Distribution of Glass Eel by the Water Surface Salinity Using Landsat TM at Pelabuhan Ratu Bay, West Java

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Abstract. Eel (Anguilla spp.) is consumed fish that has an important economic value, either for local or international market. Pelabuhanratu Bay is an area with big potential for supplying eel seed. One of important factor, which affect an eel existence, is salinity, because eel migrate from fresh water, brackish, and sea naturally although the otherwise so that need ways to describe the distribution of glass eel by the salinity. To find out the percentage of salinity, it obtained from Landsat 8 Imagery in year 2015 using salinity prediction of Algorithm Cimandiri. The research has been conducted at Cimandiri Estuary, Citepus Estuary, and Cimaja Estuary based on wet and dry months. The existence of glass eel which is obtained from the catch was occurs on dry month when the most catch was occurs at the edge of estuary. The catch is reduced if it’s farther from the edge of estuary, at the beach towards the sea and the inside of the river mouth with the percentage of salinity towards the sea is increase while the percentage of salinity towards the river is decrease.

1. Introduction
Eel (Anguilla spp.) is the consumption of fish have economic value is important both for the local market and abroad. Market demand will be very high discharge fish reaches 500,000 tons per year, mainly from Japan and Korea, the main suppliers of eel is China and Taiwan [3]. In Indonesia there are seven known species of eel that its spread is almost evenly across the waters that empties into the deep sea. This fish spawning places suspected in the Indian Ocean, namely West Sumatra [5] and [8] and later the larvae are carried by currents and tides in the direction of the coastal. One of the coastal of the south coast of Java that is directly related to the Indian Ocean was Pelabuhanratu. Therefore, these waters have a large potential for the provision of seed eel.

One of the factors that influence the life of the eel is salinity, because naturally fish eel migrate from freshwater, brackish, and marine or vice versa. Measurement of salinity directly is difficult because it requires a huge time and cost. However, [11] have made the prediction equation salinity through sea color sensing or prediction equation salinity through sea color sensing or CDOM (Colored Dissolved Organic Matter) by utilizing multiple-temporal image of Landsat-7 ETM+. The higher the CDOM then the lower salinity and low CDOM then high salinity tend. Salinity basically has no color signal directly, the value of salinity can be estimated from the colors signals are dominant elements contained in waters, such as CDOM. This research, the distribution of salinity values obtained from the equation, by utilizing Landsat 8 OLI (the operational land imager) throughout the year 2015.
According to [8] in the waters of Indonesia there are seven species of eel. **Anguilla celebensis** and **Anguilla borneensis** an endemic animal in Kalimantan and Sulawesi. **Anguilla interioris** and Anguilla obscura located in waters north of Papua Island. Anguillabicolorpasifica can be found in the northern part of Indonesia’s waters (Pacific Ocean). **Anguilla bicolor** is around the Indian Ocean (to the west of island of Sumatera and the southern island of Java). **Anguilla marmorata** is a type of eel with cosmopolitan distribution across the tropical waters. Pelabuhanratu Bay is one of the southern of the island of Java which has great potential in providing seed eel. Locations where eel fishing is at the mouth of the river. During the temporary stay in the brackish waters of eel fish in the Pelabuhanratu Bay many communities to a outcome was later arrested for cultivated or sold directly. Many of the at least catches obtained by eel catchers, depends on the good or bad the salinity in the estuary, as salinity is influenced by tides, sea currents, precipitation in catchment area, evaporation, precipitation and bathymetry of the marine. The condition which aspects influenced the writers to do research in the Pelabuhanratu Bay.

2. Methods

Eel Larvaemigrate from freshwater brackish, and marine or vice versa. Once mature, the fish discharge to the sea in order to reproduce and then die, then the larvae are carried by the current to spawning results beach and towards freshwater through the river. Freshwater has low salinity due to its concentration of less than 0.05 ppt, while the salinity seawater tends to be high because the content of more than 5 part per thousand (ppt) concentration [2]. Before entering the river from the sea, eel larvae are caught by people in the Pelabuhanratu Bay. The results of the arrest depend on factors of ups and downs of tidal, rainfall and other can affect the uneven salinity mixture. Value distribution of salinity can be known from the results of the interpretation of the image by using the equation of the salinity of the Cimandiri algorithm [9].

