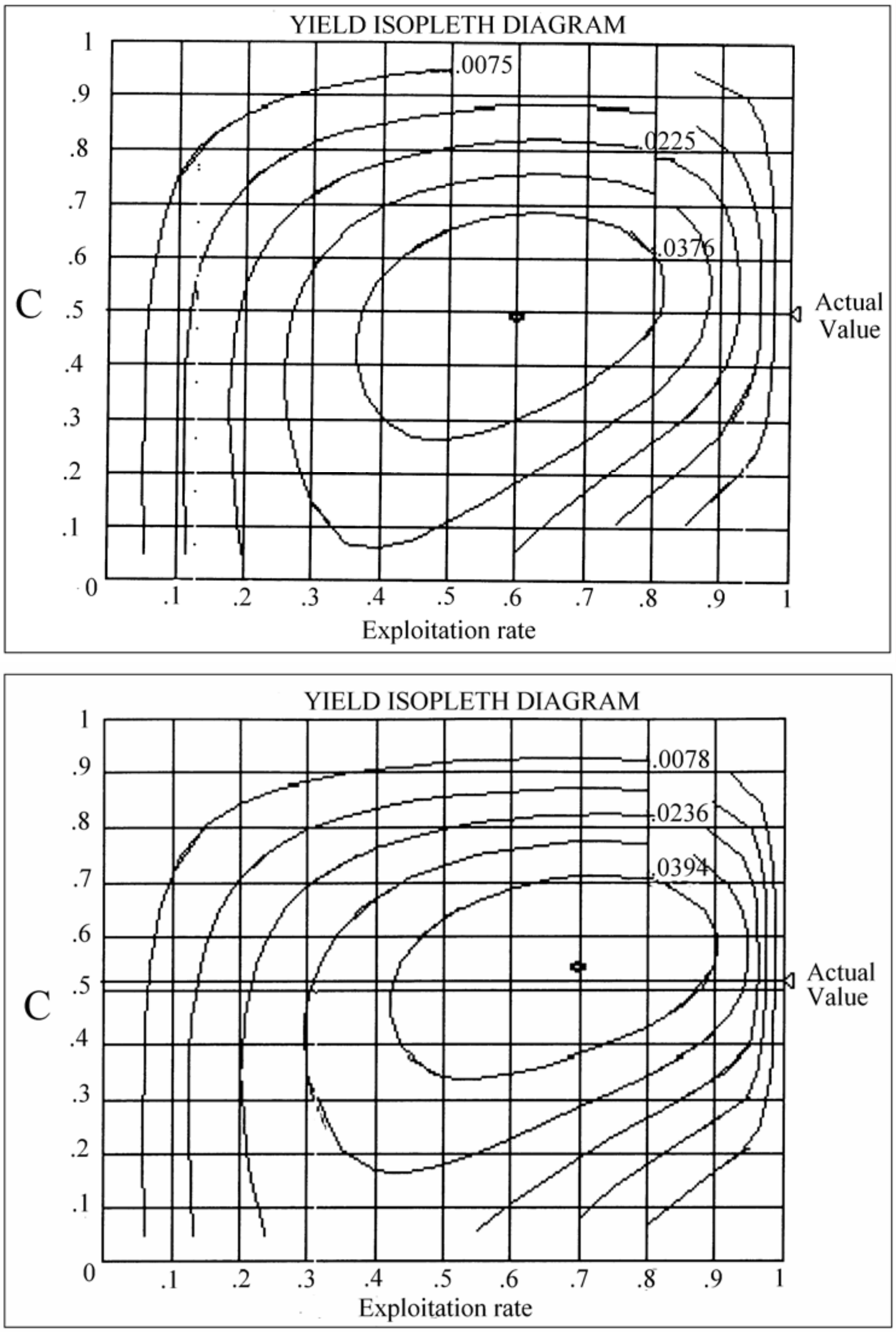


Figure 36—Lobster Yield Per Recruit Isopleths for St. Croix

Yield per recruit isopleth for (a) males and (b) females as a function of exploitation ratio (E) and size at first capture relative to asymptotic length (C) (Taken from Mateo and Tobias 2002).

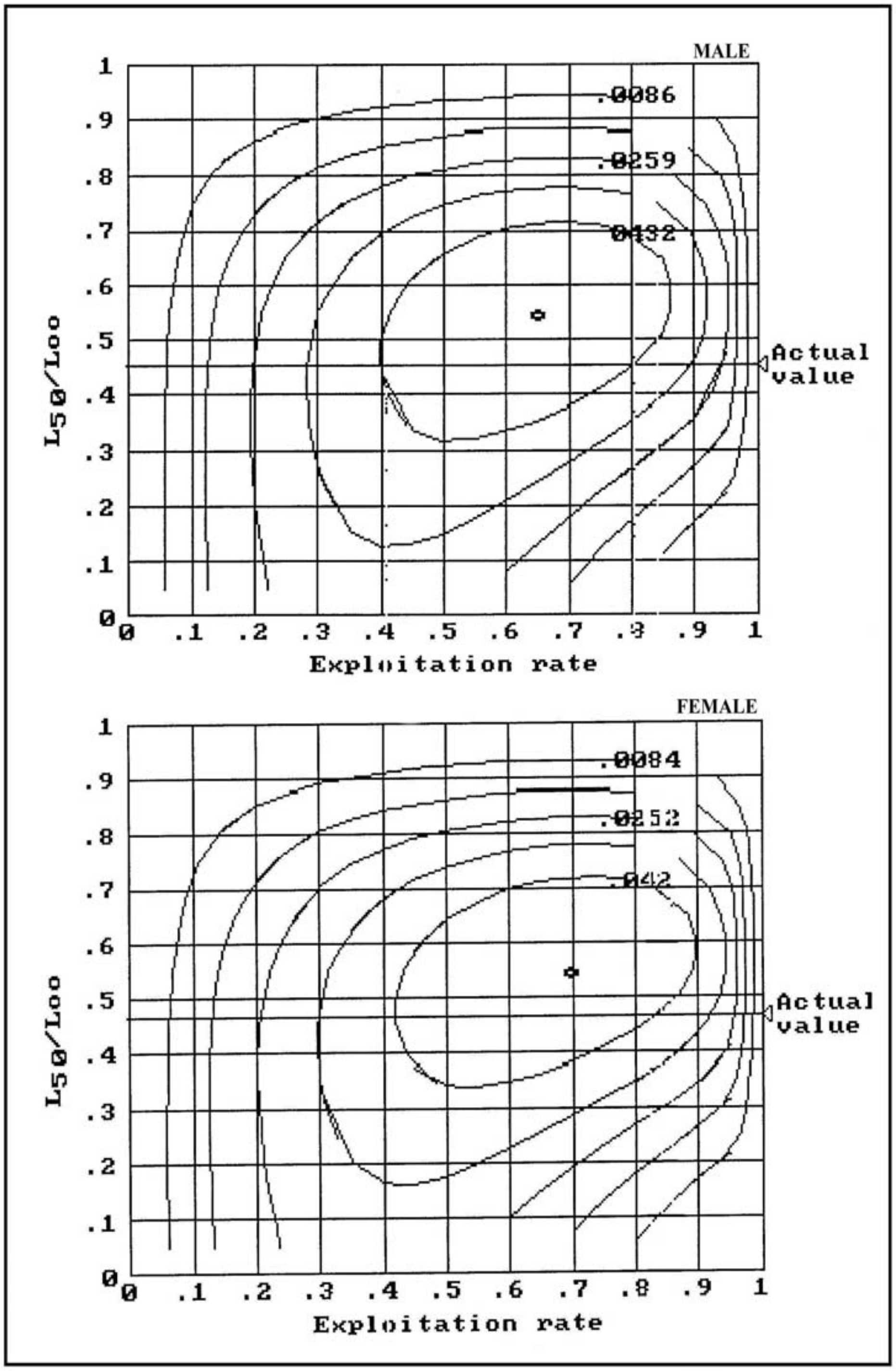


Figure 37—Lobster Yield Per Recruit Isopleths for Puerto Rico
Yield per recruit isopleth for (a) males and (b) females as a function of exploitation ratio (E) and size at first capture relative to asymptotic length ($L50/L_{\infty}$) (taken from Mateo 2004).

