Post-harvest handling practices for glass eel along rivers and tributaries in Lagonoy Gulf, Philippines

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Abstract. Post-harvest handling practices for glass eel along rivers and tributaries in Lagonoy were documented to satisfy the lack of information on the eel fishery in the Gulf. Data collection was done using key informant interview and direct fishing observation. Finding reveals that post-harvest handling practices along the rivers and tributaries along Lagonoy Gulf appear to have evolved from the techniques brought by consolidators and other buyers in the eel industry outside Bicol region. Most of the existing knowledge of local eel gatherers was based on experiences from milkfish (*Chanos chanos*) which was abundant in Bicol. In view of the economic importance of the species as a potential aquaculture species and export commodity, further studies along improvement of post-harvest handling is thereto recommended.
Key Words: euryhaline, fine-meshed nets, rapid salinity shocking, consolidators, metamorphosis.

Introduction. Glass eels are of high cost and they are export aquaculture commodity which needs delicate handling to avoid expensive losses. Lagonoy Gulf (LG) in Bicol Region is one of the potential glass eel grounds because of its proximity to Pacific Ocean where the known spawning ground for eel is situated (Marianas Island). However, despite of its potentials, production is delimited by existing post-harvest handling. It should be noted that at early-stage larvae, they are highly vulnerable due its fragile body structure; sensitiveness to handling and susceptibility to diseases and parasites compared to the adults. In addition there is practically very scarce information is available on post-harvest handling of eel in the Philippines.

Existing information reveals that glass eels are collected along major rivers and tributaries in the provinces of Albay, Camarines Sur and Catanduanes with the use of fine-meshed nets and sold to collectors and traders, most of which are based outside Bicol. Given the traditional harvesting method, poor survival is a sad reality. It is therefore imperative that post-harvest handling practices should be given due attention and explored to increase survival and income of gatherers.

This paper documents the existing post-harvest handling practices of eel gatherers along the rivers and tributaries in Lagonoy Gulf with the hope of improving glass eel survival through improved post-harvest handing methods.

Material and Method. The study covers the post-harvest handling practices of glass eel fisheries in Rivers and tributaries along Lagonoy Gulf covering the provinces of Albay, Camarines Sur and Catanduanes. Data collection was done qualitatively using key informants interview (KII) and process documentation. Secondary data were also used to augment datasets taken from primary sources. Photo-documentation was also taken to capture the actual process and document key features of post-harvest handling practices. All datasets collected were analyzed descriptively in the context of using the social, technical, economic, and environmental and policy approach.

Results and Discussion

Handling during glass eel collection. Glass eel collection in the wild is the most critical stage in the production of a quality glass eel. The glass eel collection is normally done at evening flood tide during new moon which coincide the upstream migration of glass eel (Arai 2016). In Malinao, Albay, collectors makes use of fine-meshed net set at the river mouth to catch glass eels during the incoming high tide (Figure 1). The opening of the gear is usually set facing the sea, opposite to the river mouth. The collected glass eels (Figure 2) are transfer to storage tubs using scoop net.

Ideally, collecting gears for glass eel should consider use of appropriate gear and proper handling during the harvesting not to damage or injure the fragile organism. As a general role, soft and smooth materials should be used to avoid physical damage and stress. It should be noted that stress and physical damage to the larvae predisposes the occurrence of diseases or mortalities during storage.

One common post-handling harvest practiced along Lagonoy Gulf, is the "rapid salinity shocking" (Figure 3). This is accomplished by direct transfer of the collected and sorted larvae to containers with freshwater, apparently to eliminate potential pathogens as a result of the change in salinity. The idea is based on the premise that eels are euryhaline, hence, are able to survive to changes in salinity with little chances for pathogens to survive. According to key informants, salinity shocking is a traditional way of making glass eel sterile or free from pathogens and parasites. It is also an eco-friendly practice since it does not require hazardous chemicals to do so.

