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SHORT-TERM ESTIMATE OF FINFISH BYCATCH DISCARDS IN THE INSHORE ARTISANAL SHRIMP FISHERY OF GUYANA[§]

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ABSTRACT: The artisanal shrimp fishery in Guyana is important for livelihood and food security, involving around 300 vessels owned and crewed exclusively by Guyanese nationals. This fishery uses Chinese seines and operates in major river estuaries. It targets penaeid shrimp, but also retains some finfish and is known to discard a significant but undocumented quantity of smaller finfish bycatch. The lack of knowledge regarding the bycatch is a concern for fishery management and biodiversity conservation. In this study, we quantify for the first time the finfish bycatch discards through onboard observations (July–August 2016) of a single typical vessel operating in the Demerara estuary. Wet weights of the total catch, retained catch, and finfish discards were recorded separately for each of 76 seine hauls, and subsequently presented as catch rates per trip, catch rates per seine haul (kg/haul), and catch rates standardized per hour of seine net soak-time (kg/hr). A sub-sample of finfish discards was taken from every haul to determine taxonomic composition and species-specific length frequencies. Examination of 2,012 discarded finfish distributed among 32 species revealed high taxonomic diversity, none of which were considered vulnerable by the IUCN Red List. Most finfish discards were small (modal size class 5–7 cm fork length) and included juveniles of 15 species of importance to other fisheries in Guyana. On average, a standardized total catch rate of 14.8 kg was taken per hour of seine net soak-time, yielding 3.9 kg retained catch (shrimp and a few selected finfish), 10.3 kg of finfish bycatch discards, and 0.6 kg of miscellaneous invertebrate discards. This demonstrates significant wastage (finfish discards represent about 69% of the total catch weight) and potential for negative impact on biodiversity and other commercial fisheries. The information provided here addresses an important knowledge gap in the artisanal fisheries of Guyana.

KEY WORDS: Chinese seine, catch rate, species composition, size frequencies, wastage

INTRODUCTION

The Guyanese artisanal fishery sector is an important source of food, employment and export earnings for both rural and urban communities (FAO 2005, Fisheries Department 2013). It comprises about 1,200 vessels, over 5,000 fishers, and 1,000 boat owners with most being members of cooperative societies that acquire and sell fishing rights to their members (Maison 2007). The artisanal fishery, which continues to expand annually, uses 5 main gear types: gill nets, Chinese seines, traps, caddells, and handlines (Maison 2007, Fisheries Department 2013).

This study focuses on the Chinese seine (a modified fyke net), the only gear type used to catch shrimp (primarily white-belly shrimp, *Nematopalameon schmitti*, and Atlantic seabob shrimp, *Xiphopenaeus kroyeri*) in the inshore artisanal fishery in Guyana (Maison 2007). The Chinese seine is also used to harvest King Weakfish (*Macrondon ancylodon*), Small-eye Croaker (*Nebris microps*), and catfishes (Chakalall and Dragovich 1982, Maison 2007, Richardson 2013). The Chinese seines are funnel-shaped nets, about 16 m long and 4–6 m wide at the mouth, with a mesh size that gradually declines from the mouth to the funnel. They are strung between 2 poles (referred to as ‘pens’) permanently set in the large river estuaries along the coast of Guyana in depths between 3.6–7.2 m; being a passive, fixed gear, their operation

is heavily dependent upon tidal flow (Shepherd et al. 1999, Hackett et al. 2000).

The vessels engaged in Chinese seine fishing are flat-bottom dories powered by a small outboard engine, paddle, or sail. Each vessel is licensed to fish at one or more ‘pens’ and operate between 1–10 seines fished during a tidal exchange (between 6–12 h per day), with some fishers using both tides per day (Maison 2007). Richardson (2013) estimated that there were 307 active Chinese seine vessels in 2011, representing just over a quarter of all artisanal vessels and contributing around 2% of Guyana’s total seabob landings. A more recent report, however, suggests that this contribution has dropped to <0.5% (Southall et al. 2019). The majority of the seabob resource (Guyana’s most important fishery export) is harvested by industrial trawlers operating offshore (Fisheries Department 2013, Garstin and Oxenford 2018). This industrial trawl fishery for seabob has recently been granted Marine Stewardship Council (MSC) certification (Southall et al. 2019, MSC 2019), which included an examination of bycatch by the industrial fleet (Medley 2017). However, the bycatch in the small-scale artisanal Chinese seine fishery for seabob was not included and thus remains undocumented.