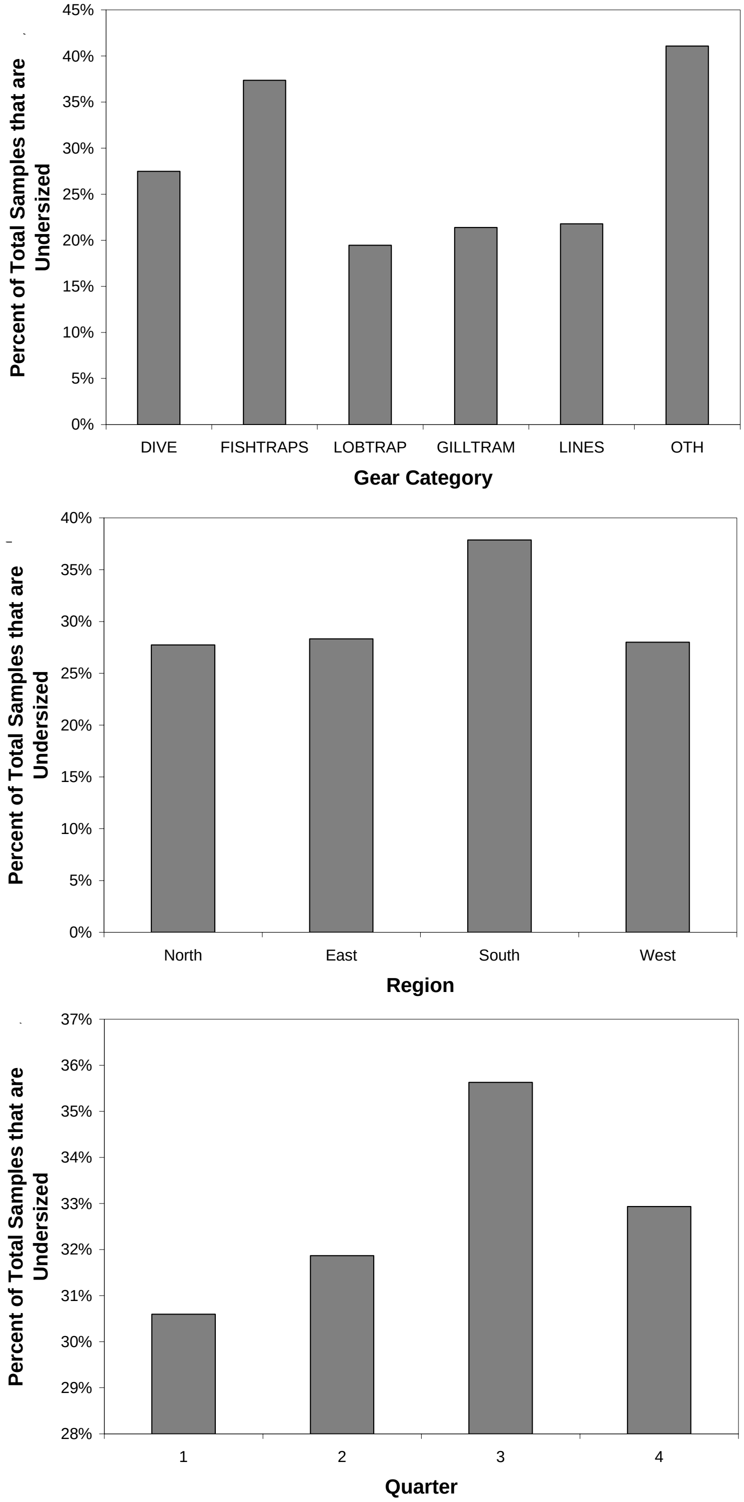


Figure 38—Undersized Puerto Rico Lobster by Gear, Region, and Quarter
The percentage of total individuals sampled by TIP found to be undersized by gear (a), region (b) and quarter (c).

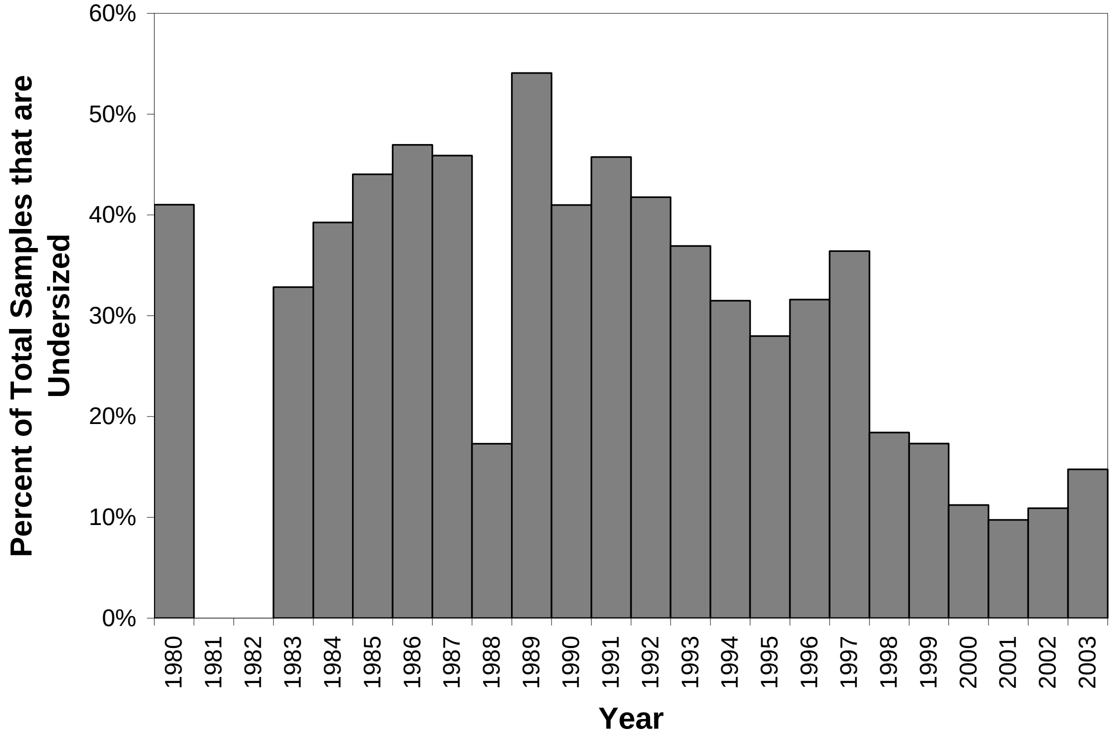


Figure 39—Percentage Undersized Lobster from Puerto Rico by Year
The percentage of total individuals sampled by TIP found to be undersized by year.

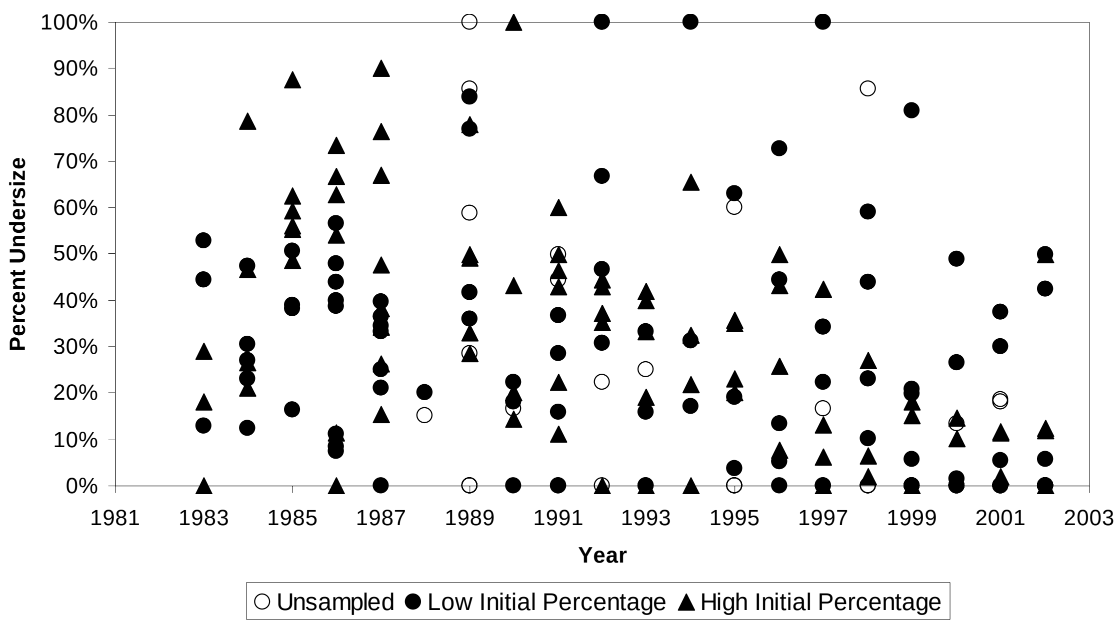


Figure 40—Percentage Undersized Lobster from Puerto Rico by Year and Muncipality
The percentage of undersized lobsters sampled by TIP separated by year and municipality.

