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Examining finfish bycatch discards in the artisanal Chinese seine fishery in the Demerara estuary, Guyana

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ABSTRACT

This study has quantified and described, for the first time, the finfish bycatch discards and fisher practices in the small-scale inshore artisanal fishery using the Chinese seine gear type operating in the Demerara estuary, Guyana. The study was conducted between July and August, 2016, onboard a typical artisanal Chinese seine vessel during every fishing trip taken over this period. A total of 16 day trips were made and 83 seine hauls completed, representing more than 66 hours of soak time. For every haul, the wet weights of the unsorted catch, the retained catch, the finfish discards and other discards were recorded, along with the seine net soak-time to determine catch rates and the proportion of the catch that is discarded. Finfish discards from each seine haul were sub–sampled to determine the taxonomic composition and individual size (length and weight) frequency distributions. A total of 2,012 individual finfish were examined and revealed high taxonomic diversity, comprising 6 orders, 17 families, 29 genera and 32 species. Of these, a total of 848 individuals (42% of the total sub–sample) belonged to the order Perciformes across 8 families, 13 genera and 13 species. The order Clupeiformes was the second most frequently occurring group, comprising 739 individuals (37%) across 2 families, 5 genera and 5 species. The third most important order was the Siluriformes with 393 individuals (20%) across 4 families, 8 genera and 11 species. Despite the overall species diversity, ten species accounted for 87% of all finfish discards and just three species; silver herring (*Lycengraulis grossidens*), bangamary (*Macrodon ancylodon*) and rockhead (*Stellifer microps*) accounted for more than half (52%) of all discarded finfish. The vast majority of the finfish discards were small with a mean length of 11.9 cm FL and presumed to be immature. The total retained catch (mostly seabob shrimp and a few finfish) recorded over this study was 194 kg, whilst the discarded finfish catch was over 470 kg. On average, 33.6 kg of finfish are discarded per fishing day, representing 69.5% of the total catch. Given that approximately 300 Chinese seine vessels fish year-round in the estuaries of Guyana, the discards are likely to be significant and to negatively impact the estuarine ecosystem and commercial groundfish fisheries, particularly those targeting bangamary. Efforts to reduce this bycatch wastage should consider implementation of bycatch reduction devises in the seines, reduction of Chinese seine fishing effort and/or developing marketable products from the bycatch that is currently discarded.

Keywords: Chinese seine, bycatch, catch rate, taxonomic composition, size frequency

LIST OF ACRONYMS

CPUE	Catch per Unit of fishing Effort
FAO	Food and Agriculture Organisation
FD	Fisheries Department, Government of Guyana
FIP	Fishery Improvement Project
GATOSP	Guyanese Association of Trawler Owners and Seafood Processors
IUCN	International Union for Conservation of Nature
MSC	Marine Stewardship Council

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1 INTRODUCTION

The small–scale artisanal fishery is an important source of food for both rural and urban Guyanese. This sector is actively pursued exclusively by Guyanese nationals and is a source of employment and export earnings. It has experienced rapid growth both in the number of fishers and volume of landings, and production is now estimated to be between 25,000 – 30,000 metric tons per year and increasing (Maison 2007, Fisheries Department 2013). This fishery consists of approximately 1,200 vessels ranging in size from 6 – 18 metres that are propelled by sails, outboard or inboard engines. There are over 5,000 fishers and over 1,000 boat owners, with most of the boat owners being members of cooperative societies which acquire and sell fishing requisites to their members (Maison 2007).

The Guyanese artisanal fishery typically operates in the area extending from estuaries and the shoreline to a depth of around 15 m, whilst the industrial vessels (mostly seabob trawlers) are excluded from nearshore fishing grounds and operate on the continental shelf out to a depth of about 50 m (Maison 2007). The artisanal fishery uses five main gear types: gill nets, Chinese seine, traps, caddells and handlines (Maison 2007, Fisheries Department 2013).

This study focusses on the Chinese seine (fyke net), the only gear type used in the inshore artisanal shrimp fishery in Guyana, catching primarily *Nematopalameon schmitt* (whitebelly shrimp) and *Xiphopenaeus kroyeri* (seabob) (Fisheries Department 2013). The Chinese seine is also used to harvest *Macrodon ancylodon (*bangamary) and *Nebris microps* (butterfish). Chinese seine fishing takes place at or around the mouths of rivers, because the operations are heavily dependent upon the influence of the river currents (Ehrhardt and Shepherd 2001).

The Chinese seines are funnel – shaped nets, 16 m long and 4 – 6 m wide at the mouth. The mesh size gradually declines from 8 cm at the mouth to 1 cm at the funnel. The nets are set in-between and attached to poles (referred to as ‘pens’) set in the river at distances of approximately 1 mile from shore. These pens are set at depths between 2 – 4 fathoms (3.6 – 7.2 m) (Hackett, Cochrane and Booth 2000). A flat-bottom dory vessel powered by a small outboard engine, paddle or sail is used in the Chinese seine fishing operations. Each vessel operates between one and ten seines. These fishing operations work in relation to the tide and spend between 6 and 12 hours per day fishing, with some operators, fishing both tides per day (Maison 2007).

According to the most recent documentation (Richardson 2013), there are an estimated 300 active Chinese seine vessels (307 Chinese seine vessels in 2011), representing just over a quarter of all artisanal vessels and contributing around 2% of Guyana's total seabob landings. The majority of seabob (Guyana's most important fishery export) is harvested by around 88 industrial trawlers operating offshore (Garstin, Oxenford and Maison 2017). Interestingly, this fleet has undergone a pre-assessment by the Marine Stewardship Council (MSC) for consideration of the seabob fishery becoming MSC certified (FIP 2019). As a result, the Guyanese industrial seabob fishery with support of the Guyana Government signed, in 2012, a formal agreement to establish the Guyana Seabob Trawl Fishery Improvement Project (FIP) (FIP 2019). The FIP is working to advance management and operational practices within the fishery towards the standards that will allow it to become MSC certified (FIP 2019). This includes monitoring and reduction of bycatch in the trawl fishery (FIP 2019). However, the FIP is not addressing the undocumented bycatch that is known to occur in the artisanal Chinese seine fishery whilst harvesting seabob. It is worthy to note that the Guyana Seabob shrimp fishery has been certified sustainable against the MSC fisheries standard (FIP 2019).

Bycatch is variously defined in the literature. Hall (1996) defines bycatch as all non-target fish, whether retained and sold, or discarded. According to Gillett (2011) the term bycatch has several meanings, and there is an additional difficulty of applying the concept of bycatch to small-scale fisheries. The terms bycatch and target catch can be relatively clear in large-scale fisheries of developed countries, where there is an objective of capturing certain high-value species. However, these concepts become increasingly irrelevant in the progression to small-scale fisheries in developing countries, where almost everything in the catch has economic value and can be a target (Gillett 2011).

According to the UN Food and Agriculture Organisation (FAO), bycatch threatens the long-term sustainability of many fisheries and the maintenance of biodiversity in many areas, resulting in increased food insecurity, and adversely affecting the livelihoods of millions of fishers and fish workers reliant on fish resources globally (FAO 2011). Matos-Caraballo, Cartagena-Haddock and Peña-Alvarado (2007) state that bycatch is an important issue in the management of fisheries. In addition, Peckham et al. (2007) highlight that bycatch data are essentially lacking in the artisanal fishery sector which dominates coastal waters mostly in developing countries. Furthermore,

Mahon (2001) highlights that the estimation of retained bycatch and bycatch discards is critical for effective management of fisheries resources.

Research on bycatch for the small-scale fishery is a relatively unexplored area in Guyana and is one of the constraints for fisheries management. As Maison (2007) points out, the management of the fisheries resources has been a challenge for the Guyana Fisheries Department (FD). This is further explained by MacDonald et al. (2015) who state that the Guyana FD struggles to efficiently monitor and manage its small-scale artisanal fishery sector because of the unreported bycatch discards and the rough estimates of retained bycatch. Furthermore, this lack of information, particularly for the artisanal Chinese seine fishery that contributes to the national seabob yield, may compromise future MSC certification.

It is against this background that this study assessed the bycatch discards of finfish in the Chinese seine gear type used by the inshore artisanal fishery sector in Guyana within the Demerara estuary.

1.1 Study aim and objectives

The primary aim of this research is to determine the species composition and estimate the quantity of finfish bycatch discards taken by the Chinese seine fishery operating within the estuary of the Demerara district of Guyana. The specific objectives were to:

- Record all finfish species discarded by a typical Chinese seine vessel.
- Measure the length and weight of individual finfish from a representative subsample of the discards from the Chinese seine.
- Determine the average catch per unit of effort (CPUE) for the retained catch and the discarded catch.
- Report on the handling practises for bycatch discards by local fishers.

2 METHODS

This study was conducted over the summer of 2016 in the Demerara river estuary through onboard, at-sea measurements of the retained catch and discarded catch (commonly called 'the waste'), and through observation and informal interviews with fishers during typical artisanal fishing operations, using Chinese seines.

