Local wisdom of "Jukung" boat design in Cilacap district, Central Java, Indonesia

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Abstract. Small-scale fishermen have started to use boats made from fiberglass instead of wood. Each region has its own characteristics and habits in making ships while adjusting the characteristics for the conditions of each region. Cilacap district is one of the centers of shipbuilding using fiberglass. The purpose of this study was to identify the influence of fishing habits on local wisdom of Jukung boat design in Cilacap district, Central Java, Indonesia. The data collection method is a survey with direct observations and interviews. 5 boats were measured and descriptively analyzed. Jukungs in Cilacap are made in local shipyards, the majority of which were centered in Lekong Village, North Cilacap district. The boats were made from a hereditary mould without plans for ship design, drawings, or naval architecture and calculations. The habits of the community that can be raised as local wisdom are the bow patterns, names and axes.
Key Words: fiberglass boat, local wisdom, ship design, shipyard.

Introduction. Several regions in Indonesia are characterized by local wisdom in making boats. Many examples of local wisdom are still preserved, for example from the Sea Tribe in Riau, Bangka and Belitung, and the Bontobahari Bulukumba village community in South Sulawesi, with its famous "pin" boat (Kurniasari et al 2013). According to Suwarno et al (2017), Kandang Semangkon village is one of the traditional shipyards for construction, maintenance and repair. One type of boat produced here is "ijon-ijon", which is specifically used to catch fish. Traditional shipbuilding in Kandang Semangkon is generally a personal effort, non-formal in nature, so it is not a legal entity. The skills of boat makers are self-taught, based on experience and hereditary. There is no drawing design or advance design used when making a boat. The facilities and infrastructure used are still relatively simple (not utilizing modern technology).

The Sea Tribe is one of the tribes that inhabit the waters of Riau, Bangka and Belitung. Because they live on boats an important amount of time, they are often called "boat people". The Sea Tribe collect sea products only to fulfill their daily needs, without commercial exploitation. This is why they have simple tools used for fishing, not due to limited resources and technological knowledge. However, they adapt to sea and fishing obstacles according to their natural knowledge. They plan strategies to maintain their existence against challenges. The Sea Tribe still relies on stars to determine the direction of the boat when fishing. They do not use more sophisticated technology, like compasses (Suwarno et al 2017).

The people of Bontobahari, Bulukumba, South Sulawesi, are known experts in the maritime field. Renowned for their expertise in making "Pinisi" boats, the region became the center of the largest boat making industry in Indonesia (Kurniasari et al 2013). Therefore, it is not surprising that Bontobahari is dubbed "Butta Panarita Lopi" or "the land of boat makers". The people work together between villages in making boats with complex technology. In addition, there are a number of beliefs as a representation of boat making in Bontobahari that cannot be separated from the harmony between humans and the sea or nature.

Small-scale fishermen still dominate fishing vessels in Indonesia (Ambari 2019). The amount of wood for small and medium shipbuilding is running low (Pardi & Afriantoni 2017). Therefore, fishermen have begun to use fiberglass (FRP) to make boats because the costs incurred are smaller (Anwar 2012) and the boat is easier to make (Afrianto et al 2014). Fiberglass vessels are made using boat moulds and laminates (Ardhy et al 2019).

The process of shipbuilding in the area is made using moulds that have been passed down through generations and without calculating naval architecture (Marzuki et al 2017). This becomes a problem for local shipyards in making boats, although the boats produced can be well used by fishermen and are in accordance with the standards of the Indonesian Classification Agency (BKI) (Dewi 2019). Local shipyards adapt to previous boats when making moulds (Yulianto et al 2013).

The success of fishing activities cannot be separated from the ability of fishing units. One component of fishing that is very influential on the success of fishing operations is the boat/ship used. The specifications and suitability of the used vessel, and the target of capture are influential in the success of the fishing operations. So far, in terms of maneuverability, speed, seaworthiness, navigable area, design and construction, engine propulsion and equipment, wooden fishing vessels are mostly made with traditional technology without considering the planning aspects and without using the naval architecture rules. However, these rules are necessary to enable a vessel to have better characteristics, so that it can increase successful fishing operations. Therefore, the science of naval architecture is necessary in the construction of a vessel.

