U.S. Caribbean Fish Trap Fishery Costs and Earnings Study

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ABSTRACT

This article summarizes the main findings of the US Caribbean fish trap fishery costs and earnings study. The study collected economic and demographic data about fish trap fishermen in Puerto Rico and in the US Virgin Islands. In-person surveys were administered to one hundred randomly selected trap fishermen. The survey elicited information on household characteristics, annual catch and revenue, trap usage, capital investment on vessels and equipment, fixed and variable costs and on the spatial distribution of traps. In addition, fishermen were asked how they would respond to a trap reduction program. Comparisons across islands showed a high degree of heterogeneity among fishery participants. This article also details how this information will be used to develop economic models to evaluate management proposals.

KEY WORDS: Fish trap, socio-economics, U.S. Caribbean.

Estudio sobre Costes e Ingresos de la Pesquería de Nasas en el Caribe Americano

Este artículo resume los principales resultados de un estudio de costes e ingresos de la pesquería de nasas en el Caribe Americano. El estudio recolecto información económica y demográfica sobre pescadores que utilizan nasas en Puerto Rico e Islas Vírgenes Americanas. Cien encuestas se administraron a pescadores de nasas seleccionados al azar. La encuesta solicitó información

sobre las características del hogar, ingresos y capturas anuales, uso de nasas, inversión de capital en embarcaciones y equipo, costos fijos y variables y distribución espacial de las nasas. También se indago como los pescadores se comportarían frente a un programa de reducción de nasas. Comparaciones entre islas muestra un alto grado de heteroneidad entre los participantes de esta pesquería. Este artículo también señala como se utilizará esta infamación para desarrollar modelos económicos que evalúan propuestas de gestión.

PALABRAS CLAVES: Nasas, socio-economía, Caribe Americano

INTRODUCTION

The fish trap fishery is one of the most valuable fisheries in the U.S. Caribbean. In Puerto Rico, this fishery accounts for 22 percent of the landings and 24 percent of the revenue. Spiny lobster and snappers account for over 60 percent of the revenue. In the U.S. Virgin Islands, fish traps are responsible for 37 percent of the landings and revenue. Spiny lobster and triggerfish alone account for 48 percent of the revenues.

Fish traps are commonly used in coral reef and related habitats, where they target a variety of species including spiny lobsters, deep-water snappers, shallow-water snappers, grunts, and groupers. During the last decade, the impact of traps on coral reefs has been the focus of considerable debate. A number of organizations, including environmental groups, have expressed concern over the physical damage caused by the setting and hauling of traps (Sheridan et al. 2003). Early research indicated that 40% of the traps off St. Thomas were placed over hard corals, resulting in an estimated annual loss of 100 m^2 of hard coral (Quandt 1999). Healthy reefs can yield up to 35 metric tons of fish per square kilometer annually (Russ 1991). However, on-going research suggests that about 20% of the traps are on hard coral in the U.S. Virgin Islands (Sheridan et al. 2003). More recently, Garrison et al. (2004) found that in St. John, fishermen preferentially set traps in algal plains.

In addition to potential habitat damage, the non-selective nature of fish traps is another source of concern. Fish traps catch a variety of overexploited reef fish species. Reef-fish species, particularly groupers, are vulnerable to harvesting because of their life history characteristics, which include slow growth, delayed reproduction, and sedentary behavior. For example, Nassau and Goliath groupers remain overexploited, despite commercial harvest bans since the early 1990s. Because of the widespread use of traps by small-scale fishermen, addressing the anthropogenic impacts of habitat-gear interactions not only requires biological assessments but also socioeconomic assessments.

In anticipation of the need to evaluate the effects of proposed trap regulations on fishermen and their communities, we conducted a costs and earnings study. The primary objective of the study was to collect socio-economic information on the U.S. Caribbean fish trap fishery to support the management and conservation efforts of the Caribbean Fishery Management Council (CMFC). The draft Amendment to the Fishery Management Plans (FMPs) of the U.S. Caribbean to Address Required Provisions of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) is

considering among other alternatives, either reducing the number of existing fish traps and/or phasing out their use over a five to ten year horizon. Socio-economic assessments are vital to evaluate the potential impacts of trap regulations on fishermen and fishing communities.

This study describes the salient socio-economic characteristics of the U.S. Caribbean fish trap fishery. The questionnaire elicited information on household demographics, annual catch and revenue, fishing practices, capital investment on vessels and equipment, fixed and variable costs, behavioral response to a hypothetical trap reduction program, and the spatial distribution of traps. However, for space sake, we only present information on demographics, capital investment on vessel and equipment, and revenue and cost structure of the fleet.

In addition to providing summary statistics, we discuss how this data can be used to develop models that evaluate the economic performance of various regulatory proposals such as a trap reduction program. The study encompasses the Commonwealth of Puerto Rico and Territory of the U.S. Virgin Islands (i.e., St. Thomas, St. John, and St. Croix).