2.1 Survey area

Fishing and sampling were done within two licenced fishing pens, namely: Jetti and Fort Mouth located in the estuary of the Demerara River, Georgetown, Guyana (Figure 1). The area is characterised by muddy bottom and a vast input of brown, low-saline water.

Figure 1: Satellite image showing approximate location of the study site in the Demerara River estuary. Shown are the fishing pens Fort Mouth and Jetti where the Chinese nets were set, and the village of Goed Fortuin where interviews were conducted. Insert maps shows location of Guyana (sources: satellite image from Google Earth; inset maps adapted from World Health Organization https://www.who.int/countries/guy/en/)

Observations took place on a single fishing vessel and informal interviews were done with fishers departing and landing at the Goed Fortuin village, Essequibo Islands, West Demerara, located approximately 10 km from the capital city of Georgetown (Figure 1).

2.2 Data collection

2.2.1 Sampling period

A total of 16 days of field observations and onboard at–sea sampling was undertaken between 25 July and 28 August 2016, covering all of the neap tides occurring within this 5-week period. The artisanal vessels only fish at the mouth of the Demerara River during neap tides because of the reduced current speeds, which allow for effective setting of the gear. The first set of neap tides over which data were collected occurred from July 25th to 30th, the second set was from August 9th to 14th and the third set from August 23rd to 28th 2016.

2.2.2 Vessel and fishing operation

At–sea data collection was carried out on a single registered artisanal vessel (Boat # 731, Figure 2a). The selected vessel was typical of the smaller artisanal vessels in Guyana, being an open, wooden, flat-bottomed boat, with a length of 7 m (23 ft), powered by an outboard engine and operating one Chinese seine per fishing trip. The vessel was chosen based on the captain's motivation to support the research, willingness to accommodate the field observers on his vessel, and having a registered boat with the Ministry of Agriculture, together with fishing-pen licences to work within the study area.

Fishing was done within two permitted fishing pens located at Fort Mouth and Jetti of the Demerara estuary (Figure 1). On typical fishing/sampling days, one Chinese seine (a stationery passive gear that relies on tidal flow) was set in a pen (comprising two permanent poles to which one Chinese seine is attached) at one of the locations (one location was fished each day) (Figures 2c,d). The Chinese seine was made by the fisher, with a mesh size ranging from 20 cm (8") at the mouth to 0.6 cm (¼") at the funnel (tapered bag end). The mesh size is reduced in one inch (2.5 cm) increments as the net tapers towards the funnel end until it is 2.5 cm (1"). The mesh is then further reduced from 2.5 cm (1") at the mouth of the bag by quarter inch (0.6 cm) increments down to a final 0.6 cm (¼") mesh size at the bag end.

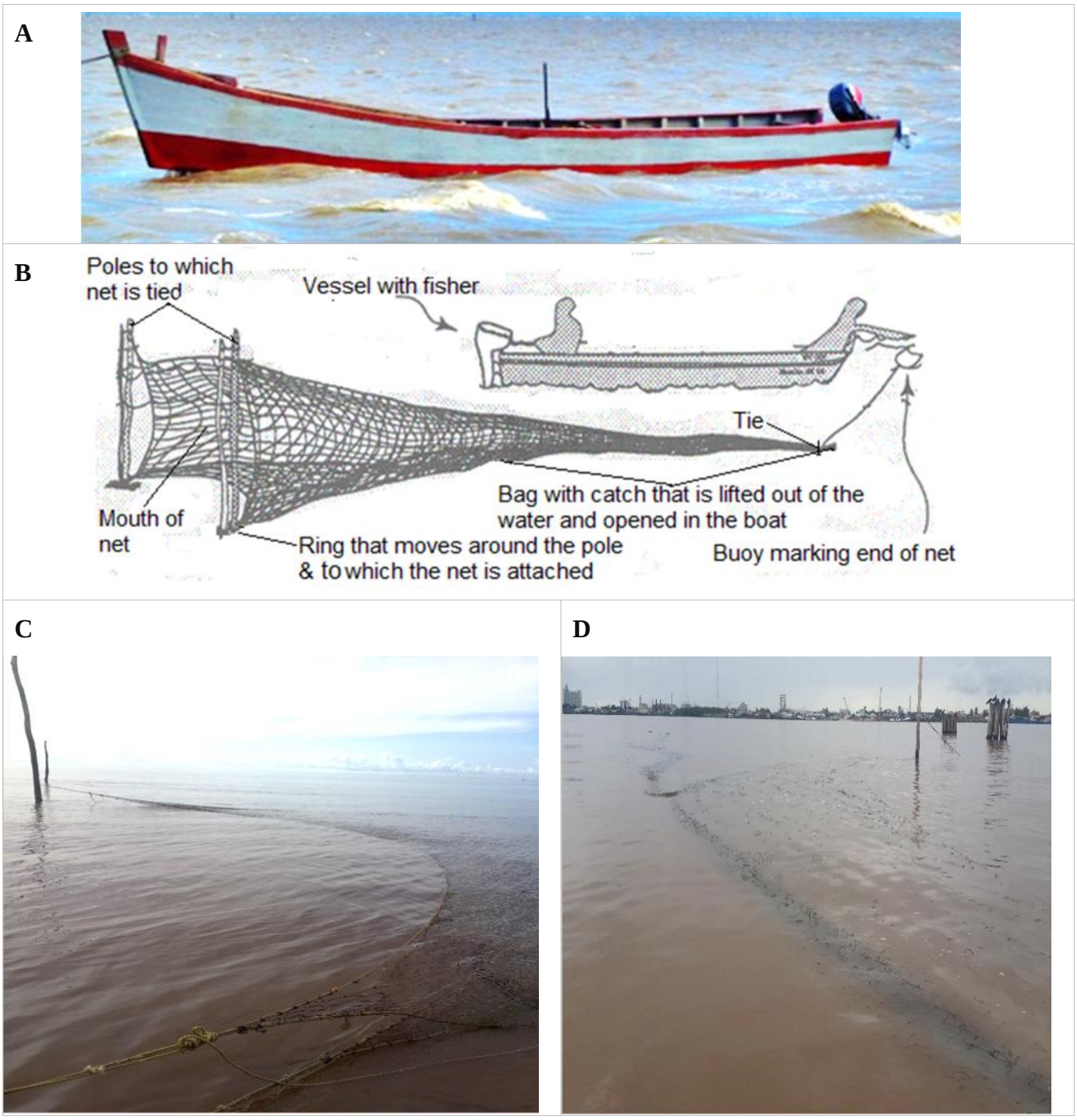

Figure 2: Photographs and Diagram showing: A. The fishing vessel. B. Diagram of a typical Chinese seine operation. C. The net under strong tidal flow. D. The net at slack tide. Photographs: L. Kalicharan (2016). Diagram adapted from Babb (2007), drawing by C. Lietar.

2.2.3 Sampling methodology

The actual time of setting and retrieving the seine, exact soak time, and the state of tide at which the fishing commenced were recorded for each trip. The number of hauls completed along with the individual soak time for each set was also recorded for each fishing trip. Typically, the Chinese seines worked within the study area are set just after high tide to fish the falling tide and under ideal conditions, retrieved at low tide after six hours of soak time. However, in practice, the soak time strictly depended on the change of the water's course determined by the conditions of the estuary on that given day.

Once set, individual hauls would be made based on the fisher's observations of how full the net bag is. Without untying the seine, only the bag is retrieved into the boat and emptied into a 'tub' (Figures 3a, b). This end of the seine is then reset after each individual haul. The entire net is typically only retrieved at the end of the fishing day.

The tub (Figure 3a) and the unsorted catch were weighed together using an analogue scale on board the vessel to the nearest 0.1 kg. The weight of the tub was subtracted from the overall weight for each haul per trip, to acquire the total catch (target/retained catch plus bycatch species) weight to the nearest 0.1 kg.

The total catch (emptied into a first tub) was then sorted by hand by the fisher using a wooden hand pick to remove all the unwanted large (mostly adult) finfish (Figure 3c). These were then placed into a second tub (Figure 3d) for measurement (although normally they would have been discarded directly overboard at this point). Any large target finfish species (typically bangamary and butterfish) were placed together into a third tub, and the target shrimp (mostly seabob) are sorted into a separate container. Finally, the remaining catch (composed of smaller-sized target finfish species and bycatch) was manually sorted by the fisher. The smaller-sized target finfish were placed into the third tub together with the other larger target finfish species to be retained, whilst all the other small-sized bycatch species (which the fisher would normally discard overboard) were placed into the second tub for measuring along with the larger species previously removed.

Subsequently, all the bycatch finfish species for discard (large and small) in the second tub were weighed together using an analogue scale on-board the vessel. The weight of the tub was subtracted from the overall weight of the unsorted catch for each haul per trip, to acquire the weight of each fraction of the catch to the nearest 0.1 kg. The targeted finfish catch (retained catch) in the third tub was also weighed as previously described. Finally, the targeted seabob catch (a component of the retained catch) held in a separate container was also weighed using the same protocol for each haul per trip.

