Spatial Distribution of Lift Net (bagan) and The Impact on 
*Sardinella lemuru* Catches in Senggrong Bay, Banyuwangi

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Abstract. The spatial distribution of lift net (bagan) and the impact on the *Sardinella lemuru* 
(lemuru) catches in Senggrong bay - Banyuwangi has been analysed. The data used in this study 
consists of Pleiades satellite data, aerial photographs of unmanned aerial vehicle (UAV) or drones 
and in situ measurements in the same period. Fishery data during 2013 to 2017 were analysed to 
determine the variability of Lemuru catches. The analysis of bagan spatial distribution was 
performed using visual interpretation technique. Spatial distribution of bagan was analyzed by 
overlaying data at different period. The results show that the number of bagan in Senggrong bay 
were 85 unit and spread evenly throughout the bay. In the northwest monsoon, the bagan were 
spreadin the northern part of the bay, while in the southeast monsoon, the bagan were shifted to 
the south due to the high waves and wind speed. Lemuru spawning time was occurred in May – 
July. During spawning time, the amount of Lemuru catches by bagan was relatively low. The peak 
of lemuru catch was occurred in the period of October to January. The impact of bagan on the 
decreasing of lemuru abundance is relatively low.

1. Introduction
Fisheries resources in the Bali Strait are one of the main elements of economic growth in Jembrana-Bali 
and Banyuwangi-East Java. Fishery production in the Bali Strait consists of Lemuru, mackarel, layang and 
tembang fish (Suherman, 2012). Fisheries production in the Bali Strait has fluctuated, where in 2004 the 
number of fish catches was decreased to 6,932.8 tons/year, but in 2009 there was a very significant 
increase up to 31,379.0 tons/year. The fish catches in the Bali Strait were dominated by Lemuru 
(*Sardinella lemuru*) [15]. Lemuru fishing covers 71% of the total production or around 23,899 tons/year 
[13]. Lemuru fishing season occurred from October to January [10]. The utilization of pelagic fish 
resources in the Bali Strait is carried out by various fishing gear consist of purse seine (*slerek*), gill nets, 
*payang*, coastal trawl and lift net (bagan). The number of purse seine is relatively more than other fishing 
gear, while fish catches using lift net is relatively less than other fishing gear, [7].

One of the lift net locations in Banyuwangi district was Senggrong bay. Located between Jawa island 
and Bali island, Senggrong bay is one of the potential fishing zone for lift net which is operated by 
Muncar-Banyuwangi fishermen, [10]. There are two types of lift net, namely floating lift net (bagan 
apung) and fixed lift net (bagan tancap) [1]. The fixed lift net is usually made of bamboo that pinned in 
relatively shallow waters. It has a certain height above the sea surface to operate a net at the bottom, [11].
Since the construction was pinned in seafloor, the fixed lift net cannot be moved. The productivity of lift net depends on the depth of the sea, the distance from the coast and the density of the sea water [3].

Floating lift net was made of bamboo with additional floating material or drum. It can float on the sea surface and be easily moved to other places that are considered as a potential fishing zone [17]. Since the floating lift net unpinned into the sea floor, it can be operated in deeper waters. With the net depth of around 10 m, a floating lift net can be operated in up to 50 m water depth [1].

The number and spatial distribution of lift net operated in Senggrong bay change along with the monsoon. There is also a new or a damaged lift net. Therefore it is necessary to have both spatially and temporally comprehensive observation. The use of very high-resolution satellite data can provide information about the spatial distribution of lift net. On the other hand, the use of an unmanned aerial vehicle (UAV) or commonly called a drone can complement satellite data capability. A drone takes aerial photographs from a height of about 300 meters uninterrupted by cloud cover and provides very detailed data [18].

The existence of lift net on the coast of Banyuwangi Regency has caused a conflict of interest and is thought to contribute to damaging the ecosystem. The spatial distribution of lift net has complained because they are considered to take the area of other fishing gear. The use of lights causes fish to tend to congregate around the lift net rather than into the other fishing gear. Besides that, the use of small mesh size on the lift net is also strongly suspected of catching juvenile and immature fish. This condition is feared to disrupt the life cycle of fish so that the availability of adult fish decreases. The increasing number of lift net is suspected to cause the failure of Lemuru recruitment process from juvenile to become adult fish, especially on feeding ground and nursery ground of Lemuru. The aims of this study were to analyze the spatial distribution of lift net and the impact on the variability of Lemuru catches in Senggrong bay – Banyuwangi.

2. Materials and Methods
Data of the lift net spatial distribution in Senggrong bay was obtained from Pleiades satellite on April 30, 2018 and May 5, 2018. The use of satellite imagery from two different recording dates is intended to complement the cloud-covered area. The clear cloud satellite image will support the identification of the lift net in full area coverage. Pleiades satellite 1A and 1B produce an image with a spatial resolution of 70 cm on the panchromatic channel, and 2.8 m on multispectral channels [2].