METHODS

The sampling designed called for a voluntary, in-person interview of 60 fishermen in Puerto Rico, 20 fishermen in St. Thomas and St. John, and 20 fishermen in St. Croix. For each geographic area, the sampling plan divided fishermen into two or three strata (or tiers) to reflect the scale of operation, defined by the number of traps owned, from which a simple random sample was drawn.

The number of traps owned to qualify for a given tier varied by island. In Puerto Rico, tier I consisted of fishermen who owned between 1 - 40 fish traps, tier II was made up of fishermen who possessed between 41 and 100 fish traps, and tier III consisted on fishermen who held in excess of 100 fish traps. In St. Thomas and St. John, tier I was composed of fishermen who held between 1 and 50 fish traps, tier II consisted of fishermen who had between 51-150 fish traps and tier III was made up of fishermen who had in excess of 150 fish traps. Lastly, in St. Croix, tier I was made up of fishermen who had less than 19 fish traps and tier II consisted of fishermen who had in excess of 20 fish traps (Table 1).

The rationale for the stratification was to capture the fleet's heterogeneity (i.e., small, medium, and large-scale operators) and to minimize the possibility of inadvertently marginalizing or excluding components of the fleet. Thus, the stratification disproportionately sampled large-scale operators while broadly mirroring the universe of the trap fishermen. In addition, the stratification made the survey more cost effective and convenient to administer. Scale of operation tiers were determined in consultation with local fisheries experts.

Table 1: Survey universe, sample size, and number of responses by tier

Area	Tier (number of fish traps)	Population (number of fishermen)	Target number of interviews	Number of completed interviews	Number of contacts
Puerto Rico	1-40	258	30	30	57
	41-100	53	20	22	31
	[3]101	13	10	8	13
Puerto Rico Total		324	60	60	101
St. Thomas and St. John	1-50	19	8	5	19
	51-150	20	7	10	17
	[3]151	13	5	5	9
St. Croix	1-19	31	13	13	30
	[3]20	14	7	7	12
USVI Total		97	40	40	88
Grand Total		421	100	100	188

To meet the requirements of the sampling protocol, interviewers contacted selected fishermen from a randomized list that recorded fisherman's name, address, and phone number. Surveyors were also instructed to select a replacement if fishermen:

i) Refused to participate,
ii) Were not available due to illness, death, or travel, and
iii) Could not be contacted after eight, separate attempts.

When the number of willing participants prevented the contractors from meeting the stratum goal, interviewers completed additional interviews in other strata. This allowed the contractors to reach the one hundred interviews required under the contract. This situation occurred twice, as surveyors conducted two additional interviews in the second tier stratum for Puerto Rico and three extra interviews in the second tier stratum for St. Thomas and St.

John (Table 1).

Notwithstanding considerable effort and resources devoted to this endeavor, the actual response rate was 53.2%. We calculated the response rate by dividing the total number of completed interviews over the total number of people contacted (Table 1). A close examination at the non-response reasons showed that 52 fishermen were unreachable and 18 fishermen refused to participate. This accounted for 59.1% and 20.5% of the non-response rate, respectively. If we ignore those fishermen who were unreachable, and those who no longer fished with traps (i.e., no longer qualified); then, the effective response rate increased to 80.6%.

RESULTS

Demographic Profile

The age of the sampled population ranged from 23 to 84 years. On average, Crucian fishermen were older than Puerto Rican, St. Thomian, and St. Johnian fishermen. St. Croix fishermen's average age was 57 years whereas Puerto Rican fishermen's average age was 51 years, and St. Thomian and St. Johnian fishermen's average age was 48 years (Table 2). With the exception of St. Thomas and St. John fishermen, the greater the number of traps owned, the older the fisher. Frequency analysis showed that there were 4 respondents in the 20 to 29 age group, 17 respondents in the 30 to 39 age group, 20 respondents in the 40 to 49 age group, and 27 respondents in the 50 to 59 age group. Twenty respondents were in the 60 to 69 age group, 9 respondents in the 70 to 79 age group, and 3 respondents in the 80 to 89 age group.

The survey showed that the respondents were seasoned commercial fishermen. As a group, Puerto Rican and Crucian fishermen had 30, and 29 years of fishing experience, respectively; whereas St. Thomian and St. Johnian fishermen had 25 years of fishing experience (Table 2). As a group, St. Thomian and St. Johnian, Puerto Rican, and Crucian fishermen had 10, 10, and 9 years of formal education, respectively (Table 2). Commercial fishing experience varied considerably across tiers, with the exception of Puerto Rico stratum. In St. Croix, participation in the fishing industry ranged from 25 years in the lower trap tier to 38 years in the higher trap tier. Notwithstanding, the prevalence of fish traps in the Caribbean, most respondents did not operate fish traps for their entire commercial fishing history. Fishermen from Puerto Rico, St. Croix, and St. Thomas and St. John had been fishing with fish traps for 23, 23, and 21 years, respectively.