However, in contrary to the usual practice, reports of Rodriguez et al (2005) revealed that in the case of European eels, *Anguilla anguilla*, the practice could lead to high mortality, susceptible to disease and difficulties in the weaning glass eel during acclimatization, and thus contribute to low quality of seeds for aquaculture market. However, the report may not be applicable to all species of eel since every species has different response to salinity changes (Taqwa et al 2018; Ingram et al 2001; Wilson et al 2004; Kearney et al 2008).

In addition, one important aspect that needs attention is the occurrence of by-catch or unintended catch during the collection. These are predators and other species that go with the glass eels however, discarded and left dying along the shore. In some cases, by-catch ends up into animal feeds. However, this practice does not provide opportunity for the species to reach a stage where their economic value can be maximized, but economic losses associated to discarding. Significantly, this practice contributes to the decline of non-target species as well as the shift in species dominance and occupation of certain ecological niches due to discarding (Alverson et al 1994).

Figure 1. Collection of glass eels in Balsa River, Malinao, Albay.

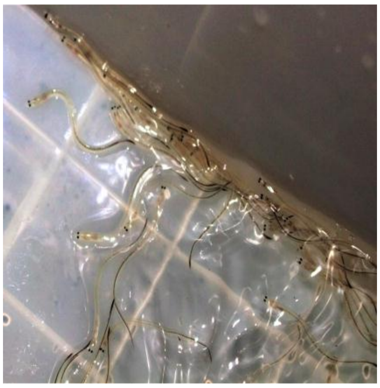

Figure 2. Glass eels caught in Lagonoy River, Camarines Sur.

Figure 3. Salinity shocking of collected glass eels using freshwater.

Handling upon landing of glass eels. Once the glass eels are landed, they go through a series of steps before being delivered to the next market chain. Glass eels should be active and acceptable in terms of quality. The steps followed during storage in LG are combination of traditional practices done by the local fishers and knowledge adopted from consolidators in the area. The said steps are as follows:

a. Preparation of storage materials. In the initial storing, materials such as tubs (big, ≥50L and small, <50L), small-sized scoop nets and aerators must be prepared ahead of time. Materials made of plastics are preferred being easy to handle and clean. The materials used are sanitized with sodium hypochlorite (NaOCl, 5.25%; 140 ppm), processing based-detergents and clean water. To neutralize chlorine in the storage materials, sodium thiosulfate ($Na_2S_2O_3$) was applied. For practical reason, the operators identify the presence of chlorine by smelling and judged it based on intensity of the odor. High traces of chlorine in the container which can transfer into the conditioning water will affect the health condition of the larvae. El-Bouhy et al (2006) reported that too much amount of chlorine may result to abnormal swimming behavior, restlessness, and decrease respiratory rate with signs of anoxia, congested gill tissues and excessive mucus secretion on body surface of dead fish.

b. Sorting and grading of collected glass eels. During the hauling from the fine-meshed nets, larvae of other species go with the glass eels. This includes fish fry, crustaceans, shrimps, and debris. To separate glass eels from other species sorting was done by scoping glass eels from the container using bowl, cup or shells and transferring it to another clean container for glass eels only as shown in Figure 4. After which, they were graded based on species, size and physical conditions.

Figure 4. Sorting and grading of collected glass eels.

Species identification. A species identification chart Fumiaki Shirotori et al (2016) is shown in Table 1. This method is based on the works of Shirotori et al (2016) and Han et al (2012) which primarily consider pigmentation on the caudal fin (see Table 1 for details). Key informant interview result reveals that this technique was adapted from consolidators and managers who often visit to buy glass eels. Among the species of glass eels, *Anguilla japonica* is the easiest to identify since there is absence of pigmentation in its caudal fin. On the other hand, *Anguilla bicolor pacifica* and *Anguilla marmorata* are quiet tedious to identify since the pattern and concentration of pigments are not consistent all the time. The only distinguishing factor among the two is the extension of pigments at the tip of the tail of *A. bicolor pacifica.* Moreover, *A. luzonensis* and *A. marmorata* is also quite similar in terms of caudal pigmentation pattern and distinguished through rigidity of pigments which is mostly exhibited by *A. luzonensis* (Shirotori et al 2016; Han et al 2012).