Figure 3: Photographs of sampling methodology. A & B. show the unsorted catch being emptied into a typical tub used by fishery. C. shows the initial sorting to remove unwanted large finfish. D. shows a second tub containing the large finfish bycatch that would normally have been discarded overboard. Photographs taken in 2016 by author, L. Kalicharan.

2.2.4 Sub-Sampling strategy

Thereafter, a sub-sample of the small-sized finfish discards (in second tub), representing at least 5 % of this bycatch volume, was collected. This sub-sample of small-sized finfish, together with the larger-sized finfish (Figure 3d) was then examined at sea, onboard the vessel. For each individual, recorded were: its local name, life condition, fork length measurement using a measuring board to the nearest 0.1 cm, and weight using a digital hand scale to the nearest 1 g. Life condition was recorded as one of three categories: 'Good' (likely to survive when discarded), 'Poor' (unlikely to survive) and 'Dead'.

In addition, individual photographs of all bycatch species were taken as a means of digitally documenting the discards according to local names and to assist with identification to species level. Samples of the species were collected where necessary and preserved in a 10% formaldehyde solution for taxonomic confirmation at a later date. Identification to species level was guided by Professor Donald Taphorn, a Research Associate at the Royal Ontario Museum (Ichthyology) Toronto, Canada.

2.2.5 Documentation of fisher practices for handling bycatch

The handling practices utilized for discarded bycatch species were documented from onboard observations by digital photography, and by informal interviews with fishers operating vessels within the study area.

2.2.6 Data handling and analysis

At–sea data were recorded in a water-resistant notebook. On returning to shore, all data were transferred to an Excel 2013 database. For general descriptions of species size and weight composition, the haul data from all 16 fishing days were used. Bycatch rates per haul were calculated as a percentage of total unsorted catch weight per haul. For this information, haul data from 14 of the 16 fishing days were used, as these were the days that all the relevant data were collected (i.e. weight of unsorted catch, of bycatch and of retained catch per haul). The hauls from the first two fishing days were not included because the weights of the separate catch components were not recorded. Based on the objectives of this study, simple descriptive and statistical analyses were performed using Excel 2013.

3 RESULTS

3.1 Sampling effort

A total of 16 fishing trips were conducted between July 25 and August 28, 2016 onboard a single small-scale artisanal fishing vessel (Figure 2a). This resulted in a dataset comprising 83 hauls with a total soak time (during the falling tide) of 66 hours and 4 minutes (3,985 minutes) (Table 1). Fishing was done within two licensed fishing pens: (i) Jetti (13 trips) and (ii) Fort mouth (2 trips), in the Demerara River estuary (Figure 1), and resulted in the capture of more than 470 kg of finfish bycatch to be discarded (Table 1).

Table 1: Summary of fishing trips over the research period showing trip number, date, location, number of hauls and total soak time. The total weights of the retained catch, discarded finfish and other discards are also shown for each trip.

Trip No.	Date (m/dd/yr)	Location of pen	No. hauls	Soak time (min)	Retained catch (kg)	Finfish discards (kg)	Finfish discards (% catch wt)	Other discards (kg)	Other discards (% catch wt)
1	7/25/2016	Jetti	3	148	-	-	-	-	-
2	7/26/2016	Jetti	4	202	-	-	-	-	-
3	7/27/2016	Fort Mouth	9	312	13.96	40.98	72.8	1.35	2.4
4	7/28/2016	Jetti	6	173	13.30	29.40	66.8	1.30	3.0
5	7/30/2016	Jetti	3	137	9.40	25.00	69.4	1.60	4.4
6	8/09/2016	Jetti	6	369	31.00	58.20	64.3	1.30	1.4
7	8/10/2016	Jetti	7	282	15.43	50.56	68.8	7.51	10.2
8	8/11/2016	Jetti	5	200	5.70	36.60	81.3	2.70	6.0
9	8/12/2016	Jetti	4	243	28.10	31.20	50.3	2.70	4.4
10	8/13/2016	Jetti	3	155	20.80	28.60	57.8	0.10	0.2
11	8/14/2016	Jetti	10	773	22.00	53.20	69.6	1.20	1.6
12	8/23/2016	Jetti	5	166	10.10	22.30	66.6	1.10	3.3
13	8/24/2016	Jetti	5	184	6.10	28.70	80.8	0.70	2.0
14	8/25/2016	Jetti	4	238	5.40	20.40	70.6	3.10	10.7
15	8/26/2016	Fort Mouth	5	230	4.20	25.40	84.4	0.50	1.7
16	8/28/2016	Jetti	4	155	8.60	19.90	68.4	0.60	2.1
Total			83	3967	194.09	470.44	-	25.76	-
Mean per trip (SD)			5 (2.1)	248 (154.2)	13.86 (8.6)	33.60 (3.48)	69.42 (9.00)	1.84 (1.85)	3.81 (3.18)

3.2 Species composition of finfish bycatch discards

A total of 2,012 individual finfish across 6 orders, 17 families, 29 genera and 32 species were identified in the sub–sampled finfish bycatch discards. A summary of their taxonomic composition and bycatch frequency is provided in Table 2 and Figure 4. Furthermore, a photographic record of

all 32 species is given in Figure 5, and a summary of their relative importance in the bycatch (% contribution by number) as well as their IUCN conservation status and importance to Guyanese fisheries is given in Table 3. Virtually all of the species documented are listed by IUCN Red List as being of 'least concern' and a few are listed as 'data deficient' (Table 3).

Among the 2,012 individuals sub-sampled, a total of 848 individuals (representing 42% of the bycatch) were documented in the Order Perciformes across 8 families, 13 genera and 13 species. The dominant family was the Sciaenidae (drums and croakers) and the second and third most frequently caught species were both from this family. These were bangamary (*Macrodon ancylodon)* and rockhead *(Stellifer microps*) with a total of 367 and 311 individuals being recorded and representing 18.2% and 15.5% of all individuals in the sampled finfish bycatch, respectively (Tables 2 and 3, Figure 4).

The order Clupeiformes was the second most frequently occurring group in the discarded finfish bycatch, comprising of 739 individuals (37% of bycatch discards) across 2 families, 5 genera and 5 species. Silver herring (*Lycengraulis grossidens*), neckley (*Odontognathus mucronatus*) and brown herring (*Anchoa spinifer*) from this order were the first, fourth and fifth most commonly caught finfish bycatch species at 371, 227 and 108 individuals respectively, representing 18.4%, 11.3% and 5.4% of all the bycatch discard species sampled (Tables 2 and 3, Figure 4).

The third most important order was the Siluriformes with 393 individuals (20% of bycatch discards) across 4 families, 8 genera and 11 species. Highwater (*Hypophthalmus marginatus*) from this order was the sixth most frequently caught individual species in the bycatch with 107 recorded representing 5.3% of the bycatch discards (Tables 2 and 3, Figure 4).

Despite the high taxonomic diversity, 10 species accounted for 87% of the finfish discards (by number) and just three species; silver herring (*Lycengraulis grossidens*), bangamary (*Macrodon ancylodon*) and rockhead (*Stellifer microps*) accounted for more than half (52%) of all discarded finfish (Figure 4).

Table 2: Summary of the taxonomic composition of the finfish bycatch discards sub–sampled from the artisanal Chinese seine fishery in the Demerara estuary.

Order	Family	Species	FAO Common name	Local name	Count	Order sub-total
Batrachoidiformes	Batrachoididae	*Batrachoides surinamensis*	Pacuma Toadfish	Pacu	1	1
Clupeiformes	Engraulidae	*Anchoa spinifer*	Spicule/Panama Anchovy	Brown Herring	108	
		Anchoviella lepidentostole	Broadband Anchovy	Suriname Mullet	26	
		Lycengraulis grossidens	Atlantic Sabretooth Anchovy	Silver Herring	371	
	Pristigasteridae	*Odontognathus mucronatus*	Guiana Longfin Herring	Neckley	227	
		Pellona harroweri	American Coastal Pellona	Shad	7	739
Perciformes	Carangidae	*Oligoplites saliens*	Castin Leatherjacket	Copperfish	34	
		Selene vomer	Lookdown	Bapise	3	
	Centropomidae	*Centropomus pectinatus*	Tarpon Snook	Chinese Snook	11	
	Gobiidae	*Gobionellus oceanicus*	Highfin Goby	Backra Cackey	1	
	Haemulidae	*Genyatremus luteus*	Torroto Grunt	Anafolks	1	
	Lobotidae	*Lobotes surinamensis*	Atlantic Tripletail	Paggy	2	
	Polycentridae	*Polycentrus schomburgkii*	Guyana Leaffish	Guyana Leaffish	1	
	Sciaenidae	*Cynoscion jamaicensis*	Jamaica Weakfish	Table Bashaw	24	
		Lonchurus elegans	Blackfin Croaker	Chinese Butterfish	11	
		Macrodon ancylodon	King Weakfish	Bangamary	367	
		Nebris microps	Smalleye Croaker	Butterfish	8	
		Stellifer microps	Smalleye Stardrum	Rockhead	311	
	Trichiuridae	*Trichiurus lepturus*	Atlantic Cutlassfish	Silverbelt	74	848
Pleuronectiformes	Achiridae	*Achirus achirus*	Drab Sole	Flounder	6	6
Siluriformes	Ariidae	*Aspistor quadriscutis*	Bressou Sea Catfish	Softhead Sea Catfish	55	
		Bagre bagre	Coco Sea Catfish	Catfish	9	
		Amphiarius rugispinis	Softhead Sea Catfish	Tweetwee	98	
		Sciades herzbergii	Pemecou Sea Catfish	Mud Cuirass	24	
	Aspredinidae	*Aspredo aspredo*	Banjo	Banjoman	8	
	Auchenipteridae	*Pseudauchenipterus nodosus*	Cocosoda Catfish	Sweetman	37	
	Pimelodidae	*Brachyplatystoma filamentosum*	Kumakuma	Kumakuma	19	
		Brachyplatystoma sp.		Himara	20	
		Brachyplatystoma vaillantii	Laulao Catfish	Laulau	15	
		Hypophthalmus edenatus	Highwaterman Catfish	Highwater (Sp 2)	1	
		Hypophthalmus marginatus		Highwater	107	393
Tetraodontiformes	Tetraodontidae	*Colomesus psittacus*	Banded Puffer	Pufferfish	25	25
Total						**2,012**