The aerial photograph of drones recorded on April 10, 2018 was used to complement satellite data. The drone platform was operated at an altitude of 300 meters and is controlled on autopilot from the Ground Control Unit. The device carries a camera with a capacity of 12 MP resulting in a high spatial resolution about 9-10 cm [18]. The drone used in this study is a fixed-wing UAV type AP-Plane 1550FW with a wingspan of 1.55 meters made of Styrofoam with an additional layer of scoulet, 9 " / 10" / 11 " propellers, atmega / arm base flight control, with a maximum cruising distance of 35 km.

Spatial distribution of lift net was identified by visual interpretation of Pleiades satellite and drone data. Visual interpretation was carried out based on the identification of hue, colours, shapes, sizes, roughness, patterns, sites and associations of objects [9]. Field survey was conduct using the Global Positioning System (GPS) on 12th-13th September 2018. By applying the overlay process of satellite data, drone data and GPS data, it can be seen that several units of lift net were shifted to another location. The fishery data were based on Muncar-Banyuwangi fishing port during 2013 to 2017. The monthly average analysis is carried out based on the type of fish caught and fishing gear.
3. Results and Discussion

Interpretation of Pleiades satellite imagery and drone data was conducted to identify the spatial distribution of the lift net. Spatial distribution of lift net was presented in Figure 1.a and Figure 1.b. Based on the key interpretation, lift net has a bright hue with brown color. Usually lift net was made of dry bamboo. The lift net has a rectangular shape. It measured around 14m – 16m with parallel pattern. The bamboo was tied and arranged to be a working space and an operating base of the net.

The lift net has a square shape with bright hues, brown colors, and parallel stripes pattern. It can be interpreted using Pleiades satellite images. The use of drone data can provide more detail identification. The spatial resolution of drone data was about 5 cm. The size of the bamboo used to construct lift net ranges from 7 cm to 20 cm.

Figure 2 shows the spatial distribution of lift net in Senggrong bay interpreted from satellite images recorded on April 30, 2018 and May 5, 2018. During April-May 2018 which is the 1st transition of the monsoon, the lift net was spread evenly in both the southern and northern parts of Senggrong bay. The area was located at 8°35’S to 8°38.5’S and 114°25’E to 114°28’E. The number of the lift net was 85 units. It spread in the coastal zone with the distance up to 2 miles. The distance of lift net with each other varied between 100 m to 400 m.

To analyze the shifting of lift net, field survey was conducted in September 12 - 13, 2018. The visual appearance of lift net in Senggrong bay was shown in Figure 3. The drone data on April 10, 2018 shows the spatial distribution of lift net in the northern part of Senggrong bay at the latitude of 8°36’S - 8°37.3’S and longitude of 114°25’E - 114°26.5’E as in Figure 4. A usually the lift net was shifted to another place to anticipate high waves and wind speed. As the monsoon changes, the oceanographic factors also change. Change in oceanographic factors will affect the fish abundance.
Figure 2. Spatial distribution of bagan fishing gear based on interpretation of Pleiades satellite images

Figure 3. The visual appearance of lift net in Senggrong bay
The GPS data was overlaid with drone data to analyze displacement of lift net as shown in Figure 5.

**Figure 5.** Overlaid data of bagan location based on drone data and GPS measurement
Figure 5. shows the spatial distribution of lift net in the northern part of Senggrong bay based on drone data on April 10, 2018. The location was represented by a yellow point symbol. While the red point symbol represents the spatial distribution obtained from GPS measurement on September 11, 2018. The overlaid area is around 8°36'S - 8°37'S and 114°25'E - 114°26.5'E. There were 7 units of lift net in the northern part of Senggrong Bay in April 2018. In September 2018 only 2 units remained in that location, this condition was caused by the sifting of the lift net.

The GPS data also overlaid with satellite data to observe the displacement of the lift net as presented in Figure 6. There are lift net displacement in the southern part of Senggrong bay. In April 2018, lift net was generally spread from north to south. The lift net was located no more than 1.5 miles from the shoreline. During September, the lift net was spread wider than in April, with the location was up to 2 miles from the shoreline. This is due to the increase of wave height, wind speed and current.

![Figure 5](image1.png)

**Figure 5.** Overlaid data of lift net in the northern part of Senggrong bay based on drone data on April 10, 2018. The location was represented by a yellow point symbol. While the red point symbol represents the spatial distribution obtained from GPS measurement on September 11, 2018. The overlaid area is around 8°36'S - 8°37'S and 114°25'E - 114°26.5'E. There were 7 units of lift net in the northern part of Senggrong Bay in April 2018. In September 2018 only 2 units remained in that location, this condition was caused by the sifting of the lift net.