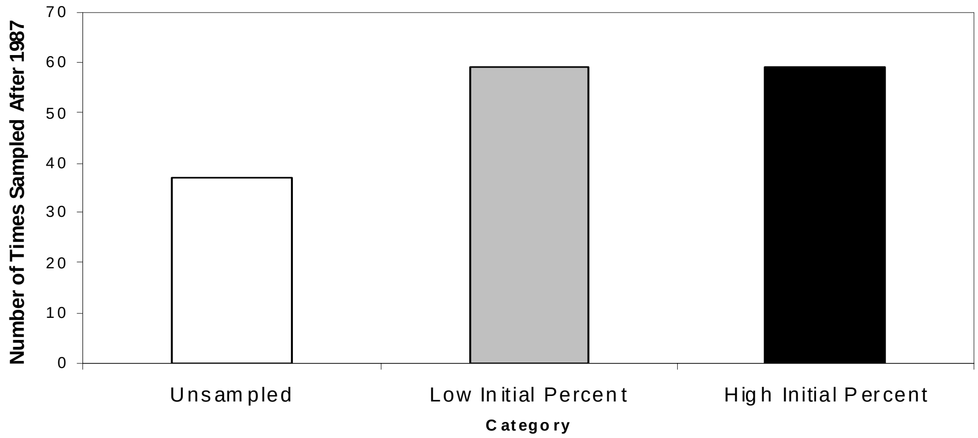


Figure 41—Puerto Rico Municipalities by TIP Sampling Category
The total number of municipalities sampled by TIP, as stratified by the category of undersized lobsters sampled.

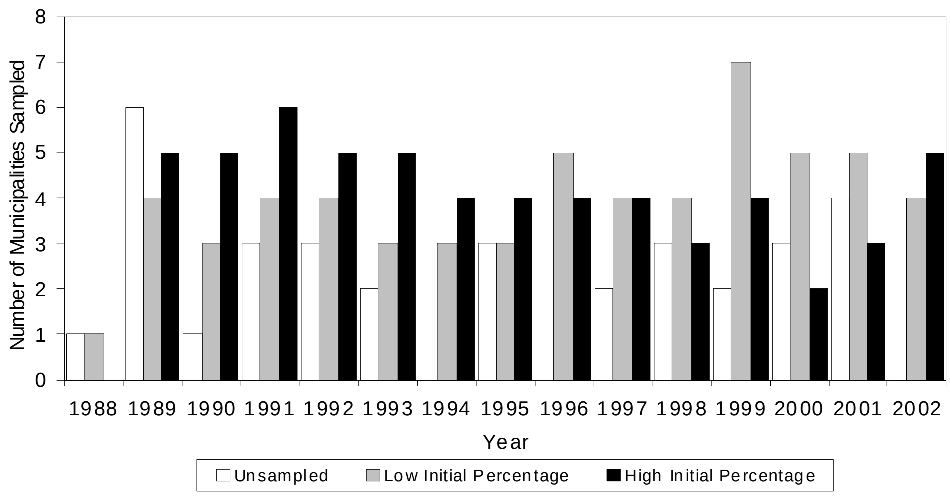


Figure 42—Puerto Rico Municipalities by TIP Sampling Category and Frequency of Undersized Lobster
Stratification of the number of municipalities sampled each year by TIP, categorized by the frequency of immature lobsters that were landed.

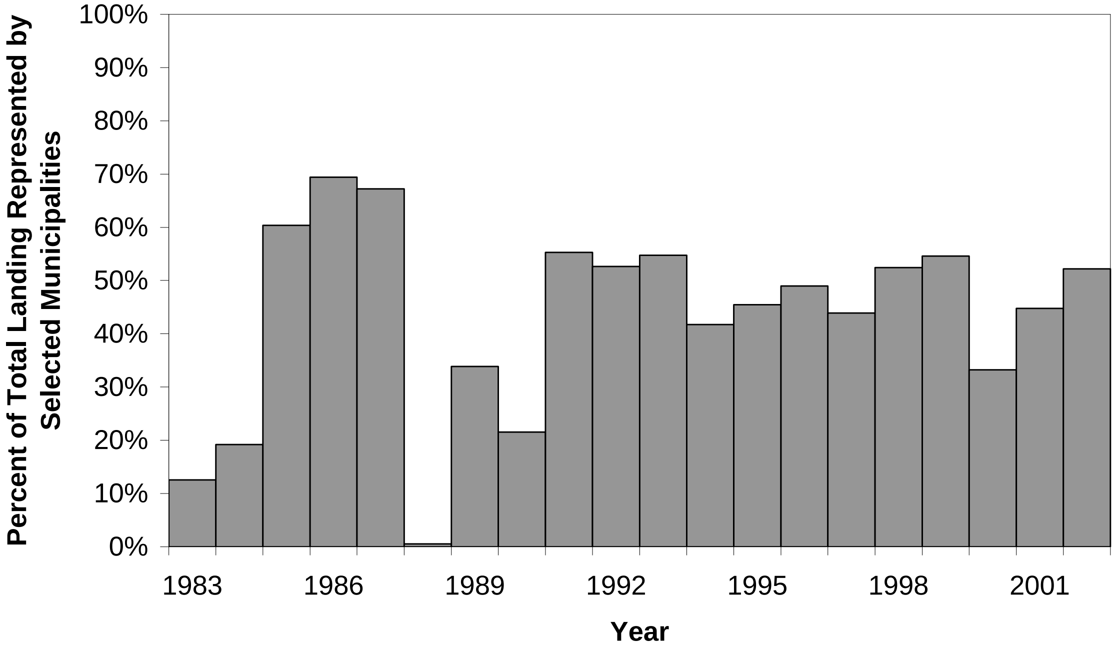


Figure 43—Proportion of Total Lobster Landings from Municipalities Analyzed
The percentage of total landings brought to port in municipalities selected for analysis.

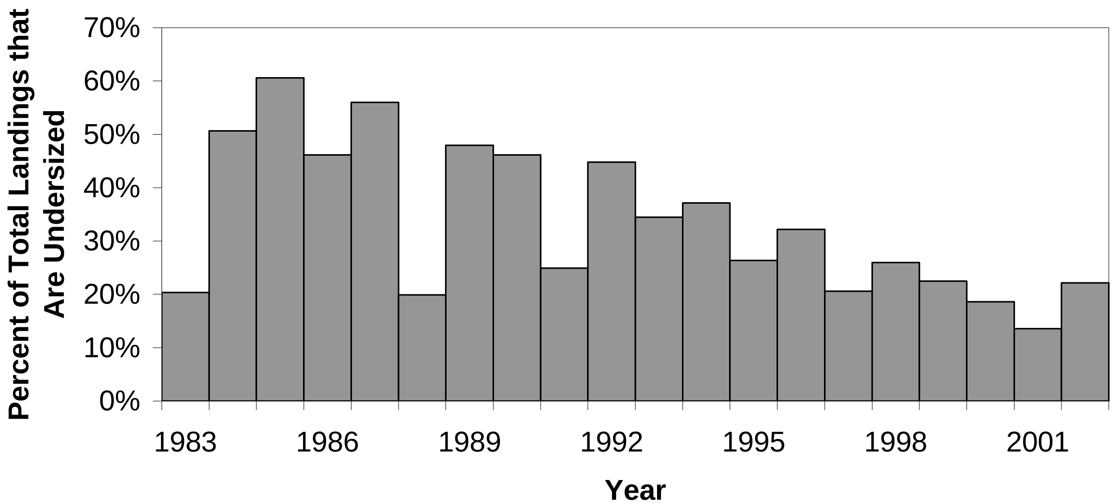


Figure 44—Estimated Percentage of Undersized Lobster in Puerto Rico
The percentage of undersized lobsters found to be in the landings data from Puerto Rico calculated by applying the TIP data to the expanded landings.

