Management Implications for Restrictions on the use of Gill and Trammel Nets in St. Croix, U.S. Virgin Islands

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ABSTRACT

The St. Croix gill and trammel net fishery selectively targets large herbivorous parrotfish species, and their removal may ultimately have a substantial impact upon the health of the coral reefs. Commercial catch records show that reef fish landings by fishers using nets in St. Croix have gradually increased since 1990 and currently exceed fish trap landings. In 2002/03, 75.9% of all parrotfish landed were caught by nets, 23.6% by traps and 0.6% by other methods. A total of 43 gill and trammel net fishers and 105 nets were identified in the fishery from a 2003 commercial fisher census survey. Based on the analysis of 35 complete biostatistical samples from commercial net fishers from 1998 to 2005, the average total number of fish per sample was 295 and the average total weight of the catch was 302 pounds. Parrotfish represented 88% of the catch by weight and 82% of the catch by number. Bycatch from the fishery can be significant and includes endangered and protected sea turtle species, federally protected reef fish, small or undesirable fish species, coastal sharks and benthic invertebrates (stony corals, fire coral, gorgonians, sponges and algae). Problems exist in the net fishery from fish spoilage and wanton waste, fish dumping, and derelict nets "ghost fishing". Recommendations have been made to ban the use of gill and trammel nets. Methods to mitigate the impacts to net fishers are addressed.

KEY WORDS: Management, nets, U.S. Virgin Islands

Implicaciones en el Manejo por Restricciones en el Uso de Transmallos y "Gill Nets" en St. Croix, U.S. Virgin Islands

La pesca con "gill nets" y transmallo en St. Croix atrapa de manera selective especies grandes de peces loro herbivoros, y su eliminación puede, por último, tener un impacto substancial sobre la salud de los arrecifes de coral. Registros comerciales de capturas muestran que el desembarque de peces arrecifales por pescadores usando redes en St. Croix ha aumentado gradualemente desde 1990 y, actualmente, exceden el desembarco de peces en trampas. En el 2002/03, 75.9% de todos los peces loro desembarcados fueron capturados por medio de redes, 23.6% con trampas y 0.6% con otros métodos. Un total de 43 pescadores con "gill nets" y transmallos, y 105 redes fueron identificados en las pesquerías durante un censo comercial de pesca en 2003. Con base en el análisis de 35 muestras bioestadísticas completas de pescadores comerciales con redes, entre 1998 y 2002, el promedio de peces por muestra fue 295 y el promedio del peso de la captura fue do 302 libras. Los peces loro representaron el 88% de la captura por peso y 82% de la captura por número. La captura no intencionada durante la pesca con redes puede ser significativa e incluye especies de tortugas marinas en peligro y protegidas, peces arrecifales protegidos federalmente, especies de peces pequeñas y no deseadas, tiburones costeros e invertebrados bénticos (corales pétreos, corales de fuego, gorgónidos, esponjas y algas). Existen problemas en la pesca con redes debido al desperdicio de peces y a desechos en malas condiciones, vertimiento de peces y redes abandonadas "pesca fantasma." Recomendaciones son hechas para prohibir el uso de "gill nets" y transmallos. Métodos para mitigar los impactos para los pescadores con redes son propuestos.

PALABRAS CLAVES: Redes, manejo, U.S. Virgin Islands

INTRODUCTION

In the U.S. Caribbean, the fishery for shallow water, reef-associated fishes is artisanal in nature, involving multiple gear types and methods used to harvest over 180 species (Caribbean Fishery Management Council 1985). The United States Virgin Islands (USVI) has some 380 registered commercial fishers and most of them (~ 220 fishers) reside on the island of St. Croix (Kojis 2004).

Like USVI fisheries found to the north (St. Thomas and St. John), the St. Croix fishery for reef fishes has historically been considered small-scale. Fish traps are considered the traditional harvest method (Brownell 1971) although other gears are also commonly used (line, net, spear). St. Croix commercial fishers use small, open boats (20 - 26 feet in length) with outboard engines which are trailered to widely-dispersed access points. These

characteristics make it difficult to collect adequate fisheries statistics. Indeed, historic data sets for St. Croix reef fish landings are rare or incomplete (Appeldoorn *et al.* 1992). Reported landings of reef fish by the St. Croix commercial fishery from 1996 to 1999 were ~ 0.4 million pounds per year, with fish traps accounting for about 43% of landings (recalculated from Tobias *et al.* 2000).

In this paper we describe the emergence of net fishing as the most important commercial method of reef fish harvest on St. Croix. No comparable fishery yet exists on St. Thomas and St. John, nor to our knowledge does one exist elsewhere in the Caribbean. Net fishing now accounts for more of St. Croix annual landings than traditional gears (e.g. fish traps), and we contend that this shift represents a fundamental change in harvest capacity of the local fishery. Potential ecological impacts of net fishing have generated concern among fishers, user groups, and resource managers leading to a proposed ban on net fishing (see Tobias 2004). Here, we present a summary of available information about the St. Croix fishery including an account of the method of fishing, observations on bycatch, proposed management actions, and alternatives to mitigate impacts to fishers.

