RESEARCH ARTICLE

The Post-Harvest Handling Practices of Glass Eel in Aparri, Cagayan: Operations, Challenges and Recommendations

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ABSTRACT

This study documented the post-harvest handling of glass eel gatherers in Aparri, Cagayan which can serve as baseline information for the establishment of possible management measures to improve the practices of glass eel gathering, conditioning and maintenance for a more sustainable utilization of the stocks and avoid large post-harvest losses in the process. The demographic profile, post-harvest handling practices, and challenges encountered in each step of post-harvest practices were determined. The study was conducted through individual interviews with 165 glass eel gatherers and five local consolidators. Results revealed that the age of respondents was between 41 and 50 years old; the majority are males and most have reached the elementary or secondary level of education. Sorting by the gatherers is done through improvised sorters or manually and done at the collection site or at landing depending on the health of the glass eels. The local consolidators start conditioning glass eels upon delivery by the gatherers following various steps such as sorting, weighing, water exchange, packaging in plastic bags with oxygen, and storing them in Styrofoam boxes, done twice a day. Major challenges experienced by glass eel gatherers and local consolidators include uncontrolled price, insufficient supply or harvest and high fuel and transportation costs hence, prize stabilization, involvement of key players in the industry for the better bargaining scheme and standard operating procedures in stock conditioning and maintenance are some aspects to consider to address the major issues and challenges.

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1. INTRODUCTION

The Cagayan River is considered to be the longest river in the Philippines. According to the Department of Environment and Natural Resources- Cagayan River Basin Management Council, it has an area of 27, 493.49 sq. km which extends to 9 provinces from three comprising regions: Cordillera Administrative Region, Cagayan Valley, and Central Luzon, to include the provinces of Apayao, Kalinga and Mountain Province; Cagayan, Isabela, Nueva Vizcaya and Quirino; and Aurora, respectively.

The Cagayan River is also home to various aquatic species that are commercially and economically important to the fisheries sector such as elvers, (Ame et al, 2013) among others. Similarly, eel species, in the genus Anguilla, have been known to thrive in the river estuaries of Cagayan with five known species such as *Anguilla bicolor pacifica, A. celebesensis, A. japonica, A. luzonensis,* and *A. marmorata (*Aoyama et. al, 2015).

Various life stages of all Anguilla species, ranging from juveniles to adults, are harvested and traded on a global scale, with current demand being mainly in East Asia for consumption (Crook, 2014). These species are traded live since they are for farming to compensate the decline in the collection of temperate anguillid eels in recent years (SEAFDEC, 2019).

According to the study by Ame et al (2013), the increasing demand as brought by huge potential

of glass eels in selected Asian countries contributed to income generation of fishers in the coastal communities of Cagayan. However, based on the data presented in the same paper, the result of the stock assessment conducted in Aparri, Cagayan showed fluctuating trends on supply and migration upstream from 2007 to 2012 due to previous preference of buyers and importers, with the lowest mean catch at 2.71 kg in 2009 and highest in 2012 at 15.21 kg. Additionally, the lowest mean catch per unit effort was recorded at 0.38 kg per gatherer in 2011.

Despite the economic and cultural importance of glass eels, only a few studies have been conducted about their post-harvest handling aspect. Further, fewer studies are conducted focusing on the post-harvest strategies employed for glass eel collection, market, and transport. Hence, this study focused on the documentation of the different practices of post-harvest handling of glass eels, as well as determining the different challenges encountered by gatherers and consolidators to recommend actions for a more sustainable use of the resources. More importantly, this study will serve as baseline information for the crafting of various policies to sustainably manage the gathering of glass eels to maximize its economic benefits while protecting its population

2. MATERIALS AND METHODS

2.1 Study area

The study was conducted in five villages in Aparri, Cagayan only: Toran, Bisagu, Macanaya, Punta, and Sanja (Fig. 1), where the majority of the glass eel supply currently originates. Glass eel fishing, in addition to fishing for other marine species, is one of these village's primary sources of income. Some of the respondents were gathered at the village hall while some were interviewed at their houses.

2.2 Data collection

The data was collected through the conduct of individual interviews to active glass eel gatherers and consolidators in Aparri, Cagayan identified by the village officials and local fisherfolk leaders. The respondents came from the principal collection sites or villages designated during the pre-testing of the questionnaires.

2.3 Selection of respondents

This study included interviews with five local consolidators and 165 glass eel gatherers. The respondents came from the principal collection sites or villages designated during the pre-testing of the questionnaires.

The sample size (n) was computed based in the Cochran's (1963) formula at 95% confidence level with a 5% marginal error using the formula:

$$n_o = \frac{(Z_{\alpha/2})^2 PQ}{e^2}$$

$$n_{adj} = \frac{n_o}{1 + \frac{n_0}{N}}$$

where n is the sample size, Z is the selected critical value of desired confidence level, P is the estimated proportion of an attribute present in the population, Q