SEDAR 8

Stock Assessment Report 2

Caribbean Spiny Lobster

SECTION IV. Review Workshop

SEDAR
1 Southpark Circle # 306
Charleston, SC 29414

Consensus Summary Report

Caribbean yellowtail snapper (*Ocyurus chrysurus*)
Caribbean spiny lobster (*Panulirus argus*)
South Atlantic – Gulf of Mexico spiny lobster (*Panulirus argus*)

Prepared by the SEDAR 8 Review Panel for:

Caribbean Fishery Management Council
Gulf of Mexico Fishery Management Council
South Atlantic Fishery Management Council

Edited by Andrew I. L. Payne for
SEDAR 8, 16-20 May 2005
San Juan, Puerto Rico

Executive summary

The SEDAR 8 Review Workshop met in San Juan, Puerto Rico, from 16 to 20 May 2005. The Panel itself comprised the Chair and a reviewer appointed by the CIE, four US technical experts, the SEDAR facilitator, and two stakeholder representatives. All documentation, including background documentation provided to earlier Data and Assessment Workshops, was provided to the Panel in good time for prior review, and was comprehensive for the job in hand.

The meeting considered three stocks, Caribbean yellowtail snapper, Caribbean spiny lobster, and South Atlantic – Gulf of Mexico spiny lobster. Able presenters had been assigned by the Assessment Workshops and went to great trouble to explain the background behind and the output from the assessments. For only one of these stocks, South Atlantic – Gulf of Mexico spiny lobster, were extensive additional runs requested during the meeting. Discussions for all three stocks focused on the assessments and what they meant in terms of the Review Workshop's Terms of Reference, the documentation of relevant comments about them, derivation of suggestions for future research and monitoring, and canvassing of stakeholder opinion. Finally, some time was spent evaluating the SEDAR assessment process in full, as requested.

For Caribbean yellowtail snapper, the data were deemed insufficient to provide a signal to underpin management advice, though the assessment methodology itself was sound. The importance of well-designed, systematic, long-term targeted research programs needed to construct adequate time-series of catch and abundance indices was stressed. Currently, it seems that data quality control independent of the data collection process has not been effectively realized, and validation of historical and future collections is urgently needed. Partnerships with fishermen are clearly one way to achieve this, and the need to look at the stock as part of a species assemblage or community was noted. Of the many research suggestions made, highest priority was assigned to the carrying out of fishery-independent surveys, the collection of more catch data, including specifically the recreational fishery, and the collection of age and length data from commercial and recreational catches and from fishery-independent surveys.

For Caribbean spiny lobster, the data were also deemed currently insufficient to provide the required management advice, though again the methodology applied was sound. The Panel noted that the data series could seemingly be split into two components, before and after about 1992, and focused much discussion on why this might be and how best to model it in future. Additional factors and modifications to the modelling approach were proposed for consideration in an attempt to understand better the dynamics of the population, and high priority was suggested be assigned to the creation of a standardized recruitment index. Other priority research and monitoring included incorporating historical data into existing data sets, and utilizing refined models (better to identify viable hypotheses). Partnerships with fishermen were again proposed to facilitate the data collection process.

In respect of South Atlantic – Gulf of Mexico spiny lobster, the data and assessments were accepted, as was the base-case ICA model of stock dynamics. Several further runs were requested and provided, but overall the base-case results were considered the best and not likely to be unreliable. Some time was spent discussing relative stock status with respect to overfished levels and the importance of this stock in terms of the whole population in the Western Atlantic. The various stocks likely primed each other with larvae and recruits. There was also strong support to re-establish an observer program for the commercial trap fishery. Other research priorities should include a broadening of the fishery-independent indices of abundance, the provision of improved growth information, perhaps through tagging, and

modelling of various scenarios covering a range of hypotheses concerning recruitment and changes in gear selectivity, as well as suitable performance indicators.

Comments on the SEDAR assessment process stressed: the need for better communication with and dissemination of information to stakeholders; the need for an advanced plan for assessments and a comprehensive glossary of terms; the continuity of personnel throughout each workshop process, in terms of stakeholders perhaps finding new ways of ensuring their participation; incorporation of fishermen's knowledge into the assessment process better; the need to maximize the time for preparing data series; the importance of independence in the review process, though not solely through CIE-contracted reviewers; and the importance of providing for the Review Panel an executive summary for substantive documents, a succinct table of model parameters, and if appropriate a table of management options.

1. Introduction

1.1 Time and Place

The SEDAR 8 Review Workshop met in San Juan, Puerto Rico, from 16 to 20 May 2005.

1.2 Terms of Reference for the Review Workshop

1. Evaluate whether data used in the analyses are treated appropriately and are adequate for assessing the stocks; state whether or not the input data are scientifically sound.
2. Evaluate the adequacy, appropriateness, and application of the methods used to assess the populations; state whether or not the methods are scientifically sound.
3. Recommend appropriate or best-estimated values of population parameters such as abundance, biomass, and exploitation.
4. Evaluate the adequacy, appropriateness, and application of the methods used to estimate stock status criteria (population benchmarks such as MSY, F_{msy}, B_{msy}, MSST, MFMT). State whether or not the methods are scientifically sound.
5. Recommend appropriate values for stock status criteria.
6. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status and, if appropriate, evaluate stock rebuilding; state whether or not the methods are scientifically sound.
7. Recommend probable values for future population condition and status.
8. Ensure that all desired and necessary assessment results (*as listed in the SEDAR Stock Assessment Report Outline*) are clearly and accurately presented in the Stock Assessment Report and that such results are consistent with the Review Panel's consensus regarding adequacy, appropriateness, and application of the data and methods.
9. Evaluate the Data and Assessment Workshops with regard to fulfilling their respective Terms of Reference and state whether or not the Terms of Reference for previous workshops are adequately addressed in the Data Workshop and Stock Assessment Report sections;
10. Develop recommendations for future research for improving data collection and stock assessment.
11. Prepare a Consensus Report summarizing the peer review Panel's evaluation of the reviewed stock assessments and addressing these Terms of Reference. (Drafted during the Review Workshop with a final report due two weeks after the workshop ends.)

1.3 List of Participants

Participants	Affiliation
Review Panel:	
Andrew Payne	CIE, Chair
Paul Medley	CIE, Reviewer
Richard Appeldoorn	University of Puerto Rico
James Berkson	NOAA Fisheries/RTR Unit
Edward Schuster	St Croix Fisheries Advisory Cttee
Simon Stafford	GMFMC Advisory Panel
Ian Stewart	NOAA Fisheries/NWFSC
Doug Vaughan	NOAA Fisheries/SEFSC
Presenters:	
Liz Brooks	NOAA Fisheries/SEFSC
Nancie Cummings	NOAA Fisheries/SEFSC
David Die	University of Miami, RSMAS
John Hunt	Florida FWC
Robert Muller	Florida FWC
Mike Murphy	Florida FWC
Josh Sladek Nowlis	NOAA Fisheries/SEFSC
Francisco Pagan	University of Puerto Rico
Jerry Scott	NOAA Fisheries/SEFSC
Monica Valle	University of Miami, RSMAS
Observers:	
Mark Drew	Nature Conservancy, St Croix
Michon Fabio	CFMC Advisory Panel
Tony Iarocci	SAFMC
Joe Kimmel	NOAA Fisheries SERO
Barbara Kojis	US Virgin Islands DFW
Jimmy Magner	St Thomas Fishermen's Assn
Eugenio Pinero	CFMC
Julian Magras	St Thomas Fishermen's Assn
John Merriner	NOAA Fisheries SEFSC
Miguel Rolon	CFMC
Roger Uwate	US Virgin Islands DFW
Roy Williams	GMFMC
Staff support:	
John Carmichael	SEDAR
Cynthia Morant	SAFMC
Lloyd Darby	SEFSC
Graciela Garcia-Moliner	CFMC

1.4 Review Workshop working papers

An impressive quantity of documentation was provided before the meeting by the facilitator. Much of this pertained to material provided to either the Data Workshop or Assessment Workshop for each of the three review species. However, specific material for the review workshop itself was also provided, and this is listed below.