The bycatch of the inshore artisanal fishery is relatively unexplored in Guyana, and Maison (2007) notes that this

[§]This article is based on a presentation given in November 2018 at the 71st annual Gulf and Caribbean Fisheries Institute conference in San Andres, Columbia.

is one of the largest challenges faced by the Guyana Fisheries Department (FD). The Guyana FD struggles to monitor and manage its inshore artisanal fishery sector because of the unreported bycatch discards and the rough estimates of retained bycatch (Gascoigne 2013, MacDonald et al. 2015). This lack of information, particularly for the artisanal Chinese seine fishery that contributes to the national seabob yield, may ultimately be questioned in future MSC certification assessments. Thus, it is against this background that this short-term study assesses, for the first time, the bycatch discards of finfish from the Chinese seine fishery within the Demerara River estuary of Guyana.

MATERIALS AND METHODS

Survey site

Observations and sampling took place within 2 licensed fishing pens, Jetti and Fort Mouth, located in the estuary of the Demerara River, Georgetown, Guyana (Figure 1). The area is characterized by a shallow, muddy bottom and strong flow of brown, low-salinity water. Like many other Chinese seine fishing vessels, we departed and landed at the Goed Fortuin village, located on the Essequibo Islands, which is in West Demerara, a short distance upstream of the capital city of Georgetown (Figure 1). This allowed observation and informal conversations with other Chinese seine fishers to enrich our understanding of the fishing operations in this fleet.

Field data collection

Field data were collected via a fishery-dependent survey. Observations and sampling were carried out during standard fishing trips of a registered inshore artisanal vessel between July and August 2016. The single vessel was typical of the artisanal vessels in the Chinese seine fleet, being a 7 m, open, wooden, flat-bottomed dory powered by an outboard engine. It operated a single Chinese seine per fishing trip at one of 2 licensed fishing pens around neap tides. The Chinese seine was about 16 m long with a mesh-size that tapered from 20 cm at the mouth to 0.6 cm at the funnel or bag end (see Kalicharan and Oxenford 2019).

The Chinese seine was usually set up at slack high tide to fish the falling tide and was retrieved at low tide. Each fishing trip usually lasted 6–7 h, although this varied depending on the time of the tide and estuary conditions. During this period, the seine was ‘hauled’ at haphazard intervals based on the fisher’s observations of how full the net funnel had become. This was performed by hauling only the funnel bag into the boat and emptying the entire catch (subsequently referred to as ‘total catch’) into a plastic tub, before re-tying the end and throwing it back overboard to continue fishing. The exact soak-time for each individual haul was recorded together with the wet weights of the total catch, as well as each catch component separately, measured to the nearest 0.1 kg using an analog scale. Catch components included

the ‘retained catch’ (comprising mostly shrimp with a few large finfish), the ‘finfish discards’ (all finfish to be thrown back), and ‘other discards’ (miscellaneous invertebrates to be thrown back). A sub-sample of finfish discards (representing about 5% by weight) was taken from each haul, prior to throwing them overboard. Thereafter, each fish specimen was individually



FIGURE 1. Satellite image showing approximate location of the study sites in the Demerara River estuary, Guyana. The fishing pens at Fort Mouth and Jetti were where the monitored Chinese seines were set, and the fishing village of Goed Fortuin from which the Chinese seine vessel operated are shown. Insert maps show location of Guyana in South America, and of the Demerara River in Guyana.

recorded by local name, condition (visually assessed as good [likely to survive], poor [unlikely to survive] or dead), and fork length (FL, 0.1 cm). Any species which could not be identified in the field were photographed and retained for assistance from experts at the University of Guyana and the Royal Ontario Museum, Canada.

Data from all 16 fishing days were used for determination of bycatch species composition, individual finfish length and weight data, and number and soak-time of hauls per day. However, data from only 14 fishing days were used for determination of catch rates, since catch weights were not recorded during the first 2 sampling trips.

Data analysis

Catch rates (as CPUE) were calculated as 1) total weight per day fishing trip, 2) total weight per seine haul, and 3) total weight standardized to per hour of seine net soak-time, since the soak-times were variable. Change in CPUE over the duration of the fishing trip was examined using box and whisker plots of standardized total weight (kg/h) for each of the 3 CPUE metrics (total catch, retained catch, finfish discards). We considered that the data over time were independent since the Chinese seine hauls were haphazardly cleared of the catch periodically during any one sampling event during each tidal period. Thus, we statistically compared standardized CPUE (kg/h) using one-way ANOVAs. If a significant difference was identified, we separated mean

values with a Tukey's honest significant difference (HSD) post-hoc test. Finally, retained catch to finfish bycatch ratios were based on wet weights, and length-frequency distributions were plotted for all finfish discards together as well as separately for the most commonly caught finfish bycatch species. These simple descriptive statistics were estimated using the functions in Microsoft Excel 2013 and the IBM SPSS Statistics 19 software package.