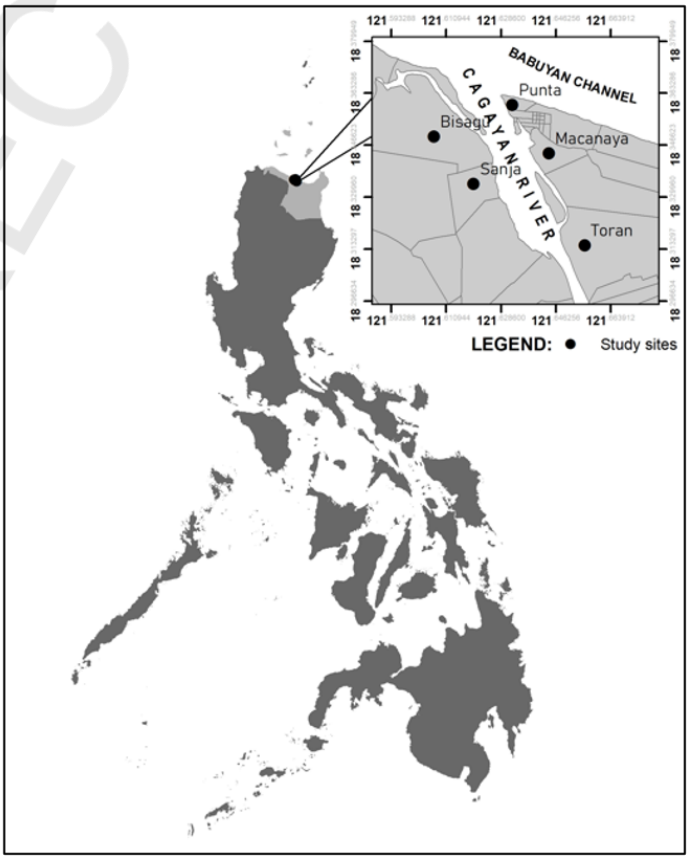

Figure 1. Map showing the study/ interview sites in Aparri, Cagayan

is P-1, and e is the desired level of precision. The total population (N) was based from Tattao *et al.* (2023).

2.4 Research instrument

Two sets of separate survey questionnaires for glass eel gatherers and for local consolidators were used in this study. The questionnaires included demographic profiles, handling practices from collection and landing sites for glass eel gatherers and conditioning prior to and preparation for transportation for local consolidators.

2.5 Data analysis

All datasets were descriptively examined using excel spreadsheets and the Statistical Package for Social Sciences tool. The demographic profiles of the respondents, and all other information covered in the questionnaire were expressed using percentages and frequencies.

The different aspects in the post-harvest handling of glass eels were documented in this study. A photo documentation was taken in order to capture the entire process and document the different key aspects of post-harvest handling of glass eels from collection to conditioning prior to transport to areas outside the region.

3. RESULTS

3.1 Demographic profile of glass eel gatherers and consolidators

Table 1 shows the demographic characteristics of glass eel gatherers and consolidators. The age range of glass eel gatherers ranged from less than 20 to more than 70 years old, with the majority falling between 41 and 50. It is also consistent with the reported average age of household heads in fishing areas, which is 41 years (Siason, 2001). Meanwhile, consolidators have an average age of 47 years. The eel gatherers consist of 95% males and 5% females, whereas the consolidators are 60% males and 40% female.

In terms of civil status, 80% of consolidators are married and 20% are single, while 75% of glass eel gatherers are married, 24% single, and 1% widowed. The majority of responders (48.5%) come from households with 4-6 individuals. For the educational background, the majority of the consolidators are at the secondary (40%) and college (40%) levels, whilst the glass eel gatherers are largely at the primary (47.3%) and secondary (35.2%).

Aside from glass eel harvesting and consolidation, some respondents have additional sources of income. Aside from fishing, 40% of them are sub-consolidators of glass eels while another 40% are consolidating various marine fish species for transfer

Table 1. Profile of the Local Consolidators and Glass Eel Gatherers in Terms of Age, Gender, Civil Status, Educational Attainment, Household Size and Other Sources of Income

Particulars	Consolidators (%)	Glass Eel Gatherers (%)
Age		
10-20		4.8
21-30		22.4
31-40	20	20.6
41-50	40	23.0
51-60		18.8
61-70	40	8.5
More than 71		1.8
Gender		
Male	60	95.2
Female	40	4.8
Civil Status		
Single	20	23.6
Married	80	75.2
Educational Attainment		
Elementary	20	47.3
Secondary	40	35.2
College	40	12.7
Vocational		1.2
Preferred not to say		3.6
Household size		
1-3	20	12.1
4-6		48.5
7-10	40	13.9
more than 10	40	1.2
Preferred not to say		24.2
Other Sources of income		
Fishing	40	
Freshwater Aquarium Fish Trading	20	
Consolidation of other marine fishes	40	
Farming		21.8
Driving (PUVs, tricycle)		6.1
Carpentry Works		0.6
Wine Making		0.6
None		70.9

to other places, including Metro Manila, particularly during lean season of glass eels. In addition to being a distributor of fish food, one of the consolidators rears and sells freshwater aquarium fish. Other sources of income for glass eel gatherers include farming (21.8%), driving public utility vehicles or tricycles within the community (6.1%), carpenter work (0.6%), and "Lambanog"-making, a local wine (0.6%), with 70.9% having no other source of income except glass eel gathering.

Additionally, in terms of their number of years in glass eel gathering, majo rity were 11-20 years (38%), 21-30 years (22%), 31-40 years (17%), 0-10 years (13%), 41-50 years (6%) and 51-60 years (3%). As for the local consolidators, 40% were 0-10 years and 11-20 years while 20% was 21-30 years in glass eel consolidation.

3.2 Postharvest handling practices of glass eel gatherers

3.2.1 Fishing gears used

Countries that source wild glass eels use a variety of fishing gear, including fyke nets, scoop nets, and aggregating devices but glass eel gatherers in Aparri, Cagayan use a single particular gear, the Fyke Net, also known as "tanggar" (Fig. 2). It is made out of cylindrical or conical bags installed on rings or other rigid structures and held together by anchors or stakes (Ame *et al.*, 2013; Mutmainnah *et al.*, 2016). Glass eel gatherers make use of a "screen" during the season of other species such as anchovies when they want to catch glass eels as well (Fig. 3).

