Engineering Bycatch Reduction in St. Thomas Fisheries: Development of Escape Vents for St. Thomas Fish Traps

Ingeniería Utilizada en la Reducción de Pesca Incidental en las Pesquerías de St. Thomas: Desarrollo de Ventanas de Escape para las Nasas de St. Thomas

Recherches sur la Réduction des Captures Accessoires par les Pêcheries de St Thomas: Développement de Dispositifs d'Échappement pour les Nasses de St. Thomas

DAVID OLSEN[1] and RONALD L HILL[2]
[1]*St. Thomas Fishermen's Association, St. Thomas, US Virgin Islands.* olsen41@aol.com.
[2]*NMFS, Southeast Fisheries Science Center, Galveston, Texas USA.* ron.hill@noaa.gov.

ABSTRACT

Escape vents of various dimensions were installed in strings of fish traps then given to fishermen who were told to fish them in their normal fashion and in their normal locations. Catch from each trap was bagged separately and returned to shore where species were identified, counted, and measured. Various vent designs and within-trap locations were evaluated for their ability to retain target species and sizes while reducing bycatch, based on these catch data. Final results identified optimal width and height as well as the optimal location on the trap. In addition to the demonstrated results, fishermen reported that the final design and location for installation basically eliminated the bycatch of undersized, thin-bodied fish in their catches.

KEY WORDS: Fish traps, escape vents, bycatch, Virgin Islands

INTRODUCTION

National Standard 9 of the Magnuson-Stevens Fishery Conservation and Management Act [As Amended Through January 12, 2007 (Section 104-297)] states that "Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch." Since little information has been available on either bycatch rates or mortality, the St. Thomas Fishermen's Association (STFA) undertook projects with partners such as MRAG and NMFS to characterize fisheries and bycatch. This paper summarizes efforts to reduce bycatch in trap fisheries in the northern US Virgin Islands (USVI) in collaborative research between fishermen and scientists.

In the northern USVI, fish and lobster traps continue to account for about 70% of the total reported landings, with hand line and seine net fishing landing significant but smaller proportions. Fish traps are regulated as a commercial gear requiring an annual commercial fishing license, prescribed identification on each trap, and mandatory reporting of commercial catch and other summary information. Currently the annual reporting is comprised of 12 monthly reports supplied by fishermen. Recent changes to reporting forms were intended to solicit information on bycatch but reporting rates have not exceeded 10-15% since this practice was instituted in 2002.

The Caribbean Fisheries Management Council (CFMC) has previously addressed bycatch concerns by regulating mesh size in fish traps. Research on the effect of mesh size on retention (Appeldoorn and Posada 1992, Olsen et al. 1978, Rosario and Sadovy 1991), led to sequential regulated changes in mesh sizes. Olsen et al. (1978) compared 1-inch hexagonal mesh, 1 by 2 inch rectangular and 1¼-inch hexagonal mesh and demonstrated significant increases in the catch of small fish in traps with the smaller mesh sizes. In the 1985 CFMC Reef Fish Plan, the minimum mesh size for fish traps was set at 1¼ inch hexagonal mesh (CFMC 1985). In 1990 (CFMC 1991) the minimum mesh size for fish traps was increased from 1¼ inch to 2 inches square (in St. Thomas/St. John but not in St. Croix) due to continuing concerns over bycatch levels. Following this regulation, fishermen reported significant decreases in bycatch retention although no directed studies of the impacts were undertaken in the USVI following the change.

Olsen et al. (this volume) are reporting on studies undertaken by the STFA and partners, which have identified the bycatch components from the various St. Thomas fisheries (full details in Olsen et al., In prep.). The current paper summarizes efforts to reduce bycatch and mortality by experimental selection of escape vents.

MATERIALS AND METHODS

The current study consisted of three elements:

i) A diving study in which traps were stocked with fin-clipped fish and observed before and after hauling with the traps being set between 1 and 7 days,
ii) Analyses of fish behavior in traps using diver observations and underwater video, and
iii) Field-testing of various escape vent configurations.

The diving studies and fish behaviors are being reported elsewhere (Hill et al., This volume, Hill et al., In prep.)

Traps Tested

Standard St. Thomas fish traps were used. Ten traps were placed at 250-foot intervals on a rope string which was 2,500 feet long. The various vents (two of each design) and two control traps (no vents) were arranged in random order along each string. Normal hauling rate is around 2.5 feet/second. In all phases, except for phase 4, two vents were placed on the bottom side of the trap away from the funnel. Vents with widths [cm (inches)] of 2.5 (1), 3.2 (1¼), 3.5 (1⅜), 3.8 (1½), 4.4 (1¾), 5 (2), and heights of 10 (4), 14.6 (5¾), 15.2 (6), 24.8 (9¾), 45.7 (18) were tested in various phases (Table 1). Vent sizes will be discussed in English units for convenience. Phases 3 and 4 included comparisons with different vent placements (upper vs. lower/front vs. back) in the trap walls.