RESULTS

An overall total of 16 fishing trips and 83 hauls were monitored during the neap tides occurring between mid-July and the end of August 2016, representing a total soak-time (during ebb tide) of 66 h and 7 min (3,967 min) (Table 1). The mean soak-time for each fishing trip was 4 h and 8 min (248 min), although there was considerable variation (for example Trip 11 fished both tides and recorded a total of 12 h 53 min (773 min) soak-time, Table 1). The mean soak-time for each haul, calculated as mean soak time per mean number of hauls, was 48 min. Fishing took place within 2 licensed fishing pens; Jetti (13 trips, 69 hauls) and Fort Mouth (2 trips, 14 hauls) in the Demerara River estuary (Figure 1), and resulted in the capture of more than 470 kg of finfish bycatch discards.

Species Composition

A total of 2,012 individual finfish across 6 orders, 17

TABLE 1. Summary of fishing trips and number of Chinese seine hauls per trip sampled in the artisanal shrimp fishery of Guyana, showing actual catch weights. Total catch refers to the entire unsorted catch. Retained catch refers to the portion of the catch kept by the fisher and comprises predominantly shrimp with a few selected finfish. Discarded catch refers to the portion of the catch thrown back overboard by the fisher and is shown separately here as finfish discards and other miscellaneous invertebrate discards. Discards are also shown as a percentage of the total catch weight. kg = kilograms weight; wt = wet weight.

T rip. No.	Date (m/dd/yr)	Location of pen	No. hauls	Soak time (min)	Total catch (kg)	Retained catch (kg)	Discarded catch			
							Finfish		Others	
							(kg)	(% wt)	(kg)	(% wt)
1	7/25/2016	Jetti	3	148	-	-	-	-	-	-
2	7/26/2016	Jetti	4	202	-	-	-	-	-	-
3	7/27/2016	Fort Mouth	9	312	56.28	13.96	40.98	72.8	1.35	2.4
4	7/28/2016	Jetti	6	173	44.00	13.30	29.40	66.8	1.30	3.0
5	7/30/2016	Jetti	3	137	36.00	9.40	25.00	69.4	1.60	4.4
6	8/09/2016	Jetti	6	369	90.50	31.00	58.20	64.3	1.30	1.4
7	8/10/2016	Jetti	7	282	73.50	15.43	50.56	68.8	7.51	10.2
8	8/11/2016	Jetti	5	200	45.00	5.70	36.60	81.3	2.70	6.0
9	8/12/2016	Jetti	4	243	62.00	28.10	31.20	50.3	2.70	4.4
10	8/13/2016	Jetti	3	155	49.50	20.80	28.60	57.8	0.10	0.2
11	8/14/2016	Jetti	10	773	76.40	22.00	53.20	69.6	1.20	1.6
12	8/23/2016	Jetti	5	166	33.50	10.10	22.30	66.6	1.10	3.3
13	8/24/2016	Jetti	5	184	33.50	6.10	28.70	80.8	0.70	2.0
14	8/25/2016	Jetti	4	238	28.90	5.40	20.40	70.6	3.10	10.7
15	8/26/2016	Fort Mouth	5	230	30.10	4.20	25.40	84.4	0.50	1.7
16	8/28/2016	Jetti	4	155	29.10	8.60	19.90	68.4	0.60	2.1
Total			83	3967	690.28	194.09	470.44	-	25.76	-
Mean (SD)			5.2 (2.0)	248 (154.2)	49.31 (19.8)	13.86 (8.6)	33.60 (12.54)	69.42 (9.00)	1.84 (1.85)	3.81 (3.18)

Table 2. Finfish bycatch discard species in the artisanal shrimp fishery of Guyana, sampled from 16 Chinese seine hauls in the Demerara River estuary between July and August 2016. Data include number captured (n), individual size metrics, and condition. Importance to other fisheries in Guyana is shown as a footnote in the column containing the local names. IUCN categories: LC - least concern, DD - data deficient, NA - not assessed. FL = fork length; sd = standard deviation. Condition categories: Good - fish likely to survive when thrown back, Poor - fish unlikely to survive when thrown back, Dead - fish dead upon capture.