3.2.2 Handling during collection

The gatherers devised two types of scoop nets to facilitate the sorting of glass eels from the bycatch (Figure 6). The fine-meshed scoop net (Figure 6a) mentioned by the respondents is mostly used in sorting the glass eels from the by-catch. It is an improvised fine-mesh net used to catch the glass eels after passing through a scoop net made of B-net (Figure 6b). The placement of the scoop nets is shown in Figure 6c.

3.2.3 Handling at landing

Despite the use of the scoop nets, some by-catch species will still go with the glass eels, especially those of similar size such as goby fry, "*baraw-baraw*", "*tangil*", other species of eels, etc. Hence, other glass eel gatherers (particularly those that do not sort using the improvised sorters) use the fine-meshed scoop nets (Fig.6a) to collect the catch and small bañeras (Fig. 5) to sort out other species that may be present such as goby fry, ponyfishes, engraulids, and other eels at the landing site.

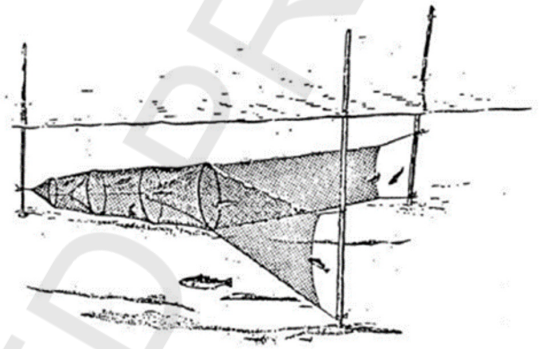

Figure 2. Stationary fyke net fixed by bamboo stakes in Aparri, Cagayan (Ame, 2013).

Figure 3. The "screen" used by the fishers during season of anchovies.

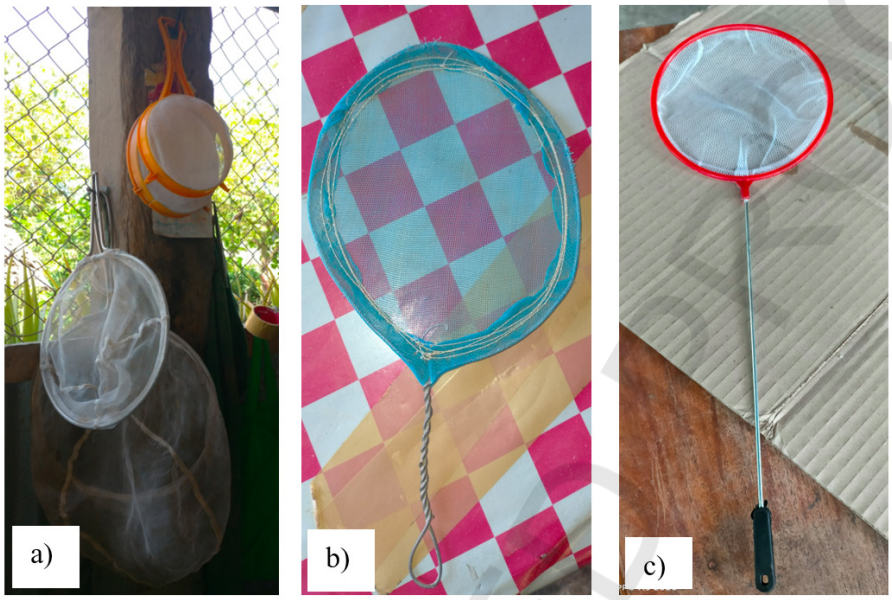

Figure 4. Different types of strainers used in sorting glass eels. a) orange strainers are used to remove water during weighing;b) improvised flattened scoop used for sorting;c)scoop net usually used for aquarium fish(used by one of the local consolidators) but are also used for sorting the glass eels

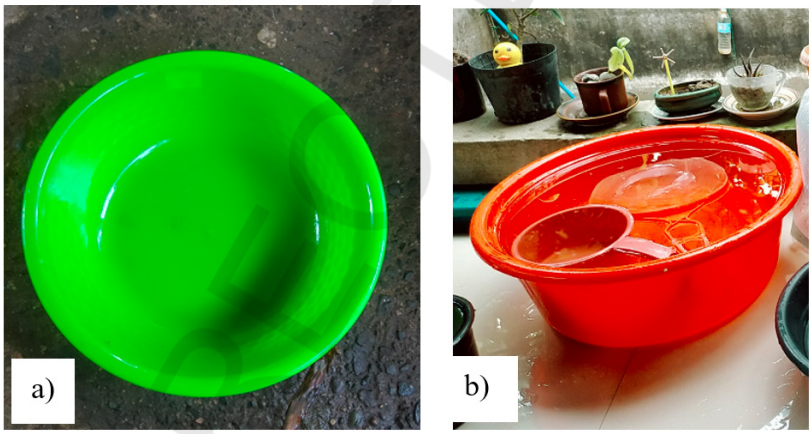

Figure 5. Small bañeras. a) used during water exchange and sorting of glass eels; b) used for the cooled water to facilitate water exchange