Emergence of a Net Fishery on St. Croix

The primary motivating force behind the emergence of a net fishery on St. Croix was likely a decline in catch rates of traps and other gears (Appeldoorn *et al.* 1992, Rogers and Beets 2001) during a prolonged period of economic recession on the island. However, additional factors also contributed to some extent to a shift in the predominant fishing method. Six hurricanes impacted St. Croix during the 10-year period from 1989 to 1999 causing substantial losses of traps (W. Tobias Pers. observation). Many trap fishers could not afford to replace their gears or were reluctant to risk additional loss. "Pot theft" of catch from traps (or of the traps themselves) has been a longstanding problem in the USVI (Sylvester and Dammann 1972). The threat of gear loss to storms or to thieves predisposed fishers towards adopting a gear type that could be removed from the sea upon completion of a days' fishing. Mainland commercial sales interests may have exerted an influence too. Expansion of St. Croix's net fishery coincided with a net ban in Florida in 1994 (Anderson 2002), and salesmen from Atlantic and Gulf Fishing Supply Company (a large supplier of fishing gear in Florida) visited the Virgin Islands to promote net gear that was unmarketable in Florida (Tobias 2004).

METHODS

The scope of this paper will be limited to the method of net fishing which utilizes gill and trammel nets placed near the seafloor (with or without the use of scuba divers) to target schools of parrotfish and surgeonfish. Excluded from our discussion are the various other net fishing methods and gears (e.g. seine nets, umbrella nets, cast nets) which are also commonplace on St. Croix. The nets in use in the St. Croix net fishery are of two types: gill or trammel. Gill nets are generally single-walled and made of monofilament. They capture finfish by entangling them by the gills in the meshes of the net (Barnette 2001). Trammel nets are made up of two or more panels, with outer panels of larger mesh size than the inner panel. Fish swim through the outer panel and hit the inner panel, which carries it through the other outer panel, creating a bag and trapping the fish. Smaller and larger fish become wedged, gilled or tangled (Barnette 2001). Both gill nets and trammel nets are fished with weights at the bottom and floats at the top.

Data Resources

Reported commercial landings were obtained from the Division of Fish and Wildlife (DFW) Commercial Catch Report (CCR) database. Fishers submit CCRs to DFW on a monthly basis. Reports include fishing effort (gear type, area fished, duration, etc.) and landings information which the fisher records in pounds according to species groups (rather than species). The CCR database is presently being revised and some gaps exist in data sets (K.R. Uwate, personal communication).

More detailed information on landings was obtained from port sampling interviews. DFW collects species-level biostatistical data (length and weight) from complete catches of commercial fishers who voluntarily participate in the port sampling program. These data are maintained in the Trip Interview Program (TIP) of the Southeast Fisheries Science Center, National Marine Fisheries Service. Thirty-five port samples were collected from net fishers between April 1998 and September 2005. It is noted that samples were non-randomly collected - port sampling agents focused efforts towards cooperative fishers who were judged to be among the most productive using their respective gear types (W. Ventura, personal communication). The port sampling data reported here was obtained from six different fishermen all of whom used trammel nets in conjunction with scuba diving. No port samples were available from fishers that used gill nets or from fishers that used nets without scuba.

With sponsorship from the Caribbean Fishery Management Council (CFMC), DFW conducted a commercial fisher census in 2003 (see Kojis 2004). Data from this census are excerpted where relevant. Results are also included from opinion surveys of recreational fishers (Messineo and Uwate 2004) and the marine recreation industry (Gordon and Uwate 2003) which were collected by DFW during development of a strategic plan for USVI fisheries.

Finally, we drew upon a variety of additional information resources available to us in order to prepare this paper. These included: informal interviews and discussions with commercial fishers, direct observations of net fishing trips,

public hearings, and investigations of net fishery discards.

RESULTS

Attributes of the St. Croix Net Fishery

A summary of the St. Croix gill and trammel net fishery, as reported by fishers during the 2003 CFMC census, is shown in Table 1. A total of 43 commercial fishers participate in the fishery and they reported employing the services of 61 helpers. Most of the fishers reported using gill nets (34) rather than trammel nets (9). Gill net fishers owned 78 nets, 69 of which were fished. Trammel net fishers owned 27 nets, 23 of which were fished. Average net size was comparable among gill and trammel net fishers in terms of length (gill net = 397 ft, trammel net = 483 ft) and height (gill net = 6.4 ft, trammel net = 6.0 ft). Fishers also reported similar levels of effort using both net types in terms of average soak time (gill net = 3.8 hrs, trammel net = 4.1 hrs) and average number of trips per week (gillnet = 3.1, trammel net = 3.3). More detailed aspects of net construction are also shown (Table 1). Data on the method of net fishing were not solicited. Therefore it is not known how many fishers use scuba to set and fish their nets

Net Fishing Methods

We distinguish between two methods used by St. Croix net fishers. Some fishers use a more conventional

Table 1. Summary of the St. Croix gill and trammel net fishery. Data were obtained during a census of USVI commercial fishermen as reported in Kojis (2004).

	Gill Net	Trammel Net	Total
Fishers			
Number of Net Fishers			
Full Time	20	8	28
Part Time	14	1	15
Total	34	9	43
Number of Net Fishers Using Other Gears			
Net and Other (Trap, Diving, Line)	32	9	41
Net Fishing Only	2	0	2
Number of Helpers			
Average	1.3	1.9	-
Range 0 – 3	1 – 3	-	
Total	44	17	61
Gear			
Number of Nets Owned	78	27	105
Number of Nets Fished	69	23	92
Material			
Monofilament	18	7	25
Nylon	16	2	18
Net Length (ft)			
Average	397	483	-
Range 90 – 1,200	200 – 1,000	-	
Net Height (ft)			
Average	6.4	6.0	-
Range 3.0 – 12.0	4.0 – 8.0	-	
Mesh Size - Square (in.)			
Average	2.0	2.0	-
Range 1.3 – 3.5	1.0 – 3.0	-	
Mesh Size - Stretch (in.)			
Average	3.0	3.5	-
Range 1.8 – 5.0	3.0 – 6.0	-	
Fishing Effort			
Soak Time (hrs)			
Average	3.8	4.1	-
Range 1 – 8	3 – 7	-	
Number of Trips / wk (with any gear type)			
Average	3.1	3.3	-
Range 1 – 5	1 – 5	-	

method of net fishing (e.g. Barnette 2001), setting their nets from boats and fishing their gear in an unattended and relatively passive manner. These fishers select either gill or trammel nets. However, St. Croix fishers have developed a second method of net fishing which is more unconventional and may yield larger catches. It is a very active form of fishing which utilizes scuba divers. Nets are set in strategic locations and schools of target fish are driven into the nets. Generally, divers tend the nets continuously or nearly so. These fishers prefer to use trammel nets. Diver-assisted net fishing appears to be a technological advancement which is unique to St. Croix. With the cooperation of fishers, we made direct observations of this fishing method, as described below.