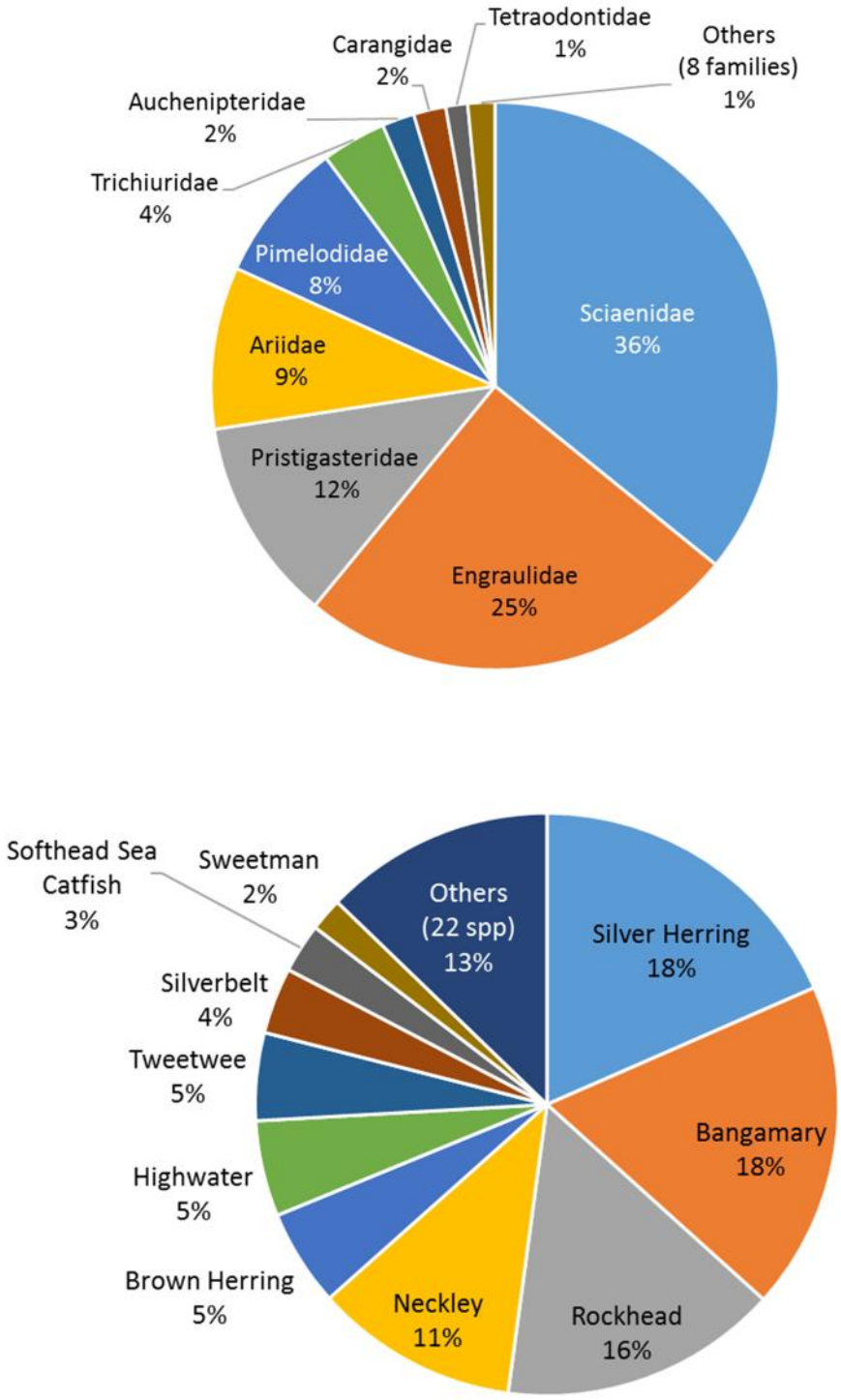

Figure 4: Relative abundance (% by number) of finfish bycatch discards sub-sampled from the Chinese seine fishery in the Demerara estuary. Top panel shows the 17 families recorded, with the top nine (representing 99% of the finfish discards) shown by family name. Bottom panel shows the 32 species recorded, with the top 10 (representing 87% of the finfish discards) shown by species name.

(1) Rockhead

(2) Silver Herring

(3) Brown Herring

(4) Himara

(5) Neckley

(6) Sweetman

(7) Softhead Catfish

(8) Pacu

(9) Tweetwee

(10) Chinese Snook

(11) Butterfish

(12) Bangamary

(13) Flounder

(14) Pufferfish

(15) Copperfish

(16) Shad

(17) Highwater sp. 1

(18) Highwater sp. 2

(19) Banjoman

(20) Paggy

(21) Suriname Mullet

(22) Catfish

(23) Kumakuma

(24) Anafolks

(25) Backra Cackey

(26) Chinese Butterfish

(27) Silverbelt

(28) Table Bashaw

(29) Guyana Leaffish

(30) Laulau

(31) Bapise

(32) Mud Cuirass

Figure 5: Photographs of the 32 finfish bycatch discards species sub–sampled from the artisanal Chinese seine fishery in the Demerara estuary. All photographs taken by author, L. Kalicharan (2016), except for no. 28, Table Bashaw, source: *http://www.pesqueirapionei*

3.3 Size and weight frequencies of the finfish bycatch discards

3.3.1 All species

Over all species and individuals in the bycatch discards sub-sampled from the Chinese seine, the size range was considerable, from 1.9 to 88.5 cm FL and from <12 – 1,395 g (Table 4, Figure 6). Note, however, that the mean weights are strongly biased upwards because the analogue balance used could not weigh individuals less than 12 g. This resulted in the omission of weights for 1,098 individuals (54.6% of the total sub–sample). The mean length was small, being just 11.9 cm FL (SE 0.25), and the upwardly biased mean weight was 72.7 g (SE 4.3) (Table 4). The modal size was 6 cm FL and 25 g wt (Table 4, Figure 6).

Table 3: Summary of selected characteristics of the 32 finfish bycatch species documented from the artisanal Chinese seine fishery in the Demerara estuary. Shown is the percent bycatch discards of total sub-sampled for each species. The status of each species by IUCN Red List categories: LC–'Least Concern', DD–'Data Deficient' and NA–'Not Assessed'. Also shown is the commercial or recreational importance to Guyana's and other fisheries.

Species name	Common name	% of bycatch discards	IUCN category	Value to Guyana fisheries		Other values	Information sources
				Com	Rec		
Batrachoides surinamensis	Pacu	0.05	LC	✓	×	A food fish species taken by the commercial fishing industry in Trinidad & Tobago and French Guiana	Collette 2011
Anchoa spinifer	Brown Herring	5.4	LC	×	×	Used mainly as fish meal, but is also sometimes marketed fresh. In Colombia, it is used as a feed in crocodile farms	Munroe et al. 2015
Anchoviella lepidentostole	Suriname Mullet	1.3	LC	✓	×	One of the most important fishery resources for the whole of the south coast of São Paulo state, Brazil	Mendonca & Sobrinho 2013
Lycengraulis grossidens	Silver Herring	18.4	LC	×	×	Important to commercial fisheries and as a baitfish in recreational fisheries in other South American countries	Giacometti & Vieire 2013
Odontognathus mucronatus	Neckley	11.3	LC	✓	×		
Pellona harroweri	Shad	0.35	LC	×	×	Captured in artisanal fisheries off Venezuela and the Guianas; Consumed locally, but there is no targeted fishery.	Munroe 2015
Oligoplites saliens	Copperfish	1.7	LC	×	×	Sold fresh in fish markets in other South American countries	Smith-Vaniz et al. 2015
Selene vomer	Bapise	0.15	LC	×	×	It is a component of recreational fisheries in coastal pelagic fishery of Trinidad and Tobago	Smith-Vaniz et al. 2015
Centropomus pectinatus	Chinese Snook	0.55	LC	✓	×		
Gobionellus oceanicus	Backra Cackey	0.05	LC	×	×		
Genyatremus luteus	Anafolks	0.05	NA	✓	×	It is targeted in Venezuela and other countries throughout its range	Lindeman et al. 2016
Lobotes surinamensis	Paggy	0.10	LC	✓	×	Taken in relatively small numbers in Atlantic commercial fisheries. Important recreational fisheries species	Carpenter & Robertson 2015
Polycentrus schomburgkii	Guyana Leaffish	0.05	NA	×	×		
Cynoscion jamaicensis	Table Bashaw	1.8	LC	✓	×		