NUMBER	TITLE	Author
	Working Papers	
SEDAR8-RW1	Further explorations of a stock production model incorporating covariates (ASPIC) for yellowtail snapper (*Ocyurus chrysurus*) in the US Caribbean	J. Sladek Nowlis
SEDAR8-RW2	Length frequency analysis of Caribbean spiny lobster (*Panulirus argus*) sampled by the Puerto Rico commercial Trip Interview Program (1980-2003)	S.D. Chormanski, D. Die, S. Saul
SEDAR8-RW3	Maturity of spiny lobsters in the US Caribbean	D. Die
	Supplementary Documents	
SEDAR8-RD24	Preliminary estimations of growth, mortality and yield per recruit for the spiny lobster *Panulirus argus* in St. Croix, USVI. *Proc. Gulf Carib. Fish. Inst.* 53: 59-75	I. Mateo, W.J. Tobias
SEDAR8-RD25	Population dynamics for spiny lobster *Panulirus argus* in Puerto Rico: Progress report. *Proc. Gulf Carib. Fish. Inst.* 55: 506-520	I. Mateo
	Assessment Reports	
SEDAR8-SAR1	Stock assessment report for Caribbean yellowtail snapper	J. Sladek Nowlis
SEDAR8-SAR2	Stock assessment report for Caribbean spiny lobster	J. Sladek Nowlis
SEDAR8-SAR3	Stock assessment report for South Atlantic – Gulf of Mexico spiny lobster	R. Muller, J. Hunt

2. Terms of Reference

2.1 Background

Generally, the Review Workshop is the third meeting in the SEDAR process, and this situation pertained to all three stocks reviewed during SEDAR 8. The Panel was pleased to be able to record that the terms of reference set for Data Workshops and Assessment Workshops for the three stocks were fully met, but there was some concern expressed that pressure may have been brought to bear on participants at some of those workshops to progress management further than was possible from the available data. Quite simply, data time-series, and in some cases recent basic biological data, were likely unable to support the development of meaningful assessments for the stocks just yet.

Notwithstanding, the Panel was impressed by the quantity and quality of the work that had gone into the various assessments. The presentations were well structured and clear, and the information provided through the presentations, and in response to questions, gave an excellent basis for the Panel's subsequent deliberations and conclusions.

2.2 Review of the Panel's deliberations

The deliberations on each species are presented in the form of responses to the terms of reference questions specifically, followed by relevant comments on the discussions, suggestions for future research, and stakeholder opinion, the last two not specifically in order of priority.

A. *Caribbean yellowtail snapper*

<u>Terms of reference</u>

1. Evaluate whether data used in the analyses are treated appropriately and are adequate for assessing the stocks; state whether or not the input data are scientifically sound.
The data were treated appropriately, but were not adequate yet for assessing the stocks.

2. Evaluate the adequacy, appropriateness, and application of the methods used to assess the populations; state whether or not the methods are scientifically sound.
The two methods were appropriate for exploring the potential for an assessment, but ultimately merely showed the inadequacy of the data. Nonetheless, the methods are scientifically sound, if given appropriate data.

3. Recommend appropriate or best-estimated values of population parameters such as abundance, biomass, and exploitation.
An acceptable assessment had not been developed, so appropriate population parameters were not produced.

4. Evaluate the adequacy, appropriateness, and application of the methods used to estimate stock status criteria (population benchmarks such as MSY, F_{msy}, B_{msy}, MSST, MFMT). State whether or not the methods are scientifically sound.
An acceptable assessment had not been developed, so estimates of stock status criteria were not produced.

5. Recommend appropriate values for stock status criteria.
An acceptable assessment had not been developed, so appropriate stock status criteria were not produced. Although a number of key reference points were provided (B_{msy}/B_0, SPR_{msy}, F_{msy} – given selectivity vector) and seem to be robust across the various models, they do not provide information on current stock status.

6. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status and, if appropriate, evaluate stock rebuilding; state whether or not the methods are scientifically sound.
No population projections were possible.

7. Recommend probable values for future population condition and status.
No population projections were made or possible, so probable values for future population condition and status were not produced.

8. Ensure that all desired and necessary assessment results (*as listed in the SEDAR Stock Assessment Report Outline*) are clearly and accurately presented in the Stock Assessment Report and that such results are consistent with the Review Panel's consensus regarding adequacy, appropriateness, and application of the data and methods.
All desired and necessary assessment results are clearly and accurately presented in the Stock Assessment Report for the species, but they are currently uninformative on stock status. These results are consistent with the Review Panel's consensus regarding adequacy, appropriateness, and application of the data and methods.

9. Evaluate the Data and Assessment Workshops with regard to fulfilling their respective Terms of Reference and state whether or not the Terms of Reference for previous workshops are adequately addressed in the Data Workshop and Stock Assessment Report sections.
The Data Workshop fulfilled its Terms of Reference. The Assessment Workshop fulfilled its Terms of Reference to the extent possible, given the limitations of the data.

10. Develop recommendations for future research for improving data collection and stock assessment.
See below the comments section.

<u>Comments</u>

The Review Panel offers the following comments regarding research needs and the data and assessment of yellowtail snapper.

1. Well-designed, systematic research programs are essential to providing the data necessary for effective management. Much of the research reviewed lacked the necessary sample sizes and regular (ongoing) data collection needed to construct an adequate time-series of catch and abundance indices.

2. The yellowtail snapper fishery is unique among Caribbean fisheries with regard to fishing methods and timing, and the needed research designs. It is an important fishery in the U.S. Caribbean. The design of data collection must take into account the unique aspects of the fishery, and therefore sampling effort will need to be either added or redirected to target yellowtail snapper more effectively.

3. A commitment to long-term research and data collection is essential for effective management. Short-term research and data collection are not the solution to the data

problems identified in this assessment. Long-term research and monitoring are necessary in the Caribbean, as in any other managed fishery. Based on the studies and data available, it is clear that the resources necessary to collect essential data are not currently available to support scientifically based management of yellowtail snapper in the region.

4. Throughout the region, data quality control independent of the data collection process has not been effectively realized. Validation of historical and future collections is needed for the data to be used appropriately for any type of assessment. Documentation of changes in data collection and management methods must be maintained and provided to those charged with conducting the assessments and reviews.

5. The Panel recognizes the significant effort that has been put into data collection in the region and emphasizes that, although the resulting data are insufficient for an assessment at this time, they will be useful for assessment in future when combined with additional data identified elsewhere in this report. Past efforts are not wasted, but rather their data will play an important role, providing the temporal contrast needed by assessment models. The recommendations below are offered as improvements to the current data collection, not as replacements.

6. The Panel strongly endorses the need to develop partnerships with local fishermen to conduct research and to collect needed data. Partnerships with the fishing community and other stakeholders are a cost-effective way to collect components of the data necessary for the assessment process. Currently, it is clear that there is a high level of interest in the fishing community to cooperate with management agencies in collecting data, and this partnership should be encouraged and strengthened. This would also facilitate ongoing cooperation and participation by fishermen in the management process, benefiting all involved.

7. Monitoring and assessment of yellowtail snapper should be undertaken with due consideration given to the species' importance in the overall species assemblage and community. Future ecosystem management will likely dictate such a course of action.