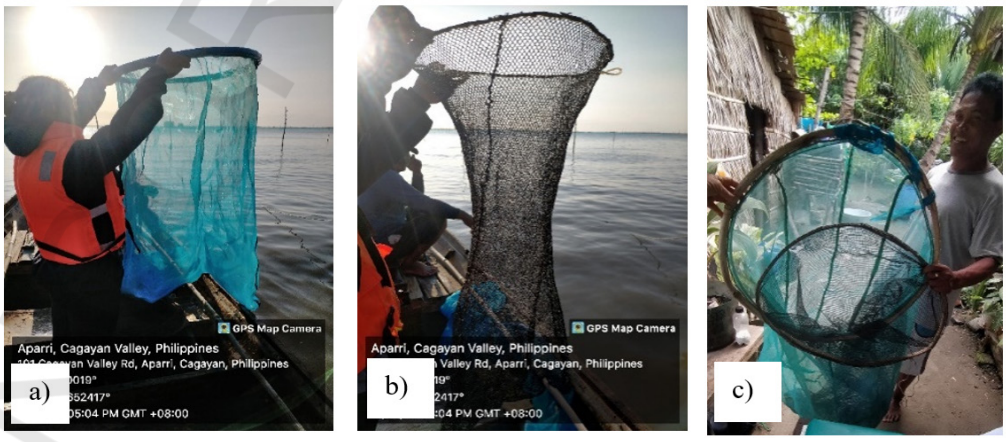

Figure 6. Improvised sorters devised by the glass eel gatherers in the community. a) fine-mesh net to catch the glass eels, b) a net with a mesh size of 0.8cm to sort the glass eels from the by-catch, c) position of the scoop nets during sorting.

3.3 Post-harvest handling practices of local consolidators

Based on historic practice and observations from other consolidators, and due to absence of facilities and standard procedures for conditioning and stock maintenance of glass eels, various steps are strictly followed by the local consolidators. Upon delivery by the gatherers, the glass eels will be put in small bañeras, followed by sorting, weighing then placing them in plastic bags and styrofoam boxes for storage.

3.4 Similarities and differences among local consolidators

The local consolidators have similar practices in conditioning and storage of glass eels particularly on the use of number of ice packs, volume of water and amount of salt used, size of styrofoam boxes, the use of refractometer and thermometer. The practice varies from local consolidators, depending on the area where they are at (Table 2). In Punta, Aparri, the local consolidators use only 6 packs of ice, in Toran, 20 packs. The volume of water used is form 105L to 200L while the salt used is 1-3 cups. Most of the local consolidators use large size styrofoam boxes (11.5"x17.5") for storage and transport. One of the consolidators also make use of refractometer and thermometer to check the salinity and temperature of the water prior to water exchange and reoxygenation.

Table 2. Similarities and differences in the steps of conditioning among the glass eel consolidators in Aparri, Cagayan

Materials Used	Punta	Toran	Aparri West
Number of Ice packs	6 packs	20 packs (during cold weather) 25-27 Packs (during summer season)	Unknown
Volume of water	105-200 L	200 L	Unknown
Amount of salt used	1-2 cups	Approx. 3 cups	Unknown
Size of Styrofoam boxes	11.5"x17.5"	-11.5"x17.5" (during conditioning -Jumbo size during transport	11.5"x17.5"
Refractometer	Yes	No	No
Thermometer	Yes	No	No

3.5. Post-harvest losses

There are three types of post-harvest losses experienced by the eel gatherers: during collection, at landing, and during transport of glass eels to the consolidators. Most of the post-harvest losses are during collection and at landing (during sorting). While the local consolidators suffer post-harvest losses after weighing and sorting of glass eels delivered to them by the glass eel gatherers especially when the river water is turbid.

Table 3 shows that for the glass eel gatherers, highest loss was observed during collection at 21-25% equivalent to 52.5 g to 250 g and at landing at 11-15% corresponding to 27.5 g to 150 g. However, majority of the respondents experience losses at less than 5% only during collection and at landing which is equivalent to 12.9 g to 50 g.

As for the local consolidator, PHL reach as high as 40% of mortality and lowest at 1-5% (Table 4) particularly during the first days of conditioning. The number of glass eels per kilo is at 6, 000 to 6,200 pieces with an average size of 5.3 cm during the conduct of this study. According to the fishers, glass eels are larger in size, lesser in number per kilo during rainy season.

3.6 Challenges encountered by glass eel gatherers and local consolidators

Various problems were encountered by the glass eel gatherers aside from post-harvest losses (Table 5). Low buying price (94.54%) is the major problem encountered by glass eel gatherers followed by alleged dredging/mining activity (3.03%); pressure

Table 3. Percentage and volume of losses of glass eels during collection and landing (before transport to the consolidator's place)

% PHL	During Collection		At Landing		Volume (g)
	Freq	%	Freq	%	
<5%	157	95.2	160	97.0	12.9 - 50
6-10%	4	2.4	1	0.6	15 - 100
11-15%	2	1.2	4	2.4	27.5 - 150
21-25%	2	1.2			52.5 - 250
Total	165	100.0	165.0	100.0	

Table 4. Post-harvest losses experienced by the glass eel consolidators during conditioning

Percentage losses	Frequency	Percentage
1-5%	1	20
6-10%	2	40
26-30%	1	20
40-50%	1	20
TOTAL	**5**	**100.00**

Table 5. Problems encountered by the glass eel gatherers in Aparri, Cagayan

Problems encountered	Frequency	Percentage (%)
Price	159	94.54
Dredging/Mining activity	5	3.03
Pressure from brokers/ consolidators	2	1.21
High cost of transport	2	1.21
TOTAL	**5**	**100.00**

from brokers/consolidators (1.21%); and high cost of transportation (1.21%). Similar problems faced by glass eel gatherers were also mentioned by Ame et al. (2013), ranked according to impact severity such as 1) lack of support from the government; 2) mining; 3) no definite livelihood; 4) children forced to participate in gathering; and 5) low buying price.

There are also various problems encountered by the local consolidators (Table 6) such as: 1) uncontrolled price, 2) insufficient supply, 3) cancellation of orders due to customs restrictions (in the past), 4) duration of trips, and 5) delayed payments of buyers.