Field-Testing

i) Field-testing took place between September 2010 and March 2012. Results were later compared with a pilot project conducted during 2008.
ii) Eight fishermen were provided with test strings throughout the current project and four during the 2008 pilot project. (Two additional fishermen were rotated in during the project for a total of ten.)
iii) Fishermen were told to fish the study traps in exactly the same manner as they normally fished their own traps.
iv) During trap hauling, the entire catch was emptied into a plastic (sand bag) bag numbered according to the number on the trap.
v) The catch was returned to shore where the project port sampler:
   - Recorded the GPS coordinates and depths for the start and end of the string
   - Identified the various species.
   - Measured Fork Length (FL) and Total Length (TL) to the nearest mm.
   - Had the fisherman identify which fish were retained for sale and which were bycatch and the reason why the bycatch was being discarded.
vi) The data were then recorded in an MS Access database along with the date, moon phase and age, for later analysis.

RESULTS

Locations of all of the 402 field-testing trips and 196 diving trips reported in Hill et al., (this volume) in the study are shown in Figure 1.

Ninety-four species and 13,561 individuals were caught during the pilot study and field-testing effort. The invasive lionfish (*Pterois volitans*), which did not appear in our study traps until April of 2011 (although it had been present in St. Thomas since 2009), ended up being the 19th most common species. A total of 10 vent designs were evaluated over the course of the combined pilot study and field-testing effort. Four classes of bycatch/discards were identified: Ciguatoxic, Regulatory, Non-Commercial Species, Too small. Species that were too small were further categorized as either boxfish or thin-bodied, not-boxfish species (TBNB). These TBNB species, including many reef herbivores, were our primary targets for release through escape vents.

Table 1. Comparison of various trap vent studies.

Source	Vent Height (inches)	Vent Width (inches)	Trap Mesh Size	Fish/ Trap Haul (Control Traps)
Munro (1999)	2.76	1.10	1 inch	10.0
	3.15	1.18		
	3.54	1.30		
	3.54	0.98		
Johnson (2010)	7.87	0.98	1 inch	11.8
	15.75	0.98		
STFA Pilot (2008)	6	1	2 Inch	4.65
	4	1		
	4	2		
STFA CRP (2010)	6	1 ¾	2 Inch	5.44
	5 ¾	1 ½		
	5 ¾	1		
	18.0	1		
	5 ¾	1 ⅜		
	9 ¾	1 ⅜		
	5 ¾	1 ¼		
Olsen, Dammann and Laplace (1978)			1 inch	32.8
			1 by 2 inch	17.5
			1.5 Inch	1.8

The boxfish showed no reduction in traps with the vents except the largest widths of the pilot study. Almost all of the non-boxfish bycatch species exhibited reductions in catch/trap when the best-performing, 1⅜ by 5¾ inch vents were employed. Reductions were highest in the thin-bodied species, with 90% reductions in both *Cantherhines pullus* and *Acanthurus bahianus* and 86% reduction in *Acanthurus coeruleus*. Overall the 1⅜ by 5¾ inch vents located on the front of the trap released 45% of the bycatch compared to the control traps.

When weight per trap haul was calculated, the average size of fish in control traps was significantly less than in the 1⅜-inch vented traps ($p < 0.004$ when tested with one-way ANOVA). The average total catch per trap in control traps was not significantly different from traps with 1⅜-inch vents.

The only other vent design that matched the performance of the 1⅜-inch vent was the "1-inch edge" vent recommended by Johnson (2011) which had both high retention of commercially important species (97% of the control) and low retention of the "too small, not boxfish" portion of the bycatch (32%) (Figure 3).

In addition to evaluating effectiveness of escape vents, our study revealed additional factors affecting trap studies or fisheries. We studied sample numbers vs. variation in trap catches for a better understanding of their sampling efficiency. We evaluated physical factors such as bottom temperature, moon phase, and season for correlation with catches. Although many of these results will be presented in Olsen and Hill (In prep.), the seasonality exemplifies the findings.