Lonchurus elegans	Chinese Butterfish	0.55	DD	×	×		
Macrodon ancylodon	Bangamary	18.2	LC	✓	×		
Nebris microps	Butterfish	0.40	LC	✓	×		
Stellifer microps	Rockhead	15.5	LC	×	×		
Trichiurus lepturus	Silverbelt	3.7	LC	×	×	A retained bycatch species from the Surinamese seabob fishery. It is marketed fresh, frozen, and salted.	Hornby et al. 2015
Achirus achirus	Flounder	0.30	LC	×	×	May become an important species for fisheries, as it is considered a highly esteemed food fish in Brazil	Munroe, Buddo &. Bendeck. 2015
Aspistor quadriscutis	Softhead Sea Catfish	2.7	LC	×	×		
Bagre bagre	Catfish	0.45	LC	✓	×		
Amphiarius rugispinis	Tweetwee	4.9	LC	×	×		
Sciades herzbergii	Mud Cuirass	1.2	LC	✓	×		
Aspredo aspredo	Banjoman	0.40	NA	×	×		
Pseudauchenipterus nodosus	Sweetman	1.8	NA	×	×		
Brachyplatystoma filamentosum	Kumakuma	0.94	NA	✓	✓		
Brachyplatystoma sp.	Himara	0.99	NA	×	×		
Brachyplatystoma vaillantii	Laulau	0.75	NA	✓	✓		
Hypophthalmus edenatus	Highwater (Sp. 2)	0.05	NA	×	×		
Hypophthalmus marginatus	Highwater	5.3	NA	✓	×	A commercially important freshwater species of the Brazilian Amazon Basin.	FAO 2014
Colomesus psittacus	Pufferfish	1.2	LC	×	×	A component of the aquarium trade, and is exported from Brazil, Colombia, and Peru	Shao et al. 2014

Table 4: Summary of size data for all finfish bycatch discards sub–sampled from the artisanal Chinese seine fishery in the Demerara estuary

Parameter	FL (cm)	Wt (g)
Mean	11.9	72.7
Standard Error	0.25	4.3
Standard Deviation	11.1	130.6
Mode	6	25
Minimum	1.9	12
Maximum	88.5	1395
Count (n)	2012	914

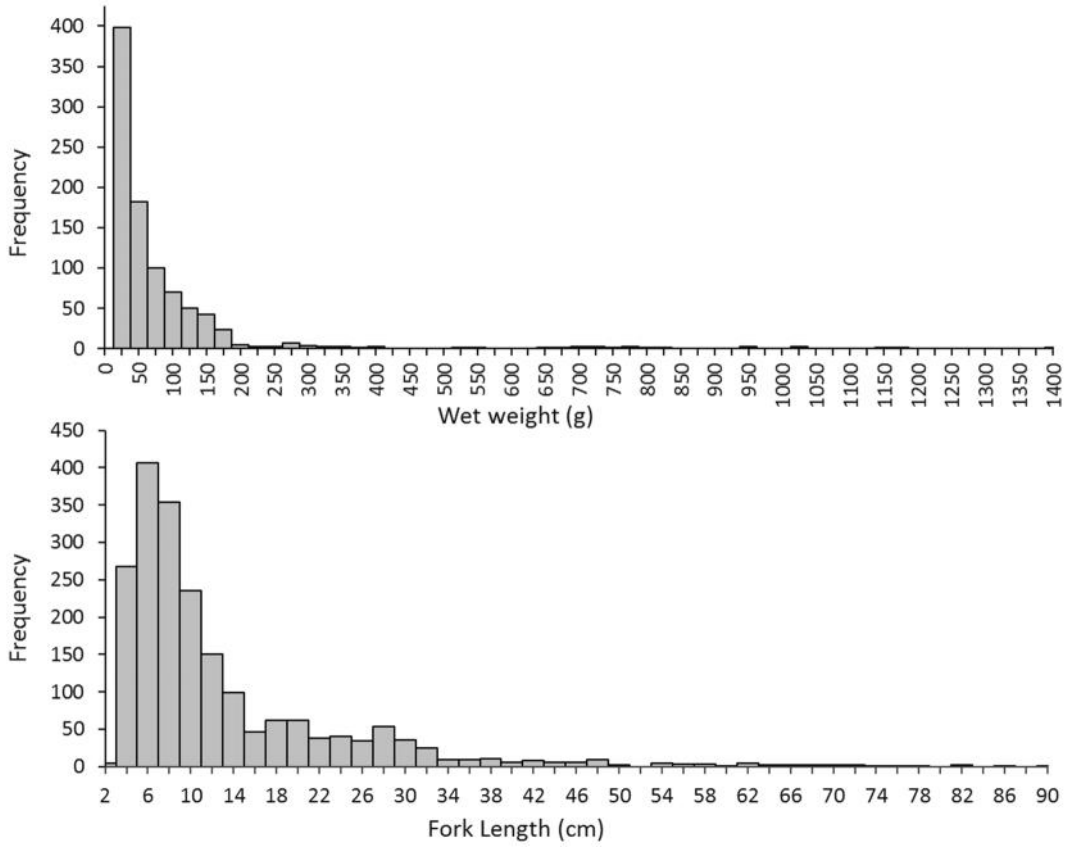

Figure 6: Size frequency distributions of all finfish bycatch discards sub–sampled from the artisanal Chinese seine fishery in the Demerara estuary. Top panel shows whole wet weights (g) (n=914), bottom panel shows fork length (cm) (n=2012).

3.4 Selected species

Ten species (silver herring, bangamary, rockhead, neckley, brown herring, highwater, tweetwee, silverbelt, softhead sea catfish and sweetman) accounted for 87% of the total finfish bycatch discards (Tables 2 and 3, Figure 4) and were selected for further analysis. It is worth noting that three (bangamary, neckley and highwater) are commercially important to other fisheries in Guyana, and three others (brown herring, silver herring and silverbelt) are known to have commercial value to other fisheries in South America (Table 3). Interestingly, some of the largest bycatch individuals (≥ 30 cm in FL) were discarded because they have no economic value locally (e.g. tweetwee, softhead sea catfish, silverbelt and sweetman). A summary of the length data for the top 10 species is provided in Table 5 and their individual length frequency distributions are given in Figure 7.

Table 5: Summary of Fork Length (cm) distributions for top most abundant finfish bycatch species sub–sampled from the artisanal Chinese seine fishery in the Demerara estuary

Species	Common name	Fork length (cm)						
		Mean	SE	SD	Mode	Min	Max	Size at maturity (cm)
L. grossidens	Silver herring	6.6	0.2	4.4	4	1.9	29	NA
M. ancylodon	Bangamary	8.3	0.1	2.4	9	2.5	14.3	23.7
S. microps	Rockhead	5.6	0.1	2.4	5	2	18.2	NA
O. mucronatus	Neckley	6.6	0.1	1.4	5.5	2.6	11	NA
A. spinifer	Brown herring	12.4	0.3	3.6	15	4.7	20	NA
H. marginatus	Highwater	27.6	0.4	4.6	28.5	13.4	40.8	NA
A. rugispinis	Tweetwee	19.5	0.6	5.6	23	4.4	32	NA
T. lepturus	Silverbelt	49.4	1.9	16.6	41.5	16.0	88.5	50.6
A. quadriscutis	Softhead sea catfish	14.2	1.3	9.7	7	3.5	34.3	NA
P. nodosus	Sweetman	22.0	0.7	4.3	16.7	5.5	29.0	NA

Size at maturity was listed as unknown in FishBase for eight of the 10 selected species (Table 5). However, bangamary is reported to reach maturity at a length of about 23.7 cm (Froese and Pauly 2019), which is above the size of all the bangamary discards in this study (length range 2.5 – 14.3 cm), indicating that all would have been immature individuals (Table 5, Figure 7). For silverbelt, with a reported size at maturity of 50.6 cm (Froese and Pauly 2019) about half of the discards were likely immature (Table 5, Figure 7).