Recommendations for future data collection and research

Fishery-independent data

- A new independent sampling regime to target yellowtail snapper more effectively should be created, because current methods do not allow temporal or spatial coverage.
- Visual surveys can provide useful fishery-independent data. The methods would, however, vary, based on the depth of the insular shelf.
- The output of other existing studies (NOAA and non-NOAA) should be examined to see if alternative fishery-independent sampling already exists.

Life history data

- Fecundity data should be collected
- Maturity data should be collected
- Growth information should be collected
- The parameter natural mortality needs investigation on the basis of better data

Catch data

- Recreational catches need to be sampled and quantified better
- Information on trip species targeting is needed
- Information on the location of catches is sometimes not good, and should be improved
- Identification of species in the snapper complex in the US Virgin Islands is crucial to future assessments
- Historical data from the US Virgin Islands need to be collected from fishermen, if they exist
- Port samplers need to modify their schedules to target yellowtail snapper landings, and to sample sizes of the species need to increase
- TIP sampling in the US Virgin Islands needs to be revitalized

Age and length frequency data

- These are needed from all commercial catches
- These are urgently required from recreational catches
- Fishery-independent surveys can provide these crucial data

Genetic / otolith microchemistry studies

- Stock structure is important in assessments, and genetics and otolith microchemistry offer hope to unravel it in future

Spatially explicit studies

- Identification of spawning areas and the source of recruits is important
- Construction of habitat maps will help identify stratification for research designs
- Combination of habitat maps with fish counts and habitat models will aid in providing population estimates
- Development of a GIS map of yellowtail snapper landings throughout the species' geographical range could help in the production of a distribution map of catches

Mark-recapture studies

- This could help identify movements and migrations
- Fishing mortality estimates could be derived
- Population estimates would be enhanced with such studies
- Such studies could help solve the perplexing question of stock structure

Of the above, the Panel places the highest priority on the following, understanding the need to maximize the likelihood of generating an acceptable assessment of the stock in the near future:

- The carrying out of fishery-independent surveys
- Collection of more catch data, including specifically the recreational fishery
- The collection of age and length data from commercial and recreational catches and from fishery-independent surveys

Stakeholder opinion

- The need for robust education of fishermen and other stakeholders is acknowledged. Such education should be of a two-way nature and would potentially lead to an enhancement of their trust in the assessment and management process, especially if they were to become involved in research program design.
- The fact that most of the product in the yellowtail snapper fishery is sold retail and that there are no fish houses (at least in the US Virgin Islands) makes any meaningful future stock assessment in the region extremely dependent on cooperation with the local fishermen.
- A paucity of recent socio-economic information continues to hinder the development of integrated biological, economic, and social assessments.
- Partnerships with organizations such as NGOs, which are often staffed by highly qualified people and are perhaps also less constrained by political influence, can mobilize extra resources in meeting some of the research objectives.
- Biological and habitat/ecosystem research information is as important in the assessment process as catch data.
- Over the past 35+ years of fishing, yellowtail snapper abundance has remained stable.
- Detailed data (information) on yellowtail snapper catch are lacking for US Virgin Islands commercial landings. The lack of this type of data has introduced uncertainty into the determination of stock status. Therefore, collection of detailed catch information there is suggested as a top research priority.

B. *Caribbean spiny lobster*

<u>Terms of reference</u>

1. Evaluate whether data used in the analyses are treated appropriately and are adequate for assessing the stocks; state whether or not the input data are scientifically sound.
The data were treated appropriately, but they were not sufficiently informative to assess stock status. An alternative explanation is that the data may be inconsistent with the assumptions of the models being applied.

2. Evaluate the adequacy, appropriateness, and application of the methods used to assess the populations; state whether or not the methods are scientifically sound.
The methods were appropriate to explore the potential for an assessment, but ultimately were limited by the uninformative nature of the data. The Panel expressed some concern about the method used to standardize the stock abundance indices. The GLM and delta-lognormal approach is appropriate, but determining terms in the model based purely on statistical criteria can lead to bias in the index. Future assessment workshops need to reconsider how the various effects might influence an abundance index, and choose to test GLM terms accordingly.

3. Recommend appropriate or best-estimated values of population parameters such as abundance, biomass, and exploitation.
It had not been possible to produce an acceptable assessment so appropriate population parameters were not recommended.

4. Evaluate the adequacy, appropriateness, and application of the methods used to estimate stock status criteria (population benchmarks such as MSY, F_{msy}, B_{msy}, MSST, MFMT). State whether or not the methods are scientifically sound.
An acceptable assessment had not been developed, so estimates of stock status criteria were not produced.

5. Recommend appropriate values for stock status criteria.
An acceptable assessment had not been developed, so appropriate stock status criteria were not produced. Analysis of % catch under minimum size coupled with other YPR studies showed the current minimum size to be appropriate to maximize YPR, and trends in relative abundance indices and length distributions indicate some stability over the past 20 years, but these results do not provide information on stock status. YPR analyses suggest that the Caribbean spiny lobster fishery is not experiencing growth-overfishing (i.e. the ratios of current to MSY-level exploitation rates were consistently <1). Although it would be tempting to draw a specific conclusion on stock status from this information, there are a number of reasons to avoid doing so. The recruitment-based models indicated a wider range of uncertainty regarding overfishing, and the YPR analyses were limited by assumptions about key parameters (e.g. natural mortality, stock-recruitment shape) and a limited time frame. Consequently, the Review Panel concluded that Caribbean spiny lobster stock status remained unknown.

6. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status and, if appropriate, evaluate stock rebuilding; state whether or not the methods are scientifically sound.
No population projections were possible.

7. Recommend probable values for future population condition and status.
No population projections were possible, so probable values for future population condition and status were not produced.

8. Ensure that all desired and necessary assessment results (*as listed in the SEDAR Stock Assessment Report Outline*) are clearly and accurately presented in the Stock Assessment Report and that such results are consistent with the Review Panel's consensus regarding adequacy, appropriateness, and application of the data and methods.
All desired and necessary assessment results are clearly and accurately presented in the Stock Assessment Report, but they remain uninformative on stock status. The results are consistent with the Review Panel's consensus regarding adequacy, appropriateness, and application of the data and methods.

9. Evaluate the Data and Assessment Workshops with regard to fulfilling their respective Terms of Reference and state whether or not the Terms of Reference for previous workshops are adequately addressed in the Data Workshop and Stock Assessment Report sections.
The Data Workshop fulfilled its Terms of Reference. The Assessment Workshop fulfilled its Terms of Reference to the extent possible, given the limitations of the data.

10. Develop recommendations for future research for improving data collection and stock assessment.
See below the comments section.

Comments

1. With the available data, an interesting story becomes evident. The data series can seemingly be split into two components, before and after about 1992. In the first part of the time-series, the abundance indices decline. The models were able to recreate the decline in nominal CPUE on Puerto Rico / St Thomas / St John. This is a common pattern found in exploited fish populations, biomass steadily decreasing, and fishing mortality steadily increasing. The second part of the time-series shows the abundance index remaining steady while the catch increases, a trend inconsistent with our expectation of a fishery in a closed system. As catch increases above the level that was causing a population decline in the first portion of the time-series, we would expect the abundance index either to continue to decline or for the decline potentially to accelerate. Instead, the abundance index levels off as the catch increases. Because of this situation, standard production model approaches do not fit the entire time-series, because they do not have the ability to recreate the observed behavior.

The Panel therefore suggests that additional factors be considered in an attempt to understand better the dynamics of the population. One possibility is that recruitment may have increased during the second half of the time-series, allowing for increased catch without reducing population size. Another possibility is that fishermen may have moved into new areas, accessing a previously unexploited portion of the population, so allowing for increased catches. Other possible hypotheses involve changes in the gear used, or in post-settlement survival, and/or changes in post-larval settlement rates.

It should be possible to modify the modelling approach to produce a model that would support the observed data. One way to do this would be to allow the recruitment parameter r to increase over the second part of the time-series. This would require refining a model unique to the system, perhaps moving beyond the standard modelling software currently used. Once a model can recreate the behavior observed in the data, it should be possible better to identify hypotheses for the cause of the behavior.