Family	Species	Common name	Local name	IUCN	Count (n)	Individual size (FL cm)				Condition (%)		
						Mean	sd	Max.	Min.	Good	Poor	Dead
Batrachoididae	<i>Batrachoides surinamensis</i>	Pacuma Toadfish	Pacu ^c	LC	1	16.5	-	-	-	100	0	0
Order Batrachoidiformes subtotal					1							
Engraulidae	<i>Anchoa spinifer</i>	Spicule Anchovy	Brown herring	LC	108	12.4	3.6	20.0	4.7	7	59	33
	<i>Anchoviella lepidentostole</i>	Broadband Anchovy	Suriname mullet ^c	LC	26	6.5	3.5	22.5	4.3	0	96	4
	<i>Lycengraulis grossidens</i>	Atlantic Sabertooth Anchovy	Silver herring	LC	371	6.6	4.4	29.0	1.9	1	51	48
Pristigasteridae	<i>Odontognathus mucronatus</i>	Guiana Longfin Herring	Neckley ^c	LC	227	6.6	1.4	11.0	2.6	0	68	32
	<i>Pellona harroweri</i>	American Coastal Pellona	Shad	LC	7	26.4	1.5	27.8	23.4	86	0	14
Order Clupeiformes subtotal					739							
Carangidae	<i>Oligoplites saliens</i>	Castin Leatherjacket	Copperfish	LC	34	8.3	3.3	18.0	3.0	6	0	94
	<i>Selene vomer</i>	Lookdown	Bapise	LC	3	7.1	3.4	11.0	4.4	0	67	33
Centropomidae	<i>Centropomus pectinatus</i>	Tarpon Snook	Chinese snook ^c	LC	11	14.9	4.8	24.5	9.0	64	27	9
Gobiidae	<i>Gobionellus oceanicus</i>	Highfin Goby	Backra cackey	LC	1	11.1	-	-	-	100	0	0
Haemulidae	<i>Genyatremus luteus</i>	Toroto Grunt	Anafolks ^c	NA	1	7.2	-	-	-	0	0	100
Lobotidae	<i>Lobotes surinamensis</i>	Tripletail	Paggy ^c	LC	2	14.5	9.2	21.0	8.0	50	50	0
Polycentridae	<i>Polycentrus schomburgkii</i>	Guyana Leafish	Guyana leafish	NA	1	6.3	-	-	-	0	100	0
Sciaenidae	<i>Cynoscion jamaicensis</i>	Jamaica Weakfish	Table bashaw ^c	LC	24	14.1	4.4	21.9	6.3	25	25	50
	<i>Lonchurus elegans</i>	Blackfin Croaker	Chinese butterfish	DD	11	17.8	4.1	23.5	11.5	36	27	36
	<i>Macrodon ancylodon</i>	King Weakfish	Bangamary ^c	LC	367	8.3	2.4	14.3	2.5	0	59	41
	<i>Nebris microps</i>	Smalleye Croaker	Butterfish ^c	LC	8	10.0	2.5	13.1	6.5	0	0	100
	<i>Stellifer microps</i>	Smalleye Stardrum	Rockhead	LC	311	5.6	2.4	18.2	2.0	2	36	62
Trichiuridae	<i>Trichiurus lepturus</i>	Largehead Hairtail	Silverbelt	LC	74	49.4	16.6	88.5	16.0	3	62	35
Order Perciformes subtotal					848							
Achiridae	<i>Achirus achirus</i>	Drab Sole	Flounder	LC	6	18.5	11.0	32.0	2.7	67	17	17
Order Pleuronectiformes subtotal					6							
Ariidae	<i>Aspistor quadriscutis</i>	Bressou Sea Catfish	Softhead sea catfish	LC	55	14.2	9.7	34.3	3.5	35	35	31
	<i>Bagre bagre</i>	Coco Sea Catfish	Catfish ^c	LC	9	13.0	5.6	20.0	5.0	22	44	33
	<i>Amphiarus rugispinis</i>	Softhead Sea Catfish	Tweetwee	LC	98	19.5	5.6	32.0	4.4	78	10	12
	<i>Sciades herzbergii</i>	Flapnose Sea Catfish	Mud cuirass ^c	LC	24	31.7	15.7	48.0	6.0	79	13	8
Aspredinidae	<i>Aspredo aspredo</i>	Banjo	Banjoman	NA	8	15.6	10.2	39.0	8.0	100	0	0
Auchenipteridae	<i>Pseudauchenipterus nodosus</i>	Cocosoda Catfish	Sweetman ^c	NA	37	22.0	4.3	29.0	5.5	84	8	8
Pimelodidae	<i>Brachyplatystoma filamentosum</i>	Kumakuma	Kumakuma ^{c,R}	NA	19	17.6	5.8	30.0	10.0	32	5	63
	<i>Brachyplatystoma</i> sp.	unknown catfish	Himara	NA	20	19.4	5.0	28.5	9.5	60	30	10
	<i>Brachyplatystoma vaillantii</i>	Laulao Catfish	Laulau ^{c,R}	NA	15	21.3	9.7	37.5	11.0	53	47	0
	<i>Hypophthalmus edenatus</i>	Highwaterman Catfish	Highwater	NA	1	22.0	-	-	-	0	0	100
	<i>Hypophthalmus marginatus</i>	Long-whiskered Catfish	Highwater ^c	NA	107	27.6	4.6	40.8	13.4	92	2	7
Order Siluriformes subtotal					393							
Tetraodontidae	<i>Colomesus psittacus</i>	Banded Puffer	Pufferfish	LC	25	8.8	7.9	27.5	2.2	20	48	32
Order Tetraodontiformes subtotal					25							
Total	32 species				2012	12.0	11.1	88.5	1.9	17%	44%	39%