Trap fishermen's formal education ranged between 1 to 16 years. About 53 percent of the respondents had not completed high school. The majority of the respondents were highly dependent on commercial fishing for their household income. In St. Croix, commercial fishing made up 83% of the fishermen's household income, whereas in St. Thomas and St. John and Puerto Rico, commercial fishing contributed 74% and 68% of the household income, respectively (Table 3).

Table 2: Demographic characteristics

Variable	Region	Tier I	N	Tier II	N	Tier III	N	All	N
Age of fish trap fisherman (years)	Puerto Rico	50.33 (2.84)	30	52.14 (2.33)	2 2	54.87 (1.63)	8	50.81 (2.3)	60
	St. Thomas & St. John	50.40 (4.94)	5	49.20 (1.91)	1 0	43.20 (3.42)	5	48.14 (2.13)	20
	St. Croix	55.07 (3.45)	13	62.57 (2.51)	7			57.41 (2.50)	20
Commercial fishing experience (years)	Puerto Rico	29.80 (2.79)	30	31.18 (2.35)	2 2	31.25 (2.48)	8	30.08 (2.26)	60
	St. Thomas & St. John	20.0 (4.11)	5	29.0 (2.03)	1 0	25.8 (4.01)	5	24.91 (1.96)	20
	St. Croix	24.61 (3.68)	13	38.29 (1.50)	7			28.87 (2.51)	20
Commercial fishing experience with fish traps (years)	Puerto Rico	22.33 (2.57)	30	28.09 (2.52)	2 2	27.12 (2.99)	8	23.47 (2.09)	60
	St. Thomas & St. John	20.0 (4.11)	5	26.3 (2.67)	1 0	23.6 (3.26)	5	23.32 (1.99)	20
	St. Croix	18.08 (3.41)	13	28.71 (4.03)	7			21.39 (2.67)	20
Formal education (years)	Puerto Rico	9.68 (0.656)	28	9.73 (0.56)	2 2	8.75 (0.97)	8	9.65 (0.52)	58
	St. Thomas & St. John	9.25 (1.37)	4	10.55 (0.54)	9	10.80 (0.94)	5	10.19 (0.56)	18
	St. Croix	8.08 (0.69)	12	10.66 (1.06)	6			8.85 (0.58)	18

Table 3: Indexes of fishing dependence

Variable	Region	Tier I	N	Tier II	N	Tier III	N	All	N
Percentage income derived from commercial fishing	Puerto Rico	64.0 (5.72)	28	88.81 (3.361)	2 1	78.12 (5.49)	8	68.73 (4.57)	57
	St. Thomas & St. John	49.0 (18.03)	5	85.5 (4.73)	1 0	93.0 (4.57)	5	74.04 (6.93)	20
	St. Croix	84.23 (5.55)	13	81.43 (7.78)	7			83.36 (4.53)	20
Percentage of commercial fishing income derived from fish trap fishing	Puerto Rico	56.14 (5.55)	28	68.75 (4.45)	2 0	84.37 (5.54)	8	59.37 (4.49)	56
	St. Thomas & St. John	50.75 (16.6)	4	61.0 (6.95)	1 0	73.0 (9.89)	5	61.00 (6.54)	19
	St. Croix	61.82 (8.84)	11	99.29 (0.51)	7			74.86 (5.77)	18
Number of dependents (including self)	Puerto Rico	3.27 (2.51)	30	3.36 (0.30)	2 2	2.87 (0.36)	8	3.27 (0.21)	60
	St. Thomas & St. John	2.80 (0.63)	5	2.6 (0.34)	1 0	3.2 (0.46)	5	2.82 (0.29)	20
	St. Croix	3.46 (0.32)	13	3.14 (0.62)	7			3.36 (0.29)	20
Percentage of catch retained for personal or family use (%)	Puerto Rico	2.76 (0.77)	23	2.93 (0.55)	2 1	4.73 (1.65)	7	2.88 (0.60)	51
	St. Thomas & St. John	7.6 (2.98)	5	1.6 (0.41)	1 0	1.0 (0.32)	4	3.78 (1.16)	19
	St. Croix	2.17 (0.51)	12	3.14 (0.62)	7			2.49 (0.4)	19

The contribution of fish traps to commercial fishing income ranged from 51% in the lowest St. Thomas and St. John trap tier to 99% in the highest St. Croix trap tier. On an island basis, fish traps' contribution to fishing income was 75 % in St. Croix, 61% in St. Thomas and St. John, and 59% in Puerto Rico. In contrast, lobster traps' contribution to fishing income ranged from 0% in St. Croix to 14% in St. Thomas. In Puerto Rico, lobster traps' contribution to fishing income was 11% (Table 3).

The number of dependent household members ranged from 1 to 8, including the respondent. Overall, 90% of the households had at least one dependent. The average number of dependents across islands was constant, ranging between 2.8 in St. Thomas and St. John and 3.4 in St. Croix (Table 3).