Net fishers demonstrated an impressive knowledge about behavior and movement of preferred parrotfish species. Fishers emphasized that their success depends critically upon this knowledge. They often scout for areas of large aggregations, and some fishers have identified "highways" that are predictably used by fish during their evening migration between diurnal foraging grounds and nocturnal reef slope or deep reef resting grounds. Highways may occur within spur and grooves zones or along sand channels through hard bottom communities. Nets are set across highways to intercept migrating schools or "runs" of fish.

Direct observations of several trammel net fishing trips allow us to present a generalized picture of the fishing method. A single large net of perhaps 1,500 ft in length is erected underwater by linking smaller individual sections (each several hundred feet in length). Net sections are enclosed in mesh bags and dropped to divers who begin extending the net underwater. The lead line is secured to the bottom by placing it in or under rubble, corals, gorgonians, or other bottom features [securing the net reduces escapement]. Terminal sections of the net are folded back several hundred feet to form pockets on both ends. A central funnel-shaped pocket may also be used. During our observations, nets were fished from mid-afternoon until past sunset although some net fishers reportedly prefer to fish morning or mid-day fish runs. Divers swim the length of the net to clear it of turtles and sharks. Towards sunset, divers begin "coaching" or scaring fish into the net. Most of the target fish - schooling parrotfish – were seen to be caught during the last hours of daylight. At the termination of fishing, the net and catch is hauled into the boat by helpers while a diver frees the net from bottom obstructions. After the net and catch are hauled aboard, fishers return to shore. Typically, the catch is "picked" from the net at the fisher's home, sorted into coolers, and iced for sale the next day.

In discussions, net fishers identified variables which limit the success of their method. High seas and strong winds make setting and hauling nets difficult or impossible. Strong currents cause the nets to "lie down" and also reportedly alter fish movement patterns. Sharks, which are periodically attracted to struggling fish caught in nets, may destroy gear and allow fish to escape. For this reason, sharks are typically dispatched immediately with a powerhead and become part of the catch. When sea turtles become entangled, they may lift nets from the bottom and allow fish escapement. Fishers report that they free turtles when encountered in their nets.

Net Fishing Catch

Based upon reported landings for St. Croix, available data indicate that total reef fish landings remained relatively stable over a 14 year period (not shown). However, during this same time period, landings from traps fluctuated or declined while reported landings from nets showed a gradual increase (Figure 1). In fishing year 2002/03 – the last period for which complete data was available - reported landings from nets exceeded those from traps.

Reported reef fish landings by species group for 2002/03 are shown in Table 2. Parrotfish and surgeonfish represented 56.2% (198,586 pounds) and 12.9% (45,759 pounds), respectively, of reef fish landings by weight. Of the reported landings, 75.9% of parrotfish were caught by nets, 23.6% by traps and 0.6% by other methods. Traps caught a higher percentage of surgeonfish by weight (62.9%) than was reported for nets (36.5%) or other methods (0.7%).

Analysis of port sampling data provides additional information on trammel net fishing effort and catch. On an average net fishing trip, the fisher set 3.2 nets (tied together) with a total length of over 1,100 feet and a soak time of 4.8 hours (Table 3). The average catch was comprised of 295 fish with a weight of 302 pounds. On average, parrotfish comprised 88.1% of the catch by weight and 82.4% of the catch by number (average = 233 fish) per sample. The acanthurid, *Acanthurus coeruleus*, represented 10.5% by number and 5.1% weight (Table 4). Six parrotfish species predominated in port samples from trammel net fishers' catches, and three species (*Sparisoma viride*, *S. chrysopterum*, and *S. rubripinne*) accounted for most (64.8%) of the landings (Table 4). Twenty-seven additional species were caught in lesser abundances, averaging less than 1% of the total catch by weight.

Data for the three most common parrotfish species in trammel net landings were examined over a 2-year time period from May 2002 to March 2004. Length-frequency data from 16 port samples are shown for *S. viride*, (Figure 2), *S. chrysopterum* (Figure 3) and *S. rubripinne* (Figure 4). Average fork length (in cm $\pm$ St.Dev) was 283.3 $\pm$ 38.0 for *S. viride* (n = 1,096), 283.9 $\pm$ 30.9 for *S. chrysopterum* (n = 950), and 288.6 $\pm$ 25.2 for *S. rubripinne* (n = 824). Average weight (in g $\pm$ St.Dev) was 559.1 $\pm$ 231.1 for *S. viride*, 512.8 $\pm$ 158.2 for *S. chrysopterum*, and 523.4 $\pm$ 121.2 for *S. rubripinne*. It should be noted that at least some net fishers prefer to harvest parrotfish of intermediate "plate" size (~ 1 pound) due to market demands (anonymous communication).