Making a map of the distribution of salinity with Landsat imagery by 2015 is done using the equation to the algorithm Cimandiri [9], as follows:

$$\text{Salinity (ppt)} = 29,983 + 165,047 \times (B2) - 260,277 \times (B3) + 2,609 \times (B4)$$

Where:

- **B2** = *Blue waves*
- **B3** = *Green waves*
- **B4** = *Red waves*

Further data processing is performed after the observation field. Map of the spread of salinity results in data processing data processing early will be merged with the larval fish catching point location where the dots are derived from information obtained from the results of the interview fishermen who catch eel larvae (‘impun’). Other data processing are as follows:

1. Data processing precipitation Rainfall data were not presented in the form of a map but in tabular form for then analyzed with salinity
2. Processing of data forecasting tides seawater surface Data about the ups and downs of seawater is not presented in the form of a map but in tabular form for later analyzed by the salinity of the surface and the distribution of eel larvae (impun). To simplify the analysis will be made of graphs forecasting tides per hour

The processing of data of sea surface currents (direction and speed of the flow) average data speed and direction of the surface current remains daily tabular data are presented as the source of the data. The current sea level at each time of observation are also presented for analysis.
3. Result and Discussion
In this research on the measurement of salinity surface waters is done based on a wet month (March 24, and April 25, 2015) and the dry month (August 15 and September 16, 2015). For more details can be seen in Figure 1, 2, and 3.

Figure 1. Salinity Surface Waters of Cimandiri Estuary in wet and dry months

Figure 2. Salinity Surface Waters of Citepus Estuary in wet and dry months

Figure 3. Salinity Surface Waters of Cimaja Estuary in wet and dry months
Based on the results of the measurements of salinity surface waters using Landsat ETM using Cimandiri Algorithm [9] based on known CDOM:

1. The whole area of study is the estuary in the Pelabuhanratu Bay which has a minimum and maximum salinity values that be different. The value of the salinity in the waters of the Pelabuhanratu Bay has the minimum salinity values 5.02683 ppt on April 25, 2015 and the maximum value is 32.2708 ppt on August 15, 2015. The Cimandiri Estuary of the minimum salinity value 5.0268 ppt and 29.7146 ppt maximum value on April 25, 2015. The Cimandiri Estuary the minimum salinity values is 5.5553 ppt and 29.7146 ppt maximum value on April 25, 2015 and estuary salinity value Cimaja Estuary minimum 5.4249 ppt on August 15, 2015 and the maximum value 29.7146 ppt on April 25, 2015.

2. The region with salinity 0.5-5 ppt of the results from Algorithm salinity model was not found in the area of research in the region of the Pelabuhanratu Bay (Cimandiri, Citepus and Cimaja Estuary).

3. Areas with salinity value 5-18 ppt of the results from Algorithm salinity model can be found on the estuary and part of the Pelabuhanratu Bay.

4. Areas with salinity value 18–30 ppt of the results from Algorithm salinity model can be found on most of the estuary and the Pelabuhanratu Bay.

Estuary area have salinity values varied between 0.5-30 ppt [6]. The value of the salinity of the Pelabuhanratu Bay based on the estuary of the Cimandiri, Citepus and Cimaja obtained from the results of the prediction at the Cimandiri Algorithm upon salinity CDOM made by (Supriatna et al., 2015) averaged just consists of two zones are Mexo-mesohaline Mexo-and polyhaline. Based on table 1, the zoning of the Cimandiri estuary, Cimaja estuary and Citepus Estuary averages has 2 zones are Mexo-mesohaline (5-18ppt) and Mexo-polyhaline(18-30ppt)

| Location | March 24 | April 24 | August 15 | Sept 16 | Zone |
|----------|----------|----------|-----------|---------|------|
| Cimandiri | 28.8009  | 29.7146  | 28.1239   | 28.3983 | Mexo-mesohaline and Mexo-polyhaline |
|          | 5.04429  | 5.02683  | 5.58921   | 5.07053 |      |
| Citepus  | 29.5044  | 29.7146  | 28.1374   | 28.3983 | Mexo-mesohaline and Mexo-polyhaline |
|          | 6.33286  | 5.55539  | 6.88039   | 5.81782 |      |
| Cimaja   | 29.5044  | 29.7146  | 27.5934   | 28.3983 | Mexo-mesohaline and Mexo-polyhaline |
|          | 5.96557  | 5.78921  | 5.42493   | 5.68135 |      |

Source: Data processing (2016)

Here are the waters of zoning in the Cimandiri, Citepus and Cimaja Estuary upon salinity surface waters are seen based on the wet and dry month:

1. In the wet month at the Cimandiri Estuary on March 24, and April 25, 2015, the water has a salinity of 5-18 ppt (Mexo-mesohaline) which is the water of the river enough to dominate the water because of zoning extends approximately 2 kms from the mouth of the river which took place on March 24, while on April 25, 2015. The water of the river extends more or less is a 450 m from the mouth of the river. It can occur due to high rainfall which resulted in a flow of water from the River to the great sea and the mouth of the estuary is Cimandiri River is great river compared Cimaja and Citepus River.