Percentage utilization of catch for personal or family use was relatively low. Regionally, the percentage of personal or family catch use ranged from 2.5% in St. Croix to 3.8% in the St. Thomas and St. John. Notwithstanding these results, the lowest trap tier in St. Thomas and St. John exhibited a relatively high percentage for personal or family consumption of catch (7.6%). US Virgin Islands Territorial regulations require individuals who use pots and traps for personal consumption to obtain a commercial fishing permit (Table 3).

Vessel and Equipment Characteristics

The value of fully rigged vessels ranged from $400 to $250,000. Fifty-one percent of the fleet was worth $10,000 or less. The St. Thomas and St. John fleet had the highest mean value, averaging $58,518. The Crucian and Puerto Rican fleets were of considerably less valuable averaging $19,831 and $8,652, respectively. Capital investment value increased with trap usage (Table 4).

The length of the vessels ranged from 14 to 40 feet. Fifty-nine percent of the vessels were at least 23 feet in length. As a group, the fleet based in St. Thomas and St. John had larger vessels averaging 28 feet (Table 4). The fleets based in St. Croix and Puerto Rico had an average length of 21 feet. While mean vessel size increased with the number of the traps owned, there was very little variation across tiers (i.e., less than five feet in difference).

The age of the fleet varied between 2 and 60 years. About 50 percent of the sampled fleet was at least 14 years old. Fishermen from St. Thomas and St. John had the relatively older vessels relative to their counterparts. The fleet's mean age was 18 years in St. Thomas and St. John, and 16 years in St. Croix and Puerto Rico (Table 4). With the exception of the Puerto Rico's trap tier II, vessel age increased with the number of traps owned. The fleet's engine propulsion ranged from 8 to 400 horsepower (hp). The mean engine power was 208 hp in St. Thomas St. John, 108 hp in St. Croix, and 77 hp in Puerto Rico (Table 4).

Fiberglass hulled vessels were prevalent across the islands (Table 5). All of the vessels sampled in St. Thomas and St. John had fiberglass hulls compared to 95% of the vessels in St. Croix and 87% of the vessels in Puerto Rico. The few wooden hulled vessels corresponded to the lower trap tiers of Puerto Rico and St. Croix (Table 5).

Table 4: Vessel characteristics

Variable	Region	Tier I	N	Tier II	N	Tier III	N	All	N
Fully rigged vessel value ($)	Puerto Rico	5,431.03 (1,053.08)	29	18,598 (2,516.72)	21	31,750 (10,752)	8	8,652.393 (1,033.95)	58
	St. Thomas & St. John	33,100 (3,550.68)	5	56,111 (7,456.77)	9	99,000 (31,657)	5	58,518 (8761.98)	19
	St. Croix	18,346 (4,276.15)	13	23,667 (10,908)	6			19,831 (4332.42)	19
Vessel length (ft)	Puerto Rico	19.8 (0.62)	30	24.5 (0.77)	22	24.75 (1.19)	8	20.77 (0.51)	60
	St. Thomas & St. John	26.0 (2.57)	5	27.7 (1.38)	10	31.0 (2.15)	5	27.90 (1.21)	20
	St. Croix	20.23 (0.87)	13	23.29 (2.07)	7			21.18 (0.88)	20
Vessel age (years)	Puerto Rico	15.97 (1.76)	30	18.54 (2.19)	22	15.25 (1.64)	8	16.36 (1.361)	60
	St. Thomas & St. John	16.4 (2.96)	5	17.7 (2.14)	10	21.2 (3.564)	5	18.1 (1.62)	20
	St. Croix	15.46 (2.05)	13	16.0 (3.52)	7			15.63 (1.787)	20
Engine power (hp)	Puerto Rico	65.04 (12.12)	27	131.73 (14.87)	22	61.12 (125)	8	76.72 (9.80)	57
	St. Thomas & St. John	187.0 (33.95)	5	228.0 (12.04)	10	210.0 (5.55)	4	208.44 (13.99)	19
	St. Croix	98.69 (23.10)	13	129.29 (27.66)	7			108.21 (18.09)	20

Table 5: Number and percent of hull construction and engine types

Variable	Region		Tier I	%	Tier II	%	Tier III	%	Tier %
Hull construction	Puerto Rico	Fiberglass	23	76.67	21	95.45	8	100	86.67
		Wood	6	20	1	4.55	0	0	11.67
		Non- response	1	3.33	0	0	0	0	1.67
	St. Thomas and St. John	Fiberglass	5	100	10	100	5	100	100
		Wood	0	0	0	0	0	0	0
		Non-response	0	0	0	0	0	0	0
	St. Croix	Fiberglass	12	92.31	7	100			95
		Wood	1	7.69	0	0			5
		No response	0	0	0	0			0
Engine type	Puerto Rico	Inboard	0	0	7	31.82	1	12.5	13.3
		Outboard	27	90	15	68.18	2	75	80.0
		Other	3	10	0	0	1	0	0
		Non-response					1	12.5	6.67
	St. Thomas and St. John	Inboard	3	60	8	80	4	80	75
		Outboard	2	40	2	20	1	20	25
		Other	0	0	0	0			0
		Non-response	0	0	0	0			0
	St. Croix	Inboard	0	0	1	14.3			5
		Outboard	13	100	4	57.14			85
		Other	0	0	1	14.3			5
		Non-response	0	0	1	14.3			5