Table 6. Problems encountered by the glass eel consolidators

Problems	Frequency	Percentage
Price	3	60.0
Insufficient supply	2	40.0
Duration of trips	1	20.0
Cancellation of orders	2	40.0
Delayed payments	1	20.0

4. DISCUSSIONS

4.1 Demographic profile of glass eel gatherers and consolidators

Notably, the demographic profile of the respondents from the various sampling sites do not differ significantly from each other. The demographic findings demonstrate that fishing is not only for men but also for women (Mercado and Mercado, 2016). When the price of glass eel in the area skyrocketed for a few years, from Php 2,500.00-14,000.00 per kg in 1990 to Php 7,000.00-40,000.00 per kg in 2009-2012 (Ame *et al*., 2013), even females and children went to shore to collect glass eels. However, when the price dropped in the same year, the female involvement declined until just a handful of them remained due to very low selling price unlike then when even a few glass eels cost much. Now, the traditional practice where males are in-charge of fishing while females of selling the fishery products (Libero *et al*., 1985) are more observed in the area.

As for the educational background of the respondents, similar findings were discovered in Surigao Del Sur, Philippines where the majority of fishers are elementary level attainees (Mercado & Mercado, 2016), and in Cagayan De Oro, where the majority have completed high school but none have attended college. According to Cahaya (2015), the world's poorest live in distant areas such as coastal settlements, with little access to healthcare and education. In the study conducted by Belardo & Candelaria (2023), a fisherfolk indicated that one of the hindrances for families in coastal villages to send their children to school is the distance of educational institutions to their localities which will require cost for transportation.

Aside from glass eel gathering or consolidation, there are also other sources of income for some of the respondents especially when glass eel in the area is scarce particularly during the summer season when the water is clearer and water temperature is higher which is supporterd by O'Leary (2022) stating that the major drivers of eel migration include water temperature and clarity of water.

4.2 Postharvest handling practices of glass eel gatherers

4.2.1 Fishing gear used

The fyke net or "tanggar" used is made of fine mesh netting material, commonly called by fishers as "screen", its cone-shaped bags measure up to 20 m long while the wings measure up to 10 m. It is normally set up at night during the ebb phase to make deployment easier, and it has been observed that glass eel migration occurs at night during tidal rising. This is true during the new moon, which coincides with the upstream migration of glass eels (Arai, 2016), as well as the first and last quarter moon phases, and is hauled early the following morning, regardless of peak or lean season. Furthermore, fishers install fyke nets for glass

eels during the new moon since the catch is higher than during the full moon (Valdez and Castillo, 2016).

Results also show that the glass eel fishery is most active between September and February. From March to August, glass eel capturing is uncommon due to "stop buying," as fishers frequently refer to it due to low catch rates, lengthening the conditioning period since it would also take longer to complete the orders from buyers outside the region. During the lean season, other species such as anchovies are numerous in the area that is generally targeted; so, instead of utilizing the glass eel-specific fyke net, illustrated in Fig. 2, they utilize a fyke net designed for catching anchovies and "screen", as the locals call it, to gather glass eels (Fig. 3). The "screen" is affixed at the end of the fyke to catch bag for glass eels.

Majority of the glass eel gatherers set their nets in the afternoon or in the evening and haul them after 6 to 8 hours. Hauling alone typically takes up to 30 minutes only however, it takes longer when there are things attached to the net such as algae and other debris in the water brought by the current. This takes time for cleaning since the nets cannot be hauled right away to avoid damage to the gears although this could possibly cause stress to the glass eels caught as well.

4.2.2 Handling during collection

Glass eels are sensitive species and they are prone to stress. To reduce mortalities, the gatherers have improvised a secondary gear for collecting the glass eels from the fishing gear, thereby separating the bycatch. This practice is based traditionally and was passed on to them by their elders. This facilitates the collection and transfer of glass eel gatherers to the plastic bags, when necessary or to bañeras for further sorting at landing. The glass eels and other by-catch species will be placed in the scoop net made of B-net (Fig. 6b) while the mosquito net/ fine-meshed scoop net (Fig. 6a) will catch the glass eels together with other small-sized by-catch species such as goby fry, ponyfishes, other species of eels among others. In cases when there are many by-catch, the glass eels will be sorted further manually at landing.

4.2.3 Handling upon landing

Glass eels are sorted either at the collection site (through the use of improvise sorters) and at landing by placing the glass eels in fine meshed scoop nets, and transferred to bañeras for further sorting. The glass eels which are placed in bañeras will then be sorted manually, by picking them by hand, with the notion that glass eels are hardy species and they do not get stressed easily. The glass eels will be placed in another container, for further sorting since other species tend to go with the glass eels such as goby fry and other species of eels, among others. However, this increases the chance of mortality due to injury and damage to fragile organisms (Nieves & Nolial, 2019), prior to placing them in plastic bags.

After sorting, the glass eels will be placed in plastic bags containing oxygen and water from nearby taps or deep wells, each weighing approximately 200-400 g. However, depending on the weather, which typically impacts the turbidity of the water, the glass eels are packed at the gathering location, landing site, or even their homes. When the water is turbid, especially after a flood, the gatherers usually carry little oxygen tanks provided by the consolidators as well as plastic bags to pack the glass eels right away because they are weaker in this situation. The fishers will bring tap water or water from deep wells, along with a pack or two of ice to reduce the temperature.

Once packed, the species will be immediately transported to the consolidators for accurate weighing and to avoid further mortality, as they are incapable of holding the glass eels for extended periods. In Toran, Aparri, the consolidators weigh and pick up the glass eels from the fisher's homes, while some gatherers try to sneak and sell their catches to other consolidators for a higher price.