^c commercially important species in Guyana, ^R recreational species in Guyana

families, 29 genera and 32 species were identified in the sub-sampled bycatch discards, all of which are considered by the IUCN Red List as being of 'Least Concern' or listed as 'Data Deficient' or 'Not Assessed' (Table 2). Five families were dominant: the Sciaenidae, Engraulidae, Pristigasteridae, Ariidae, and Pimelodidae, together accounting for 90% (by number) of the sampled finfish discards. Just 4 species, Atlantic Sabertooth Anchovy (*Lycengraulis grossidens*), King Weakfish (*Macrodon ancylodon*), Smalleye Stardrum (*Stellifer microps*), and Guiana Longfin Herring (*Odontognathus mucro-*

natus) accounted for 63% (by number) of all finfish discards (Table 2). Of note, individuals of several of the discarded species (e.g., King Weakfish, Smalleye Croaker (*Nebris microps*), and Flapnose Sea Catfish (*Sciades herzbergii*)) were retained if considered large enough to sell in the market. Furthermore, a total of 15 finfish discard species are considered of some commercial value to other fisheries in Guyana and 2 are also considered as recreationally important species (Geer 2005, Gascoigne 2013, MacDonald et al. 2015, authors' personal knowledge; see Table 2).

Size Frequency

The individual size of all finfish discards ranged between 1.9–88.5 cm FL, with the vast majority being very small (modal size class: 5–7 cm FL; Figure 2A, Table 2). Size frequencies of the 4 dominant (most numerous) finfish discard species are given in Figure 2B. The larger-sized individuals that were discarded were Long-whiskered Catfish (*Hypophthalmus marginatus*), Softhead Sea Catfish (*Amphiarus rugispinis*), Atlantic Cutlassfish (*Trichiurus lepturus*), and Cocosoda Catfish (*Pseudochenipterus nodosus*) (Table 2).

Condition

The seine net soak-time varied from 13–145 min (mean 48 min, Table S1) and depended on the strength of the tidal flow and the abundance of catch. Despite the net be-

ing emptied quite frequently, and the fact that the smallest sized finfishes in the bycatch were often swirled in a tub of water immediately on release from the net to wash them out from the target shrimp catch, the finfish bycatch mortality was high. Most sub-sampled finfish discards were found to be highly unlikely to survive when thrown back, with 44% judged to be in poor condition and 39% already dead (Table 2). The most sensitive species (total count $n > 5$, condition

Catch Rates

dead >90%) were Castin Leatherjacket (*Oligoplites saliens*) and Smalleye Croaker, while the most hardy species (total count $n > 5$, condition good >75%) were Softhead Sea Catfish, Flapnose Sea Catfish (*Sciades herzbergii*), Long-Whiskered Catfish, and American Coastal Pellona (*Pellona harroweri*) (Table 2). The typical catch handling protocol used by Chinese seine fishers whereby the total catch is generally left in the boat for some time before being sorted certainly contributes unnecessarily to the poor condition of the discards when they are eventually returned to the water.