2. In dry in the month of the Cimandiri Estuary on August 15, and September 16, 2015, Mexo-polyhaline zone (18-30ppt) dominating the waters of the estuary. Salinity tend to increase due to low rainfall and sea water brought to the estuary with the help of the tides tend to be much.

3. In the wet and the dry months in the Citepus estuary is Mexo-polyhaline zone, which dominated (18-30 ppt) that is because different estuary type compared to the Cimandiri
Estuary. The mouth of the estuary sand covered Citepus and including small when compared to the estuary mouth of the Cimandiri which resulted in the distribution of water to the sea slightly so that more sea water entering the mouth of the estuary.

4. In the wet and the dry months in the Cimaja estuary is Mexo-zone dominated polyhaline (18-30 ppt). In the wet zone Mexo-mesohaline (5-18 ppt) very small only approximately 70 m from the mouth of the river. That is because the mouth of the Cimaja is not great and water flow its not heavy because it is the type of rocky river.

In the wet months on March 24, and April 25, 2015, have the precipitation resulting in high salinity surface waters estuary at a point sample belongs are range between 17-19 ppt caused the presence of input water is rain water that neutral. On the waters of the Pelabuhanratu Bay itself, the highest salinity on March 24, and April 25, 2015 has a high value is 29.5044 ppt and 32.1454 ppt.

In the dry months on August 15, and September 16, 2015, salinity or high tend to be larger than in the wet. It is also caused by low rainfall even on August 15, and September 16, 2015, no rains in the Pelabuhanratu Bay. On the waters of the Pelabuhanratu Bay itself, the highest salinity has a value of 32.2708 ppt and 29.1798 ppt.

Tides sea water becomes an important factor of mixing fresh water with salt water in the estuary area. The tidal Indonesia into four different, Java's south coast have tidal type mixture leaning daily doubles (mixed tide, prevailing semi diurnal). This is a tide that occurs twice and twice the tide receded during the day but sometimes one plug and one time recede by having different time and altitude. In this study the tidal data used is tide forecasting data that was in the fishing port of Pelabuhanratu. Forecasting data that are used based on the wet (24 March and 25 April 2015) and the dry months (August 15 and September 16, 2015). The adjusted data recording on satellite images Landsat, where time is observed by image is 09.00-10.00.

Condition of the tidal all the time by waters are experiencing image coverage. Where on March 24, 2015, high advance water of 76.26 cm, dated April 25, 2015, level high water of 38.49 cm, August 15, high water of 35.91 cm face and on September 16, 2015, the level of the waters of 40.29 cm. On March 24, 2015 is the highest level. Tidal is the external power that evokes the movement of a mass of water and affect change high water at the mouth of the face [2], because the densities of fresh water lower than sea water, the mass of the freshwater will tend to be at the top of the mass of sea water. To be able to happen then the mass mixing sea water must be greater than the mass of the freshwater and there should be a driving force that resulted in the throes of water. The higher the face of the water, the greater the mass of the water that goes into the river, so that the mixing of salinity that occurs around the mouth of the greater. The greater mixing of salinity that occurs, the value of increased salinity estuaries. In contrast, low to high sea indicates at least the mass of sea water coming into the estuary, allowing the mixing of salinity that occurs in the estuary into a small.

The results processing of imagery, shows that at the time the highest pairs is 76.26 cm on March 24, 2015, salinity in the estuary of the Cimandiri tend to moderate that is contained in the Mexo-mesohaline salinity value of 15-19 ppt, while in the estuary of the Citepus and Cimaja tend high are ranges of 20-24 ppt. On April 25, 2015 high face of water were in 38.49 cm where the salinity at the mouth of the Cimandiri tend to moderate range of 16-19 ppt, while in the estuary of the Citepus and Cimaja tend high are 20-23 ppt. On August 15, 2015 level of water were in 35.91 cm where the salinity at the mouth of Cimandiri, Citepus and Cimaja tend high are 21-23.5 ppt. On September 16, 2015 face high water was at 40.29 cm where the salinity at the mouth of Cimandiri, Citepus and Cimaja tend high are 21-23.6 ppt.