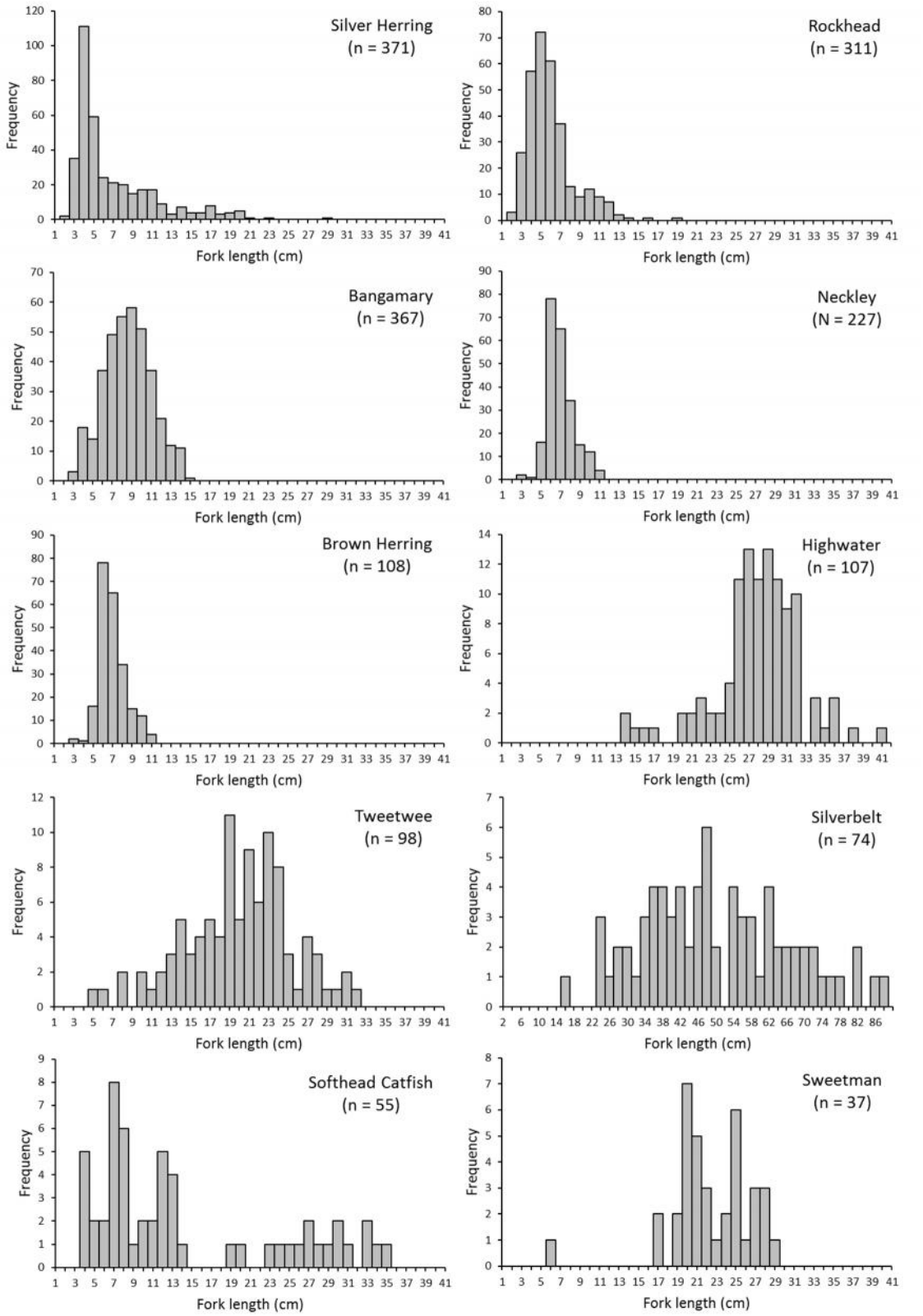

Figure 7. Size frequency distributions for top most abundant species (representing 87% of total) of finfish bycatch discards sub–sampled from the artisanal Chinese seine fishery in the Demerara estuary. Size is shown as fork length (cm) (n=2012). Note that size scale is different for silverbelt.

3.5 Life condition of individuals

The majority (44 %) of finfish bycatch discards that were sub-sampled were found to be in poor condition and unlikely to survive when thrown back. An additional 39 % were already dead, whilst just 17% were considered to be in good condition and likely to survive when discarded overboard (Figure 8, Table 6).

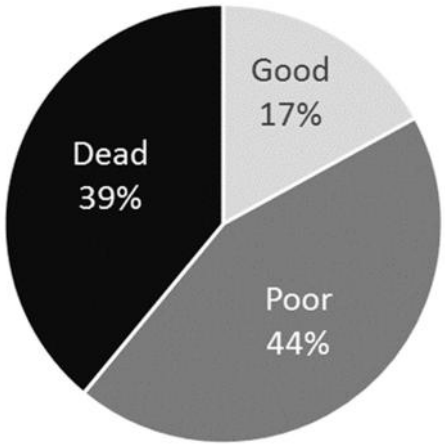

Figure 8: Life condition (% by number) of the finfish bycatch discards that were sub–sampled from the Chinese seine fishery in the Demerara estuary.

A significant proportion of the discards comprised species of value to other fisheries in Guyana or neighbouring South American countries (Table 3) and the discard mortality of these species appeared to be particularly high. For example, silver herring (accounting for 18 % of discards) had only a 1% probability of surviving on being thrown back, since 51% of individuals were in poor condition and 48 % were already dead (Table 6). Likewise, bangamary (also accounting for 18 % of discards) appeared to have no potential for survival with 59 % of individuals being in poor condition and the remaining 41 % already dead. Rockhead (representing 15.5% of discards) had only 2% of discards likely to survive with 36% recorded as being in poor condition and 62% already dead. Neckley (11.3% of discards) had no potential for survival (68 % in poor condition, 32% dead), while brown herring (5.4% of discards) had the highest chance of surviving at just 8% (59% in poor condition, 33% dead).

Table 6: Overview of life conditions as a percent of total count for all finfish bycatch species sub–sampled from the Chinese seine fishery in the Demerara estuary.

Scientific name	Local name	Total count (n)	Life condition					
			Good		Poor		Dead	
			no.	%	no.	%	no.	%
Batrachoides surinamensis	Pacu	1	1	100	0	0	0	0
Anchoa spinifer	Brown Herring	108	8	7	64	59	36	33
Anchoviella lepidentostole	Suriname mullet	26	0	0	25	96	1	4
Lycengraulis grossidens	Silver Herring	371	5	1	188	51	178	48
Odontognathus mucronatus	Neckley	227	0	0	155	68	72	32
Pellona harroweri	Shad	7	6	86	0	0	1	14
Oligoplites saliens	Copperfish	34	2	6	0	0	32	94
Selene vomer	Bapise	3	0	0	2	67	1	33
Centropomus pectinatus	Chinese Snook	11	7	64	3	27	1	9
Gobionellus oceanicus	Backra Cackey	1	1	100	0	0	0	0
Genyatremus luteus	Anafolks	1	0	0	0	0	1	100
Lobotes surinamensis	Paggy	2	1	50	1	50	0	0
Polycentrus schomburgkii	Guyana Leaffish	1	0	0	1	100	0	0
Cynoscion jamaicensis	Table Bashaw	24	6	25	6	25	12	50
Lonchurus elegans	Chinese Butterfish	11	4	36	3	27	4	36
Macrodon ancylodon	Bangamary	367	0	0	215	59	152	41
Nebris microps	Butterfish	8	0	0	0	0	8	100
Stellifer microps	Rockhead	311	7	2	112	36	192	62
Trichiurus lepturus	Silverbelt	74	2	3	46	62	26	35
Achirus achirus	Flounder	6	4	67	1	17	1	17
Aspistor quadriscutis	Softhead Sea catfish	55	19	35	19	35	17	31
Bagre bagre	Catfish	9	2	22	4	44	3	33
Amphiarius rugispinis	Tweetwee	98	76	78	10	10	12	12
Sciades herzbergii	Mud cuirass	24	19	79	3	13	2	8
Aspredo aspredo	Banjoman	8	8	100	0	0	0	0
Pseudauchenipterus nodosus	Sweetman	37	31	84	3	8	3	8
Brachyplatystoma filamentosum	Kumakuma	19	6	32	1	5	12	63
Brachyplatystoma sp.	Himara	20	12	60	6	30	2	10
Brachyplatystoma vaillantii	Laulau	15	8	53	7	47	0	0
Hypophthalmus edenatus	Highwater (sp 2)	1	0	0	0	0	1	100
Hypophthalmus marginatus	Highwater	107	98	92	2	2	7	7
Colomesus psittacus	Pufferfish	25	5	20	12	48	8	32
Overall		**2012**	**338**	**17**	**889**	**44**	**785**	**39**

Ironically species with little or no commercial value fared better. For example, the potential of highwater to survive when discarded was high, with 92 % of individuals being in good condition, only 2 % in poor condition and 7 % already dead. Likewise, many of the sea catfishes (Order Siluriformes) such as: tweetwee, sweetman, kumakuma, mud cuirass and laulau were generally found to be in good condition and likely to survive when discarded (Table 6).

3.6 Catch per unit of effort (CPUE)

Catch rates were calculated using several different units of fishing effort. A day fishing trip was the crudest level of fishing effort used, regardless of number of nets, hauls or time spent fishing. Although 16 fishing trips and 83 seine hauls were observed in total, catch weights were not recorded for the first two days of sampling and therefore, the CPUE data are based on 14 trips spanning the period of July 27 to August 28, 2016 (Table 1).