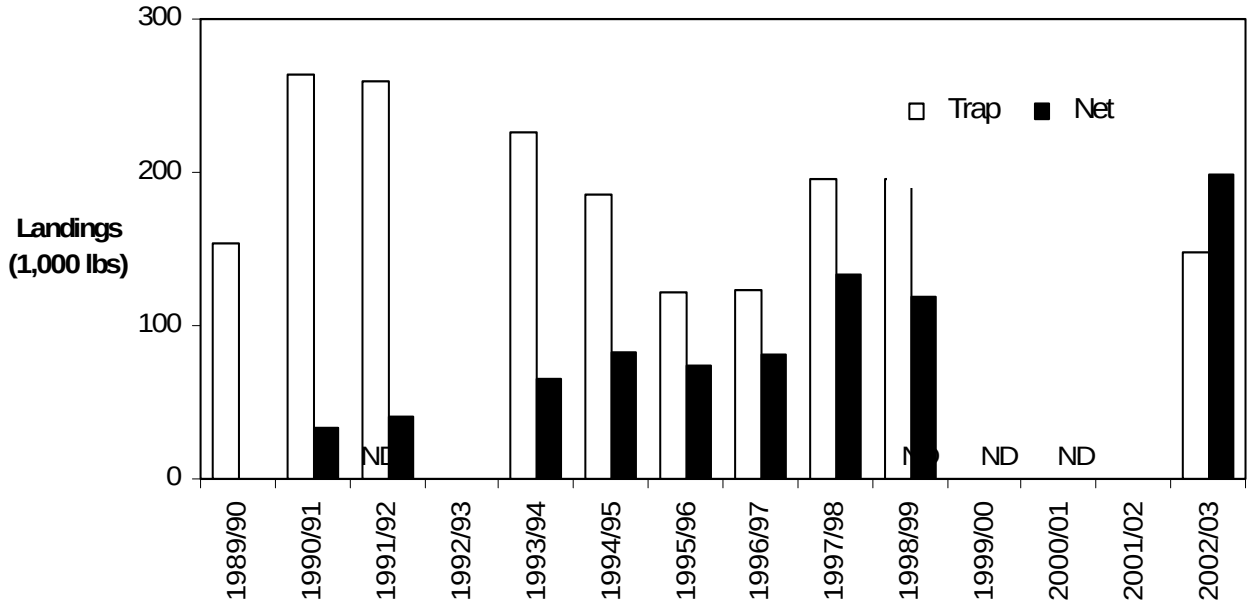

Figure 1. Reported St. Croix reef fish commercial landings by trap and net for fishing years 1989/90 to 2002/03. ND = no data available.

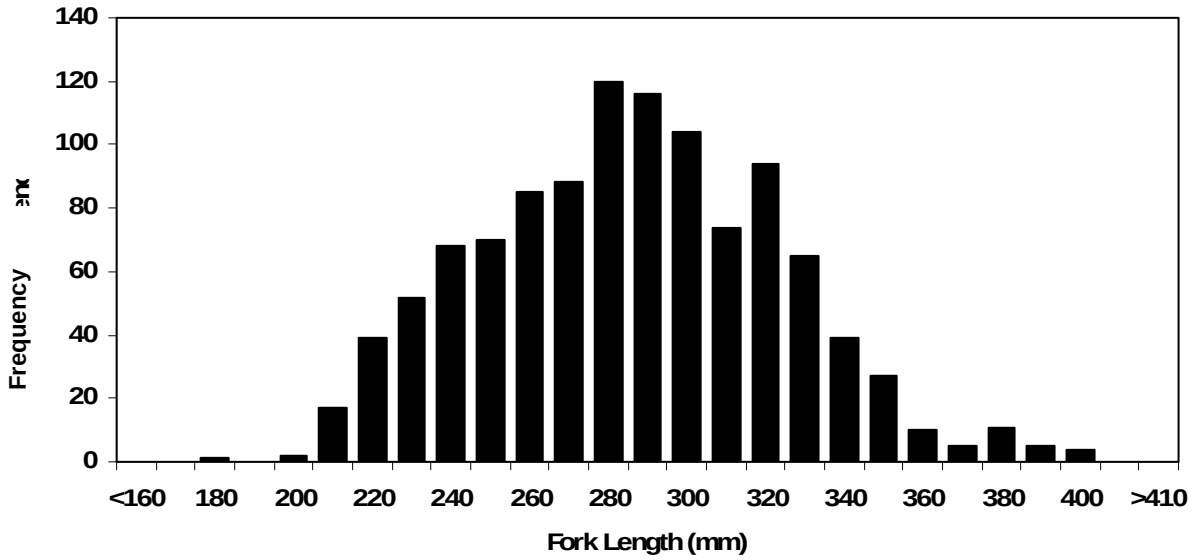

Figure 2. Length-frequency distribution of *Sparisoma viride* landed by trammel net fishers based upon 16 port samples from 2002 to 2004 (n = 1,096).

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Fishers			
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Range 90 – 1,200	200 – 1,000	-	
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Mesh Size - Stretch (in.)			
Average	3.0	3.5	-
Range 1.8 – 5.0	3.0 – 6.0	-	
Fishing Effort			
Soak Time (hrs)			
Average	3.8	4.1	-
Range 1 – 8	3 – 7	-	
Number of Trips / wk (with any gear type)			
Average	3.1	3.3	-
Range 1 – 5	1 – 5	-	

Table 2. Reported St. Croix reef fish landings by species group for fishing year 2002/03.