Engine types varied across the islands. Outboard engines were more common in Puerto Rico and St. Croix whereas inboard engines were prevalent in St. Thomas and John. In St. Croix and Puerto Rico, outboard engines accounted for 85% and 80% of engines types used, respectively. Only 25% of the engines in St. Thomas and St. John were of the outboard type (Table 5).

Mechanical trap haulers and depth recorders were the most common onboard equipment used (Table 6). About 55% of the sampled population had mechanical trap haulers. In St. Thomas and St. John, all of the respondents reported owning haulers compared to 51.7% in Puerto Rico and 20% in St. Croix. Mechanical trap haulers were more prevalent in the higher trap tiers. Forty-seven percent of the fishermen surveyed stated having depth recorders. Depth recorders were more common in the St. Thomas and St. John fleet (80%) and least common in the Puerto Rican fleet (37%).

Thirty-seven percent of the sampled population had global positioning systems (GPS). Sixty-five percent of the vessels in St. Thomas and St. John were equipped with GPS compared with 31.7% in Puerto Rico. About 25% of the Crucian fleet had GPS (Table 6).

The limited presence of emergency position indication radio beacons (EPIRBS) and radar was common among the fish trap fleet. Only eight percent of all respondents had EPIRBS and only one percent had radar. Thirty-five percent of the St. Thomas and St. John fleet had an EPIRB whereas five percent of the St. Croix fleet had an EPIRB. These results are consistent with Kojis (2004), who found that 9% of the US Virgin Islands fleet had EPIRBs, and that the St. Thomian and St. Johnian fleet carried almost twice as many EPIRBs as the Crucian fleet. None of the Puerto Rican vessels sampled had an EPIRB. Only one fisherman in St. Croix had radar. None of the St. Thomian and St. Johnian and Puerto Rican vessels sampled had radar (Table 6). Kojis (2004) found that about 1.6 % of the U.S. Virgin Islands fleet had radars.

Trap Characterization

Respondents fished between 1 and 350 fish traps. On average, Puerto Rican respondents fished 39 fish traps whereas St. Thomian and St. Johnian and Crucian respondents fished 94 and 27 fish traps, respectively (Table 7). The number of fish traps built or bought ranged between 0 and 175 (Table 7). Fifty-two percent of the sampled population built or purchased 25 fish traps or less. The survey showed that Puerto Rican fishermen built or bought 30 fish traps, St. Thomian and St. Johnian fishermen built or bought 30 fish traps, and Crucian fishermen built or bought 25 fish traps.

Table 6: Number and percent of various fishing equipment

Region	Equipment usage	Tier I	Percentage	Tier II	Percentage	Tier III	Percentage	Tier Percentages
Puerto Rico	Mechanical trap hauler	6	20	18	81.82	7	87.5	51.67
	Depth recorder	10	33.33	10	45.45	2	25	36.67
	GPS	8	26.67	8	36.36	3	37.5	31.67
	Radar	0	0	0	0	0	0	0
	EPIRB	0	0	0	0	0	0	0
	Other	2	6.67	0	0	0	0	3.33
St. Thomas and St. John	Mechanical trap hauler	5	100	10	100	5	100	100
	Depth recorder	3	60	9	90	4	80	80
	GPS	2	40	8	80	3	60	65
	Radar	0	0	0	0	0	0	0
	EPIRB	0	0	3	30	4	80	35
	Other	0	0	2	20	0	0	10
St. Croix	Mechanical trap hauler	1	7.69	3	42.86			20
	Depth recorder	5	38.46	4	57.14			45
	GPS	2	15.38	3	42.86			25
	Radar	0	0	1	14.29			5
	EPIRB	0	0	1	14.29			5
	Other	1	7.69	0	0			5