Fishing vessels are used for fishing activities at sea (Iskandar & Pujiati 1995). Fishing vessels are used in fishing, collecting fish resources, fisheries research, training and to control water resources (Nomura & Yamazaki 1977). Thus, fishing vessels have some minimum requirements for use (Nomura & Yamazaki 1977), which mainly target the strength of the structure of the hull, stability and storage facilities.

Each region has its own characteristics (Juniarta et al 2013) and the habits of fishermen in making boats are also different (Rukayah & Thaba 2018; Putra 2019). Cilacap Regency is one of the districts producing fiberglass vessels, but their work can be used by fishermen from other regions. This is interesting and there needs to be a study related to the habits of Cilacap fishermen in making vessels, so that boats made in Cilacap district can be accepted in various other regions. Therefore, this study aims to identify the influence of fishermen habits on local wisdom of "Jukung" boat design in Cilacap district, Central Java, Indonesia.

Material and Method

Description of the study sites. Data was collected in the Cilacap district in November 2019. The survey method was used for data collection. Samples were collected for one boat from each coastal district in five locations from Cilacap district : Kampung Laut, North Cilacap, South Cilacap, Kesugihan and Nusawungu (Figure 1). Observations of the size and boat design were made to obtain data on the distribution of samples in the shipbuilding locations. 5 shipyard owners were interviewed to get information related to the fishermen habits in making boats that can be appointed to be local wisdom. The data (boat size, shape of the boat, boat motif, and the uniqueness of the boat) was processed and analyzed descriptively. Finally, the data was used to make fiberglass "jukung" local boat plans in Cilacap district. The research locations are presented in Figure 1.

Vessel measuring and obersvations. The data used in this study are primary and secondary data. Primary data obtained was ship dimension measurement data including overall length (LOA), beam length (B) and depth (D) (Figure 2). The steps in measuring ship dimensions are:

1. Setting the position of the ship to flat water by using a waterpass tool that is placed on the keel and width of the hull.

2. The wood placed at the end of the bow and stern of the ship is used as a place for the spread of rope/yarn called the standard line. This rope is arranged so that it is located above the longitudinal center line of the ship.

3. The determination of the ordinate point along the boat; the length of the boat was divided into 11 ordinates, where the 0 ordinate was at the stern and the 10 ordinate was in the direction at the bow. A horizontal relief line was drawn to be projected on the hull of the ship using a pendulum that has been marked every 20 cm. Measurements were taken for each ordinate whose height starts from the standard line to the sheer, the height of the sheer to the base line, the width of the hull, and the width of the bow height. For the outside of the hull, a horizontal distance was measured from the sheer to the base line, projecting each point downward with the marked pendulum thread.

4. High slope is obtained by stretching the thread with ballast from the end of the bow to the base line. Furthermore, measurements were taken at the horizontal distance from the yarn to the bow height every 10 cm.