The 14 monitored fishing trips yielded 194.1 kg wet weight of retained catch (seabob, white-belly shrimp, King Weakfish, Smalleye Croaker and Flapnose Sea Catfish) and produced 470.4 kg of finfish bycatch discards and 25.8 kg of other miscellaneous discards (e.g., jellyfishes and small crabs) (Table 1). This corresponds to a mean CPUE of 13.9 kg (± 8.6 sd) of retained catch, 33.6 ± 12.5 kg of finfish discards, and 1.8 ± 1.9 kg of other discards per fishing trip at the Jetty and Fort Mouth pens in the Demerara estuary during July and August 2016 (Table 1). This indicates that on average 69.4% of the total catch weight comprised finfish discards and 1.8% comprised other discards, translating into an overall mean retained catch to finfish discard ratio of 1:2.4 by weight (Table 1). At a finer resolution, the mean CPUE was 2.6 ± 3.6 kg of target species and 6.2 ± 4.3 kg of finfish discards per seine haul, or 3.9 ± 4.5 kg of target species and 10.3 ± 7.4 kg of finfish discards per hour of seine net soak-time (Table S1).

Standardized CPUE (kg/h) varied over the duration of a fishing trip with the total catch rates generally increasing after the first hour of fishing and decreasing again after 4 h, suggesting maximum catch rates coinciding with peak tidal flow rate (Figure 3). A comparison of standardized CPUE over the first 5 h (for which there were sufficient data) indicated a marginally significant difference in the mean standardized CPUE for total catch ($F_{2,63} = 2.803$, $p = 0.033$), but individual post-hoc Tukey tests failed to confirm significant differences between any of the pairs (Table S2), possibly due to the large differences in the sample sizes among categories. A significant difference was apparent for finfish discards ($F_{4,63} = 4.467$, $p = 0.003$) with post-hoc tests confirming a significant difference only between hour 1 and hour 2 (Table S2). The retained catch rate did not differ across the tidal period ($F_{4,63} = 0.863$, $p = 0.491$; Figure 3).

DISCUSSION

This study represents the first species-level documentation of the finfish bycatch discards in the artisanal Chinese seine fishery of Guyana. We report a high diversity of 32 species that make up the finfish discards, representing about 69% of the total catch weight by a single, typical Chinese seine vessel operating in the Demerara River estuary in July

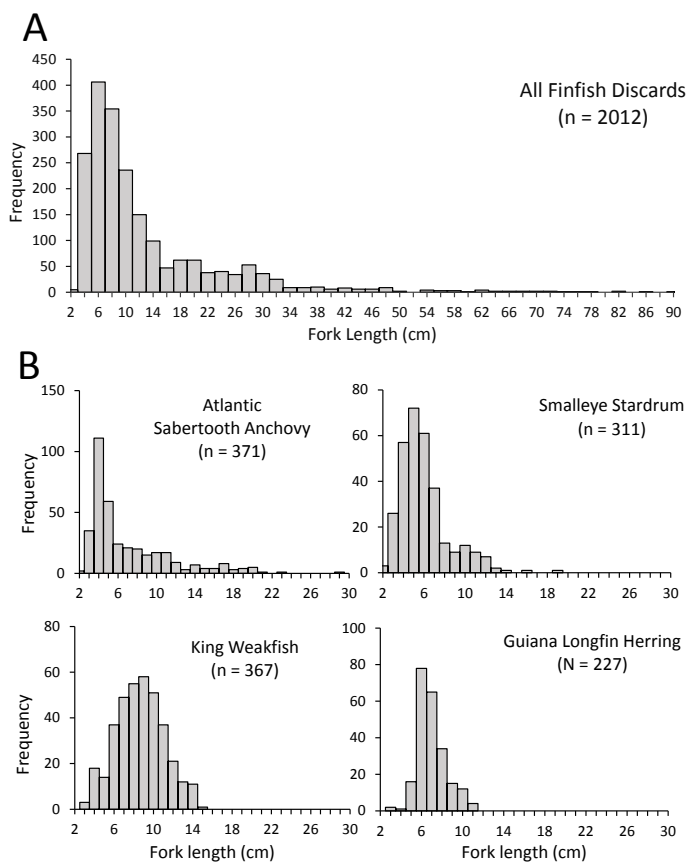


FIGURE 2. Length-frequency distributions for finfish discards taken by Chinese seine in the artisanal shrimp fishery of Guyana. A. All finfish discards. B. The 4 dominant species discarded.

ing emptied quite frequently, and the fact that the smallest sized finfishes in the bycatch were often swirled in a tub of water immediately on release from the net to wash them out from the target shrimp catch, the finfish bycatch mortality was high. Most sub-sampled finfish discards were found to be highly unlikely to survive when thrown back, with 44% judged to be in poor condition and 39% already dead (Table 2). The most sensitive species (total count $n > 5$, condition