The process of transferring glass eels to freshwater is comparable to that of "rapid salinity shocking" in Lagonoy Gulf, where glass eels are transferred to freshwater immediately after being caught. Glass eel gatherers in the area rely only on traditional knowledge, as opposed to those in Lagonoy Gulf, who do so to make the glass eel sterile or free of infections and parasites (Nieves & Nolial, 2019). In contrast, when the glass eels are weak, particularly due to the presence of small jellyfish locally known as "*tangil*" or tiny species of jellyfish; "*baraw-baraw*" or very small species of shrimps; and garbage, the common practice is to add a pinch of salt in the belief that the glass eels will become stronger as a result, though when asked to elaborate, they say it was simply an effective practice even among their elders. This could be similar by a study on the effects of salinity on European eel larvae (Politis *et al*., 2018) and greater larval growth and survival in Japanese eel at 50% lower salinity (Okamura *et al*., 2009). Furthermore, it is currently argued that lowering salinity allows weaker larvae to survive due to lower osmoregulatory expenditures, which leads to higher energy availability (Okamura *et al*. 2016)..

4.3 Post-harvest handling practices of local consolidators

Individual fishers are unable to keep glass eels alive for extended periods (Cuvin-Alarar *et al.*, 2019) due to the expensive cost of using oxygen tanks, ice, and other essentials for storing live fish such as glass eels. Unsuitable methods and practices for preparing glass eels for shipping can lead to increased stress and up to 40% mortality (EFSA, 2008) and conditioning is one way of regaining or reactivating the strength and healthy condition of glass eels (Nieves, 2019). Also, temperatures at 26-29^0 C must be maintained to limit pigmentation and weight loss in the glass eels (Nielsen and Prouzet, 2008).

There are five major steps done by the glass eel consolidators in conditioning the glass eels. These are 1) preparation of storage materials; 2) sorting and weighing; 3) packaging in plastic bags with iced water (Fig 8b); and 4) packing in styrofoam boxes the plastic bags along with 1 to 2 ice packs to maintain low temperatures (Fig. 8c).

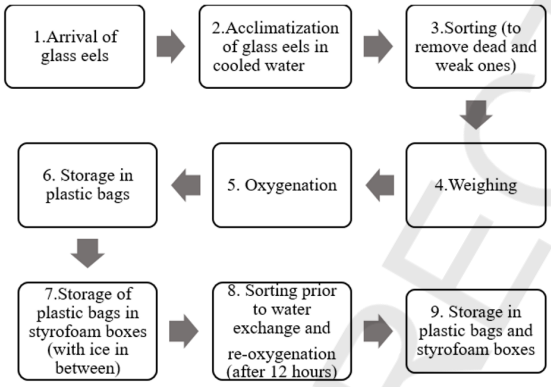

Figure 7. Process flow of conditioning and stock maintenance of glass eels by the local consolidators

4.3.1 Preparation of materials needed for the entire process

Glass eels are fragile organisms that are sold live, thus when they arrive to the local consolidator's location, materials for storage should be prepared. Preparing items such as tubs, drums, iced water containers, strainers, bañeras, weighing scales, oxygen tanks, plastic bags, refractometer (for one of the consolidators), styrofoam boxes, and ice packs ahead of time is necessary to facilitate the work thus reduce stress (Fig. 8).

4.3.2 Sorting

Glass eels are rarely categorized by species, though some know how to do so; instead, they are sorted by isolating sick, damaged, or dead glass eels caused by stress during collection and transit. To avoid injuring the sensitive creatures, they sort the glass eels using makeshift strainers (flat and made of soft materials).

Weak and damaged glass eels that are likely to recover are isolated by placing only 150 g per plastic bag. One of the consolidators isolates them for culture, while another throws them back into the sea. The dead glass eels are either fed to chickens and ducks, fried as table food, or fed to aquarium fish, as one of the consolidator's primary occupation is the breeding and sale of freshwater aquarium species.

4.3.3 Weighing

Aside from knowing the number to be packed, the glass eels are weighed to determine the

Figure 8. Materials used for packaging and storage of glass eels. a) prepared iced water prior to packaging, b) plastic bags for packing glass eels, c) styrofoam box with ice packs in between plastic bags

amount paid to the gatherers. To make the operation more efficient, digital weighing balances are used. Currently, the price for a kilo of glass eel in the region, as dictated by the local consolidators, is only between Php 500.00 and Php 1000.00 particularly during the months of January to March and July to December, which is too low for the gatherers. The rest of the months, aside from lean season where the maximum catch is only 500 g per gatherer and majority of catches at 100 g per fishing operation, are usually called "stop buying" months due to scarcity of catches and too low buying price for the glass eels. Further, the local consolidators receive little orders from outside the region as well. According to them, the price decreased since the issuance of Fisheries Administrative Order 263 banning the exportation of glass eels.

Additionally, weighing is done to minimize losses during conditioning since crowding is not recommended for the fragile organisms. Aside from the weighing balance, improvised strainers and commercially bought ones are used to minimize injury.

4.3.4 Water Exchange and Re-oxygenation

Water exchange and re-oxygenation is done up to three times a day depending on the health status of the glass eels. It is typically done twice a day, at 6 in the morning and 4 in the afternoon, when the weather is cooler than the rest of the day, to minimize stress. This is done repeatedly up to 7 days or more depending on the demand and the health of the glass eels.

During water exchange, glass eels will be poured in small bañeras, strained and then placed in another small bañera containing newly prepared iced-water, discarding the previously used water. It will then be packed in plastic bags containing the same amount of water and oxygen as before.