Table 7: Trap usage characteristics

Variable	Region	Tier I	N	Tier II	N	Tier III	N	All	N
Number of fish traps fished last season	Puerto Rico	24.7 (2.41)	30	63.77 (5.35)	22	212.25 (21.66)	8	38.62 (2.28)	60
	St. Thomas & St. John	33 (6.31)	5	107.3 (8.15)	10	161 (5.02)	5	93.58 (4.09)	20
	St. Croix	20.23 (3.57)	13	42.14 (8.18)	7			27.05 (3.54)	20
Number of fish traps fished built or bought last season	Puerto Rico	24.43 (3.34)	30	45.73 (6.59)	22	71.25 (9.77)	8	29.79 (2.9)	60
	St. Thomas & St. John	12.2 (2.98)	5	31.1 (3.65)	10	53.2 (13.21)	5	29.72 (3.75)	20
	St. Croix	18.31 (3.83)	13	40.71 (9.143)	7			25.28 (3.88)	20
Average life of fish traps	Puerto Rico	1.35 (0.15)	29	1.58 (0.19)	22	3.37 (0.61)	8	1.47 (0.12)	59
	St. Thomas & St. John	5.17 (1.27)	3	4.85 (0.51)	10	4.8 (0.72)	5	4.92 (0.45)	18
	St. Croix	1.25 (0.27)	13	1.5 (0.20)	7			1.33 (0.19)	20
Cost of arrowhead traps ($/unit)	Puerto Rico	88.75 (13.78)	16	112.22 (9.67)	9	133.33 (14.82)	6	94.33 (11.32)	31
	St. Thomas & St. John	260 (34.34)	2	243.76 (23.25)	4	250 (22.64)	3	251.11 (15.64)	9
	St. Croix	123.57 (19.93)	7	108.75 (10.84)	4			118.77 (13.92)	11

The most common trap design was chevron or arrowhead style. Antillean Z (or S) traps, rectangular and star traps are also used. Although Z-traps are considered the most productive trap design, fishermen prefer the smaller-sized arrowhead and square traps because they are easier and less expensive to build and larger number of them can be safely deployed. The cost of a fish trap complete with rope and buoys varied significantly. On average, arrowhead traps commanded $94 in Puerto Rico, $251 in St. Thomas and St. John, and $119 in St. Croix (Table 7). The high variability in trap longevity and cost is due to the size and construction materials employed. Traps usually have a supporting frame and a mesh. Reinforced steel, wood, plastic, or some combination of these materials, make up the trap frame, whereas galvanized wire or plastic coated wire make up the trap mesh (Schärer et al. 2002, Kojis 2004). Galvanized wire lasts about a year whereas plastic coated wire lasts about two years (Schärer et al. 2002). In addition, many fishermen do not use buoys (i.e., set traps blindly) to protect themselves from theft and poaching and to minimize trap loss due to entanglement (Schärer et al. 2002, Kojis 2004).

Fishing Practices

The number of trips per week ranged between 1 and 6. Fishermen from St. Thomas and St. John took fewer but longer trips than their Puerto Rican and Crucian counterparts. As a group, St. Thomian and St. Johnian fishermen took 1.4 trips per week while Puerto Rican fishermen took 2.1 trips per week, and Crucian fishermen took 2.5 trips per week (Table 8). Seventy two percent of the respondents mentioned that they took a maximum of two trips per week. Most fishing trips start at dawn and finished early in the afternoon. Over eighty-two percent of the trips lasted eight hours or less.

Fishermen from St. Thomas and St. John fished on average of nine hours per trip whereas fishermen from Puerto Rico and St. Croix fished for six hours (Table 8). The number of traps hauled also varied. Table 8 shows that St. Thomian and St. Johnian fishermen hauled 68 fish traps per trip, while Puerto Rican and Crucian fishermen hauled 27 and 26 fish traps per trip, respectively.

St. Thomian and St. Johnian fishermen soaked their fish traps for seven days while Puerto Rican and Crucian fishermen soaked their fish traps for six and four days, respectively (Table 8). These results are consistent with earlier findings by Schärer et al. (2002) who report that 53% of the Puerto Rican fishermen use single trap layouts. The same study notes that the mean soak time for Puerto Rican fish traps was five days.

The number of traps per string varied considerably across islands. On average, St. Thomian and St. Johnian fishermen had 8.7 traps per line while Puerto Rican and Crucian fishermen 2.2 and 1.6 traps per line, respectively (Table 8). In St. Croix, 84 percent of the respondents had a single trap per line. In St. Thomas and St. John, only 10 percent of the respondents had a single trap per line. About fifty-five percent of the St. Thomian and St. Johnian fish trap fleet had at least 10 traps per string. Over forty-three percent of the Puerto Rican respondents used one traps per string.