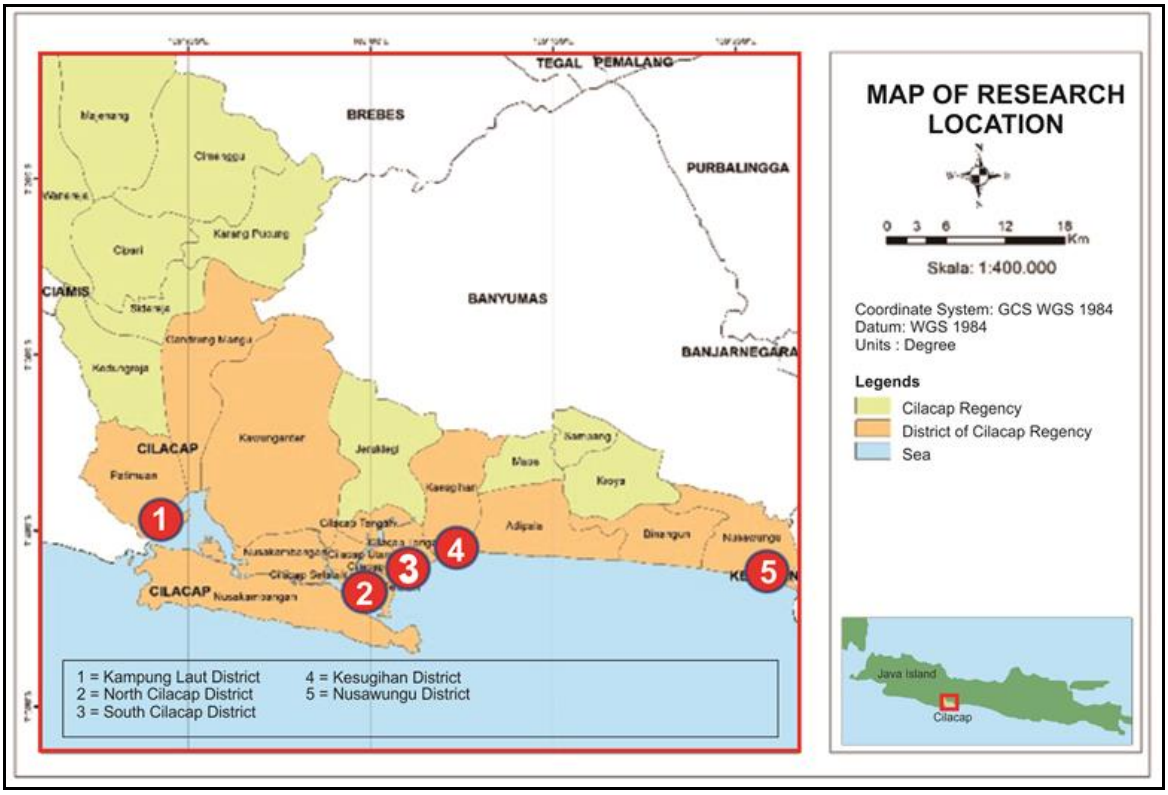

Figure 1. Data collection sites in Cilacap district, Central Java, Indonesia.

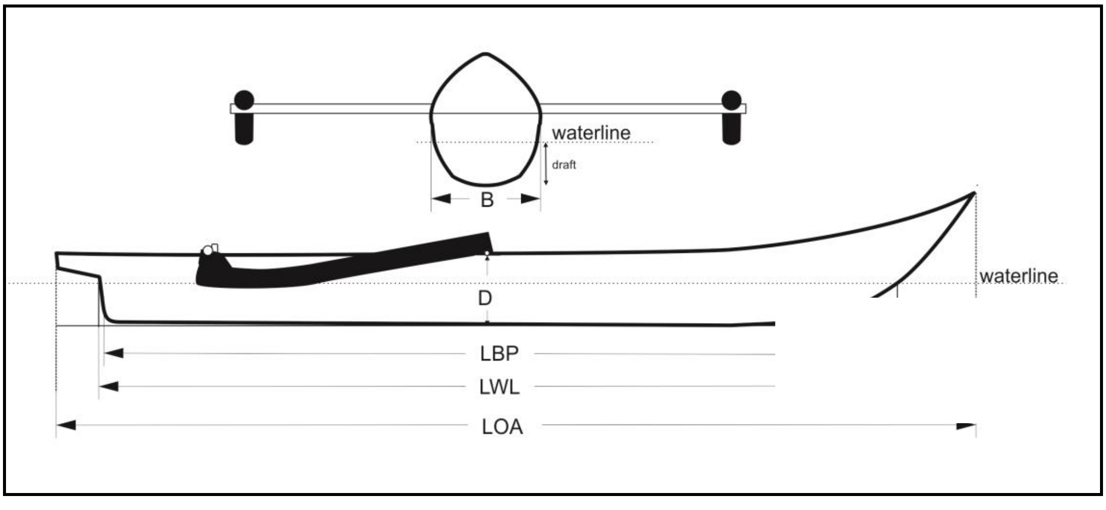

Figure 2. Boat dimensions; D - depth; B - beam length; LBP - length between perpendicular; LWL - length of waterline; LOA - overall length.