Table 1
The species identification chart for glass eel based on Shirotori et al (2016) and Han et al (2012)

Species	*Caudal pigmentation description*	*Illustration*
A. marmorata	With caudal pigmentation but not touching the end/tip of the tail; inner pigmentation is scattered	
A. bicolor pacifica	With caudal pigmentation that extends to the tip/end of the tail	
A. japonica	No caudal pigmentation	
A. luzonensis	The same with *A. marmorata*, however, inner pigmentation are rigid and not scattered	

Among the species, *A. japonica* is the most sought for by consolidators and exporters because of its popularity and price as an aquaculture species. *A. japonica* also performs better in terms of growth and survival rates (Nielsen & Prouzet 2008). Unfortunately, reports on the declining population of the annual recruitment of *A. japonica* glass eels led to Japanese farms in looking to alternative species for importation from the late 1960s (Tsunogai 1997). Alarmingly, this species is currently listed under endangered species on the IUCN Red List for Threatened species (Jacoby & Gallock 2014; Jacoby et al 2014). Thus, the need for alternative species for eel aquaculture in Japan has become the center of discussions. Among all other tropical species, *A. bicolor* becomes the second option or substitute for eel fry aquaculture due to similar texture and taste; availability; and potentiality for culture (Anon 2013, 2014; Arai 2014; Crook 2014). Other species of tropical eels such as *A. marmorata* is not yet utilized for culture despite its abundance and very evident population distribution in the Philippines and other Asian countries (Jamandre et al 2007).

In rivers and tributaries along Lagonoy Gulf, the most important species identified are *A. marmorata* and *A. bicolor pacifica.* However, it is noteworthy to mention of the existence of a very few *A. japonica* in Camarines Sur and Albay. Among the three species identified, *A. marmorata* comprised the highest species composition while *A. bicolor pacifica* is the least. Cheng & Tzeng (1996) reported that the age of leptocephalus at metamorphosis determines the dispersal range of eel and found that faster-growing leptocephalus metamorphosed early. Tzeng (2010) revealed that *A. marmorata* grew faster and metamorphosed earlier than *A. japonica* and possibly to *A. bicolor pacifica* which explains the variation of species as well as the abundance of *A. marmorata* in the three provinces considering the proximity of LG to the known spawning ground. It is interesting to note that in Catanduanes less than 1% of the glass caught is *A. bicolor pacifica* compared to those caught in Albay and Camarines Sur. It could be inferred that *A. bicolor pacifica* has longer metamorphosis compared to *A. marmorata* as indicated by its dominance (99%) in the said provinces. Between the Albay and Camarines Sur, observation showed that *A. bicolor pacifica* in Camarines Sur is slightly higher than in Albay, but when it comes to *A. marmorata,* Albay had the highest composition. This observation could be explained by their proximity to the spawning area in the Pacific as well the influence of Kuroshio Current. Thus, species with faster metamorphosis must be able to settle in the nearest freshwater environment for their early growth phase. This contention is supported by Kuroki et al (2007) which reported that A*. bicolor pacifica* has longer metamorphosis requirement. Moreover, Arai et al (1999), Schmidt (1925) and Tsukamoto (1992) reported that the duration of oceanic migrations of tropical eels seems to be related to the distance and complexity of the oceanic current system between the spawning ground and the river habitats.

Grading. Grading the sizes of glass eels was done in order to select the market preferred eel fry. In essence, grading is dictated by the international market, glass eels price and demand depend on the characteristic and sizes of their body. Table 2 shows the criteria for market preferred glass eels and elvers. It is noteworthy to mention that the presence of pigmentation has a great effect on the market acceptability of glass eels though the sizes are almost the similar. Local market or within the Philippines, slightly pigmented glass eels is acceptable for aquaculture purpose but not in the international market. In terms of elvers sometimes referred to as "kuroko", export market is not an issue in FAO 202 as long as the size is below the legal size of 6 inches (15.24 cm) compared to glass eel which ban the exportation under FAO 2042. Unfortunately, "kuroko" is not fully acceptable to international markets. With this, the culture of glass eels to "kuroko size" in the Philippines began.