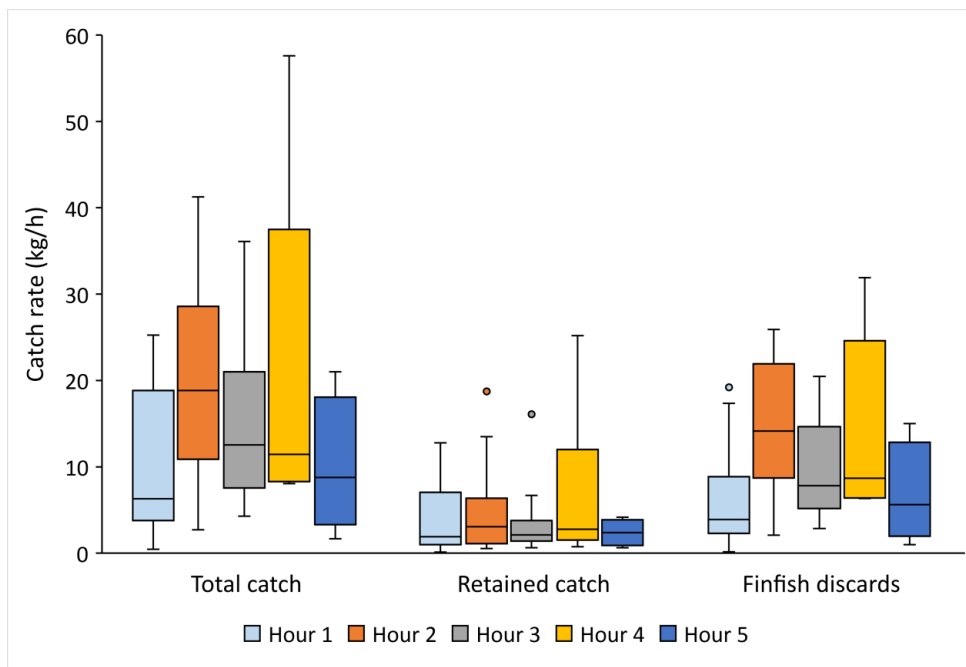


FIGURE 3. Box and whisker plots comparing Chinese seine standardized catch rates (standardized to kg/h of seine net soak-time) over time (hour) from the start of fishing each day for various categories of the catch. Data are from 14 fishing trips on a Chinese seine vessel in the artisanal shrimp fishery of Guyana. Boxes show first and third quartiles, horizontal lines show the median, whiskers show data range, and points show outliers.

and August 2016. This is considerably higher than the taxonomic diversity reported for a 2-year study of the artisanal Chinese seine discards in neighbouring Suriname (10 finfish discard species listed, although a greater number of finfish species were retained than in our study; Babb 2007). In contrast, however, the discard biodiversity reported over a 2-month study of the artisanal trawl fishery in Gulf of Paria, Trinidad was greater with 55 finfish species (Hosein 2018¹). Although none of the discard species are listed as vulnerable by the IUCN, the ecosystem impact of this discarded bycatch is difficult to assess since there is no specific information available on the trophic ecology of Guyanese waters, and the life history and stock status of most of the species is poorly or completely unknown (Gascoigne 2013). However, albeit using data from a single vessel over a 2 month sampling period, the fact that most of the finfish discards represent early life stages (and are already dead or in very poor condition when discarded) together with the fact that the Chinese seine fleet is relatively large (around 300 vessels), should be of some concern. This is particularly so with regard to maintaining the fish biodiversity of Guyana's river estuaries which serve as critical nursery areas for many species including those of commercial and recreational importance (Hackett et al. 2000).

The high level of discards also has implications for other commercial fisheries. For example, in our study King Weakfish was one of the top 4 discard species with 100% being immature (<17.7 cm FL, Fredou et al. 2015; Cardoso et al. 2018) and either dead or in poor condition when discarded. King Weakfish is considered a major food fish in Guyana and is

sold in both local and international markets (FAO 2013). King Weakfish is exploited by several other artisanal fisheries using pin (beach) seines and nylon gillnets, and by the industrial groundfish trawl fishery (Maison 2007, Richardson 2013) and is an important commercial species in other countries sharing the Guianas–North Brazil shelf stock (e.g., Venezuela, Suriname, French Guiana and Brazil; Fredou et al. 2015). Furthermore, several analyses of groundfish fisheries in Guyana have expressed concern regarding the level of harvesting of certain species, particularly King Weakfish and Smalleye Croaker, concluding that the former was fully exploited by gillnets and the industrial trawl fishery, and attention was drawn to the capture of juvenile groundfish by Chinese seine gear (Ehrhardt and Shepherd 2001, FAO 2005).