Species Group	Landings by Gear Type (lbs) Nets	Traps	Other	Total
Parrotfish	150,657	46,825	1,104	198,586
Surgeonfish	16,692	28,762	305	45,759
Grunt	6,812	23,302	516	30,630
Snapper	5,172	17,816	2,153	25,141
Triggerfish	4,475	10,665	267	15,407
Shellfish (Ostraciidae)	3,039	7,423	148	10,610
Grouper	1,800	5,357	1,087	8,244
Jack 5,944	580	901	7,425	
Porgy	1,775	3,034	0	4,809
Goat (Mullidae)	150	3,747	0	3,897
Barra (Sphyraenidae)	1,813	669	362	2,844
Shark	80	0	0	80
Angel (Pomacanthidae)	0	52	0	52
Totals	198,409	148,232	6,843	353,484

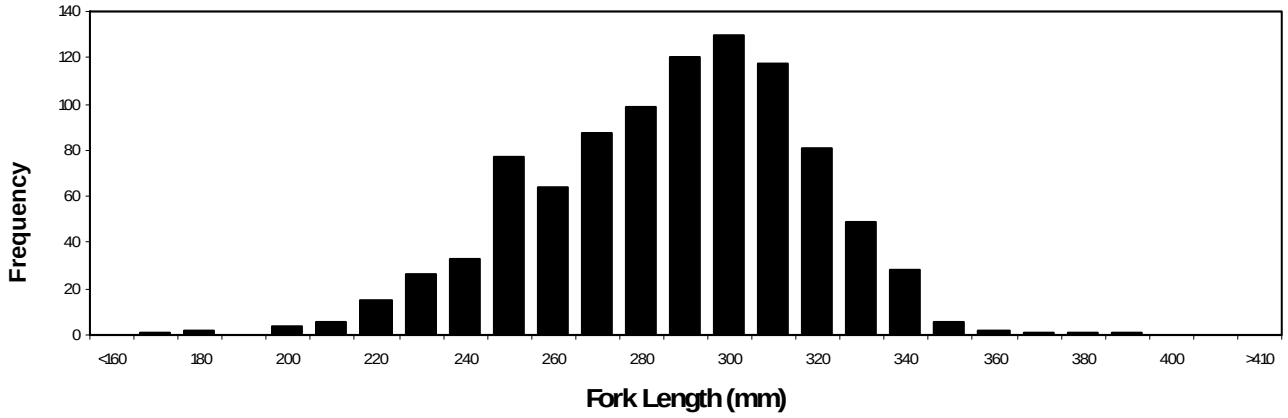

Figure 3. Length-frequency distribution of *Sparisoma chrysopterum* landed by trammel net fishers based 16 upon port samples from 2002 to 2004 (n = 950).

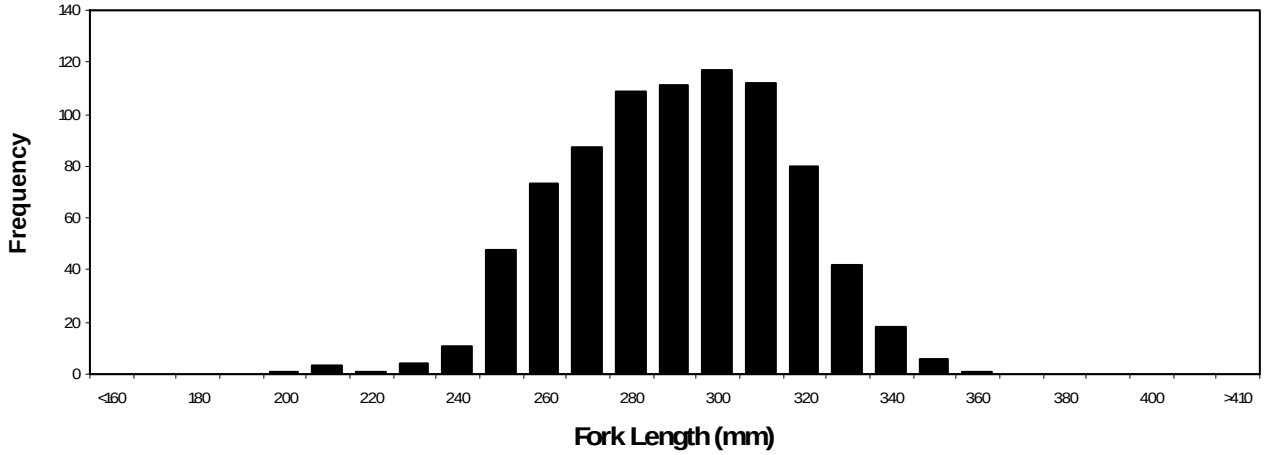

Figure 4. Length-frequency distribution of *Sparisoma rubripinne* landed by trammel net fishers based upon 16 port samples from 2002 to 2004 (n = 824).

Table 3. Effort and catch of St. Croix trammel net fishers based upon port sampling interviews. Data are from 35 interviews conducted between April 1998 and September 2005.

	Average	Standard	Range
Effort			
Number of Nets Fished	3.2	1.9	1 – 7
Total Net Length (ft)	1,115.1	471.2	400 – 2,000
Soak Time (hrs)	4.8	1.0	2.0 – 7.3
Catch			
Number of Fish	294.9	124.9	120 – 586
Weight of Fish (lbs)	301.7	138.0	109.4 – 568.2

Table 4. Catch composition of St. Croix trammel net landings. Based upon 16 port samples collected between 1998 and 2002.