Table 2

Matrix of criteria for market preferred eel fry and fingerlings

Stage	*Length size (cm)*	*Body pigmentation*	*Market acceptability*	
			Local	*International*
Glass eel	≤7.00	Absent	Accepted	Accepted
Glass eel	≤7.00	Slightly present	Accepted	Rejected
Elver	≤15.24	Present on the half of the body	Accepted	Rejected
Elver	≥15.24	Present all over the body	Accepted	Accepted/Rejected

Source: KII & BFAR 2014.

In Lagonoy Gulf, the common sizes of glass eels range from 4.1 cm to 7 cm with a ranging weight of 0.05 g to 0.21 g. The number of glass eels per kilo comprised of 4,000 to 6,000 individuals. It is noteworthy to mention that the length of the glass eels in the provinces varies at the same period of catch. Glass eels from Camarines Sur (5.2-7.0 cm) are slightly longer than those lengths of GE from Albay (5.3-6.7) and Catanduanes (4.1-5.1 cm) in the same time of collection, respectively.

c. Quarantine of rejected glass eels. Some consolidators practice the quarantine of slightly damaged or injured glass eels to revive its strength and health conditions. Glass eels under this condition are those with more than 50% chances of recovery from common diseases or physical damage as presented in Table 3. Quarantine tubs are much smaller than the conditioning tank/tubs about 10-20 gallon capacity. Eel fry are group based on their health conditions (physical damage or physiological illness).

The most common cases in quarantine of glass eels in LG were the physical damage brought by scratches and cuts during the collection. The traditional practice of local's collectors/gatherers is placing 1 tablespoon of salt per gallon of water or oxytetracycline at 125-250 mg per 10 gallons of water as prophylaxis. Glass eels are exposed in treated water for about 4-5 hours and then a total replacement of clean water. Rigorous aeration is observed while adjusting again to the changed water.

Table 3

Common diseases/ physical damage of collected glass eels as experienced by eel collectors/gathers

Disease/ Damage	*Nature of disease/ Damage*	*Symptoms*	*Treatment*
Cuts	Physical	Slightly cuts or incomplete parts such as fin or scratches	Methylene blue or oxytetracycline
Red Fin	Bacterial	Rotting of caudal fin	Salt solution
Red Eel Pest	Bacterial	Swelling, red spots, and ulcerated lesions on skin	Antibiotics such as oxytetracycline
Parasites	Parasitic	Mucus frayed fins, respiratory distress, white patches on skin and rubbing off parasites on the side of the tub	Salt solution or formaldehyde

Handling during conditioning. Conditioning is one way of reducing or reactivating the strength and healthy condition of glass eels after stressful manual sorting and grading. This is also a phase where selection of the best live glass eels is screened before transport. To accomplish this, a 50-liter tub capacity is filled with freshwater to 15 cm and stocked with 500 pieces of glass eels. As a prophylactic treatment, water in the tub was mixed with 10 drops of methylene blue per gallon of water and aeration provided in the next 24 hours to prevent proliferation of bacterial and fungal infection during conditioning and transport.

It is worth mentioning, that the temperature of the conditioning medium should be maintained at 26-29°C to avoid mortalities (Nielsen & Prouzet 2008). This will likewise limit weight loss and pigmentation as this may affect the quality and market preference. It should be noted that transparent glass eels are preferred than dark pigmented ones (Nielsen & Prouzet 2008). However, according to the key informants, mortalities of glass eels are somewhat unpredictable though same water quality requirement for "kawag-kawag" (milkfish fry) is adopted. They also mentioned that during conditioning, glass eels are too sensitive to sound as they swim in groups at the corner bottom of the conditioning tub and stays there for long time.