It proves that the higher the face of the water, the greater the mass of the water that goes into the river, so that the mixing of salinity that occurs around the mouth of the greater. The greater mixing of salinity that occurs, the value of increased salinity estuaries. In contrast, low to high sea indicates at least the mass of sea water coming into the estuary, allowing the mixing of salinity that occurs in the estuary became small is not always evident, because the tidal a variable cannot stand on its own without the influence of other variables.
The speed and direction of the currents of the ocean surface is one of the factors that influence the spread of salinity in the sea. Sea surface current velocity can determine how fast sea water with high salinity can be mixed with river water that has low salinity. The faster the speed of the current sea level then the faster mixing between seawater and river water salinity variation will happen so that the higher. If the speed of the current sea level slowly, then mixing that occurs will be less and less, so the low salinity variation.

Judging from the geographical location, the Pelabuhanratu Bay only got the direction of currents that come from the west and south. The direction of flow on the surface of the waters in the Pelabuhanratu Bay in wet (March 24, and April 25, 2015) and the dry months (August 15, and September 16, 2015). In the wet (rainy season) sea current is moving from the west to the east or south while in dry (dry season) move from south to north or west.

The speed and direction of the flow of surface salinity in the estuary waters. In the wet months on March 24, 2015 at current speed 0.29 m/s with the direction of flow from east to west, the salinity of the surface waters in the vicinity of the mouth of the Cimandiri tend low, due to the location of the mouth of the Cimandiri leading towards the west with the flow direction. At the mouth of the Citepus and Cimaja Estuary, the salinity of the surface are likely to be high because of the location of the mouth of the estuary to the south so no transfers at a rate of flow.

In the month of March 25, 2015, the current speed 0.21 m/s in a direction from north to south flow of the salinity in the estuary of the Cimandiri increase and at the mouth of the Citepus and Cimaja tends to fall because the direction of the mouth of the estuary Citepus and Cimaja southwards where the direction of the flow on March 25, 2015 from north to south.

In the dry month of August 15, 2015, the speed flow 0.27m/s with the direction of flow from west to east the salinity at the mouth of the Cimandiri likely to moderate because on that date the rain does not occur and the direction of ocean currents towards the mouth of the estuary so that sea water entering the mouth of the estuary of more of the water that comes from the river and at the mouth of the Citepus and Cimaja higher compared with Cimandiri estuary ranged from 20.0-23.5 ppt.

In the dry months on September 16, 2015, speed flow 0.13m/s in a direction from north to south flow of the salinity in the estuary of Cimandiri, Citepus and Cimaja, tend high are ranges between 20-24 ppt.

Changes of salinity on free waters is relatively small when compared with that occurs in coastal regions. As it known to many coastal waters to enter freshwater from the mouth of estuaries, especially at a time of much rain. Closely related to the presence of salinity adjustments osmotic pressure between the cytoplasm of cells in the body of the fish with the circumstances surrounding salinity. In addition to the closely related to the osmotic pressure adjustment, then the salinity also determine the buoyancy of the pelagic eggs of its nature. Besides changes in the salinity of the water mass changes often show and stability conditions.

Eel larvae (impun) do the spawning at a depth of 400-6,000 metres under the sea with a temperature of 16°-18°C and the parent discharge will die after spawning process. After that eel larvae will be heading to waters with low salinity to mature before returning to sea for breed. Based on Figure 4, the following relationship with salinity results catch fish eel larvae (‘impun’) at the mouth of Cimandiri, Citepus and Cimaja in wet and dry month:

1. On the wet months (March 24, and April 25, 2015) are not carried out the arrest, because there is no larvae. In the wet at the mouth of the surface salinity waters of Cimandiri estuary on March 24, 2015, ranges between 15-18 ppt and on April 25, 2015, ranged between 14.3-18 ppt in the Meso-mesohaline zone. At the mouth of the surface salinity Citepus Estuary waters on March 25, and April 25, 2015, ranges between 20-24 ppt in the Meso-polyhaline zone. At the mouth of the surface salinity waters Cimaja estuary on March 24, 2015, ranges 20-24,7 ppt and on April 25, 2015 ranged from 20-23,4 ppt in the Meso-polyhaline zone.
2. In the dry months (August 15, and September 16, 2015) catches eel larvae (‘impun’) reached 179 kg, where the mouth of the Cimandiri with the largest capture results is 102 kg, the mouth of Citupus with results is 26 kg and the mouth of the Cimaja with the results is 51 kg.