![Figure 6](image2.png)

**Figure 6.** Overlaid data of bagan location based on satellite image and GPS measurement

Based on Muncar Fishing Port administration, the number of lift net in Senggrong bay from 2013 to 2017 has fluctuated as shown in Table 1.

| Year | 2013 | 2014 | 2015 | 2016 | 2017 |
|------|------|------|------|------|------|
| Number of Lift net | 91   | 96   | 102  | 105  | 98   |

Table 1. The existing lift net in Senggrong bay
[12], found that the currents in the Bali strait was change direction as a result of monsoon changes. During northwest monsoon, the wind direction tends to flow eastward. While during southeast monsoon it tends to flow westward. The wave height in September was relatively higher than that in April. Wave height in September can reach up to 1.8m, while in April only ranges from 0.8m to 1m.

Field observations in April 2018 show that fishermen use a small boat to go to locations and to transport the fish to the port as shown in Figure.7. There are 5-6 boat operated, each boat serving 10 to 15 units of lift net. Fishing port activities are usually carried out in the morning at around 7:00 local time. Fish catch on April 12, 2018 was not too much, it only about 40kg consist of scad mackerel and anchovy.

**Figure 7.** Small boat to support bagan operations in Senggrong bay

Based on the data of Muncar Fishing Port administration during 2013 - 2017 as displayed in Figure.8, it can be seen that the catch of the lift net was comprised of scad mackerel, anchovies, small size Lemuru (semenit), slipmouth fish and squid. Each type of fish has a different fishing season which is influenced by various factors. The production value of lift net has been standardized with the maximum value of each fish type so that the graphic displayed was distributed with a value between 0 - 1.

**Figure 8.** Fish production of bagan in Senggrong bay during 2013-2017
Figure 9 presents the production of fish caught by various fishing gear during 2017. Fish production consists of mackarel, lemuru, tuna and skipjack. Fish production during 2017 in Muncar port was dominated by mackarel, which reached more than 200 tons in October. The production of Lemuru, tuna and skipjack were relatively low, with a production rate below 50 tons/month. Lemuru fish production was relatively very small or could be said to disappear in 2017.

![Graph showing fish production](image)

**Figure 9.** Fish Production of mackarel, lemuru, tuna and skipjack in Muncar fishing port during 2017

Based on the data in previous years, it was observed that Lemuru fish was the main production in the Bali strait as presented in Figure. 10.

![Graph showing fish production](image)

**Figure 10.** Production of lemuru in Muncar fishing port during 2013 - 2017
The peak production of lemuru during January-February occurred in 2015 and 2016. The peak of lemuru production also occurred in November 2014. Lemuru production in January to August 2013 was relatively low, but in September it increased.

The monthly average of Lemuru fish production is presented in Figure 11. Lemuru fishing in Bali strait peaks in November, then decline until July. In June there was a slight increase of lemuru fish production. Fish production began to increase again in August until reached its peak in November. This is in accordance with [13]. The fluctuations of Lemuru fishing in the Bali strait were strongly correlated with oceanographic phenomena, such as monsoon and upwelling [6].

Figure 11. Monthly average of lemuru production in Muncar fishing port during 2013 - 2017

The monthly average production of Lemuru fish by lift net was presented in Figure 12. Lemuru fishing in Senggrong bay peaks in October to January with production number of around 20 - 35 tons/month. Lemuru fishing reaches the lowest production in May to August around 2 - 3 tons/month. This result confirmed that the production of Lemuru in June was not produced by lift net in the Senggrong bay. The production of sempenit fish were not dominated by lift net, because the distribution of sempenit fish was evenly distributed throughout Bali strait [19,10].

Figure 12. Monthly average of lemuru production of bagan 2013 - 2017

The result in in accordance with [4]. The abundance of Lemuru fish in Bali strait has a very strong correlation with the concentration of chlorophyll-a. The chlorophyll-a concentration may fluctuate due to the influence of oceanographic phenomena. The high concentration of chlorophyll-a in the Bali strait
during southeast monsoon was related to upwelling which carries nutrients from a deeper layer of water to
the surface [8]. Upwelling was characterized by a high concentration of phosphate, nitrate, organic matter
and silicates which are nutrients that support the growth of phytoplankton [15].

The catches of pelagic fish around Java island including Bali Strait were influenced by oceanographic
phenomena such as upwelling, el nino - la nina, Indonesian Through Flow (ITF), and Indian Ocean Dipole
mode (IOD). Specifically, it was stated that the Lemuru catches in the Bali strait were affected by
upwelling that occurred from September to November [5]. During el nino period there was upwelling
which caused an increase of plankton abundance as a fish food source in Bali Strait [13]. Catch per unit
effort (CPUE) for Lemuru fish in the Bali strait was strongly influenced by chlorophyll-a concentration
[14].

4. Conclusion
Spatial distribution of lift net in Senggrong bay was generally spread evenly from north to south with
distances from the shoreline not more than 2 mil. The total number of lift net was about 100 units with the
distribution tending to be more accumulated in the southern part of Senggrong bay. Along with monsoon
change from northwest monsoon to the southeast monsoon, some of the floating lift nets will be shifted to
other locations to anticipate the increase of wind speed and wave height. The impact of lift net on the
decline in the abundance of Lemuru was relatively small. This condition was proved by small amount
of fish production from May to July which is the spawning season of Lemuru. Lemuru fish production peaks
in November.

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