The 14 fishing trips yielded 194 kg of target catch (seabob, white-belly shrimp, bangamary, butterfish and mud cuirass) and produced 470 kg of finfish bycatch discards (Table 1), demonstrating a mean CPUE for finfish bycatch per trip of 33.6 kg (± 12.5 kg) for the Jetti and Fort Mouth licensed pens in the Demerara estuary during this period. This translated into an overall mean catch ratio of 69.4% finfish discards, 3.8 % other discards (jelly fish and few small crabs) and 26.8% target catch by wet weight (Table 1). The typical metrics for a fishing day are summarised in Table 1, showing that on average 5 seine hauls are made, with an average total soak-time of 249 minutes.

CPUE was also calculated at a finer resolution of fishing effort, using catch of finfish discards per seine haul, and also by standardising to catch per hour of seine soak-time (Table 7). On average 9.1 kg (SD ± 7 kg) of total unsorted catch was retrieved per seine haul, yielding an average of 6.2 kg (SD ± 4 kg) of finfish bycatch to be discarded. This represents an average of 69.5% (by weight) of finfish bycatch discards (Table 7).

Standardising each haul to mean catch per hour translates to an average of 0.25 kg (SD ± 0.19 kg) of total unsorted catch retrieved per hour of seine soak-time, yielding an average of 0.17 kg (SD ± 0.12 kg) of finfish bycatch to be discarded.

Table 7: Summary of total unsorted catch and finfish bycatch discards shown as catch per unit effort (CPUE) in wet weight (kg) using different units of fishing effort. Shown are catch per hour of seine soak-time, and catch per seine haul.

Trip No.	Haul number	CPUE (kg per hour seine soak-time)		CPUE (kg per seine haul)		Finfish bycatch discards (% of total catch weight)
		Total unsorted catch	Finfish discards	Total unsorted catch	Finfish discards	
3	1	0.02	0.01	1.2	0.4	30.2
3	2	0.07	0.06	1.8	1.4	76.8
3	3	0.12	0.11	1.6	1.4	91.4
3	4	0.56	0.41	8.9	6.5	73.0
3	5	0.69	0.36	11	5.8	52.7
3	6	0.21	0.19	5	4.6	92.0
3	7	0.16	0.14	15	13.7	91.3
3	8	0.19	0.14	4.2	3.2	75.7
3	9	0.16	0.08	7.6	4	52.6
4	1	0.07	0.05	3	2	66.7
4	2	0.31	0.18	5	2.8	56.0
4	3	0.40	0.27	12	8	66.7
4	4	0.39	0.24	13	8	61.5
4	5	0.47	0.41	7.5	6.5	86.7
4	6	0.09	0.06	3.5	2.1	60.0
5	1	0.12	0.06	5.5	3	54.5
5	2	0.42	0.32	10.5	8	76.2
5	3	0.31	0.22	20	14	70.0
6	1	0.11	0.06	10.5	5.5	52.4
6	2	0.22	0.13	21	12.5	59.5
6	3	0.96	0.53	24	13.3	55.4
6	4	0.63	0.41	12.5	8.2	65.6
6	5	0.14	0.11	7	5.4	77.1
6	6	0.19	0.16	15.5	13.3	85.8
7	1	0.01	0.00	0.5	0.16	32.0
7	2	0.18	0.12	3.5	2.4	68.6
7	3	0.60	0.38	14.5	9	62.1
7	4	0.45	0.27	12.5	7.5	60.0
7	5	0.15	0.10	9.5	6.5	68.4
7	6	0.37	0.29	19	15	78.9
7	7	0.35	0.25	14	10	71.4
8	1	0.08	0.06	3	2.5	83.3
8	2	0.17	0.13	7	5.4	77.1
8	3	0.19	0.16	5	4.2	84.0
8	4	0.22	0.19	10	8.8	88.0
8	5	0.43	0.34	20	15.7	78.5
9	1	0.32	0.10	36	11.8	32.8
9	2	0.12	0.10	4.5	3.6	80.0
9	3	0.15	0.11	4	3	75.0
9	4	0.27	0.19	17.5	12.8	73.1
10	1	0.09	0.06	5	3.5	70.0
10	2	0.09	0.07	3	2.1	70.0
10	3	0.60	0.33	41.5	23	55.4
11	1	0.07	0.04	6	3.5	58.3
11	2	0.07	0.05	6	4	66.7
11	3	0.03	0.02	4	2.4	60.0

11	4	0.03	0.02	5	3.5	70.0
11	5	0.29	0.24	8	6.6	82.5
11	6	0.22	0.18	6	4.8	80.0
11	7	0.08	0.06	4.5	3.2	71.1
11	8	0.17	0.11	5.5	3.4	61.8
11	9	0.17	0.12	12.5	9.1	72.8
11	10	0.20	0.14	18.9	12.7	67.2
12	1	0.07	0.02	4	1.2	30.0
12	2	0.28	0.14	5	2.5	50.0
12	3	0.37	0.29	7	5.5	78.6
12	4	0.55	0.43	10.5	8.2	78.1
12	5	0.14	0.10	7	4.9	70.0
13	1	0.04	0.03	3	1.8	60.0
13	2	0.42	0.29	8	5.5	68.8
13	3	0.50	0.43	11.5	9.8	85.2
13	4	0.26	0.23	7	6.2	88.6
13	5	0.13	0.12	6	5.4	90.0
14	1	0.05	0.03	6.5	5	76.9
14	2	0.51	0.29	8.7	5	57.5
14	3	0.21	0.16	9	6.7	74.4
14	4	0.13	0.11	4.7	3.7	78.7
15	1	0.01	0.00	0.6	0.3	50.0
15	2	0.20	0.16	4.5	3.6	80.0
15	3	0.32	0.30	8	7.6	95.0
15	4	0.22	0.19	6.5	5.8	89.2
15	5	0.14	0.11	10.5	8.1	77.1
16	1	0.06	0.04	3.6	2.7	75.0
16	2	0.42	0.28	7.5	5	66.7
16	3	0.38	0.26	13.5	9.5	70.4
16	4	0.12	0.07	4.5	2.7	60.0
Mean	**5**	**0.25**	**0.17**	**9.1**	**6.2**	**69.5**
SD	**2.1**	**0.19**	**0.12**	**7**	**4**	**14.4**

3.7 Handling practises for bycatch discards

The on-board observations provided clarity on how bycatch discards are handled on a typical artisanal vessel operating the Chinese seine. In this section, an explanation of the process is outlined.

Unwanted bycatch from this gear type is simply referred to as ‘waste’ by the local fishers. Moreover, they refer to the finfish bycatch discards specifically as ‘bonefish’. The total unsorted catch retrieved from the gear is first emptied into a holding container, commonly referred to as a ‘tub’ (Figure 3). Following this, the fisher will sort the catch. During this stage, large target finfish species (e.g. bangamary, butterfish and mud cuirass) are collected and placed in a separate tub,

while large unwanted species (e.g. softhead sea catfish, sweetman and tweetwee) are instantly dumped overboard as bycatch discards.

Moreover, whenever there is high abundance of the target seabob and whitebelly shrimp in the retrieved catch, the catch undergoes a process called ‘washing’ to remove small unwanted bycatch. For this technique, the fisher leans over the side of the boat, holding the tub. The container is then held in the water and carefully filled, while keeping the rim of the tub above the water’s surface. In the process, the smaller sized bycatch species are floated out of the tub, leaving mostly the seabob (Figure 9). In cases where the washed seabob catch still has 'fingerling' finfish bycatch mixed in, it is then handed-picked and the fingerlings discarded overboard.

In addition, another technique called ‘blowing’ is utilised to rid the gear of non-target bycatch species when there is a very high proportion. Blowing is simply the release of the bycatch (finfish and non-finfish species) directly from the bag of the seine (whilst keeping it in the water). This is done when there is a particularly high abundance of ‘waste’. The technique of blowing is done mainly to relive the bag of the seine of the pressure that the build-up of the unwanted species create, which, if kept in the seine for the entire soak-time would result in most of the target catch being killed or damaged. Interestingly, none of the finfish bycatch from the Chinese seines fished within the Demerara estuary are kept for alternative uses such as processing into fish meal or other products. They are simply discarded overboard.

A **B**

Figure 9: Photographs showing the process of ‘washing’ the targeted seabob catch to discard unwanted small-sized finfish by–catch. A. Shows the tub being filled with water. B. Shows the ‘waste’ being floated out of tub. All photographs taken by author, L. Kalicharan (2016).

4 DISCUSSION

This study represents the first quantitative description of the Chinese seine fishery operated by the inshore artisanal fishery in the Demerara estuary. It provides critical insight on finfish bycatch discards caught by this gear type and serves as a baseline model for scaling up the study to cover more vessels over a longer time period.

The Demerara estuary is an important ecological system that marks the transition between fresh water and the open sea and is known to serve as a breeding or nursery area of many of the commercially important fishery species in Guyana (Hackett, Cochrane and Booth 2000). The estuary is also one of the most important fishing sites utilised by the small–scale inshore artisanal fishery operating the Chinese seine gear type (Fisheries Department 2013). The Demerara River also serves as the shipping channel for Port Georgetown, which stretches for 16 km inward from the river mouth. In view of its industrial significance, the Guyanese Fisheries Department has ceased to permit fishing within this 16 km stretch of the river. More so, the department has been reducing the number of fishing pen licences issued to fishers working close to the mouth of the Demerara River.