3. On the dry months in the estuary salinity surface waters of Cimandiri estuary on August 15, 2015 range between 21-23 ppt with the results captured 56 kg and on September 16, 2015, ranged from 21-24 ppt with the results captured 46 kg in the Mexo-polyhaline zone. At the mouth of the surface salinity Citepus estuary waters on August 15, 2015, range between 21-24 ppt with the results captured September 16, 2015, and 15 kg range between 20-22 ppt with the results captured 11 kg in the Mexo-polyhaline zone. At the mouth of the surface salinity waters Cimaja estuary on August 15, 2015, range 22-24 ppt with the results captured 27 kg and on September 16, 2015, range between 20-23 ppt with the results captured 24 kg in the Mexo-polyhaline zone.

4. On August 15, 2015, the most catches in the estuary mouth is in the Cimandiri estuary that is on point samples 1 and 2 with catches of 25kg and 13kg with the highest salinity 21.67 ppt and 21.43 ppt. Getting away from the mouth of the estuary, the catch is reduced as was the case in the sample points 3, 4 and 5 with a value of salinity increases towards the sea and the salinity value towards river decreases with salinity value 20.93 ppt, 22.27 ppt and 22.81 ppt. On September 16, 2015, the catch at point 1 and 2 samples with catches of 20 kg and 12 kg with the highest salinity 21.96 ppt and 20.81 ppt. Same as of on August 15, 2015, on September 16, 2015, also happens that is increasingly far from the mouth of the estuary, the catch is reduced as was the case in the sample points 3, 4 and 5 with a value of salinity increases towards the sea and the salinity value towards river decreases with salinity value 20.56 ppt, 23.57 ppt and 23.64 ppt.

5. On the Citepus estuary on August 15, 2015, catches at each sample point location is relatively the same amount of the catch 15 kg with an average value of salinity in the sample point 23 ppt. The number of catches at the mouth of the estuary more compared with catches at the point of the other samples. As of August 15, 2015, the date of September 16, 2015, the number of catches at each sample point location relative amount equal to 11kg with an average value of salinity in each sample point is 21 ppt and the number of catches at the mouth of the estuary more compared with catches at the point of the other samples.

On August 15, 2015, the most catches in the Cimaja estuary is at the mouth of the estuary at the point samples 1 and 2 with catches of 8 kg with the highest salinity 23.12 ppt and 22.74 ppt. Getting away from the mouth of the estuary, the catch is reduced as was the case in the sample points 3, 4 and 5 with a value of salinity increases towards the sea and the salinity value towards river decreases with salinity value 23.58 ppt, 22.59 ppt and 21.81 ppt. On September 16, 2015, the catch at point samples 1 and 2 has a value of catches and the salinity value equal to catches of 8 kg with the highest salinity 21.70 ppt. Same as of August 15, 2015, on September 16, 2015, also happens that is increasingly far from the mouth of the estuary. The catch is reduced as was the case in the sample points 3, 4 and 5 with a value of salinity increases towards the sea and the salinity value towards river decreases with salinity value 22.78 ppt, 21.56 ppt and 20.13 ppt.

![Figure 4](attachment:image.png)

**Figure 4.** The graph of the relationship of the level of salinity with the results of taking eel fish larvae.
4. Conclusion

Based on the results of analysis and discussion, then it can be inferred that the fish larvae eel distribution at the mouth of Cimandiri River, Citepus River, and Cimaja River obtain from the results of the drilling program at the fisherman’s catch and salinity occurred during the dry months where most catches occurred at mouth of the estuary. The catch is reduced if farther from the mouth of the estuary is on the coast towards the sea and the inside of the mouth of the river with the highest salinity towards the sea is increasing while the value of salinity towards the river reduced. Variations of salinity in the estuary area are determined by the big nothingness of mixing that is affected by rainfall, tidal and the sea current conditions. High salinity occurs when rainfall is low, the state of the tide at the speed of sea current that high move horizontally. Low salinity occurs when high rainfall, the tidal is state ebbs and the current speed of moving horizontally.

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