There appears to be little known about the other 3 top species discarded in our study (Atlantic Sabertooth Anchovy, Smalleye Stardrum, and Guiana Longfin Herring), including their size-at-first maturity. However, given that their modal sizes in the discarded catch of the Chinese seine were considerably smaller than their reported maximum and common sizes listed in FishBase (<https://www.fishbase.org>; Froese and Pauly 2019), it is reasonable to assume that the vast majority of the discarded catch of these species also comprises juveniles. In fact, consultations in Guyana regarding the groundfish fishery in 2012 raised the high volume of trash fish (discards) in the Chinese seine fishery as a matter of concern (Gascoigne 2013), and listed the lack of protection of juveniles as the second highest ranking issue for immediate attention (FAO 2013). These concerns were also raised regarding the Chinese seine fishery in neighboring Suriname (Babb 2007).

The mean retained to discard catch ratio of 1:2.4 could be considered relatively low compared with many tropical shrimp fisheries (which may exceed 1:20; Eays 2007). How-

¹ Hosein, S. 2018. Preliminary study of by-catch species composition and community metrics of the artisanal shrimp trawl fishery in the Gulf of Paria, Trinidad. M.Sc. research paper, University of the West Indies, Cave Hill, Barbados. 28 p.

ever, we note that it is difficult to compare bycatch ratios among studies because of the different definitions of bycatch and target (retained) catch used in different shrimp fisheries (Eayrs 2007), the range of gear types, fishing methods, and fishing grounds, and the variety of research sampling methods used in different studies. For this reason, we compare our findings only with those of Babb (2007) who studied the Chinese seine fishery using the same boat types and gear in the estuaries of large rivers in neighboring Suriname. In contrast with our study, Babb (2007) reported that the weight of retained catch was always higher than the discards. This is likely a result of greater local market demand in Suriname for species considered to be trash in Guyana. The difference could also be because our study took place over just 2 months, in a fishery that was noted by Chakalall and Dragovich (1982) to experience changes in catch rates of the different catch components as a result of seasonal patterns in rainfall and river flow.

Regardless of the comparisons, the total finfish discards of the entire fleet of Chinese seiners in Guyana (around 300 vessels) is likely several orders of magnitude larger than the 2012 estimate of just 8 mt reported by Gascoigne (2013). For example, based on the catches of the single vessel monitored in this study that only fished one seine net per trip, and fished for only 5–6 d around neap tides (i.e., for about 10 d a month), a very crude but likely conservative estimate of finfish discards per month would be around 336 kg per vessel, which could amount to around 4 mt a year for a single vessel based only on a 2 mo (July–August) sampling period. Not only does this present a possible ecosystem impact and loss of potential biomass yield to other fisheries (see Babb 2007), but it also represents a senseless waste of fish protein that could otherwise be processed for consumption, bait, aquaculture feed, or fertilizer. For example, Atlantic Sabertooth Anchovy, the dominant discard species in this study, supports commercial fisheries in Brazil, Argentina and Uru-

guay and is also used as bait for recreational rod fishing in the latter (Mai and Vieira 2013). It is also worth noting that neighboring Suriname uses considerably more of their bycatch from the Chinese seine fishery (Babb 2007).

Concern over the destructive fishing practices of the artisanal Chinese seine fishery in Guyana with regard to the perceived capture and discard of juveniles of many different species has been long-standing (e.g., WECAFC 2001, 2002, FAO 2005). This concern was again raised by many fishery stakeholders in the most recent consultations held in Guyana in support of formulating a fishery management plan (FMP) for the shrimp and groundfish fisheries (SOFRECO 2013). We recommend that this limited study should be scaled up to increase the sample size of vessels examined, to include other estuaries where the Chinese seine gear is important, and to determine any seasonal patterns in catches. However, the study as it stands is the first to examine the discards in detail in this fishery and has contributed to one of the cross-cutting issues to be solved: absence of data on discards, as stated in the 2013–2018 FMP (Fisheries Department 2013). These facts will contribute to a better understanding of the extent and nature of the discards in this fishery and therefore could inform science-based management actions to improve the fishery. For example, the quantification of likely discards per vessel per year provides strong justification for reducing the use of Chinese seines or investing in improvements in gear or fishing practices to reduce the unwanted bycatch. However, any such action will need to address the socio-economic aspects of the fishery as well. Likewise, documentation of retained (target) and discard catch rates over the duration of the ebb tide and fish handling practices could inform improvements to reduce bycatch while minimizing loss of target catch. Finally, quantification of discards by species provides information necessary for considering potential marketable products that would avoid wastage of any unavoidable bycatch.

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