Table 8: Fishing trip characteristics

Variable	Region	Tier I	N	Tier II	N	Tier III	N	All	N
Number of weekly trips	Puerto Rico	2.07 (0.18)	25	2.46 (0.21)	14	2.28 (0.11)	7	2.13 (0.15)	46
	St. Thomas & St. John	1.0 (0)	5	1.3 (0.15)	10	2.2 (0.16)	5	1.41 (0.07)	20
	St. Croix	2.46 (0.31)	12	2.71 (0.33)	7			2.54 (0.23)	19
Trip duration (hours)	Puerto Rico	5.36 (0.31)	25	6.78 (0.42)	14	7.14 (0.51)	7	5.62 (0.26)	46
	St. Thomas & St. John	6.5 (1.30)	5	11.6 (1.47)	10	9.1 (0.95)	5	9.11 (0.78)	20
	St. Croix	4.96 (0.4)	12	6.78 (1.16)	7			5.55 (0.47)	
Number of traps hauled per trip	Puerto Rico	23.08 (2.44)	25	38.71 (3.51)	14	69.43 (4.19)	7	27.13 (2.08)	46
	St. Thomas & St. John	33.0 (6.31)	5	87.4 (8.3)	10	89.6 (9.61)	5	68.07 (4.61)	20
	St. Croix	21.92 (3.62)	12	33.43 (6.46)	7			25.7 (3.23)	19
Soak time (days)	Puerto Rico	4.68 (0.59)	25	4.32 (0.43)	14	6.71 (0.92)	7	5.73 (0.92)	47
	St. Thomas & St. John	7.0 (0)	5	6.9 (0.32)	10	6.6 (0.31)	5	6.86 (0.15)	20
	St. Croix	3.5 (0.48)	12	3.71 (0.71)	7			3.57 (0.40)	19
Number of traps per line	Puerto Rico	2.0 (0.31)	25	2.96 (0.55)	14	3.0 (0.83)	7	2.171 (0.27)	46
	St. Thomas & St. John	3.6 (1.45)	5	11.9 (1.13)	10	11.2 (1.3)	5	8.7 (0.76)	20
	St. Croix	1.83 (0.57)	12	1.28 (0.20)	7			1.65 (0.39)	19

Revenue and Costs

The average St. Thomian and St. Johnian and Crucian fisherman annual gross revenue was $39,018 and $33,317, respectively (Table 9). The average Puerto Rican fisherman annual gross revenue was $15,306. Annual gross revenues generally doubled with increasing tier size. For instance, the lowest St. Thomas and St. John tier reported gross revenues of $17,600, the middle tier reported gross revenues of $34,092, and the highest tier report gross revenues of $77,900 (Table 9).

Economists recognize two types of cost: variable and fixed. Variable costs are those expenses incurred during the operation of the vessel. These vary with the level of harvesting activity. Variable costs can be further categorized into running expenses, which include fuel, lubricants, bait, ice, food, and supplies, and into crew labor expenses. Typically, crew wages are paid as a share of the trip's revenue after deducting operating expenses. Crew compensation excludes returns to owner-operator labor.

The survey showed that the annual average running costs for the St. Thomas and St. John fleet were $ 7,426 and the annual average running costs for the St. Croix fleet were $5,653. The Puerto Rican fleet annual average running costs were $3,550. Fuel expenses accounted for 54.8% of the running costs in St. Thomas and St. John, 48.3% in Puerto Rico and 45.6% in St. Croix. Bait expenses were responsible for 22.6% of the running costs in St. Thomas and St. John, 22.5% in St. Croix and 14.2% in Puerto Rico. Grocery costs varied between 10.8% and 20% of the running costs. Table 9 shows crew compensation by the various trap tiers.

Fixed costs are those expenses incurred regardless of whether the vessel operates or stays idle. They are independent of the level of fishing activity. Fixed costs include mooring fees, hull, engine, and fishing gear maintenance and repair expenses, fishing permit and vessel registration fees, vessel and gear mortgage payments, and insurance payments. Annual average fixed costs were $9,813, $4,202, and $2,348 for the St. Thomas and St. John, St. Croix, and Puerto Rico fleets, respectively (Table 9). Maintenance expenses account for the largest share of the fixed costs. Over fifty percent of the total fixed costs in St. Thomas and St. John, and St. Croix were due to vessel and gear maintenance (other than fish traps) whereas in Puerto Rico they accounted for 35.2% of such costs. Fish trap maintenance costs were the highest in Puerto Rico where they accounted for 52.2% of the fixed costs. Fish trap maintenance was responsible for 28.3% of the fixed costs in St. Croix, and for 15.3% of the fixed costs in St. Thomas and St. John.

Table 9: Revenue and costs

Variable	Region	Tier I	N	Tier II	N	Tier III	N	All	N
Annual gross revenue ($)	Puerto Rico	11,198 (1929.74)	29	27,837 (3,271.4)	19	54,940 (6,810.32)	7	15,306 (1,663.53)	55
	St. Thomas & St. John	17,600 (4,637.24)	5	34,092 (6469.31)	10	77,900 (10,645)	5	39,018 (4,017.98)	20
	St. Croix	24,340 (6,130.38)	11	50,136 (12,466)	7			33,317 (5,898.84)	18
Annual running costs ($)	Puerto Rico	3,173.88 (704.11)	25	5,696.79 (1,049.57)	14	4,282.57 (1,051.98)	7	3,549.51 (599.48)	46
	St. Thomas & St. John	3,952 (361.53)	5	6,520.8 (610.67)	10	13,894 (2,164.61)	5	7,425.6 (604.53)	20
	St. Croix	4,888.32 (787.51)	12	7,216.86 (938.33)	7			5,653.29 (612.09)	19
Annual crew payments ($)	Puerto Rico	2,607.88 (619.06)	24	6,326.07 (1,108.44)	12	9,641.74 (2,216.13)	6	3,326.36 (544.73)	42
	St. Thomas & St. John	3,959.47 (1,710.15)	5	11,413 (2,298.34)	10	41,427 (12,226)	5	16,193 (3,242.53)	20
	St. Croix	10,127 (4,409.26)	11	24,017 (11,441)	7			14,961 (4,910.84)	18
Annual fixed costs ($)	Puerto Rico	1,775.83 (654.95)	30	3,985.45 (437.85)	22	7,015.25 (1,150.07)	8	2,347.51 (528.45)	60
	St. Thomas & St. John	9,252 (3,868.49)	5	7,690 (1,166.06)	10	13,900 (2,250.05)	5	9,813.23 (1,586.03)	20
	St. Croix	4,653.85 (1,081.14)	13	3,201.43 (1,067.47)	7			4,201.98 (815.48)	20