Statistical analysis*.* The measurement sheet data has been collected, the line plan is drawn manually and assisted by Autocad student version. Then proceed with the calculations of the ratio of the main dimensions of the boat, which consist of the length of the boat (L), width of the boat (B), and the depth of the boat (D) were conducted. In addition, the shipbuilding process was also observed.

Results and Discussion. Fishing vessels are fishing facilities used by fishermen to increase income. The ship is a fishing operation transportation media used to transport fish from the fishing grounds to the port. The average boat used by Indonesian fishermen has different size variations. Most fishing vessels in Indonesia are dominated by small fishing vessels. Based on statistics published by the Ministry of Maritime Affairs and Fisheries (KKP) in 2018, the composition of Indonesian national fishing vessels is dominated by vessels less than 5 gross tonnage (GT) size, with 69% of all national fishing vessels. In general, vessels measuring less than 5 GT are slender vessels. To maintain the stability of a boat with a slender shape, fishermen add an outrigger mounted on the sides of the boat, called "katir". Boats using "katir" (bars made of bamboo, wood, or fiberglass) are generally used to operate fishing gears like gillnets, or fishing gear that are classified as passive.

Fiberglass "Jukung" in Cilacap district have a slim shape and have a "katir" as a counterweight (Figure 3). The majority of boats are classified as multipurpose vessels. Multipurpose vessels use more than one type of fishing gear adapted to the main target fish (Wahyuningrum et al 2012), but the majority use gillnets, with a total of 1332 boats (Cilacap District Fisheries Department 2019).

Figure 3. Jukung in Cilacap district.

Based on information from local fishermen, fiberglass boats using outboard motors are found in 5 sub-districts, namely Kampung Laut, South Cilacap, North Cilacap, Kesugihan and Nusawungu. From each sub-district, one boat was measured and observations were made. The observations showed that the majority of boats were made at a shipyard in Lengkong village, North Cilacap district. Local shipyards make moulds based on hereditary experience and adjust the demand for fishermen ordering boats without lines plans and naval architecture calculations first, but the quality and standards of the local shipyards are still in accordance with the standards of the Indonesian Classification Bureau (Dewi 2019). The majority of local fiberglass shipyards in Cilacap district are found in Lengkong Village, Mertasinga Village, North Cilacap district (Table 1).

Table 1

Project selection matrix rules

No	*Sampling location*	*Shipyard*
1	Kampung Laut	Lengkong, North Cilacap
2	South Cilacap	Lengkong, North Cilacap
3	North Cilacap	Lengkong, North Cilacap
4	Kesugihan	Menganti, Kesugihan
5	Nusawungu	Lengkong, North Cilacap

Fiberglass vessels are in great demand because they are durable, easy to manufacture, and cheaper (Afrianto et al 2014). The determination of the shipbuilding place considers, among other things, the suitability of the price with existing capital, raw materials used by the shipyard, and the quality of the work on boats already made. Information and marketing are carried out through a basis of trust and mouth-to-mouth marketing.

Based on the results of interviews with shipyard owners, there are several sizes that have been made as a template for generations. Boat moulds made in several sizes can be seen in Table 2.

Table 2

The main sizes of ship moulds

Mould number	*Mould size (meters)*		
	Length	*Width*	*Depth*
1	9.8	1.05	0.68
2	9.9	1.1	0.73
3	10.75	1.15	0.8
4	10.75	1.2	0.8
5	11	1.25	0.82
6	11	1.3	0.83

The average length of the boat is 9.8 m, with a maximum of 11 m. The most popular fishing boat has a length of 10.75 m with a width of 1.15 m. The shipyard will basically adjust the size of the ship according to the size requested by the fisherman. If there is a size that is not in the mould, the shipyard will only insulate ships that are close in size to adjust to the size requested by local fishermen.