4.3.5 Packaging during conditioning and storage

After weighing, the glass eels will be placed in plastic bags containing cooled water and oxygen. One of the local consolidators uses a thermometer to monitor the temperature of the water for water exchange at 16-18^{o}C, which is often obtained after adding 6 ice packs in 105 L of tap water, whilst other consolidators add 20-27 ice packs to 200 L of tap water. According to one of the local consolidators interviewed, 20 ice packs are added to 200 L of water during colder seasons and 25-27 ice packs during warmer seasons. The amount of ice packs added depends on the size of the drum or container utilized.

4.4 Similarities and differences among local consolidators

The amount of salt added varies according based on the local consolidators. The use of salt is particularly when the water in the Cagayan River is turbid, especially during floods, since glass eels are weaker during this time, according to the responders.

Each plastic bag contains around 2 liter of water, which is subsequently combined with oxygen (75% of the plastic), often weighing 200 to 250 g each bag. Those that are weak but can still be salvaged are isolated and packed in plastic bags 150-200 g per plastic bag.

The conditioning temperature should be kept between 26^{o}C and 29^{o}C to avoid mortalities (Nielsen & Prouzet, 2008) and to limit weight loss and pigmentation in glass eels caused by prolonged stocking (Nieves & Nolial, 2019), as transparent glass eels are preferred over dark pigmented ones Nielsen & Prouzet (2008). As a result, the plastic bags will be stacked with one to three ice packs to keep the temperature cold until the following day, when the water will be changed and re-oxygenated. Six to eight plastic bags will be inserted in each Styrofoam box (large size), with ice packs placed in between.

Furthermore, the packed glass eels will not be fed anything during the stocking and conditioning process, and will be starved until they are transported to avoid stress from long-distance transport, as described by Baliao *et al.*, 1998.

The differences and similarities in the practices of the local consolidators may be attributed to the absence of established standard procedures in conditioning glass eels, instead, their methods are solely based on traditional practice and observations from practices employed by other consolidators and buyers outside the region.

4.5 Post-harvest losses

Post-harvest losses occur in every step of the value chain (Ochieng, 2020), typically higher in the artisanal fisheries (Kumolu-Johnson & Ndimele, 2011). Further, post-harvest losses are influenced by post-harvest handling practices ranging from storage facilities to modes of distribution to the global market (Srinath *et al.*, 2008).

Both glass eel gatherers and local consolidators suffer post-harvest losses. Post-harvest losses among glass eel gatherers are usually caused by improper handling, poor weather condition, lack of buyers/ "stop buying, lack of efficient gear and presence of excessive volume of species such as jellyfish, locally known as "tangil", garbage, and small shrimps known as "baraw-baraw" causing the eel to be weak, injured and/or dead during hauling. Although majority of the fishers stated that during collection/hauling, only less than 5% of the total catches are removed every time and another less than 5% at landing since these glass eels will be further sorted.

With these causes, fishers have been practicing steps to improve the quality of glass eels gathered for a long time, such as adding ice to the water to avoid mortalities, which was supported by Nielsen and Prouzet (2008), who stated that temperatures must be kept between 26°C and 29°C to avoid mortalities. Then, place the glass eels in plastic bags weighing 150-200 g each with oxygen and a pinch of salt. The practices employed by fishers for all the sampling sites are similar, if not the same and they were traditional practices passed on to them by their ancestors who were also gathering glass eels in the past, they have never attended trainings related to post-harvest handling of glass eels or any live fishes. Majority of the glass eel gatherers are in the glass eel industry for 11-30 years, some were even longer reaching up to 51-60 years since they started when they were very young. These glass eel gatherers are children and relatives of these old fishers in the community especially due to lack of opportunities for education of the children. All of these fishers do not stock glass eels for long and delivers them to the local consolidators within the day due to lack of materials used in conditioning and maintenance of glass eels such as oxygen tanks, Styrofoam boxes among others and these would incur additional expenses to the glass eel gatherers.

Meanwhile, the consolidators experience both physical (mortality and weight loss) and economic losses. Physical losses typically occur when glass eels die after paying the gatherers, who are paid based on the weight of the glass eel. Another is the weight loss of glass eels following conditioning for seven days or more. Economic loss occurs when attempting to amass a sufficient volume of glass eels for transportation. In such cases, those that were previously stocked would develop pigmentation as a result of the lengthy stocking, which buyers will not prefer. The local consolidators have also highlighted causes such as oxygen loss due to the duration of duration of trips and mixing of newly caught glass eels to the conditioned ones just to compensate for the orders outside the region resulting to higher mortality rates.

The local consolidators interviewed in this study however have varying experiences in the industry, although what is common is that their practices were based on traditional knowledge and observations from the eel farms where they deliver glass eels. It was noted that most of the mortalities during conditioning is recorded at the initial stage, and respondents claim that this is due to the quality of water where the species are caught. According to the respondents, they have reached losses reaching up to 40% mortality particularly when the water is turbid due to frequent rains and heavy flooding since glass eels are observed to be more sensitive at this time. During summer, when then water is clearer, glass eels are stronger and losses due to mortality only reach up to 10%. However, there are no study to support this claim although studies coincide with the statements of the respondents that catch peak appears when tidal range rose and temperature drops (Shuai *et al*, 2023). Nonetheless, according to the respondents, high mortality happens only during the initial duration of conditioning, oftentimes associated with the handling of the glass eel gatherers to the delivered eels and the turbidity of the estuary where they are caught. Towards the end of the conditioning period, less to no mortality is observed following strictly the steps in conditioning and maintenance of glass eels.

While consolidators try to minimize losses using somewhat different methods to condition the glass eels, but the most popular include re-oxygenation, maintaining chilly temperatures by adding ice to the water and within the storage boxes, and exchanging water two to three times each day. One of them even uses mineral water, but others merely use tap. One of them also uses a refractometer to monitor and keep the salinity at 10 psu and temperature ranges at 16 to 18 degrees Celsius. The same treatment is given to weak glass eels, but they are isolated.