Clearly, understanding the dynamics of recruitment in this fishery is crucial. There is therefore a great need to create a standardized annual recruitment index to support any assessment of this stock.

2. The Panel strongly endorses the development of partnerships with local fishermen, to conduct research and to collect the data needed for assessments. Partnership with the fishing community is a cost-effective way to collect components of the needed data. Currently, there is a high level of interest in the fishing community to cooperate with management agencies in collecting data, so the partnership should be encouraged and strengthened. This would also facilitate ongoing cooperation and participation by fishermen in the management process, benefiting all involved.

Recommendations for future data collection and research

Improve and complete historical data on relative abundance indices and catch

- For the commercial fishery
  - Recover pre-1983 data for Puerto Rico
  - Create/recover pre-1975 data for the US Virgin Islands by working with the fishermen's associations
  - Use the newly available US Virgin Islands data for the period 1987–1992
  - Use structured interviews with fishermen to assess gear changes
- For the recreational fishery
  - Estimate historical and current levels

Fishery–independent monitoring

- The Panel identified an apparent inconsistency between the assessment model assumptions of recruitment as a direct function of spawning stock. This appeared to be important enough to warrant two recommendations: 1) to build additional flexibility into the models to allow time-varying recruitment (or at least recruitment dynamics); and 2) to seek to establish a fishery-independent index of recruitment, which is deemed to be crucial. Based on presentations made during the review, there appears to be a tested method for conducting such a survey, and these types of data are currently being used in the SA-GOM lobster assessment. The method consists of placing a series of post-larval collectors in appropriate areas and consistent sampling their catch. This approach appears to be conducive to cooperative research, utilizing fishermen's knowledge of the area as well as their frequent visits to sampling areas. The Panel strongly endorses the need for such a survey to provide a data series for use in the Caribbean spiny lobster assessment, preferably with a sampling design covering both platforms, given the uncertainty about the spatial coupling of recruitment dynamics
- It is necessary to develop and implement sampling program(s) specific to both pre-recruit and adult Caribbean spiny lobsters
- It is crucial to increase sampling effort in the US Caribbean.
- There will be benefit in further diversifying the regions sampled to include equal coverage of areas frequently fished
- Visual surveys for size structure, abundance, and YPR could provide useful time-series of data

Revise the trip interview program (TIP) database exhaustively

- Completing the historical data set would be valuable
- Revitalizing TIP sampling in the US Virgin Islands would have many benefits, not just for the Caribbean spiny lobster stock
- Effort should be directed at key species, generating trip-target information, and obtaining needed detail

Length distribution of the catch

- For the commercial fishery
  - Complete incorporation of non-digitized data for the US Virgin Islands (TIP)
  - Recover historical length data for Puerto Rico and the US Virgin Islands from other studies prior to the TIP

- For the recreational fishery
  - Determine length distributions

Conduct studies to understand the ecology of early juveniles (25 mm carapace length)

- Habitat use needs to be understood better
- More needs to be known about settlement habitat
- Information on movements and migrations needs to be sought
- Clarity of the mortality rates needs to be sought

Spatially explicit studies

- Identify spawning areas and sources of recruits
- Build/acquire habitat maps to identify stratification for research designs
- Combine habitat maps with density counts and habitat models to provide population estimates
- Develop a GIS map of spiny lobster landings throughout the geographic range of the stock, producing catch distributions

Mark-recapture techniques

- Such studies could hone knowledge of abundance
- The techniques could provide additional information on movements and migrations
- Habitat preferences would be better understood

Stock structure

- Stock structure is important in assessments, and genetics offers hope to improve knowledge

Future assessments

- These should explore further use of length structure and density from closed areas as reference points
- Assessments need to be repeated when significant quantities of previously unavailable historical data have become available
- Alternative stock assumptions need to be considered during assessment
  - That of a wider Caribbean stock
  - That of the stock of the US Caribbean and neighboring islands
- The use of nominal CPUE should be considered in future assessments
- The modelling approach needs to be modified to produce a model that would support the observed data. Within the model, the recruitment parameter r should be allowed to increase over the second part of the time-series, perhaps moving beyond the standard modelling software currently used.

Of the above, the Panel places the highest priority on the following, understanding the need to maximize the likelihood of generating an acceptable assessment of the stock in the near future:

- Develop/strengthen fishery-independent data collection
- Incorporate historical data into existing data sets
- Utilize refined models (better to identify viable hypotheses)

Stakeholder opinion

- Priority should be given to research that supports efforts to collect new catch data and increase port sampling. Research efforts should foster involvement of and collaboration with fishers.
- The fact that most of the product in the Caribbean spiny lobster fishery is sold retail and that there are no fish houses (at least in the US Virgin Islands) makes any meaningful future stock assessment extremely dependent on cooperation with the local fishermen.
- There is need at least to explore approaches to identify and incorporate socio-economic and other data types into the model. Some such data may indirectly be reflected but still influence CPUE, and may be available for 20 years or more. Examples are (i) employment; (ii) fuel costs; (iii) coastal development, e.g. on St Croix the number of homes per hectare is a significant predictor of water quality, and water quality may impact habitat and species populations; (iv) km of roads; (v) average *per capita* income.

C. *Spiny lobster in the Southeast United States*

Introduction

A comprehensive overview of the data and models used for the SE lobster assessment was provided. The assessment models explored included ASPIC, a modified DeLury model, catch-curves, untuned VPA, and an integrated catch-at-age (ICA, developed by Ken Paterson) model. The results presented focused primarily on the DeLury and ICA models, with ICA the preferred base-case assessment model.

Panel requests for further analyses during the meeting

1. Additional sensitivity runs using the ICA model, intended to explore the effect of the base-case selectivity assumptions on the results:

- Try an alternate year (>1993) to transition from estimated to constant selectivity
- Try constant selectivity in the early period, then estimated selectivity thereafter, if possible.

The values estimated with three alternative selectivity assumptions were very close to the base-case model result. However, the CVs of recent fishing mortality did increase when the shortest period of constant recruitment was assumed. The second part of the request was not feasible using the current model framework. The Panel was nevertheless satisfied that the base-case results were not likely to be unreliable as a consequence of the selectivity assumptions used.

2. Try a run estimating natural mortality (M) using the DeLury model.

On attempting this, M was not considered to be reliably estimated, but the value used in the base-case model did appear to be consistent with the data.

3. Explore alternative methods for projecting future recruitments with uncertainty, possibly including

- Extrapolation of the recent estimated trend
- Re-sampling from residuals about the mean
- Re-sampling from Monte-Carlo results

A projection including variability in model parameters was completed. The qualitative results were similar for projections based on $F_{current}$ and $F_{20\%}$, although projected harvest levels were somewhat lower than the deterministic values. The Panel was satisfied that the approach adequately reflected uncertainty in future projections.

4. Subsequent to the first three requests, an additional request was made to produce a decision or scenario table based on the model runs already completed and evaluated by the Panel.

Three alternate recruitment scenarios were presented: similar to the last 12 years, similar to the last 4 years, and based on a stock-recruit curve. Respectively, these roughly corresponded to two levels of constant (high and low) recruitment, and to stock-sensitive recruitment. Three alternate management targets were simulated through F values of $F_{5\%}$, $F_{20\%}$ and $F_{30\%}$. However, after reviewing a series of results from this analysis, the Panel concluded that no further material needed to be included in this report or for them to formulate their decisions.

<u>Terms of reference</u>

1. Evaluate whether data used in the analyses are treated appropriately and are adequate for assessing the stocks; state whether or not the input data are scientifically sound.
The data used in this assessment were treated appropriately and are considered fully adequate to assess the stock.

2. Evaluate the adequacy, appropriateness, and application of the methods used to assess the populations; state whether or not the methods are scientifically sound.
The methods used in this assessment were adequate, appropriate, and scientifically sound.

3. Recommend appropriate or best-estimated values of population parameters such as abundance, biomass, and exploitation.
The base-case assessment model provided the best estimates for these values.