4.1 Key discard species

The discarded finfish bycatch was taxonomically diverse with a total of 32 species recorded, but was dominated by 10 species accounting for 87% of all discards, with just six species (considered here) accounting for 74%: *L. grossidens* (silver herring), *M. ancylodon* (bangamary), *S. microps* (rockhead), *O. mucronatus* (neckley), *A. spinifer* (brown herring), *H. marginatus* (highwater). This differs somewhat from neighbouring Suriname where Babb (2007) identified *A. aspedo, T. lepturus, Bagre* spp and *S. microps* as the major species discarded by their artisanal Chinese seine fishery.

Silver herring, one of the two most numerous of the discarded species in this study (representing 18% of total discards) is a schooling, marine, pelagic, inshore species that is also found in estuaries and in freshwater (Giacometti & Vieire 2013). Although the size range caught and discarded was large (1.9 - 29 cm FL) the modal size was just 4 cm FL. The size at maturity appears to be unknown for this species, but given that the maximum size is listed in FishBase as 26 cm TL and that it is

common up to 20 cm TL (Froese and Pauly 2019), it is highly likely that the majority of the discards represents immature individuals. Furthermore, there was little chance of survival for any of the individuals discarded since 99% were in poor condition or already dead. At an international level, this species is considered a species of 'Least Concern' by the IUCN Red List, and is not targeted by any commercial fisheries within Guyana, having no economic value on the local market. As such there is no direct conflict between local fisheries. However, the species has potential value, given that it is of commercial importance (frozen) and also used as bait by the recreational rod fishing in Uruguay and Argentina (Giacometti and Vieira 2013). Whether the bycatch discards for this species in the Guyana Chinese seine fishery are likely to have any impact on the resource fished elsewhere in South America cannot be determined without information on the stock structure.

Bangamary, also representing 18% of the total finfish discards in this study, occurs in estuarine and inshore zones, which have been found to be principal nursery and rearing grounds for this species. The young are typically found in estuaries in high abundance when more fresh water is pouring out to sea, i.e. mostly during the rainy season. This species tends to move into offshore marine water as adults (Hackett, Cochrane and Booth 2000). The size range caught and discarded was small (2.5 – 14.3 cm FL) with a modal size of just 9 cm FL. Babb (2007), reports that this species is utilised by the Chinese seine fishery in Suriname at an average length 12.5 cm. On the contrary, this study highlights that individuals only individuals larger than 14 cm are retained and marketed in Guyana. Bangamary size at maturity is 23.7 cm as listed by FishBase (Froese and Pauly 2019) and Babb (2007). As such, it is evident that the majority of the discards represent immature individuals. Furthermore, there was no potential for any of the discarded individuals to survive since 100% were in poor condition or already dead. Bangamary is listed as 'Least Concern' by the IUCN Red List and is a one of the targeted species of the Chinese seine fishery. It is also exploited by other fisheries and gear types (pin seine, nylon gillnet and trawl fisheries) in Guyana and therefore, has significant commercial value on the local and international markets. However, sub-regional stock assessments of this species indicate that the long–term sustainability of the stocks are under threat and harvesting levels by the groundfish fisheries in Guyana are a matter of concern (FAO 2005). This situation along with the high levels of bycatch of juvenile bangamary highlighted by the current study confirms the importance of reducing the bycatch of this species

and others, if the Guyanese groundfish fishery is to ever be considered sustainable over the long–term, based on the MSC standards.

Rockhead which represents 16% of the total finfish discards in this study, is a brackish, marine species that is commonly found over sandy mud bottoms in coastal waters and is also present in river estuaries (Froese and Pauly 2019). The size range caught and discarded was relatively small (2 - 18.2 cm FL) with a modal size of 5 cm FL. The size at maturity for this species is unknown, however, the maximum size of this species is listed in Fishbase as 20.0 cm TL, with a common length of 12.0 cm TL (Froese and Pauly 2019). Given this, it is highly likely that the majority of the discarded individuals of this species represents immature individuals. Moreover, there was little chance of the survival for any of the discarded individuals since 98% were in poor condition or already dead. Rockhead is listed as 'Least Concern' by the IUCN Red List, and is not targeted by any fishery in Guyana, thus, this species has no economic value on the local market. As such, there is no direct conflict between local fisheries. Interestingly, we found no other reports of this species having commercial value in other regions. To understand whether the bycatch discards for this species in the Guyana Chinese seine fishery is likely to have any impact on resources fished elsewhere cannot be determined without more ecological information on food webs and connectivity between populations.

Neckley (representing 11% of total finfish discards) is commonly found in shallow coastal waters over sand and mud bottoms, particularly at river mouths in estuaries and some distance upstream of freshwater rivers. The size range caught and discarded was small (2.6 - 11 cm FL) with a modal size of just 5.5 cm FL. The size at maturity appears to be unknown for this species, but given that the maximum size is listed in FishBase as 19.2 cm TL with a common length of 12 cm (Froese and Pauly 2019), it is highly likely that the majority of the discards represents immature individuals. Additionally, there was no potential for any of the discarded individuals to survive since 100% were in poor condition or already dead. This species is also listed as 'Least Concern' by the IUCN Red List. Neckley is a common local food fish, and has economic value in the local market. As such, individuals greater than 12 cm are retained by the Chinese seine fishery whilst the smaller sizes are discarded, principally because small sized individuals are easily damaged at due to their soft consistency which reduces the market value. Carpenter (2002) reported that this

species is also taken in the artisanal fisheries of the Guianas, however, like Guyana, there is no defined fishery.

Brown herring which represents 5% of the total finfish discards in this study, occurs in shallow coastal waters, lagoons and mouths of rivers, usually at 5 to 30 m, typically forming large schools (Munroe et al. 2015). The size range caught and discarded was relatively small (4.7 - 20 cm FL) with a modal size of 15 cm FL. The size at maturity for this species is unknown, however, the maximum size listed in Fishbase is 24.0 cm TL, with a common length of 20.0 cm TL (Froese and Pauly 2019). Given this, it is likely that the majority of the discarded individuals of this species represents immature individuals. Furthermore, there was little chance of survival for any of the individuals discarded since 92% were in poor condition or already dead. This species is considered a species of 'Least Concern' by the IUCN Red List, and is not targeted by any commercial fisheries within Guyana, having no economic value on the local market. As such, there is no direct conflict between local fisheries. However, the species has potential commercial value, given that it is used mainly as fish meal and is also marketed fresh in other countries. In Colombia, it is used as a feed in crocodile farms (Munroe et al. 2015). Moreover, in order to understand whether the bycatch discards for this species in the Guyana Chinese seine fishery is likely to have any impact on the resource fished elsewhere cannot be determined without assessment of the stock.

Highwater, representing 5% of the total finfish discards in this study, is a pelagic species which feeds primarily on zooplankton. The size range discarded was relatively large compared with most discards (13.4 – 40.8 cm FL) with a modal size of 28.5 cm FL. Notably, those larger than 41 cm FL were retained and sold on the local market. The size at maturity for this species appears to be unknown, however, the maximum size listed in Fishbase is 55.0 cm TL (Froese and Pauly 2019). As such, the proportion of juvenile discards are likely to be much less than for most of the bycatch species in the Chinese seine fishery. Furthermore, there was a better chance of survival than for most discards, since 92% were found to be in good condition. This species is listed as 'Not Assessed' by the IUCN Red List. There is no special fishery for this species in Guyana and thus no real direct conflict between local fisheries. However, highwater is a commercially important freshwater species of the Brazilian Amazon Basin (Welcomme, Valbo-Jorgensen and Halls 2014)..

4.2 Catch rates

The mean catch rate over the study period (July – August 2016) was 9.1 kg of total unsorted catch per seine haul, yielding an average of 6.2 kg (69.5% of total catch) of finfish bycatch to be discarded. This represented a mean daily catch rate for a single Chinese seine vessel of 33.6 kg of finfish discards. The vast majority of these discards are in poor condition or already dead when thrown back, partly because of the tedious catch sorting process, and most are very small, representing immature individuals. Given that there are in excess of 300 Chinese seine vessels operating in the estuaries of Guyana (Fisheries Department 2013) this study demonstrates that a significant amount of finfish (comprising both commercial and non-commercial species) is being wasted by this fishery and that there is likely to be at least some negative impacts on the sensitive estuarine ecosystems and other fisheries targeting adults of these discard species.

5 CONCLUSION

In conclusion, the quantitative results of this limited study indicate significant bycatch wastage by the Chinese seine fishery. As such there is ample justification for scaling up the study to cover more vessels and all months of the year to determine the full extent of the bycatch issue and potential for damage to the ecosystem and other fishery resources of commercial importance to fisheries in Guyana and neighbouring South American countries. Based on our observations there is also some potential for reducing the bycatch wastage by using some kind of bycatch reduction device in the seine nets and by developing marketable products from the discards.

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