To design a fishing boat, the plans that must be included are: general arrangement, lines plan, profile construction, midship section, engine seating and boom construction. Planning drawings are very useful in the construction of a fishing vessel, such as a lines plan that is useful for determining the layout and size of a ship's room, hatches, engine room, steering room, crew room, fishing equipment room (Fyson 1985). According to Fyson (1985), there are several factors that influence the design of a ship, which can be grouped: available resources, tools and methods of capture, geographical characteristics of a catching area, seaworthiness of the ship and the safety of the crew, regulations relating to ship design, selection of appropriate materials for construction, handling and storage of catches and economic factors.

The main dimensions consisting of length (L), width (B) and depth (D) largely determine the ability of a ship. Therefore, in designing a ship, these need to be considered carefully. The measurements of the vessel length, according to BPPI (2006), include:

1. Total length or LOA (length over all); it is the horizontal distance measured starting from the leading point from the bow height to the backward point of the stern. This total length is the largest length of a ship and is measured in line with the ship's keel.

2. Distance along the perpendicular line or LPP/LBP (length of perpendicular/length between perpendicular) is the horizontal distance calculated from the perpendicular to the stern vertical line. The LBP is the length between the foreside of the stem and the afterside of the centerline of the rudder stock. The perpendicular line (fore perpendicular) is an imaginary line that lies perpendicularly on the intersection between the length of waterline (Lwl) and the hull on the bow. The stern vertical line (after perpendicular) is an imaginary line located on the stern or behind the steering shaft (for ships that have a steering shaft).

3. The length of the water line is the horizontal distance calculated from the point of intersection between the water line with the bow height to the point of intersection between the water line and the stern height.

A boat's line plan design was constructed based on the observations on the 5 sample boats, with the same mould model (Figure 3). The lines plan is technical drawing for a boat. It is used as a guide in shipbuilding, especially for curvature in the hull (Susanto 2010). Lines plans are made using values obtained from the measurement results, then used to perform hydrostatic calculations. A lines plan consists of 3 components, namely: a picture of a side view of a ship (profile plan), a picture of a ship from above (half breadth plan) and a picture of a front view of a ship (body plan). The local shipyards do not yet use a ship lines plan in making ordered ships. There are exceptions when the party ordering the ships prepare their own ship lines plans. The boat lines plan in Figure 4 shows the line design that can be used as a basis for making boats by local fishermen. The boat's waterline shows the hydrodynamic shape of the boat's submerged part, so that water friction on the boat will be minimized and the speed will increase.

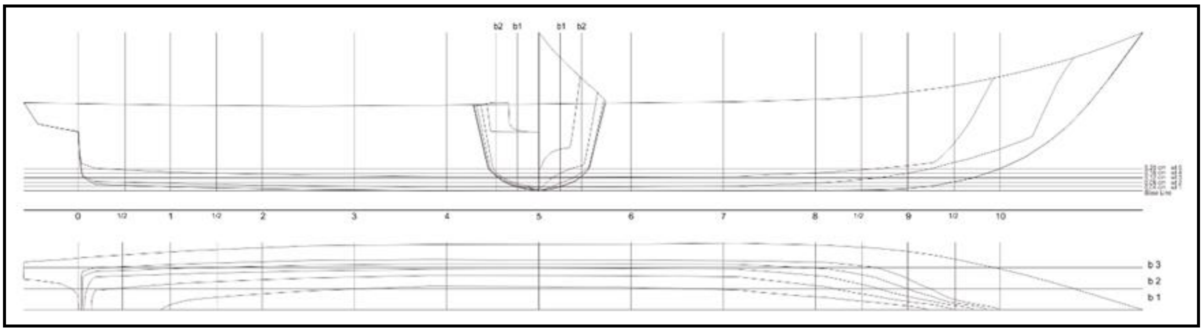

Figure 4. Lines plan of vessel in Cilacap district, Central Java, Indonesia.

Based on observations, the boat has the shape of a raked bow, because it has a pointed shape leaning forward (Bangun et al 2017). In addition, the ship has a transom stern shape transverse beams as engine mounts (Bangun et al 2017; BKI 2020). The shape of a casco (body of boat) resembles the shape of the letter "u", so the ship is included in the casco u-bottom type category (Novita & Iskandar 2008).