Species	Frequency (%)	Average per Sample		% of Total Catch	
		Number	Weight (lbs)	Number	Weight
Sparisoma viride	100.0	75.6	93.2	26.4	30.5
Sparisoma chrysopterum	100.0	70.6	82.3	24.6	26.9
Sparisoma rubripinne	68.8	39.4	54.6	13.8	17.9
Sparisoma aurofrenatum	62.5	32.4	18.7	11.3	6.1
Acanthurus coeruleus	81.3	30.0	15.4	10.5	5.1
Scarus vetula	50.0	8.7	14.7	3.0	4.8
Scarus taeniopterus	50.0	5.8	5.8	2.0	1.9
Bodianus rufus	50.0	3.8	3.9	1.3	1.3
All other finfish (27 species)*	-	20.5	17.0	7.1	5.6

* All other finfish represented less than 1% of the total catch by weight. These species were, in order of decreasing abundance: *Cephalopholis fulvus*, *Acanthurus chirurgus*, *Caranx ruber*, *Haemulon plumieri*, *Halichoeres radiatus*, *Acanthurus bahianus*, *Balistes vetula*, *Melichthys niger*, *Holacanthus tricolor*, *Haemulon flavolineatum*, *Epinephelus guttatus*, *Holocentrus rufus*, *Haemulon sciurus*, *Haemulon melanurum*, *Ocyurus chrysurus*, *Calamus sp.*, *Lutjanus apodus*, *Haemulon carbonarium*, *Trachinotus falcatus*, unident. lutjanid, *Caranx latus*, *Cantherhines macrocerus*, *Cantherhines pullus*, *Caranx bartholomaei*, *Lutjanus mahogoni*, *Gerres cinereus*, and *Psuedupeneus maculatus*.

Net Fishing Bycatch

Detailed information on net fishing bycatch is presently unavailable although a forthcoming study may allow more explicit comparison of bycatch rates among fishing gears/methods on St. Croix (R. Trumble, personal communication). Here, we present our observations that relate to net bycatch.

In the method of trammel net fishing described above, fish are picked from the net when fishers return to shore or to home. This practice precludes live release of unwanted catch (undesirable species, undersized individuals). The quantity of net fishing bycatch may be substantial - observers estimated almost 50 pounds of "throw-away" fish in one very large (> 700 lbs) trammel net haul.

Direct observations of trammel net fishing confirm that bycatch is an important concern. During one observation, four sea turtles (three green and one hawksbill) were caught in the net – all were released alive by the fisher. However, on three subsequent observations no sea turtles were caught (the frequency of net-sea turtle interaction is not known and may be a function of the fishing location). Coastal shark species were also taken including blacktip, reef, and nurse sharks. Observed finfish bycatch largely resembled those species listed in Table 5 (see below), including foureye and banded butterflyfish – both federally protected species. Bycatch of benthic invertebrates included stony corals, fire corals, gorgonians, sponges and algae.We have investigated a number of incidents involving discarding or "dumping" of fishes and other marine life which were almost certainly net fishery bycatch. At five such incidents, detailed information was collected on species composition (Table 5). Bycatch had been discarded into trash dumpsters (incidents #1 and #5), onto a public beach (incident #3 and #4), or dumped along a public roadside (incident #2). Collectively, discards were comprised of 932 fish (31 fish species from 18 families). One dead hawksbill sea turtle – a federally protected species – was also found at incident #1. The composition of discards included finfish species of little market value (e.g. flying gurnard, *Dactylopterus volitans*, or porcupinefish, *Diodon hystrix*) as well as commercially valuable species which were small, disfigured, or otherwise unmarketable (Table 5).

Dumping of preferred food fish species (parrotfish) has been reported by commercial fishers and by workers at a public landfill (anonymous communications). Although the incidents were not confirmed, it is believed that food fish were discarded by net fishers after the catch had spoiled [finfish spoil rapidly in warm tropical waters when nets are fished for too long (Gobert 1992, Acosta 1994)]. The large catches associated with net fishing may occasionally overwhelm processing or marketing capacities of fishers, leading to spoilage. Such "wanton waste" is prohibited by USVI law.

Ghost fishing was observed on only one occasion. We recovered a gill net entangled in coral reef habitat near Frederiksted. It had been abandoned for an unknown period of time but continued to catch fish (one coney, two scorpionfish, one white grunt, one blue runner) and dislodge benthic invertebrates (one rose coral head, one gorgonian and eight branching sponges). Lost gear may occur more frequently among those fishers who use the net in a passive manner, setting nets from a boat without the aid of divers.

Table 5. Net fishery bycatch from five discard incidents on St. Croix between 2002 and 2005. Asterisks (*) show species typically retained as catch.

		Number of Fish Observed / Incident				
Family	**Species**	**#1**	**#2**	**#3**	**#4**	**#5**
Acanthuridae	*Acanthurus bahianus*	14	38	32	187	340
	*Acanthurus chirurgus**	16	-	-	-	-
	*Acanthurus coeruleus**	17	22	4	4	14
Balistidae	*Balistes vetula**	1	-	1	-	-
	Melichthys niger	4	-	4	19	-
Bothidae	*Bothus lunatus*	3	9	-	1	1
Carangidae	*Caranx bartholomaei**	-	-	1	-	-
	*Caranx ruber**	-	-	2	3	-
Carcharhinidae	*Carcharhinus perezi**	-	-	1	-	-
Chaetodontidae	*Chaetodon ocellatus*	-	-	-	2	-
	Chaetodon striatus	10	7	31	7	3
Dactylopteridae	*Dactylopterus volitans*	-	-	-	-	2
Dasyatidae	*Dasyatis americana*	1	-	-	-	-
Diodontidae	*Diodon hystrix*	25	6	3	8	2
Haemulidae	*Haemulon chrysargyreum*	-	1	-	-	-
	*Haemulon flavolineatum**	2	4	-	-	1
Holocentridae	*Holocentrus rufus**	2	-	-	-	-
Labridae	*Halichoeres radiatus**	4	-	-	-	-
Monocanthidae	*Aluterus scripta*	1	-	-	-	-
	Cantherhines macrocerus	-	-	-	3	-
	Cantherhines pullus	15	2	1	2	4
Ostraciidae	*Lactophrys bicaudalis*	-	1	-	-	-
	Lactophrys triqueter	2	9	-	-	-
Pomacanthidae	*Holacanthus tricolor**	1	-	-	1	3
Scaridae	*Scarus taeniopterus**	1	1	-	-	1
	*Sparisoma aurofrenatum**	-	-	-	-	11
	*Sparisoma chrysopterum**	1	-	-	-	1
	*Sparisoma rubripinne**	-	-	1	-	-
	*Sparisoma viride**	-	-	-	-	1
Scorpaenidae	*Scorpaena plumieri*	2	2	1	2	3
Serranidae	*Cephalopholis fulvus**	-	-	-	1	-
Cheloniidae	*Eretmocheleys imbricata*	1	-	-	-	-
	Totals	122	102	82	240	387