DISCUSSION AND CONCLUSION

Resource and habitat degradation, and poverty imperil the survival of small-scale fishing communities. Confronting these challenges demands policies that ensure that the harvesting potential is commensurate with the productivity of the resource and habitat. The present study contributes to management by describing the socio-economic condition of the U.S. Caribbean fish trap fleet. The study highlights the presence of a diverse fleet. The study found that an important segment of the small scale sector was highly dependent on this fishery. In some instances, trap fishing accounted for 50 - 80% of their household income. The study also highlighted differences in the harvesting technologies, scale of operation and practices employed. For instance, St. Thomas and St. John fishermen had considerable more capital invested in the fishery (vessel, fishing equipment, etc) than their St. Croix and Puerto Rico counterparts. The study also showed appreciable difference in harvesting practices. For example, St. Croix and Puerto Rican fishermen, on average, tended to set one or two traps per line, whereas, St. Thomas and St. John fishermen tended to set nine traps per line.

While costs and earnings studies provide helpful information for describing the socio-economic conditions of the fishery, their value lies in the provision of accurate economic data that can be used to develop economic models to evaluate management proposals. For example, if managers were interested in examining the socio-economic impacts of a trap reduction plan, several relationships, such as value marginal product (VMP) and marginal cost (MC), could be estimated. Figure 1 presents the schematics of a stylized economic model that examines rationalizing the number of traps. The VMP is the gross revenue that is generated by adding one more trap into the fishery. As more traps are added into the fishery, the productivity per trap decreases. The MC is the expense of tending one more trap. The area underneath the VMP curve captures the total gross revenue and the area underneath the MC curve captures the total cost. The difference between these areas is the economic profit. If we assume that the fishery is operating under open access conditions, then the fleet would continue to set traps until the VMP is equal to the MC of tending then. If the Council decides to limit the number of traps from $E_{\text{with traps}}$ to $E_{\text{w.o.traps}}$, then the forgone benefits would be given by the area ABC. The forgoing analysis assumes that the stock remains constant.

The development of bioeconomic models could further contribute to realize the full economic potential of the fishery. Bioeconomic models could assist not only in identifying socio-economic benchmarks, such as maximum economic yield and optimal yield, but also could help estimate harvesting paths that maximize social welfare. This study can also yield valuable information to investigate the socio-economic effects of other regulatory proposals such as gear and vessel buybacks, harvest quotas, and access limitations.

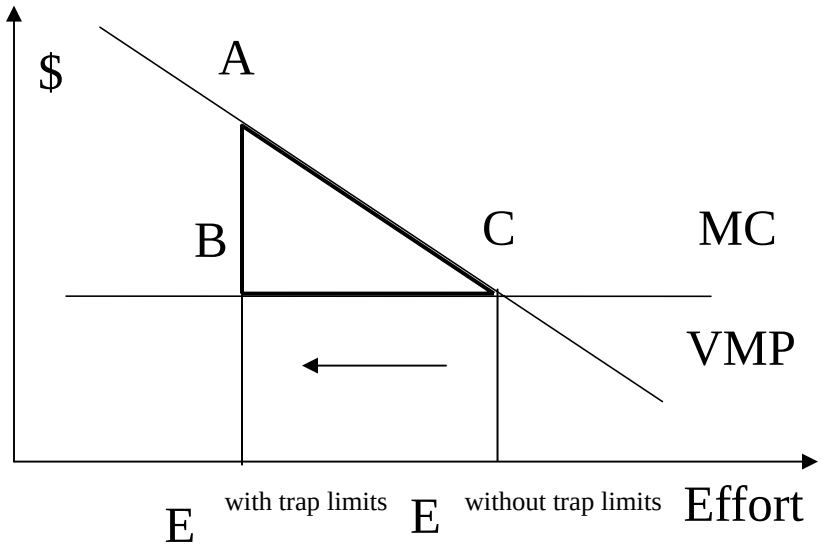

Figure 1: Economic impact of trap reduction proposal

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