The size of the ratio of the main dimensions of a boat (L, B and D) can be used to analyze the performance (shape) and affect the ability of a ship. The values of L/D, L/B, and B/D need to be considered in technical calculations, types of materials and applicable regulations. According to Fyson (1985), in the design of a boat, the comparative characteristics of the main dimensions are important and must be considered. The comparison between L and B affects the resistance and speed of the ship; if the L/B ratio decreases, it affects the speed of the ship, decreasing it. The B/D is a factor that influences stability. If the B/D value increases, the stability will be better, but the propulsive ability will worsen. L/D influences the lengthening strength of the ship. If the L/D value enlarges, it will cause the ship's longitudinal strength to weaken. Thus, the analysis of the suitability between ship design and its function and designation needs to be conducted. The values of the L/D, L/B, and B/D proposed by Nomura & Yamazaki (1977) are presented in Table 3.

Table 3

The main sizes of ship moulds

Ship group	*Ship length (m)*	*GT*	*L/B*	*L/D*	*B/D*
towed/dragged gear	<22	-	<6.3	<11.5	>1.75
static gear	<20	<5	<5	>11	>2.5
		5-10	5	11	2.2
		10-15	5	10.5	2.1
		>15	5	10	2
Encircling gear	<22	-	4.3	<10	>2.15

Note: L - length; D - depth; B - width; GT - gross tonage.

General design drawings are general pictures showing the overall layout of the ship. This will affect the stability of the ship, work comfort, work safety and ease of work in fishing operations, so that activities will be improved. The general arrangement must also pay attention to the purpose of capture, the type of fishing gear used, the operational process and the place where the fishing is conducted. In general, local boats have the same general arrangement as presented in Figure 4.

Based on Figure 5 the boat has several layouts. The bow section has a bow buoyancy reserve and serves as a place for fishermen to monitor the fishing process and the condition of the shipping channel. The double base serves as a central buoyancy reserve. The double base is used for fishing gear storage. The middle part is used for the cool box. At the stern, there is a stern reserve buoyancy which has a bulkhead to hold water as well as the boat's captain. At the end of the stern there is an outboard motor for driving.

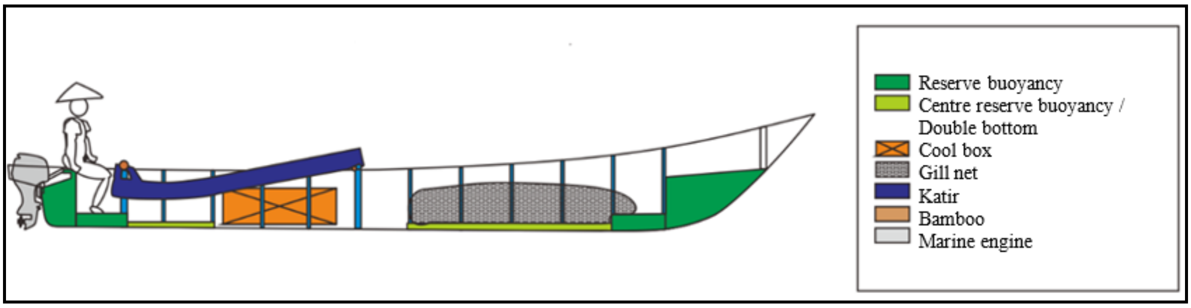

Figure 5. General arrangement of vessel in Cilacap district, Central Java, Indonesia.

Cilacap district has a unique form of "katir", using a laminated pipe and its curved shape, with an average of 3 m in length (Figure 6). The "katir" is mounted from the midship to the stern and it is accompanied by a straight bamboo rod as a connector between the right and left sides. This is adjusted to the habits of fishermen, who use gillnets at the bow of the ship.