A Comment about Landings

Using descriptive statistics for the St. Croix net fishery (above), it is possible to calculate net fishery landings for comparison to reported landings of the net fishery (~ 200,000 pounds in 2002/03). If there were 43 net fishers who made three trips per week and caught 300 pounds per trip, then net fishery landings would be over two million pounds. This estimate is an order of magnitude larger than reported landings. The discrepancy may be partially explained by unreasonably high estimates of fishing effort. For example, part time fishers probably make fewer than three trips per week and their catches are likely to be far less than 300 pounds. Nonetheless, it is important to note that if average catch size (as determined by port sampling) is indeed reflective of a large proportion of actual catches, then it would require only *seven* trammel net fishers making two trips per week to harvest over 200,000 pounds. Thus, it would seem that reported net fishery landings are an unreasonably low estimate of annual landings. This also implies that commercial fishers have substantially under-reported landings, as suggested previously (Rogers and Beets 2001, Tobias 2004). We suspect that actual net fishery landings are intermediate between these two estimates and closer to one million pounds annually. At current market values (parrotfish sell for $3.50/lb whole), net fishery landings would then be valued at about US $3.5 million annually.

Public Sentiment Towards Net Fishing

In opinion surveys and censuses, commercial fishers of St. Croix expressed concern over net fishing. Of 215 St. Croix fishers interviewed during the 2003 CFMC census, most (67.8%) responded that fishing was worse now than 10 years ago and the most often cited reason (38.9%) for the decline was that net fishers were taking too many fish (Kojis 2004). This recurring sentiment was voiced by the St. Croix marine recreational industry (Gordon and Uwate

2003) and recreational fishing club members (Messineo and Uwate 2004). In each survey, a large number of St. Croix respondents identified excessive net fishing as a problem and felt there was a need to regulate the use of nets.

In response to concerns voiced by commercial fishers and other user-groups, the issue of regulating net fishing was reviewed by the St. Croix Fisheries Advisory Committee (FAC) [FACs are responsible for making management recommendations to local government authorities]. The FAC concluded that a complete ban on gill and trammel net fishing would be the single most effective and enforceable management action. A public hearing was held on January 19, 2005 to gather additional input from St. Croix fishers and other stakeholders. Net fishers contended that a complete ban on nets would be too great an economic impact for them and instead proposed less restrictive measures such as weekly, seasonal, or area closures for net fishing. The FAC deliberated over the fishers' proposed alternatives but concluded that partial closures would not reduce fishing effort sufficiently to reverse overharvesting and would be impractical to enforce. DPNR and FAC have subsequently formulated regulatory measures which, when implemented, would ban the use of bottom set gill and trammel nets but will allow provisions for fishing with nets to harvest baitfish. At the time of this writing, regulations are pending final approval of the USVI Government.

DISCUSSION

Impacts to Fish Stocks

Brownell (1971) suggested that full development of commercial fisheries in the USVI was hindered by coral reef habitat; that modern high-yield techniques (e.g. trawling) could not be applied to the jagged, irregular bottoms of reef areas. Generally, fishers can only use static or passive gears (trap, line, net) in such reef habitats (Acosta 1994). St. Croix fishers have apparently made a significant advancement towards the harvest of reef fish from complex habitats using diver-assisted net fishing. By utilizing scuba divers to set and actively work nets, they have gained access to reef habitats that were generally inaccessible to fishers using passive gears. This method of net fishing, when combined with detailed knowledge of fish behavior, is quite effective at capturing large schools of parrotfish. Although uncertainties associated with reported landings information preclude an accurate assessment, it is probable that net fishing has allowed an increase in annual parrotfish harvest.

In Puerto Rico, commercial fishers also utilize nets to harvest reef fish. Compared to St. Croix, the Puerto Rican net fishery is much larger (Matos-Caraballo *et al.* 2005a) and occurs within a far greater area of fishable waters, Nonetheless, St. Croix reported landings of parrotfish were 50% larger than that of Puerto Rico (Matos-Caraballo *et al.* 2005b). Scuba gear is not commonly used by net fishers in Puerto Rico due to high investment costs (D. Matos-Caraballo, Pers. communication). Scuba diving appears to substantially augment the effectiveness of net fishing and this may account for the greater parrotfish landings by the St. Croix net fishery.