4.6 Challenges encountered by glass eel gatherers and local consolidators

The low buying price is a major problem among glass eel gatherers since the price of glass eels has never increased since 2012 due to the banning of the exportation of glass eels. This is also associated with the high cost of fuel used for the boats in setting and hauling the nets, especially since the catch of glass

eels is scarce most of the time. Also, they complain of the alleged mining activities along the Cagayan River estuary which disrupt the ecosystem, blocking the entrance of the glass eels, and decreasing the setting areas due to the deployment of large mining vessels, resulting in a lesser volume of catches. Aside from this, pollutants such as fuel/oils during mining operations lead to weaker glass eel individuals, resulting in increased mortality. Others also stated that aside from a decline in catches, set fyke nets are destroyed during mining operations, without them being compensated by the mining companies.

In addition, pressure from buyers happens when the glass eel gatherers, due to poverty, borrow money from the consolidators. In return, the consolidators expect them to give them their catches despite lower buying prices compared to other local consolidators due to "*utang na loob*" (translated as a debt of gratitude) culture. Aside from this, the high costs of fuel (diesel and gasoline) have also become a problem for the glass eel gatherers following the low buying price and low volume of catches. Despite the low volume of catches and high cost of fuel, the glass eel gatherers have no choice but to still fish since most of them have no alternative livelihood. However, they complained of a low volume of catches and that their catch would not even be enough to compensate for the cost of their transportation. Further, high fuel costs have become a big problem for glass eel gatherers, particularly in Aparri West since they would need to travel their catches by boat to Aparri East where most of the local consolidators are situated.

As for the local consolidators, one of the most common challenges is the uncontrolled pricing of glass eels especially since the cost of transporting glass eels is high considering that the Cagayan Valley region is a long drive to the meeting place with the buyers. For the sub-consolidators, the gasoline for them to transport the glass eels from Aparri West to Aparri East is provided by their buyers but the fare going to and from the buyer's place is their own.

Insufficient supply of glass eels particularly during lean season is also a problem encountered by the local consolidators since it will take time for them to complete the amount ordered to them. Due to the low volume of catches, conditioning is extended, sometimes, glass eels develop pigmentation which is not acceptable to the buyers since transparent glass eels are preferred. In the past, the local consolidators have also experienced large losses due to the cancellation of orders brought about by the strict implementation of FAO 263, banning the exportation of glass eels. Large numbers of glass eels were delivered to Manila but were held due to such customs prohibitions. Also, a decrease in buyers was experienced by the consolidators since most of their clients in the past were importers from Asian countries for aquaculture purposes. To date, the local farmers are their only clients, and sometimes, delayed payments are also experienced.

Lastly, the duration of trips sometimes becomes a problem since the glass eels are only provided with oxygen that will last for up to 8 hours. This becomes problematic during uncontrolled circumstances such as traffic jams. To avoid this, the glass eels are transported early at night.

5. Conclusion

According to the demographic profiling, the average age of consolidators and gatherers ranges from 41 to 50 years old, with more males doing fishing operations and females focusing on processing. The majority of the consolidators are at secondary and college level, whereas the gatherers are primary school level. The gatherers' households typically include 7 to more than 10 individuals, and the majority of them rely on fishing as a source of income. Eel collection is usually done early in the morning and sorting is done either at the collection sites or at landing through a specified traditional sorter devised by the fishers. Packaging is done at an estimated weight of 150 g-400 g per plastic bag added with cooled water and a pinch of salt when the water is turbid.

The consolidators conduct strict steps in the conditioning of glass eels, done twice a day, such sorting and weighing; packing them in plastics with ice; oxygenation; packing them in covered styrofoams with ice in between; water exchange and re-oxygenation.

Major issues faced by gatherers are low prices, pressure from local consolidators, and high fuel and transportation costs. Local consolidators also face issues such as uncontrolled pricing of glass eels, insufficient supply, trip duration, cancellation of orders, and delayed payments from their buyers resulting to physical and economic losses.

Based on the results of the study, the following are recommended to address some of the issues, challenges and problems faced by the glass eel gatherers and local consolidators such as price stabilization for glass eels by involving the local consolidators and glass eel gatherers, organizing groups and creating platforms for them to discuss and decide for better bargaining scheme in terms of price for the benefit of all, establishment of alternative livelihood programs for glass eel gatherers when

catch limits for glass eel is set for the sustainable management of the glass eel fishery, development and implementation of appropriate registration scheme including licensing and reporting system for eel conditioning facilities and conduct studies on the establishment of conditioning tanks and standard operating procedures in conditioning and storage of glass eels. Additionally, for LGUs to enact ordinances for spatio-temporal limits to allow some of the glass eel population to migrate upstream upon the conduct of seasonality and biological studies on the species. Lastly, it is recommended to conduct a study to further investigate the percentage losses in every step of the conditioning and maintenance to address possible challenges in each step to further minimize losses.

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AUTHOR CONTRIBUTIONS

Casco RM: Conceptualization, Methodology, Formal Analysis, Writing-draft preparation and Writing-Review and Editing the manuscript. **Asprec MJ**: Conceptualization, Review of the Manuscript and Supervision. **Castro MR**: Conceptualization and Review of the Manuscript. **Angeles IP**: Conceptualization and Review of the Manuscript. **Ballad EL:** Conceptualization, Formal Analysis, Supervision and Review of the Manuscript. **Ame EC**: Conceptualization, Formal Analysis, Supervision and Review of the Manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in any way.

ETHICS STATEMENT

The authors obtained prior informed consent from all participants included in this study.

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