A 24-hours starvation prior to transport and reducing water temperature is done to condition and reduce stress of glass eels over long distance transport. Baliao et al (1998), reported the reduction of water temperature in the holding tanks of grouper fry prior to transport ideally less than 5°C per hour and should be brought down to 18°C to prevent temperature shocking that could lead to stress during transport. After the pre-conditioning period, sorting and culling of glass eels is done in order to remove weak or wounded glass eels. It is also noteworthy to mention that if the harvested glass eels were not sold immediately soon after collection, operators kept them for about 2–4 days or more depending on their quality condition, market prices and transport availability (Nielsen & Prouzet 2008). In LG areas, local gatherers traditionally practice temporary storing of the glass eel in an excavated circular earthen pond measuring 1.0 meter in diameters and 0.25 m depth equipped with shaded roofing made of coconut piles that is a meter higher from the earthen structure. Sometimes, plastic liners or "trapal" are installed for easy harvesting of the glass eels when the buyers come. They also used it as storage during lean season since they are targeting a certain quota before selling their catch. The catch quota is dependent on the quantity of glass eels ordered by the buyers.

KI interview of elderly gatherers reveals that during the early period, they use clay pot locally known as "pelon" as storage for the collected glass eels. They considered it as cost-effective and reduce problems of ice leakage to lower water temperature during conditioning or storage. According to them, clay pot has its natural cooling effect that is stable and long-lasting compared to icing.

Handling during packaging. A total of 500 sorted and culled glass eels are placed in double plastic bags with 1/3 water and 2/3 oxygen for long period of transport while 1/3 water per 1/2 oxygen short distance transport. Small amount (4 drops per liter of water) of methylene blue is poured in the water. A separate cool tubs were prepared and about three (3) eel fry bags was placed inside with cube ice over it. According to the KI, during the early times fiber-weaved bags locally known as "bayong" is used before the styrobox or cool tubs. One fry bag for every "bayong" is practiced. Cube ice is placed over the top of the plastic bags to maintain the coolness of water during transport. Direct contact of melted ice in the transport water should be prevented as it will result to abrupt changes in the temperature of transport water which may cause stress. To prevent, a separate plastic bag with ice is used and placed over the fry bags. According to KI, the reason of placing fry bags into styrofoam box or cool tubs is not only to maintain low temperature but also to prevent physical damages during transport that may cause mass mortality. It should be noted that with relatively low temperature, metabolic rate becomes low as well as their physical activity, which explains the need to lower temperature during transport. Operators observed that when glass eels concentrate more at the bottom corners of the plastic bags, proper handling should be taken to avoid mortalities due to physical damage.

Proper labeling of styrofoam/cool tubs is also an important practiced among consolidators during transport. The label is pasted in the upper right side of the cool tubs (sometimes the insulated styrofoam box) labeled as "LIVE ANIMAL, THIS SIDE UP" (Figure 5). This label will ensure that the package will be properly handled during transit up to its final destination. Unfortunately, local gatherers do not observe this practice.

Figure 5. Packaged glass eels for transport from Lagonoy, Camarines Sur.

Handling during transport. Transport of glass eel in LG is done early in the morning or late in the afternoon. However, if the glass eels are transported during noon time, the number of glass eel is reduced to about 100-300 individuals and more ice over the bag are placed. It should be noted that in crowded situation, oxygen consumption is higher particularly at high temperature. In this way, stress and mortalities is avoided. No feeding is also observed before transport as this may cause water pollution and feces will compete with the oxygen consumption. In the conditioning and transport period, temperature plays an important role in the success of quality glass eels. The optimum temperature for different eel species varies. In *A. japonica* the temperature ranges between 25-28°C while in *A. anguilla* ranged 23-25°C (Seymour 1989; Heinsbroek 1991); and 26.5°C for *A. australis* and *A. dieffenbachii* (Kearney et al 2008). However, Golombieski et al (2003) reported that the temperature ranges in the plastic bag that could upkeep the survival of live fish during transport was at lower value range. Though lowering the temperature on the water medium might lower the metabolic rate, still there was discrepancy on the limitation of temperature (Ross & Ross 1984).

Conclusions. Post-harvest handling practices along the rivers and tributaries along Lagonoy Gulf appear to have evolved from the techniques brought by consolidators and other buyers in the eel industry outside Bicol region. Although, local gatherers have some traditional knowledge about post-harvest handling of glass eels, most of which are experiences from *C. chanos* and other local species. This is not surprising since eel industry is not established in Bicol Region. However, in view of the economic importance of the species as a potential aquaculture species and export commodity, further studies along improvement of post-harvest handling is thereto recommended.

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