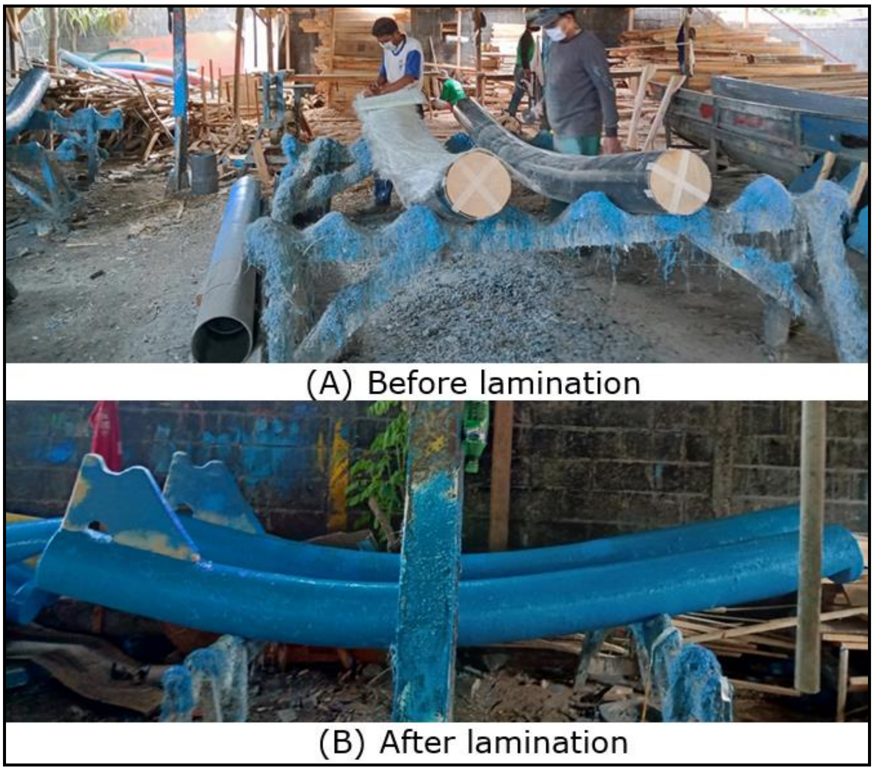

Figure 6. The process of forming the "katir" of a boat.

Local fishermen tend to prioritize the aesthetics and the prowess of the boat they use. The "katir" in the district of Cilacap is different from "katir" in other areas. The majority of boats have "katir" made of straight bamboo, or paralon, laminated, and not curved. Thus, the "katir" in the Cilacap area can be appointed as a specific boat characteristic and can be considered as local wisdom in the Cilacap district. In general, local vessels in Cilacap distric have various patterns, but there are many similarities, namely the patter in the bow of the boat (Figure 7).

Figure 8 shows the process of producing fiberglass fishing vessels. The motif of the ship's picture on the bow of the ship is the expression of an art for the local shipyard. The process of writing the name and logo on the boat are not easy, because they are drawn directly on the mould. The typeface in writing the name of the ship is also a sign of the shipyard making it.

Figure 7. Picture motif of the ship.

Figure 8. Process of production vessel. 1 - preparing the mould; 2 - drawing the ship's name, logo and style; 3 - preparation of laminated material; 4 - lamination process; 5 - installing the ship's frame and bulkhead; 6 - finishing.

The motif and name of the ship are characteristic to each region. Likewise, in the Brondong area, Lamongan, local fishermen provide a distinctive drawing motif on local boats depicting a princess with beautiful eyebrows on the bow (Putra 2019). This is similar to some local boats in Cilacap district, where they are described as a manly person and has a mustache on the bow. Therefore, the motif of drawing local vessels in the Cilacap district and the process of “batik” (making the name and logo of the ship) can be considered local wisdom of the people in Cilacap district.

Conclusions. Fiberglass “Jukungs” in Cilacap district are made at local shipyards and are centered in Lekong Village, North Cilacap District. Ship moulds are made without plans for ship design drawings and naval architecture calculations, with hereditary knowledge. The customs of the community that can be considered local wisdom are the drawing motifs, the bow's style of the ship, the name of the ship and the shape of the ship's “katir”.

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