Seasonal Effects

Most of the species caught had periods of seasonal catch abundance. Fishermen report that the period around Lent is accompanied by poor fishing. Our study results support that observation. There appear to be two "seasons" in the trap fishery. The first covers the period from March through July with low catch per trap haul. This is followed by a period of higher landings extending from August through February (Figure 2). There was approximately 40% difference in the catch/trap between the low period and the high period. When the monthly catch rates were calculated for the 17 most frequent species in the study, there were similar patterns. Highest catch/trap haul for many species occurred between August and February and a period of lower landings occurred from March to July (Figure 2). Catches of a number of species, for example, queen triggerfish (*Balistes vetula*), red hind (*Epinephelus guttatus*), longspined squirrelfish (*Holocentrus rufus*), blue tang (*Acanthurus coerulus*), doctorfish (*Acanthurus chirurgus*), schoolmaster snapper (*Lutjanus apodus*), white grunt (*Haemulon plumierii*), and bluestriped grunt (*Haemulon sciurus*) exhibited strong seasonality.

CONCLUSIONS

The combination of SCUBA diving observations coupled with extensive sample size during the field-testing provide strong results that escape vents offer a means to reduce bycatch of thin-bodied reef herbivores, such as surgeonfishes, while retaining target species/sizes and also suggest a number of concerns which must be considered when using fish traps as sampling devices.

In our study, using standard fishing traps and methods, the cumulative average CPUE did not begin to stabilize until at least 40 trap hauls had been made. Use of fish traps to determine associations with bottom types (e.g. Garrison et al. 2004) or standing stock (T. Gedamke, Personal comm.) may require sample sizes that are much higher than previously realized. Sources of variability likely include lunar influences, seasonal effects, and short-term behavioral effects. Far from being static devices where fish enter and remain until the traps are hauled, video and diving analysis indicates that fish are continually entering and

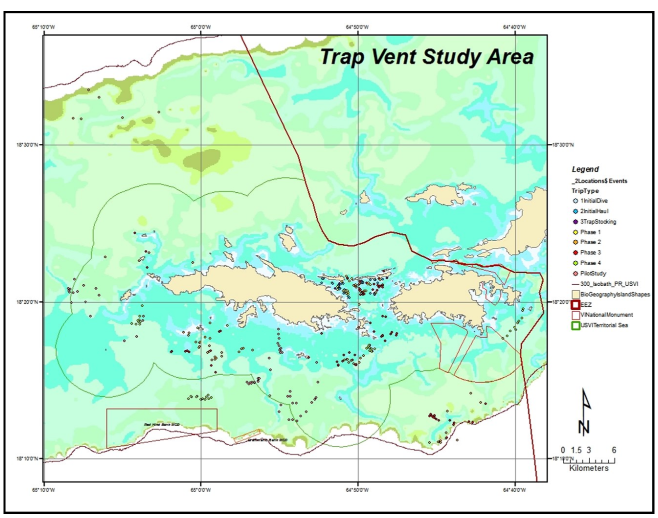

Figure 1. Locations of field-testing trips.

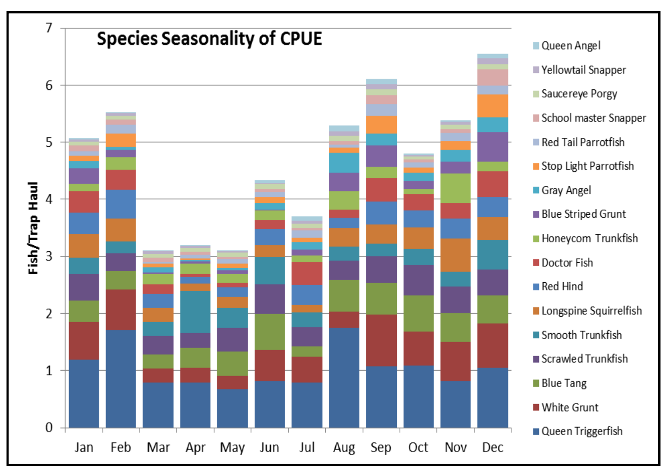

Figure 2. Seasonal variability in the number of fish/trap haul for the 17 most abundant species in the study.

leaving fish traps and that the "catch" is primarily a sample in time of the inhabitants, as also reported by Munro et al. (1971).

Analysis of the data on vent width suggests two alternatives. The 1⅜-inch vents were generally the most effective in achieving a balance between releasing target bycatch (TBNB) while still retaining a high proportion of catch. The one exception was the traps with the "1-inch edge" vent suggested by the work of Johnson (2010) where an extra rebar was welded in a corner to create an escape vent that extended the full height of the trap. This vent both released the target bycatch and retained a high proportion of the commercially valuable sizes and species. However, installation cannot be accomplished by retrofitting traps; this vent has to be installed during trap construction or while returning traps to shore. This is not practical for St. Thomas fishermen. The second option, installation of a 1⅜ by 5¾ inch vent can be easily accomplished in working traps. This operation was repeatedly carried out throughout the current study as vents were changed out during the various phases. Wire mesh was snipped and the vent was wired in.