4. Evaluate the adequacy, appropriateness, and application of the methods used to estimate stock status criteria (population benchmarks such as MSY, F_{msy}, B_{msy}, MSST, MFMT). State whether or not the methods are scientifically sound.
Because of the lack of direct linkage between spawning stock and subsequent recruitment, there is no comparable proxy benchmark for SSB. For this reason, SSB/SSB_{msy}, MSY, and related criteria could not be estimated. A proxy benchmark for F was available from the SAFMC Fishery Management Plan for Spiny Lobster (Amendment 6) based on static SPR (F_{oy} = 30% SPR, and $F_{msy\ proxy}$ = 20% SPR). The method used in this assessment for estimating stock status criteria for F was adequate, appropriate, and scientifically sound.

5. Recommend appropriate values for stock status criteria.
There was considerable discussion as to whether the $F_{20\%}$ threshold makes biological sense, given that values are likely to be close to this level under historical rates of fishing mortality. It was noted that, if all portions of this Caribbean stock had high fishing mortality rates, this might not be biologically reasonable over longer time-scales. The long-term average is currently estimated to be SPR = 19%, presumed to be sustainable though slightly below the limit. The Panel concluded that there was no basis for recommending alternative benchmarks. Based on the assessment model results presented, overfishing does not appear to be occurring at the moment. Indeed, there is no evidence that growth-overfishing would occur even at very high rates of fishing mortality, given current estimated selectivity patterns. However, the stock status relative to overfished levels cannot be evaluated.

6. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status and, if appropriate, evaluate stock rebuilding; state whether or not the methods are scientifically sound.
The methods used in this assessment were adequate, appropriate, and scientifically sound. The Panel preferred the revised projections including uncertainty in estimated model parameters.

7. Recommend probable values for future population condition and status.
There was no indication that future population conditions and status would be below the current levels reported from the base-case assessment model.

8. Ensure that all desired and necessary assessment results (*as listed in the SEDAR Stock Assessment Report Outline*) are clearly and accurately presented in the Stock Assessment Report and that such results are consistent with the Review Panel's consensus regarding adequacy, appropriateness, and application of the data and methods.
The necessary results fulfilling the SEDAR stock assessment report outline were presented. Additional analyses were performed in response to requests made by the Panel, the summary results of which are included in this report.

9. Evaluate the Data and Assessment Workshops with regard to fulfilling their respective Terms of Reference and state whether or not the Terms of Reference for previous workshops are adequately addressed in the Data Workshop and Stock Assessment Report sections.
The Data and Assessment Workshops appeared to have met their respective terms of reference fully.

10. Develop recommendations for future research for improving data collection and stock assessment.
See below the comments section.

<u>Comments</u>

The Review Panel offers the following comments regarding research needs:

1. Discussion of the ability to estimate the relative stock status with respect to overfished levels focused on the connectivity of the entire Caribbean spiny lobster population and the relative importance of the SA-GOM area in the total. It was noted that catches from the area make up <10% of the catch in the western Atlantic, and that present understanding of oceanographic patterns indicates that it is quite likely that the area receives larvae from other areas. This statement is based on the duration of the larval period and the speed and direction of prevailing currents. Critical information required to evaluate fully whether the stock is overfished include: identifying the source of the larvae settling in the SA-GOM area as well as determining the proportion of larval production from the area that is retained locally. A broad assessment of the Caribbean population would be desirable, but is impractical at this time.
2. There was support from both stakeholders and scientists at the Panel to re-establish an observer program for the commercial trap fishery. This program could supply useful data to be used directly in the present assessment model including: an index of pre-recruit numbers, adults, and other information that cannot be gained through other methods. Efficient coordination and communication between participants (both industry and scientists) must be a priority in planning this program. The Panel recognized that the program will be most valuable as the duration of the time-series increases, and planning should reflect this.

<u>Recommendations for future data collection and research</u>

Data from the commercial fishery

- Re-establish a commercial fishery observer program (described above).

Fishery-independent indices of abundance

- Standardize existing data sets that may be used for juvenile and legal-sized indices of abundance
- Design new monitoring programs to collect systematic, consistent, and statistically rigorous data.

Improved growth information

- Tagging projects should be initiated to obtain growth-rate data from larger (CL >100 mm) lobsters
- Activity may need to be focused in areas of reduced exploitation (such as the Tortugas) to allow capture of these larger individuals in appreciable numbers
- Reconcile growth information from Lipofuscin and tagging data

Modelling

- Conduct Monte Carlo simulations to test $F_{20\%}$ and $F_{30\%}$ threshold and target reference points against various performance criteria. The stock assessment workshop for the stock should develop various scenarios covering a range of hypotheses concerning recruitment and changes in gear selectivity, as well as suitable performance indicators, including catch and measures of SSB. Risks in the performance indicators associated with applying the threshold and target should be generated in future assessments.

<u>Stakeholder opinion</u>

- Fishing pressure has decreased in the Keys because (i) there are less traps as a result of the Trap Certificate Program, (ii) recent efforts to curtail a rapidly expanding illegal dive fishery, (iii) the loss of dock space and subsequent selling out as gentrification continues at an increasing rate, (iv) the loss of suitable crew as a direct consequence of the increasing cost of living in the Keys.
- Fishermen are very willing to sit down with scientists to devise long-term observer/sampling programs that enmesh with operational activity and satisfy crucial needs for data.

2.3 Recommendations for future SEDAR assessments

In terms of the terms of reference provided to the Review Workshop, opportunity was given to all participants (as well as to the Review Panel) to comment upon the whole SEDAR assessment process. What follows is a non-prioritized list of the main points made.

- There is a strong need for enhanced communication, specifically to stakeholders, about what SEDAR is trying to achieve in terms of management.
- To date, there has not been full acceptance from all, and this is put down at least partially to the lack of education and training of certain key parties about the process. Their cooperation is essential if SEDAR is to succeed in its objectives.
- An advanced plan of what species is to be handled when is essential for all those who need and wish to be involved in the process.
- There is need for a (web-based) Glossary of Terms used.
- Continuity of personnel in the workshops is crucial to ensuring both acceptance and enhanced understanding.
- Dissemination of the information created and the results in terms of management action are not always perceived by stakeholders to have been achieved, so it was felt that Councils should make greater effort in this regard, at all levels of the process.
- Several participants, both technical and representing fishermen, felt that greater effort should be made to maximize the time for preparation of data series, assessments, and review material. The Panel shied away from suggesting a deadline for receipt of material prior to each workshop, realizing that the very nature of some data would always make collection to the last possible moment necessary, but stressed that late receipt could easily lead to delayed or less informative assessments of stock status.
- As mentioned several times elsewhere in this report, strong cases were made for incorporating fishermen's knowledge better into the assessment and management process.
- The Review Panel requires the presence of scientists who have not been involved in the Data and/or Assessment Workshops. This may not be a preferred requirement for the participating stakeholders. Stakeholders would clearly benefit and be better able to participate fully in the review process if they had been present throughout all meetings. The Councils could maximize meeting this recommendation by considering paying stipends to participating stakeholders to compensate them for lost earnings.

- There was strong feeling that the anticipated changed representation on the Review Panel may not be most appropriate for the SEDAR area. While understanding and wholeheartedly endorsing the need for independent peer review, a strong case could be made for Panel representation to include stakeholders, biologists knowledgeable about the species, and stock assessment scientists who were not involved in the immediate assessment. It was felt unlikely that such people would be able to participate in the discussions at the current enthusiastic level unless they were formally accepted as members of the Panel.
- Allied to the above and notwithstanding what was ultimately decided on the make-up of the Panel, there was unanimity that the independence of the Review Panel chair (currently appointed by the CIE) was paramount and matched well the objective of independence.
- Given the volume of documentation associated with such reviews and the shortage of time often available to assimilate it, the Review Panel and other participants stressed the need for a clear executive summary to be provided for all substantive documents being addressed. Further, there was a call for a succinct table of model parameters (estimated and observed) to be provided for each assessment along with, if appropriate, a table of management options (e.g. a decision table) and the risks associated with them.