Impacts of the net fishery upon St. Croix fish stocks are not yet known. Artisanal fishing can dramatically alter the size structure of reef fish populations (Hawkins and Roberts 2003a). Studies conducted in Puerto Rico indicate that gill nets and trammel nets are size-selective (Acosta 1988, 1994) and capture fish of larger size than other gears (Matos-Caraballo 1991, Gobert 1992, Valdés Pizzini *et al.* 1992). Available data from the St. Croix trammel net fishery are equivocal on this point. Parrotfish caught by trammel net fishers of St. Croix were relatively large, and generally did not include smaller size classes (Figures 2-4). Further, the mean capture sizes of three target species (*S. viride*, *S. chrysopterum*, and *S. rubripinne*) from the net fishery in 2002 - 2004 were similar to those of trap-caught fish in 1990 (see Appeldoorn *et al.* 1992). Thus, there is presently no direct evidence for altered size structure in these species. However, size-selectivity of nets and/or size preference of fishers may act to bias landings data. Fisheries-independent observations are needed to determine if landings data adequately reflect the underlying populations from which the fish were caught (Acosta 1994).

For sex-changing species such as parrotfish, chronic removal of large individuals may reduce the reproductive output of populations (Hawkins and Roberts 2003b). In the case of the St. Croix net fishery, we suggest that the fishing method may act to reduce reproduction in another way. Because parrotfishes are social and gregarious spawners, an entire breeding school might be removed with a single set of a net. Whether net fishers specifically target spawning-related activities of parrotfish is not presently known. However, other methods (e.g. fish traps) seem unlikely to so thoroughly disrupt social behaviors or spawning activities of adults.

Ecosystem Impacts

Net fishing may impact coral reef habitats directly through interaction of gear with benthic communities or through removal of invertebrates as bycatch. Barnette (2001) suggested that nets have minimal impact upon the benthos. Based upon our limited observations of one form of active (diver-assisted) trammel net fishing, we identified concerns about negative gear-habitat interactions on St. Croix. Elsewhere, investigators also have reported that hauling of fishing nets causes damage to corals and associated members of benthic communities (Munroe *et al.* 1987, Ohman *et al.* 1993, Jennings and Polunin 1996). Bycatch of benthic invertebrates was observed in this study, including stony corals, fire coral, gorgonians, sponges and algae. The magnitude of habitat-gear interaction and invertebrate bycatch requires additional

study.

Ultimately, indirect impacts of net fishing may be of far greater consequence for St. Croix coral reef ecosystems. The St. Croix net fishery selectively targets large herbivores – parrotfish, and to a lesser extent surgeonfish - which are the primary vertebrate grazers on Caribbean coral reefs. Vertebrate herbivores play an important ecological role in coral reef ecosystems. Their removal through overfishing has been linked to phase-shifts of reef system, from coral-dominated to algal-dominated communities (Hughes 1994). The increased harvesting of reef herbivores afforded by net fishing may sufficiently reduce fish stocks such that ecosystem effects are manifested.

Mitigation

Pending regulations would ban the use of gill and trammel nets. How will the St. Croix net fishery respond to such a ban? Facing the loss of their preferred gear, fishers should shift to the next most productive available gear type in order to sustain their income. Most net fishers already use other methods of fishing and only two fishers reported fishing exclusively with nets (Table 1). Nonetheless, the fishers' transition into different fishing methods will require additional monetary investment to acquire new fishing gear.

A net buy-back program has been proposed to give financial assistance to fishers during transition from nets to other gear types. DFW has received a $75,000 grant from NOAA-Fisheries for the buy-back of gill and trammel nets. Through FAC deliberations and additional discussions with fishers, a strategy for buy-back was developed involving weighted compensation. Fishers will receive payments based upon their share of the fishery, with shares being defined based upon reported landings during the previous five years. This strategy will provide greater compensation to those fishers whose earnings have been most dependent upon net fishing. In addition to buy-back funds, fishers will be offered a series of workshops on the availability of low-interest loans through the Small Business Development Agency.

At present, it is not clear which gear types fishers will select as an alternative to net fishing. Fishers and resource managers have discussed a return to more traditional fishing practices using traps. However, expansion of the trap fishery may be difficult to realize. Net fishers who switch to traps may be unable to sustain their incomes unless they utilize a substantial number of traps. The fish trap fishery of the U.S. Caribbean has come under greater scrutiny by federal agencies (e.g. Sheridan *et al.* 2005) and expansion of this sector may be unreasonable. Given a general reduction in the area of fishable waters of St. Croix due to a national monument expansion and development of a territorial marine park, a large increase in trap numbers will also create new conflicts within and among user-groups. Further, the threat of pot theft has not diminished and requires resolution. ncreased enforcement patrols are necessary if net fishers are to be encouraged to shift into the fish trap fishery.

Given the multi-gear nature of the St. Croix fishery, a number of displaced net fishers will select methods other than trap fishing. Scuba diving with spear may become the preferred method of reef fish harvest for some of these commercial fishers. Diving might be an especially popular choice among trammel net fishers who would presumably be more inclined towards an active, underwater method of harvesting. As an alternative, fishers are being encouraged to shift to line fishing for pelagic species. DFW has developed and maintained a fish aggregating device (FAD) program with the goal of shifting commercial fishers to target seasonally abundant pelagic species (tuna, dolphin, wahoo) in place of reef-associated species. The FAD program is effective and popular with USVI fishers, and the high-catch rates at FADs suggest that a commercial-scale pelagic fishery could be further developed (W. Tobias, Personal observation).

The goal of the net buy-back program is to minimize economic hardship to fishers who are impacted by a ban on net fishing. It is hoped that by making financial resources available, fishers will receive adequate support during transition into another fishery.

ACKNOWLEDGMENTS

The authors wish to acknowledge the fishers who participated in the DFW port sampling program, shared their observations and opinions, and/or allowed us to observe their fishing methods. Port samples were collected by Willy Ventura and Hector Rivera. NOAA-Fisheries generously provided funds to initiate a net buy-back program. Data for this report were collected with funds from NOAA-Fisheries State/Federal Cooperative Statistics Program and Inter-Jurisdictional Program.

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