Data collected during efforts by St. Thomas fishermen to reduce the number of traps by 20% have indicated that they have around 4,700 traps in the water at present (CFMC 2011). Traps are lost at a rate of approximately 10%/year (http://www.stfavi.org/files/LostTrapReport.pdf) indicating that it would take up to 10 years to replace all of the traps with an escape vent created in this manner. Thus, use of a pre-constructed vent type that can be easily installed at sea would seem to be the desired option. Our study results indicate that the optimal design would involve a 1⅜ by 5¾ inch vent placed in the front (away from the funnel) side of the trap.

While reductions in numbers of fish by certain trap configurations were evident, the most informative measures involved biomass and/or mean lengths. We found a measurable increase in the average weight of fish in the 1⅜ by 5¾ inch vented traps when compared to the controls even though the average total weight/trap haul was nearly identical for both vented and control traps. In her work, Johnson (2010) found significant increases in the average sizes retained in vented traps while in the current study, we saw consistent but only moderate increases. We attribute the differences to mesh size; she was using traps with 1-inch mesh while St. Thomas fishermen used 2-inch square mesh, which already releases many of the smaller fish. In an earlier study of the effect of mesh size on traps (Olsen et al. 1978) 1-inch mesh traps caught 17.9 times more fish when compared to 1½-inch mesh traps. St. Thomas fishermen report that the introduction of 2-inch mesh resulted in a significant decrease in the numbers of small fish retained in the traps. During Phase 4 of this project, participating fishermen reported catches that were nearly entirely market sized fish, eliminating the necessity to sort following hauling.

The results of the current study have been well-received by fishery managers. The CFMC has undertaken discussions about possible funding of full implementation of the final vent design. If significant reductions in bycatch can be verified following implementation, management restrictions such as annual catch limits may be re-considered (CFMC 2012).

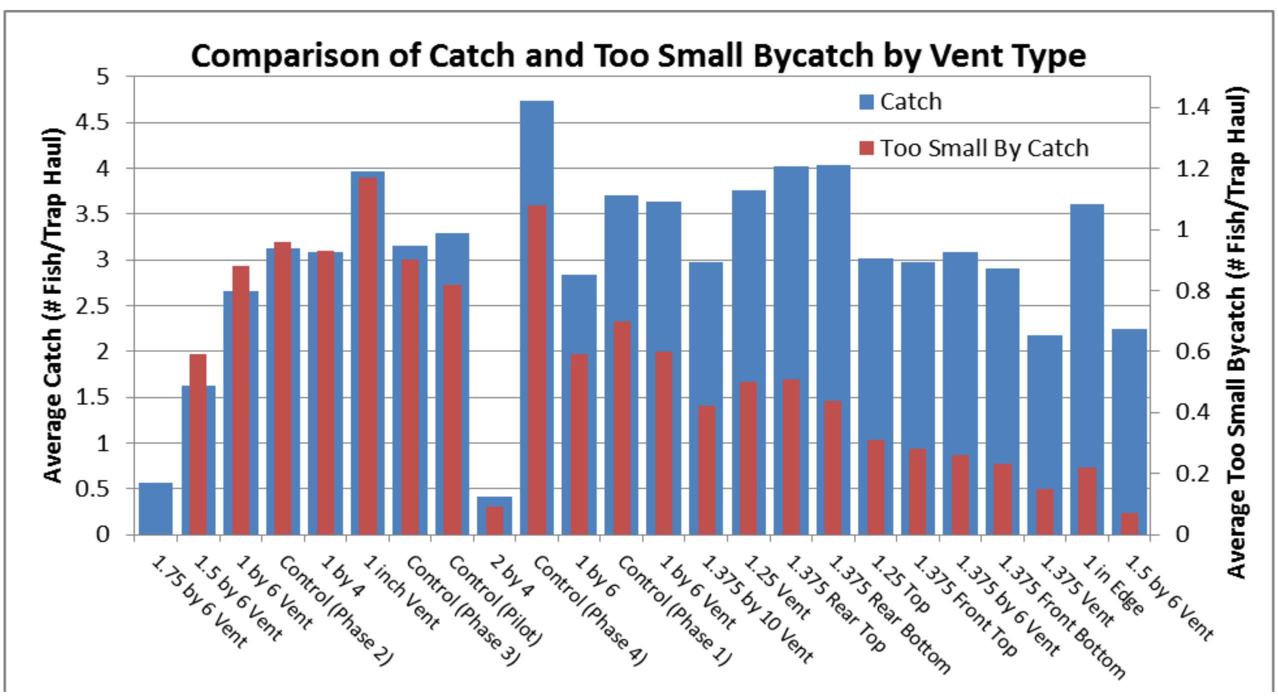

Figure 3. Catch and "too small bycatch" (not including boxfish) ranked in order of the proportion of catch to bycatch.

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